



CONSOLIDATED ANNUAL ACTIVITY REPORT 2019

22 June 2020

In accordance with Article 20 of the Statutes of the S2R JU annexed to Council Regulation (EU) No 642/2014 and with Article 23 of the Financial Rules of the S2R JU.

The Annual Activity Report will be made publicly available after its approval by the Governing Board.

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FACTSHEET

Name	Shift2Rail Joint Undertaking (hereinafter S2R JU or S2R)
Objectives	<p>The Shift2Rail Joint Undertaking is a public-private partnership in the rail sector, providing a platform for cooperation that drives innovation in the years to come. The S2R JU pursues research and innovation (R&I) activities in support of the achievement of the Single European Railway Area and should improve the attractiveness and competitiveness of the European rail system.</p> <p>The S2R JU contributes to:</p> <ul style="list-style-type: none"> • a 50 % reduction of the life-cycle cost of the railway transport system (i.e. costs of building, operating, maintaining and renewing infrastructure and rolling stock), • a 100 % increase in the capacity of the railway transport system, • a 50 % increase in the reliability and punctuality of rail services (measured as a 50 % decrease in unreliability and late arrivals). <p>The S2R JU shall propose innovative solutions to be explored, tested and demonstrated in operational environment and/or “zero on site” to achieve market uptake. Beyond that, with the deployment of its innovative solutions the S2R JU will foster connections between people, regions, cities, and businesses, supporting the socioeconomic objectives of the Union</p>
Founding Legal Act	Council Regulation (EU) No 642/2014 of 16 June 2014 establishing the Shift2Rail Joint Undertaking ¹ (S2R Regulation)
Executive Director (ED)	Mr Carlo M. Borghini, as from 16 May 2016
Governing Board (S2R GB)	<p>European Commission (EC) members (at 20/01/2020):</p> <ul style="list-style-type: none"> • Henrik HOLOLEI, DG MOVE • Elisabeth WERNER, MOVE DDG 2 <p>EC alternate (at 31/12/2019):</p> <ul style="list-style-type: none"> • Ratso SIGNE (RTD.I) <p>Industry members (at 20/01/2020):</p> <ul style="list-style-type: none"> • ALSTOM Nicolas CASTRES-SAINT-MARTIN • Hitachi Rail STS Antonella Trombetta • AZD Praha Vladimir KAMPIK • BOMBARDIER TRANSPORTATION Massimo SIRACUSA • CAF Imanol ITURRIOZ • DEUTSCHE BAHN Hans Peter LANG • EUROOC Thomas PETRASCHKE • HACON Lars DEITERDING

¹ OJ L 177, 17.6.2014, p. 9

	<ul style="list-style-type: none"> • <i>INDRA</i> Javier Rivilla LIZANO • <i>KNORR - BREMSE</i> Hans-Christian HILSE • <i>NETWORK RAIL (Industrial Spokesperson)</i> Andy DOHERTY • <i>SIEMENS</i> Roland EDEL • <i>SMARTDEMAIN</i> Henk SAMSON • <i>SMARTRACON</i> Michael Meyer zu HÖRSTE • <i>SNCF</i> Carole DESNOST • <i>THALES</i> Alberto PARRONDO • <i>TRAFIKVERKET</i> Bo OLSSON • <i>VVAC+</i> Filip KITANOSKI <p>Industry alternates (at 20/01/2020):</p> <ul style="list-style-type: none"> • <i>ALSTOM</i> Sophie PERROCHEAU • <i>Hitachi Rail STS</i> Nadia MAZZINO • <i>AZD Praha</i> Michal PAVEL • <i>BOMBARDIER TRANSPORTATION</i> Richard FRENCH • <i>CAF</i> Jorge DE CASTRO • <i>DEUTSCHE BAHN</i> Ralf MARXEN • <i>EUROC</i> (to be appointed) • <i>HACON</i> Rolf GOOßMANN • <i>INDRA</i> tbc • <i>KNORR - BREMSE</i> Jasmina BRACKOVIC • <i>NETWORK RAIL</i> Felicity OSBORN • <i>SIEMENS</i> Jürgen SCHLAHT • <i>SMARTDEMAIN</i> Javier Bonilla DÍAZ • <i>SMARTRACON</i> Jaizki MENDIZABAL • <i>SNCF</i> Christophe CHERON • <i>THALES</i> Yves PERREAL • <i>TRAFIKVERKET</i> Christer LOFVING • <i>VVAC+</i> Erik STOCKER <p>Other participants (at 20/01/2020):</p> <ul style="list-style-type: none"> • Carlo M BORGHINI Executive Director of the S2R JU <p>Observers (at 20/01/2020):</p> <ul style="list-style-type: none"> • Josef DOPPELBAUER (ERA) • Anna GIGANTINO (ERA) • Angela DI FEBBRARO (SC) • Sarah BITTNER-KRAUTSACK (SRG)
Other bodies	<p>Scientific Committee (SC)</p> <p>States Representatives Group (SRG)</p> <p>Innovation Programmes' Steering Committees (IP SteCos)</p>
Staff	<p>24 at 31 December 2019 including 3 Seconded National Experts (SNEs) and excluding one exceptional recruitment (cf. 2.6)</p>

2019 Budget	<p>The initially adopted budget was amended a first time on 24 June 2019; by year end, in agreement with the Governing Board as per minutes of the meeting of 4 December, the Executive Director transferred EUR 2 million in terms of commitments and payments appropriations, from Title 3 to Title 4 in order to be made available immediately to the S2R JU Call 2020, in accordance with S2R JU FR art.6.5 and with the GB Decision.</p> <p>As a result, the Final Adopted Budget amounted to EUR 82.8 million in commitment appropriations, of which EUR 76.7 million for operational expenditure, EUR 3.5 million for administrative expenditure and EUR 2.6 million of unused appropriations not required in the financial year but needed to meet early 2020 commitments. In payment appropriations, the Final Adopted Budget was EUR 81.3 million, of which EUR 74.9 million for operational expenditure, EUR 3.7 million for administrative expenditure and EUR 2.6 million of unused appropriations not required in the financial year.</p>
Budget implementation	<p>Based on the above, the Budget implementation in terms of commitment appropriations is at 100% and, in terms of payment appropriations at 89% (both excluding the unused appropriations not required in the financial year). The payment appropriations' implementation presents a constant improvement compared to previous years (78.6% in 2017 and 82.3% in 2018). The implementation of Administrative budget was EUR 3.5 million in commitment appropriations and EUR 3.6 million in payment appropriations, respectively representing 100% and 96.1% of budget execution. Applying sound financial management, the JU makes use of multi-annual framework contracts in particular in Title 2. The Administrative budget corresponds to approximatively 4% of the JU Budget. The Operational Budget was implemented at EUR 76.7 million in commitment appropriations (100%) and EUR 66.3 million (88%) in payment appropriations.</p>
Grants	<p>In September 2019, the S2R JU awarded 17 grants as a result of the 2019 Call launched on 15 January 2019 based on the amended Annual Work Plan (AWP) 2019. One topic has not been covered (equating to EUR 2 Million unspent from the call). All 17 grant agreements were signed between September and December 2019, allowing the timely start of the projects. In total, the awarded and signed grants will fund Research and Innovation activities up to EUR 74.8 million against a total value of EUR 148.6 million. In this respect, it should be noted that the Founding Members other than the Union and the Associated Members (jointly referred to as the "Other Members") agreed to limit their requests for funding to 44.44% of the total project cost.</p>
Strategic Research Agenda	<p>The S2R JU Programme is described in the Multi-Annual Action Plan (MAAP) adopted by the S2R GB in 2015.</p> <p>In November 2019, the S2R JU MAAP was updated. It consists now of two parts:</p> <ul style="list-style-type: none"> - Part A – Executive View, adopted by the S2R JU Governing Board on 27 October 2017 by Decision N°7/2017; - Part B – Technical Content, annexed to the Decision of the GB N° 9/2019; <p>The original MAAP of 2015 is maintained as a reference document.</p>

Call implementation	<p>The Call 2019 was implemented already at the beginning of the year. The award of the call 2019 took place during the Governing Board meeting of 4 September 2019. With an exceptional commitment and effort, the Other Members and OC together with the JU were able to reach the signature of 17 grants related to the Call 2019 by year end. Two other grants related to the Call 2018 were signed in the first quarter 2019. In accordance with a multi-annual calendar, all the preparatory works of the Call 2020 were realized in 2019 and on 14 November 2019, the S2R GB adopted the AWP 2020 and budget.</p>
Participation, including SMEs	<p>Under the 2019 Call, 90 Small and Medium Enterprises (SMEs) participated to the 2019 Call (20.0%) and 40 SMEs were retained for funding (44%). SME's represent 30% of the entities selected in the Open Calls projects.</p>

EXECUTIVE SUMMARY

The Shift2Rail Joint Undertaking (S2R JU or S2R) is a public-private partnership under the Horizon 2020 Framework Programme² established to manage and coordinate mission-oriented Research and Innovation (R&I) activities for a major transformation in rail systems in Europe.

The S2R JU was officially established on 7 July 2014, following the adoption of Council Regulation (EU) No 642/2014 of 16 June 2014 establishing the Shift2Rail Joint Undertaking (S2R Regulation).

During 2019, the S2R JU has progressed towards achieving its targets, delivering the S2R Programme implementation ensuring an effective and efficient sound financial management.

Programme Status

By the end of 2019, the Programme reached a pivotal milestone in term of Programme implementation: more than 50% of the Programme has been delivered in view of the TRL6/7 operational demonstrations planned for conclusion in 2022. At large, all Projects have delivered the planned activities: only 8 TDs/WAs report having performed less than 80% of their planned activities in the year, of which one TD below 50%. In addition, by year-end, also the R&I activities of the Call 2019 started: they set the implementation of the first TD Demonstrators at TRL 6/7. In total, it is estimated that the Total Project Cost of the activities performed in 2019 amounts to EUR 117.5 million, of which EUR 98.9 million delivered by the Members other than the European Union (hereinafter Other Members).

During the month of April 2019, the S2R JU assessed its R&I activities through a third Control Gate exercise³. This exercise took into account the deliverables and reports submitted in the context of the Annual Review of the 2015-2016 and 2017 Projects coordinated by the Other Members. The S2R JU also ensured through this process that the recommendations made during the previous Control Gate Assessment had been properly applied. The overall result is that the Programme benefited from such feedback, built upon also external expertise.

The quality of some submitted deliverables was below standard and the S2R JU requested several re-submissions of deliverables and suspended technical and financial reports. This process is still particularly demanding as no advance planning can be made. In 2019, the S2R JU piloted with some projects a new continuous review process of deliverables combined with a control gate at the moment of the annual review. In this way, the concerned projects were much less at risk of being subject to payment suspensions due to the quality of the deliverables, as those were already corrected or resubmitted. The pilot made by the JU was considered successful and it will be extended further during 2020.

In addition, this process is integrated in the overall Programme monitoring realized through the quarterly meetings of the Innovation Programmes (IPs) where it is assessed how the different R&I activities organized in Projects are progressing.

² Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11 December 2013 establishing Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020), OJ L 347, 20.12.2013 and Council Decision (EU) No 2013/743/EU of 3 December 2013 establishing the specific programme implementing Horizon 2020 (2014-2020), OJ L 347, 20.12.2013, p. 965.

³ In accordance with the procedure set in the S2R Governance and Process handbook, transparently published on the S2R website: https://shift2rail.org/wp-content/uploads/2017/12/S2RJU-Governance-and-Process-Handbook_20171010_v11_Cleanv-nd.v2.pdf

Similarly to the previous year, the S2R JU decided not to insert the 2018 Other Members Projects in the Control Gate assessment process of 2019 (no Project Review) due to the limited number of results available; those projects will perform their first Control Gate assessment in 2020.

The S2R JU Programme Team conducted also projects review meetings for non-S2R Members during 2019. The request of such projects to better interact with the reviewing experts and the S2R Programme Managers will have to be considered at the light of the future staffing of the JU.

This Programme assessment allowed the S2R JU to confirm that overall the progress of the activities has been in line with the expectations. In addition, the launch of the system approach activities within IPx allowed providing additional coherence and consistency between the interdependencies of the implementing Projects.

Considering the status of the progress of the TDs reported in Section 1.7. Only few TDs show delays compared to the initial scheduling, mostly due to external factors.

In such cases, the JU has requested the concerned Project Teams to put in place the necessary mitigating measures.

- IP1

Positive progress has been reported on all TDs that on average have reached 98% of the estimated work planned in 2019 and all IP1 TDs started between 2016 and 2017 have reached the significant milestone of being half-way through their implementation. TD1.8 instead only started at the end of 2019 because it is a newly introduced activity to greening the heating and ventilation system, showing the ability of IP1 to tackle new challenges. The initial results in each TDs show that the investment in research and innovation is going to bring the expected results in terms of more efficient, lighter, automated and customer oriented passenger trains.

The TDs are preparing for the TRL 6/7 demonstrations and are producing quality technical results. Several IP1 innovation results are expected to affect European or international standards; for this reason, its work is closely monitored and activities are shared with standardisation setting organisations and regulatory bodies. During 2019, synergies between IP1 and IP2 have continued in particular with regard to Train Control and Monitoring System (TCMS) and telecoms. The IP1 programme has also contributed with valuable results to Cross Cutting Activities (CCA) work areas (Energy, Noise and Vibration, Smart Maintenance, Virtual Certification, etc.).

- IP2

Positive progress has been reported on all TDs that on average have reached 94% of the estimated work planned in 2019 and all IP2 TDs started between 2016 and 2017 have reached the significant milestone of being half-way through their implementation. TD2.8 on “virtual coupling” instead only started at the end of 2018, showing also some implementation delays and having reached an overall implementation maturity at 30% by the end of 2019. S2R started to provide, in 2019, to the European Union Agency for Railways the first sets of specifications for a number of ERTMS Game Changers, and notably on Automated Train Operation over ETCS and Moving Block. Test

benches are ongoing or finalised and the pilot tests for interoperability purposes will start soon to demonstrate the validity of the specifications, allowing as well for fine-tuning where needed.

The preparations for the ATO demonstrator progressed very well; nevertheless there are still pending discussions on the availability of the NR train and network for the demonstrations. Where such issues would not be solved within the 1st Quarter 2020, the demonstration will have to take place in another network.

Overall, the results achieved are key milestones for the market uptake of the solutions of this IP and prepare the integration of functions and its specifications in the Control Command and Signalling TSI, in the next revision, currently targeted by 2022. The work performed in IP2 will show how R&I will feed the new regulatory framework and become a test bed for the future deployment of S2R innovative solutions. The next couple of years will demonstrate the expected Game Changers benefits of IP2 to ERTMS: in particular, how the rail sector in S2R is able to feed the working groups of ERA that will shape R&I results in regulatory proposals for future proof systems.

With particular regard to the activities of IP2, in agreement with the GB, the ED adopted a decision establishing a renewed Programme Governance and Change Management to foster the integration of innovations and subsystems making use of a new functional (or better service-oriented) system architecture. The renewed Programme Governance and Change Management will support the integration within the S2R Programme of new concepts, ideas, solutions, etc. compared to the MAAP and its AWP. This renewed Programme Governance and Change Management are also an answer to the initiatives brought forward by Infrastructure Managers and Railway Undertakings in terms of subsystems specific architectures...

- IP3

As in the previous years, this IP suffered of an uneven progress between TDs. On average IP3 has reached 89% of the estimated work planned in 2019, but TDs 3.1 to 3.5 have suffered in 2019 with the full implementation of their expected activities. Switches and crossings, track and bridges and tunnels activities are therefore showing a delay in their overall implementation, estimated in average at 30% (instead of a theoretical 50%). The S2R JU is asking related projects to implement mitigation measures and there is confidence that as with some additional efforts in 2020 the gap could be closed. In general, all R&I is moving towards the operational environment demonstrators, with very good progress showed by the Asset Management activities (TDs 3.6 to 3.8), Energy management (TDs 3.9 and 3.10) and the Future Stations (TD3.11), all of which reached their milestone of being half-way through their overall implementation.

- IP4

Moderate progress has been made on all TDs that on average have reached 85% of the estimated work planned in 2019. IP4 shows good progress towards the final demonstrations. IP4 has a dedicated ITD which is integrating all technologies coming from the TDs and it is already testing functionalities with an agile approach. In 2019, IP4 fully embraced the Mobility as a Service Functionality, evolving its original concept of passenger information system focusing more and more towards cities concerns. A significant number of testing activities in real cities has been

planned and work is made to ensure a timely delivery of the technology. The S2R JU is addressing with the Members an acceleration of the technological progress in order to avoid that real-life testing activities would not happen because of implementation delay.

- IP5

In 2019, the TDs reached an average implementation rate of 67%, including some key results, such as the first CBM-dashboards streaming live data from the locomotive fleet, as well as a demonstrator for intelligent video gates, and the testing of distributed power in push-pull operation of a commercial freight train. The running projects (AWP2015 to AWP2018) consumed less than 50 % of the overall IP5 budget, with a defined scope largely on analysis, requirements and technology specification. Consequently, the 50% milestone of overall progress has not been reached, yet. Nevertheless, some key IP5 demonstrators will already follow in 2020. Where delays were detected, S2R JU addressed also the issue with the IP5 and TDs leadership to ensure that mitigating measures are dealt by in a systemic manner and adequate resources are assigned for quality delivery of the planned work.

Great expectations are built especially on TD 5.1, considering the work to be performed on freight ATO in coordination with IP2, in view of the upcoming TRL7 demonstrator in Switzerland, additional CBM innovations and the prototype development of a standard European digital automatic coupler. The reorganization of IP5 introduced in the new MAAP Part B promotes a more consistent approach to innovative solutions for rail freight, resulting in a combination of digitalization-driven developments and migration plans, which may pave the way for a substantial change in the business. Nevertheless, the acceleration in some of key aspects of IP5 may require additional resources to achieve market impact - resources not yet available for rail freight in the S2R Programme.

- CCA

The Cross Cutting Activities were able to catch up the slower pace showed in 2018, with an average of 93% of implementation of planned activities for 2019. Several Work Areas are close to successful completion...

The work performed on the Key Performance Indicators demonstrates that the approach through Releases provides opportunity for monitoring the progress of the Programme, while assessing the different contributions of the TDs and their relations. Nevertheless, the progress achieved might be at risk if the efforts are not duly matched by the continuation contributions of the TDs as well as scenario beyond the usual “comfort zones”.

- IPX

The activities implemented around IPX have provided some initial results in 2019 but they are still at their early implementation stage. Some issue were encountered in the recruitment of some PhDs, which now has been solved. Activities around the system of system approach have started

with Linx4Rail which is supposed to deliver a draft version of the first railway Functional System Architecture by mid-2020.

Programme Management and MAAP

In terms of Programme Management, the S2R JU took some corrective measures for the synchronisation of the Programme, resulting in the acceptance of few deliverables submission delays that will not affect, in principle, the overall Programme results. During this process, it clearly appeared that there is not a continuous internal communication process within the Other Members' entities.

By Decision N°15/2015 of 27 November 2015, the Governing Board adopted the first version of the MAAP. By Decision No 7/2017 of 27 October 2017, the MAAP has been amended. Parts 1 and 2 of the MAAP were replaced by a new Part A, including the S2R JU high-level objectives. In 2018 and 2019, the Other Members, in coordination with the JU, worked on the MAAP Part B, to align it with the vision set in the MAAP Executive View Part A, to take stock of the results of the ongoing Projects, of new technologies/businesses emerging in view of future demonstrations paving the way to future deployment activities. During the 22nd GB meeting of 14 November 2019, a consolidated version of the MAAP, including the new Part B was adopted.

The S2R JU Multi-Annual Action Plan therefore consists of two parts:

- Part A – Executive View, adopted by the S2R JU Governing Board on 27 October 2017 by Decision N°7/2017;
- Part B – Technical Content, annexed to the Decision of the GB N° 9/2019;

the original MAAP of 2015 will be maintained as a reference document.

With a holistic approach, the role of the S2R JU is also to ensure that interactions between the various IPs are adequately considered and managed, as technological developments in one part of the system could lead to changes in performance, or even create barriers, in other parts. In addition, cross cutting activities include research on long-term economic and societal trends such as customer needs and human capital and skills, which must be taken into account by the different IPs.

In this respect, at the end of 2019, in agreement with the GB, the ED adopted a decision establishing a renewed Programme Governance and Change Management to foster the integration of innovations and subsystems making use of a new functional (or better service-oriented) system architecture. The renewed Programme Governance and Change Management will support the integration within the S2R Programme of new concepts, ideas, solutions, etc. compared to the MAAP and its AWP.

The aforementioned ED Decision includes also the establishment of a formal advisory support to the ED in the form of a new ED Programme Board.

R&I activities launched in 2018 and prepared for 2019

In September 2019, the S2R JU awarded 17 grants as a result of the 2019 Call launched on 15 January 2019 based on the amended Annual Work Plan (AWP) 2019. One topic has not been covered (equating to 2 Million Euros unspent from the call).

17 grant agreements were signed between September and December 2019, allowing the timely start of the projects. In total, the grants will co-fund Research and Innovation activities up to EUR 74.8 million against a total value of EUR 148.6 million. The CFM part of the Call was implemented through the Lump Sum approach with start demonstrating its benefits.

As in the case of the previous years and for the full duration of the Programme, the Founding Members other than the Union and the Associated Members (jointly referred to as the “Other Members”) of the S2R JU agreed to a funding rate of maximum 44.44% (this would mean a net 41.44% for an Other Member after having considered its obligations), demonstrating a strong commitment to deliver the most ambitious Railway R&I Programme for a major transformation to rail systems, once deployed.

203 entities, of which 40 SMEs (20.0%), were retained for funding in the 2019 Call. The participants represented 25 countries, of which 17 EU Member States and 2 Countries associated to the Horizon 2020 Framework Programme (See Annex C for details).

To facilitate a future stronger participation from the EU-13 Member States, feedbacks received by the S2R JU suggests that it will be important to integrate successful S2R R&I results with longer-term demonstration activities, encompassing a wider geographical sector involvement and impact across Europe, to bridge the way towards future deployment.

In December 2019, the S2R JU started the process for the preparation of the 2020 Call that was finally published on 7 Jan 2020 in the Horizon 2020 Funding & tender opportunities portal and based on the original version of the AWP 2020 adopted by the S2R JU GB on 14 November 2019. This lengthy process includes the key contribution of the S2R Members, the review and advice at different points of the SC, SRG, ERA and UR-ID and the adoption by the S2R GB, after the overall work was finalized under the responsibility of the Executive Director.

Activities aligned to feed the successor of the S2R JU

The S2R JU current activities are progressing towards their demonstrations in 2022 and paving the way to the R&I activities to be performed by the S2R successor, ensuring a proper phase out and phase in of the two Programmes. The S2R technological demonstrators are the building blocks of a more systemic railway transformation which is strategically driven by the European Commission’s Digitalisation Agenda and Green Deal.

In September 2019, in agreement with the European Commission services, Shift2Rail organised the first workshop in the form of a brainstorming discussion on the next partnership and the ambition of the rail sector. The European Commission participated to the event as observer.

Further to this, S2R was asked to contribute to the 1) S2R Impact Assessment coordinated by DG RTD and 2) to the “Supporting analysis for defining the future rail research and innovation partnership under the next multi-annual financial framework” coordinated by DG Move. The S2R JU, its members and stakeholders provided all necessary background to the contractors of the European Commission in interviews and by disseminating the necessary material/questionnaires.

In addition, the JU coordinated and supported the development of a High Level Paper on the S2R successor, the candidate European Institutional Partnership “Transforming Europe’s Rail System”. As part of its preparations to set new R&I European partnerships under the next research and innovation framework programme, Horizon Europe, the European Commission asked the rail sector (EIM, CER with the technical support of UIC, UNIFE, UITP, ERRAC, etc.) in autumn 2019 to develop the key features of a future European partnership. The S2R JU, in its role of sectorial stakeholders’ integration,

coordinated the various inputs, which led to the submission of a first version of the High Level Paper to the Commission services in December.

This work was also an opportunity for the S2R JU to re-assess the maturity level expected to be reached by the different streams of work, the potential in terms of market take up of R&I outputs, and indicate the areas of improvements to foresee for the next generation of R&I projects, the so called “transforming projects”.

The results of the Inception Impact Assessment which closed in August 2019 and for which 46 feedbacks were provided are available on the following website:

<https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/11910-European-Partnership-for-transforming-Europe-s-rail-system> . The public consultation lasted from 11 September to 12 November 2019; results will be published on the above-mentioned website.

Other activities

In order to provide administrative support to the Programme execution, the JU has progressed in the recruitment of staff filling budgetary open positions; at the end of the year, 24 position were filled, including 3 SNEs. The JU is subject to high turnover mostly due to the fact that other Union JUs and Agencies are in the position to offer Temporary Agent posts (TA) instead of Contractual Agent posts (CA). In fact, contrary to almost all other Union Institutions, Agencies and JUs, the S2R JU has a Staff Establishment Plan with 25% TAs positions and 75% CAs positions; in almost all other cases, these percentages are reversed!

With regard to communication and dissemination activities, the S2R JU further reinforced its communication and dissemination activities. In 2019, the first edition of Shift2Rail’s Catalogue of Solutions was published, illustrating successful R&I results in the form of possible stand-alone and integrated products. It highlights the benefits of Shift2Rail solutions for final users, operators, infrastructure managers and/or suppliers, as well as specifying delivery dates.

The catalogue of solutions was presented by the JU at the [World Congress on Railway Research](#) in Tokyo. In addition to participating in flagship international events such as WCRR and Digital Transport Days, Shift2Rail also supported a number of regional Info Days to continue raising the awareness of the programme and to mobilise rail stakeholders at local level, encouraging cooperation.

In order to increase cooperation in Member States, the S2R JU signed a Memorandum of Understanding (MoU) with the Czech Republic on 4 January 2019; and with ETSI on 14 May 2019. In January 2020, a MoU was signed with the Basque Region.

In addition to the efforts on stakeholder involvement, the JU further continued improving its internal organisation as to provide continuous support to its Members and beneficiaries. By implementing its internal control system, performing defined control activities as well as assessing and managing risks, the JU has ensured the sound financial management of EU funds.

With regard to the Discharge in respect of the implementation of the Budget of the S2R JU for the financial year 2018 and the European Parliament resolution, the present report provides in its different sections the answers requested by the Budgetary Authority. All actions stemming from audit recommendations have been implemented without delay, thus reinforcing the internal management and control system of the S2R JU.

Suggestions from the SRG and the SC to improve the present report have been taken into account.

It can be concluded that, thanks to the commitment of both Members and Programme Office, 2019 has seen the S2R JU accelerating its progress towards delivering the Programme with a clear final users focused approach.

United Nations Sustainable Development Goals (UN SDG)

The R&I work performed by the S2R JU contributes to, at least, 6 out of 17 UN SDG. In particular, the S2R Programme contributes to

- building resilient infrastructure,
- promoting inclusive and sustainable industrialization processes – at manufacturing or operational levels,
- fostering innovation at all levels of the value chain,
- promoting inclusive and sustainable economic growth, tackling also aspects related to human capital opportunities and impact of new technologies on future skills and competences,
- new mobility and transport models towards smart and sustainable cities and regions, connecting people and providing new socio-economic opportunities,
- the urgent actions taken at Union level to combat climate change and its impacts,
- promoting gender equality at all its levels.

During the last three years of activities and more in 2019, S2R shifted from being technology driven to a mission oriented Programme, designed to meet passengers and shippers needs, contributing to achieve sustainable mobility and transport, where railway offers an integrating platform in a multimodal approach, enabled by new technologies, in particular digitalization, automation, telecoms and satellite services. Also in 2019, S2R continued with the application of the agreed implementations measures stemming out of the Action Plan addressing the suggestions for improvement indicated in the Interim Evaluation of S2R of 2017.

S2R remains strongly delivery oriented while coupling the need of further exploring new solutions to harvest their full benefits.

INTRODUCTION

The S2R JU was established by Council Regulation (EU) No 642/2014 of 16 June 2014 (S2R Regulation) with, in Annex I, the S2R Statutes.

The S2R JU is a public-private partnership in the rail sector established under Article 187 of the Treaty on the Functioning of the European Union, providing a platform for the rail sector as a whole to work together with a view to driving innovation in the years to come. Inter alia, the S2R JU shall manage all rail-focused R&I actions co-funded by the Union.

The S2R JU is a mission-oriented Programme delivering a major system transformation, bringing railway at the centre of advanced integrated mobility.

The Vision of S2R JU is

TO DELIVER, THROUGH RAILWAY RESEARCH AND INNOVATION, THE CAPABILITIES TO BRING ABOUT THE MOST SUSTAINABLE, COST-EFFICIENT, HIGH-PERFORMING, TIME DRIVEN, DIGITAL AND COMPETITIVE CUSTOMER-CENTRED TRANSPORT MODE FOR EUROPE.

The mission statement of the S2R JU is

“Shift2Rail: moving European railway forward”

Rail R&I conducted within the S2R JU must contribute to addressing the challenges faced by the rail sector, through a comprehensive and coordinated approach to R&I focusing on the needs of the rail system and of its users, including in Member States that do not currently have a railway system within their territory.

This is part of a clear legal framework, where the European Commission, DG MOVE in particular, inter alia defines the transport and mobility policies, the S2R JU contributes to delivering and challenging them through its R&I Programme and ERA acts within its regulatory mandate under the 4th Railway Package.

In addition to the Union, the S2R JU has eight Founding Members other than the Union⁴ and nineteen Associated Members. The latter were selected following a call for expression of interest to become Associated Member of the S2R JU^{5 6}.

In this respect, its main objective is to implement the S2R Programme, R&I activities in the railway sector in Europe, through the collaboration between stakeholders in the entire railway value chain, also outside the traditional rail sector, with particular attention to SMEs, research and technology centres and universities.

⁴ Consisting of rail equipment manufacturers Alstom Transport, Ansaldo STS, Bombardier Transportation, Construcciones y Auxiliar de Ferrocarriles (CAF), Siemens AG, Thales and infrastructure managers Trafikverket and Network Rail

⁵ Commission Decision N° C(2014) 7084 final

⁶ AERFITEC consortium, Amadeus IT Group SA, AZD Praha s.r.o., CFW consortium, Deutsche Bahn AG, DIGINEXT, EUROCC consortium, Faiveley Transport, HaCon Ingenieurgesellschaft mbH, Indra Sistemas S.A., Kapsch CarrierCom, Knorr-Bremse GmbH, MER MEC S.p.A., Patentes Talgo S.L., Railenium Swi'TRACK'EN consortium, Smart DeMain consortium, SmartRaCon consortium, SNCF, Virtual Vehicle Austria consortium+

The Union tasked the S2R JU with its Regulation and Statutes, *to manage all rail- focused research and innovation actions co-funded by the Union, ensuring coordination among projects and providing all stakeholders with relevant and available information on projects funded across Europe.*

This task is complemented by the request of the Union to the S2R JU *to establish and develop — and ensure the effective and efficient implementation of — a strategic Master Plan (the ‘S2R Master Plan’)*, which has been endorsed by the Council⁷, and which provides a high-level view of what needs to be done; it explains why and by when. It sets the framework for the research and innovation (R&I) activities to be performed within and beyond the S2R Programme and the deployment activities to be carried out by all operational stakeholders, coordinated to achieve the Single European Railway Area.

The S2R JU has developed, together with its Members and advisory bodies, the S2R MAAP, which translates the S2R Master Plan into detailed, result-oriented R&I activities to be performed to start delivering the S2R partnership vision as from 2014 onwards. The S2R MAAP contains two parts: an Executive View developed in 2017⁸ (Part A) and a technical part (Part B) which was revised between 2017 and 2019⁹. Overall, the S2R JU shall:

- contribute to the implementation of H2020 Regulation and in particular part of the Smart, Green and Integrated Transport Challenge under the Societal Challenges pillar of Decision No 2013/743/EU;
- contribute to the achievement of the Single European Railway Area, to a faster and less costly transition to a more attractive, user-friendly (including for persons with reduced mobility), competitive, efficient and sustainable European rail system, and to the development of a strong and globally competitive European rail industry;
- play a major role in rail-related R&I, ensuring coordination among projects within its overall Programme. It provides all stakeholders with relevant and available information on R&I activities funded across Europe. It shall also manage all rail-focused R&I actions co-funded by the Union;
- actively promote the participation and close involvement of all relevant stakeholders from the full rail value chain and from outside the traditional rail industry. In particular, it fosters the involvement of small and medium sized enterprises (SMEs), as defined in Commission Recommendation 2003/361/EC (8);
- develop demonstration projects in interested Member States including those that do not currently have a railway system established within their territory.

The S2R Joint Undertaking shall, more specifically, seek to develop, integrate, demonstrate, and validate innovative technologies and solutions that uphold the strictest safety and security standards and the value of which can be measured against, inter alia, the following key performance indicators:

- a 50 % reduction of the life-cycle cost of the railway transport system, through a reduction of the costs of developing, maintaining, operating and renewing infrastructure and rolling stock, as well as through increased energy efficiency;
- a 100 % increase in the capacity of the railway transport system, to meet increased demand for passenger and freight railway services;

⁷ <http://ec.europa.eu/transport/modes/rail/doc/2015-03-31-decisionn4-2015-adoption-s2r-masterplan.pdf>

⁸ https://shift2rail.org/wp-content/uploads/2017/11/Shift2Rail-MAAP-Part-A_Executive-View_webfinal.pdf

⁹ https://shift2rail.org/wp-content/uploads/2019/12/GB-Decision-9-2019_MAAP-Part-B.pdf

- a 50 % increase in the reliability and punctuality of rail services (measured as a 50 % decrease in unreliability and late arrivals);
- the removal of remaining technical obstacles holding back the rail sector in terms of interoperability, product implementation and efficiency, in particular by endeavouring to close points which remain open in Technical Specifications for Interoperability (TSIs) due to lack of technological solutions and by ensuring that all relevant systems and solutions developed by the S2R Joint Undertaking are fully interoperable and fitted, where appropriate, for upgrading;
- the reduction of negative externalities linked to railway transport, in particular noise, vibrations, emissions and other environmental impacts.

R&I activities are performed by the Other Members and any other eligible entity. They are co-funded or procured by the S2R JU in accordance with its budget availabilities and in compliance with the H2020 Regulation¹⁰, its Rules of participation¹¹ and the S2R Financial Rules. To this end, the S2R JU shall organise calls for proposals and/or for tenders for supporting the R&I activities.

As specified in Article 17 of the S2R Statutes,

- a. up to 40 % shall be allocated to founding members, other than the Union, and their affiliated entities
- b. up to 30 % shall be allocated to associated members and their affiliated entities;
- c. at least 30 % shall be allocated by way of competitive calls for proposals and calls for tenders.

As for the “open and competitive calls” (point c. here above), also the award of the R&I activities to the Other Members (a. and b. here above) is through competitive calls in compliance with H2020 Rules of Participation and/or calls for tenders, under the relevant eligibility criteria.

1. IMPLEMENTATION OF THE ANNUAL WORK PLAN 2019

1.1. Key objectives 2019 and associated risks

In 2019, the S2R JU activities were driven by the overarching objective to progress the S2R R&I Programme according to the revised MAAP and detailed in the AWP 2019.

The main operational achievements in 2019 can be summarized as follows:

Delivery of Programme R&I activities

During 2019, the Other Members and the OC Projects continued the implementation of the S2R Programme through 84¹² Projects and some procurement contracts, awarded and signed since 2016, for an estimated R&I Total Value of EUR 577.0 million. Details are provided in Section 1.6.

¹⁰ <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:347:0104:0173:EN:PDF>

¹¹ http://ec.europa.eu/research/participants/data/ref/h2020/legal_basis/rules_participation/h2020-rules-participation_en.pdf

¹² 4 Light house projects (2015) not included.

In addition, the Programme supervision and monitoring was implemented through specific 43 Control Gates (24 project reviews of 18 CFM projects, 19 project reviews of 17 OC projects) executed all along the year, which represent an increase of 80% of workload on Control Gates activities for the S2R JU staff, this is significant (as the staff did not increase nor any other activities ended) and reflect the fact the 2019 (and 2020 is expected too) is at the apex of the overall operational JU activities. Additionally, work has been performed on the elaboration of some CCA activities on KPIs and Standards in particular, the review of the technical part of MAAP (MAAP-B), the management of 6 quarterly IP Steering Committees and the follow up of the grant implementation (amendments, reporting, etc.).

Signature of grants related to the 2019 Call for proposals

In 2019, the S2R JU awarded and signed 17 grants for a Total value of EUR 148.6 million

- topics (RIA and IA) open to S2R JU Other Members with a total value of the actions of EUR 130.8 million (max S2R funding EUR 57.6 million);
- topics (RIA and IA) where the S2R JU Members are excluded from participation, with a total value of the actions of EUR 17.8 million (max S2R funding EUR 17.2 million).

The activities planned in the AWP 2019 have been implemented with the exception of those related to topic S2R-OC-IP1-03-2019 “*Support to the development of technical demonstrators for the next generation of brake systems*” has not been conducted as no proposals were submitted under this topic. After careful assessment of the related TDs operational impacts, the GB decided under a proposal from the ED to transfer the unspent related budget to the AWP2020.

Signature of procurement contracts related to 2019 calls for tenders and procurement contracts (see for more details section 1.8-call for tenders and 2.4-Procurement and contracts).

In 2019 the framework contract - Communication and event services and supplies – launched in 2018- was signed. In addition, in 2019 the Implementation of the framework contract “Support to ERTMS European Action Plan to pave the way for the deployment of the future S2R Innovative Solutions” continued.

Stakeholder management and external relations have been further improved through a closer collaboration with the European Union Agency for Railways (ERA) in different areas, with the European Railway Research Advisory Council (ERRAC), as well as with the different International and European organizations and associations. A continuous and constructive exchange took place with other Union bodies and agencies, such as GSA, FCH JU, SESAR JU, CleanSky JU and ECSEL.

In addition, the S2R JU signed a Memorandum of Understanding (MoU) with the Czech Republic on 4 January 2019 and with ETSI on 14 May 2019. In January 2020, a MoU, negotiated during 2019, was signed with the Basque Region.

The JU has also enhanced its communication efforts through the participation in specific activities, workshops and events in order to promote the S2R Programme participation and inform worldwide the achievements of the S2R JU Partnership.

The following sections describe how these objectives have been achieved, the activities performed and the resources used. In Annex C performance is measured against the set of agreed KPIs.

Risks

The annual exercise of 2019 consisted of an in-depth assessment of risks based on the 2018 annual exercise, which had been performed with the support of an external advisory company. The corresponding risks associated with the Programme activities and the financial administration of the JU, requiring continuous ED (and when relevant GB) attention, as well as the corresponding risk mitigation actions have been communicated via the S2R JU AWP 2019.

The annual risk assessment performed allowed concluding that the average Shift2Rail risk profile presents a moderate/high net criticality. No risk appears as having a very high or unacceptable net criticality score.

In the context of this report, only those risks which require continuous attention and treatment by the ED and, when relevant, by the S2R GB, because of their criticality level assigned, are reported. They are summarised in the table below together with an update on mitigating actions.

Risk identified	Action Plan	2019 Follow up
<p>Due to the evolving needs of the users and stakeholders' expectations, the MAAP is no longer adequate/in line with stakeholders' acceptance resulting in not achieving the JU's objectives.</p>	<p>In general:</p> <ul style="list-style-type: none"> • proper planning and regular follow up at IPSteCo/SIWG • projects' control gates • regular reporting to GB, including with the support of the S2R JU advisory groups. <p>At project level:</p> <ul style="list-style-type: none"> • decision made on consensus based approach in IP Steering Committee (SteCo)/ System Implementation Working Group (SIWG)/GB • use of advisory group in Projects • involvement of States Representatives Group (SRG) • involvement of User Requirement Implementation and Deployment Working Group (URID-WG). 	<p>Actions implemented as foreseen. A revised MAAP, including the new Part B was adopted by the GB in November 2019.</p>
<p>In accordance with the Horizon 2020 Rules for Participation and considering the resources available on a yearly basis, the Programme shall be implemented through Projects financed by annual grants. Largely, this may result in a piecemeal approach instead of</p>	<p>Qualitative mitigating measures are identified and implemented to contain and monitor the identified risks. This is realised through the Governing Board, SIWG and IP SteCos which maintain a Programme view compared to a piecemeal project view. S2R JU will keep on assessing the sound financial</p>	<p>Actions implemented as per Action Plan.</p>

Risk identified	Action Plan	2019 Follow up
innovative solutions towards a new integrated, connected and automated railway system. This may result in questioning the sound financial management of the implementation process through grants, especially regarding Members already selected through open competition and commitment.	management risks and possible adequate measures implemented accordingly.	
`Interdependencies create delays or inadequacies in the completion of activities in grants that are complementary or prerequisites to grants to be awarded under following AWP, generating a negative cascading effect.	Ensure, through adequate program management, strengthened monitoring and reporting of projects, including gate reviews to determine whether specific actions need to be taken with regard to a specific project (re-orientation, early closure, etc.).	Actions implemented as per Action Plan.
Cross-project collaboration required to achieve the programme objectives may not be achieved due to 'silo-project management' or restrictions related to 'licenses', 'patents', 'IPR Member's sharing policies' or 'accessibility of past OC project results'.	<ul style="list-style-type: none"> • significant implication of SIWG • decoupling IP structure from AWP topics • further fostering the use of a common S2R Cooperation Tool and sharing functionalities • dedicated cross-IP meeting • IP coordinators meeting • models and guidance from S2R JU • SIWG informal conflict resolutions • simplification of legal structure for collaboration. A S2R JU Common Collaboration Agreement (Common COLA, or 'CCOLA') is under preparation. • in order to ensure connection with national activities, the JU will consider signing specific collaboration agreements with other European and international Organizations, Regions and Member States. 	Actions implemented as per Action Plan.
Delays in project execution or other impediments (e.g. staff-resource constraints) might lead to underspending of resources.	<ul style="list-style-type: none"> • Better monitoring of the consumption • Re-allocation of activities (Revision of activities in the Programme & MAAP) 	Actions implemented as per Action Plan. Together with the Members, the JU performed an in-depth review on budget/IKOP at Programme completion. This

Risk identified	Action Plan	2019 Follow up
	<ul style="list-style-type: none"> Monitoring from conception phase of Grant Agreement (GA) until final payment (and multi-annual objective at programme level). 	was performed with the objective to optimize the use of the Programme resources in the Call 2020.
High staff turnover together with difficulties to attract new people (e.g. due to the general 'rivalry for talent') might result in positions being filled in with delays (increased risk during peak moments) and as a consequence leading to difficulties in getting the work done or achieving the JU's objectives; this may include a negative impact on other employees' motivation).	This risk is intrinsic to the S2R JU Staff establishment plan. Nevertheless, within the budget constraints, a career plan for staff has been prepared and business continuity is ensured. In 2018, the Governing Board adopted a revised decision on Learning and Development; implementing policy was adopted in April 2018 by the ED. Enhancing the planning of activities will allow for better risk management. Recruitment of short term resources (interim or trainees) should be aligned accordingly.	Actions implemented as per Action Plan.
Significant cuts in the EU's budget might lead to a decrease in the JU's budget which might result in insufficient (financial) resources to realise the objectives of the JU.	The S2R JU Membership shall put in place all the measures to provide all the elements to the budget authority to reduce such a risk. The S2R JU together with the Other Members are working actively in demonstrating that the S2R Programme is already providing results (TRA, Innotrans, Demo, etc.). Moreover, the available resources will be subject to proper planning and regular follow up with Members and at IPSteCo/SIWG level, Projects control gates level, and subject to regular reporting to the GB.	Actions implemented as per Action Plan.
Lack of adequate dissemination of results may result in suboptimal information reaching the end-user/interested parties, which could compromise the JU's impact.	The S2R JU provided a series of guidelines to the projects and fostered the use of the Horizon 2020 instrument as the Common Dissemination Booster. Proper planning and regular follow up at IPSteCo/SIWG and projects' control gates' levels are ensured.	Actions implemented as per Action Plan.
Characteristics of the project setup (e.g. the project execution team at a task/sub-task level belongs to one and the same private company without applying a broader	Demo planning, regular follow up at IPSteCo/SIWG and projects control gates' levels are ensured.	Actions implemented as per Action Plan.

Risk identified	Action Plan	2019 Follow up
scope) might result in a project outcome that represents a single company solution and is therefore non-interoperable on a broader spectrum, and is not in line with the philosophy of the JU.		
Difficulties in obtaining the necessary authorisation(s) to organise project demonstrations might provoke a significant delay resulting in the inability to organise these demonstrations or in their partial organization.	Planning anticipation (Demo planning) and regular follow up at IPSteCo/SIWG, ERA involvement and regular reporting to GB are ensured.	Actions implemented as per Action Plan.
Impediments during a project (e.g. changes in regulation/ non-achievement of harmonised requirements/unforeseen planning difficulties in resource planning etc.) might lead to the project not being executed in a timely and/or adequate manner, preventing S2R solutions from reaching the market.	<p>Ensure the following actions:</p> <ul style="list-style-type: none"> • appropriate implementation/exploitation plans in GA and at TD/IP level • national migration strategies • investigate possible instrument to support deployment at EU level and implement S2R JU strategy/support • regular follow up of S2R standardisation roadmaps • coordination with RASCOP, and also directly with ERA, CEN/CENELEC/ETSI • Regular follow up at IPSteCo/SIWG • regular updated with URID WG • Monitoring of the regulatory environment 	Actions implemented as per Action Plan.
The rollout of the developed technologies is not taken into account, but should be already considered at the design stage to reach high market acceptance in a short time-frame.	Project design should consider the identification of a proper business case to accelerate market acceptance, within the overall partnership of the S2R JU.	Actions implemented as per Action Plan.
Risk that a lengthy process leading to a possible S2R2 Programme may negatively impact the ongoing R&I activities, with, on the one hand, Members looking at the	Transparent and timely involvement of the membership in the next Multiannual Financial Framework (MFF) preparation	Actions implemented as per Action Plan.

Risk identified	Action Plan	2019 Follow up
future instead of investing on current R&I activities, and, on the other hand, de-commitment in case of negative decision		

With regard to the negotiations on the UK Withdrawal Agreement and the start of the transition period, the S2R JU monitored the situation in accordance with the instructions issued by the competent Commission services and has followed the guidance provided by the latter.

During 2020, a detailed risk assessment will be performed which will also reflect the implementation of the new Internal Control Framework.

1.2. R&I activities: the S2R Programme

The S2R MAAP translates the S2R Master Plan into detailed, result-oriented R&I activities to be performed with the objective of delivering the S2R vision as from 2016 onwards.

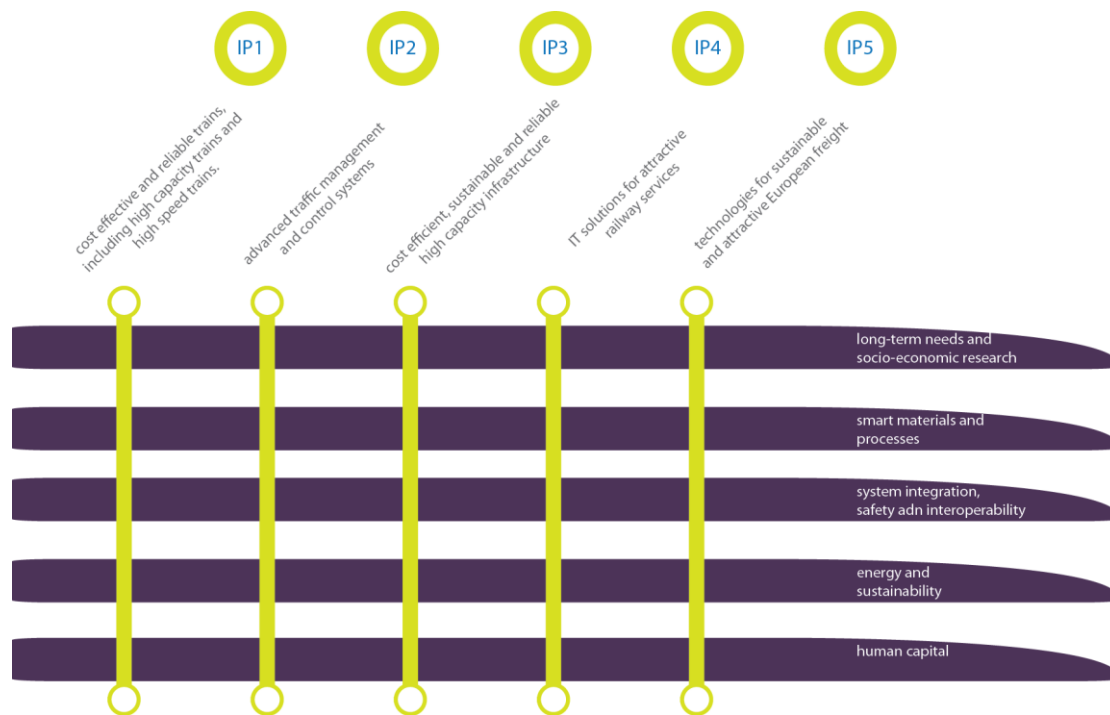
Addressing through R&I the challenges as they are detailed in the MAAP Executive View opens three opportunities for the railway:

- To become the backbone of current and future mobility concepts (e.g. mobility as a service-MaaS) and on-demand future logistics, through integrations with other modes in view of reaching a climate neutral European economy by 2050;
- To identify and establish new market segments for exploitation;
- To enhance the overall competitiveness of the industry, both in Europe and globally.

This is what the Regulation tasks the S2R JU to do when requesting it to manage all rail-focused research and innovation actions co-funded by the Union. Developing the Innovation Capabilities requires a coordinated effort among different rail and non-rail stakeholders to drive innovation at levels in Europe. The S2R JU and its Programme are designed to make a decisive contribution to delivering the essential knowledge and innovation that will provide the building blocks to develop the Innovation Capabilities.

The work conducted within the S2R framework is structured around five asset-specific Innovation Programmes (IPs), covering the different structural (technical) and functional (process) sub-systems of the rail system. These five IPs are supported by work in five cross-cutting areas (CCA) covering themes that are of relevance to each of the projects and which address the interactions between the IPs and the different subsystems:

- IP1: Cost-efficient and Reliable Trains, including high-capacity trains and high-speed trains
- IP2: Advanced Traffic Management & Control Systems
- IP3: Cost-efficient, Sustainable and Reliable High-Capacity Infrastructure
- IP4: IT Solutions for Attractive Railway Services
- IP5: Technologies for Sustainable & Attractive European Freight.



S2R introduced in the updated MAAP also some IPx activities, R&I designed to look beyond currently planned technology applications (of the Technology Demonstrators) and how to integrate the S2R TDs with new operational concepts. IPx activities will help to realise the global optimal approach for this System of Systems, which is railway mobility, by starting to build a railway Functional System Architecture and a Conceptual Data Model (CDM).

With a holistic approach, the role of the S2R JU is also to ensure that interactions between the various IPs are adequately considered and managed, as technological developments in one part of the system could lead to changes in performance, or even create barriers, in other parts. In addition, cross cutting activities include research on long-term economic and societal trends such as customer needs and human capital and skills, which must be taken into account by the different IPs.

Different types of activities contribute to the Programme development, including:

- studies, fundamental and “blue-sky” research (TRL 0 – 2),
- scientific/applied research and laboratory demonstrations (TRL 3 – 6)
- operational demonstrations and innovation activities (TRL 6-7)
- other supporting activities.

In addition to these activities that are co-funded by the S2R JU and conducted within the scope of the S2R Programme, the Other Members are required to conduct Additional Activities with a view to leveraging the effect of the overall R&I. These Additional Activities are not eligible for financial support from the S2R JU but must contribute directly to the broader objectives set out in the Master Plan.

At the end of 2019, in agreement with the GB, the ED adopted a decision establishing a renewed Programme Governance and Change Management to foster the integration of innovations and subsystems making use of a new functional (or better service-oriented) system architecture. The renewed Programme Governance and Change Management will support the integration within the S2R Programme of new concepts, ideas, solutions, etc. compared to the MAAP and its AWP.

The aforementioned ED Decision includes also the establishment of a formal advisory support to the ED in the form of a new ED Programme Board. The ED Programme Board role is primarily:

- monitoring the progress of the Programme,
- identify risks and opportunities and related mitigating actions,
- providing strategic guidance and making recommendations with regard to the management Programme,
- advise the Executive Director in solving issues escalated to his attention in accordance with the S2R Regulation on Programme implementation and propose a way forward,
- advise the Executive Director on the need to complement the Programme with specific expertise to be contracted as needed,
- assist and advise the Executive Director in any matter of relevance,
- the ED Programme Board works by consensus;
- the Executive Director shall report to the Governing Board about the work performed by the ED Programme Board.

At the end of October 2019, the S2R JU presented the Catalogue of Solutions, which presents successful R&I results in the form of possible stand-alone and integrated implementable solutions. It highlights the benefits of Shift2Rail solutions for final users, operators, infrastructure managers and/or suppliers, as well as specifying delivery dates. This milestone publication demonstrates to the entire rail community and beyond the potential of Shift2Rail solutions in contributing to a more sustainable, punctual, interoperable, high-capacity rail system, providing a backbone for the whole mobility and transport sector in Europe. The Catalogue of Solutions is therefore an important milestone, which demonstrates the potential impact of S2R R&I when its results will be industrialized and introduced in the market.

1.3. Call for proposals and grant information

Considering the annual budget availabilities and the R&I activities planned in the S2R MAAP, the S2R Programme is implemented through combined and interdependent multi-annual Projects. This structured interdependence of the S2R Projects reflects the Technological Demonstrators (TD) and Work Areas (WA) approach set within the Programme and each IP and CCA.

The following table summarises the amounts and topics available under the 2019 Call, against Budget Commitments of 2019. This Call, based on the amended Annual Work Plan 2019, was launched on 15 January 2019 and awarded by the JU following the Decision of the S2R GB of 4 September 2019¹³.

It is presented showing the values of the topics open to Other Members (CFM) and those excluding them (OC).

Call	Type	Estimated S2R JU funding	Number of topics
H2020-S2R JU-2019	CFM	57.5 M€	6
	OC	19.3 M€	12

The total number of proposals received in response to the call for proposals was 50:

¹³ Governing Board Decision No 0717/2019 of 4 September 2019: https://shift2rail.org/wp-content/uploads/2019/09/GB-Decision-07-2019_Call-2019.pdf

Call	Type	Number of proposals received	Number of topics
H2020-S2RJU-2019	CFM	8	6
	OC	42	11

The total S2R JU contribution requested by all the submitted proposals amounted to EUR 117.9 million compared to EUR 76.8 million available for funding:

Call	Type	Requested S2R JU funding	Estimated S2R JU funding available
H2020-S2RJU-2019	CFM	58.8 M€	57.5 M€
	OC	59.1 M€	19.3 M€

On 4 September 2019, the S2R GB agreed with the proposal of the ED to award grants, which resulted in the following data:

Call	Type	Total Project Cost	S2R funding	IKOP	Other contributions to R&I
H2020-S2RJU-2019	CFM	130.9 M€	57.6 M€	73.2 M€	
	OC	17.7 M€	17.2 M€		0.6 M€ ¹⁴
	TOTAL	148.6 M€	74.8 M€	73.2 M€	0.6 M€

The S2R JU Other Members submitted project proposals to cover five call topics open to them.

The value of activities to be performed by the S2R JU Other Members in the coming years in respect to the amounts awarded and signed of this call corresponds to EUR 130.8 million that will be funded by the S2R JU up to EUR 57.6 million. These projects normally started on 1 December 2019, however for some projects an earlier start date was agreed to guarantee continuity with previous R&I activities.

Following the grants awarded from the call 2019 and those in 2016, 2017 and 2018, the overall value of Other Members ongoing projects is EUR 489.9 million which are expected to be co-funded by the S2R JU up to EUR 216.7 million.

The applicants to the OC covered 11 out of 12 topics open to them. The value of the activities to be performed by the awarded consortia amounts to EUR 17.7 million: EUR 17.2 million to be funded by the S2R JU up to 100% or 70% of the eligible direct costs, subject to respectively being RIA or IA actions. The overall OC amount of ongoing projects awarded in the 2016-2019 calls is EUR 79.9 million. The S2R GB on 4 September 2019 approved the list of actions selected for funding proposed by the Executive Director; evaluation result letters were sent to all applicants on 10 January 2020.

¹⁴ This is the difference between the Research and Innovation activities declared by a beneficiary and the funding received from the JU.

Call topics open to S2R JU Other Members: Awarded and signed projects

TOPIC	ACRONY M	TITLE	PROJEC T VALUE € M	GRANT € M	IN KIND CONTR. € M	START DATE	END DATE
S2R-CFM-IP1-01-2019	PIVOT2	Performance Improvement for Vehicles on Track 2	40,1	17,8	22,3	01/10/2019	31/12/2022
S2R-CFM-IP2-01-2019	X2RAIL-4	Advanced signalling and automation system - Completion of activities for enhanced automation systems, train integrity, traffic management evolution and smart object controllers	41,1	17,9	23,2	01/12/2019	28/02/2023
S2R-CFM-IP3-01-2019	IN2SMAR T2	Intelligent Innovative Smart Maintenance of Assets by integRAted Technologies 2	23,1	10,2	12,9	01/12/2019	30/11/2022
S2R-CFM-IP5-01-2019	FR8RAILIII	Smart data-based assets and efficient rail freight operation	13,1	5,8	7,2	01/09/2019	31/08/2022
S2R-CFM-IPX-CCA-01-2019	LINX4RAIL	System architecture and Conceptual Data Model for railway, common data dictionary and global system modelling specifications	5,2	2,2	3,0	01/12/2019	30/11/2022
S2R-CFM-CCA-01-2019	FINE2	Furthering Improvements in Integrated Mobility Management (I2M), Noise and Vibration, and Energy in Shift2Rail	8,2	3,6	4,6	01/12/2019	30/11/2022

TOTAL			130,8	57,6	73,2		
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Open call topics for S2R JU non-Members: Awarded and signed projects

TOPIC	ACRONYM	TITLE	PROJECT VALUE € M	GRANT € M	START DATE	END DATE
S2R-OC-IP1-01-2019	CARBODIN	Car Body Shells, Doors and Interiors	3,6	3,6	01/12/2019	30/11/2021

TOPIC	ACRONYM	TITLE	PROJECT VALUE € M	GRANT € M	START DATE	END DATE
S2R-OC-IP1-02-2019	NEXTGEAR	NEXT generation methods, concepts and solutions for the design of robust and sustainable running GEAR	2,6	2,6	01/12/2019	30/11/2021
S2R-OC-IP2-01-2019	4SECURAIL	FORMAL METHODS AND CSIRT FOR THE RAILWAY SECTOR	0,5	0,5	01/12/2019	30/11/2021
S2R-OC-IP2-02-2019	OPTIMA	cOMmunication Platform for Traffic ManAgement demonstrator	2,2	1,9	01/12/2019	28/02/2023
S2R-OC-IP3-01-2019	FUNDRES	FUTURE UNIFIED DC RAILWAY ELECTRIFICATION SYSTEM	0,8	0,8	01/12/2019	30/11/2021
S2R-OC-IP4-01-2019	RIDE2RAIL	Travel Companion enhancements and RIDE-sharing services synchronised to RAIL and Public Transport	3.0	3.0	01/12/2019	31/05/2022
S2R-OC-IP5-01-2019	LOCATE	Locomotive bOgie Condition mAiNTEnance	1,5	1,5	01/11/2019	31/10/2021
S2R-OC-IP5-02-2019	SMART2	Advanced integrated obstacle and track intrusion detection system for smart automation of rail transport	1,7	1,5	01/12/2019	30/11/2022
S2R-OC-IPX-01-2019	RAILS	Roadmaps for A.I. integration in the rail Sector	0,3	0,3	01/12/2019	30/11/2022
S2R-OC-IPX-02-2019	TRANSLATE 4RAIL	Translation for breaking language barriers in the railway field	0,2	0,2	01/12/2019	30/11/2021
S2R-OC-CCA-01-2019	TRANSIT	Train pass-by noise source characterization and separation tools for cost-effective vehicle certification	1,3	1,3	01/12/2019	30/11/2022
TOTAL			17,7	17,2		

For the open call projects, the respective grant agreements were signed in December 2019 and all the activities normally started on 1 December 2019.

1.4. Progress against KPIs / Statistics (Annex C)

The Key performance Indicator results for the year 2019 are presented in Annex C. The JU has taken into its scoreboard all Horizon 2020 indicators, which have been established for the entire Research

family by the Commission, to the extent they can be applied to the JU in view of providing meaningful results.

Comments to some indicators are provided in the table in the Annex or in the related section of the report, to which the indicators refer. In addition, the S2R JU is presenting more detailed results of its performance monitoring in specific areas, e.g. key figures provided in the section dealing with the call for proposals and the following evaluation process.

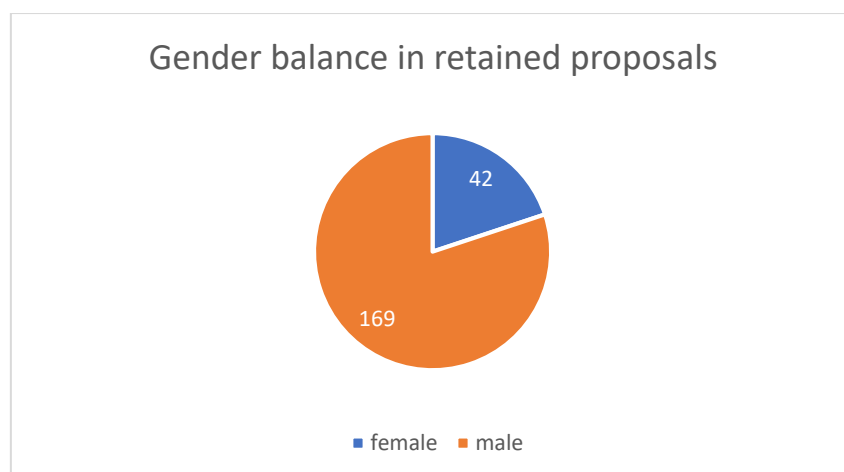
Within the context of the CCA activities, during 2019 the S2R JU continued the work on the next Release of the KPI model that had been presented in 2018 as Release 1.

Following quarterly updates given to the IP/CCA SteCo and the GB, a dedicated GB workshop on KPIs was held in September. The Release 2.0 of the KPI model was then presented during the meeting of the Government Board in November 2019. The publication of the web-based tool, which is used as communication mean to present the Shift2Rail Innovation potentials, is foreseen for 2020 following the completion of some additional work. Refined figures have been annexed to the AWP2020 and are shown in table IV.

1.5. Evaluation: procedures and global evaluation outcome, redress, statistics

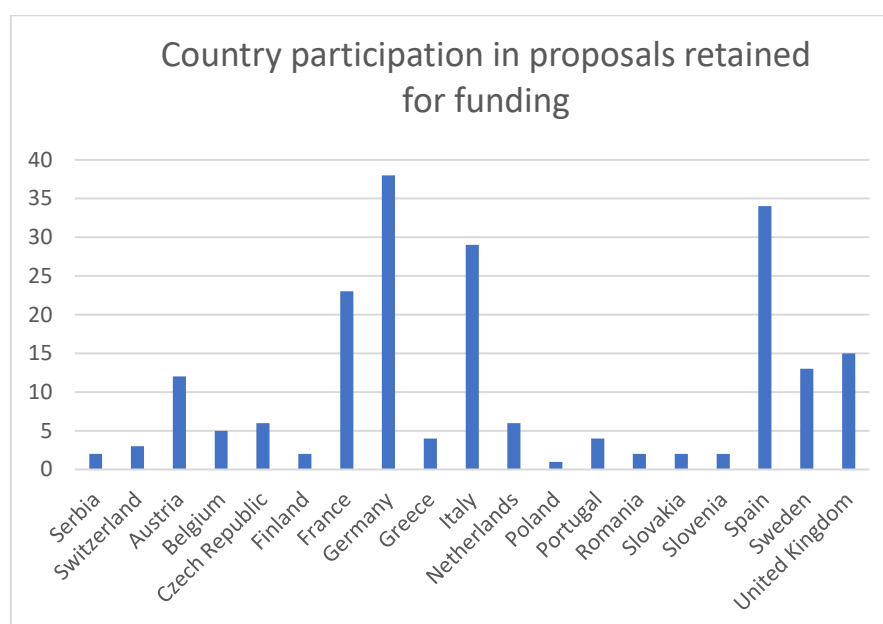
The evaluation process took place in June and July 2019. The proposals were evaluated by 36 external experts from 12 different Member States (with a gender balance of 25 male and 11 female). Six independent experts performed the task of recorders supported evaluators. These experts, also selected from the EC database, facilitated the drafting of consensus reports as dedicated rapporteurs but did not assess proposals. Experts were divided in six different panels, with a dedicated rapporteur for each panel. An independent observer was appointed to monitor the whole process. For the evaluation of the Lump Sum Grant proposals, three independent financial experts provided support to the experts in charge. The consensus meetings in July 2019 were moderated by staff from the S2R JU with additional observers from DG MOVE, DG RTD and ERA.

The total number of proposal evaluated was 48: 17 were retained for funding with a success rate of 35.4%. The number of participants in the evaluated proposals was 389, represented by 79 female, 309 male and 1 with no gender information provided. 203 participants were retained for funding with a success rate of 52.2%. Out of the retained participants in terms of co-signatory of proposals, 42 were female (success rate 53.2%), 160 were male (success rate 51.8%) and 1 with no gender information provided. Out of the 17 retained proposals for funding with 17 coordinators involved, 7 were female (success rate 46,7%) and 10 were male (success rate 30,3%). On supported researchers no data are available yet.



SMEs participating were 90 and 40 were retained for funding, with a success rate of 44.4 %. SMEs represent respectively the 23.1% and the 19.7% of total and retained participants for funding. SME's represent 30% of the entities selected in the OC projects.

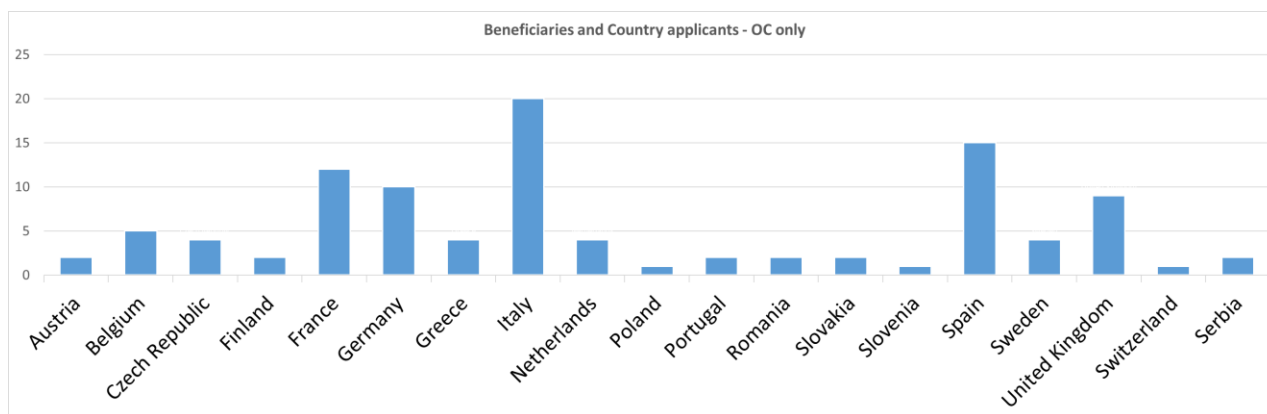
From a geographical perspective, 25 countries participated to the call, 22 were from the EU Member States and 3 from Associated Countries¹⁵. After the evaluation, the participating countries to the retained project for funding were 19 of which 17 from EU and 2 from Associated Countries (see details in ANNEX C).



The majority of the participation to the Call 2019 is from the EU-15 Member States. To facilitate a stronger participation from the EU-13 Member States it is important to integrate R&I activities with demonstration and deployment activities with sector involvement in a future programme agenda.

For the Open Calls, the beneficiaries are from the following countries:

¹⁵ EU Member States include the United Kingdom given status at the time of the launch and evaluation of the call.



1.6. Activities carried out in Grant Agreements

At the end of 2019, taking into consideration projects reaching their completion and new awarded activities, 72¹⁶ projects were ongoing (32 CFM and 40 OC): 56 projects were distributed on the 6 Innovation Programmes, and 10 projects on the Cross Cutting Activities and 6 projects in IPx, as follows:

IP1: Cost-efficient and Reliable Trains, including high-capacity trains and high-speed trains

Project Title	Call Reference	Period	Project Value (signed GA)
PIVOT	S2R-CFM-IP1-01-2017	01/10/2017 - 31/12/2019	€ 17 432 048
CONNECTA	S2R-CFM-IP1-02-2016	01/09/2016 - 30/09/2018	€ 11 480 307
CONNECTA-2	S2R-CFM-IP1-02-2018	01/10/2018 - 31/03/2021	€ 9 687 622
PINTA	S2R-CFM-IP1-01-2016	01/09/2016 - 31/12/2018	€ 28 855 184
PINTA-2	S2R-CFM-IP1-01-2018	01/09/2018 - 30/11/2020	€ 28 534 184
Mat4Rail	S2R-OC-IP1-01-2017	01/10/2017 - 30/09/2019	€ 3 495 216
RUN2RAIL	S2R-OC-IP1-02-2017	01/09/2017 - 30/09/2019	€ 2 732 464
SAFE4RAIL	S2R-OC-IP1-02-2016	01/10/2016 - 31/12/2018	€ 6 681 211
SAFE4RAIL-2	S2R-OC-IP1-01-2018	01/10/2018 - 30/04/2021	€ 3 991 632
PIVOT2	S2R-CFM-IP1-01-2019	01/10/2019 - 31/12/2022	€ 40 155 405
CARBODIN	S2R-OC-IP1-01-2019	01/12/2019 - 30/11/2021	€ 3 549 291

¹⁶ Four Lighthouse projects (2015) not included. One Open Call project, Dynafreight in IP5, has been finalised.

NEXTGEAR	S2R-OC-IP1-02-2019	01/12/2019 - 30/11/2021	€ 2 573 877
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IP2: Advanced Traffic Management & Control System

Project Title	Call Reference	Period	Project Value (signed GA)
X2Rail-1	S2R-CFM-IP2-01-2015	01/09/2016 - 30/04/2020	€ 41 224 381
X2Rail-2	S2R-CFM-IP2-01-2017	01/09/2017 - 31/08/2020	€ 30 152 828
X2Rail-3	S2R-CFM-IP2-01-2018	01/12/2018 - 30/11/2021	€ 38 728 459
X2Rail-4	S2R-CFM-IP2-01-2019	01/12/2019 - 28/02/2023	€ 41 109 700
VITE	S2R-OC-IP2-02-2015	01/11/2016 - 31/10/2018	€ 947 756
ASTRAIL	S2R-OC-IP2-01-2017	01/09/2017 - 31/10/2019	€ 1 797 307
ETALON	S2R-OC-IP2-02-2017	01/09/2017 - 29/02/2020	€ 1 699 999
MOVINGRAIL	S2R-OC-IP2-01-2018	01/12/2018 - 31/12/2020	€ 1 299 135
GATE4RAIL	S2R-OC-IP2-02-2018	01/12/2018 - 30/11/2020	€ 1 019 994
EMULRADIO4RAIL	S2R-OC-IP2-03-2018	01/12/2018 - 31/05/2020	€ 748 097
4SECURAIL	S2R-OC-IP2-01-2019	01/12/2019 - 30/11/2021	€ 549 875
OPTIMA	S2R-OC-IP2-02-2019	01/12/2019 - 28/02/2023	€ 2 249 897

IP3: Cost-efficient, Sustainable and Reliable High-Capacity Infrastructure

Project Title	Call Reference	Period	Project Value (signed GA)
In2Track	S2R-CFM-IP3-01-2016	01/09/2016 - 30/04/2019	€ 6 324 052
IN2SMART	S2R-CFM-IP3-02-2016	01/09/2016 - 31/10/2019	€ 16 405 563
In2Stempo	S2R-CFM-IP3-01-2017	01/09/2017 - 31/08/2022	€ 13 439 981
Fair Stations	H2020-S2RJU-OC-2017	01/09/2017 - 31/12/2019	€ 1 199 875
IN2DREAMS	H2020-S2RJU-OC-2017	01/09/2017 - 31/10/2019	€ 2 195 715
S-CODE	S2R-OC-IP3-01-2016	01/11/2016 - 31/10/2019	€ 4 999 771
MOMIT	H2020-S2RJU-OC-2017	01/09/2017 - 31/10/2019	€ 599 172
ASSETS4RAIL	S2R-OC-IP3-01-2018	01/12/2018 - 31/05/2021	€ 5 506 631

FUNDRES	S2R-OC-IP3-01-2019	01/12/2019 - 30/11/2021	€ 749 540
In2Track2	S2R-CFM-IP3-01-2018	01/11/2018 - 30/04/2021	€29 676 014
IN2SMART2	S2R-CFM-IP3-01-2019	01/12/2019 - 30/11/2022	€ 23 091 203

IP4: It Solution for Attractive Railways Services

Project Title	Call Reference	Period	Project Value
CO-ACTIVE	S2R-CFM-IP4-01-2015	01/09/2016 - 31/05/2019	€ 7 621 915
ATTRACKTIVE	S2R-CFM-IP4-02-2015	01/09/2016 - 31/05/2019	€ 5 256 030
CONNECTIVE	SR2-CFM-IP4-01-2017	01/09/2017 - 30/06/2022	€ 7 906 243
COHESIVE	S2R-CFM-IP4-02-2017	01/09/2017 - 30/06/2022	€ 4 039 492
My-TRAC	S2R-OC-IP4-01-2017	01/09/2017 - 30/09/2020	€ 3 494 476
SPRINT	S2R-OC-IP4-01-2018	01/12/2018 - 31/12/2020	€ 1 999 500
SHIFT2MAAS	S2R-OC-IP4-02-2018	01/12/2018 - 31/12/2020	€ 1 499 906
MaaSive	S2R-CFM-IP4-01-2018	01/11/2018 - 31/05/2021	€ 11 692 236
RIDE2RAIL	S2R-OC-IP4-01-2019	01/12/2019 - 31/05/2022	€ 2 999 993

IP5: Technologies for Sustainable & Attractive European Freight

Project Title	Call Reference	Period	Project Value
ARCC	S2R-CFM-IP5-02-2015	01/09/2016 - 31/10/2020	€ 3 600 360
FFL4E	S2R-CFM-IP5-03-2015	01/09/2016 - 31/07/2019	€ 3 375 017
FR8HUB	S2R-CFM-IP5-01-2017	01/09/2017 - 31/08/2020	€ 9 900 990
FR8RAIL	S2R-CFM-IP5-01-2015	01/09/2016 - 31/08/2019	€ 7 826 783
FR8RAIL II	S2R-CFM-IP5-01-2018	01/05/2018 - 30/04/2021	€ 12 450 390
INNOWAG	S2R-OC-IP5-03-2015	01/11/2016-30/06/2019	€ 1 500 562
OptiYard	S2R-OC-IP5-01-2017	01/10/2017 - 30/09/2019	€ 1 499 900
SMART	S2R-OC-IP5-01-2015	01/10/2016 - 30/09/2019	€ 999 599
M2O	S2R-OC-IP5-01-2018	01/12/2018 - 31/12/2020	€ 599,955

Project Title	Call Reference	Period	Project Value
LOCATE	S2R-OC-IP5-01-2019	01/11/2019 - 31/10/2021	€ 1 499 072
SMART2	S2R-OC-IP5-02-2019	01/12/2019 - 30/11/2022	€ 1 708 737
FR8RAILIII	S2R-CFM-IP5-01-2019	01/09/2019 - 31/08/2022	€ 13 061 601

IPX:

Project Title	Call Reference	Period	Project Value
FLEX-RAIL	S2R-OC-IPX-01-2018	01/12/2018 - 30/06/2021	€ 1 099 230.00
TER4RAIL	S2R-OC-IPX-02-2018	01/12/2018 - 30/11/2020	€ 499 992
B4CM	S2R-OC-IPX-03-2018	01/12/2018 - 30/11/2021	€ 124 951
MVDC-ERS	S2R-OC-IPX-03-2018	01/12/2018 - 30/11/2021	€ 125 000
RAILS	S2R-OC-IPX-01-2019	01/12/2019 - 30/11/2022	€ 299 953
TRANSLATE4RAIL	S2R-OC-IPX-02-2019	01/12/2019 - 30/11/2021	€ 248 094

CCA: Cross Cutting Activities

Project Title	Call Reference	Period	Project Value
FINE1	S2R-CFM-CCA-02-2015	01/09/2016 - 31/10/2019	€ 3 017 282
IMPACT-1	S2R-CFM-CCA-01-2015	01/09/2016 - 30/04/2018	€ 674 958
IMPACT-2	S2R-CFM-CCA-01-2017	01/09/2017 - 30/08/2022	€ 7 096 428
LINX4RAIL	S2R-CFM-IPX-CCA-01-2019	01/12/2019 - 30/11/2022	€ 5 216 494
PLASA-2	S2R-CFM-CCA-01-2018	01/09/2018 - 31/10/2020	€ 1 853 384
GoSAFERAIL	S2R-OC-CCA-04-2015	01/10/2016 - 30/09/2019	€ 1 298 750
OPEUS	S2R-OC-CCA-02-2015	01/11/2016 - 31/10/2019	€ 797 130
SMaRTE	S2R-OC-CCA-01-2017	01/09/2017 - 31/10/2019	€ 731 202
TRANSIT	S2R-OC-CCA-01-2019	01/12/2019 - 30/11/2022	€ 1 308 718
FINE2	S2R-CFM-CCA-01-2019	01/12/2019 - 30/11/2022	€ 8 179 973

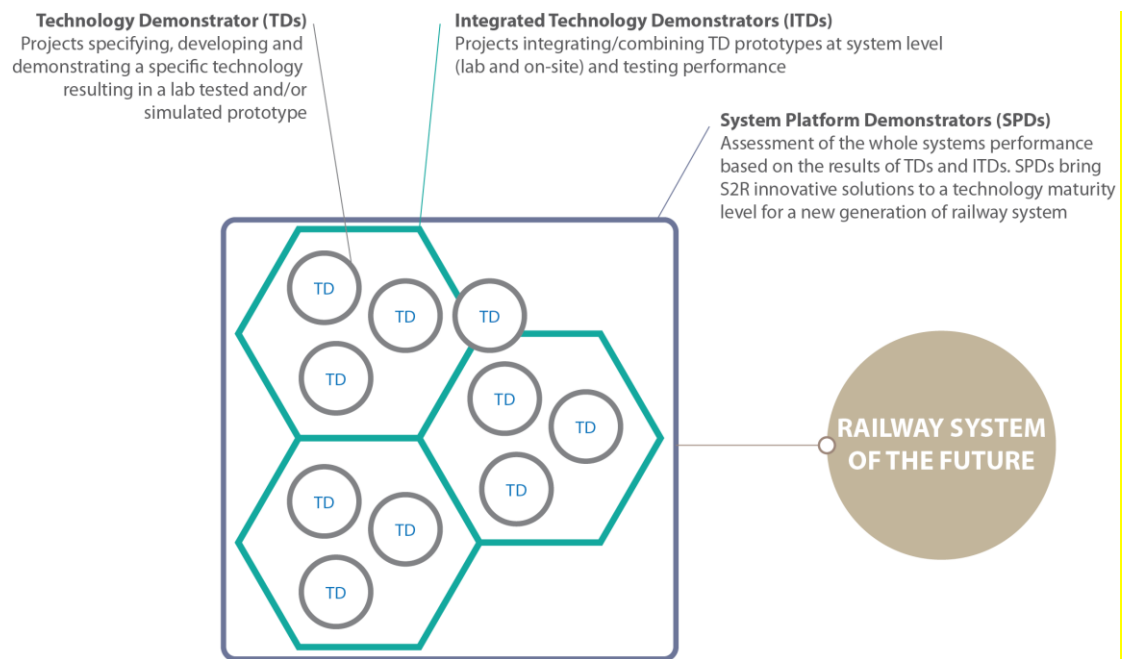
Closed Projects related to Call for member topics for S2R JU Members

TOPIC	ACRONYM	TITLE	PROJECT VALUE	GRANT	START DATE	CLOSURE DATE
S2R-CFM-CCA-03-2015	PLASA	Smart Planning and Safety for a safer and more robust European railway sector	0,8	0,3	01/09/2016	07/06/2019

Closed Projects related to Open call topics for S2R JU non-Members

TOPIC	ACRONYM	TITLE	PROJECT VALUE	GRANT	START DATE	CLOSURE DATE
S2R-OC-IP2-01-2015	CYRAIL	Cybersecurity in the RAILway sector	1,5	1,5	01/10/2016	16/11/2019
S2R-OC-IP2-03-2015	MISTRAL	Communication Systems for Next-generation Railways	0,5	0,5	01/11/2016	28/06/2019
S2R-OC-IP4-01-2016	GoF4R	Governance of the Interoperability Framework for Rail and Intermodal Mobility	1,8	1,8	01/11/2016	10/10/2019
S2R-OC-IP4-02-2016	ST4RT	Semantic Transformations for Rail Transportation	1,0	1,0	01/11/2016	19/04/2019
S2R-OC-CCA-01-2015	NEAR2050	NEAR2050 - future challenges for the rail sector	0,4	0,4	01/10/2016	21/09/2019
S2R-OC-CCA-03-2015	DESTINATE	Decision supporting tools for implementation of cost-efficient railway noise abatement measures	10	10	01/11/2016	19/07/2019
S2R-OC-IP5-02-2015	DynaFreight	Innovative technical solutions for improved train DYNAMics and operation of longer FREIGHT Trains	0.9	0.9	01/11/2016	31/06/2018

The practical demonstration of S2R R&I activities is being carried out using a combination of single technology demonstrators (TDs), integrated technology demonstrators (ITDs and resulting into the Innovation Capabilities) and system platform demonstrators (SPDs).



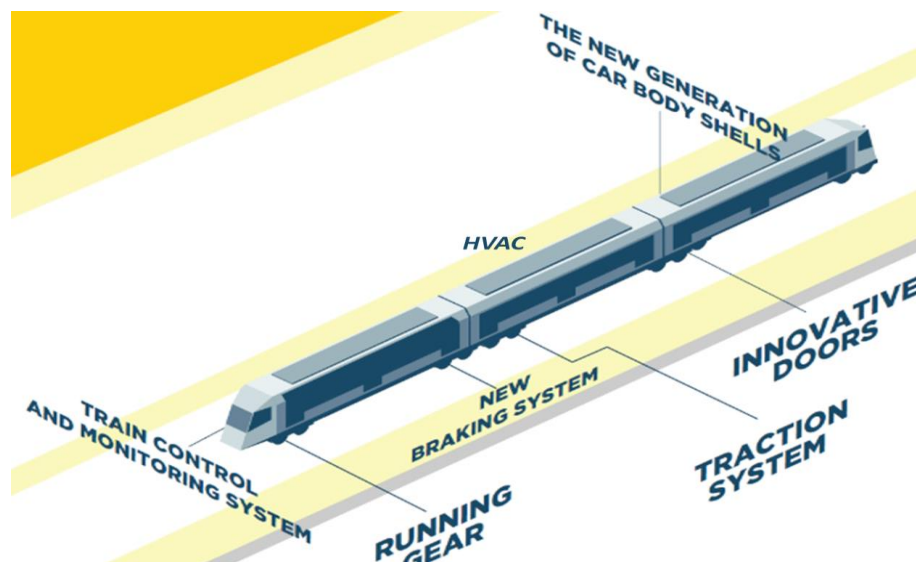
The following sections illustrate the progress achieved in the Technology Demonstrators at the end of 2018. The contributions from the TDs to the delivery of the innovation capabilities (as mentioned in the MAAP (part A) were elaborated in the MAAP (part B), adopted by the GB in November 2019.

1.7. Towards delivering the S2R Programme

This section presents by Innovation Program the progress of ongoing projects implementing the R&I activities measured through the achievements in the development of Technology Demonstrators. A market correspondence table per TD was published in the MAAP (draft Part B) in May 2019.

1.7.1. IP1 Cost-efficient and Reliable Trains, including high-capacity trains and high speed trains

The pictures below gives a visual perception on where the TDs will introduce improvements



TD 1.1. Traction systems Demonstrator

The TD develops new traction components and subsystems using mainly silicon carbide (SiC) technologies leading to new architectures. The activities aim at producing Technology Demonstrators (including a traction system based on independently rotating wheels) to be implemented into a metro, a sub-urban train, a regional train and a high-speed train. The SiC application opens up many new opportunities improvements in this key technology area. Besides improved energy efficiency, maintenance costs, it gives additional optimisation possibilities enhancing customer value, such as noise reduction and efficient cooling.

TD progress

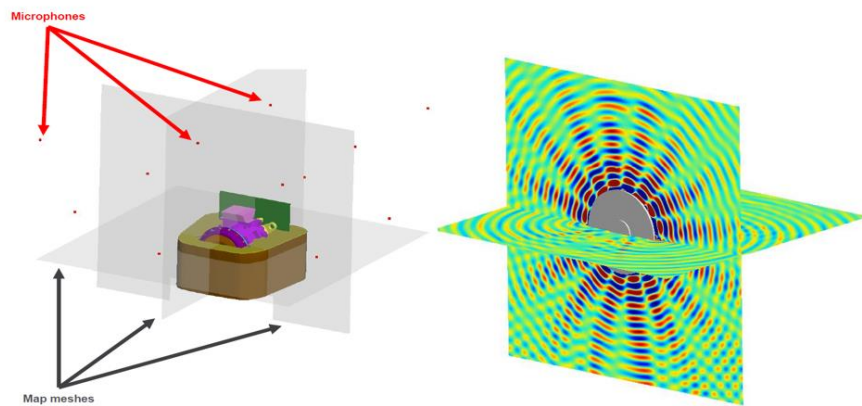
TD1.1 builds on the progress made by the PINTA project and ongoing action PINTA2 (both CFM projects).

The main objective for 2019 was the development of prototypes of Traction components at TRL5-6 levels, preparing further validation for the future trains testing (TRL7).

The work carried out in 2019 has given the following main results:

- Prototypes development and test in lab environment of SiC based Traction components for tramways, metro, sub-urban and regional trains, preparing further demonstration on trains in (tramways) or future work (Metro and Regional demos). On HST the development of a wheel motor prototype is ongoing, targeting further on train demonstration. In more detail, the final control algorithm of traction drives and dynamic behaviour study of the train dealing with the new wheel-motor have been done and reported.
- Update of the Traction TD 7 KPIs achievements: The KPIs progress confirms that most of the targets defined for the end of S2R are achievable. The main benefits of the newly developed traction components to be mentioned in the case of the Regional platform (as example) are as follows: reduction of energy consumption (-10%) at train level, traction maintenance cost (-12%), reliability improvement (+10%), weight, volume savings (-5%; -17%). Important noise savings are also reported on tramway and sub-urban applications.

- On Acoustic noise, different methods to calculate the noise based on computational fluid dynamic (CFD) simulation results have been investigated with the purpose of finding out their accuracy versus computation cost (in terms of time and complexity). The figure below shows results from an acoustic simulation using as an input steady-state CFD simulation that has a low computation cost. So far, promising results have been achieved since the developed methods provide means to more easily identify the source of the noise and optimize the design towards lower noise.



Simulation of acoustic noise on a traction motor with fan. Model with traction motor (left) and cutplanes on which the sound pressure is plotted for a specific frequency (right).

- On EMI emissions: a simulation methodology for common mode currents and to obtain a transfer function to calculate the magnetic field emissions, the compatibility between the power supply and the power supply systems, the overvoltage created by the train harmonic currents exciting the line impedance resonances has been built.
- On traction reliability, the work on power semiconductor lifetime models for the forecasting of device lifetime continued. It will be used in future predictive maintenance algorithms to reduce maintenance costs. The work focused on the use of accelerated test results to generate a reliability model. Investigations concluded that the Weibull approach gives a better estimation (from 50 to 75% of the cases) of failure rates and survival functions, compared to the Poisson model. Especially with very few data points Weibull is more precise.
- On virtual validation and certification, a list of tests to be virtualized has been identified for: Control Electronics, Thermal design, Mechanical integration, Power electronics. To extend this approach, quality processes TRL-like and simulation norms have been analyzed. The work progressed well and is on track in view the objective of saving up to 20% of the validation cost (30% of savings being the long term target beyond S2R time frame).

The Traction TD is ongoing according to schedule. The availability of power semi-conductors at affordable price is still a topic to be monitored carefully.

TD1.1 Traction Systems demonstrator								
2015	2016	2017	2018	2019	2020	2021	2022	...
	Finished: Roll2Rail, PINTA			Ongoing: PINTA2		AWP 2020: CFM, OC		

During 2019, 15 deliverables were planned out of which 13 were released. TD1.1 has reported having accomplished 95% of the planned work up to the end 2019, which represent 55% of the overall TD. Activities on e-transformer development have been stopped due to lack of high voltage components at necessary production scale (above 10kV).

The TD Traction work, in the PINTA2 project, will continue in 2020 with the same objectives of paving the way for future TRL 7 on trains demonstrations by the end of S2R programme.

TD 1.2. Train control and monitoring system (TCMS)

The development of a new-generation TCMS (Train Control and Monitoring System) will allow overcoming current bottlenecks caused by physically coupled trains. The new drive-by-data concept for train control, along with wireless information transmission, aims at making new control functions possible; it involves interaction between vehicles and consists, providing high safety and reliability levels with very simple physical architectures.

TD Progress

The TD1.2 builds on the progress made by CONNECTA and Safe4Rail as well as the work in progress of the projects CONNECTA-2 and Safe4RAIL-2.

In 2018, the TD had reached the definition of general specifications for the next generation TCMS, including a comprehensive list of use cases and the corresponding high level system architecture.

In 2019, a new phase started in the TD1.2 with the development of prototypes in order to validate the specification of these technologies. These prototypes cover different pillars of the Next Generation TCMS and will be tested in an integrated manner in laboratory demonstrators in 2020. During 2019, the specification of these laboratory demonstrators was accomplished for both, urban and regional environments. Apart from the specification of the demonstrators, which envisages the architecture of the Next Generation TCMS in a train, the use cases to test different system-level applications have been defined.

The development of aforementioned pillar technologies up to TRL4/5 is in progress, with some important milestones already achieved:

- Two different implementations of Functional Distributed Framework (FDF) have been deployed, one based on Autosar Adaptive Platform and another based on Integrity RTOS.
- Over these FDF a common HVAC application is being integrated, demonstrator the potential of the Application Profile regarding the cross-platform interoperability.
- In the FDF Drive-by-Data (DbD) technologies have also been integrated, meaning that IEEE TSN-based network interfaces have been integrated, the TRDP deployment has been adapted to support DbD principles and new Safe Train Inauguration has been deployed, including beacon frame based orientation validation which allows to remove train lines in the inauguration. TD1.2 is developing DbD-compliant ETBNs, Consist Switches, and cards for End Devices and expected to be finished in 2020.
- The Functional Open Coupling (FOC) application has been redefined as a service-oriented function which provides much more versatility and scalability. Based on this new concept different FOC implementations over the FDF is being deployed. The TD1.2 is working in parallel deploying the needed Service Registry function for the new FOC concept.

- The Simulation Framework allowing software and hardware in the loop simulations, which will be used as a basis to perform system-level use case validation with simulated or remote subsystem logics.

In addition, the specifications of additional Application Profiles have been issued, focusing in Lavatories subsystem and in the standardization of ATO-TCMS interface. This last interface standardization is a long-path process which includes up to GoA4, being the current work focused on GoA2. This work will feed the Rail Functional System Architecture in IPX, in collaboration with IP2.

The TD has also addressed the specification of the Evolved Wireless Train Backbone (WLTB) based on direct communications and the Wireless Consist Network adapted to the Next Generation TCN architecture. Two implementations of the Adapted ETBN compliant with the new WLTB specification are deployed in parallel and the development of a LTE-based communication devices is expected to be fulfilled in 2020.

TD1.2 Train Control and Monitoring System Demonstrator								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: Roll2Rail, CONNECTA, SAFE4RAIL				Ongoing: CONNECTA-2, Safe4RAIL-2		AWP 2020: CFM, OC		

In 2019, 19 deliverables out of 19 planned have been delivered. The overall progress is in line with the plan. TD1.2 have accomplished around 95% of the planned work up to end 2019, which represents 58% of the overall TD progress.

TD 1.3 Car body shell

The new generation of car body shells using composite or other lightweight materials will be a step change in the sector, leading to significantly lighter vehicles that carry more passengers within the same axle load constraints, use less energy and have a reduced impact on rail infrastructure.

TD Progress

The TD1.3 builds on the progress made by PIVOT and Mat4Rail projects.

In 2019, the TD has delivered the material assessment/characterization and has performed different tests for manufacturing. The tests demonstrated fulfilment of one of the TD targets set at the beginning of the programme: meet fire standards (EN 45545-2) for the pre-preg (pre-impregnated) solution.

This material is available for the four different partial and full demonstrators defined in the MAAP (metro, tramway, regional and high-speed train). The main drivers for the developments was weight and cost reduction, through functional integration and simplification of the assemblies.

Design activities have been completed with the analysis of the structures, Finite Elements Analysis (FEA); and optimization on the defined models has been performed to assess the requirements defined in the technical specification in view of validating the concepts presented. The results show

that the reduction in weight achievable is greater than 15% in all the cases, reaching 1 t reduction in the full carbody of a HST consist (25%).

Regarding standardization activities, a new working group in CEN to establish a new “Process standard for the introduction of new materials” started in 2019 with active contribution of TD1.3. This is the first step for the introduction of composite materials as structural material in rolling stock and facilitate a massive acceptance of these materials by the main stakeholders.

TD1.3 Carbody Shell Demonstrator								
2015	2016	2017	2018	2019	2020	2021	2022	...
	Finished: Roll2Rail, Mat4Rail							
			Ongoing: PIVOT, PIVOT2, CARBODIN					
					AWP 2020: OC			

During 2019, 16 deliverables were planned out of which 16 were released. TD1.3 has reported having accomplished 100% of the planned work up to the end 2019, which represent 45% of the overall TD.

TD 1.4 Running gear

TD 1.4 will develop innovative combinations of new architectural concepts, new actuators in new lighter materials leading to new functionalities and significantly improved performance levels.

TD Progress

The TD1.4 builds on the progress made by PIVOT and RUN2RAIL. In 2019 the TD delivered the following:

- *Sensor and health monitoring functionality*

New sensor systems fulfilling with the established requirements specifications were developed. During the development of the system aspects such reliability, cost and robustness were considered. The integration procedure with TCMS and a reduction target of 5-15% of running gear maintenance costs has been defined.

- A hardware to monitor in-service stresses of railway axles has been developed with the aim of optimising the periodicity of non-destructive inspections. A prototype hardware to monitor axle vibration and detect wheel flats and wheel out of roundness has been designed, produced and tested on a full-scale roller rig. Methods to detect faults in the powertrain and in primary suspensions have been defined; and an initial validation of these methods has been obtained based on laboratory experiments and simulation.

- *Active Suspension and control technology*

Semi-active and active radial systems for bogies and independent rotating wheel running gear have been developed. Furthermore, active systems for height control of the vehicle have been developed in order to adapt the train to different platforms; and a method for the validation

of active suspension systems as well as for the active steering systems has been established. Testing requirements and methodologies have been defined.

Several new active systems for conventional vehicles and an innovative vehicle concept based on single axle running gears have been suggested and the benefit quantified. Authorisation of vehicles with active systems has been reviewed and guidelines with filled in examples provided.

- *Noise and Vibration reduction*

Vibration and acoustic responses of suspension element were used as input data for prediction tools to allow the optimization and decision making of their designs. The vibroacoustic characterization was tested and validated.

A comprehensive methodology for predicting the transmission of noise and vibration from the running gear to the carbody has been developed and validated by field tests. The newly developed models have been used to assess the effect of various changes to the running gear on noise and vibration. In particular, an initial assessment has been made of the effect of novel lightweight materials and active suspensions systems and an optimisation strategy for controlling the structure-borne noise transmission has been demonstrated, leading to a potential reduction of the rolling noise by 2dB.

- *Optimised Materials*

A composite bogie component with low structural requirements out of composite material was produced and presented. A development of a composite frame for an independent rotating wheel running gear with high structural requirements has been started. The first calculations show a potential frame weight reduction by 50%. Furthermore, the ADI (austempered ductile iron) spoke wheel track tests were performed and valuated. Comparing this innovative solution to the conventional wheels of a metro application, the wheel weigh is reduced by approx. 10%.

A new method for production of aluminium alloy powder suitable for use in additive manufacturing of railway running gear components has also been developed and tested. Material samples have been manufactured using the selective laser melting technique and the new powder and the mechanical properties of the samples have been verified. A method for the robotic layup of long fibre composite components has been developed including a novel robotic applicator. Scale components have been built using these techniques and the results have been used to establish life cycle costs and benefits of using these novel materials and techniques in railway running gear components.

- *Virtual certification*

The methods currently used in the railway sector and assessment of current methodology were investigated. Following the guidelines established by EN 14363:2016, assessment of the requirements and a level of usability of the methodology were carried out. Improvements of the current methodology (based on the assessment of EN 14363) and improvement of the methods to validate models against measurements will be proposed in further work.

TD1.4 Running Gear Demonstrator								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: Rol2Rail, Run2Rail					Ongoing: PIVOT, PIVOT2, NEXTGEAR			
						AWP 2020: OC		

During 2019, 14 deliverables were planned out of which 13 were released. TD1.4 has reported having accomplished 95% of the planned work up to the end 2019, which represent 45% of the overall TD.

TD 1.5 Brakes

The aim of the TD on new braking systems is to provide braking systems with higher brake rates and in particular to improve performance.

TD Progress

In 2019, the TD1.5 has built on the progress made by PIVOT and PINTA-2 and achieved the following:

- *High SIL electronics*

In 2019, the prototype for electronic distributor valve (HW + SW) which is able to replace today's pneumatic distributor valves and to control brake system with higher precision and advanced control algorithms was built and the test bench for laboratory validation has been designed.

- *Innovative friction pairings*

In 2019, the new concept for eco-friendly friction pairing was developed consisting of cast axle mounted disc with materials with adapted properties and modular design brake pads (organic materials or mixed, sintered and organic), reducing weight and braking dust of current solutions and improving braking performance. Laboratory tests on the dynamometer test-bench were performed.

- *Electro-mechanic brake*

In 2019, functional and performance requirements on electro-mechanic brake have been collected, evaluated and agreed upon. Furthermore, two variants of laboratory demonstrator have been developed: one with conventional disk brake mechanics with hangers as an interface to the bogie and the other one with compact disk brake mechanics. The actuator itself is integrated in already existing brake mechanics. The system is designed to withstand the same environmental conditions as current pneumatic systems do (i.e. temperature range between -25°C and 70°C, snow, ice, salty environment etc.).

- *Virtual validation and certification*

One of the major cost drivers for authorization of braking systems at present is the necessity to perform comprehensive laboratory and on-train tests as a final validation of the system performance. In 2019, a detailed concept for virtual validation and certification of braking system has been

developed. Two proofs of concept were done on WSP system, both confirming the validity of the proposed approach.

- *Adhesion management*

Multiple measurement campaigns on test trains and test rigs took place. In October 2019, a two-week measurement campaign was performed to investigate the effect of sanding on brake performance of a DEMU on leaves, validating ATLAS test rig and collecting data for the adhesion model.

Furthermore, a questionnaire to infrastructure managers and railway undertakings was compiled to gather more information about requirements for the development of adhesion related systems and railway standards.

TD1.5 Brake Systems Demonstrator								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: Roll2Rail, CONNECTA, SAFE4RAIL, PINTA				Ongoing: PIVOT, PIVOT2				

During 2019, 15 deliverables were planned out of which 15 were released. TD1.5 has reported having accomplished 95% of the planned work up to the end 2019, which represent 45% of the overall TD.

The overall progress of the TD is in line with the plan. TD1.5 is estimated to have accomplished around 90% of the planned work up to end 2019, which represents 45% of the overall TD.

TD 1.6 Doors and Access Systems Demonstrator

The TD aims at moving away from current access solutions based on honeycomb or foam and aluminium frame with aluminium or steel skins in order to reduce their drawbacks on energy consumption, noise and thermal transmission. New lightweight composite structures could be introduced to perform better at existing safety and reliability levels, reducing platform dwell times and increasing overall line capacity. Customer-friendly information systems and improved access for people with reduced mobility using sensors like camera, lasers or sensitive edges are part of this new development.

The TD1.6 builds on the progress made by PIVOT and MAT4RAIL Projects.

Entrance System

In 2019, TD1.6 has continued the work initiated earlier in the programme for door leaves (research on new design of profile, improvement of filling material towards more complex acoustic structure thanks to thermal and acoustic study). Acoustic tests on panels and study of new types of structural profiles have been performed leading to the creation of 3 door leaves concepts based on the obtained results.

With important fire and smoke constraints, advantages and disadvantages of thermoset resins, honeycombs or foam as filling materials, glass or carbon fibers have been studied in parallel with manufacturing process out of autoclave process (i.e. infusion, RTM, hand-layup, press molding), resulting to the selection of the most promising manufacturing process for composite solutions for doors leaves, as well as the resin and fibers in order to later produce a full composite door leaf.

Out of the 11 door leaves concepts grouped in 4 main blocks (monoblock, structural glass, structural panel and structural profile) identified in 2018, the 3 best candidates in terms of weight reduction, isolation and cost have been selected. Large scale mock-ups of the proposed metallic and composite door leaves have been produced, resulting in the detection of blocking points for the 3 concepts based on 3D-printing (size of door leaf, long fiber deposit and fire & smoke capabilities).

Persons with Reduced Mobility, Safety and Door Entry Surveillance solutions

Using the general specification of Entrance System and the detailed specification of a boarding aid written and approved in 2018, TD1.6 has proposed different concepts of solutions, which have all important impacts on train's design. After a preliminary assessment of the 13 concepts, a detailed assessment of 2 concepts occurred (out of the 13 concepts preliminary assessed), leading to the production of a 3D model for the best candidate, which is based on an lateral ramp implemented inside the vestibule and extended with a bridging plate and / or a ramp outside the vehicle .

In parallel, a low scale mock-up of a new platform-based solutions of platform-train interface for autonomous boarding of persons with reduced mobility has been manufactured (TD3.11).

Regarding Safety and Door Entry Surveillance solutions, several sensors (e.g. laser scanner, ultrasonic sensors, cameras, radar) have been assessed and tested in regards of a list of selected functions (platform detection, horizontal and vertical position of the platform, virtual push button, passenger detection during door closing, contactless passenger detection on step, passenger detection during step deployment). The technologies allowing the maximum of functions in one device have been pre-selected for further development in 2020.

TD1.6: Doors and Access Systems Demonstrator							
2015	2016	2017	2018	2019	2020	2021	2022
			Finished: PIVOT				...
			Ongoing: PIVOT, PIVOT2, CARBODIN				

During 2019, 5 deliverables were planned out of which 5 were released. TD1.6 has reported having accomplished 100% of the planned work up to the end 2019, which represent 45% of the overall TD.

TD 1.7 Train Modularity in Use (TMIU)

The TD develops new modular concepts for train interiors that allow operators to adapt the vehicle layout to the actual usage conditions, and will improve passenger flows, thus optimizing both the capacity of the vehicle and dwell times.

TD Progress

The TD1.7 builds on the progress made by PIVOT and MAT4RAIL Projects.

In 2019, a Design to Cost study has been done for Interiors design to identify the main opportunities to reduce the cost and time to change an interiors design. Two main aspects of modularity were evaluated: modularity of the layout and modularity of the atmosphere. As a result, two main concepts of panels will be developed in 2020: Type 1, 'Section of train' with only few large panels filled; Type 2, 'Free design' with several small panels with more freedom of materials and shape.

In 2019, a concept of Ultralight Seat has been produced and its comfort has been validated by experts from operators/manufacturing companies. Additionally, the technical feasibility of the energy grid concept (electric panel without cable) has been also validated by several member's experts involved in the TD1.7.

The topic driver's cabin has progressed with the analysis of a current desk and the identification of the main opportunities of digitalization or capabilities to change current technologies.

TD1.7: Train Modularity In Use (TMIU)								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: Roll2Rail, Mat4Rail					Ongoing: PIVOT, PIVOT2, CARBODIN			

During 2019, 3 deliverables were planned and released. TD1.7 has reported having accomplished 100% of the planned work up to the end 2019, which represent 45% of the overall TD.

TD 1.8 HVAC

The aims of the TD1.8 is to provide "Heating, Ventilation Air conditioning and Cooling" systems (HVAC) within rail vehicles using eco-friendly natural refrigerants instead of current artificial refrigerants solution that have a very high environmental impact.

Within TD1.8 two HVAC demonstrators with CO2 refrigerants will be specified, simulated, developed and tested in real operation for one year (TRL7). At the end of the programme these HVAC units should be ready for further industrialisation for application within new trains and for the refurbishment of existing trains.

Further activities are the pre-standardisation of mechanical, electrical and control interfaces of HVAC-units as well as fundamental work on alternative refrigerants.

TD Progress

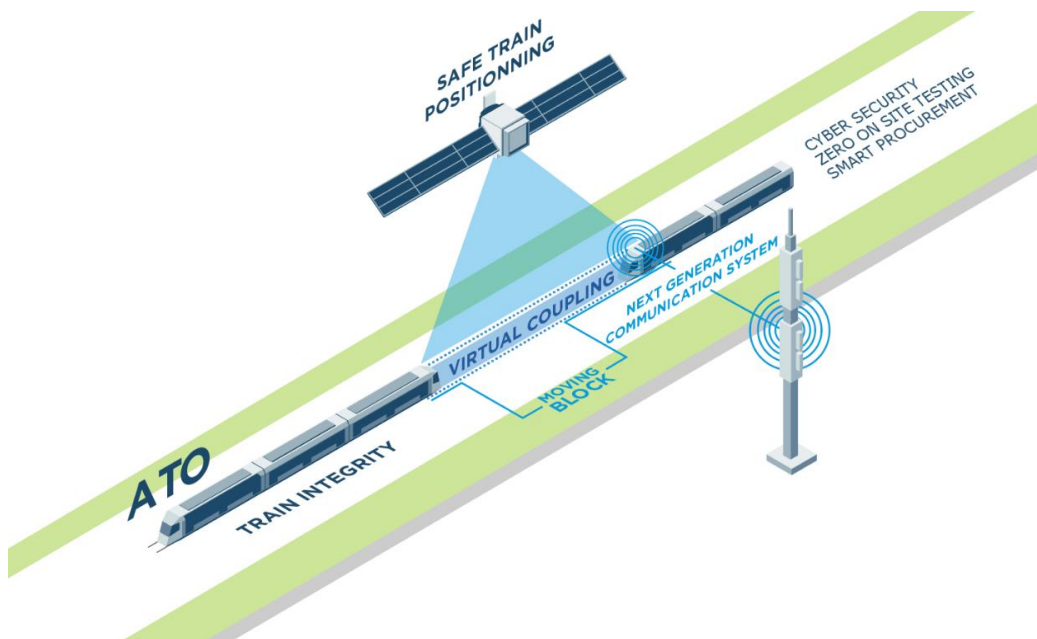
The first activities have only started within PIVOT-2 in December 2019. Therefore, progress will be reported in 2020.

TD1.8: HVAC								
2015	2016	2017	2018	2019	2020	2021	2022	...
					Ongoing: PIVOT2			
					AWP 2020: CFM			

During 2019, 0 deliverables were planned. TD1.8 has reported having accomplished 100% of the planned work up to the end 2019, which represent 5% of the overall TD.

1.7.2. IP2 Advanced Traffic Management and Control System

The pictures below gives a visual perception on where the TDs will introduce improvements.



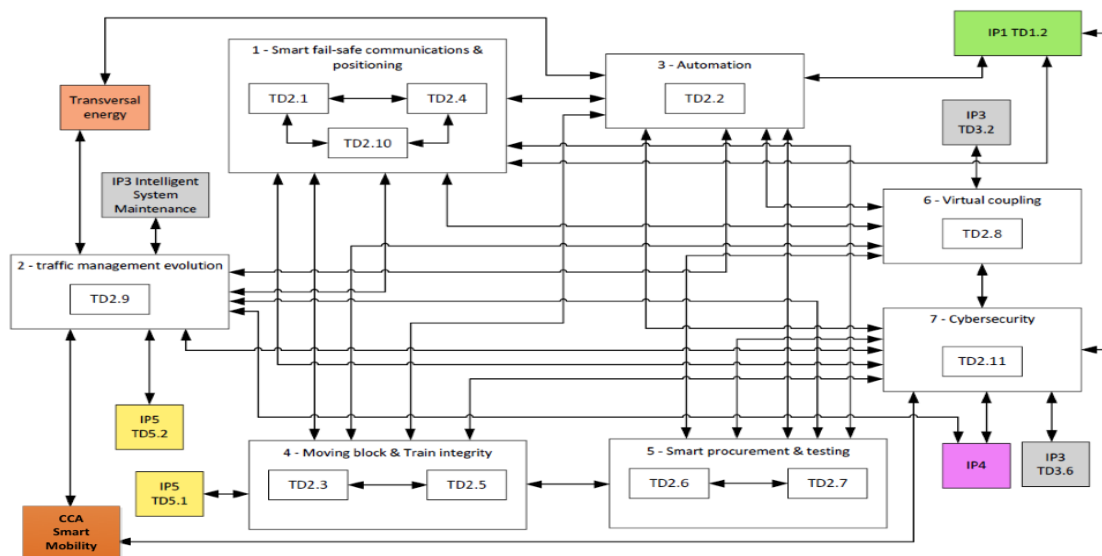
The aim of IP2 is to design and develop a control, command and communication systems that goes beyond being only a contributor to the control and safe separation of trains, and to become a flexible, real-time, intelligent traffic management and automation system.

IP2 builds on ERTMS, that, although deployed in Europe to a limited extent, including on core rail corridors, is a worldwide dominant solution for railway signalling and control systems. Current ERTMS systems do not sufficiently take advantage of new technologies and practices, including use of satellite positioning technologies, high-speed, high-capacity data and voice communications systems (Wi-Fi, 4G/LTE), automation, as well as innovative real-time data collection, processing and communication systems. These have the potential to considerably enhance traffic management (including predictive and adaptive operational control of train movements), thereby delivering improved capacity, decrease traction energy consumption and carbon emissions, reduce operational costs, enhance safety and security, and provide better customer information - all in all, the potential for achieving major cost efficiency results for railway operations.

Key Technology Demonstrators under development in IP2 will contribute to the new release of the CCS TSI, planned in 2022. Those TDs will contribute to the ERTMS Game Changers (ATO, FRMCS, Moving Block/ETCS Level 3 and train positioning). Coordination work has started in 2019 and is expected to continue beyond 2020.

In December 2019, LINX4RAIL, a S2R IPX project, was launched with the objective to create the first common rail Functional System Architecture. The project will gather input across all IPs, external initiatives, such as RCA, OCORA, EULYNX, railML, and harmonise the way solutions are designed, developed and integrated. The common approach will allow to lower the life-cycle costs by enabling modularity, develop new business models, and overall increase the efficiency of the railways with seamless data exchange. The outputs of the two work streams, System Architecture and Conceptual Data Model (CDM), will trigger the implementation of the suggested changes into running S2R initiatives. The existing IP2 projects, and X2Rail-4, started in December 2019, will be one of the first S2R initiatives where this common vision will be implemented.

The picture below shows the TDs connections and dependencies within IP1 and with other IPs and CCA.



TD 2.1: Adaptable communications for all railways

The purpose of this TD is to overcome the shortcomings in the current European Train Control System (ETCS) and Communications-Based Train Control (CBTC) and deliver an adaptable train-to-ground communications system usable for train control applications in all market segments, using packet switching/IP technologies (GPRS, EDGE, LTE, Satellite, Wi-Fi, etc.). The system will facilitate migration from existing systems such as GSM-R, providing enhanced throughput, safety and security functionalities to support the current and future needs of signalling systems and well beyond; it will be resilient to interference and open to developments in radio technology.

TD Progress

This TD builds on the following projects: X2RAIL-1, X2RAIL-3 and EMULRADIO4RAIL. The open call project MISTRAL was completed in October 2018.

The main achievements in 2019 were the following:

- Update of the User Requirements Specifications
- Delivery of the Business Model
- Delivery of the System Specification
- Delivery of the Prototype development report
- Development of the prototypes and demonstrators proceeding during 2019

Started in 2018, the cooperation between S2R and UIC project FRMCS (Future Railway Mobile Communication System) led to further updates of the User Requirement Specification document in both projects in 2019, initially delivered in 2017 to take into account the alignment with the Project FRMCS. This cooperation will continue in 2020 in order to ensure full alignment within the sector, ahead of the preparation of integration of the results in the Control Command and Signalling Technical Specifications for Interoperability (CCS TSI). The System Specification from TD2.1 was discussed in detail with the FRMCS project and will influence the Functional Requirements Specification as well as the System Requirement Specification for FRMCS in 2020/2021. In addition, synergies with the work

performed under the umbrella of IP1 (TD1.2 – Wireless TCMS) are also contributing to fostering the system approach across the Programme.

The Field Test strategy activity was launched in 2019 with the objective of defining the test strategy (for the field) that is built on the high-level test strategy defined and the subsequent lab testing activity planned. The final document planned for end of 2020 will detail the different field test phases, provide a timeline with milestones and propose technology demonstrators and trial sites for the forthcoming field-testing activity. Test criteria will be drawn from the ‘Requirements’ deliverable and test methodology proposed.

In 2019, the development of all planned prototypes have been finished and the integration to the three demonstrators has started. The NaaS Scenario have been analysed and findings were described in the Business Model Deliverable.

Furthermore, the activities related to the Antenna system specifications for adaptable communications in railway environment have also been kicked-off.

The activity will not only focus on the train antenna system, but will also take into account requirements for the trackside antenna systems. It will encompass both electromagnetic considerations and requirements such as spectrum bands, bandwidth, radiation pattern and re-configurability, polarisation, system adaptability, combination and integration of different radio technologies, as well as mechanical requirements such as platform integration, positioning, size, height, weight and lifetime. The objective in this regard is to study, assess and specify on-board and ground-based antenna systems.

TD2.1: Adaptable communications for all railways (quality of service, interfaces to signalling)								
2015	2016	2017	2018	2019	2020	2021	2022	2023
		Finished: MISTRAL						
		Ongoing: X2Rail-1, X2Rail-3, EMULRADIO4RAIL						
						AWP 2020: CFM, OC		

In 2019, 10 of the 11 planned deliverables were delivered. The overall progress is in line with the plan. TD 2.1 has reported having accomplished 95% of the planned work up to the end 2019, which represents 60% of progress of the overall TD.

TD 2.2: Railway network capacity increase (ATO up to GoA4 – UTO)

ERTMS/ETCS, the current generation of main line signalling, faces a growing challenge to provide the performance improvements and increases in line capacity needed by (European) Main Line operators.

Using Automated Train Operations (ATO) with ETCS is an answer to this challenge. This technology is already vastly deployed in urban transport where different grades of automation are implemented including driverless and unattended operation. The objective of this technology demonstrator is to develop and validate a standard ATO up to GoA3/4 over ETCS, where applicable, for all railway market segments (mainline/high speed, urban/suburban, regional and freight lines).

TD Progress

This Technology Demonstrator currently builds on the following projects: X2RAIL-1, launched in 2016 and ASTRail, launched in 2017 and completed at the end of 2019. X2RAIL-1 is developing the

specifications for ATO GoA2/4 over ETCS while ASTRail focused on identifying which technologies coming from other application fields could be transferred to the rail sector.

Further to the delivery of the first version of the specifications for ATO GoA1/2 in April 2018, ERA has reviewed and assessed (as ERTMS System Authority) together with the ERTMS Users Group (EUG) and UNISIG the ATO GoA1/2 deliveries and their impact on the current ERTMS/ETCS specifications.

The reference Test Bench results have been issued in November 2019 based on interoperability tests performed on the Reference Test Bench in January 2019. Different types of issues have been raised:

- **Non-Compliance:** A test bench combination did not comply with Subset-125 requirements. An update of the concerned ATO Subsystem is foreseen.
- **Supplier Understanding:** Suppliers understood in a different way some requirement within Subset-125. Clarifications of the corresponding requirement are proposed to ERA.
- **Subset Specification:** Some Subset-125 requirements appeared to be wrong or misleading. New requirements or modifications are proposed to ERA.
- **Test bench issue:** The development of the test bench itself is not compliant with the test bench reference document. An update is foreseen, when other interoperability tests are scheduled again.

Consequently, the findings raised allow refining some requirements in the specification approved by ERA. These refinements are managed through “change requests” (following the official ERA ETCS CCM process) which will be submitted to ERA for approval. In addition, new interface documents will be submitted to ERA.

This step was done following the definition of the operational requirements and included the system requirements and the ETCS on-board/ATO on-board interface requirements. The reference test benches were finalised at the beginning of 2019; and the pilot tests for interoperability purposes will run in March 2020.

In parallel, the TD has continued working on the requirements for Automatic Train Operations up to Grade of Automation 4 (unattended train operations).

The following documents have been completed (preliminary versions):

1. Operation Requirement Specification which includes:
 - The operation contexts and the associated actors
 - The operation Use Cases (modelled by sequence diagrams)
 - Logical Architecture
 - Interface definition
 - Users interface principles
2. System Requirement Specification which includes:
 - The functional requirements allocated to the Logical Architecture
 - Interface specifications (FIS level) between the Logical Components.

The work will continue in 2020 with the projects launched at the end of 2019, X2RAIL-4 and SMART-2 (obstacle detection for GoA3/4, linked to IP5).

TD2.2: Railway network capacity increase (ATO up to GoA4 – UTO)								
2015	2016	2017	2018	2019	2020	2021	2022	2023
			Finished: ASTRail					
			Ongoing: X2Rail-1, X2Rail-4, SMART2					

In 2019, the TD has delivered all three expected deliverables. TD 2.2 has reported having accomplished 100 % of the planned work up to the end of 2019, which represents 50% of the overall TD. The overall progress is considered to be in line with the plan, despite the delay in execution of the pilot tests in the United Kingdom, which are still pending in the final solution.

TD 2.3: Moving Block

The key objective of this technology demonstrator consists of improving line capacity by decoupling the signalling from the physical infrastructure on the one hand, and removing the constraints imposed by trackside train detection, on the other. This will allow the transit of more trains on a given (main) line, especially for high-density passenger services. The system is expected to be compatible with existing ERTMS specifications and will enable progression towards CBTC (Communication Based Train Control) functionalities for urban applications.

TD Progress

This TD currently builds on the following projects: X2RAIL-1 (2016), X2RAIL-3 and MOVINGRAIL, both launched in 2018. ASTRAIL was completed in 2019 and was supporting the development on the hazard analysis. X2RAIL-1 and X2RAIL-3 are developing moving block operational and engineering rules, system specifications as well as the application analysis while MOVINGRAIL supports the validation work of those rules and system specifications.

In 2019, the TD completed the deliverables for the system requirements, the operational and engineering Rules as well as the preliminary Safety Analysis, based on sixteen identified scenarios. The work in the TD is ongoing, with further analysis foreseen in order to provide a validation of the Requirements, Operational and Engineering Rules. The Safety Analysis is being extended to include quantified safety analysis, based on the Common Safety Method.

Two additional topics are now being examined:

- Testing of Moving Block systems: How to test a Full Moving Block system with continuous variables;
- Future enhancements beyond the current ETCS Baseline: How to make use of advances such as always on, always located EVCs and the impact of an enhanced interface between Train Integrity and the ETCS On-Board.

One of the objectives of this TD is also to provide improved strategies and advanced methods for moving block testing which can meet key stakeholder requirements while minimising on-site testing. User requirements for Moving Block testing have been collected during the May 2019 workshop while reviewing the outcomes of previous and on-going projects addressing ETCS level 3 developments. The results from workshop have been used to formulate a Moving Block Signalling Test Strategy, which will be issued as a deliverable in early 2020.

Taking as input the information from the key stakeholder interviews and a literature review, a deliverable describing an operational concept and testing strategy for moving block testing is under finalisation for delivery in January 2020. This will feed into the development of an extensible architecture, interface definitions and automated testing routines, to be completed in 2020.

In 2019, the TD finalised the first Moving Block specifications, divided as “System Specifications”, “Operational and Engineering Rules” and “Preliminary Safety Analysis”, all of which were provided by the S2R JU to the European Union Agency for Railways.

TD2.3 Moving Block								
2015	2016	2017	2018	2019	2020	2021	2022	2023
			Finished: ASTRail					
			Ongoing: X2Rail-1, X2Rail-3, MOVINGRAIL					
					AWP 2020: CFM, OC			

In 2019, the TD has delivered 4 out of the 4 expected deliverables. TD 2.3 has reported having accomplished 100 % of the planned work up to the end of 2019, which represents 50% of the overall TD. The overall progress is in line with the plan, despite initial delays in finalising the first version of the set of specifications in 2019.

TD 2.4: Fail-Safe Train Positioning (including satellite technology)

This Technology demonstrator aims at developing both (a) a fail-safe, multi-sensor train positioning system based on the virtual balise concept, applying Global Navigation Satellite Systems (GNSS) technology, as a functional block of the current core of ERTMS/ETCS and (b) an enhanced, safe, multi-sensor, stand alone train positioning subsystem that calculates the train travelled distance, speed and absolute train position including the analysis and solution of the track discrimination problem.

It will enable the use of other new technologies (e.g. inertial sensors) or sensors (e.g. accelerometers, odometer sensors) to boost the quality of train localisation and integrity information, while also reducing the overall life cycle costs, in particular by enabling a significant reduction in all conventional trackside (train) detection systems, such as balises, track circuits or axle counters.

TD Progress

This TD currently builds on the following projects: X2RAIL-2. The complementary open call project ASTRail was completed in October 2019.

X2RAIL-2 focuses on the development of the architecture, proof of concepts, and specifications for laboratory testing. ASTRail studied the requirements and possible knowledge transfer from the aeronautical standards regarding application of GNSS to rail signalling.

The key achievement for this TD in 2019 has been the definition and delivery of both the first and the final versions of the System Requirement Specifications (i.e. functional and non-functional requirements) of the Fail-Safe Train Positioning (including satellite technologies) based on the virtual balise concept, and also the related System Architecture.

Both deliverables define the guideline specifications for the preparation of demonstrators of a GNSS based positioning system in Shift2Rail IP2 TD 2.4, which will then be tested in laboratory and in field.

The results from these tests will then be used to further refine the architecture, as well as functional and interface definitions and in making choices where options currently exist.

The main goal of the defined requirement specifications and the architecture is to provide a functional solution fully interoperable with the ERTMS legacy system. Therefore, the introduction of the virtual balise as specified in both deliverables would not reduce the performance with regard to the current ERTMS installations.

Finally, during the architectural design phase, a preliminary System Functional Hazard Analysis has been performed and enclosed in the System Architecture Specification deliverable. Such Hazard Analysis allowed the identification of safety requirements as well as applicable conditions, which shall be respectively implemented and observed to eliminate the hazards resulting from the analysis or to reduce the risk associated with those hazards. No criticality has been identified during such preliminary hazard analysis.

Further activities during the remaining tasks have been planned to improve the details of the specifications and obtain the specification of the FFFIS interfaces.

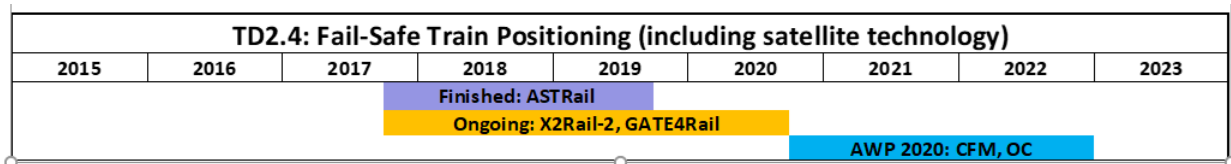
On-site GNSS performance tests were carried out in Italy, Czech Republic and Germany, in addition to data collected in the framework of the GSA-funded project, STARS (GA 687414). The analysis performed in this task focused on three technologies: GNSS, radio-localization, and kinematic sensor. Most relevant achievements from the GNSS signal analysis can therefore be summarized as:

- Interference measurements in GNSS bands indicated several RFI events; however, none of them was significantly harmful for positioning function,
- Comparison of selected statistics estimated based on panoramic figures and measured GNSS data was performed showing good correlation of both approaches (i.e. analysis of the panoramic data and the GNSS data); as a consequence, the panoramic figures can be used as a source of local visibility data for a prediction performance tool,
- Processing of GNSS data was mainly focused on multipath assessment; and the related applied techniques can be further considered to be part of measures against multipath feared event.

Furthermore, the methodology for performance assessment of kinematic sensors was prepared. The feasibility of the methodology was proven by its application on real sensor data and would be the basis of the parallel research stream (Stream2, created by the G.A. amendment) concerning the Enhanced Odometry and Safe Stand Alone Train Positioning.

The TD also ensured valuable collaborations with EUG on the Future Localization System and with the European GNSS Agency on the Cost Benefit Analysis for future evolutions of GNSS in railways. In addition, the first preliminary specification document of Enhanced Odometry and Safe Stand Alone Train Positioning is being delivered as an internal development baseline.

The open call project GATE4RAIL started in 2019 and it is expected to provide a GNSS automated virtualized test environment. The concept and methodology have been defined and are currently being reviewed.



TD2.4 has reported having accomplished 90% of the work planned work up to the end of 2019, which represents 50% of the progress of the overall TD.

TD 2.5: On-board Train integrity

This Technology Demonstrator aims at specifying and prototyping an innovative on-board train integrity solution, capable of autonomous train-tail localisation, wireless communication between the tail and the front cab, safe detection (SIL4) of train interruption and autonomous power supply functionality without the deployment of any fixed trackside equipment. This functionality will be developed for those market segments (e.g. freight and low traffic lines) lacking such functions.

TD Progress

This TD currently builds on the following projects: X2RAIL-2 and ETALON. Both projects started in September 2017. The activities will continue in X2RAIL-4, launched in December 2019.

The main achievements in 2019 includes the completion of activities related to the definition of requirements:

- functional requirement review with results of OTI FSM formal validation (D4.1)
- functional architecture and interface specification (D4.2)
- functional requirements specification (D4.3)

Preliminary development activities have been started by defining four TRL4 demonstrators for passengers and freight application domains with wired and wireless communication technologies.

Activities include:

- Candidate technologies selection :
 - Concerning wireless on-board communication network for short-range communications, ZigBee and 6LowWPAN are the most suitable technologies due to their low consumption and robustness and security. Moreover, IEEE 802.11p is recommended not only for short-range communications, but also for medium range communications, according the implementation cases studied. For long-range communications, IEEE 802.11 family protocols and LTE are the preferred candidates, due to their advantages regarding fast transmission of high amount of data.
 - Concerning energy harvesting solutions, the following technologies have been compared: vibration harvester, electromagnetic harvester, solar and wind harvester. A compared analysis showed that vibration and electromagnetic are interesting solutions but may present an insufficient amount of energy to power the OTI devices. Passive RFID solution is presented as an appropriate solution, but the cost of installing RFID readers on-track is

too high, and for train integrity purposes, this cost is unacceptable. Solar and wind harvesters can be useful. To sum up the harvesting solutions, none of the presented solutions accomplishes all criteria. It is therefore necessary to choose a mixed solution based in solar and wind harvesting and piezoelectric harvesting in case that the impact over the wagon design is not too critical.

- Several convoyed waves over power lines solutions have been analysed in order to take into account the existence of old generation electrified trains where Ethernet link is unavailable. Although these analysed solutions are feasible, they may be discarded due to interoperability and cost constraints.
- The TD ran an analysis of solutions defined by the complementary open call project ETALON:
 - ETALON solutions represent an OTI product class 3 with devices installed in each waggon and integrity criteria based on separation sensors between adjacent waggons. Moreover, a network topology discovery technique allows identifying train composition and determining train length. Energy is provided by vibrations that allows generating status messages each 5 seconds. No batteries are considered to avoid maintenance constrains. Instead, a super capacitor is used to store energy.

In general, the proposed wireless technology is suitable to support a NLOS communication between train tail and front cabin. Energy harvesting based on vibration generates required energy with train running at a certain speed, therefore a super capacitor is adopted to provide energy when the train is at stand-still. In case of long period at stand still and OTI system is out of power, the train mission can start in L2 and transition in L3 can be performed subsequently when sufficient energy is available.

- ETALON solution constitutes an OTI Product Class 3 that implies equipping all wagons to implement the on-board train integrity functionality. High redundancy is provided by installing four devices per wagon. Main limitations for this class consist in significant installation impact involving all waggons and OTI functionality unavailability if one waggon is not equipped or two adjacent devices on the same side of one waggon are in fault. A benefit for this class consists in supporting the train length determination functionality.

A new task will address the definition of requirements for train length determination. Specifications activities have been started in July 2019 as per planning. Functional requirements and interface specification for train length determination have been submitted to WP4 internal review.

TD2.5: On-board Train Integrity								
2015	2016	2017	2018	2019	2020	2021	2022	2023
Ongoing: X2Rail-2, ETALON, X2Rail-4								

In 2019, four of the five expected deliverables have been delivered. TD 2.5 has reported having accomplished 95 % of the planned work up to the end of 2019, which represents 60% of the overall TD.

TD2.6: Zero on-site testing (control command in lab demonstrators)

The development of a new laboratory test framework comprises simulation tools and testing procedures for carrying out open test architecture with clear operational rules and simple certification of test results. It aims at minimising on-site testing (with the objective of zero on-site testing) by setting-up full laboratory test processes, even when systems comprise subcomponents of different suppliers. The test framework will also allow remote connection of different components/subsystems located in various testing labs.

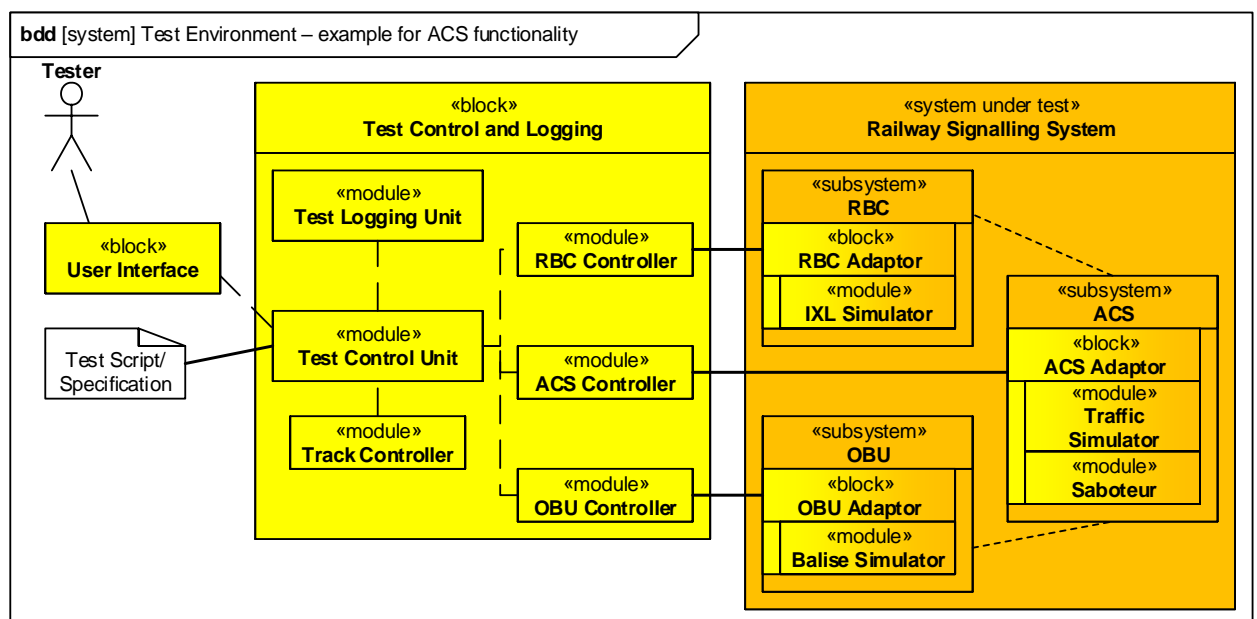
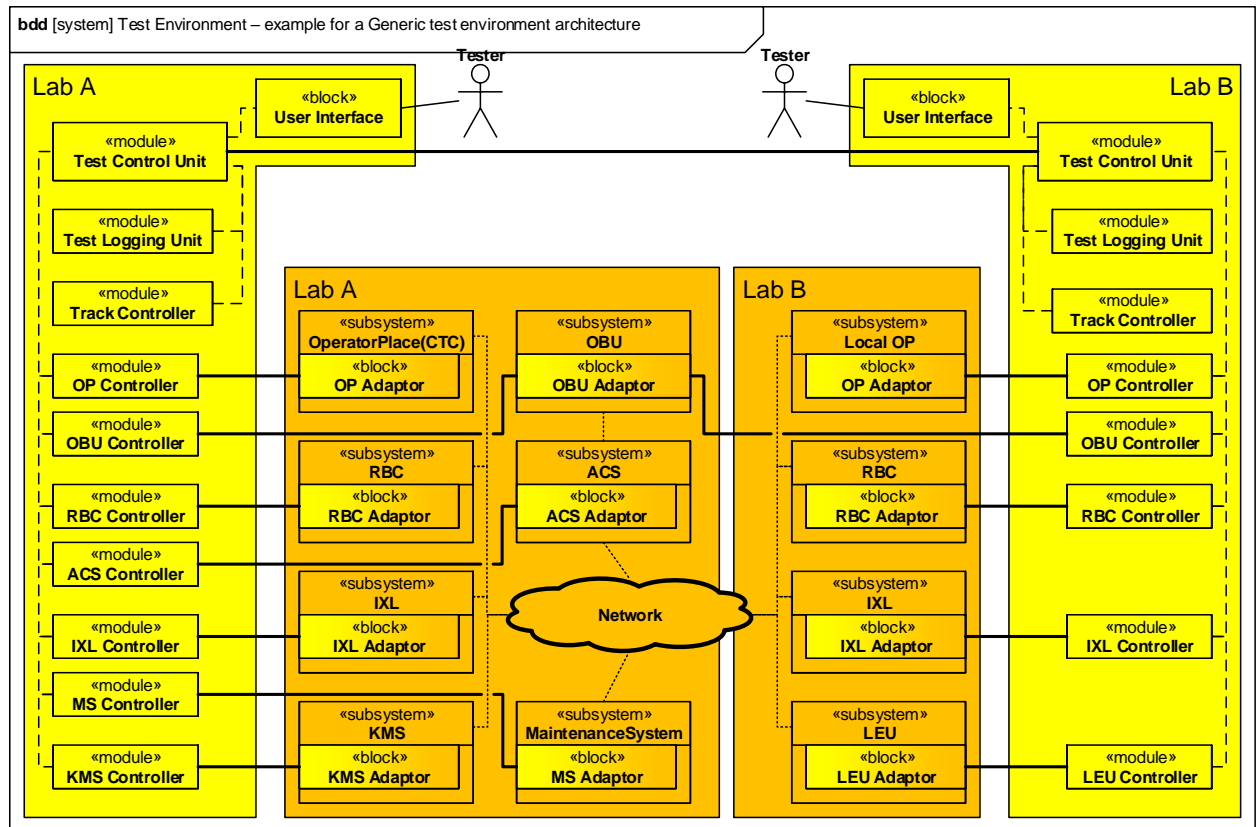
TD Progress

The activities related to this TD were started in X2RAIL-1 and the first results have been ready since December 2018. These results include a benchmarking analysis, the description of the test process and the definition of a full system test architecture for the necessary test environment to support shifting testing from the field to the lab. In this timeframe the results of the VITE open call have been jointly analysed and taken into account.

The TD activities have continued in 2019 within the framework of X2Rail-3 and the open call project, GATE4RAIL. The focus for 2019 was the definition of a generic communication model, data modelling for the test environment and providing different prototype variances. These prototype variances include:

- Prototypes for performance, validation and stress testing;
- Prototypes for testing activities with distributed test environments;
- Prototypes for subsystem testing and integration testing.

In 2019, the generic communication model has been defined. In this generic communication model, several different interfaces and adapters are specified down to the level of FFFIS (Form Fit Functional Interface) specifications. The result should have been delivered by the end of 2019. Nevertheless, they will make part of an important cornerstone for the implementation of the prototypes as shown in the overview of the 2 architecture models. The FFFIS specifications are reflected by the bold lines between the adapters and the controllers.



An initial data model to set up the common prototypes is under discussion; and the analysis using formal modelling for verification of this data is on-going.

With respect to the prototypes, preparation by the different partners is ongoing including the definition of the verification process. In 2020, the emphasis will be put on implementing the prototypes as defined and integrated.

TD2.6: Zero on-site testing (control command in lab demonstrators)								
2015	2016	2017	2018	2019	2020	2021	2022	2023
		Finished: VITE						
		Ongoing: X2Rail-1, X2Rail-3, GATE4Rail						
					AWP 2020: CFM			

One of the two deliverables expected in 2019 from X2RAIL-3 has been delivered on time. The deliverable on the data model is slightly delayed, which will allow / facilitate alignment with LinX4Rail and the CDM approach started in the end of 2019. In further steps collaboration with the complementary project GATE4RAIL has started and will need to be intensified in 2020, the project contributing to create a simulation environment to support the creation of an automated update of test environment. GATE4RAIL has delivered 4 of the 5 deliverables expected in 2019 for this TD. TD2.6 has reported having accomplished 90% of the work planned work up to the end of 2019, which represents 50% of the progress of the overall TD.

TD2.7: Formal methods and standardisation for smart signalling systems

Formal methods (FMs) provide the means to establish correctness of a system model with respect to given properties, to improve verification, certification and authorisation processes, while reducing the need for extensive field tests in the future. Verifying safety is considered to be one of the most compelling use cases for FMs. FMs and standard interfaces aim to contribute to reduced life cycle cost and time-to-market, increased market competition and standardisation, and improved interoperability and reliability. While standard interfaces are orthogonal to formal methods (one can use one without the other), they help increase competition, and enable more efficient use (and reuse) of formal methods.

TD Progress

During 2019 this TD built on X2RAIL-2 and ASTRail which was completed in October 2019. The open call 4SECURAIL was launched at the end of 2019 and will contribute to activities of this TD from 2020 onwards.

ASTRail focused on identifying technologies in other application fields, which have the potential to be transferred to the rail sector. ASTRail also performed a literature survey of formal methods and a case study, applying formal and semi-formal methods to a simplified version of moving block with ATO.

Key activities in 2019 included the application of formal and semi-formal methods to the Level Crossing application and its interface, selected in 2018, to enable the comparison and evaluation of the different methods using several FMs use cases. A main achievement has been that several main use cases for formal methods are being used, including a variety of different state-of-the-art methods and tools. This is expected to provide results that reflect the potential of FMs for rail control subsystems in deliverables due in 2020, including the business case deliverable.

TD2.7: Formal methods and standardisation for smart signalling systems								
2015	2016	2017	2018	2019	2020	2021	2022	2023
		Finished: ASTRail						
		Ongoing: X2Rail-2, 4SECURAIL						
					AWP 2020: CFM			

In 2019, one deliverable in X2RAIL-2 was postponed to 2020. Hence, TD 2.7 has reported having accomplished 90% of planned work up to the end of 2019, which represents 55% of the overall TD.

TD2.8: Virtually – Coupled Train Sets (VCTS)

This technology demonstrator targets the enabling of ‘virtually coupled trains’, capable of operating much closer to one another, within their absolute braking distance, and of dynamically modifying their own composition on the move (virtual coupling/uncoupling of train convoys), while ensuring at least the same level of safety which is provided at present.

TD Progress

The TD started in December 2018 with the target of achieving the conceptual definition of the VTCS by September 2019 and of finalising the safety and performance analysis by February 2020. Given these milestones, 2019 focused on the definition of the virtual coupling system concept:

- Identification of the relevant operational scenarios of application;
- The characterisation of the virtual coupling system by mean of its core functionalities, based on the scenarios of application, and also on the input of complementary project (i.e. the open call project MOVINGRAIL or other work streams as CONNECTA-2/TD1.2), the;
- Association of the core functionalities to a functional architecture of the system, which shall then be the basis for further developments of the work stream (e.g. system requirements, and impact analysis on existing infrastructure).

The functional description developed has been used to feed the ongoing safety and performance analysis (expected to be delivered by February 2020). The overall system concept has been defined and will still be reviewed to include the results of the safety analysis:

- Further clarification on requirements (in order to guarantee univocal analysis and interpretation);
- An accurate decomposition of functions, in order to simplify the association of safety targets to specific functions of the VCTS;
- An improved overall functional architecture to better allocate safety requirements to elements of the virtual coupling system and to simplify the exporting of safety requirements to other elements of the railway infrastructure.

The most relevant preliminary findings deriving from the conceptual definition are the following:

- With respect to the existing operational constraints of railway networks, the VCTS provides its main advantage when replacing the current procedures for building consists by mean of mechanical devices (e.g. couplers) involving a meaningful saving of time;
- The improvement of network capacity provided by VCTS depends largely on the network topology; while the possibility of coupling/splitting with high efficiency is provided, some exported safety constraints (especially on wayside infrastructure, e.g.: interlocking) may limit this advantage;
- In general, a number of safety constraints is exported by VCTS to the existing signalling infrastructure, for which the current work are not only focussed on develop general system requirements, but also to address incremental levels of automation of the overall railway system, e.g.: if the line is equipped with ERTMS, or with legacy signalling systems, or with ATO.

Further activities will therefore include:

- The completion of the VCTS concept and functional requirements, including the initial results of the safety analysis;
- The completion of VCTS safety analysis by February 2020;
- The launch of the activities related to the system requirements definition.

TD2.8: Virtually – Coupled Train Sets (VCTS)								
2015	2016	2017	2018	2019	2020	2021	2022	...
Ongoing: X2Rail-3, MOVINGRAIL								

For 2019, only one deliverable was planned in X2RAIL-3. TD2.8 is reporting having accomplished 70% of the planned work up to the end of 2019, which represents 30% of the overall TD.

TD2.9: Traffic management evolution

An optimised Traffic Management System (TD 2.9) aims at improving traffic management operations with automated processes for data integration and exchange with other rail business services. The backbone of the new architecture will be a scalable, interoperable and standardised communication structure applicable within an integrated rail services management system. These features will be combined with new business service applications (e.g. advanced driver advisory system, or intelligent, automated and flexible dispatching systems including conflict detection and resolution) to allow for predictive and dynamic traffic management in both regular and degraded situations. It will use and integrate real-time status and performance data from the network and from the train, using on-board train integrity solutions and network object control functions, supported by wireless network communication.

TD Progress

This TD currently builds on the work performed in X2RAIL-2, for which the TD is expected to be completed by February 2020. The activities will then continue in X2RAIL-4 and the complementary action OPTIMA (open call) which was launched in December 2019.

The TD has specified the first set of data for Traffic Control, Time Table Management, ATO (GOA2), Asset status, weather information and others which will be implemented on the Integration Layer. This specification needs to be covered from the modelling scheme for the Canonical Data Model and will together with standardized API Interfaces and a specified WEB-IF secure the interoperability between systems of different vendors and allow the integration of legacy installations.

The second significant contribution for the integration of different systems is the specification of a standardized operator's workstation, which will support different levels of Multi-user and Multi-application integration strategies within a control room.

New and advanced principles for Traffic Management have been defined and described. This process started with proposed use-cases from the WP partners, which were then benchmarked and optimized

against Infrastructure Managers' specific new models such as "Digitale Schiene" from Deutsche Bahn. Activities will continue to specify in more depth the selected use-cases.

The key rules and design principles for the demonstrators/prototypes have been designed specifying which processes shall be documented to proof the concept. This general concept will also be applied for the enhancement of the prototypes up to TRL6.

All partners involved in the development of a demonstrator/prototype for the different tasks/activities have started the design following the guidelines already specified.

The development of the prototypes and demonstrators has started in 2019 and will continue in 2020.

Finally, in the last few weeks of 2019, the TD started to align with the Open Call project, OPTIMA. TD2.9 has prepared specifications with implementation proposals for the API interfaces for OPTIMA, which will be handed over in 2020.

TD2.9: Traffic management evolution								
2015	2016	2017	2018	2019	2020	2021	2022	2023
				Ongoing: X2Rail-2, X2Rail-4, OPTIMA				

The four deliverables planned for 2019 have been delivered. TD 2.9 has reported having accomplished 100% of the planned work up to the end of 2019, which represents 60 % of the overall TD.

TD2.10: Smart radio-connected all-in-all wayside objects

The objective of this technology demonstrator is to develop an autonomous, intelligent, maintenance free smart equipment ("box") which has the capacity to connect with any signalling wayside object and communicating device in the area (wireless), guaranteeing safety and security, by the definition of a common architecture and of requirements and interface specifications. The TD will develop concepts for locally derived power, for the overall reduction of power consumptions and required cabling as well as to specify interfaces with control, power, diagnostics and maintenance systems using both low and high capacity wireless links.

These "intelligent" objects - knowing and communicating their status conditions - would not only provide opportunities in terms of cost reduction and asset management improvement, but also establish new means for management and control of railway network information.

TD Progress

This TD currently builds on the following projects: X2RAIL-1, launched in 2016 and ETALON, launched in 2017. The activities will be taken further in X2RAIL-4, launched in December 2019.

In 2019, the TD focused on completing the definition of the System Architecture and related Interfaces.

The System Architecture and Interfaces definition is based in the conclusions of the previous deliverables (Analysis of Economic models and Requirements and Standards) and has been

implemented in the Arcadia Methodology (ARChitecture Analysis and Design Integrated Approach) supported with Capella as the tool for Model Based Systems Engineering (MBSE).

Therefore, in the design process, the Operational Scenarios, Use Cases and Business Needs and Requirements are considered with their correspondence into the Capella model: First, at Operational Analysis, Use Cases are linked with Capabilities and Business Needs with Activities. Secondly, the Traceability matrix between Requirements and Activities is completed. Finally, at System Analysis level Activities are propagated to Functions.

As result of the previous process, the System Architecture has been defined and implemented with Arcadia methodology in Capella tool, based on four main units: Control Unit, Power Unit, Communication Unit and Diagnosis and Maintenance Unit. Additionally Interfaces definition with external system has been completed.

The structured planning of an overall system demonstrator has also been delivered, based on identified solution in the Analysis of Economic models, the Requirements and the definition of System Architecture and Interfaces. In this planning, the demonstrators for each partner are described to be developed in two phases to reach first TRL4 and then TRL6, in the framework of the X2RAIL-4 project.

The TD also focuses on the identification, incorporation and evaluation of an energy harvesting solution for Smart Radio connected wayside objects, which contribute to the main objective of TD2.10, i.e. to minimize trackside infrastructure.

TD2.10: Smart radio-connected all-in-all wayside objects								
2015	2016	2017	2018	2019	2020	2021	2022	2023
Ongoing: X2Rail-1, ETALON, X2Rail-4								

The two deliverables planned for 2019 were delivered on time. Overall progress was in line with the plan. TD 2.10 reports having accomplished 100% of the planned work up to the end of 2019, which represents 55 % of the overall TD.

TD2.11: Cybersecurity

The interconnected digital railway network at European level is constantly growing and will keep on growing, which will increase the number of risks associated to security. Hence, there is a growing need to handle these cyber-security threats in railway systems. This technology demonstrator aims at achieving the optimal level of protection against any significant threat to the signalling and telecom systems in the most economical way (e.g. protection from cyber-attacks and advanced persistent threats coming from outside).

TD Progress

The activities of the TD are addressed via the projects X2Rail-1 and X2Rail-3, as well as on CYRAIL, completed in 2018. The open call project 4SECURAIL was launched at the end of 2019 and will provide its first initial results (on C-SIRT) in 2020.

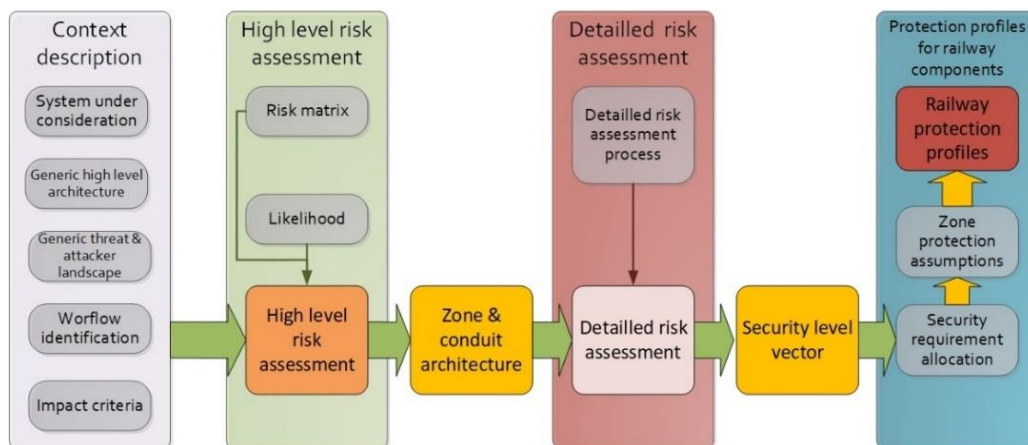
The following activities have been completed:

- Assessment of the suitability of IEC 62443 as cybersecurity framework;

- Generic risk assessment of railway generic signalling architecture;
- “Security by design “use cases;
- Railway specific generic protection profiles;
- Demonstrator description.

The IEC 62443 cybersecurity framework is a set of evolving cybersecurity standards. Therefore, in order to assess the suitability of the IEC 62443 as a cybersecurity framework for railway, a second version of the security assessment report has been delivered in view of analysing the suitability of the IEC 62443 standards issued most recently (principally IEC 62443-4-1).

A second major achievement for the TD consists of the delivery of the risk assessment, based on the IEC 62443 standard, of a generic signalling railway architecture and the identification of the needed security level target for the different zones.



One of the other main questions raised by the TD is “how to design cyber secured railway component”. Due to the specificities of the railway sector (small sector with very long development and life cycle, and high level of certification), it has been decided to start the analysis by investigating all interdependencies that could impact the implementation of “security by design” at product supplier level through two use-cases considering both top-down and bottom-up approaches. Based on this analysis, a first set of draft guidelines and recommendations for security by design implementation in the railway sector has been drafted. This will then serve as an input for a deeper analysis of the IEC 62443-4-1 “security by design” requirements.

Eventually, the TD worked on the definition of the scope of the cybersecurity demonstrators.

The TD also started defining a more concise structure for railway protection profile to make them both more generic and more sustainable. Protection profile definition started for shared services.

TD2.11: Cyber Security								
2015	2016	2017	2018	2019	2020	2021	2022	2023
		Finished: CYRAIL						
		Ongoing: X2Rail-1, X2Rail-3, 4SECURAIL						
					AWP 2020: CFM			

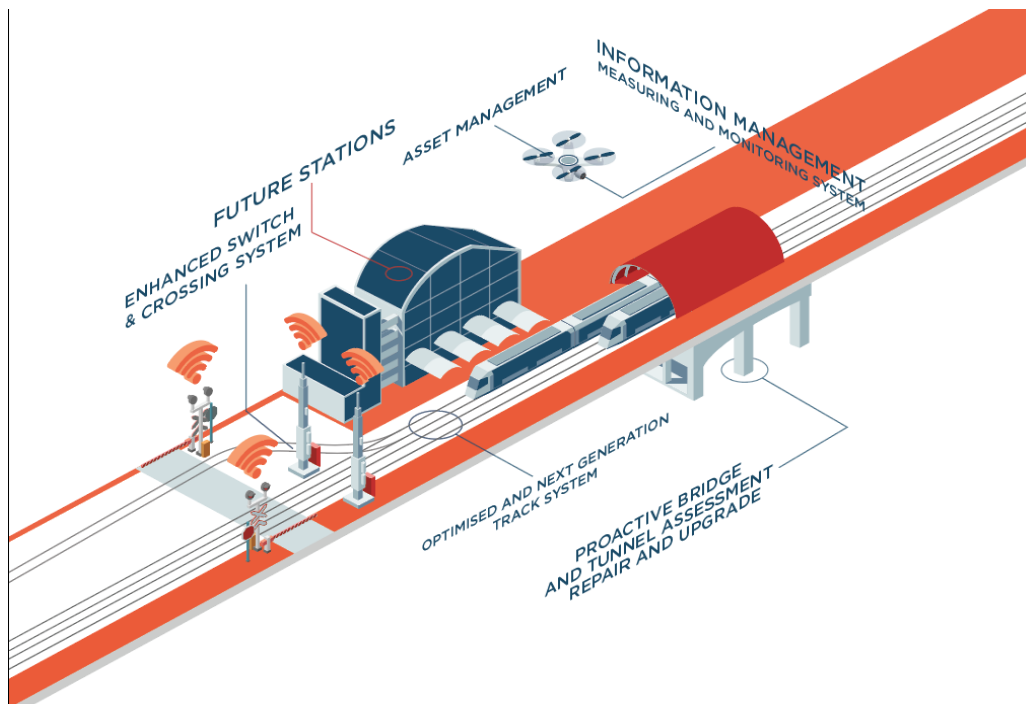
In 2019, the four planned deliverables were delivered on time. The overall progress is considered to be in line with the planned activities.

In addition to these activities, the TD participated actively to the standardisation and the coordination of the cybersecurity approaches for railway at European level. TD members participated as member or guests to the following groups: RASCOP, ESCO, ER-ISAC, TC9X/WG26 (cybersecurity) and Railsec platform.

The TD has reported having accomplished 100% of the planned work up to the end 2019, which represents 55% of the overall TD.

1.7.3. IP3 Cost Efficient and Reliable High Capacity Infrastructure

The pictures below gives a visual perception on where the TDs will introduce improvements

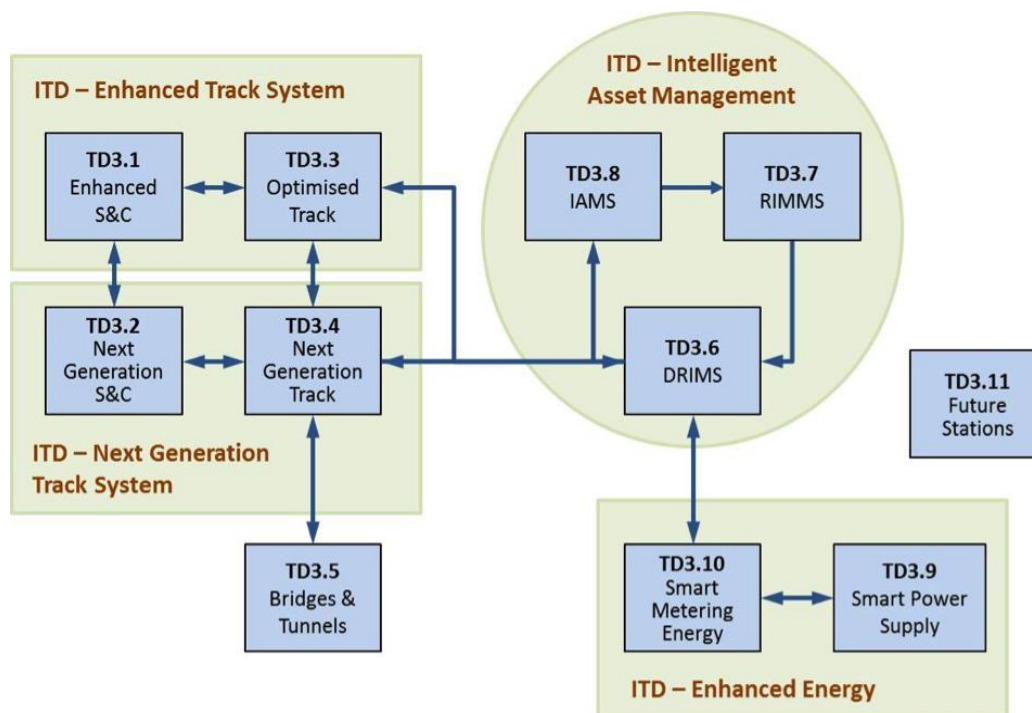


The design, construction, operation and maintenance of rail network infrastructure have to be safe, reliable, supportive of customer needs, cost-effective and sustainable. In order to deliver the benefits of market opening and interoperability and to reduce the life cycle costs of rolling stock and on-board signalling systems, the network diversity needs to be eliminated, notably through a migration towards common high-performing infrastructure system architecture.

Activities that can support the reduction of infrastructure maintenance costs, such as simplified procedures or automation, need to be led in priority. They should propose solutions that can be rapidly and efficiently deployed. Furthermore, the infrastructures have to be managed in a more holistic and intelligent way using lean operational practices and smart technologies that can ultimately contribute to improving the reliability and responsiveness of customer service, as well as the capacity and the whole economics of rail transportation.

In order to be competitive with other modes but also integrated with them, compatibility between different modal infrastructures (including multimodal hubs, changing points and stations) needs to be ensured and based on principles of interoperability and standardisation.

The picture below shows the connections and dependencies within the IP3.



TD3.1 Enhanced Switch & Crossing System Demonstrator

The TD3.1 aims at improving the operational performance of existing Switches and Crossings (S&C) designs through the delivery of new S&C sub-systems with enhanced Reliability, Availability, Maintainability and Safety (RAMS), improved Life Cycle Cost (LCC), sensing and monitoring capabilities, self-adjustment, noise and vibration performance, interoperability and modularity.

TD Progress

The TD3.1 builds on the progress made by IN2TRACK and IN2TRACK-2.

In 2019, final results on the identification of the core S&C issues and missing links between existing failures and root causes has been identified (wear, (plastic) deformation and crack initiation/growth due to rolling contact fatigue).

An approach for modelling S&C as a whole system was developed, aiming to create a modelling approach that will enable the impact of the whole S&C system performance to be assessed, when changes are made to one or more S&C sub-systems or components.

The design of an enhanced switch & crossing has been completed in 2019, including promising research results on switch geometry / rail profile, whole system stiffness / support, modular bearer joints, optimised rail steel grades, additively manufactured crossing and laser clad S&C rails. The production of the demonstrator has started and installation is foreseen in Q3/2020 to start the on-field measurement campaign.

A demonstrator showcasing promising networking technologies for S&C CBM has been developed to show monitoring acceleration (triggered by vibration of train), monitoring temperature (triggered by time interval) and monitoring motor current (triggered by switch movement) .These three data were integrated using the railML and SensorML data formats and transmitted over Ethernet to a server. Due to the complexity and limitations of these data formats, collaboration with IPX is foreseen in 2020 to benefit from the work on the CDM workstream.

Electromechanical Impedance Technique for the deterioration inspections of Cast Manganese Crossings have been investigated. EMI was identified as a potential method for early detection and continuous monitoring of discontinuities in the crossings. Further activities will be needed to validate the promising simulation results (Lab scale demonstrator / field test).

TD3.1 Enhanced Switch & Crossing System								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: In2Rail, IN2TRACK				Ongoing: IN2TRACK2		AWP 2020: CFM		

During 2019, 2 deliverables were planned out of which 2 were released. TD3.1 has reported having accomplished 80% of the planned work up to the end 2019, which represent only 30% of the overall TD.

TD 3.2 – Next Generations Switch & Crossing System Demonstrator

TD 3.2 aims to provide radically new system solutions that deliver novel methods for directing trains between tracks to unlock additional network capacity, while reducing maintenance needs, traffic disturbances and life cycle costs. Step-change solutions are prioritised over short-term incremental improvements and therefore a longer-term implementation timescale is anticipated.

TD Progress

Progress during 2019 was made primarily through work undertaken as part of the open call project S-CODE. Continuation of feasible solutions are scheduled to be delivered during 2020 and beyond, by the subsequent IP3 TD3.2 members call projects.

During 2019, TD3.2 entered into the final two stages of their initial methodology, including (i) system integration and concept validation and (ii) evaluation and assessment for integration. A range of sub-system technologies and demonstrators were ultimately presented, each of which were aligned for possible application to one or more generic, whole system S&C concepts. These concepts included:

1. Back-to-back, bi-stable switch: highly flexible, single switch rail, replacing the need for two switches and eliminating crossing discontinuity and associated high wheel to rail impact forces (requires a 'lift and drop' switch mechanism);
2. Single slender switch: introduces a single, highly flexible switch rail capable of enabling both through and diverging routes of a turnout without the need for a crossing panel (*i.e.* also eliminated high wheel to rail contact forces associated with the crossing interface);
3. Pivoting rail switch: a concept using the general principle of swing-nose crossings to move the switch blades and ensure, as above, continuity in wheel to rail interaction (*i.e.* also reducing dynamic wheel to rail contact forces);
4. Vehicle-based switch: passive switch and crossing design with no moving parts. Vehicle switches between routes through onboard, vehicle steering mechatronics. This concept would require a significant step change due to the constraint of restricting the use of existing state-of-the-art vehicles on 'passive switch' routes;
5. Sinking switch: left and right switch rails lower and raise simultaneously to activate through and diverging routes. Switch 'sinks' sufficiently low to provide adequate flange clearance.

The above ideas are not whole system solutions that have been produced, rather they are general concepts to partially feed the below TD 3.2 sub-system / component technologies and demonstrators:

- | | | |
|--|---|---|
| • Autonomous inspection using drones and non-contact tech. (TRL 4) | • Novel locking mechanism using magnets (TRL 4) | • Optimising the properties of concrete bearers and track structure (inc. self-healing) (TRL 4) |
| • Condition monitoring of points movement using conventional technology and model-based analysis (TRL 7) | • Feedback controller with fault-tolerant scheme (TRL 4) | • Maglev actuator (TRL 4) |
| • Application of composite sleepers and bearers (TRL 7) | • Tuneable stiffness fasteners (active structure) (TRL 4) | • High redundancy actuator (TRL 4) |
| • Acoustic inspection and monitoring of S&C (TRL 4) | • Functionally graded steel crossing (TRL 4) | • Lock using materials with changeable properties (TRL 4) |
| | • Neo-ballast (TRL 7) | • Building Information Models (BIM) for S&C (TRL 4) |

During early 2020, these will be put through a broader industry evaluation, via the TD3.2 members, with all feasible technologies transferred for high TRL work within the programme.

To provide additional detail, below are some key demonstrators achieved during 2019:

Sensor placement demonstrator: On conventional S&C, sensors are mounted to the surface to remotely monitor for changes in material response to external loads. The vision for next generation S&C assets is to include sensors and condition monitoring as part of the whole system initial design as opposed to an 'added extra'. The TD investigated this concept by embedding sensors within a 3D

printed, scale-model of a crossing to demonstrate sensor positioning and possible output responses to dynamic loading (*i.e.* results simulation).

Condition monitoring software: Linked to the sensor placement work, condition monitoring software has been developed to assess sensor system data and convert it to S&C asset health monitoring information. The impact of component deterioration on the wider system can be simulated.

High-redundancy actuation (HRA): A ‘hardware-in-the-loop’ simulation of HRA has been delivered to demonstrate how several (small) actuators, assembled in a parallel and series configuration, can be used to provide both additional driving force but also significant improvements in sub-system reliability. This is achieved through enabling degraded operation in the event of individual actuators failures, ensuring network availability and enough time for planned maintenance to be scheduled.

Self-healing, high-damping concrete bearers: The principal focus of this study was to evaluate the self-healing properties of concrete using different self-healing methods with the inclusion of crumbed rubber (*i.e.* to enhance a high degree of damping in concrete). The three approaches to self-healing explored are bacteria-based, chemical-based and improved autogenous (natural process intrinsic to the material properties).

Lock using materials with changeable properties: This workstream has looked at the potential of incorporating materials with changeable properties into the switch locking mechanism to incorporate a degree of controllability and self-adjustment. The TD examined dilatant materials, electro-rheological (ER) fluid and magneto-rheological (MR) fluid. A self-adjusting closed-loop controller has been designed and integrated within a software demonstrator based on the MR lock.

Additional progress was made in 2019, including:

- the precise definition of the use case and input data for a Building Information Modelling (BIM) demonstrator, working towards a full Digital Twin.
- research into the use of state-of-the-art drone technology to achieve beyond state-of-the-art, automated basic visual inspection (BVI) of critical S&C components has also commenced. This work compliments similar activities within IP3 TD3.7, which have look specifically at the inspection of overhead catenary wires and embankment slope stability.
- the design of a grooved rail crossing system to eliminate wheel to rail contact discontinuities and subsequent high contact forces experienced on existing systems. Work resides at the concept modelling stage and will be further developed in 2020.

TD3.2 Next Generation Switch & Crossing System								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: In2Rail, S-CODE					Ongoing: IN2TRACK2		AWP 2020: CFM	

During 2019, 5 deliverables were planned out of which 5 were released. TD3.2 has reported having accomplished 92% of the planned work up to the end 2019, which represent 40% of the overall TD.

TD3.3 Optimised Track System

The TD challenges track construction assumptions, currently implicit in track design, and explores how innovative solutions in the form of products, processes and procedures can provide enhanced reliability, availability, sustainability, less capacity consumptions together with LCC savings. The aim is to derive medium-term solutions thus requiring harmonisation with current solutions and regulations. The TD pays attention to the wheel/rail interaction that needs to work properly for good performance of the entire railway system.

TD Progress

The TD3.3 builds on the progress made by IN2TRACK and first stage of IN2TRACK-2 and the description below summarises the most important results achieved during 2019.

Field demonstration of new bainitic rail for higher performance are currently ongoing, the monitoring has started and the current results show good performance of the rail in terms of resistance of rolling contact fatigue.

Field tests for Friction Modifier (FM) have been performed with different friction modifiers/lubricants to determine the friction behaviour in operational conditions, aiming to reduce Rolling Contact Fatigue (RCF), wear and N&V. In addition, investigation on safety criteria for FM in terms of adhesion have started and first positive results have been presented, providing a good control of FM dosage.

With regard to the novel type of fastening with variable track gauge, certification process and preparation of installation have started in 2019 and activities should continue in 2020.

Novel measures for the wheel/rail performance have shown good results in the simulation environment in terms of the ability to find track areas that generate bad vehicle's stability. Further analysis of comparing results with real field data have started.

The development of transition zones for the new slab track concept is on-going and will be tested on-field during 2020. Additionally, the evaluation of the LCC and RAMS for the new slab-track concept (modular hybrid track) has started.

The TD delivered the analysis on key influencing parameters for track performances at the end of 2019 and prioritised areas of improvement on enhanced track system which includes the investigation on existing failures and root causes as well as the influence on operational parameters, operational failures and related costs.

TD3.3 Optimised Track System								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: In2Rail, IN2TRACK					Ongoing: IN2TRACK2		AWP 2020: CFM	

During 2019, delays on the technical progress in IN2TRACK (including an amendment increasing the action duration) have impacted the ramp-up of IN2TRACK2 due to the strong interdependency of the two projects. A recovery plan has been initiated in 2019 and should be assessed and deployed Q1 2020.

During 2019, 2 deliverables were planned out of which 2 were released. TD3.3 has reported having accomplished 70% of the planned work up to the end 2019, which represent 40% of the overall TD.

TD3.4 Next Generation Track System

This TD aims at drastically improving the track system targeting a time horizon some 40 years beyond present state-of-the art. This implies that step changes in performance are highly prioritised. The TD process follows a tightly integrated chain, setting out from initial identification of long-term needs of the railway and potential solutions to meet these. The TD is organised around a gradual refinement in design and evaluation of solutions.

TD Progress

Work contributing to TD3.4 within 2019 has been carried out in the Shift2Rail project IN2TRACK2, which is the first project after the work of the lighthouse project IN2RAIL within this TD. IN2RAIL, which provided a framework to assess innovative track solutions. IN2TRACK2 aims to identify and take forward suitable concepts to address the full range of technical objectives set out in the Multi-annual Action Plan (MAAP), whilst taking forward a selection of technologies explored within IN2RAIL. In particular, work carried forward from IN2RAIL includes the following:

Asphalt track solutions: the use of asphalt as a formation treatment has been developed, to demonstrate and quantify the benefits of incorporating a layer of asphalt into a ballasted track system which has a weak formation. A high-level design has been developed and a technical demonstrator planned for installation in operational track in 2020 to TRL 7. Condition monitoring, bespoke to the asphalt track site, forms an integral part of the early development work to enable future system performance to be understood and analysed.

Rail defect repair technologies suitable for autonomous operation: complex interactions between the wheel and rail can lead to discrete defects developing on the rail head. An innovative automated solution for the discrete defect repair of rail using a low preheat process for the repair of defects is being developed, with a prototype demonstrator planned in 2020.

Results are expected within 2020, although initial work has been carried out in 2019, which has focussed on the following areas:

- Requirements and conceptual design of next generation slab track solutions and repair (up to TRL 3).
- Use cases for innovative geotextiles and feasibility study for smart fibre-based soil reinforcement solutions, based on innovative fibrous material (to TRL4).
- Analysis of rail deformation and deterioration, and effects of wheel tread damage for identification of wheel loads for next generation of operational control (up to TRL4).
- Development of contactless ultrasonic rail defect monitoring for small-depth defects less than 5mm, which are currently difficult to detect (up to TRL 5).
- Track stiffness monitoring, based upon axle box acceleration so that the rate of change of track stiffness can be derived from the evolution trend of track stiffness (up to TRL 4).

TD3.4 Next Generation Track System								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: In2Rail				Ongoing: IN2TRACK2		AWP 2020: CFM, OC		

During 2019, no deliverable was planned. Due to resources mobilization issues in 2019, TD3.4 has reported having accomplished 70% of the work planned for 2019 and 15% of the originally planned work overall up to the end of 2019. Progress is expected to be achieved during 2020 with the ramp up of IN2TRACK2 work.

TD3.5 Proactive Bridge and Tunnel Assessment, Repair and Upgrade Demonstrator

The main objective of the TD is to improve inspection methods and repair techniques in view of reducing costs, improving quality and extending the service life of existing structures. A main objective also consists of reducing the cost for new bridges regarding bridge dynamics. Reduction of noise and vibrations are also among the prioritised objectives.

TD Progress

During 2019 the work related to this TD has been performed within the projects IN2TRACK and IN2TRACK-2 and the open call project Assets4Rail. Significant steps towards the demonstration have been taken:

An autonomous image-based tunnel lining inspection system has been developed using high definition images of tunnel lining paired with precise positioning, lidar scanning and an autonomous digital image correlation software capable of automatically detecting significant changes in the external aspect of the tunnel lining. Several test runs have been made, the technology bringing economic and capacity related benefits and also improvements in worker safety.

Optical measurement methods - ground based and un-manned aerial vehicle (UAV) mounted - have been used to test the applicability of several image-based technologies in the creation of digital twins, detection of damage and identification and tracking of changes in geometry and structural behaviour of bridges. In addition, trials using un-manned aerial vehicles for bridge inspections have demonstrated that the data is of improved quality compared to the traditional methods and provides sufficient information to the asset owners to assess the overall condition of the bridge. The benefits of these enhanced inspection methods include reduced traffic disruption, decreased costs and enhanced worker safety.

In regards to novel techniques to reinforce or replace bridge elements, The TD3.5 has analysed and tested enhancement of old masonry arch bridges by using concrete liners, cross ties and fibre reinforced polymer pattress plates. Old steel bridges have had single structural elements or whole deck sections replaced by statically equivalent fibre reinforced polymer elements. In addition, using carbon fibre reinforced polymer plates to reinforce stringer to floor beam connections has been studied and experimentally tested. The implementation of successful research results would allow bridges to be upgraded instead of a much more costly and time demanding replacement.

Additionally, several on-going activities are paving the way to tangible results by end of 2020. Among others:

Functionality and robustness of fibre optical distributed sensors have been positively tested in laboratory and operational environment to be further implemented as part of a tunnel health monitoring system solution. Additionally, laboratory tests on new materials for drainage pipes in Tunnels have also been tested.

Regarding Bridge health monitoring system, a solution to monitor fatigue consumption of bridges has been developed and prototype demonstration has begun - sensors have been installed on a bridge and algorithms for data analytics have been developed.

First noise monitoring on real metallic bridges have been performed, solution to improve fatigue capacity of metallic bridges have been developed (a specific bridge for demonstration has been selected) and prototype for underwater monitoring of scour is under development.

Regarding bridge dynamics for high speed, several full-scale test have been undertaken to study bridge dynamics including resonances, damping and bridge soil interaction and the TD should proceed with the analyse of the results in 2020.

TD3.5 Proactive Bridge and Tunnel Assessment, Repair and Upgrade								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: In2Rail, IN2TRACK				Ongoing: IN2TRACK2, Assets4Rail		AWP 2020: CFM		

During 2019, 10 deliverables were planned out of which 11 were released. TD3.5 has reported having accomplished 85% of the planned work up to the end 2019, which represent 30% of the overall TD.

The progress in this TD is expected to be significantly accelerated during 2020, as relevant demonstrators will be installed and performed. By mid 2020, the TD3.5 is expected to be on schedule.

TD3.6: Dynamic Railway Information Management System (DRIMS) Demonstrator

The TD defines an innovative system for the management, processing and analysis of railway infrastructure data obtained from TD3.7 (Railway Integrated Measuring and Monitoring System (RIMMS) Demonstrator). The aim is to provide high-quality input to TD3.8 Intelligent Asset Management Strategies (IAMS).

TD Progress

During 2019 period, both the S2R project IN2SMART and the S2R project IN2DREAMS, ended. These projects have contributed to the related activities of the TD, paving the road to the next S2R project IN2SMART2.

Starting from the two main scenarios, one focused on long term maintenance and operation decision needs, the other focused on short term and day by day maintenance and operation decision needs, defined at the first stage of the TD work, several demonstrators have been developed, each related to one of the two scenarios. Various techniques of process mining, anomaly detection and predictive analytics have been applied to a set of use cases involving different aspects of railway assets (such as earthworks, bridges, track geometry, rail defects, S&C, track circuits and track equipment) and achieving TRL 4/5. The results obtained through these demonstrators provide solutions are:

- A set of anomaly detection system prototypes has been developed covering, for each specific use case, data acquisition and preprocessing, data-driven model development, validation and testing strategies. The study involved a wide variety of railway assets, from signalling wayside components (i.e. track circuits and switches) to railway track components (i.e. rails, fasteners and sleepers). The work done covered the analysis of complex phenomena such as the effects of assets degradation and malfunction in their electrical behaviour (this is the case of signalling assets), the interaction between the degradation of track geometry and other rail equipment, the interaction between the vehicles passage on the rail and the track status and the degradation of railway track earthworks. The effectiveness of intelligent data-driven models in all the use cases identified has been proved. More in details, both supervised and unsupervised scenarios have been identified (availability or absence of anomaly labels respectively) and many different techniques have been applied: from clustering-based techniques (e.g. K-Means, DBSCAN) and specific methods for anomaly detection (e.g. Isolation Forest, OCSVM) to classification-based techniques (e.g. KNN, Random Forest, SVM) and Neural Networks (e.g. CNN). Results achieved in each specific use case showed good overall performance demonstrating the applicability of data-driven models for the solution of the defined problems in the railway sector and the possibility of using these technologies in operative environments.
- Process mining: in order to face the lack of data related to process mining, which has been a common issue across all use cases, the aim of this year of work has been to provide recommendations to apply process mining to asset maintenance processes. The main conclusion is that in the railway asset management domain, process mining is currently not capable of providing high quality results yet, due to low quality of process-related event logs or the lack of them. In order to change this, the organizations need to implement changes in data gathering and its management. This imply additional costs and must be leveraged with the benefits that process mining can provide: process and planning enhancement in terms of time, costs and resources.
- A set of predictive modelling approaches has been implemented and tested. The study involved a wide variety of railway assets, contributing to different decision-making steps within asset management processes and managing properly the complexity related to the processing of heterogeneous data. Different techniques have been applied: ARIMA models to predict switches failures; Support Vector Regression models and Moving Average models to predict track circuits failures; Precipitation Compensation Algorithm to compensate for weather effects on track circuits reducing weather-related false alarms; bridges degradation and intervention costs predictions; Bayesian estimation with particle filter, SVM regression, Random Forest regression to predict track geometry degradations; Cox modelling and Breiman permutation to predict fasteners anomalies and the time between earthworks status changes; predictive model for rail defects; ANOVA models and Markov-based degradation models to predict earthworks degradations.

The results obtained will be the basis for the next demonstrators and improvements in order to achieve a higher TRL.

Two specific use cases have been chosen to validate the work in progress on the Integration Layer and on the Conceptual Data Model, building two successful prototypes the purpose of which is to transfer proprietary data to the end user through a standard data model :

- A prototype has been built to provide evidence of the data transfer from the proprietary format to CDM format and storing it in the Integration Layer. To validate this prototype the track circuits use case, related to anomaly detection and compensation for weather effects, has been used.
- A prototype focused on data modelling with the target to converge to a shared semantic for data to be exchanged. This prototype provides the foundation for a standardized data representation in the context of track circuits anomaly detection, having multiple data sources communicating information in a standardized way.

The prototypes have demonstrated different results regarding data model (through the usage of a CDM data model structure), data exchange formats (through the usage of JSON, XML and HDF5) and data message protocols (two open message protocols have been tested).

Aiming to improve the prediction accuracy and decrease the cost predictions, innovative work on the TD was done with the investigation definition of IT solutions (including a cloud-based open data management platform (ODM), that is used for data collection, aggregation and analysis, exploiting intelligent learning algorithms) and methodologies for advanced visual and rule-based data analytics (improving and facilitating the operators work in the exploration of the causes of the issues, generating knowledge through the interaction of the operator with the system).

Additionally, metrics for performance assessment applied to the predictive models have been defined, improving the prediction accuracy and identifying the more relevant parameters for predictions.

In addition, investigation was done in the field of IT solutions and methodologies for business-secure decision support in the field of data processing and analytics for railway asset management, studying the application of smart contracts in the railway ecosystems:

Research on Blockchain and Smart Contracts positively demonstrated a potential to support the digital transformation of processes by improving safety of the systems and bringing more transparency for operational improvement, in terms of cost, fraud reduction, and risk reduction. In this regard, a proof of concept has been developed in 2019, which leverages on both data and visual analytics technologies and Distributed Ledger Technologies (DLT) to better manage maintenance actions in the railways context. The proposed Proof Of Concept counts of three main modules: a module to handle the maintenance processes as reliable data source thanks to the Distributed Ledger Technologies, a module to predict the restoration time from maintenance operations, and a module to develop the visual analytics models for displaying the information to the operators coming both from the DLT and the data Analytic models.

TD3.6 Dynamic Railway Information Management System (DRIMS)								
2015	2016	2017	2018	2019	2020	2021	2022	...
		Finished: IN2SMART, IN2DREAMS				Ongoing: IN2SMART2		
						AWP 2020: OC		

During 2019, 11 deliverables were planned out of which 11 were released. TD3.6 has reported having accomplished 100% of the planned work up to the end 2019, which represent 50% of the overall TD.

TD3.7: Railway Integrated Measuring and Monitoring System (RIMMS) Demonstrator

The TD aims at providing innovative tools and techniques to capture information on the current status of infrastructure assets in a non-intrusive and fully integrated manner. To this end, the TD focuses on infrastructure asset status data collection in close interaction with TD3.1 Enhanced Switch & Crossing System Demonstrator and TD3.5. Proactive Bridge and Tunnel Assessment, Repair and Upgrade Demonstrator.

TD Progress

The contributing S2R projects to the progress in TD3.7 during 2019 were IN2SMART, MOMIT and ASSETS4RAIL.

Use cases based on Unmanned Aerial Vehicle (UAV) and robots have been performed based on real environment with TRL 3/4 level. The three robotics demonstrators and 3 UAV demonstrators provided insights concerning benefits and potential limits, and compared to Infrastructure Managers constraints and expectations:

- UAV demonstrators : catenary inspection, natural hazards and asset digitalization
- Robotics demonstrators : non-contact rail defect detection, continuous monitoring of Stress-Free-Temperature (SFT) and improved georeferencing
- Satellite technology : monitoring of ground movement, hydraulic activities, vegetation, civil structures

Results concluded on the following main benefits: closer inspection, useful to early identify anomalies; maintenance addressed on specific sites; increase of safety for maintenance personnel – no risk during inspection; time saving - quick surveys; cost effective (no need to disrupt train schedules). Potential limitations (to be addressed in further activities) were highlighted (especially for UAV): international and national rules for UAV flight (no permission to flight over specific areas); high cost to systematically cover an entire railways system; requirements regarding the integration of UAV and SAT technologies within maintenance practices and tools (CSM analysis to be performed at least); achievement of UAV campaigns depends on weather conditions.

Demonstrators enabled also to identify potential enhancement regarding the regulation, norms and standards. Two main groups of requirements have been proposed:

- Requirements related to the European UAV Regulation. The main issue relates on proposing and using, as a target, standard scenarios adapted to Railway industry. 3 standard scenarios are proposed and aim at facilitating the deployment of drones solutions for Maintenance and Asset Management,

- Requirements related to norms impacting SFT measurement. The main issue is to anticipate the conditions, and to adapt criteria and rules, for supporting the testing, validation and integration of new measurement approaches and tools.

The on-board prototypes for monitoring of track and switch and crossing systems have been finalized during the first part of 2018, refining parts such as monitoring sensors (mainly accelerometers), system architecture, data collection and data processing. The track monitoring system was installed in an in-service train and successfully tested at a maximum speed of 300km/h. Different algorithms for the analysis of monitoring data were developed and tested. The results are very satisfactory and comparable in terms of measurement results to the certified ones. The main advantage of the new system is the possibility to install it on operating trains, performing continuous monitoring and not only on specially equipped vehicles performing scheduled monitoring.

In order to monitor and measure the transversal position estimation of the wheel to rail, multi-criteria decision making (MCDM) analysis has been carried out to select the most suitable and rational technology. Different sensor solutions have been compared according to the defined criteria such as dimensions and weight, energy consumption, robustness, etc. Stereo camera and thermal imaging camera were selected as the most promising solutions for an experimental investigation - static laboratory tests has been performed for both technologies. The sensor housing has been developed to install the stereo camera sensor on a track geometry recording car and the field test has been performed for data collection. In 2020, the measurement data will be analysed to find out whether the selected sensor system is able to detect the variation of the wheel position on the rail. Investigation on thermal camera will continue as well in 2020.

In 2019, an architecture for a generic proxy framework that enables extracting data from signalling system has also been finalized with a defined concept to be applied on both legacy systems and in future signalling and telecoms systems. The defined architecture has been developed out of a comprehensive list of requirements agreed between all participating in TD3.7.

The conclusions from a hazard analysis include some specific recommendations to be considered when developing and applying a proxy framework to an in-use legacy system as well as mitigation suggestion for potential hazards.

A proof-of concept as a lab-demonstrator has been developed. The lab-demonstrator implements the proxy for gathering data from a train detection device, a light signal and a sensor. A common data model was designed and implemented in the lab demonstration so that all the data instances were transcoded in such a common data model.

Monitoring solutions for rolling stock impact on infrastructure have been developed and validated up to TRL 4-5 for several use cases, covering the four main work streams: rolling stock monitoring, wheel defects, vehicle weight and vehicle identification.

- 1) For the rolling stock monitoring a video solution based on a linear high resolution camera has been adapted with a focus on automatic measurement of some vehicle features, such as suspension spring height and brake shoe thickness.
- 2) For the wheel defects work stream the following solutions have been proposed: wheel flat detection both via 2 types of optical fibre sensors (one based on fibre Bragg Grating technology and the other on existing telecom fibre) and via new innovative vibrational acoustic sensors, a study of the representability of wheel defects through a single slice video monitoring (being this the solution normally used by many wheel geometry measurement systems).

- 3) For the vehicle weight work stream a solution based on a newly patented low cost sensor has been developed and validated mainly in laboratory and partially in field.
- 4) Finally for the vehicle identification use case two OCR (Optical Character Recognition) solutions have been compared first, one based on a commercial OCR software dedicated to rail applications and another based on open source OCR software, both using data captured by the linear camera of the rolling stocks measurement work stream (item 1 above). Then the RFID implementation in Sweden has been described and validated in terms of accuracy and miss hits in a period of 6 months.

In addition, starting from a study of the state of the art, the TD has defined and prototyped a Wayside Monitoring system based on machine vision to detect different defects and perform measurements on the rolling stocks such as wheel profile, wheel surface damages, suspension failures and mechanic failures of brake systems. The checks to be performed have been prioritized through a FMECA analysis and aligned within TD3.7 community, validation activities to be continued in 2020.

TD3.7 Railway Integrated Measuring and Monitoring System (RIMMS)								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: In2Rail, IN2SMART, MOMIT					Ongoing: IN2SMART2, Assets4Rail			

During 2019, 43 deliverables were planned out of which 40 were released. Further progress is expected during 2020 from both Assets4Rail and IN2SMART2 projects. TD3.7 has reported having accomplished 90% of the planned work up to the end 2019, which represent 50% of the overall TD, resulting in an overall good progress.

TD3.8: Intelligent Asset Management Strategies (IAMS)

The vision of the TD is a holistic, whole-system approach of asset management employing collected and processed infrastructure data provided by TD3.7 Railway Integrated Measuring and Monitoring System (RIMMS) Demonstrator and TD3.6 Dynamic Railway Information Management System (DRIMS) Demonstrator. This includes translating long-term strategies into day-to-day execution of the maintenance and other short term maintenance activities. It also includes new and advanced working methods, tools and equipment and logistics solutions, supporting the LEAN execution of intelligent maintenance processes.

TD Progress

Following the work already achieved by the TD through IN2RAIL in the fields of State of Play and Risk and Asset Management based Strategy, the TD3.8 also aimed in IN2SMART at investigating intelligent asset management and execution strategies as well as new advanced working methods, tools and equipment, logistics solutions, supporting the LEAN execution of maintenance processes.

Work was undertaken in the development of the prototypes of a LEAN inspection and tamping process, which avoids pre-measurements. The “direct” use of inspection data to determine the work of the tamping machines is the key innovation. The result of this progress in TD3.8 was the successful deployment and presentation of the TD3.8 demonstrator ‘Lean Tamping’ as a S2R quick-win demonstration at InnoTrans (See report 2018).

Work during 2019 focused on the further elaboration and analysis of use cases for IAMS process which aim to accompany the design of the generic framework. A number of use cases have been addressed, covering a broad range of planning problems in Asset Management. The following relevant use cases may be mentioned in this context:

- The TD worked on representing uncertainties in whole lifecycle cost models supporting the medium to long-term planning of asset interventions on the railway infrastructure. The prototype model created in this use case allows option selection using distributions of costs rather than point estimates. The additional information on the cost uncertainties will help users make better decisions and mitigate the risk of incurring higher costs. The use case is developed to a point where it can be picked up and published or further developed by IMs.
- A use case about earthworks. The overall objective of this study is to improve different aspects of the earthworks (EWs) maintenance process by applying carefully selected data mining techniques, and to use the information extracted from them to build an Intelligent Asset Management System (IAMS) at the strategic level. Work included the development of a strategic IAMS model based on Petri Nets to investigate optimal intervention schemes so as to offset the effect of earthworks degradation under budget and resource constraints. The result is a model based on strategic KPIs (Intervention volumes, Costs, Health of the infrastructure). The model has been validated and has improved capabilities: Asset tracking, Improved granularity, Higher versatility related to factors such as examinations, restrictions or degradation paths.
- A use case for planning maintenance tasks. Knowing the status of assets is only a first step. For efficient maintenance operation it is necessary to utilize the asset status and to assess the risk that other assets, not included in the foreseen annual work plan, might fail before the next opportunity and make the decision to add extra work. In this way, the reliability will increase, and avoidable disruptions will be prevented. The main objective of the use case was to reduce the track working time while maintaining the network quality at a certain level. Therefore, the new planning approach focuses on the systematic usage of combination possibilities of interventions to ensure a reduction of transition times. Furthermore, the duration of an intervention was included via a distribution function which enables the IM to quantify the robustness of the computed plan. The use case results build a very promising foundation for further developments.
- The development of technologies for enhanced maintenance execution through two core tasks: Integrated inspection and tamping process (see above) and Robotic Maintenance Execution. The objective of Robotic Maintenance Execution is to develop the prototype of an Autonomous Rail Vehicle to enable automated robotic Inspection and Maintenance. A modular design with open system architecture, plug-and-play interchangeable robotic tool and equipment sets will enable the vehicle to be deployed for multiple intelligent inspection and maintenance activities. The physical concept demonstrator built in 2019 is currently capable of performing the following 4 operations: Autonomous fault search, Simulated repair with a robot mounted effector, Communication with a remote user, Recovery to base. The physical concept demonstrator has a precision of approx. +/- 5mm in terms of vehicle positioning and simulated repair. The software-in-the-loop demonstration used ROS (Robotic Operating System) to simulate a real road-rail vehicle (Unimog U400), mounted with a real robot arm (ABB IRB6640) with nominal real sensors (Hokuyo UTM-30LX), travelling on a stretch of plain line single track railway.

TD3.8 Intelligent Asset Management Strategies (IAMS)								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: In2Rail, IN2SMART					Ongoing: IN2SMART2			
						AWP 2020: OC		

During 2019, all the ongoing work as defined in the project In2Smart has been completed. All related deliverables which had been scheduled were released. Further progress is expected during 2020 and following years in the project In2Smart II and the OC for 2020 S2R-OC-IP3-03-2020: Advanced tools and equipment: collaborative robots & wearable mobile machines (TD3.8)

During 2019, 5 deliverables were planned out of which 5 were released. TD3.8 has reported having accomplished 100% of the planned work up to the end 2019, which represent 50% of the overall TD.

TD3.9: Smart Power Supply Demonstrator

The global objective of the Smart Power Supply Demonstrator (TD3.9) is to develop a railway power grid in an overall interconnected and communicating system. This will enable improvements and optimizations regarding train traffic capacity, energy losses and costs, energy supply security and availability for the railway system and environmental impact.

TD Progress

In 2019, the TD1.9 builds on the progress made by IN2STEMPO that has successfully exploited the work of In2Rail.

The TD delivered the basic design as well as the hardware and network structure specifications of the Smart Control demonstrator to pave the way to the upgrading of the station control systems within 16,7 Hz railway networks, introducing IEC 61850 and process bus. The planned demonstrator on a transportable switchgear panel was almost ready for manufacturing at the end of 2019 and associated hardware components have been selected according to the specifications in order to complete the installation and T&C of the demonstrator in a 16,7 Hz substation in 2020 .

In regards to the second TD demonstrator (proof of concept for Flexibles-AC-Transmission-System – FACTS – in 50 Hz railway systems) public feeding grid interface specifications has been defined and an evaluation of the new 50Hz AC Smart Power Supply based on substations parallel feeding and FACTS equipment's have been conducted in 2019. Based on this output, the specifications for the FACTS equipment and the control/protection solutions has been delivered.

A simulator for Smart AC traction power system to check the usability of all simulated components and test the interaction of the different elements and components of the demonstrator have been created and first tests occurred, validating the feasibility of balancer and reactive power control systems in a railway substation to improve the power quality.

TD3.9 Smart Power Supply								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: In2Rail				Ongoing: IN2STEMPO, FUNDRES				

During 2019, no deliverable were planned. TD3.9 has reported having accomplished 100% of the planned work up to the end 2019, which represent 50% of the overall TD.

TD3.10: Smart Metering for Railway Distributed Energy Resource Management System Demonstrator

The objective of the Smart Metering Demonstrator (TD3.10) is to achieve a fine mapping of energy flows within the entire railway system, as a basis of any energy management strategy.

TD Progress

TD3.10 builds on the progress made by the IN2DREAMS project and ongoing action IN2STEMPO.

In 2019, TD3.10 provided an energy metering service (demonstrated in an operational environment) through a dynamically reconfigurable platform offering improved reliability, ease of monitoring and on-the-fly optimisation for the entire railway system. This includes a heterogeneous secure and resilient telecommunication platform comprising both wireless and wireline technologies converging energy and telecom services. This infrastructure interconnects a plethora of monitoring devices and end-users to the railway control centre and includes an ODM (Open Data Management) platform for data collection, aggregation and analysis, able to scale with the railway operators' needs. This platform is non-intrusive exploiting advanced signal processing and intelligent learning algorithms.

One of the exploited application aims at identifying the optimal driving styles in terms of energy efficiency of an operational tramway system. To achieve this, the data management platform has been deployed enabling collection and monitoring of energy, kinematic and environmental parameters. Preliminary results indicate that the proposed approach can reduce the energy consumption in railway systems by 10%.

The sensors, data collection and transmission devices as well as the data storage and applications, such as energy prediction models were successfully implemented in 2019 in two Use Cases of the Smart Metering Concept as defined in the MAAP:

1. The Commercially Operated line (CO-OP) Use Case on a line in commercial operation south of London.
2. The Stationing and Maintenance facilities operation (STM-OP) Use Case in the Saragossa tramway depot.

In the CO-OP Use Case two DC substations are live monitored, namely Bletchingley Tunnel and Chiddingstone, as well as a 22 kV AC junction, namely Crowhurst Junction. The current and voltage sensors are transmitting synchronised measurements to a cloud database for power and energy patterns analysis.

In the STM-OP Use Case the Saragossa tramway traction substation and low voltage cabinets were instrumented to send energy measurements. A complementary environmental set of sensors (anemometer, light radiation, temperature and humidity) are sending data in order to establish correlations with energy consumption.

Installation activities occurred for both Use cases and preliminary conclusions on the analysis and exploitation of the measurements will occur early 2020.

TD3.10 Smart Metering for Railway Distributed Energy Resource Management System								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: In2Rail, In2Dreams					Ongoing: IN2STEMPO			

During 2019, 7 deliverables were planned out of which 7 were released. TD3.10 has reported having accomplished 100% of the planned work up to the end 2019, which represent 40% of the overall TD.

TD3.11: Future Stations

The primary objective of the TD is improved customer experience at stations increasing thus the number of customers that will use rail as their preferred transport mode. The TD is organised around four identified key functional demands; two demands relate to improving capacity, safety and security in large stations, one demand relates to the design of small stations with the objective of reducing whole life costs and standardising design where possible and the final demand relates to platform to train accessibility.

TD Progress

TD3.11 builds on the progress made by the FAIR STATIONS project and ongoing action IN2STEMPO.

TD3.11 has conducted in 2019 PRM socio-technical studies (focus group discussion, observational trips, PRM questionnaires and stakeholder questionnaires) and the main conclusions are:

- The most cardinal design factors are information & signage, safety, HFE & accessibility and PTL.
- PRMs feel that design for accessibility is not done with all PRMs groups in mind.
- The most highly impacted PRM groups are wheelchair users and the blind.
- Crowd flow was identified as an overarching concern, particularly during peak times.
- PRMs are more likely to need help in the station than boarding even less when alighting.
- Most stakeholders would be supportive in the implementation of station designs that promote accessibility.

A survey of over 5000 general public users revealed that about 51% of them had mobility impairment and would therefore be classified as PRMs.

Regarding crowd management, several technologies have been evaluated to identify the ones that can provide valuable improvements in system efficiency and reliability. The most significant improvement is enabled by two completely different innovations:

- Deep Learning based video processing algorithms, able to detect people and count them autonomously after a proper training phase.
- Three dimensional cameras that, exploiting the depth information (i.e. the distance of a point from the camera) can detect the presence of people in a more reliable way.

The combination of these technologies in a unique system represents a significant improvement for the crowd monitoring and management. Additionally, a crowd flow model that includes persons with reduced mobility has been developed, implementing the specificity of PRM.

Concerning crowd Management in High Capacity Stations the definition of 4 use cases was finalized: infrastructure design, training, what-if (testing solutions for operators) and forecast (warn operators in advance). Concerning integration and real experimentation, first implementation of the use case Operator training has started. This use case places the station operator in a virtual environment in which he can be trained to react to possible crowd incidents. A global environment that connects a control centre, equipment as well as synthetic video wall is built.

Concerning “Improved Station Designs and Components” the preparation of the Functional and Utility Program for the Demonstrator Platform Jurata Station in the north of Poland has been completed. Also an overview report on IT2Rail (IP4) was prepared to develop synergy on new ticketing systems, a technical solution for Train Passenger Occupation system has been finished (pilot action) and an analysis of existing ticketing technologies and development plans was prepared.

Three conceptual designs of PTI Gap filler were developed in 2019 and a prototype has been built to validate in laboratory the best evaluated solution. The developed PTI gap filler is applicable for different type of vehicles (with narrower door with steps or wider door without steps) and can compensate horizontal and vertical gaps for all types of platforms. The sensor system incorporates quick positioning of the boarding mechanism without jeopardizing safety. A LiDAR sensor detects the train and the door position. The control system then applies sensor-based collision detection for deployment of the extendable blade that closes the PTI gap.

The main benefits of the automated boarding system are:

- Fully automated, efficient deployment.
- Reduces train dwell time.
- Improves PTI safety.
- Universal solution for the general public and PRMs

TD3.11 Future Stations								
2015	2016	2017	2018	2019	2020	2021	2022	...
			Finished: FAIR Stations					
			Ongoing: In2Stempo					

During 2019, 12 deliverables were planned out of which 5 were released. TD3.11 has reported having accomplished 92% of the planned work up to the end 2019, which represent 40% of the overall TD.

1.7.4. IP4 IT Solutions for Attractive Railways Services

In order to become more attractive, rail must respond to customer needs to support seamless door-to-door multimodal journeys encompassing different modes of transport. Rail must achieve interoperability with other transport modes and mobility services, within different regions, cities and across borders. In order to achieve this, rail needs to take due advantage of the ever growing connectivity of people and objects, the availability of European Global Navigation Satellite System (GNSS) based location and other means of localisation, the advances in cloud computing, Open Data and Big Data Analytics and the wide dissemination of Internet and social media. Multimodal integration will also take benefit from existing rail standards as FSM and TAP TSI.

The pictures below gives a visual perception on where IP4 Technological Demonstrators will introduce improvements.

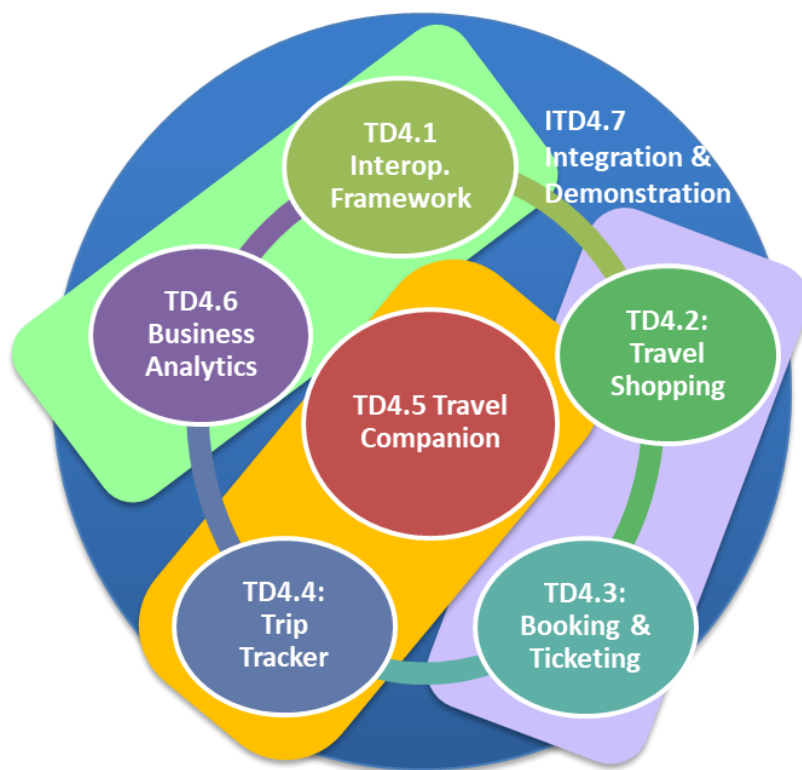


To achieve this the IP4 ecosystem aims to integrate and make interoperable all possible transport modes and travel services: rail, urban transport (metro, tram, and buses), airlines, private cars (such as the use of toll roads and parking, which have an associated price) and also shared modes (cars and bikes). Thus, multimodality and the use of public transport are being fostered, making it easier for travellers to connect with rail stations and airports, regardless of where and how they start their journey. For the future, Demand Responsive Transport and Ride Sharing will be included in the ecosystem to ease the access to everyone to long distance trips, even to those living in not well connected areas.

IP4 Ecosystem has also evolved to implement at European Level the new Mobility-as-a-Service (MaaS) paradigm, which considers the mobility system as a whole in order to achieve an optimal and sustainable transport scheme. This way, the IP4 ecosystems facilitates the task to create formal contracts that could involve the agreements, business rules and financial compensation that shall occur between the different stakeholders when combining their services into a joint product. In the future, this component will evolve to be used also to create MaaS Packages that integrate a variety of transport services that could include multiple Transport Service Providers.

IP4 is organised around 7 Technological Demonstratos within three priority research and innovation areas as shown in the graph below.

- Technical Framework: Interoperability Framework and Business Analytics
- Multimodal Travel Services: Travel Shopping and Booking and Ticketing
- Customer Experience Applications: Travel Companion and Trip Tracker



IP4 projects are contributing to develop innovations in each TD. All the outcomes of IP4 project will contribute to one single Integrated Technological Demonstrator (iT4.7), which will merge all the developments.

TD 4.1 Interoperability Framework

The aim of the TD is to facilitate multimodal travel in a highly diverse environment and with many transport modes. Interoperability at the semantic level defines formal and explicit models of the transportation domain in an open, standard, machine-readable language that is exchanged automatically by computers, therefore allowing seamless access to all transport data and services in a multimodal and distributed environment. Hence, TD 4.1 is a key technology enabler for a complete transformation of the European transportation ecosystem.

TD Progress

The TD covers different aspects of the Interoperability Framework, including the implementation of components with basic capabilities, definition of architectural principles, analysis of the state of the art with respect to ontology conversion tools and reference ontology, and the understanding of current and future demand for the Interoperability Framework.

In 2019, the work continued in all these aspects within 2 projects: CONNECTIVE and SPRINT. One of the main achievements for the period consists of the integration of the orchestrators deployed in ATTRACTIVE and Co-Active with the available Travel Service Providers (TSPs). The integration of the different TSPs into the IP4 ecosystem and the connection with the software developed by other IP4 projects, has allowed the IP4 platform to demonstrate end to end functionalities, and to achieve at IP level the first software release, (ALPHA RELEASE). Thanks to CONNECTIVE project, at least 7 different TSPs (Travel Service Providers) have been integrated (demo environments), covering four European

countries and several modes including train, metro, bus and plane, but also private modes along with shared cars and bicycle providers. New services and capabilities, which had not been demonstrated in past projects, have also been integrated. This includes after sales and ancillary services. TD 4.1 has also worked closely in alignment with the Open Calls Shift2MaaS and My-Trac in order to integrate the TSPs proposed in this project, such as EMT Málaga, into the IP4 ecosystem.

To achieve those results, the TD4.1 has also worked towards the enhancement of the **IP4 ontology**, guiding other projects to contribute to the review of the existing ontology based on their needs and new capabilities identified. New types of components have also been deployed, such as the ASP which shields orchestrators from the complexity of the IF and the various conversions. Furthermore, a conversion has been provided, based on ontologies, to interoperate with TRIAS format or possible future EN version. Thus, the TD contributed to the S2R standardisation roadmap development plan.

It is particularly important for this TD to provide mechanisms which allow TSPs to **register in the IP4 ecosystem**, making their services available to the various IP4 components, and leading in this way towards the creation of multimodal solutions. With this objective, an evolution of the existing Asset Manager has been designed and is being implemented, which aims at simplifying the process of joining the ecosystem and managing the existing assets that are needed for conversions, to interact with TSP interfaces etc. Moreover, TD4.1 has designed the **Operator Portal**. The Operator portal will be the software interface which will act as the front end for Travel Services Provider. It will provide the access point for TSPs to join the ecosystem. The designed Operator Portal will provide the following functionalities:

- Registration of a TSP to interact with the IP4 Ecosystem. This functionality will interact with the developed Asset Manager Software.
- The Contractual Management Market Place deployed in TD4.2
- The Transactions screen developed in TD4.3.

During this year, the main functionalities have been designed, and technologies were selected for the front and backend. Moreover, Identity Management and Access Management through single sign-on has been provided.

The components used, which follow IT2RAIL results, have been migrated to new technologies and architecture in order to provide more flexibility and better performance as well as to facilitate their creation and the integration of new TSPs. The re-design of some components such as the RDF Repository and the Travel Expert Resolver has also started, and will be completed and implemented in next period, with the objective of enhancing the existing capabilities of those components:

- In the case of the RDF repository, an additional component has been deployed that allows to load easily GTFS data from TSPs in the repository.
- In the case of the enhancement of the Travel Expert Resolver, that previously only worked with the shopping functionality, has been improved in order to operate with other travel functionalities such as trip tracking, for example, allowing a more flexible architecture.

Additional activities have also been performed which aim to continue evolving the IF in the future and to assure scalability in real environments. The first results of these activities include the establishment of the basis of an automated process to compose converters according to the information published on the Asset Manager, as well as an initial draft of a reference architecture for the IF and scalability and testing infrastructure. The design of additional tools for collaborative ontology editing, mappings suggerer (to facilitate the mapping among TSP interfaces and IP4 ontologies) and assets lifecycle management have started this year, and will continue in the next period. While the solutions are not

fully ready and still require additional work towards optimal performance and scalable solutions – which is in particular valid for the integration of TSPs which still requires significant manual work - it is important to highlight the relevance of integrating gradually new TSPs to start demonstrating the functionalities and advantages of the system on the one hand, and the importance of the IF within the IP4 ecosystem on the other.

TD 4.1 Interoperability Framework								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: IT2RAIL, GOF4R, ST4RT				Ongoing: CONNECTIVE, SPRINT, RIDE2RAIL			AWP 2020: CFM	

During 2019, 15 deliverables were planned in relation to the IF in the active projects. Fourteen of them were released as expected, and the last one, which is related to the Additional Release, will be issued in the first weeks of 2020. Since the beginning, TD4.1 has accomplished 90% of the planned work up to the end 2019, which represents approximately 40% of the overall TD objectives.

TD 4.2 Travel Shopping

The concept of TD 4.2 Travel Shopping is both to enable, and to respond to an emerging single European multimodal transport market place within a Single European Transport Area (SETA). The IP4 approach will promote the integration of distributed travel operators' data and services and the orchestration of services such as expert journey planning and offer building for all modes. It will benefit from the Interoperability Framework that enables applications based upon different interfaces, standards or coding lists, to communicate meaningfully but without costly application adaptations with the existing legacy systems of all stakeholders.

TD Progress

The TD4.2 contribution to IP4 System is to enhance the technical facilitation of a one-stop-shop capability, to enable comprehensive choice of itineraries and offers from modes/operators able to respond to customer mobility requests, especially through the use of existing services from all stakeholders by interfacing their legacy systems.

The basic idea of the travel shopping system was designed within IT2Rail (Lighthouse Project) using a distributed architecture. This decentralized approach was enhanced within the project Co-Active, which was successfully finalised in 2019. Co-Active's final event was held in November 2019 in Brussels. The main technical outcomes of this project regarding TD4.2 are:

- Differentiating of Journey Planning and Offer Building;
- Establishing journey validation methods;
- Definition and handling of cross-TSP business rules;
- Adding new modes for personnel transport, like private car, bike and car sharing;
- Handling of first failure cases.

After a detailed specification phase in 2017 and a first implementation of a pilot for the InnoTrans2018, the objective of Travel Shopping in 2019 was to enhance the InnoTrans pilot by the aforementioned in order to meet the objectives of the COHESIVE alpha release.

The milestones 'Co-Active finalization' and 'COHESIVE alpha release' has been reached in 2019. The first one was the development of the final release (FREL) in May. The second milestone was the full integration of all Co-Active's developments into the S2R IP4 Ecosystem.

RIDE2RAIL project also started in November 2019: it will enhance the functionalities of TD4.2 by promoting an effective Ride Sharing practice of citizens, making it a complementary transport mode that extends public transport and rail networks. The RIDE2RAIL framework for intelligent mobility will integrate and harmonise realtime and diverse information about rail, public transport, ride-sharing and crowdsourcing in a social ecosystem, which will allow users to compare and choose between multiple options/services classified by a set of criteria – including environmental impact, travel time, comfort, cost – according to their needs.

TD4.2 Travel Shopping								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: IT2RAIL, Co-Active					Ongoing: MaaSive, RIDE2RAIL			
					AWP 2020: CFM			

During 2019, five deliverables out of three were finalised. The two remaining deliverables are slightly delayed and will be delivered in the beginning of 2020.

Since the beginning, TD4.2 has accomplished 85% of the planned work up to the end 2019, which represent 80% of the overall TD.

TD 4.3 Booking & Ticketing

Today, even within a given mode of transport (air, rail, urban, etc.), the rights to travel have, in the best case, a limited interoperability between the various travel service operators; and this interoperability is almost non-existent between the modes themselves. The aim of this TD is to orchestrate multiple but parallel interactions with several booking, issuing, payment and ticketing engines, including the all-important roll-back activities. This will radically simplify the traveller's life, by abolishing uncertainties and complexities associated with 'behind-the-scenes' multiple booking, issuing, payment and ticketing processes.

TD Progress

During 2019, and within the scope of the project Co-Active which is now finalized, TD4.3 focused its efforts on completing the implementation and integration of all components with other IP4 TDs and within the overall ALPHA RELEASE demonstration. TD4.3 follows a number of releases established at IP4 level, which were aimed at demonstrating gradually the functionalities being deployed. This means that the results achieved so far are able to be demonstrated within a specific scope, but are not yet a final version ready for a market uptake, as new functionalities, modes of transport (such as transport

on demand) and paradigms (such as MaaS) are expected to be introduced in each new project and release until the end of Shift2Rail.

On one hand, orchestrators are one of the main components developed to allow parallel calls (through the Interoperability Framework) to the different Travel Service Providers (TSP) involved in a multimodal service. Moreover, the orchestrators apply the needed logic to integrate this information. The orchestrators that have been created and integrated in Co-Active provide capabilities for multimodal booking, ticketing, ancillary services (i.e. lunch, WiFi) and for after sales services (cancellation, refund). Special component has been finalized in this period, in order to support re-accommodation process, which validates if the entitlement is still valid in the new alternative scenario, or it has to be cancelled and issued again.

It is worth mentioning that the orchestrators have been built taking into consideration different transport modes requirements, not only public transport and rail, but also air and private modes (such as parking and toll). Within MaaSive, as a continuation of these activities, new capabilities and flows affecting those orchestrators have been identified during this period, for example to allow purchasing Ancillary services at any moment (currently only available at booking time), and also new orchestrators and components related to the future provision of Mobility as a Service capabilities.

Also, during the year, the activities have been finalized in relation to issuing, clearing and settlement capabilities, allowing not only the generation of the entitlements and tokens needed for each trip segment, but also the distribution of the corresponding payments to each TSP. The “visual” part of it, that allows TSPs to see all the issuing transactions and status of clearing payments, has been improved in the last period, and a new functionality has been implemented. The latter allows to create and download personalized reports summarizing all the clearing transactions associated to each TSP. These functionalities are accessible to TSPs, once registered and logged in in the Operator Portal (provided by TD4.1), together with CMMP capabilities (deployed in TD4.2).

These activities have been complemented by the analysis of business and contractual management aspects, which in 2019 focused on the formalization inside the IP4 specifications of contractual B2B rules that govern the business relationship between the transportation partners. The study was extended to include B2G considering legal aspects at European level. The impacts analysed include, for the funding by public bodies, requirements on financial processing and especially revenue management when part of the revenue shall be settled to agencies (e.g. operator delivering a service under a gross contract) or be settled to financing bodies (e.g. case of PPP, either DBFO or BOO). However, most of the analysed impacts are related to regulations established at different levels (European, national). These include the protection of passenger rights (such as right to non-discrimination, right to mobility, right to information, right to raise complaints etc), the regulation of the competition, the ITS directives that establish requirement on technologies, the code of conduct (COC)¹⁷ between business players, the management of taxes, and the protection of end-user privacy, among others.

Most of the Co-Active outcomes of this year have been demonstrated as part of the final integration and results in the ALPHA RELEASE demo organized in November 2019. The former have also been the

¹⁷ (EC) No 80/2009 of the European Parliament and of the Council of 14 January 2009 on a Code of Conduct for computerised reservation systems and repealing Council Regulation (EEC) No 2299/89

Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport Text with EEA relevance

starting point of the MaaSive activities that have been progressing in 2019, with special focus on improving the orchestration, the validation and inspection capabilities, as well as on the initial design of Customer Relationship Management (CRM) capabilities non-existent in previous projects.

TD4.3 Booking and Ticketing								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: IT2RAIL, Co-Active					Ongoing: MaaSive, RIDE2RAIL			
						AWP 2020: CFM		

During 2019, out of eight deliverables six have been provided. The two additional deliverables, which have not been finalized yet, will be delivered in 2020.

Since the beginning, TD4.3 has accomplished 80% of the planned work up to the end 2019, which represents approximately 75% of the overall TD.

TD 4.4 Trip Tracker

The Trip Tracker will assist a traveller throughout his multimodal journey with technologies, which accurately and timely notify travellers of any unforeseen difficulties on their individual trip, and providing alternative routes to limit impacts of delays. When a disruption occurs, this TD will provide assistance by calculating with a multimodal approach both whole new itineraries door to door, and from the current position or even only single legs. Trip Tracker will analyse and correlate available static data (such as timetables, topologies), dynamic data (such as road traffic data, transport real time data, operational feeds, social networks) and passengers' data (such as preferences, itinerary, locations).

TD Progress

The basic idea of a trip tracking system was designed within IT2RAIL (LP) comprising the activation, disruption detection and alternative managing of an itinerary. Shift2Rail IP projects expanded the architecture of this trip tracking system to a modular one consisting of the Tracking Orchestrator, different partial Trip Trackers and the corresponding Event Source Management. Results were demonstrated through an intermediate Quick Win Release on the InnoTrans 2018.

Main attention for 2019 was the development of the final release of the ATTRACKTIVE project the output of which contributes to the Alpha release in COHESIVE project. All planned partial Trip Tracker and additional functionalities have been developed and connected to the Tracking Orchestrator. This version has been demonstrated in the Final Event and Final Review of the ATTRACKTIVE project that took place in November in Brussels. This event was as well an important milestone for the Alpha Release of Cohesive. It provided for an important platform to disseminate the results and to get in contact with potential future users and partners. In addition to this event, dissemination and communication activities have taken place organised by each partner individually.

To demonstrate how powerful the chosen architecture is, several partial Trip Tracker based on different data bases have been developed and connected to the Tracking Orchestrator:

- SIRI SX specifies a European data interface standard for exchanging information about the planned, current or projected performance of real-time public transport operations between different computer systems.
- GTFS-RT defines a common format used by many international companies. It is agreed between the sector companies and managed by Google.
- GTFS Static Data standard relies on flat text files, containing the descriptions of the transportation network elements and is widely used.
- VDV based data is based on the VDV 454 interface, a German standard defined by the association of German public transport organisation.
- Mobile Device: In this case the mobile itself is used to provide Trip Tracking assistance even if the TSP for a specific segment does not provide real time Events
- Prognosis: Out of big data analysis predicted events are generated which are forwarded through an GTFS-RT based partial Trip Tracker

It should be noted that the testing of a system based on real time data is of special challenge. It was therefore decided to develop a special partial Trip Tracker called “disruption pTT”. This partial Trip Tracker enables through a Web User Interface the setting of individual delays, disruptions/cancelations or platform changes respectively for each segment of a trip. The activation of this “real time data” can be direct after data is entered for a segment or postponed to enable parallel obstacles for several affected segments. On this basis, it is possible to test the Complex Event Processing in detail.

As a result, it was possible to prove that the Complex Event Processing of the Tracking Orchestrator works properly. Some of the results are:

- Delays with no effects for the whole trip are not displayed (delay too short or at the end of a trip)
- Delays/disruptions with effect for the trip is forwarded as push notification to the traveller
- All platform changes are forwarded to the traveller (except for a change in the final station).

As a side effect of this dPTT it can be checked if a shopped trip itself shows the expected modes and segments.

Finally, an Alternative Manager software module has been developed. This specific module, will try to find an alternative route by calling the Travel Shopper developed by the project Co-Active. Such a new route is then also checked by the Trip Tracking System as to ensure that this is a valid one. The reason for this additional check is that the real time information the Trip Tracker is relying on may be newer than that of the Travel Shopper ones. The overall performance is quite high due to in parallel working pTTs and the high performance of the Complex Event Processing which is the same as the one generally used for the Trip Tracking system.

To gain an even more flexible architecture, it is planned to integrate the Interoperability Framework between the Tracking Orchestrator and the partial Trip Tracker as well as between the pTT and the Event Sources. This enables an easy integration of new pTT and/or Event Source. Within 2019 a first architectural design was discussed.

Among others, the aim is to perform the integration of the partial Trip Tracker developed in the project My-Trac into the overall S2R Trip Tracking system, adding new mechanisms to track a journey, based on the collection, elaboration and integration of real time and historical data from diverse sources.

This activity has been started in 2018 and well proceeded in 2019 with the goal to have a common demonstration on the InnoTrans 2020.

TD4.4 Trip Tracker								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: IT2RAIL, ATTRACKTIVE								
		Ongoing: My-TRAC, MaaSive, RIDE2RAIL						
					AWP 2020: CFM			

Regarding the progress, four projects have contributed to the development of TD4.4 during 2019: Connective (through the connection with the IF), ATTRACKTIVE, Co-Active and My-TRAC. All deliverables have been finalised and delivered in 2019. The overall progress is in line with the plan in the S2R MAAP.

The Open Call My-TRAC started in September 2017 and is slightly delayed. The reason is that extra work than expected has to be done to comply with European GDPR; this is important for trip tracker functionalities as well.

The Trip Tracker Demonstrator targets TRL 6/7. Since the beginning, TD4.4 has accomplished 90% of the planned work up to the end 2019, which represent 70% of the overall TD.

TD 4.5 Travel Companion

The overall objective of the TD 4.5 Travel Companion is to research, implement and evaluate a seamless and interoperable platform offering new levels of interaction between travellers and transport stakeholders along with an innovative ubiquitous adaptive front-end to the global transportation service ecosystem.

Thanks to their own personal and secured 'Travel Companion' travellers will have access to all travel services needed for the journey (shopping, booking, ticketing, trip tracking, preferences, cancellation, ancillary services as well as novel forms of experiences) which will extend and transform the journey to a real door to door experience.

TD Progress

During 2019, the main progress consisted of the finalization of getting access through the travel companion to all functionalities required for the Final Release and was planned within the ATTRACKTIVE project. This work is based on the achievement and the integration of the different modules developed by all the partners.

During the third period, an intermediate solution (Quick Win) was developed to be demonstrated on the InnoTrans 2018, this version was based on manual indoor positioning. In 2019 vision based positioning of the traveller has been added. Update of in-station experiences has been done using the Location-Based Experience Editor to handle this new way of localisation and improve the results obtained during the last period.

In 2019, the Location-Based Experience Editor has been finalized to facilitate the creation of Location-Based Experiences by non-computer specialized user.

In addition, the positioning and guidance functionality has been developed and tested. Three main topics have been treated.

- Logical position: gives traveller information about their current location according to planned data (Stops to the next destination, minutes to get to the platform, etc.)
- Physical position indoor and outdoor: In contrast to logical position, the physical position gives the real location. Outdoors is done naturally by GPS signal showing the position in Google Maps. In contrast to outdoor positioning, GPS does not work indoors. Several solutions are available in the market. All of them need to create a model of the station that will be used further. For technical, performance and low maintenance effort reasons it was decided to use the system from NavVis. The corresponding model in this case is based on laser-measured data with simultaneously shot pictures in all three directions of a building. This solution is ready for productive and industrial usage.
- Guidance: Guidance on a trip has been tested with the following information provided: final station, start station and intermediate station. Guidance information outdoors can be displayed on the smart device display and on a smart watch. At the moment, it is limited to the smart watch.

Two other modules have been also finalized during this period, the token management and the payment module. These modules enable the user to fulfil the complete issuing flow, which means that the user now is able to use his/her credit card (functionality integrated through Google Pay; needs real credit cards but for the moment payment is simulated) and if the payment is successful, the user will be able to visualize the tokens for the available segments of the trip. The user will be able to see and use for validations those tokens in format 2D at any time during the trip.

In the same way, the Cloud Wallet software module has been finalized. All required services have been developed. This functionality will allow the components of the IP4 platform to identify and manage the users profile and data. The cloud wallet includes data bases to store all information related to the users (user info, managed trips, user preferences etc.). This will allow the platform to tailor the offered travellers to the user preferences, for example.

In addition, particular attention was paid to carrying out tests in order to be able to deliver a functional version of the application, which is the Alpha release in COHESIVE project. This version was demonstrated in the Final Event and Final Review of the ATTRACKTIVE project during November 2019 in Brussels.

Specific synergies between IP3 and IP4 have been identified for the Travel companion in 2019 and will be elaborated in the future.

My-TRAC has focussed during 2019 on the implementation of the first version of the mobile App, which can be found in Google Play under My-TRAC keywords, and on the execution of the pilots in the four sites provided by the project: the Netherlands, Lisbon, Athens and Barcelona. With the data gathered through this first version of the pilots, it will be possible to improve the models used to tailor the recommendations to the users during the second phase of the pilot which is foreseen to take place between April and June 2020.

TD4.5 Travel Companion								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: IT2RAIL, ATTRACKTIVE					Ongoing: My-TRAC, MaaSive, RIDE2RAIL			
						AWP 2020: CFM		

During 2019, seven deliverables were planned for TD5 and all of them have been released. Regarding the progress, four projects have contributed to the development of TD4.5 during 2019: ATTRACKTIVE, MaaSive, My-TRAC and COHESIVE. Since the beginning, TD4.5 has accomplished 90% of the planned work up to the end 2019, which represent 80% of the overall TD.

TD 4.6 Business Analytics

The TD will provide a common business intelligence foundation for all products and services transport providers based on the access to open-ended web of transportation data offered by the Interoperability Framework (TD4.1).

Based on descriptive, predictive and prescriptive analytics using multimodal data sets generated by the services developed in IP4, the TD will help the passenger carriers to better adapt their level of service to the passengers demand and to optimize their operations. TD4.6 will also provide interactive and dynamic visualization capabilities.

Data privacy is also an important issue in transportation: European GDPR – General Data Protection Regulation has been effective since May 2018. In this context, anonymization services will be developed in CONNECTIVE to guarantee privacy and confidentiality.

TD Progress

The TD objective for 2019 relies on works performed in the CONNECTIVE project. The CONNECTIVE project adopts two approaches to develop Business Analytics. The first approach is a bottom-up approach: it aims at managing real data from real operators, to be able to build robust big data platforms and to propose rich algorithms. This approach is complemented with a top-down approach to identify what information operators would value, regardless of any existing implementation.

Regarding Business Analytics platform, it has been decided in 2018 to propose a common architecture across the partners, with different implementations done by each partner, mostly around the Big Data Hadoop Hortonworks framework or similar. In 2019, big data platforms have been enriched and tested with the data collected in the different use cases. In particular, GPU architectures (architecture that uses video memory and that allows to be much faster than classical big data architecture) that have been tested and benchmarked are now integrated in the platforms to enrich visualization capabilities. Besides these powerful visualisation tools, new concepts of virtual reality to perform Analytics have also been tested and first implementations have been done. Activities will continue in 2020 with data coming from one of the use cases.

As different platforms are built in the project by partners, these platforms will be integrated in 2020 into the Operator Portal (defined for the other TDs), which is aimed to be the unique access point for TSPs to join the ecosystem.

On this architecture, the use cases defined in the bottom-up approach are developed and tested. Some of these use cases have already been defined in 2018 and have been enriched with new data and

algorithms. In particular, for one use case, Smart Operational Control Centres, one subway operator (who wants to keep anonymous) has accepted to share its data to develop anonymization and prediction algorithms. Results have been published in two communications (see dissemination part below). One new use case has also been developed in 2019, thanks to a real bus operator (Interbus in Madrid) who has accepted to share its ticketing and service performance data with one partner. For these use cases, some KPIs have been defined and descriptive and predictive analytics have been developed and will be enriched in 2020. Another use case, regarding maintenance activities/assets degradation impacts mitigation, has been defined. A decision support approach has also been defined to guarantee a good level of Service and travellers satisfaction in case of maintenance operations that could affect the travel.

For the top-down approach, methodology has been refined and activities with customers (in particular with Network Rail/RDG – Rail Delivery Group) will be started in 2020.

TD4.6 Business Analytics								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: IT2RAIL				Ongoing: CONNECTIVE				

In 2019, no deliverable has been produced. Three intermediate deliverables have been started and will be available in the beginning of 2020. The official deliverables will be available in June 2020.

In terms of communication and dissemination, TD4.6 has been presented at two conferences: EBDV (European Big Data Value) Forum in Helsinki in October and The Future of Transportation in Vienna in December 2019. Moreover, technical Business Analytics papers have been presented in two conferences: JDS (Journées de la Statistique) in June 2019 in Nancy, France, with a communication of anonymization techniques for privacy, and WCRR19 (World Congress on Railway Research) with a paper on predictive Analytics.

Activities in this TD will continue until 2022, supported by the activities of project CONNECTIVE.

The overall progress of the activities is in line with the schedule. It is envisaged that the new set of data coming with the “operational” on-going projects (e.g. Shift2MaaS) will allow to test and refine what has been developed so far in the TD.

ITD 4.7 Integrated Technical Demonstrator

At the core of the ITD lies the objective of opening the transportation ecosystem to new business actors, able to rejuvenate the transportation ecosystem technologies and business models, thus achieving the goals of European leadership in the market. The ITD will release, on a regular basis and for all TDs, successive versions of enriched deliverables, from early conceptual prototypes to the final version. It will act as the orchestrator of other TDs’ developments, and will ensure the systems approach to integrate the different TDs’ results.

ITD Progress

For 2019, the ITD objective was to address intermediate activities support internal technical and consistency and to coordinate the interface between the CFM projects and the Open Call projects aiming to have integrated coherent demonstrations. The regular tasks such as activity planning and follow-up, definition and production of the technical management documentation used to guarantee effective monitoring and control of activity and its progress were also included.

Activities in ITD4.7 are mainly handled and managed by the project COHESIVE. Practical integration activities started in 2018, taking over similar activities developed in IT2RAIL.

The shift of the delivery of the Alpha Release components from the ATTRACKTIVE and Co-Active project, led to a delay on the delivery of the integrated package related to the Alpha release including the definition of the demonstration and of the use cases and test cases and the integration and testing of components and the Demonstration itself.

The demonstration, done in parallel with the conclusion and final event of the ATTRACKTIVE and Co-Active projects, was concluded in November 2019. Within the demonstration, several use cases were built and a set of scenarios defined (limited to some corridors). To enable these scenarios, a set of TSPs were integrated through the interoperability framework covering Madrid, Barcelona, Berlin and Amsterdam; also Lisbon and Malaga TSP were integrated on the ecosystem within Shift2MaaS collaboration. With all these TSPs it was possible to demonstrate a group of new functionalities within IP4 ecosystem, enriching the already existing mobility ecosystem.

On this release, the main result was the possibility to demonstrate and validate all the proofs of concept from the different CFM projects in an integrated ecosystem. This means that different functionalities developed by the projects are working together such as the definition of CMMP rule between TSPs, multimodal offer building considering those rules, the possibility to include new types of TSPs like park, toll, car-sharing and bike-sharing services, after-sales services (cancellation and refund), payment service provider (google pay). The interface with the traveller was also improved, including new functionalities such as better orchestration of network data that could be provided to the passengers, the possibility of the passengers to provide feedback to the ecosystem, navigation and location based experiences.

The delay of the delivery of the Alpha release and associated material/tasks had minimum effect on the planned activities of the ITD; and it is not foreseen to present a risk to the remaining execution and objectives of the programme.

Although not part of official deliveries for this phase, intermediate compilation of technical supporting information was done. Glossaries, Ontology descriptions and specifications were compiled and prepared.

In terms of communication and dissemination, a number of activities was undertaken namely individual dissemination activities by the partners, joint dissemination and communication actions (World Conference 2019 (FTW2019) and UITP Summit).

This TD also aims to support demonstrations by bringing additional TSPs (in the case from three different regions or corridors (Lisbon, Malaga and a Central/Eastern corridor) that will integrate and enrich the IP4 ecosystem.

Several joint workshops were held to share information about the developments and functionalities available in the ecosystem and identify and define functionalities, use cases and demonstrations scenarios including consistent integration of the TSPs involved in Shift2MaaS and the functionalities and services that would make sense to each location and TSP.

Three integration and demo phases are planned one occurring at the end of November in Malaga, a second one in TRA2020 and a final one done in parallel with InnoTrans 2020. The approach considers the incremental integration of functionalities in the different sequential demonstrators.

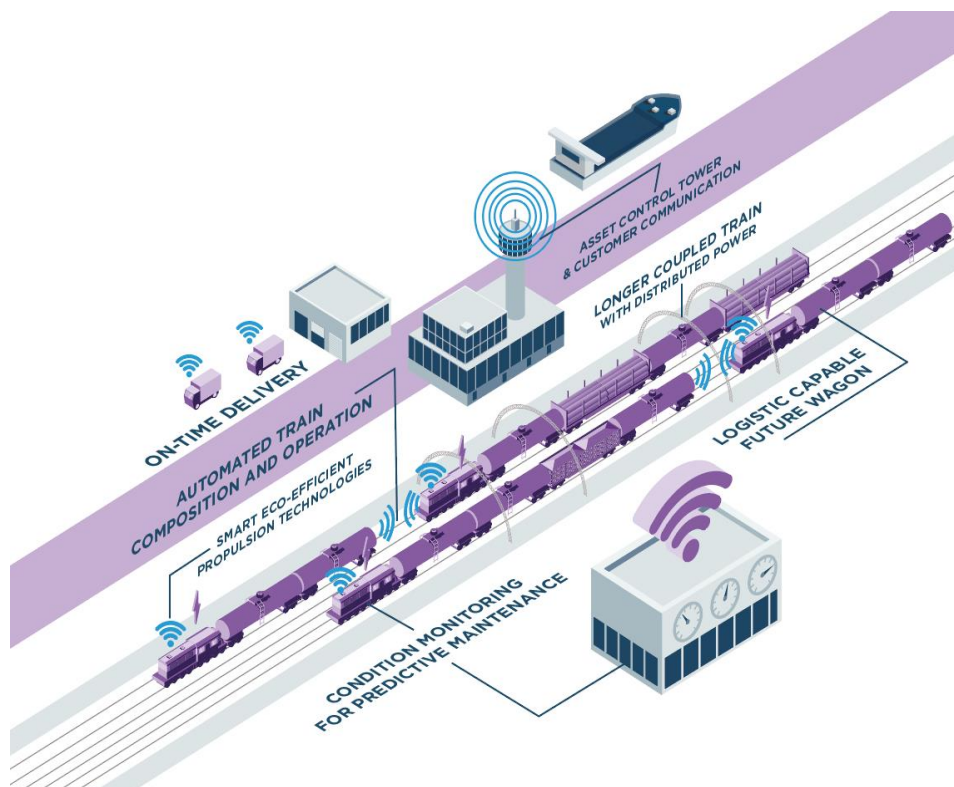
iT4.7 Integrated Technical Demonstrator								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: IT2RAIL				Ongoing: COHESIVE, SPRINT, Shift2MaaS			AWP 2020: CFM, OC	

During 2019, 4 deliverables were planned, mostly close to the end of the year, being in their final stage of preparation and review at the end of the year. These deliverables will be submitted in the first quarter of 2020.

Since the beginning, iT4.7 has accomplished 80% of the planned work up to the end 2019, which represents around 45% of the overall TD.

1.7.5. IP5 Technology for Sustainable and Attractive European Rail Freight

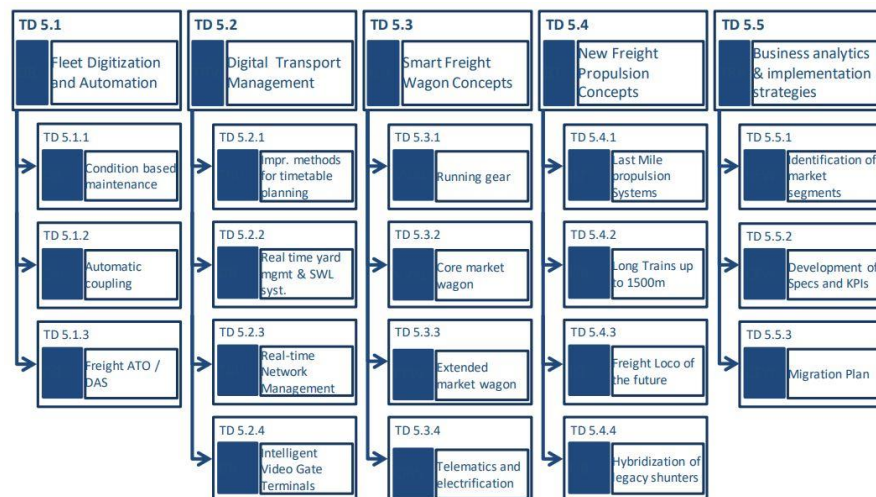
The picture below gives a visual perception on where the TDs will introduce improvements.



This IP aims at improving the cost competitiveness and the reliability of freight services in the rail sector in order to meet the ambitious objectives of almost doubling the use of rail freight compared to 2005.

This will allow achieving the White Paper objective of a shift of 30% of road freight over 300 km to modes such as rail or waterborne transport by 2030, and of more than 50% by 2050. Rail freight must be in a position to offer a cost-effective, attractive service to shippers that helps to take freight away from the already-congested road network. Work focuses on different market segments with specific technical and operational characteristics and needs.

IP5 structure unfolds along the following Technological Demonstrators



TD5.1 Fleet Digitalisation and Automation

This TD targets the adoption of two global megatrends for freight rolling stock: the digital automatic coupling for freight trains (DAC) and condition based maintenance (CBM). DAC is an important enabler for reliable data connections through the train, it will be the starting point for digitisation, leading to smart, connected assets that offer the necessary information for improved services. This TD also focuses on areas such as condition-based and predictive maintenance of locomotives and wagons and wagon monitoring systems enabling better LCC and significant operational cost reductions. Moreover, this TD deals with freight DAS and ATO the latter is developed in close collaboration with IP2.

TD progress

This TD currently progress through the ongoing work performed in ARCC, FR8HUB, FR8RAIL II and FR8RAIL III as well as the Open Calls SMART, M20, LOCATE and SMART II. In addition, the initial work was carried out in FR8RAIL and INNOWAG and SMART, which all ended mid-2019.

In the area of CBM the overall ambition can be summarized as followed:

- Development of a condition-based and predictive maintenance strategy and roadmap, as umbrella for all asset intelligence projects for rail freight
- System engineering including data crunching, modelling, behavioural research & development of mass data infrastructure for live pattern recognition and recommendation of measures
- Process conceptualization, testing, validation and change management in implementation

In 2019, the continuous analysis of the data of these components led to a development of an equalized maintenance program for a possible extension of the maintenance intervals. It has been supported by

the development of first dashboards streaming live data based on intelligent algorithms (e.g. operating hours, automatization of warning levels and maintenance task bundling). By monitoring e.g. auxiliary and power circuit temperatures improvement measures could be defined. Furthermore, future maintenance tasks and customized user interfaces have been defined to further optimize the maintenance program and to generate automated warning levels.

In the area of digital automatic coupling, the TD reviewed the specifications previously developed. Additional considerations and requests from the operators have been collected along 2019 and included in the specifications document. On the other side, the interface definition to fit the standard UIC wagons has been completed: this activity goes further than the initial definition of requirements and includes detailed information and drawings for the mechanical, electrical and pneumatic interfaces. Starting from the concept solution previously developed, together with the new inputs from the reviewed specifications, the mechanical detailed design of the coupler and the prototype development have started. This prototype includes air pressure, power and data lines according to the version type 4 coupler aligned with TIS (www.tis.ag), initiative supported by some freight operators in Europe (DB Cargo, SBB Cargo, ERMEWA, GATX, WASCOSA, etc). A first S2R prototype is expected to be tested in a laboratory environment in the beginning of 2020 and showcased at INNOTRANS in the S2R stand.

As for ATO, the TD reached a working partnership with the ATO suppliers out of IP2 to test on-board units by four suppliers. After finalisation of the design specification all preparatory documents for testing application have been prepared and submitted with the aim to run ATO tests in Switzerland in 2020. In order to arrive to this goal, a strong coordination between IP5 and IP2 was required to advance with the architecture and interface specification for the demonstrator. In the end of September 2019, the lab tests with the ATO on-board unit (OBU) at the Bombardier lab in Mannheim started. Each ATO OBU supplier has tested the TCMS integration following the developed protocol in order to minimize risks for the upcoming ATO field tests, which are now scheduled for mid-2020, on ETCS level 2 track in Switzerland.

ATO demands assurance on track clearance. IP5 have been experimenting with on-board based technologies based on CCTV which will assist / warm the ATO system regarding obstacles on the track. This on-board Camera based technologies offer a good LCC profile. Multiple dynamic field tests were conducted in May 2019 for integrated Object Detection System (ODS). The system was installed in SERBIA CARGO Locomotives series 444, and test trials took place in two sections of Serbian Railways (Nis Junction and also in the Serbian part of the freight Corridor to Thessaloniki). The outcome of the testing was good enough for assessing new requirements focused on braking distances of around 1.5 Km.

IP5 architecture principles will be used in Lynx4Rail (IPx under AWP 2020) and will focus on advanced function for automation (e.g. remote control, obstacle detection, TCMS interface standardization).

TD5.1 Fleet Digitalisation and Automation								
2015	2016	2017	2018	2019	2020	2021	2022	...
<div> <div>Finished: SMART, FR8RAIL, INNOWAG</div> <div>Ongoing: ARCC, FR8HUB, FR8RAIL II, FR8RAIL III, LOCATE, SMART2</div> <div>AWP 2020: CFM</div> </div>								

During 2019, all planned deliverables were released. Since the beginning, TD5.1 has reported having accomplished 79% of the planned work up to the end 2019, which represent 40% of the overall TD.

TD5.2 Digital Transport management

This TD targets the digitisation of processes to optimise service planning and operation thanks to real-time data gathering, steering, operation and coordination of intermodal transport at higher speed. This supports better utilisation of available capacity, by optimising access and operation of local hubs, which are essential but cost-intensive subsystems for rail freight business. The TD looks into the improvement of effectiveness in marshalling yards and terminals with the introduction of innovations in real time information management (e.g. intelligent video gate). The key challenge is to improve the interaction between yards/terminals and the network, thus reducing the lack of information and adding new decision tools that will increase the punctuality and capacity.

TD progress

This TD builds on the following projects: ARCC, SMART, OPTIYARD, FR8HUB and FR8RAIL II. Further input is expected from FR8RAIL III – started in September 2019.

The TD has been also working on how to increase capacity on the line and reduce bottlenecks by running faster freight trains. During this year, data in Railsys, a commercial traffic simulation software tool as simulator engine and data provider, have been modelled for the line Karlsruhe – Basel. For the Malmö shunting yard a demonstrator based on Railsys was assessed by planners and dispatchers. The demonstrator has a twostep optimisation module.

In 2019, the TD has managed to complete the intelligent video gate (IVG) test specification. The deliverable consists of a technical test and progress report to validate the functionality of IVG and shows the overall structure for introducing IVG technology to the market. Overall IVG has reached TRL 5 and the next step is to install IVG on terminals in Sweden and Germany.

The project OptiYard of this TD was completed in 2019, defining an improved information and communications process and simulating intelligent real-time yard operations. To do so, it provided automated optimisation algorithms for yard management and used a technical demonstrator in the form of a fully functional software module.

2019 was also the year when the project SMART finished. It developed a real-time yard management (RTYM) system. It is a web-based information system that visually represents the marshalling yard configuration, provides the possibility for manual and automated input of inbound and outbound train parameters, and provides planning of wagons sorting (marshalling) using the machine learning based optimization algorithm. The main goal in development of SMART RTYM was to provide support system for decision making process and their deviations in order to consider dispatchers' experiences while decreasing their subjective impact on the overall management system of marshalling yards.

Six main test cases were proposed with many alternatives to be implemented. Test case 1 was implemented on data provided from marshalling yard Karnobat, Bulgaria. Test cases 2-6 were implemented on data provided from marshalling yard Popovac, Niš, Serbia. The main limitations of SMART RTYM prototype are related to the dependency on real-time data, which is challenging to obtain.

TD5.2 Digital Transport management								
2015	2016	2017	2018	2019	2020	2021	2022	...
				Finished: SMART, OPTIYARD				
				Ongoing: ARCC, FR8HUB, FR8RAIL II, FR8RAIL III				

During 2019, all of the planned deliverables were released. TD5.2 has reported having accomplished 82% of the planned work up to the end 2019, which represent 65% of the overall TD.

TD5.3 *Smart freight wagon concepts*

This TD has the objective of delivering technical demonstrations of next generation running gear and wagons for freight. The next generation freight wagons will improve the competitiveness of rail freight logistics by providing more flexible and reliable high-capacity assets at competitive costs. This will be achieved by means of the technological outputs to be delivered by this TD consisting of low-noise, lightweight, high speed and track friendly freight running gear, intelligent freight wagon 2020 for core market share increase and extended markets able to provide information such as status and location.

TD progress

This TD builds on the following projects: FR8RAIL, INNOWAG, FR8HUB, FR8RAIL II and FR8RAIL III. Further input is expected in the future from the projects stemming from the call in 2020.

INNOWAG project ended in 2019 contributing to IP5 technology demonstrators with the development of different concepts of autonomous on-board wagon control units. Investigated self-powered sensor systems could be used for cargo tracing and condition monitoring of key parameters for critical types of load, such as perishable goods, high value sensitive goods and dangerous goods. Specific technologies that were implemented and tested in the project include the following:

- Vibration energy harvester;
- Powering solution through solar cells;
- Sensor systems using Bluetooth (BT) and/or RFID technologies;
- Tracing solutions based on GPS;
- Communication solutions based on BT, RFID, and GNSS.

Some of the innovative solutions developed in the project have reached a high TRL, being based on mature technologies, and were tested at TRL5-6 (e.g., CCMS based on BT, GPS and GNSS, bogie frame made of HSS, vibration energy harvester, etc.). Further development of these technologies into commercial solutions would be predictable in the near future.

In the meantime, solutions that have reached a lower TRL (RFID-based monitoring systems, predictive maintenance tools and strategies, implementation of composites in the wagon design, etc.) may require further R&D efforts.

The TD produced in 2019 a safety analysis based on defined the Use Cases for the wagon On-Board Unit (wOBU) system. The analysis of the system from the perspective of corrective actions to tackle the intolerable and undesirable hazards was performed. In Product Class 1A (Explosive substances), only one of the hazards has been considered as undesirable, but this hazard has to be mitigated not only by safety corrective actions but also security. On the other hand, Product Classes 2A (gases) and 2B (flammable liquids) presents a high rate of negligible hazards which in this preliminary stage of the work shows that the system is prepared to tackle the hazards related to safety issues.

During 2019, the activities completed are the design, pre-studies for extended market wagon. The design of the wagon structure describes the integration of single axle running gear in an aerodynamically optimized wagon for container transportation.

TD5.3 Smart Freight Wagon Concepts								
2015	2016	2017	2018	2019	2020	2021	2022	...
		Finished: FR8RAIL, INNOWAG						
			Ongoing: FR8HUB, FR8RAIL II, FR8RAIL III					
					AWP 2020: CFM			

During 2019, 8 deliverables were planned out of which 5 were released. Since the beginning, TD5.3 has reported having accomplished 73% of the planned work up to the end 2019, which represent 45% of the overall TD (even though some activities have covered a higher percentage).

TD5.4 New freight propulsion concepts

The target of this TD is to provide more attractive rail freight services to the final customer, with competitive rail solutions maximizing flexibility and efficiency while reducing the operating and maintenance costs. The focus of this TD is on improving the overall performance of today's locomotives by adding and integrating additional functionalities and technologies. Future locomotives will provide extreme flexibility for operation in non-electrified and in electrified lines, allowing private and public operators to offer broaden rail freight services according to demand without the need of changing the locomotive or allowing the new production concepts. Future locomotives will feature remote control for distributed power, thus, allowing the increase of the train length up to 1500m and consequently improving the cost efficiency of rail transport. Moreover, other areas of work include: reduced LCC, braking energy recuperation, operational efficiency increase by automating various activities such as train start-up, train preparation, start of mission, stabling and parking, shunting.

TD progress

This TD builds on the progress made with the member call project FFL4E, FR8HUB, FR8RAIL II, and the open call projects DYNAFREIGHT and M2O.

2019 TD's main goal was to run the first demonstrators developed in FFL4E, being that the Li-Ion battery based last mile propulsion and the radio remote control for distributed power to run longer and heavier trains, continuing the research activities in FR8HUB, setup and stabilize the work to be done in FR8RAL II, and to start organizing the work to be done in FR8RAIL III.

In the area of last mile, the TD demonstrated in the lab a complete propulsion system using a water-cooled Li-Ion battery with 24.5kWh. All the relevant building blocks were specified, developed and tested. Furthermore, aiming at the certification, a hazard and safety analysis was done. After the analysis of various types of propulsion systems (e.g. combustion engines – short term, battery – medium term, fuel cell – long term) and an in-depth analysis of the integration of larger diesel engine in the same space (as a short-term solution), the replacement of last mile diesel engines by a new generation of Li-Ion battery is tackled. It is planned to finish the work with another demonstrator with more than 100kWh installed, ready for even larger capacity.

In the area of long trains, the TD successfully implemented the demonstrator with a commercial freight train in push pull operation, where the locomotive at the end of the train was remotely controlled using GSM-R for the communication between both vehicles. To achieve this milestone, the system was specified, developed, tested in the lab, commissioned statically and dynamically; simulations for the longitudinal forces were performed, a safety analysis was done and finally, a 540m long freight train

was organized and equipped with strain gage sensors to measure the in-train forces and validate the simulations. At the end, the measured values were compared with the results provided by the simulations. The comparison showed that the first simulation calculated lower forces than measured and that both data sets showed the same behaviour relatively to each other. After a calibration of the parameters to reflect the real train, the simulation could be validated successfully. This is an important result regarding a future certification. The work is being continued, adding more functionalities (such as a neutral section control for instance) and increasing the number of remote controllable locomotive. The project aims at demonstrating a longer and heavier train being propelled by 3 locomotives. Along the development, simulations for longer, heavier and adversely loaded trains and further safety analysis are done.

In the area of freight loco of the future, the TD also investigated new concepts to be applied on freight locomotive bogies. This included the work on a passive radial steering system to reduce wheel wear, where in a first step various concepts were compared, one specified, developed and implemented into a Bombardier two-axle bogie to validate the simulated values. The system proved to be able to reduce wear and, consequently, the track access charges in the networks where those are implemented.

Furthermore, for the hybridization of freight locomotives, simulations were done for various use cases in order to better understand the required on-board energy storage system, especially concerning the size of it (installed kWh). Studies done showed that in average, 300-400kWh are necessary to run most of the use cases.

The TD has been also working on the simulation for smart train operation using peak power shaving, showing that, with smart driving, peak power demand can significantly be reduced without having the need to install HW like energy storage systems on-board. Optimizing the speed profile (thus the driving style) is challenging if focus is placed on peak power demand, as real-time information from the substations is required. The use of energy storage system facilitates this. A first attempt to set-up a business case has been performed.

Some technologies developed in this project have reached maturity level that allows them to enter the market soon. We may expect for example the radial steering concept evaluated and tested in this TD to become soon available to customers, as well as the radio remote control for distributed power technology developed for “Long Trains”, to be offered for standard train lengths up to 740m.

TD 5.4 New Freight Propulsion Concepts								
2015	2016	2017	2018	2019	2020	2021	2022	...
		Finished: DYNAFREIGHT, FFL4E						
		Ongoing: FR8HUB, FR8RAIL II, M20, FR8RAIL III						
					AWP 2020: CFM			

During 2019, 16 deliverables were planned out of which 7 were released. Since the beginning, TD5.4 has reported having accomplished 69% of the planned work up to the end 2019, which represent 45% of the overall TD.

TD5.5 Business analytics and implementation strategies

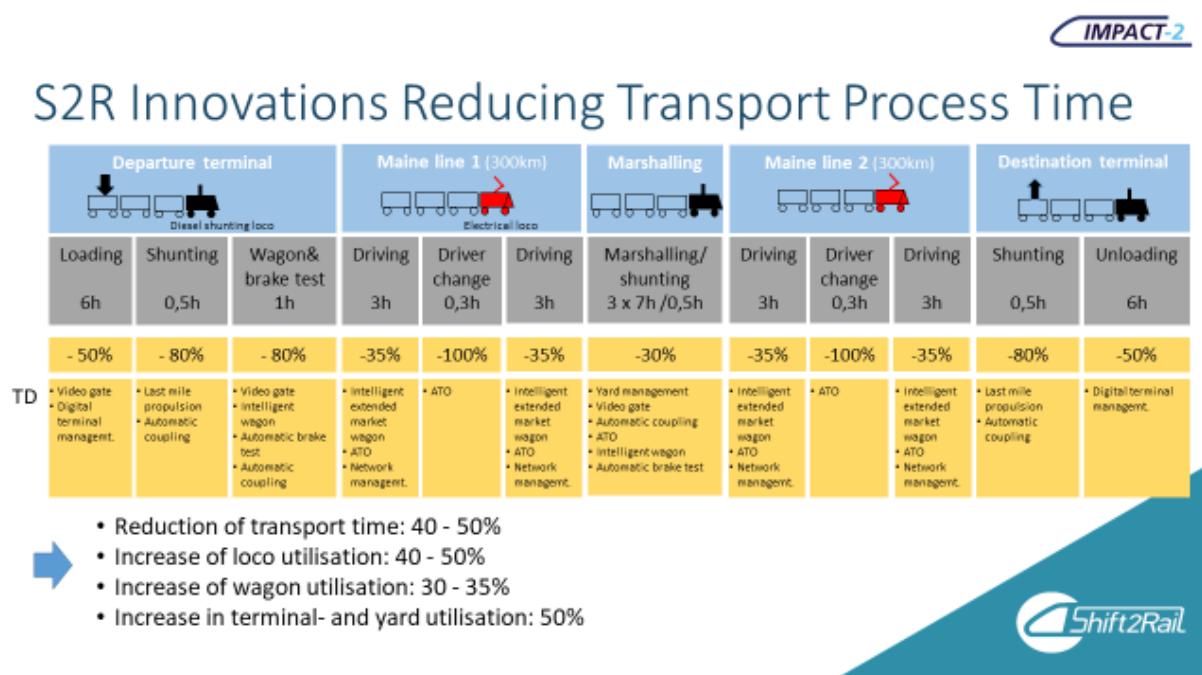
This TD ensures that IP5 develops technologies in line with the market needs and with sound plans for introductions into the market. This is provided by migration plans for implementing new technology solutions on a large scale, identifying market segments and developing specifications and Key Performance Indicators for freight.

TD progress

This TD builds on the following projects: finished projects SMART-RAIL (lighthouse project), FR8RAIL, and INNOWAG and the ongoing project FR8HUB. Cooperation have been established and intensified during 2019 with IMPACT II about KPIs.

The TD works in areas of identification of market segments, development of specifications and key performance indicators (KPIs), and in the area of migration plans. The deliverables on top level requirements propulsion and the one on KPIs for freight business were submitted in early 2019. In particular, the work on the key specifications for the wagons (core and extended market wagon) is essential for major improvements in rail freight as also today's operational modes were investigated (UIC regime with permanent train re-configuration) and future scenarios defined based on point-to-point and closed-train-loop block train operations to attract additional transport demand for rail freight. The consistent implementation of these two operating modes is essential for KPI analysis and improvement potential, because process times can be significantly reduced and asset productivity highly increased.

The TD also worked in quantifying the estimated benefits of new technologies in the form of KPIs based on model calculations. The improvement potentials of individual technologies, their dependencies and the operating modes were incorporated into the calculation model of IMPACT-2 in order to calculate the impact and benefit development. This activity covers novel wagon versus typical UIC standard wagons, running gear and automatic coupler, locomotive propulsion systems and technical specification on new propulsion last mile applications and locomotive boogie. Here below an example of how the S2R innovation in IP5 should lead to a reduction of transport process time:



The TD gave the first steps towards the preparation of the IP5 migration plan by developing a mid-term report on key technologies, further evolutionary steps and their interrelations.

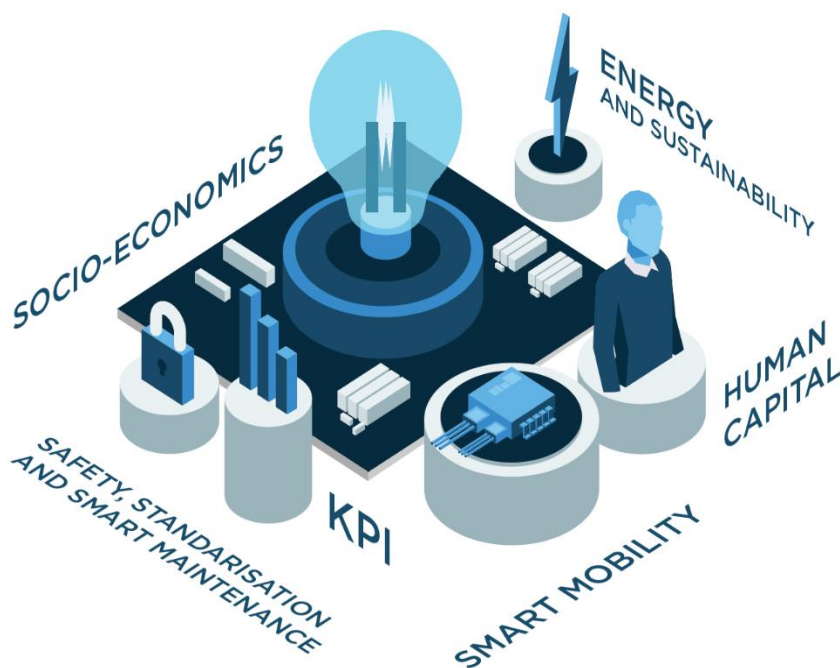
The TD developed key market analysis and migration plan for the auto coupling functionality.

TD 5.5 – Business analytics and implementation strategies								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: SMART-RAIL, FR8RAIL, INNOWAG					Ongoing: FR8HUB			

Since the beginning of 2019 FR8RAIL have had its final conference and FR8RAIL II started, TD5.5 has reported having accomplished approx. 33% of the planned work up to the end 2019, which represent 40% of the overall TD.

1.7.6. CCA Cross Cutting Activities

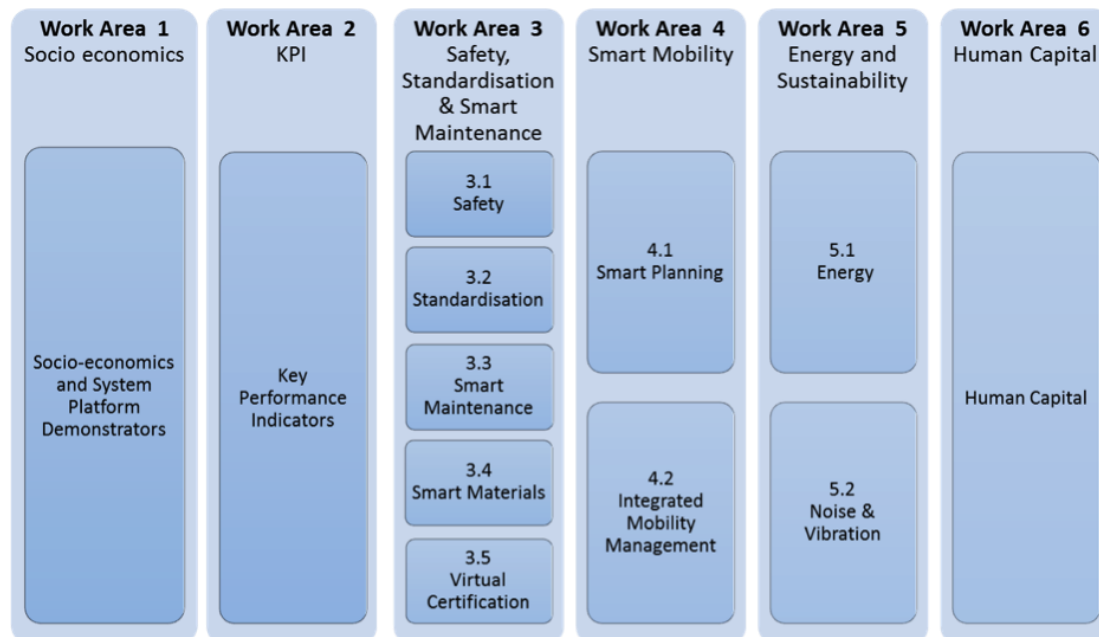
An overview of the various work areas in the CCAs is shown in the figure below.



Cross Cutting Activities are relevant to the different sub-systems of the five IPs taking into account the interactions between these sub-systems.

These Cross Cutting Activities ensure that the R&I activities within the different Innovation Programmes are closely aligned in terms of their objectives and their requirements, as well as the methodologies for evaluation and assessment of impacts. The Cross Cutting Activities facilitate a coordinated approach in order to avoid duplication and guarantee consistency.

CCA work is organised so as to achieve the objectives of the following areas:



Below a summary of the activities performed in the CCA Work Areas (WA). Activities under WA 3.4 (Smart Materials) have not started; some activities on this subject will be carried out in the dedicated Innovation Programmes.

WA1 Long-term needs and socio economic research

The objective of WA1 is to analyse the areas and the expected improvements that the works deployed under Shift2Rail bring to the European context in terms of social and economic benefits.

The work area is addressed in the CFM projects IMPACT 1, IMPACT2 and complemented by the OC project NEAR 2050.

The first phase (IMPACT-1 focused on customer needs and mobility behaviour of passengers and is followed in IMPACT-2 by a second phase (2018-2021) concentrating on customer requirements and scenarios for the railway freight sector which also includes the non-railbound first and last mile of supply chains. During 2019 the following activities have been carried out:

- Development of logistic megatrends (e.g. digitalisation, online trade...)
- Development of criteria for transport decision (e.g. cost, reliability, service ...)
- Interviews with freight customers concerning the rating of the transport criteria

Another area which is covered in this WA is developing models to evaluate the improvements brought to society by the Shift2Rail activities which do have influence on mode choice.

The attractiveness model estimates the influence of Shift2Rail innovations towards the attractiveness of rail transport for passenger on the areas such as information to the traveller, easier and more comprehensive booking and ticketing possibilities, and a more comfortable rail trip with less noise. Under the work, elementary barriers to choose rail as the choice of transport mode are identified and the major potential improvements and their quantification is defined in the model. In 2019, the attractiveness model has been accomplished and results related to the improvements coming from Innovation Programme 4 (IP4) are quantified. Preliminary results show that the implementation of the IP4 technologies can reduce the barriers that affect passenger choices for taking other modes of transport than rail, by approximately 45%.

Further objectives for 2019 were to define the approach of the mode choice models for the four S2R System Platform Demonstrators (SPDs) high-speed passenger rail, regional passenger rail, urban passenger rail (metro) and rail freight. During 2019, this implementation process included for passenger SPDs to determine the output needed from the KPI-model and attractiveness model as input to the mode choice modelling. This includes e.g. determining that attractiveness is represented using three variables in the mode choice modelling – booking & ticketing, information and comfort & services. For the rail freight SPD, the implementation process included to set up scenarios in a cost-minimizing logistics model for how reductions in transport time in different parts of the transport chain affects mode choice. Currently, a mode choice model considers a single member state, however, the work on extrapolation of the model will continue in the coming year. The baseline scenario, the use cases and the model were defined and developed. Preliminary results indicate that reduction in transport time increases rail modal share substantially.

WA1 Long-term needs and socio-economic research & SPD's								
2015	2016	2017	2018	2019	2020	2021	2022	...
		Fin: IMPACT-1, NEAR2050						
				Ongoing: IMPACT-2				
						AWP 2020: Tender		

Deliverable 3.2 which will describe the mode choice models is due March 2020 and Deliverable 3.3 with the results of the analysis is planned November 2020.

WA 2 –KPI (Key Performance Indicators) method development and integrated assessment

The objectives of the Work Area 2 are to capture the impacts of the TDs and to assess how they contribute to the key Shift2Rail targets by defining and quantifying key performance indicators for their results.

This objectives of this Work Area are achieved through the following projects:

- Lighthouse project ROLL2RAIL,
- CFM-Projects IMPACT 1, IMPACT 2, while FINE 1, FINE 2 contributes in defining the Energy KPIs those project are reported within WA5.1.
- Long term needs tender focused on the support for KPIs development.

The main objectives for 2019 were to further update the KPI model itself, based on the acquired input provided by the source projects and to collect the updated values from the technology demonstrators. All parameters have been fed into the model and an updated set of quantified values for the master plan targets “LCC”, “Capacity” and “Punctuality” has been computed.

The Shift2Rail reference scenarios, which are based on the SPDs defined in WA1.2, were stabilised by performing an exhaustive data mining and verification process. The reference scenarios were stabilised thanks to a more exhaustive data collection from railway undertakings, infrastructure manager, European rail authorities and national data sources.

The collaboration and exchange process with the TD regarding their input to the KPI models was fine-tuned. The majority of TDs contributed to the results of the release 2.0 of the KPI model which was presented in the S2R Governing Board and is included in Annex IV.

The cooperation with the consortium is ongoing on the tender “Long-term needs & socio-economic research” which will implement an IT-tool to visualise the impacts by using the KPI model. A first prototype version has been developed in autumn 2019 by the consortium working on the project.

For 2020, it is foreseen to refine parts of the KPI model, as the research is reaching higher TRL and due to the possible impact of the system architecture work within Shift2Rail. Moreover, different steps are planned to stabilise and validate the model mainly related to Innovation Programme 2 and to assess the accuracy of the provided impact of the technology demonstrators. It is foreseen to display the results of the KPI activities within Shift2Rail at InnoTrans 2020.

WA2 KPI method and integrated assessment								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: Roll2Rail, IMPACT-1			Ongoing: Tender KPIs, IMPACT-2					

During 2019, two deliverables were planned and both deliverables have been released with an agreed delay. WA2 has reported having accomplished 80% of the planned work up to the end of 2019, some activities have been moved to 2020 such as the delivery of the complete model development and the validation process. The current work represents 70% of the overall TD.

WA 3 Safety, Standardisation and Smart Maintenance

Work Area 3 builds on the activities of the projects Plasa/Plasa 2, GoSAFE RAIL, IMPACT2 and SMaRTE, the graph below refers to all the activities performed in the whole WA. All Work Areas except WA 3.4 (Smart Materials) have been running in 2019. The activities in Smart Maintenance were concluded in 2019. The conclusions on these WA can be found under the relevant section.

WA3 Safety, Standardisation, Maintenance, Materials, Virtual Certification								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: PLASA, GoSAFE RAIL, SMaRTE				Ongoing: IMPACT-2, PLASA-2				

WA 3.1 – Safety

The objective of WA3.1 is to develop a global approach for the safety of the railway system. This approach is based on a global risk assessment model and aims to provide key results to manage the safety level of the existing railway system.

In 2019, this work area was covered in the GoSAFE RAIL Open call project, which started in October 2016. The CFM project Plasa was completed in 2018.

During 2019, the developed Rail Safety Framework, which integrates risk assessment across infrastructure asset categories, was implemented within a decision support tool on two different sections of the European railway network. The framework prescribes an integrated approach for quality-oriented operational railway planning and describes how different types of data can be collected, analysed, and used in artificial intelligence applications. A case study in Ireland was used to demonstrate the tool's ability to plan maintenance and intervention strategies incorporating different objectives by decision makers. A further case study in Croatia made use of the developed Global Safety Key Performance Indicators (GSKPIs) related to structural reliability and traffic safety to demonstrate how future life cycle management and emergency management procedures could be improved and optimised. The results of the project show that by collecting near-miss GSKPIs, critical sections could be determined and permanently monitored.

Moreover, the work concluded that machine learning models could be built in order to automatically identify any change in asset conditions and plan preventive maintenance activities in a timely manner. Emergency management procedures could also benefit from the information provided by permanent monitoring systems (e.g. cameras, sensors) for response and remediation planning.

The four deliverables planned in 2019 have been delivered. WA3.1 has reported having accomplished 100% of the planned work up to the end of 2019. By the completion of the above mentioned work, the WA completed its activities.

The WA objectives defined in the MAAP were reached by delivering a decision support tool based on the risk assessment methods, this is a new approach for providing support to the designer or a decision-maker in day-to-day operation with respect to the risk assessment.

WA 3.2 – Standardization

The main objective of WA3.2 is to foster the transfer of Shift2Rail results and outcomes of innovation activities into standards or regulatory documents when needed and beneficial. It aims to provide a coordinated approach across the S2R research activities and to develop optimised pre-standardisation aligned processes with the relevant standardisation bodies, standard setting organisations, as well as ERA.

The Standardisation work area is covered in the IMPACT-2 CFM project, which started in September 2017.

In 2019, the investigation on standardisation potential of the S2R outcomes was continued across the different projects, this led to issuing version 3 of the Standardisation Rolling Development Plan (SRDP). This work will be taken forward in 2020, as the progress in research work and the gradual increase in the TD technical readiness levels will make clearer and more precise the standardisation potentials of the project results.

The progress in this collection now allows identifying better the complementarities between different Technology Demonstrators or Innovation Programmes. A topic-oriented version of the SRDP is now under preparation. Data exchange format, communication interfaces, cyber security, innovative materials, virtual validation, predictive and condition based maintenance, etc. are the technical areas where needs/opportunities for standardisation are the most commonly shared between the different IPs. In order to move forward in the progress of the activities, on an exceptional basis, the JU has complemented the limited project efforts with additional external support.

In 2019, the first topic meeting on Cybersecurity was held with the TD 2.11 leader, ERA, CENELEC, ETSI, and UIC to give a cross presentation of the results and activities in this field and better understand how, where and when a contribution from TD 2.11 results could be valuable for standard development.

In 2019, a new version of the Shift2Rail standardisation roadmap was presented to main stakeholders at the Rail Standardisation Coordination Platform for Europe (RASCOP) – chaired by the EC. The S2R JU is also systematically invited to dedicated JPC-R meetings to update on standardisation.

Since October, S2R is also contributing the European Commission task force for the definition of the EC Standardisation Requests for the next revision of the railway TSIs. Based on the data collection and road-mapping exercises, the S2R contribution aims at identifying and expressing the standardisation needs for the future implementation of innovation, as well as highlighting where and when some significant input can be expected from the research outcomes to revise or develop the standards that will be identified. This activity will continue during the first half of 2020.

During 2019, one deliverable was planned for WA3.2 and has been released. WA3.2 has reported having accomplished 100% of the planned work up to the end of 2019, which represents 50 % of the overall WA.

WA 3.3 – Smart Maintenance

This Work Area is divided into cross-system and specific vehicle topics. The development of a common smart maintenance concept is based on a synthesis of all smart maintenance concepts within the S2R programme incorporating concepts for infrastructure as well as for rolling stock. The specific vehicle topics focus on condition based maintenance for passenger trains.

The Smart maintenance work area is covered in the IMPACT-2 CFM and the SMaRTE OC project.

On the highest level of the WA the Common Smart Maintenance Concept considers the maintenance in the whole railway system. In the first steps, Smart Maintenance Concept gives an overview of existing CBM activities within Shift2Rail. Based on this overview the Smart Maintenance Concept shows common principles like the cyber physical data model as well as common requirements independent of special parts of the system or special use cases. By the end of 2019 the work concluded that two elements turned out to be essential as key factors for a successful whole system approach for maintenance. These are firstly new opportunities provided by mutual monitoring of the subsystem (the vehicle monitors the infrastructure and vice versa) and secondly the use of all kinds of available data which indicate the real condition of an asset and gives information about necessary maintenance.

The second part of WA 3.3. considers the available and necessary data as key elements for a successful implementation of smart maintenance in the railway system. In 2019, several data related issues were analysed to find necessary and useful approaches for standardisation of CBM data. Two special features of CBM data were identified for which standardisation is very useful, standardisation of data

structure and of data designation. For both these data features, WA 3.3 provides a standardisation approach recommendation.

In 2019, WA 3.3. dealt with specific use cases of CBM using the example of 4 different passenger vehicles : a regional train (Alstom ET 440 Corradia), double-deck coach (Bombardier DosTo 2010), high speed train (ICE 3/ ICE T) and suburban train

The challenge of having available data is quite common for the implementation of CBM into maintenance systems for current vehicle fleets and they underline very strongly the necessity of standardisation and harmonization of CBM Data as proposed in part two of WA 3.3.

The process of analysing the data and pattern recognition was executed.

The activities in this WA resulted in an increased knowledge about the real conditions of assets based on the analysis of the relevant CBM data. With this better understanding of the real failure behaviour, the maintainer will be able to optimise the whole maintenance process, to reduce maintenance costs as well as to increase the effect of the maintenance actions.

The Smart Maintenance Concept shows the existing obstacles and gives a generic and theoretical guideline for the development of future whole system maintenance concepts. A full-fledged integration of the results in the maintenance process of vehicles will be possible only at higher TRL (TRL 7-8). The activity of this WA was concluded in TRL 3.

WA3 Safety, Standardisation, Maintenance, Materials, Virtual Certification								
2015	2016	2017	2018	2019	2020	2021	2022	...
	Finished: PLASA, GoSAFE RAIL, SMaRTE				Ongoing: IMPACT-2, PLASA-2			

During 2019 in WA3.3, five deliverables were planned and all have been submitted. WA3.3 has reported having accomplished 100% of the planned work up to the end of 2019, which represents 100% of the overall TD (according to the planned TRL 3).

WA 3.5 – Virtual Certification

Virtual Certification is covered by the CFM project Plasa-2 which started in November 2018. The objective of virtual certification within S2R's CCA is to provide recommendations for a mixed virtual/experimental certification process, which shall ultimately lead to a significant reduction of certification costs and duration.

The work on virtual certification has started as planned with the analysis of the state of the art and the evaluation of the benefits of the approach. The first step consisted of analysing the railway standards that already allow the use of simulations for approval of vehicles or sub-systems for circulation. A deep analysis of

- previous European research projects (Pantotrain, Dynotrain, Aerotrain, Acoutrain, Euraxles),
- a benchmark in other industries (aerospace, automotive, nuclear, aircraft), and
- interactions with on-going S2R TDs (TD1.1, TD1.2, TD1.3, TD1.4, TD1.5 and TD2.6)

allowed for gathering relevant information and providing an overview of the methods and barriers encountered when replacing totally or partially field tests by virtual simulations. The deliverable (December 2019) describes the requirements, the methods (for example, methods for the validation of tools, for the comparison of results from experiments and simulations, methods to take into account variability and uncertainties, etc.) and processes (full or partial virtual process, extension of approval) used in various area. It is a first step towards the general recommendations that will be defined in the next stage (2020).

In parallel, the WA3.5 has presented its first results to and interacted with, on one hand, the CEN-CENELEC TC256 & TX9 survey group on virtual certification, whose objective is to define recommendations for the WG conveners for the introduction of virtual testing in the approval process, and, on the other hand, the French national Safety Authority (EPSF). The iterative discussions with these entities and with others which will be contacted in 2020 will help to define common generic recommendations on virtual certification.

WA3 Safety, Standardisation, Maintenance, Materials, Virtual Certification								
2015	2016	2017	2018	2019	2020	2021	2022	...
				Finished: PLASA, GoSAFE RAIL, SMaRTE				
				Ongoing: IMPACT-2, PLASA-2				

During 2019 in WA3.5, one deliverable was planned which was submitted. WA3.5 has reported having accomplished 100% of the planned work up to the end of 2019, which represents 35 % of the overall TD. This percentage is aligned with the expected progress, the Virtual Certification activities under CCA started in 2019.

Work Area 4 SMART MOBILITY

Work Area 4 builds on the results of the Roll2Rail (LP). Relevant activities were completed in the projects Plasa and GoSAFE RAIL. Activities on these areas are ongoing in IMPACT-2 and Plasa-2 and new activities started in the projects FINE 2 at the end of 2019.

WA4 Smart Planning, I2M								
2015	2016	2017	2018	2019	2020	2021	2022	...
				Finished: Roll2Rail, PLASA, GoSAFE RAIL				
				Ongoing: IMPACT-2, PLASA-2, FINE-2				

Work Area 4.1 – Smart Planning

The aim of Smart Planning is to enable railway stakeholders to make the best decisions for the overall system, for example concerning schedules and the availability of rolling stock and staff, based on up-to-date operational data, taking into account all essential information in order to ensure quality promised is delivered to customers. The task also enables optimum allocation of funds by using knowledge of all relevant system parameters and their interaction to promote the best possible use of existing capacities.

In 2019, the work of this area is addressed in the CFM project Plasa and Plasa 2. The plan for 2019 was first of all to perform a feasibility study whether the developed simulation can be used in a Traffic

Management System context. The document identifies several use cases in which a simulation tool could be useful as part of an intraday operation planning system, derive necessary requirements, and assess which modifications are required to meet these requirements.

One of the main conclusions of the work is that coupling of microscopic and macroscopic simulations is not feasible and that a simulation of a more microscopic timetable is not helpful due to the lack of operational data at that level of detail. A method to extract a macroscopic infrastructure from a microscopic infrastructure point of view without losing too much information has been developed.

For the above mentioned reasons, a feasibility study was carried out which assessed the possibility on performing simulations without having a complete set of input data, e.g. an incompletely specified timetable for freight traffic. There are certain situations where the available information is not sufficient for performing a simulation, and specific methods need to be used which can overcome the lack of information. One of these methods is that the simulation results will be evaluated against empirical macro-level data and against microscopic simulations. These methods will be further assessed in the second half of the project.

During 2019, 2 deliverables were planned, both have been released. WA4.1 has reported having accomplished 100% of the planned work up to the end of 2019, which represents 80 % of the overall TD.

Work Area 4.2 – Integrated Mobility Management

WA4.2 aims to integrate the data exchange between Traffic Management, Freight operations and Asset Management Services via the Integration Layer and to develop new business service application.

WA4.2 built on the projects IN2Rail and IMPACT-2, WP7 which started in 2017. Parallel activities are foreseen in FINE-2 project that started on 1st of December 2019.

In 2019, the aim was to finalize the collection of use-cases and to derive from them the requirements for an amendment of the data structure needed for Freight Operations to start the design of the proposed prototypes and to extract from the use-cases the requirements for the operational processes of freight management systems.

In 2019, the basic Use-cases for advanced Freight operation was described. These Use-cases represent functionalities to be addressed from the proposed prototypes such as planning of Terminal slots and train requests, several applications related to timetable, Node Management System, Node plan optimization, Specific operations for freight trains including transport operations for regular Cargo, Dangerous Goods. The scenarios developed contain further monitoring of Wagon axle box temperature, Wagon bogie vibration, Wagon tank pressure, optimizing container delivery to ports, Movement control in train load-out and unloading areas. The format to describe the use-cases was commonly agreed and applied. All Use-cases are based on the utilization of the Integration Layer to exchange data between the different clients.

Specification of necessary Data to be available on in Integration Layer has been almost completed. They cover the operations, which have been defined and will be comprised in the Canonical Data Model (CDM). The technical documents are built on TD2.9 System Requirement Specification (SRS) for the Integration Layer and will feed into the Linx4Rail project which will provide the modelling schemes for the CDM.

This work was based on the Use-cases and processes defined and deliver descriptions of the different information to be covered from a Canonical data Model. Specification of Business Rules and Logic to support high-efficient Freight Operations. The specified use-cases for advanced freight operations were analyzed to evaluate all requirements to be covered from the different operational management systems.

Development of the prototypes addressing the new advanced functionalities and demonstrators proposed from the different partners has started.

During 2019 in WA4.2, one deliverable was planned has been submitted. WA4.2 has reported having accomplished 100% of the planned work up to the end of 2019, which represents 30 % of the overall TD. This percentage is quite aligned with the expected progress, the I2M activities under CCA started in 2018.

Work Area 5 Energy and Sustainability

Work Area 5 builds on the results of the ROLL2RAIL (LP). Relevant activities were completed in the projects FINE 1, OPEUS and DESTINATE. Activities on these areas have started in the projects FINE 2 and TRANSIT end of 2019.

WA5 Energy and sustainability								
2015	2016	2017	2018	2019	2020	2021	2022	...
Finished: Roll2Rail, DESTINATE, FINE 1, OPEUS					Ongoing: FINE-2, TRANSIT		AWP 2020: OC	

FINE 1: all 15 deliverables scheduled to be completed by the end of October 2019 have been submitted. DESTINATE was already finalised during 2018 according to plan and OPEUS was finalised in autumn 2019.

WA 5.1 Energy

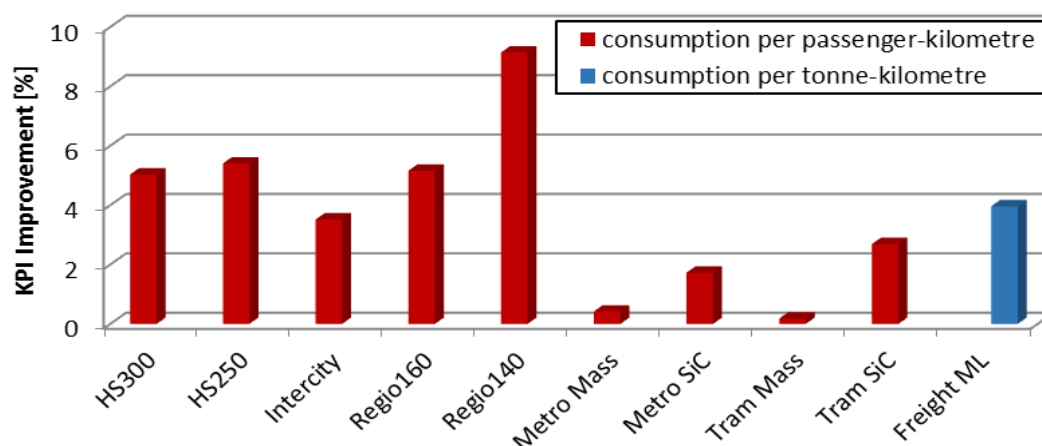
The overall objective of this work area is to develop a standardised methodology for estimation of energy consumption by simulation and measurement enabling the standardised specification of energy efficient railway systems.

The Energy work area is covered in the member's project FINE 1 and in the open call project OPEUS. The activities of WA5.1 continue in FINE-2, the project launched in December 2019.

In 2019, the main focus of the Energy WA was to finalise the proposal for Eco-labelling specific for the railway vehicles which could provide a possibility to reflect the energy and CO2 efficiencies of rolling stock.

The WA5.1 work was also aligned with the standard EN50591 (Railway Applications – Rolling Stock – Specification and verification of energy consumption), which was published in the second half of 2019. This Standard gives the bases for the energy-label methodology.

The WA finalised the interim set of energy KPIs, quantifying the energy impact of Shift2Rail technical demonstrators. A summary of KPI improvement figures per train category is given below:



The collection of information required good collaboration with the other S2R projects (Innovation Programmes) in order to gather the relevant information. The simulations for the final KPIs were carried out by the energy simulation tool developed. This simulation tool uses a methodology to calculate the energy consumption for various train and track characteristics. The tool allows the user to assess the potential of technical innovations regarding several fields of interest – e.g. optimized driving strategy through DAS/ATO, implementation of energy storage systems (ESS) or improvement of technical components (lightweight construction, improved efficiencies of traction and auxiliary components).

The tool was also used to investigate the implementation of ESS for several scenarios, including catenary-free zones as well as an increase of using regenerative braking through the on-board ESS. Beside the potential of reducing the total energy consumption, it shows that the implementation of the ESS also provides the advantage of optimising the power characteristic at the grid (e.g. minimizing power peaks).

During 2019, 10 deliverable was planned for WA5.1. Except one, all deliverables have been released. TD 5.1 has reported having accomplished 90% of the planned work up to the end of 2019, which represents 70 % of the overall TD.

WA 5.2 – Noise and Vibration

The overall objective of this work area is to reduce the annoyance and exposure to noise and vibration related to the railway sector in Europe and to provide the necessary system approach and leverage the results from all the IPs by applying effective noise control in the different technical demonstrators. The Noise and Vibration work area is covered in the CFM project FINE1 and FINE2 and in their complementary OC project DESTINATE and TRANSIT. FINE-2 as well as the corresponding OC-project TRANSIT were launched in December 2019.

During 2019, the contacts within S2R to IP projects via technical demonstrators (TDs) were consolidated and intensified. The noise targets on TD level have been determined as a set of limit values, which should be achieved by the TDs. These values have been communicated toward the S2R

IP-projects. The noise targets for TDs are defined such that the overall noise limits will be reduced by 2 dB. A noise reduction of 4 dB compared to the current emission levels is expected for parking operations.

For an overall assessment and monitoring of noise effects in the S2R TDs, a toolbox has been developed for the computational simulation and evaluation of noise reduction measures under a variety of conditions for different traffic scenarios. The focus is on noise emissions during pass-by events and parking or standstill mode.

Pass-by noise emissions were calculated considering state-of-the-art noise mitigation measures to verify the model. These were set in relation to the associated costs, serving as a basis for cost-benefit analyses (CBA). The results confirmed the main expectations regarding the noise abatement measures for pass-by events from the CBA point of view: classical noise barriers offered the maximum noise mitigation, whereby the cost-benefit ratio is the more advantageous the higher the barrier is. Topological effects due to different track positions or residential densities could be demonstrated.

These showed, for example, that noise barriers are quite effective on embankments and have almost no effect when lowered in cuttings. Measures that are applied directly to the rail (rail dampers or acoustic rail grinding) are independent of these conditions. The influence of the traffic scenario on CBA results could be neglected.

For the quantification and comparison of the acoustic effectiveness and the cost-benefit ratio of the TDs in the further course of the project, the FINE 1 model has proven to be suitable.

Additionally, a special study was undertaken to estimate how much noise can be reduced by replacing cast iron brakes with disk brakes. The study was done for train service on Swedish tracks. The main conclusion which primarily originates from the TWINS calculations is that, the effect of introducing a disk braked freight wagon that is much quieter than the cast iron braked wagon highly depends on the track quality. On a track with medium to high roughness the effect is about 2 dBA, but with a smooth track a more perceivable effect of reduced excitation from the wheel as well as reduced radiation from the wheel is seen and a reduction of 10 dBA is predicted. The findings of this investigation were used to assess the noise reduction potential for freight traffic in general.

On interior noise, the components of the modular framework, which are defined and formulated in the earlier project phases, were subjected to a detailed validation. An investigation of the interior sound field distribution for interior sources was validated by loudspeaker testing on full scale vehicles. A review of the state acoustic modelling of sound attenuation of ducts for air conditioning, simulations and validation measurements of ducts systems have been presented. Both of the statistical methods SEA and ray tracing are capable of accurately modelling the interior sound level distribution in a railway car; however, in the low-frequency region 125–250 Hz, both models over predict the sound pressure level. For HVAC ducts, it is shown that a 3D FEM methodology yields good prediction results also above the cut-off frequency of the duct, where the sound field the sound field is three-dimensionally complex distributed.

An air-conditioning unit on the roof and a train floor have been chosen to demonstrate and validate various methods for predicting structure-borne and air-borne noise transmission into the train interior. Methods investigated include in-situ Transfer Path Analysis (iTPA), FEM, and SEA. The “Body-in-White” (BiW) predicting approach is well-researched in the automotive industry and is reportedly able to produce highly accurate predictions. The approach is promising. The simulated acoustic behaviour fits qualitatively. Due the size of the models the computational effort is considerable. The methodologies developed and their validation represent an important further development of the prediction models for railway vehicle design.

Regarding characterisation of sources and assemblies the application and validation of new and improved methodologies was the major focus of work in 2019. The emphasis was on the characterization of structure-borne sound sources. On the basis of the proposals of improvements made in earlier project phase characterisation of different sources was executed as traction motor, air-condition unit and air compressor. The procedure according to the draft standard ISO 20270 was fully applied. A new and innovative method for air-borne sound source characterisation based on vibration measurements was developed, tested with computer simulation and validated for railway gear box. Also, the numerical characterisation for track at low frequencies has been investigated and improved.

Finally, the agreed industrial methodology for the specification of noise and vibration requirements of sources and assemblies as well as for a standardised characterisation has been proposed S2R IP1 projects and corresponding TDs.

During 2019, six deliverables were planned for WA5.2. All deliverables have been released. The WA managed to catch up after the delay materialised in the projects. WA5.2 has reported having accomplished 100% of the planned work up to the end of 2019, which represents 50 % of the overall TD.

Work Area 6 - Human Capital

The objective of WA 6 is to analyse the impact of future innovations resulting from the S2R IPs on the human factor in the rail system. The requirements and future needs of the humans in the system need to be taken into account in order to fully benefit from the advances in technology, for the workforce, but also for railway customers. The focus of the investigation lies on the impact on railway staff, but the impact on the customer is also considered.

WA6 Human Capital								
2015	2016	2017	2018	2019	2020	2021	2022	...
			Tender HC					
			Ongoing: IMPACT-2, SMaRTE					

The topic is addressed in the CFM-project IMPACT-2 WP 8 and complemented by the “Human Capital tender” and the ongoing OC project SMaRTE.

With regards to the job profile, in general, there will be greater emphasis on IT-qualifications related to data processing and data analysis rather than on-site mechanical engineering jobs. Many innovations are associated with data processing (example: track maintenance): data acquisition, analysis, decision-making based on the data etc. This data skill is spreading throughout all the professions. Also robotics (e.g. for maintenance) and artificial intelligence/neural networks for data analysis will increase in importance. Knowledge of IT areas will be more and more relevant and will be essential for achieving a more performant railway system.

With regards to the social interactions, there will be a shift from individual work and work in small teams to a multi-disciplinary approach/cooperative work, e.g. with IT experts, technicians, engineers working together. This requires advanced social skills to be able to work well with other professions and take their perspective into account.

Working conditions will most likely improve. Less on-site monitoring (e.g. of infrastructure) will be required due to remote monitoring. However, staff with (higher) IT skills will be needed to analyze

and interpret the data. However, new technologies can create new stresses for the staff. Therefore, it is necessary to involve staff early on to make them and their requirements a central part of the project rather than making them a victim of the change.

The requirements and needs of the humans in the system (staff and customers) must be properly taken into account in order to fully benefit from the advances in technology, both for the workforce and the railway customers. With respect to the impact of new technologies on job profiles, a complex system effects can be forecasted. Digitalisation and automation is a key enabler for the rail system and is essential that the impacts of these areas are properly addressed by the sector.

The Human Capital Report series published by the JU had a strong focus the impact on skills. These series of publications presented the skills ecosystem for the sector, assessed the impact of the Shift2Rail innovation programmes on employment and skills and finally, different measures and recommendations were defined to bridging the skills gap for the rail sector.

Within the scope of the customer oriented design, an Experience map tracing the passenger journey cycle was defined together with the different needs which are not met. This activity was supported by the development of a travel survey which helped to identify the influence of key factors behind choice of rail. Findings identified key gaps in rail provision and barriers for non-rail passengers. Based on the above mentioned information, recommendations were developed included actions to improve affordability and ticket flexibility, safety and security and facilities around stations, rolling stock comfort and trip planning tools. More costly recommendations included improving reliability, frequency and first and last mile travel experience.

During 2019, 4 deliverables were planned, out of these three have been released. WA6 has reported having accomplished 75% of the planned work up to the end of 2019, which represents 85 % of the overall TD.

1.7.7. IPx activities

Current activities in S2R are developing the fundamental building blocks that will allow the creation of interoperable solutions providing practical answers to the challenges highlighted in the S2R Master Plan and a contribution towards the achievement of the programme objectives.

The combination of these building blocks enabled the identification of new railway capabilities for the next generation of railway system, which has been highlighted in the MAAP Executive View (PART A).

In 2018, it became evident that the originally planned S2R activities (MAAP Part B), developing the fundamental building blocks of the programme, only partially address the potential disruptive technologies can bring to the railway capabilities.

For this reason, the S2R JU introduced in its Annual Work Plan 2018 and 2019 new forward looking activities, in which disruptive technologies or thinking and exploratory research can accelerate the pace towards radical system innovation. The new MAAP Part B includes a high-level description of the IPx work areas.

One of the cornerstones of IPx activities relates to the recognition of railway as an integrated system of systems and the performance of R&I activities underpinning such concept. The railway reference Functional System Architecture (which is encompassing all subsystems, including CCS) shall build upon a renewed concept of operations and mission, identify the functions and services to be delivered to

the actors of the value chain and how all this impacts the enablers to deliver it, i.e. people, resources and components (hardware and software).

While IPx focuses on functions and services, yet it does not cover all the interfaces under the work of Linx4Rail, for example with urban transport as well as a wider vision on the concept of operations.

Disruptive Innovation and Exploratory Research

The initial activities under IPx focused on the following topics:

- Concepts for the future autonomous railway vehicles “train-centric”;
- Promising disruptive technologies impacting automation systems and maintenance concepts;
- Digitalisation of railways services, operations and production;

These topics are addressed in the following four projects that the S2R JU selected in Open Calls in 2018:

- Transversal exploratory research activities for railway to identify new opportunities for innovative research and facilitate the cross-fertilisation of knowledge from other disciplines (**Ter4Rail**): The project should also support the S2R JU in its dissemination activities and have close links with the European Technology Platform ERRAC. In 2019, a first proposal for a rail innovation video context for young generation was proposed to the S2R JU. In addition, the project delivered a comprehensive map of the state-of-the-art and major tendencies of innovative research in rail technology and key stakeholders in the R&I of rail related activities. The project has also identified non-rail actors to assess the potential for synergies, as a basis for the Rail Innovative Research Observatory to be delivered at the end of the project. A detailed report on the features of urban scenarios 2050 and technologies influencing the development of rail transport has been drafted.
- Block chains as a Distributed Ledger for Attribution of Remote Condition Monitoring Data in Rail (**B4CM**): The overall aim is to develop and deliver a blockchain-based testbed for the attribution of data costs across organisational boundaries, to demonstrate the operation of the framework in the context of the European Rail Industry, enabling future developers to extend the tools produced based on a known working configuration. Due to difficulties in allocation of resources faced by one beneficiary, the project started its activities in late 2019.
- Flexible medium voltage DC electric railway systems (**MVDC-ERS**): The project started in December 2018. It will produce ground breaking knowledge on the next generation of railway power supplies and on-board traction systems to propel electric rail transport into the era of distributed generation, in line with the EU roadmap for deployment of new green transport technologies in Europe and worldwide. One of the first results is a comprehensive literature review of converters suitable for MVDC railway electrification, providing the grounds for future project work on comparative evaluation of topologies of static converters for the supply of medium voltage DC rail electrification networks.

- **FLEX-RAIL**, has a vision to target a lean, integrated and flexible railway system, which will stimulate further innovation within the rail sector and will ensure that rail services can address the future user needs. The project will forecast the evolution of key fundamental technologies, identify of technical risks and of potential blocking points, study future user needs, formulate technological concepts of future rail system and finally deliver recommendations and implications for the S2R activities.

To date, the project has delivered a review of trends, transport sector innovations and blue-sky projects. This comprehensive inventory of innovations and trends was made available in an interactive webpage (<http://flexrail.org/>).

Furthermore, two Open Call projects addressing the above objective started in December 2019:

- **Translate4Rail**: Translation for breaking language barriers in the railway field offering drivers a comprehensive set of predefined standardised messages to exchange with the infrastructure managers/traffic controller under various circumstances.
- **RAILS** project, investigating Artificial Intelligence for rail automation, predictive maintenance and defect detection, traffic planning and capacity optimisation. The funding will enable PhD researchers to investigate ways to transfer existing Artificial Intelligence developed in other sectors, in particular transport, which can support a fast take up of this technology in railways.

Rail Functional System Architecture: a system of systems approach

In 2019, the activities under the acronym IPx were redesigned to set the basis for an integrated system approach, recognizing the nature of system of systems to be tackled in its integrity to deliver the transformational changes enabled by digitalization and automation: it requires an holistic understanding and the interaction of vehicle / infrastructure / operations and processes / staff /users / regulation and standards.

2019 saw the launch of the activities toward a railway Functional System Architecture and a Conceptual Data Model (CDM), introducing a structured approach to the functional digital transformation of the railway systems in its component. The starting point has to be a shared vision on the future concept of operations of rail – possibly declined per segments when relevant and business models – under the policy leadership of the European Commission and with the involvement of the European Union Agency for Railways, in its regulatory role.

With IPx activities, S2R is already looking beyond currently planned technology applications (of the Technology Demonstrators) and is integrating them with disruptive innovations, as those described above.

Concerning the Functional System Architecture, new system approaches are considered starting with control command and signalling side building upon the input of some Infrastructure Managers with a Reference Command Control Signalling Architecture (RCA). More recently, some Railway Undertakings started to develop an Open CCS On-board Reference Architecture (OCORA). Both activities built on work started almost a decade ago in the context of EULYNX.

All these piecemeal activities are now started being integrated in the project **LinX4Rail** (operational since in December 2019), with the objective of developing the first railway reference Functional System

Architecture and defining a Conceptual Data Model (CDM), delivering a system-of-systems approach and enabling seamless data exchange.

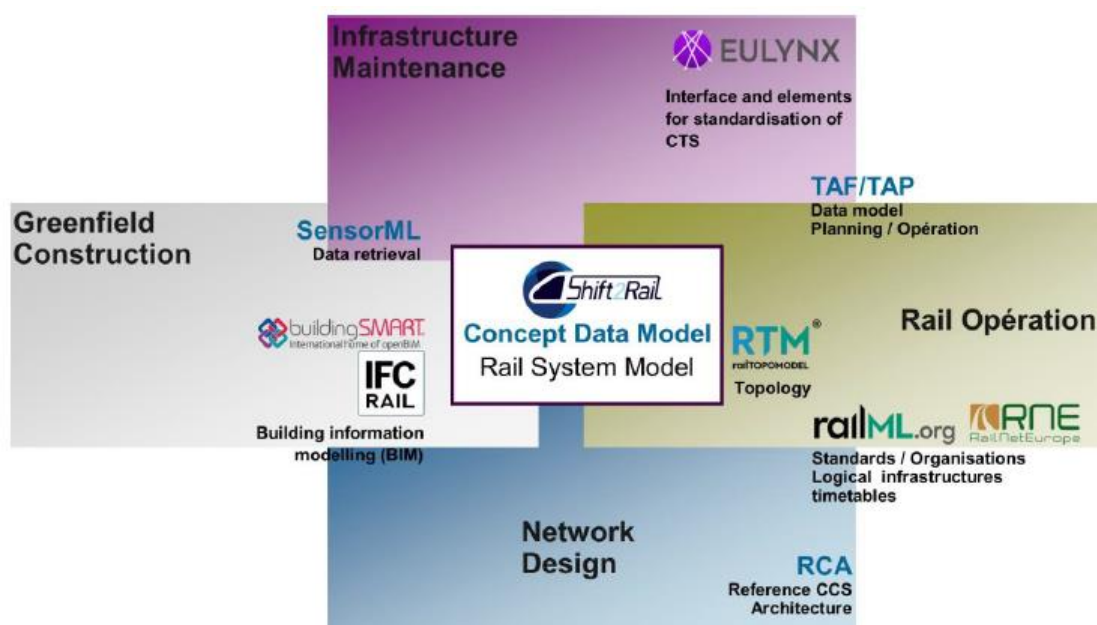


Figure X: Conceptual Data Model (CDM) ecosystem

A renewed Programme Governance and Change Management

The new integrated system approached introduced formally in 2019, although in its evolution since 2016, required also the establishment of a renewed Programme Governance and Change Management. IPx will work in conjunction with all IPs and CCA and liaise with the ED Programme Board to streamline the change management within the running projects, ensuring the latter follow well evaluated business cases for all relevant stakeholders.

The rail Functional System Architecture will become the base for a stronger Programme and rail sector integration, starting with achieving a European sectoral agreement on the way the system is operated in the future, notably with the use of the ERTMS game changers. It will set the ground for multimodal collaboration, especially in area dealing with similar aspects such as air traffic management, smart mobility, defence, etc. This approach will also enable a new set of business cases and potentially new services implementing a new system of system architecture and a new way of sharing data, thus leading to increased benefits and performance that would potentially override any concerns on migration costs.

The process, which has been agreed by Members and formalized in an ED Decision, shall ensure that individual implementing Projects' Steering is consistent and coherent with the integrated system approach considering that each single innovative solution will affect the rail system as a whole.

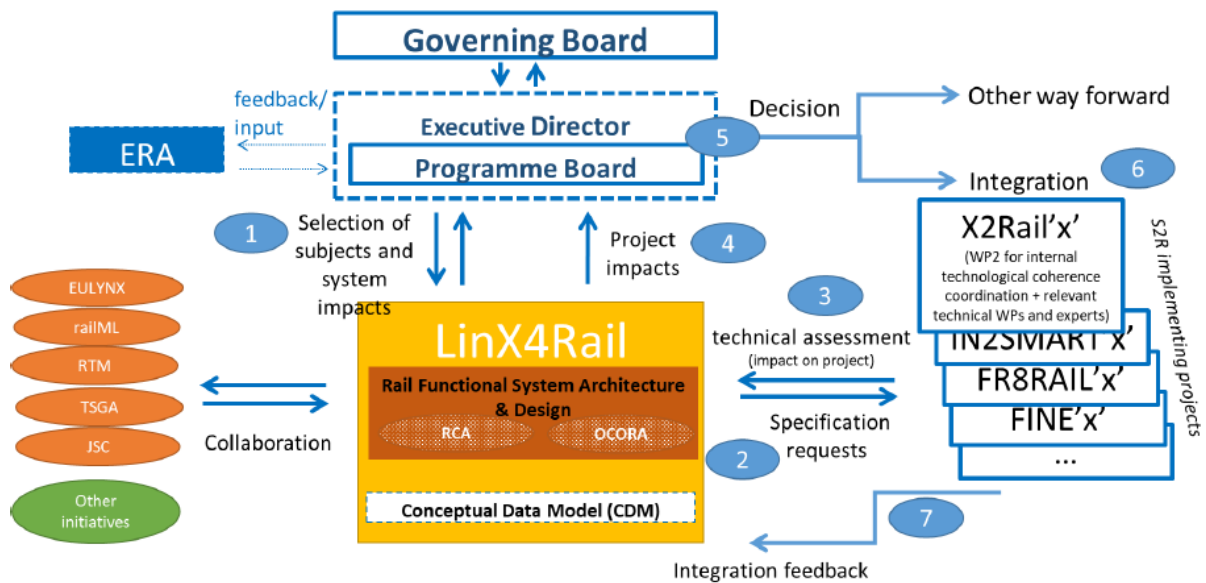


Figure Y: renewed Programme Governance and Change Management

1.8. Calls for tenders

With regard to the implementation of procurement activities, the S2R JU has complied with the principles of the EU Financial Regulation and the guidance provided in the European Commission Procurement Vademecum. This resulted in the implementation of activities obtaining the best value for money compared to other similar programmes.

The values established for the different procurement procedures, which are below any materiality level considering the total value of the R&I activities and the Programme, result from the collective knowledge of involved staff and their experience in previous private and public organizations.¹⁸

The S2R JU published the following calls for tenders in 2019 (open tender procedures):

S2R.19.OP.01 Railway operators, staff and passengers' expertise

The objective of this tender is to avail the Contracting Authority with the services of 3 contractors to ensure that the S2R JU is in the position to achieve its objectives, combining the expert knowledge of its diversified membership with the one of stakeholders not currently directly involved in the S2R Programme. Each framework contract will be implemented through specific contracts where the type of expertise, the duration of the specific services and any other relevant element will be detailed.

There are 3 lots:

- 1) Expertise in European railway operations;
- 2) Expertise in European railway human capital aspects;

¹⁸ Also in answer to point 15 of Discharge 2016 of EP, reference P8_TA-PROV(2018)0173.

- 3) Expertise in European railway passenger aspects.

The contract notice was published in the EU Official Journal on 17 May 2019.
The total value of the framework contract is EUR 2 000 000.

S2R.19.OP.02 Strategic Support to the S2R JU – provision of services to the S2R JU in the fields of the following three Lots:

- 1) LOT 1: Strategy Advice: Lot 1 covers the provision of strategy advice on the content and structure of the activities of the S2R JU or/and the S2R JU Programme and the future S2R JU remit.
- 2) LOT 2: Support to Programme management: The objective of this lot is to support the S2R JU with the implementation of the applicable programme management processes and procedures, adapted to the specific S2R JU Programme business needs. This lot is about the execution of recurring defined programme management processes/procedures that support the S2R JU Programme Management operations.
- 3) Lot 3 – Legal Assistance: The objective of this lot is to support the S2R JU with the provision of services concerning legal support and assistance in different EU legal fields, such as public procurement, grant management, data protection, intellectual property rights (including copyright issues), pre-litigation and litigation support.

A prior information notice 2019/S 242-593674 was published on 16/12/2019.
The total value of the framework contract is EUR 3 300 000.

S2R.17.OP.04 and S2R.18.OP.02. Support to the ERTMS Deployment action plan as baseline for Shift2Rail (IP2) innovative solutions – Contract Implementation – Implementation of a 4 year framework contract with a total estimated value of EUR 8 Million.

The objective of this tender is to ensure the establishment of the essential baseline for the deployment of the future S2R Innovative Solutions through the support to the coherent deployment of European Railway Traffic Management System, a horizontal priority aiming at ensuring in the interoperability of the EU railway system. The action is a part of a global project on deployment of ERTMS in the European Union, as defined in the TEN-T Guidelines and the MoU signed between the EC and the European Railway Associations in 2016. The estimated budget for 2019 amounts to EUR 0.7 million (specific contracts for 2019).

As stated in point 3.3 of the Annex I of the [Financial Regulation 2018/1046](#), the S2R JU, as a contracting authority, shall publish a list of contracts on its website no later than 30 June of the following financial year for specific contracts under a framework contract. In 2019, the specific contracts implementing the FWC were published here: <https://shift2rail.org/participate/recipients-shift2rail-funds/>

It worth noting that at the end of 2019, the following tenders are still to be finalized:

- “Technical solutions for intermodal information exchange for freight” is pending the results of a "Study on the opportunities to evolve TAF TSI to exploit synergies with e-enhanced

multimodal logistics" tendered by DG Move for input into ERA works, so to avoid duplication of scope;

- "Strategic support to the S2R JU" (open procedure - framework contract), is pending the alignment with the CCA activities, in particular the "business case" work stream.

Preparatory works are well advanced for launch in 2020.

1.9. Dissemination and information about projects results

The S2R JU aims at the dissemination of results emanating from its R&I Programme, which is made-up of Shift2Rail projects. Dissemination activities mainly target the European scientific and academic community working in the mobility field, and specifically rail, but not exclusively. Dissemination plays an essential role within the S2R Programme, being a core ingredient of its success.

All JU dissemination activities are designed to consolidate the S2R JU as the key European platform for R&I in the railway sector, where all interested parties, including manufacturers, infrastructure managers, rail operators and regulators can exchange in helping move European railway forward. The S2R JU website hosts specific Call for Members (CFM) Projects activities and links to Open Call (OC) Projects' websites and dissemination activities, as well as the Lighthouse Projects and other related projects (See also section 2.1).

Dissemination of project results was a prominent element of various Shift2Rail events during 2019, including the S2R 2019 and 2020 Info Days in Brussels, the Shift2Rail Dialogue at the Digital Transport Days in Helsinki, as well as the World Congress on Rail Research in Tokyo. At these events project results were presented and promotional material was disseminated, while project coordinators and members were invited to attend and network with new potential partners. More details on these events are available in Section 2.1.1.

2019 also saw the creation and use of the new Shift2Rail Project Communication Planning Tool. This new tool allowed all projects to share dissemination information with one another and also with the Shift2Rail Communication Team. The tool has had a multiplier effect as we have seen an increase on social media and in newsletters of the promotion of results by organisations working with Shift2Rail as well as external parties. This joint planning tool has also facilitated the identification of synergies between key messages of projects and has encouraged them to organise joint mid-term or final conferences (examples include: ARCC, FR8RAIL, FR8HUB, SMART, FFL4E, MO, INNOWAG joint final conference, PIVOT, Mat4Rail, RUN2Rail, Fair Stations joint final conference, IN2SMART and MOMIT joint final conference, ATTRACKTIVE & Co-Active joint final conference). Moreover, this tool has allowed Shift2Rail to have a global overview of all project dissemination activities, ensuring we are able to promote results in a timely and effective manner. It also has allowed monitoring and advising projects in the dissemination of their work in order to ensure they support the programme approach and contribute to the overarching Shift2Rail communication strategy.

Additionally, a cluster of S2R projects working under the S2R Innovation Programme 5 on Rail Freight (IMPACT-2, FR8Rail, FR8Hub, and IN2TRACK) jointly made use of the "*Common Dissemination Booster*" tool made available by the EC Common Support Centre (RTD, Unit J.5). This process led to the development of a [policy brief and a video](#) which both outlined the challenges and opportunities associated with the need to tackle innovation uptake as well as promote the economic attractiveness of rail freight.

Project Final Conferences in 2019:

22 January – In2Track Final Conference in Paris, France
18 June – ARCC, FR8RAIL, FR8HUB, SMART, FFL4E, MO, INNOWAG Final Conference in Munich, Germany
12 July – X2Rail-1 Final Event in Potsdam, Germany
16 September – RUN2Rail Final Conference in Paris, France
17 September – PIVOT, Mat4Rail, RUN2Rail Final Conference in Paris, France
17 September – FINE1 final Conference in Paris, France
18 September – Mat4Rail Final Event in Paris, France
25 September – OPTIYARD Final Conference in Paris, France
2 October – IN2DREAMS Final Conference in Milan, Italy
17 October – OPEUS Final Conference in Paris France
30 October – ASTRail Final Conference in Vienna Austria
5 November – ATTRACKTIVE and Co-Active Final Event in Brussels, Belgium
11 December – FAIR Stations Final Event in Brussels, Belgium

1.10. Operational budget execution

In 2019, the S2R JU Budget Amendment 1, adopted by the Governing Board on 24 June 2019, was kEUR 82 765 in commitment appropriations, of which kEUR 78 753 for operational expenditure. In payment appropriations, it was kEUR 81 257, of which EUR 76 900 was for operational expenditure.

By year end, in agreement with the Governing Board as per minutes of the meeting of 4 December, the Executive Director transferred kEUR 2 048 in terms of commitments and payments appropriations, from Title 3 to Title 4 in order to be made available immediately to the S2R JU Call 2020, in accordance with S2R JU FR art.6.5 and with the GB Decision.

As part of the same agreement, kEUR 306 were reinscribed in the budget 2019 from Members projects that release this overall amount due to efficiencies in the resources consumption. This amounts is recorded as assigned revenues. Following these changes, the total budget commitment appropriations for 2019 amounted to kEUR 83 071 and kEUR 81 563 in terms of payment appropriations.

Based on the above, the Operational Budget Title3 was implemented at kEUR 76 705 in commitment appropriations (100%) and kEUR 66 310 (88%) in payment appropriations (both excluding the unused appropriations not required in the financial year). The payment appropriations' implementation presents a constant improvement compared to previous years (78.6% in 2017 and 82.3% in 2018).

This Operational budget corresponds to approximatively 93% of the overall S2R JU Budget.

1.11. In-Kind Contributions

In accordance with article 4(3) of the S2R Regulation, *“the members of the S2R Joint Undertaking other than the Union shall report by 31 January each year to the Governing Board of the S2R JU on the value of the contributions referred to in paragraph 2 made in each of the previous financial years”*.

Article 4(2) of the S2R Regulation establishes that the total contribution to be provided by the Other Members¹⁹ and totalling EUR 470 million shall consist of:

- **IKOP²⁰ (in-kind operational)**: at least EUR 350 million, including at least EUR 200 million from the founding members other than the Union and their affiliated entities, and at least EUR 150 million from Associated Members and their affiliated entities. In accordance with Article 16(3)b of the S2R Statutes, IKOP consists “*of the costs incurred by them [the Other Members] in implementing indirect actions less the contribution of the S2R JU and any other Union contribution to those costs*”.
- **IKAA (in-kind other activities)**: at least EUR 120 million, of which at least EUR 70 million from the Founding Members other than the Union and their affiliated entities, and at least EUR 50 million from Associated Members and their affiliated entities. These contributions shall consist of the costs incurred by them in implementing additional activities outside the work plan of the S2R Joint Undertaking, which are complementary to this work plan and contribute to the objectives of the S2R Master Plan. Other Union funding programmes may support those costs in compliance with the applicable rules and procedures. In such cases, Union financing shall not substitute for the in-kind contributions from the members other than the Union or their affiliated entities.

The aforementioned In-Kind Contributions, which consist of financial expenditure executed by the Members – salaries, assets, operations, etc. – to achieve the S2R Programme and its Projects, are in addition to the financial contribution of the Other Members to the 50% of the administrative costs of the JU.

Other Members’ reporting for 2019

The Other Members of S2R submitted their reporting on IKOP and IKAA to the JU by 31 January 2020. All Members provided their reporting.

The Lighthouse projects are excluded from this reporting as assimilated to open calls and within the administrative management of the European Commission.

This report covers IKOP related R&I activities as from Sept 2016 till Dec 2019; while in terms of IKAA the activities are considered eligible as from the date of acceptance by the Other Members of the S2R JU Statutes, by means of their respective letters of endorsement.

In accordance with Article 4(4) of the S2R Regulation, the Other Members shall have the costs related to IKOP and IKAA certified by an independent external auditor appointed by the entity concerned.

IKOP and IKAA Certification

By 30 April 2019, the Other Members have provided the JU with audit certificates on the Total Project Costs (and consequently IKOP) and IKAA costs declared for the year 2018. After due examination of the relevant certification and, in particular, the audit standards applied to the issuance of the “audit certificates”, the acceptable corresponding IKOP contributions have been “validated” by the Executive Director in 2019. They have therefore been accounted towards the obligation set in Article 4(2) of S2R

¹⁹ The “Other Members” consist of the Founding Members of the JU, with the exclusion of the Union, and the Associated Members.

²⁰ As laid down in Article 16(2) and Article 16(3)(b) of the Statutes.

Regulation to the Other Members as well as recorded as Net Assets of the Joint Undertaking in the Annual Accounts 2019.

Due to the current pandemic situation, the certification of IKOP and IKAA for 2019 is expected to take longer than usual, but in any case to be concluded by third quarter 2020.

With regard to the Final Annual Accounts of S2R, all IKOP contributions reported but not validated in 2019 will be accounted for as “to be validated” considering that:

- 66% of the IKOP reported “to be validated” is already supported by the relevant certification; the rest is expected to be certified by year end;
- in accordance with the accounting principles, IKOP of year n-1 will be accounting for only in year n accounts, if and once validated in year n.

On 1 May 2020, based on the audit certificates received and the Projects’ cost statements, the situation of IKOP and IKAA is as following:

	TPC/IKOP REPORTING												
	TOTAL PROJECT COST				CO-FUNDING			IKOP					
Other Members	AAR 2016 - AAR 2018	AAR 2019	TOTAL	of which CERTIFIED	AAR 2016 - AAR 2018	AAR 2019 estimates	TOTAL	AAR 2016 - AAR 2018	AAR 2019	TOTAL	Validated as Net Assets	To be validated	Deviance as per MA Art 2(2)
Alstom	18.657.659	12.044.851	30.702.510	18.639.214	7.850.589	5.632.784	13.483.373	10.807.070	6.412.067	17.219.138	10.808.514	6.410.623	43,92%
Hitachi / Ansaldo STS	11.713.055	6.155.626	17.868.682	17.868.682	5.200.594	2.735.560	7.936.154	6.512.462	3.420.066	9.932.527	6.512.462	3.420.066	44,41%
Bombardier Transportation	11.310.426	7.744.721	19.055.148	11.221.202	4.589.102	3.268.480	7.857.582	6.721.325	4.476.241	11.197.565	6.570.523	4.627.042	41,24%
CAF	12.580.202	7.636.525	20.216.727	20.216.727	5.475.646	2.957.489	8.433.135	7.104.556	4.679.035	11.783.591	7.104.586	4.679.005	41,71%
Network Rail	4.370.084	3.388.606	7.758.689	3.630.860	2.301.770	1.644.334	3.946.104	2.068.314	1.744.271	3.812.585	1.659.126	2.153.459	50,86%
Siemens	12.936.037	7.775.806	20.711.843	20.499.457	5.669.782	3.509.424	9.179.206	7.266.255	4.266.382	11.532.637	6.196.061	5.336.576	44,32%
Thales	9.247.061	4.817.656	14.064.717	3.564.996	4.148.873	2.153.697	6.302.570	5.098.188	2.663.960	7.762.147	726.210	7.035.938	44,81%
Trafikverket	9.077.058	8.527.034	17.604.092	3.417.937	2.780.916	3.787.353	6.568.269	6.296.142	4.739.681	11.035.824	2.736.609	8.299.215	37,31%
Founding Members	89.891.583	58.090.825	147.982.408	99.059.073	38.017.272	25.689.121	63.706.394	51.874.311	32.401.704	84.276.015	42.314.090	41.961.925	
Aerfitec	1.476.573	1.318.522	2.795.095	2.368.526	656.189	585.951	1.242.140	820.384	732.571	1.552.955	464.344	1.088.610	44,44%
Amadeus	189.379	2.042.560	2.231.940	65.185	84.240	502.145	586.385	105.140	1.540.415	1.645.555	-	1.645.555	26,27%
AZD Praha	2.027.738	1.090.379	3.118.116	3.118.116	883.646	494.150	1.377.796	1.144.092	596.228	1.740.320	1.144.092	596.228	44,19%
Competitive Freight Wagon	1.968.902	868.387	2.837.289	291.340	890.526	385.911	1.276.437	1.078.376	482.476	1.560.852	-	1.560.852	44,99%
Deutsche Bahn AG	14.456.536	8.179.942	22.636.478	22.636.478	4.735.525	1.682.367	6.417.891	9.721.011	6.497.575	16.218.586	9.708.472	6.510.114	28,35%
Diginext	1.880.357	882.794	2.763.151	1.880.357	835.631	392.313	1.227.944	1.044.726	490.480	1.535.207	1.044.726	490.480	44,44%
EUROC	1.119.561	1.094.081	2.213.642	-	493.211	468.335	961.547	626.349	625.746	1.252.095	-	1.252.095	43,44%
Faiveley - Wabtec	3.991.431	3.898.362	7.889.793	3.663.639	1.713.279	1.416.008	3.129.287	2.278.152	2.482.353	4.760.505	1.919.229	2.841.277	39,66%
Hacon	4.262.423	2.439.972	6.702.395	6.702.395	1.889.206	1.089.044	2.978.249	2.373.217	1.350.929	3.724.146	2.373.207	1.350.939	44,44%
Indra	6.125.438	4.659.691	10.785.129	10.785.129	2.724.260	2.064.182	4.788.442	3.401.178	2.595.508	5.996.687	3.310.294	2.686.393	44,40%
Kontron - Kapsch	3.025.976	1.375.162	4.401.138	4.401.138	1.344.743	611.122	1.955.865	1.681.233	764.040	2.445.273	1.681.233	764.040	44,44%
KnorrBremse	2.044.614	2.654.572	4.699.186	4.653.663	904.739	1.011.942	1.916.680	1.139.875	1.642.631	2.782.506	1.089.400	1.693.106	40,79%
MerMec	1.645.351	1.916.976	3.562.328	1.645.351	730.643	851.801	1.582.444	914.708	1.065.175	1.979.884	914.708	1.065.175	44,42%
SmartDeMain	2.944.302	1.428.012	4.372.314	1.748.277	1.355.605	702.282	2.057.887	1.588.697	725.730	2.314.427	117.658	2.196.769	47,07%
SmartRaCon	2.692.390	1.556.250	4.248.640	941.245	1.001.931	689.900	1.691.831	1.690.459	866.350	2.556.809	-	2.556.809	39,82%
SNCF	2.165.521	773.180	2.938.702	849.976	1.065.913	391.108	1.457.021	1.099.608	382.072	1.481.680	-	1.481.680	49,58%
SWITRACKEN	646.312	493.019	1.139.331	235.130	276.600	218.681	495.281	369.712	274.338	644.049	5.742	638.307	43,47%
Talgo	765.071	1.283.490	2.048.561	2.048.561	336.597	706.840	1.043.437	428.474	576.650	1.005.124	425.073	580.051	50,94%
Virtual Vehicle Austria Consortium VVAC+	3.889.150	2.882.069	6.771.219	5.783.873	1.745.403	1.213.261	2.958.664	2.143.747	1.668.808	3.812.555	2.132.314	1.680.241	43,69%
Associated Members	57.317.024	40.837.420	98.154.444	73.818.379	23.667.885	15.477.345	39.145.229	33.649.139	25.360.076	59.009.215	26.330.492	32.678.722	
Total	147.208.607	98.928.246	246.136.853	172.877.453	61.685.157	41.166.466	102.851.623	85.523.450	57.761.779	143.285.230	68.644.583	74.640.647	41,79%

IKAA REPORTING				
Other Members	In-Kind Additional Activities as at 1 June 2019	In-Kind Additional Activities as at 30 April 2020	TOTAL	of which Certified as at 1 June 2020*
Alstom	11.912.418	-	11.912.418	11.912.418
Hitachi / Ansaldo STS	3.710.942	1.351.330	5.062.272	3.710.942
Bombardier Transportation	15.688.168	-	15.688.168	15.688.168
CAF	8.946.296	-	8.946.296	8.946.296
Network Rail	2.220.203	-	2.220.203	-
Siemens	8.100.000	-	8.100.000	8.100.000
Thales	7.865.106	-	7.865.106	7.865.106
Trafikverket	25.159.312	-	25.159.312	-
Founding Members	83.602.444	1.351.330	84.953.774	56.222.930
Aerfitec	1.424.635	906.397	2.331.032	-
Amadeus	2.750.000	5.315.377	8.065.377	-
AZD Praha	1.000.901	599.657	1.600.558	1.000.901
Competitive Freight Wagon	631.132	-	631.132	-
Deutsche Bahn AG	28.931.113	153.017	29.084.130	29.084.130
Diginext	810.000	180.000	990.000	530.000
EUROCC	2.126.240	1.000.000	3.126.240	-
Faiveley - Wabtec	4.375.267	187.672	4.562.939	4.375.267
Hacon	7.557.668	6.435.198	13.992.866	13.992.866
Indra	1.802.045	844.094	2.646.139	1.708.045
Kontron - Kapsch	2.138.345	1.515.534	3.653.879	3.653.879
KnorrBremse	7.387.546	1.904.264	9.291.810	6.696.236
MerMec	1.796.244	450.000	2.246.244	2.246.244
SmartDeMain	3.293.830	208.726	3.502.555	1.706.180
SmartRaCon	992.452	-	992.452	-
SNCF	934.632	-	934.632	-
SWITRACKEN	211.892	-	211.892	2.461
Talgo	2.806.984	79.337	2.886.321	2.886.321
Virtual Vehicle Austria Consortium VVAC+	5.866.379	20.448	5.886.827	5.886.827
Associated Members	76.837.306	19.799.720	96.637.027	73.769.357
Total	160.439.751	21.151.050	181.590.801	129.992.287

IKOP

The progress and acceleration realized since the end of 2016 is confirmed and is well in line with the usual Programme Management S-Curve (with 40% of linear time consumed since September 2016 and with 41.5% of the IKOP objective reported).

As indicated under the definition of IKOP, these costs represent the difference between the Total Project Value and the S2R JU co-funding (or estimated).

The 2019 IKOP is the cumulative result of the activities awarded by the S2R JU to the Other Members:

R&I activities				
				EUR million
				%

In order to allow the S2R JU to be in the position to sign the relevant grant agreements, the Union provided the necessary Commitment Appropriations to match the S2R co-funding of EUR 216.7 million above (excluding OC), against the Other Members' commitment of EUR 489.9 million. In terms of Union Payment Appropriations, they were used to provide the pre-financing up to 45% of the estimated co-funding in accordance with the relevant provisions of the grant agreements.

It should be noted that the estimated requested co-funding included in the 2019 Other Members' declarations is within the limits of the provision of the relevant Membership Agreements. In fact, Article 2.2 of each Other Member's Membership Agreement signed with the S2R JU establishes that *"the Member agrees to limit its reimbursement request in indirect actions funded under Article 3(1)(a) of the S2R JU Regulation to an amount not exceeding 44.44% of the Member's total eligible costs in implementing indirect actions. In case of research and innovation activities delivering the expected results through a series of intertwined actions throughout successive S2R JU Annual Work Plans, and without prejudice to the provisions concerning co-funding rates established in the S2R JU Annual Work Plans, this 44,44% threshold shall be applied cumulatively taking into account the final amount of reimbursement requested at the end of the last action implementing the specific intertwined research and innovation activities"*.

The percentage resulting from the cumulative declarations in 2019 is 41.79%, within the maximum level of 44.44%.

However, it is to be noted that the intermediary reports of the following Members show the most important deviation with respect to an IKOP rate below 55.56%: Network Rail, SmartDomain, SNCF and Talgo. This will be followed up by the S2R JU in 2020 and in any case will result in a grant final payment which will correspond in a cumulative rate not exceeding²¹ 44.44% rate.

IKAA

In terms of IKAA, the total expected contribution by the end of the S2R Programme is estimated at EUR 169 million (minimum EUR 120 million in accordance with the S2R Regulation). It should be highlighted that the cumulative IKAA declared in this 2019 report amount to EUR 181.6 million, thus exceeding the objective. Out of this amount, EUR 130.0 million were already certified at 1 June 2020.

²¹ In this respect, the Governing Board adopted Decision 16/2018 amending the Other Members' model Membership Agreement.

1.12. Synergies with the Union Programmes, Funds and national funded R&I

During the first months since its autonomy, the S2R JU started some activities and participated to Regional events organized by the Committee of the Regions and European Economic and Social Committee to consider how to make use of activities planned in other Union Programmes and Funds in relation with the Railway sector, in particular EFSI, Regional and Cohesion Fund. This work stream further developed during 2019.

In terms of national funded R&I activities in the Railway sector, the S2R JU invites the relevant Member States to present their programmes and projects in the context of the meetings of the SRG. This allows discussion on ways to interconnect the different activities and ensure that resources are leveraged to achieve the best results. This is an ongoing process, which becomes increasingly relevant in view of standardization processes and market uptake.

In this respect, the S2R JU signed

- a cooperation agreement with the SEESARI initiative on 18 September 2018,
- a MoU with the Czech Republic on 4 January 2019
- and with ETSI on 14 May 2019.

The JU continued contacts with the Rail Baltica Project covering the Baltic States and Poland: the objective is to ensure that rail R&I and, in particular, S2R innovative solutions are embedded in new rail projects.

During 2019, the ongoing work on collaboration agreements, in the form of a Memorandum of Understanding (MoU) or cooperation agreement, which the S2R JU may sign with various European regions and Member States, European and international organizations and bodies was pursued.

In particular, the negotiations with the Basque Region were successfully concluded and a MoU was signed on 22 January 2020.

The collaboration with the Fuel Cell and Hydrogen (FCH) Joint Undertaking started in 2018, with the co-tendering of a Study on the use of Fuel Cells and Hydrogen in the Railway Environment. This resulted in three reports being jointly presented and published on the respective websites²². The cooperation FCH JU / S2R JU came to the attention of the European Parliament and led to a joint presentation there.

This collaboration sets the basis for the future alignment of the respective programmes in view of the hybridization of rail systems making use of the FCH technologies.

Furthermore, because of this identified synergy and following the study recommendations for R&I, FCH JU inserted in their AWP2020 a R&I call on Extending the use cases for FC trains through innovative designs and streamlined administrative framework, as Innovation Action with a funding of maximum 10 million euros.

The S2R JU enhanced its collaboration with the SESAR JU on the matters related to traffic management and functional system architecture.

²² <https://shift2rail.org/publications/study-on-the-use-of-fuel-cells-and-hydrogen-in-the-railway-environment/>

In terms of synergies with other Union Programmes, the S2R JU works closely with the other Joint Undertakings sharing the same building, infrastructure, etc. maximising the opportunity for collaboration in terms of administrative and operational activities.

1.13. Launch of 2020 Calls for Proposals and Tenders

On 14 November 2019, the S2R GB adopted the AWP 2020 and budget that resulted from the work performed by the JU with its Members, partners and Bodies during large part of 2019. The S2R JU published on its website the AWP 2020, containing the text of the 2020 call for proposals in its Annexes 1 and 2, in mid of December 2019. On 7 January 2020, the S2R JU opened the 2020 call for proposals to progress more focused activities in the execution of the S2R R&I Programme in the Horizon 2020 Funding & tender opportunities portal, with a deadline for submission on 21 April 2020. This lengthy process includes the key contribution of the S2R Members, the review and advice at different levels of the SC, SRG, ERA and UR-ID and the adoption of the S2R GB, on the basis of which the overall work was finalized under the responsibility of the Executive Director.

Since its appointment, the Executive Director was requested by the Members to ensure the streamline of the S2R Programme, starting with its administration. The Executive Director, together with the Programme Office, looked at the simplification process introduced by the European Commission through the Lump Sum Grant approach; after extensive internal discussions and analysis decided to propose to the S2R GB, as part of the AWP 2018, the adoption of the Lump Sum Grant approach, which was subsequently implemented through the Lump Sum Pilot in the CFM part of the 2018 Call and maintained in 2019. This met R&I stakeholders expectations that public international bodies in charge of mission-oriented Programmes, such as the S2R JU, are willing and capable to experiment with both bringing in new expertise (e.g. establishing novel forms of collaboration to pool and share expert knowledge) and changing routines and processes to build dynamic organisational capabilities (including performance management, procurement, grants, etc.). The S2R JU is at the forefront of such processes in a risk management approach.

The implementation of the pilot Lump Sum Grant is set up in a confined Programme control framework, i.e. for the Projects to which the S2R JU Members are eligible. In fact:

- a. Although the Lump Sum Grant approach does not require the beneficiaries to report on detailed eligible costs and audit requirements during the implementation stage on the project level, the Total Project Cost of the S2R JU Members is subject to audit and certification in accordance with Article 4.4 of the S2R Regulation on the programme level. Hence, in this specific context, Lump Sum Grants halve the costs of financial audits without undermining reasonable assurance;
- b. The S2R JU Members agreed to limit their request of funding to 44.44% compared to the H2020 rates of 100% (+25% flat rate for indirect costs) or 70% (+25%) depending on the nature of the Action, which is fully described (including FTEs). As a result, the funding to be received by the S2R JU Members does not exceed the 35.5% of the direct costs sustained by the latter to deliver the R&I activities of the S2R Programme ($44.44 / 1.25 = 35.5$). This means that the financial risk embedded in the Lump Sum Grant is extremely contained within the S2R JU: only one third of the costs needed to achieve the results might be exposed to eligibility risks. This is not the case for any other programme under Horizon 2020;

- c. There is a contractual obligation stemming from the Membership Agreement for the S2R JU Members to limit their funding requests up to 44.44%, hence an obligation to deliver at least 55.56% of activities at their own costs. As a result, if the estimated Lump Sum Grant were to be overestimated compared to the Total Project Cost of one action, the concerned Members would be in the obligation to increase their activities up to the level of a balanced cumulative 44.44% funding and 55.56% IKOP (as a difference between Total Project Cost and funding received).

Consequently, the implementation of the Lump Sum Grant approach within the S2R JU Call for Members activities since 2018 and for the successive calls, although for important project values, remains in a confined environment where checks and balances are in place beyond the reporting and payment check and review performed under the Horizon 2020 rules.

The R&I planned to be performed complements the activities already ongoing, with the objectives to reach higher TRLs (up to 7) or start work on specific domains (TRL 0 – 3).

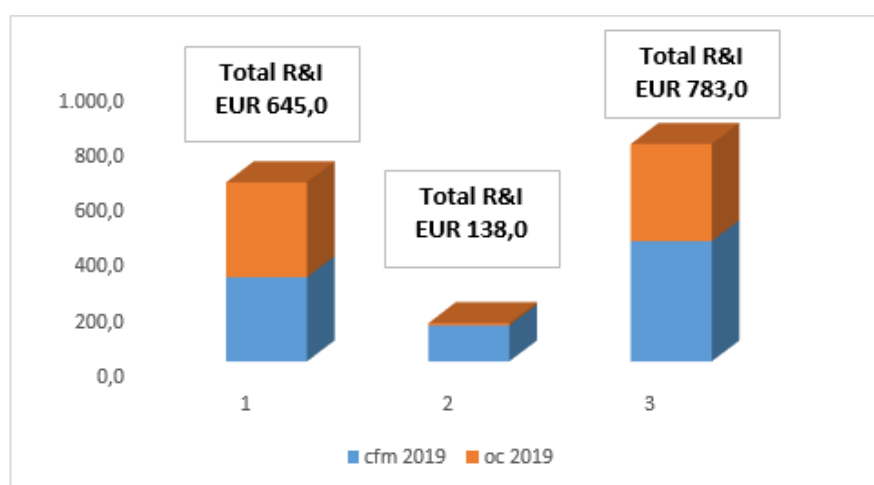
The following tables give a synopsis of the calls.

Activity	Type of call	Value of the actions (*)	Maximum S2R co-funding (*)	In-kind contribution (*)	Other contributions from non Members	Publication date
Call for Proposals	JU members eligible only	123.8	55.4	68.4	0	Q1 2020
Call for Proposals	Open, JU Members excluded	22.8	20.0		2.8	Q1 2020
Call for Tenders	Open	4.4	4.4	0	0	n/a implementation of ongoing contracts
Prizes	Open	0.5	0.5	0	0	
Operational Experts	Open, including through REA and Call for expression of interest (CEI)	0.5	0.5	0	0	
Total		152.0	80.8	68.4	2.8	

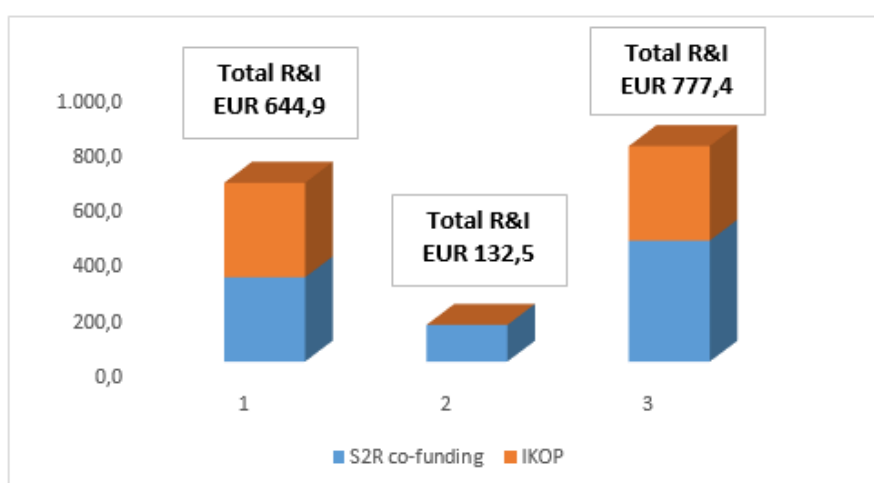
(*) indicative figures in EUR million

With the Calls 2020 R&I activities up and running, the R&I activities performed in the Programme will reach EUR 783.0 million (including Lighthouse Projects as part of the S2R initiative), of which EUR 645.0 million performed by the Other Members with a funding made available by the S2R JU up to a maximum of EUR 303.4 million.

While in accordance with the respective Membership Agreements the Other Members agreed to limit their request for funding to 44.44% of the Total Project Costs, the OC topics are co-funded at the rates established in the H2020 Rules of participation.



S2R JU R&I running activities with the Call 2020 included²³



S2R JU R&I activities Programme expected objectives

It is therefore important to mention that the S2R R&I activities are expected to exceeds the objectives as described in the JU Council Regulations. This will be further confirmed during the years 2020 and beyond.

2. SUPPORT TO OPERATIONS

2.1. Communication activities

Shift2Rail communication activities in 2019 were focused on the continued promotion of the S2R programme, and bringing as much visibility as possible to the results of its R&I activities.

²³ The total amount of 783.0m€ includes and amount of 863k€ committed under a Level 1 Global budgetary commitment covering three tenders from the AWP2019 of which contracts are expected to be signed in 2020.

Promotion of the 2019 Call for Proposals was as usual a major focus of the yearly communication activities, ensuring all relevant events and communication material produced effectively highlighted the details and interest of the Call to as wide an audience as possible: this has contributed to achieve as far as possible inclusiveness.

A key communication output developed and published in 2019, was the first edition of [Shift2Rail's Catalogue of Solutions](#), illustrating successful R&I results in the form of possible stand-alone and integrated implementable solutions. It highlights the benefits of Shift2Rail solutions for final users, operators, infrastructure managers and/or suppliers, as well as specifying delivery dates.

The Catalogue illustrating 54 innovative products and methods developed together with Shift2Rail's Members and stakeholders was launched in Tokyo during the ceremony of the Shift2Rail stand at the [World Congress on Railway Research](#) (WCRR), officially opened by Ambassador Flor, Head of the EU Delegation to Japan. The opening ceremony was attended by other Ambassadors and Embassy officials, as well as by numerous Shift2Rail Member representatives and conference participants. The Shift2Rail stand demonstrated a variety of innovations across our R&I Programme and told a story of how we are working to make mobility and transport more sustainable and connected. The stand design and demonstrations featured were an excellent test-bed for InnoTrans 2020.

In addition to organising its presence at flagship international events such as WCRR and Digital Transport Days, Shift2Rail also supported a number of regional Info Days to spread the awareness of the S2R Programme and mobilise rail stakeholders at local level, encouraging cooperation. More information on these events can be found in the dedicated section 2.1.1. below.

In parallel to the key events organised and participated in by Shift2Rail during 2019, the JU continued to build its audience and stakeholder mailing list by revamping its website and newsletter and consolidating its presence on social media. Moreover, press relations were strengthened in 2019 resulting in a larger media presence. For more detailed information and statistics covering Shift2Rail's communication channels please refer to the dedicated section 2.1.2.

All event and communication activities were supported under the Shift2Rail Communication Framework Contract implemented by two contractors, Ecorys and 20 Seconds to Midnight.

2.1.1. Events

The S2R JU participated in a number of institutional (led by the European institutions), external and internal meetings and conferences organised in Brussels, and in some of the EU Member States and beyond.

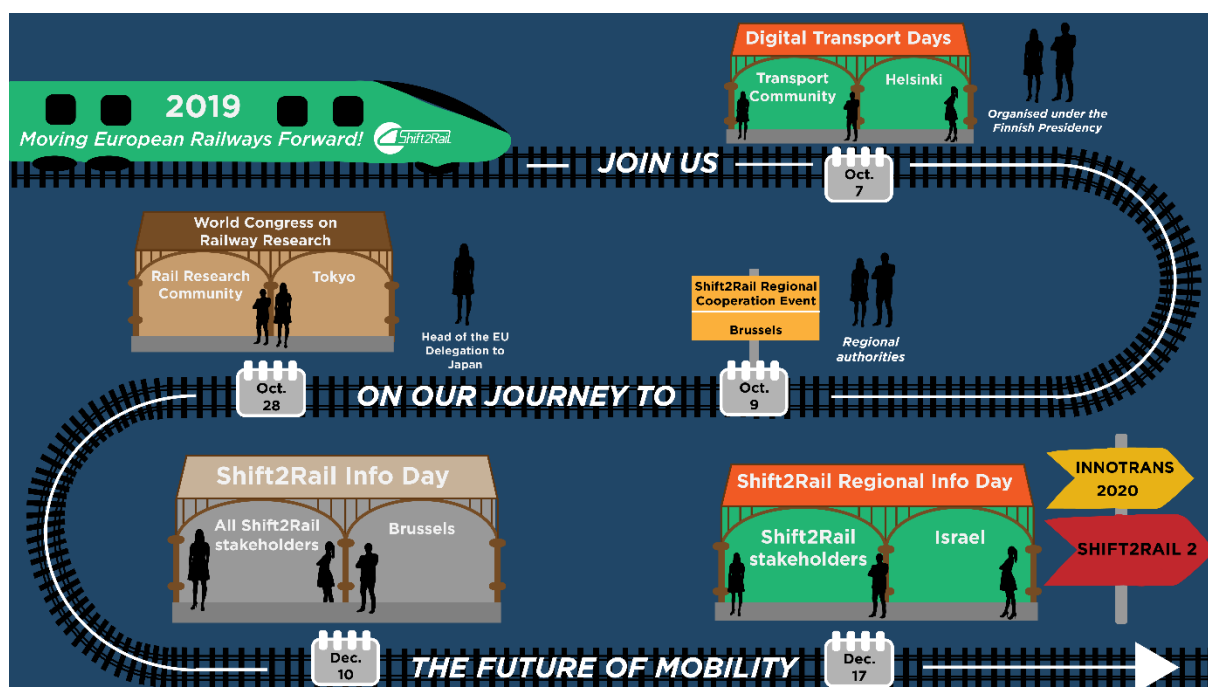


Figure 1: A glimpse at S2R participation in events during October-December 2019 (Fuller list and descriptions provided below)

Institutional events

European Research and Innovation Days – 24-26 September, Brussels, Belgium

The R&I Days brought together thousands of participants who benefitted from high-level discussions about the future research and innovation landscape. Shift2Rail’s Executive Director participated to a panel discussion within a workshop on railways of the future during the big event.

Digital Transport Days – 7-9 October, Helsinki, Finland

Digital Transport Days, an event offering a European viewpoint to digital solutions for transport and mobility held on 7-9 October 2019 in Helsinki, Finland was the main large-scale institutional event in which Shift2Rail JU participated in 2019.

The event had a strong political tone as the then European Commissioner for Transport, Violeta Bulc and representatives from the Finnish Government, including the Minister for Transport and Communications, Sanna Marin (now Prime Minister), participated. Overall, around 1,000 stakeholders attended the event.

Against the backdrop of Digital Transport Days, Shift2Rail organised a side event dedicated to rail research and innovation beyond 2020. The event consisted of two panel discussions and a presentation on the expected results of Shift2Rail innovations. The high level speakers, including Mr. Mikko Koskinen, Secretary of State to the Finnish Minister of Transport and Communications and Mr. Henrik Hololei, Director-General for Mobility and Transport, discussed the future of digitalisation and new technologies in the railway industry and exchanged about Shift2Rail’s role in moving European railways forward. About 300 participants from across 31 countries took part in the Shift2Rail Dialogue.

The Shift2Rail Executive Director participated to a panel discussion on digital and automated railways and the Head of Research and Innovation presented the related results achieved so far in the S2R Programme. The Shift2Rail JU also had an information stand making publications and goodies available.

S2R JU events

Shift2Rail Information Day 2019 – 6 February, Brussels, Belgium

The Shift2Rail JU organised its Information Day, which took place in Brussels, Belgium on 6 February 2019, in view of presenting the priorities of the 2019 Call for Proposals to stakeholders. The event gave an overview of the aims and results of the Shift2Rail Research & Innovation Programme and introduced the possibilities to get involved in bringing European mobility forward. During the day, participants were able to find out about Shift2Rail's funding opportunity: Shift2Rail Call for Proposals 2019.

Hydrogen Train Workshop – 17 May, Brussels, Belgium

The Shift2Rail JU together with the Fuel Cells and Hydrogen Joint Undertaking organised a Hydrogen Train Workshop on 17 May in Brussels, Belgium. During the event, the Joint Undertakings launched the joint "Study on the use of fuel cells and hydrogen in the railway environment". More than 100 stakeholders from across the sector attended the event

Regional Cooperation Event – 9 October, Brussels, Belgium

The Shift2Rail JU also organised a Regional Cooperation Event on 9 October in Brussels, Belgium. As a side event of the European Week of Regions and Cities, the workshop focused on building synergies between Shift2Rail and European Structural Investment Funds. The event brought together around 30 representatives from the regions, the European Commission and Parliament as well as Joint Undertakings.

Shift2Rail Information Day 2020 – 10 December, Brussels, Belgium

The Shift2Rail JU organised its Information Day, which took place in Brussels, Belgium on 10 December 2019, which aimed at providing an overview of Shift2Rail's upcoming funding opportunities for 2020. More than 200 participants from 25 countries, in addition to 250+ online viewers, representing start-ups, SMEs, larger companies, as well as national/regional bodies and research organizations attended the event. The Info Day gave an overview of the aims and results of the Shift2Rail Research & Innovation Programme and introduced the possibilities to get involved in bringing European mobility forward.

The Shift2Rail JU together with other entities organised **regional information days across Europe and beyond:**

- **Spanish S2R Info Day:** The Spanish Railway Technological Platform and Shift2Rail JU organised a debate on the future of rail Research & Innovation, with representatives from rail operators, network managers, manufacturers, and research centres. The event took place on 12 February in Madrid, Spain.
- **Finnish S2R Info Day:** Business Finland organised a workshop on Shift2Rail for motivating companies and institutions to take part of the European Programme and share national experiences. The event took place on 25 October in Helsinki, Finland.

- **German S2R Info Day:** Shift2Rail JU together with representatives from Germany organised a regional information day on 6 December in Berlin. Participants were able to find out about Shift2Rail's upcoming funding opportunity: Shift2Rail Call for Proposals 2020.
- **French S2R Info Day:** Shift2Rail JU together with the French H2020 National Contact Point, SNCF and FIF planned a regional information day on 12 December in Paris, France, which had to be postponed to January 2020 due to the strikes in France.
- **Israeli S2R Info Day:** Shift2Rail JU together with the European Transport Network Alliance organised a regional information day on 17-18 December in Jerusalem, Israel.

External events

In 2019, the Shift2Rail JU participated to major events across Europe and beyond, presenting concrete results achieved by Shift2Rail JU Members together with other key stakeholders.

Rail Live! Bilbao – 5-7 March 2019, Bilbao, Spain

The Shift2Rail JU was present at the fair with a stand, where attendees could learn more about the functioning of Shift2Rail and the process to apply for the Call for Proposals 2019. Shift2Rail staff took the opportunity to exchange views with rail undertakings from all over the world and to meet with Spanish network manager ADIF, national operator RENFE, Basque transport regional ministry and various Basque Shift2Rail members. Overall, the event was attended by over 3,000 professionals from across the sector.

Space for Innovation in Rail - 18 March 2019, Vienna, Austria

Working together to satisfy the demands of an increasingly digitalised world, S2R JU teamed up with the European Global Navigation Satellite Systems Agency (GSA) and the European Union Agency for Railways (ERA) to explore the role of satellite technology in future railway systems, in a dedicated event in Vienna. The Austrian Ministry for Transport, Innovation and Technology welcomed an illustrious group of European and international experts counting around 300 participants.

SIFER – 26-28 March 2019, Lille, France

The Shift2Rail JU had a stand at the event enabling visitors to learn about Shift2Rail's Call for Proposals 2019, ask questions and see Shift2Rail's results.

The Shift2Rail Executive Director participated to a UNIFE round-table discussion on Research and Innovation that focused on the role of R&I in helping to maintain the leadership of the European rail supply industry in the face of fierce competition from overseas. Shift2Rail's Executive Director emphasised the work of Shift2Rail that is helping companies to minimise the risk of R&I while supporting them to bring innovative solutions to the market.

The event brought together more than 400 companies from Europe and beyond.

#POLITICOMobility Summit – 8 October 2019, Amsterdam, Netherlands

As a strategic partner of #POLITICOMobility event the Shift2Rail Executive Director participated to a panel discussion focusing on railways, showing how the work of Shift2Rail contributes to the evolution of the whole mobility sector in Europe. The event brought together policymakers, regulators, disruptors and experts from across the railway sector. As part of this agreement, Shift2Rail's logo was featured on the conference programme and on social media.

12th Congress World Congress on Railway Research – 28 October – 1 November, Tokyo, Japan

The Shift2Rail JU had a 81 sqm stand presenting a selection of Shift2Rail innovations emanating from projects undertaken by our Members and other stakeholders, with a focus on the promising future of a sustainable railway system. The Shift2Rail stand at World Congress on Railway Research was officially opened by Commissioner Violeta Bulc in the presence of Ambassador Patricia Flor, Head of EU Delegation to Japan.

During the opening ceremony Shift2Rail's Executive Director launched the Catalogue of Solutions, publication which brings together the innovative products and approaches, which Shift2Rail has been working on together with Members and key stakeholders to deliver transformed rail systems.

Shift2Rail's Executive Director participated in a panel discussion focusing on R&D for Future Railways on the 31 October.

Scientific papers of 15 Shift2Rail projects were accepted to the conference, and were presented in oral sessions or interactive poster presentations. The "Adaptable Train Communication Systems" paper won one of the nine awards out of 300 papers.

8th International Railway Summit – 20-22 November 2019, New Delhi, India

Shift2Rail's Executive Director gave a keynote speech on where he offered solutions developed within the Shift2Rail R&I programme that help to best manage the growing pressure on capacity. Directly following his keynote titled 'Optimising or redesigning rail? The Executive Director moderated a panel discussion elaborating further on this topic. In addition, the Shift2Rail Executive Director joined a panel discussion to discuss if high-speed rail is worth the big investment it requires together with representatives from our member Siemens, The World Bank and the Indian high-speed rail operators.

As a knowledge partner of the Summit, Shift2Rail helped to enhance networking opportunities by sponsoring a Coffee Lounge where participants had the opportunity to find out more about Shift2Rail's work.

The 8th International Railway Summit brought together many high-level speakers from across the whole sector, including Violeta Bulc, the then European Commissioner for Transport.

In addition to the events explained in more detail above, S2R also participated to the following:

International Railway Summit – 20-22 February 2019, Frankfurt, Germany

At the Summit, Shift2Rail and UNIFE co-organised a data-themed panel discussion moderated by Shift2Rail's Executive Director Carlo Borghini. In addition, Shift2Rail's Executive Director participated to another panel discussion as a speaker focusing on the role of transport in Smart Cities.

Czech and European railway for the 21st century – one single market – 11-12 April 2019, Pardubice, Czech Republic

At the event Shift2Rail's Executive Director gave a keynote speech and participated to a panel discussion on the 4th Railway Package focusing on Research and Innovation.

Staying grounded- Flying less – 19 March 2019, European Parliament, Brussels, Belgium

Shift2Rail's Head of Research and Innovation following the invitation of MEP Lucy Anderson participated to a roundtable discussion presenting how innovations made by S2R will contribute to the goal of creating a real sustainable transport and mobility system, with a shared and multimodal approach S2R is advocating for door to door journeys.

UIC Global FRMCS Conference – 14 May 2019, Paris, France

Shift2Rail's Head of Research and Innovation was key-note speaker in this event attended by rail and telecommunication stakeholders and deliver a vision on how digitalisation and the work done by S2R will affect future rail systems. He also shared a roundtable discussion with other speakers.

7th EcoMotion event – 10-11 June 2019, Tel Aviv, Israel

Shift2Rail's Head of Research and Innovation took part of a roundtable discussion on the future of the rail system in this event dedicated to start-ups innovating on mobility services. Israeli H2020 National Contact Point and S2R State Representative Group member organised a series of meetings between the S2R JU and SMEs/start-ups interested in answering S2R calls.

Unife General Assembly – 12-14 June 2019, Dublin, Ireland

UNIFE General Assembly was attended by Shift2Rail's Executive Director as well as Shift2Rail's Head of Research & Innovation.

International Wheelset Congress – 16-19 June 2019, Venice, Italy

Shift2Rail's Head of Research and Innovation participated to a roundtable discussion on the future of rolling stock. In addition, Shift2Rail had a stand at the venue presenting its R&I work, solutions and programmes working in the area of rolling stock.

EU Transport & Railway Affairs by the European Training Centre for Railways – 8 July 2019, Bruges, Belgium

Shift2Rail's Head of Research and Innovation participated in a panel discussion on Digitalisation of railways contributing to the training organised by ETCR in collaboration with ERA and College of Europe for young engineers.

SmartRail 2019 – 17-19 June 2019, Munich, Germany

SmartRail 2019 was attended by Shift2Rail's Executive Director. In his keynote he focused on the advantages and challenges of standardising the railways.

IPIC 2019 | 6th International Physical Internet Conference – 9-11 July 2019 London, United Kingdom

At IPIC 2019, Shift2Rail's Executive Director moderated a panel discussion on rail freight innovation and participated to another panel discussion on a hyperconnected transport system. Additionally, Shift2Rail sponsored PhD students by offering them the possibility to participate to the conference where they could also discuss their research ideas with other students and established researchers.

CENELEC workshop "ICT for RAILWAYS" – 12-13 September 2019, Naples, Italy

Shift2Rail's Executive Director took part in a panel discussion presenting the future innovation strategy for European railways.

[Railway Days 2019 - Club Feroviar Investment Summit](#) – 9 October 2019, Bucharest, Romania

Shift2Rail's Head of Research and Innovation took part in a panel discussion on ERTMS in Central and Eastern Europe.

Information day on Smart, green and integrated transport – 19 October, Rome, Italy

APRE on behalf of the Italian ministry for research and education organised an information day for the H2020 last calls related to the societal challenge on transport. European Commission's, CleanSky2 JU's and other transport related representatives shared the stage with the Shift2Rail's Head of Research and Innovation, who provided a presentation on S2R activities and exhorted participants to apply to future calls.

[Intelligent Transport Systems World Congress](#), – 21-25 October 2019, Singapore

One of Shift2Rail's Programme Managers took part in the Congress by participating to a panel discussion on the challenges for the future integrated mobility. The panel discussion was moderated by Miroslav Haltuf Vice-Chairman of the Shift2Rail States Representative Group.

[Digital Rail Revolution](#) – 7 November 2019, London, United Kingdom

Digital Rail Revolution was attended by Shift2Rail's Executive Director who gave a keynote speech on achieving interoperability in rail. As sponsors of the event, Shift2Rail got high visibility at the event: Shift2Rail's logo was included to the event website, Q&A was published, mention to Shift2Rail was included to event newsletters etc.

[18th Florence Rail Forum](#) – 8 November 2019, Florence, Italy

Shift2Rail's Head of Research and Innovation participated and contributed to an experta panel discussion organised by the European Florence School of Regulation focusing on sustainable freight system in Europe.

[InnoRail 2019](#) – 12-14 November 2019, Budapest, Hungary

Shift2Rail's Executive Director gave a keynote speech on how Shift2Rail is moving from Research and Innovation towards deployment. Vice-Chairman of Shift2Rail's States Representative Group Mr Miroslav Haltuf gave an opening speech on rail sector competitiveness.

AlpInnoCT final Conference – 19 November 2019, Brussels, Belgium

About 80 people from private and public institutions involved in the freight transport at European level participated to this Interreg funded activity and discussed about the most innovative solutions for the modal shift. The S2R Head of Research and Innovation presented the innovative solutions coming out of the S2R R&I Programme and participated to a panel discussion focusing on combined freight transport.

World Bank Vienna Railways Conference – 18-20 November 2019, Vienna, Austria

Shift2Rail's Executive Director participated to a panel discussion on the role of Research and Innovation in European rail integration.

[Intelligent Rail Summit](#) – 20-21 November 2019, Paris, France

Shift2Rail's Head of Research and Innovation participated to the Summit to share how Shift2Rail is digitalising the rail system towards automation and further integration.

[Portugal Railway Summit](#) – 27 November 2019, Almada, Lisbon, Portugal

Shift2Rail's Head of Research and Innovation introduced the research programme of Shift2Rail that helps to transform the Europe's rail system.

[World Rail Festival](#) – 3-5 December 2019, Amsterdam, Netherlands

Shift2Rail's Head of Research and Innovation took part in a panel discussion on how operators, governments and disruptors can work effectively together to shape a future transport mix. As a sponsor of the event, Shift2Rail got high visibility before and during the event. This included logo on the website and marketing materials, social media promotion, inclusion to newsletters and more.

2.1.2. Communication

Website

In 2019, the homepage of the Shift2Rail website was reorganised to make the most relevant and recent information easily accessible for visitors, to improve the visibility of Shift2Rail's participation to various events and the user to quickly identify them.

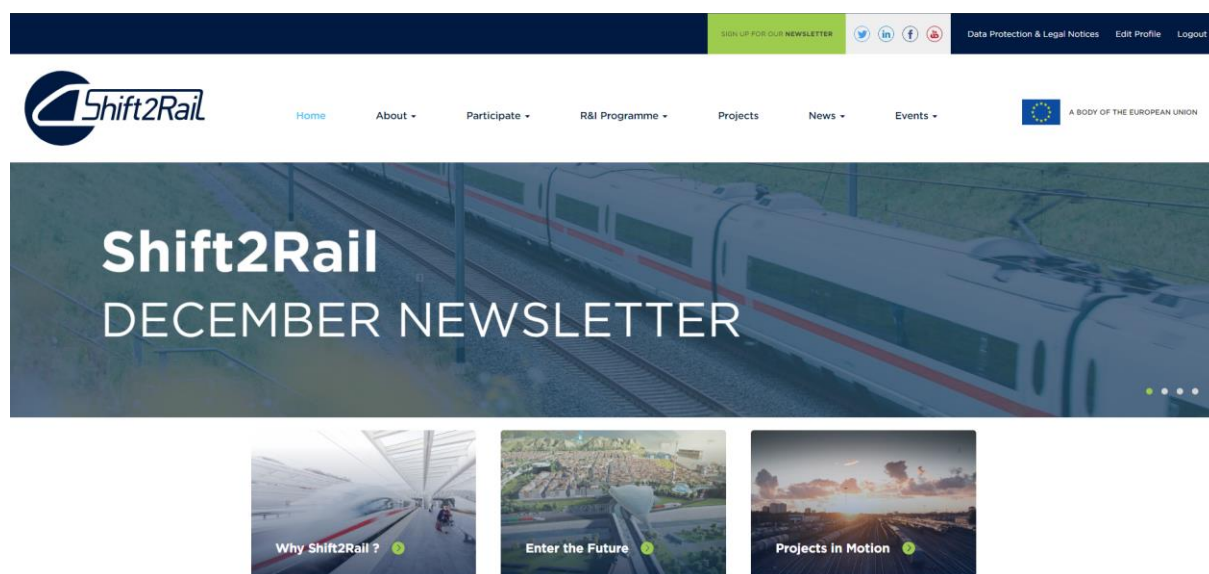


Figure 2: Shift2Rail website updates in 2019

Important developments were also undertaken to make the website easier to maintain and to give more flexibility to the Shift2Rail Communication Team. During 2019, Shift2Rail's Communication Team went through an in-depth website maintenance training with the contractor to be able to introduce the majority of changes to the website in-house without external assistance. In addition, the training session was also a good opportunity to go through all the CMS features and ask the contractor to make changes that allow easier website management for Shift2Rail staff.

R&I content

In addition to the corporate, significant efforts and improvements have been done on the R&I content that a user can get from the S2R website. In 2019, Shift2Rail's Programme Team organised all Shift2Rail's projects under Technological Demonstrators to allow visitors to easily gather related tasks and deliverables progress made by the different S2R co-funded projects. This new interface (also referred to as the Technological Demonstrator view) has helped visitors to better understand the links between the projects and the real outputs of the S2R Programme, giving at the same time improved the visibility of our R&I progress.

Data protection

In cooperation with the ICT officer, legal officer, who is the JU's DPO, and two contractors managing the shift2rail.org and projects.shift2rail.org domains, Shift2Rail's communication team was working on making the website compliant with the data protection regulation based on the instructions provided by the European Data Protection Supervisor. This work included monitoring and making changes to the webpage to eliminate the shortcomings in compliance to the regulation as well as drafting the data protection notice that would be coherent with the features on the website. As a result of this work, Shift2Rail's website is now considered compliant with the data protection regulation that also helped the domain to substantially improve its position in the EU Privacy Score Tool.

User statistics

Shift2Rail's website was visited by 79 628 unique visitors in 2019. Most visitors (48 469) were based in Europe, followed by North America (24 467 visitors) and Asia (4264 visitors). The largest number of visitors by country were based in the United States, followed by the United Kingdom, Germany, Spain and France. Shift2Rail's website was mostly visited by people using a personal computer (67 970 visitors), second most popular device being smartphone (9089 visitors). Relatively low bounce rate (29%) on the Shift2Rail website indicates that visitors find the website content interesting and informative. Average time spent on the Shift2Rail website in 2019 was 4 minutes and 6 seconds.

Newsletter

In 2019, Shift2Rail's Communication Team revamped the format of the newsletter to make the content more meaningful to readers, the look-and-feel more visually attractive, and the frequency increased. Since April 2019, the new monthly Shift2Rail newsletter has been offering readers an overview of the most important news and events, giving visibility to our projects and most of all to our innovations in the new 'Innovation in the Spotlight' section, at the heart of the newsletter. This feature systematically includes an informative and visually appealing infographic accompanied by an in-depth article about a specific innovative solution emanating from the S2R R&I programme.

Compared to previous newsletters, the 2019 editions include more projects news and results deriving from the Projects Communication Spreadsheet that is filled in by project coordinators and partners themselves. This not only gives visibility to projects but also helps to fill the newsletter with exciting and fresh content about the results coming from across the entire Shift2Rail R&I programme.

The readership of the Shift2Rail newsletter has steadily increased throughout 2019 from 936 in January 2019 to 1,402 at the end of 2019, reaching +50%. Various factors have fed into the growth of the audience including Shift2Rail's participation to numerous events, redesign of the Shift2Rail homepage offering more visibility to the newsletter, new and more attractive design of the newsletter itself and promotion of newsletter and its articles on social media.

Social media

In 2019, the S2R JU dedicated time and resources to improve the content and frequency of its posts across its social media accounts – Twitter, LinkedIn and Facebook – to engage with the rail community, aiming to constantly inform the already-converted while also reaching out to new interested stakeholders in order to ensure a growing audience for Shift2Rail activities.

The audiences Shift2Rail targets on social media depend on the channels. While on Twitter Shift2Rail is followed by a wide audience with different backgrounds, LinkedIn attracts a more specialised community interested rather in technical details and longer in-depth articles. Shift2Rail's Communication Team creates different content in order to tailor the message to these different audiences. On Twitter Shift2Rail shares daily events, short articles and posts illustrated with images and videos. On LinkedIn, however, the audience expects longer, more thought-provoking material including technical details about our innovations. While Twitter posts tend to be more popular, LinkedIn posts stimulate more online discussion, so these two channels complement each other very well ensuring we communicate at high and more granular levels.

Shift2Rail has increased the number of followers on all its social media channels. The largest increase in the number of followers in 2019 was on LinkedIn where Shift2Rail got an impressive 900 new followers. Nevertheless, the biggest audience for Shift2Rail still remains on Twitter where Shift2Rail's account has 2 912 followers out of whom 600 started following the Shift2Rail account in 2019.

Throughout 2019, Shift2Rail has put more effort into long term social media planning to make sure that all relevant information is also published on various social media platforms. Shift2Rail also focused in 2019 on engaging more intensively with other relevant stakeholders on social media (DG MOVE, DG RTD, INEA and other EU-institutions; Members and key associations) that help to support the dissemination of Shift2Rail messages and vice-versa.

In 2019, Shift2Rail also had at the heart of its strategy the support of Shift2Rail project results through its social media channels. Thanks to the collection tool developed by Shift2Rail, projects are able to directly propose content for organic or reshared posts, through the Projects Communication Planning Sheet. This has proved a successful tool in providing fresh and up-to-date content to fuel S2R channels, allowing an increase in the number of posts and a larger visibility to our audience concerning what is happening on the ground to build the rail solutions of the future.

After the various events Shift2Rail organises or participates to, social media highlights are created to showcase the most successful tweets from Shift2Rail and participants' accounts. This gives our audience the possibility to get an overview of the opinions trending during the event and promotes further engagement, acting as a complementary post-event communication tool to wrap-up videos and photo galleries.

Press

In 2019, the S2R JU was featured in articles in a range of magazines, industry press and online media. Compared to previous years, starting from 2019, Shift2Rail's Communication Team has put more effort into direct contacts to build relations with journalists and editors from different media outlets to find ways for cooperation and offer ideas for stories. This work has proved to be fruitful for both Shift2Rail and media outlets and will be continued in 2020.

In addition to Shift2Rail's news about the Call for Proposals (which have also been widely covered in different media outlets in previous years), some of the most widely covered stories about Shift2Rail include the publication of the Shift2Rail's Catalogue of Solutions and the joint study with FCH JU focusing on the use of FCH technology in railways. The launch of the Catalogue of Solutions and Shift2Rail's participation to the WCRR in Tokyo was widely picked up by the European press, but also featured in a Japanese rail journal. Various successful articles about Shift2Rail featured in the media in 2019 were popular and these have been monitored and archived as well as featured in the monthly Shift2Rails newsletter. Moreover, Shift2Rail is keen on supporting successful women in the rail sector; and during 2019 this attracted media attention.

Various events organised or participated in by Shift2Rail were attended by journalists from different media outlets who approached the JU for interviews. Journalists took part in the Info Day 2019, FCH-S2R #HydrogenTrain Workshop and WCRR in Tokyo, covering stories about our promising R&I results based on interviews with Shift2Rail's management.

In 2019, Shift2Rail also developed a simple but effective press release template, shortening the content and making it more appealing and easier to read. Shift2Rail has received positive feedback about its press releases from the journalists it has cultivated close relationships with. Journalists have also been targeted by Shift2Rail on social media which has proved effective as well. The fact that the Programme continues to become better known and the interest in its results progressively increases is reflected in the fact that Shift2Rail was featured in the media in 2019 more often than in previous years.

Media partnerships

Due to the success of the S2R Programme so far and its growing audience, during 2019 various international conferences and exhibitions approached Shift2Rail to establish media partnerships. These partnerships have been important in helping to increase our visibility and outreach.

2.2. Legal and financial framework

In 2019, the S2R JU legal framework refers predominantly to:

- Council Regulation (EU) N°642/2014 of 16 June 2014 establishing the Shift2Rail Joint Undertaking (OJ L 177, 17.6.2014, p. 9),
- The Delegation Agreement between S2R JU and the EC,
- The General Financial Regulation (EU, Euratom) 2018/1046²⁴, subject to any specific provisions of the Financial Rules of the S2R JU and the establishment act.
- The Financial Rules of the S2R JU²⁵, as adopted by the S2R JU GB on 30 July 2014 and the revised Financial Rules of the S2R JU, as adopted by the S2R JU GB on 11 December 2015. . It should be noted that the new S2R Financial Rules, following Regulation (EU/EURATOM)

²⁴ Regulation (EU, Euratom) 2018/1046 of the European Parliament and of the Council of 18 July 2018 on the financial rules applicable to the general budget of the Union, amending Regulations (EU) No 1296/2013, (EU) No 1301/2013, (EU) No 1303/2013, (EU) No 1304/2013, (EU) No 1309/2013, (EU) No 1316/2013, (EU) No 223/2014, (EU) No 283/2014, and Decision No 541/2014/EU and repealing Regulation (EU, Euratom) No 966/2012. OJ L 193, 30.7.2018, p.1.

²⁵ By Delegated Regulation (EU) 2019/887, the Commission adopted the model financial regulation for public-private partnership bodies to ensure sound financial management of Union funds and to enable public-private partnership bodies like S2R JU to adopt their own financial rules. The model financial regulation should be consistent with the provisions of Regulation (EU, Euratom) 2018/1046. The S2R JU shall adopt its financial rules in accordance with this model financial regulation.

2018/1046, have been adopted on 20 Dec 2019 – Decision 11/2019 and entered into force on 1 Jan 2020.

- The S2R JU GB Decisions adopted since its establishment, which frame the functioning of the S2R JU within the boundaries of the S2R Regulation and its Financial Rules, in particular the AWP to be approved by the GB (draft budget, Staff Establishment Plan, Scientific Priorities, calls, tenders, etc.)

In addition:

- Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11 December 2013 establishing Horizon 2020 — the Framework Programme for R&I for the period 2014-2020 and repealing Decision No 1982/2006/EC (OJ L 347, 20.12.2013, p. 104), as well as Regulation (EU) No 1290/2013 of the European Parliament and of the Council of 11 December 2013 laying down the rules for participation and dissemination in Horizon 2020 (OJ L 347, 20.12.2013, p. 81) is applicable to the grants awarded by S2R JU;
- The Staff Regulations of officials and the conditions of employment of other servants of the European Union are applicable to the staff of the S2R JU.

Additional reference documents may be found on the S2R JU's dedicated webpage: <http://shift2rail.org/about-shift2rail/reference-documents/>.

2.3. Budgetary and financial management

At the year-end 2019, the JU had implemented 100% of its commitment appropriations made available in its active budget. The payment appropriations were executed up to 88% of the active funds. The implementation when compared to the full S2R budget (including Title 4) was 97% in commitment and 86% in payment appropriations.

In GB Decision 19/2018 on 4 December 2018, the S2R Governing Board adopted the initial Annual Work Plan and Budget for 2019. There was one amendment adopted to this document during the year 2019:

- GB Decision 2/2019 of 24 June 2019, amending the initially adopted budget later in the year.

GB Decision 2/2019 corresponded to the specific needs of the JU, including the re-entering of EUR 126 000 of unused administrative appropriations in the estimate of revenue and expenditure (commitment appropriations), in accordance with S2R JU FR art.6.5, and a number of transfers within the administrative budget. These transfers had the objective to allocate better the resources needed for the administrative costs. In addition to the transfers within the administrative expenses, the overall administrative budget was increased by EUR 171 000 in commitment appropriations and by EUR 396 000 in payment appropriations.

In addition, considering the outcome of the Call 2019 in terms of expected value awarded, in agreement with the minutes of the Governing Board meeting of 4 December 2019, EUR 2 million of operational budget commitment and payment appropriations were transferred to Title 4 of the Budget (Title 4: Un-used appropriations not required in the year). This Title is of technical nature and, in accordance with the S2R Financial Rules, shows the appropriations available for applying n+3 rule on

the following budgetary years. It is used to increase transparency and accurate reporting of the JU. By allocating the appropriations in Title 4, they were identified as being used in the following years to meet the JU's legal obligations on payments and the JU could re-activate them as part of the initial budget 2020.

In particular, EUR 2 million of unused appropriations 2019 have immediately been re-allocated to the S2R JU call 2020 in accordance with the GB Decision 8/2019 of 14 November 2019, adopting the Annual Work Plan and budget for 2020.

	Commitment appropriations (including reactivations)					EUR '000
Title	Initial budget adopted	Amending budget	Transfers	Final adopted budget	Commitments made	%
	(1)	(2)	(3)	(4)=(1)+(2)+(3)	(5)	(6)=(5)/(4)
1	2 277	0	0	2 277	2 277	100 %
2	1 045	171	0	1 216	1 216	100 %
3	78 753	0	(2 048)	76 705	76 705	100 %
Total	82 075	171	0	80 197	80 197	100 %
4	565	(45)	2 048	2 568	0	0 %
GRAND TOTAL	82 640	126	0	82 765	82 765	97 %

	Payment appropriations (including reactivations)					EUR '000
Title	Initial budget adopted	Amending budget	Transfers	Final adopted budget	Payments made	%
	(1)	(2)	(3)	(4)=(1)+(2)+(3)	(5)	(6)=(5)/(4)
1	2 277	86	0	2 363	2 336	99 %
2	1 045	310	0	1 354	1 236	91 %
3	76 900	0	(2 048)	74 852	66 310	83 %
Total	80 222	396	0	78 569	69 822	88 %
4	1 035	(396)	2 048	2 688	0	0 %
GRAND TOTAL	81 257	0	0	81 257	69 882	86 %

Title 1 and Title 2 of the S2R Budget were executed up to 100% in commitment appropriations, demonstrating a reliable budgetary planning.

Title 1 - Staff Expenditure was mainly used for the salaries of the JU staff. During the year, the JU made also use of external support, to fill the gaps during the recruitment process on staff turnover and to cope with the important workload on JU activities.

The execution rate of the payment appropriations was 96% (75% in 2018), showing a constant improvement in the budget implementation in relation to the previous budgetary year.

In addition to the budget amendment under GB Decision 2/2019, the Executive Director has executed its rights in accordance with Article 12 of the S2R Financial Rules and transferred appropriations within administrative budget in the course of the year. These transfers are made to allow the JU to answer the need of resources on specific items.

Title 3 Operational Expenditure

Title 3 of the S2R Budget constitutes the JU's Operational Budget. The vast majority of the JU's budget falls under this category representing 93% of the active and overall budget (including Title 4). The budget category covers the JUs Calls for proposals, operational procurement and expert fees incurred as part of the evaluation.

The execution rate of the operational budget in both commitment and payment appropriations was respectively 100% and 88%. Majority of the payment appropriations were used for the pre-financing of the grants resulting from the 2019 calls for proposals.

Title 4 Unused appropriations not required in current Year

The amount included under Title 4 – Unused appropriations not required in current year has been established to support a transparent implementation of S2R JU Financial Rules Art.6.5, the so called n+3 rule. In accordance with the Financial Rules and the general practise of the JU, these appropriations will be reactivated in the future year budget(s) of the following year and used first.

As a part of the minutes of the GB 4 December 2019, the JU has moved some of its commitment and payment appropriations from operational line to Title 4 - kEUR 2 048 of un-used appropriations (from call 2019) have been transferred to Title 4 in order to be immediately allocated to the S2R JU call 2020.

2.4. Procurement and contracts

In order to reach its objectives and adequately support its operations and infrastructures, the S2R JU continued in 2019 to allocate funds to procure the necessary services and supplies. In the interest of sound financial management and to the possible extent, the S2R JU made use of Service Level Agreements (SLAs) with relevant Commission services and EU Agencies (ICT, training, payroll, mission, experts reimbursements, interim staff, etc.) and participated in inter-institutional framework contracts (e.g.: IT, audit, office furniture, insurance, human resources services) by signing Memorandum of Understandings. In addition, the S2R JU led or participated in inter-JUs framework contracts (e.g.: IT and data protection services), also with the objective to enhance synergies. In the first half of 2019, the S2R JU continued to use its own framework contract for communication and events services before a new framework contract in this field was signed in December.

When for specific services or supplies SLAs or a framework contract were not available, the S2R JU resorted to middle and low-value contracts.

In order to deal with exceptional circumstances, the S2R JU launched in 2019 three negotiated procedures without prior publication of a contract notice. As laid down in the EU Financial Regulation (article 74(9)), these procedures will be listed in the AAR for the year 2020.

The following negotiated procedures without prior publication of a contract notice were launched by S2R JU in 2018 :

- S2R.18.02.NP : Prestation de services concernant les missions de travailleurs intérimaires
 - Legal base : Article 134(1)(b) RAP
 - Type of contract: framework contract for services
 - Value of the contract: EUR 30 000
 - This procedure, in agreement with DG HR contract leader, allowed the JU to make use of interim staff during specific events.
- S2R.18.03.NP : WCRR 2019 event
 - Legal base : Article 134(1)(b) RAP
 - Type of contract: direct contract for services
 - Value of the contract: EUR 35165.52
 - This procedure was used to contract the organizer of the WCRR event who was the sole entity renting the exhibition space.
- S2R.18.04.NP: InnoTrans 2020 event
 - Legal base : Article 134(1)(b) RAP
 - Type of contract: direct contract for services
 - Value of the contract: EUR 36312.6
 - This procedure was used to contract the organizer of the InnoTrans event who was the sole entity renting the exhibition space.

The above contracts were published in the “Recipients of Shift2Rail Funds and Annual List of Specific Contracts” for the year 2018 at the following web page: <https://shift2rail.org/participate/recipients-shift2rail-funds/>

In order to establish the maximum values of procurement contracts, where necessary, the JU makes use of the collective experience of its staff involved in it, its Members and experts as necessary, driven by the principle of sound financial management. Although this was not formally documented in formal acts, audit trails are available also in the exchanges between the staff and the procurement sector to finalize the call for tenders before approval by the Executive Director.

During 2019 several guidance and templates for procurement procedures were updated by the Legal Officer (i.e.: calendar, tender specifications, opening and evaluation of tenders, award procedures for low value contracts, etc.) in order to adapt them to S2R JU needs. In addition, a more detailed register of direct and framework contracts, SLAs and Memorandum of Understandings have been developed to ensure a proper follow-up of the SLAs and FWCs in force.

2.5. IT and logistics

The S2R JU has implemented common ICT tools designed and made available by the EC for the financial management and Horizon 2020 call management. These tools are updated and maintained on regular basis by the EC; they require continuous input from the side of the JU, on the one hand, to correct the multiple and repetitive mistakes and, on the other hand, in terms of future developments to meet the expectations of the partnership. The follow-up of these processes absorb multiple resources of the JU.

In order to ensure the correct usage and implementation of these applications, S2R JU makes use of the training services offered by the EC on these applications.

For the execution of the call for proposals in the AWP 2019, the Horizon 2020 IT systems were used throughout the entire process: for the publication of the call, for the submission and evaluation of the proposals as well as for grant preparation.

In addition, the S2R JU participates to the joint strategic ICT plan of the JUs located in the White Atrium building. Since 2018, the physical infrastructure has been migrated to a private cloud computing provider. During the same year, the S2R JU adopted the EC's ICT systems for HR (Sysper) and daily document management (ARES) to leverage the EC's proven working technology solutions already in place, but also to streamline and further harmonize the processes, workflows, procedures of record management, document archiving and electronic document cataloguing, secure storage and document access.

2.6. Human Resources

In 2019, the S2R JU recruited the Internal Control Coordinator which had been the last position still vacant in order to fully fulfil the establishment plan. The S2R JU also replaced 4 staff members who left the team: two programme managers, one financial assistant and the IT assistant. In order to ensure the continuity of operations, after having distributed some functions to other staff, considering the need to comply with the separation of duties, the JU made use of the provisions of the Staff Regulations to recruit for 1 year a contract agent to replace a TA on long-term absence.

In 2019, the S2R JU team consisted of 24 staff members, including the SNEs, (see ANNEX B Establishment plan), without the aforementioned exceptional recruitment.

In addition to this, for the third year, the S2R JU welcomed Bluebook Trainees in accordance with the SLA signed with DG EAC.

In addition to recruitment activities as well as daily HR administration not provided by the Commission central services, particular attention was given to the swift implementation of HR-related decisions adopted by the S2R GB (Implementing rules).

Furthermore, the third reclassification exercise of the JU was successfully carried out during 2019. The JU also organised in-house trainings on different topics as foreseen by the JU's Learning and Development Policy (cf. Annex 2 Learning Paths), such as a specific training session on the prevention of psychological and sexual harassment and a training on the new implementing rules adopted by the S2R Governing Board related to the engagement of contract staff. Finally, team building activities were also organized in order to reinforce the cohesion of the team.

2.7. Data protection

The S2R JU continues to implement the EU data protection policies and legal framework. As regards the processing of personal data, the S2R JU applied the new EU Data Protection rules (Regulation (EU) 2018/1725²⁶) as from its entry into force on 11 December 2018.

²⁶ Regulation (EU) 2018/1725 of the European Parliament and of the Council of 23 October 2018 on the protection of natural persons with regard to the processing of personal data by the Union institutions, bodies, offices and agencies and on the free

To ensure compliance with the new data protection principles, the S2R JU took the following actions:

- as a “leading contracting authority”, launched a joint tender procedure with the other Joint undertakings (JUs) for a tool to serve the purpose of central on-line register of records of activities processing personal data (article 31(5) of Regulation (EU) 2018/1725) tailor made to the needs of the JUs.
- represented the other JUs in a working group on “Joint Controllershship” within the Research & Innovation Family for personal data processing operations in the "Funding and Tenders Portal".
- closely followed up the introduction of a “joint controllership” clause and a joint controllership arrangement (Article 28(1) of Regulation 2018/1725) in the replacement of the standing Service Level Agreement (SLA) with the European Commission.
- continue to update privacy policies in order to provide transparent information, communication and modalities for the exercise of the rights of the data subject (articles 14 to 16 of Regulation (EU) 2018/1725).
- Continue to include the new data protection provisions in contract templates and provide guidance to S2R staff.

As in the previous year, the role of the Data Protection Officer was exercised by the S2R JU’s Legal Officer during 2019.

3. GOVERNANCE

3.1. Governing Board (GB)

In accordance with the S2R Regulation, the S2R JU GB continued its work steering the JU through the adoption of decisions to be implemented and executed by the ED. Three meetings of the Board were convened in 2019, as well as one extraordinary GB meeting to approve the list of actions selected for funding under the S2R JU call for proposals H2020-S2R JU-2019. These GB meetings dealt with both operational and administrative aspects. Important decisions were taken, such as the approval of the list of actions proposed by the ED selected for funding under the 2019 Call, the approval of the amended Membership Agreements between the S2R JU and the members other than the Union, the adoption of the consolidated MAAP, including the new Part B, the catalogue for solutions, the renewed programme governance and change management, the financial rules of the S2R JU, the appointment of two new members of the Scientific Committee from the reserve list, and the adoption of the AAR 2018 and the AWP 2020, including the adoption of the lump sum funding pilot scheme, which was already launched in the CFM Call 2018 and the CFM Call 2019 and will significantly contribute to the administrative simplification of the R&I activities.

Following the adoption of “GB Decision 16/2018 regarding the amendment of the membership agreements between the Shift2Rail Joint Undertaking and the members other than the Union”, the revision of the Membership Agreements with the Founding Members and with the Associated Members was launched to define the maximum limit of the reimbursement requests (44.44% of the project cost) in relation to the totality of the Member’s costs in implementing intertwined indirect actions calculated cumulatively, rather than, for each indirect action, to the total costs in implementing that indirect action.

movement of such data, and repealing Regulation (EC) No 45/2001 and Decision No 1247/2002/EC.

Furthermore, on 7 June 2017, the S2R GB mandated the Executive Director to establish the necessary process to allocate EUR 5.6 million of funding still available within the Union funding available for the Associated Members. An Invitation to S2R JU Associated Members to submit an answer in view of the realignment of their activities and additional commitment to the S2R Programme was published in June 2017, ensuring transparency and equal treatment. The Invitation was made public to provide the opportunities to third entities to join existing Associated Members to perform railway R&I. Consultations on the membership agreements were conducted with the eleven associated members who answered the invitation. The Membership Agreements with the Associated Members have been revised to take into consideration the “report regarding the outcome of the invitation to Shift2Rail JU Associated Members to submit an answer in view of the realignment of their activities and additional commitment to the Shift2Rail Programme” and the subsequent negotiation process. Subject to the approval of the revised versions of the Membership Agreements by each member, the Executive Director of the S2R JU will transmit the amended membership agreements to the Governing Board for approval by written procedure by beginning of 2019.

The Decision of the Governing Board n° 01/2019 on the “approval of the amended membership agreements between the S2R JU and the members other than the Union” was adopted on 22 March 2019 and all corresponding revised Membership Agreements were signed in this respect on 21 June 2019.

During the 22nd GB meeting of 14 November 2019²⁷, the revised MAAP, including the new Part B – Technical Content was adopted, focusing on the re-prioritised R&I activities included initially in the 2015 MAAP and ensuring adequate alignment with the MAAP Part A, which was adopted by the GB on 27 October 2017²⁸. The MAAP Part B introduces a demonstration plan by Technological Demonstrators and incorporates new ideas to enable a more appropriate quantification of the impact of each new technology. The S2R JU Multi-Annual Action Plan therefore consists of two parts:

- Part A – Executive View, adopted by the S2R JU Governing Board on 27 October 2017 by Decision N°7/2017;
- Part B – Technical Content, annexed to the Decision of the GB N° 9/2019;

The original MAAP of 2015²⁹ will be maintained as a reference document.

After the entry into force of the new EU Financial Regulation (FR) on 18/07/2018, S2R JU adopted revised financial rules based on a Commission Model Financial Regulation for public-private partnership bodies (MFR). The S2R JU adopted its Financial Rules in accordance with this model financial regulation. Commission Decision C(2019) 7543 final of 29.10.2019 did not set out any exceptions for the S2R JU to depart from the rules set out in the Delegated Regulation (EU) 2019/887. The GB Decision n°11/2019 on the financial rules of the S2R JU was adopted in December 2019 and replaces as from 1 January 2020 the current S2R JU financial rules (GB Decision n° 21/2015).

²⁷ Decision of the GB n° 9/2019.

²⁸ Decision of the GB n° 7/2017.

²⁹ Decision of the GB n° 15/2015.

The Governing Board was informed of the results of the Internal Audit Service's audit on the S2R JU Grant Process (cf. Final Audit Report dated 21 October 2019) as well as the implementation of the actions included in the Action Plan in response to the IAS' recommendations.

Furthermore, a number of decisions were adopted concerning administrative issues and issues related to the personnel (adoption by analogy of rules of employment of staff of the EU).

A number of changes of the legal status of Governing Board members were reported on, including the change of Kapsch CarrierCom to Kontron and the change of Ansaldo STS to Hitachi Rail STS.

3.2. Executive Director (ED)

According to Article 10 of the S2R Statutes, the ED is the chief executive responsible for the day-to-day management of the S2R JU in accordance with the decisions of the S2R GB. The ED is the legal representative of the S2R JU. The ED is accountable to the S2R GB. He is supported by the JU staff organized in a Programme Office.

The S2R JU ED was appointed on 16 February 2016. He took up his duties on 16 May 2016.

The ED is supported by the Head of R&I and the Head of Finance and Administration. The Programme Office under his responsibility followed, in 2019, the Governance and Process Handbook which describes in details the processes and procedures to monitor the performance of the projects that will be implementing the Programme through an integrated Programme Management approach.

Moreover, following the provision to the ED of a mandate to establish relations with European regions and other European and international organizations, the cooperation with regions and international organizations has been fostered. In this respect, the ED signed an MoU with ETSI in May 2019, and an MoU with the region of the Basque Country (ES) on ESIF synergies was fully negotiated in 2019 and signed in January 2020. MoUs with CUTRIC and FERRMED were also negotiated by the ED throughout 2019 and are expected to be signed in 2020. An MoU with CEN/CENELEC is under preparation. The JU also organised the first workshop on regional cooperation and synergies with ESIF in October 2019.

Furthermore, 2019 saw the establishment of the ED Programme Board, striving to ensure that barriers experienced in the integration of new concepts in the S2R R&I activities are duly addressed, as well as to ensure that a more encompassing future system architecture would not find obstacles in their integration in the specific R&I projects.

3.3. States Representatives Group (SRG)

To date, 33 countries have nominated representatives to this group. During 2019, the SRG held its tenth meeting on 10th April in Pardubice (Czech Republic) and its eleventh meeting on 23 September in Brussels. One of the main tasks in both meetings was the consultation with the Member States and the Associated Countries on the JU's AWP 2020 as well as on the review of the MAAP and the S2R2 preparatory process.

In the tenth meeting, which took place in Pardubice, the SRG discussed the revision of the MAAP Part B, the catalogue for solutions, the S2R position paper on testing facilities, the importance for the JU to

establish regional strategic partnerships and MoUs, cooperation with ESIF funds, and the preparation of the AWP 2020 and the AAR 2018. During this meeting, emphasis was also placed on the S2R2 preparatory process and the Horizon Europe state of play. It was followed by a S2R SRG Dialogue on the future of Rail R&I on 11th April, which was organized back-to-back with the 5th Railway Conference organized on 11th-12th April.

In the eleventh SRG meeting, held in Brussels, discussions focused, inter alia, on the results of the S2R JU 2019 call and the publication of the GB Decision n°07/2019 on the call results, the AWP 2020 preparation, the S2R2 preparatory process and Horizon Europe state of play, the S2R regional cooperation workshop as well as information on on-going national railway R&I activities.

In both meetings, participants were informed in detail about the ongoing and planned activities of the JU.

3.4. Scientific Committee (SC)

The SC is an advisory body to the S2R JU focusing on the long-term research and identifying scientific and technological achievements and development priorities.

The S2R JU SC held its eleventh meeting on 13 March 2019 in Brussels.

The JU presented the revision of the first draft of the AAR 2018, the revision of the MAAP Part B, the AWP2019, as well as discussions on the preliminary draft budget 2020.

The new Rules of Procedure of the Scientific Committee were presented. The rules of procedure of the Scientific Committee were amended in December 2018 to allow SC members to be contracted as individual experts by the S2R JU for the review of S2R projects, whilst ensuring their independence and impartiality and the absence of conflict of interest. Following the approval at the 18th Governing Board meeting of the amendment to the SC Rules of Procedure, a consolidated version was published on the S2R JU website, along with the Executive Director Decision ED-18-14 of December 2018 “Request for Amendment to the Rules of Procedure of the Shift2Rail Joint Undertaking Scientific Committee”. The amended provisions are the following: Article 6, Article 11, Annexes 1 to 3.

In line with the revised Rules for Procedure, SC members indicated whether they want to engage as experts in the review of projects.

In addition, the focus in 2019 was placed on filling in the two SC vacant positions. In order to fill the two vacant positions, the profiles of the candidates on the reserve list of the call for expression of interest (S2R.SC.01.2017) were shared with the SC members under confidentiality restrictions. A written procedure to the SC was launched in April in order to put forward two names for GB approval at the GB of June 2019. The members of the SC voted taking into consideration the profiles, the complementarity of expertise, as well as potential conflict of interests. The two profiles proposed by the Executive Director of the S2R JU to the GB are those which received the support of at least two thirds of the SC members. The Governing Board adopted the Decision of the GB N° 06/2019 appointing two new members of the Scientific Committee of the Shift2Rail Joint Undertaking from the reserve list established following the call for expression of interest S2R.SC.01.2017. The following candidates are therefore selected as new members of the SC: Professor Oliver Michler and Professor Peter Vervest.

A new call for expression of interest will be launched most probably in the second half of 2020 and the rotational mechanism of one third will apply as of 2020-2021.

The twelfth meeting of the S2R JU Scientific Committee was held on 23 October 2019 in Brussels. Discussions focused, inter alia, on the results of the S2R JU 2019 call and the publication of the GB Decision n°07/2019 on the call results, the AWP 2020, the S2R2 preparatory process and Horizon Europe state of play, as well as on hyperloop developments.

The members provided specific comments on the different topics in order to contribute to the document finalisation of the draft AWP 2020.

Furthermore, as the mandates of the current SC Chairperson and Vice-Chairperson came to an end, the election process for the new Chairperson and Vice-Chairperson were organized. Members of the Scientific Committee interested in submitting their candidacy to the positions of Chairperson or Vice-Chairperson were invited to do so by 14 October 2019. All candidacies, accepted by the candidates themselves, were put to a vote among SC members during the Scientific Committee meeting of 23 October 2019. The newly elected Chairperson is Professor Angela di Febraro and the newly elected Vice-Chairperson is Professor Juan De Dios Sanz Bobi. They are elected for a period of three years, starting 1/1/2020 until 31/12/2022, which may be renewed.

3.5. Innovation Programme's Steering Committees (SteCos)

In 2016 all IP's SteCos were formally established and each of them adopted its Rules of Procedures, in line with the indications of the S2R GB.

The SteCos convened regular meetings (four meetings in total in 2019) and their role was to ensure the necessary coordination of activities within each IP and to provide input in assisting the JU in the planning of its future activities (i.e. input for the AWP 2020, the Demonstrations activities planning, the MAAP review, etc.). As from the signature of the first OC grants, the coordinators of the OC projects were invited to participate to the SteCo meetings in order to present their plans in a way to ensure coordination of actions and to maximise synergies among projects.

During 2017, the S2R JU together with the IP Coordinators work towards the evolution of the IP meetings more on technological and operational content than administration. This was further enhanced in 2018 and continued in 2019, focusing on TDs results and adding IPs' joint meetings on specific thematic areas (e.g. automation, digitalization, telecoms, cyber-security, integrated traffic management).

3.6. European Union Agency for Railways (ERA)

Article 12 of the S2R Statutes clarifies the areas of cooperation between the S2R JU and ERA. In order to ensure that strong cooperation is established with ERA, the rules of procedures of all relevant groups established by the S2R JU foresee the participation of representatives from the ERA (either as observers or direct members of these groups); this ensures that the Agency is duly prepared to take into account the results of the Programme in its activities.

As a result, staff members of ERA have been participating in meetings of the S2R GB (cf. 3.1) and the IP SteCos, but also in the groups which were tasked with the drafting of the MAAP and contributing to the S2R JU AWP.

The S2R Governance and Process Handbook³⁰ clarifies the way ERA can access the R&I activities performed within the S2R Programme in the areas of their competence, interoperability and safety. It worth to mention that the S2R JU provided to ERA in 2018 the ATO over ETCS GoA2 specification and in 2019 the Moving Block (MB) system specification, MB operational and engineering rules as well as the MB preliminary safety analysis, all as input of the possible game changers integration in the next release of the CCS TSI.

In addition, regular coordination meetings have been organised between the two EDs, operational staff and communication staff. The overall objective is to ensure that the R&I innovative solutions that will be delivered by the S2R Programme will be considered in the pipeline of ERA activities in order to avoid any step back in the future market uptake.

The role of ERA in the context of 4th Railway Package, once duly implemented, will be another asset to facilitate the deployment of the S2R Innovative Solutions.

In addition, with the objective to avoid overlapping activities, the S2R JU assess the requests for R&I coming from ERA and ensure their implementation to maximize the use of public funding. Building upon parallel structures would constitute a waste of resources.

Shift2Rail developed with ERA in 2019 a “Compendium on safety and interoperability”, which has been published on the S2R website³¹.

The S2R JU also supported the EC in its ERTMS Deployment Action Plan, participating to the ERTMS Policy Board meetings and advertising the ERTMS Deployment Action Plan Consultation on its website.

The S2R JU is also participating together with ERA to the Rail Standardisation Coordination Platform for Europe (RASCOP) chaired by the European Commission (DG Move). S2R is actively contributing providing to the group of standardisation setting organisations and the ERA the S2R standardisation rolling development plan, a comprehensive document anticipating the possible need for changes or creation of standards and regulations as a result of successful outcomes of the S2R R&I Programme.

On the coordination on standardisation and regulation issues, the S2R JU has been also participating in the EU Rail Security Platform providing expertise (also to the ERA) based on the R&I outcomes on cybersecurity applied to ERTMS.

4. INTERNAL CONTROL FRAMEWORK

4.1. Financial Procedures

The S2R JU Financial Rules, in force in 2019, were adopted by the S2R GB on 30/07/2014 and amended on 11/12/2015³². The Financial Rules do not depart from the model Financial Regulation for public-private partnership bodies referred to in Article 209 of the Regulation (EU, Euratom) No 966/2012 of the European Parliament and of the Council of 25 October 2012. Since its budgetary autonomy, the

³⁰https://shift2rail.org/wp-content/uploads/2017/12/S2RJU-Governance-and-Process-Handbook_20171010_v11_Cleanv-nd.v2.pdf

³¹ https://shift2rail.org/wp-content/uploads/2020/02/Compendium_on_safety_and_interoperability_2019.pdf

³² On 20th December 2019 the S2R JU Governing Board adopted the Decision N°11/2019 on the revised S2R Financial rules in order to align them to the General EU Financial Regulation 2018/1046 entered into force on 18 July 2018. The new S2R JU financial rules entered into force on 1 January 2020 and shall apply from this date.

S2R JU has been using ABAC (accounting system of the European Commission) for its financial management. As already mentioned, the new JU Financial Rules entered into force on 1 January 2020.

The S2R JU Manual of Financial Procedures has been prepared in line with Article 20 of the Financial Rules of the S2R JU and incorporated. The main purpose of the document is to identify actors, describe the financial circuits and detail procedures regarding the implementation of the S2R JU Budget. The financial circuits take into account the structure of S2R JU and the risks associated with the management environment.

The Financial Rules of the S2R stress the need to differentiate between the initiation of a financial transaction and the verification of the same transaction in order to guarantee the principle of segregation of duties.

The S2R JU budget in respect of this document has been divided mainly into two types of expenditure;

- Administrative Expenditure covering both; Titles 1 and 2 of S2R Budget, and
- Operational Expenditure covering Title 3 of the Budget.

A Title 4 is dedicated to account for un-used appropriations.

Due to their nature and the difference in ICT tools implemented at the S2R JU to manage them, the financial circuits between these two expenditure types are different.

The Manual of Financial Procedures describes in detail financial circuits the S2R JU implements per type of transactions and the roles and responsibilities of each actor involved. To a less extent, it also describes the basic principles on main procedures (grants & procurements). In 2017, this document has been reviewed to streamline and improve the internal financial processes.

It should be noted that the specific S2R JU financial procedures are complemented by *vademecum* established for the overall Horizon 2020 research family as well as by S2R JU Programme Handbook.

The S2R GB formally appointed the Accounting Officer of the Commission as the Accounting Officer of the S2R JU on 18/03/2016.

4.2. Ex-ante Controls on operational Expenditure

The S2R JU adopts the standard financial circuits in ABAC Workflow for the commitments and payments. The circuit has a three-step authorisation performed by the following financial actors:

- Initiating Agent (OIA and FIA)
- Verifying Agent (OVA and FVA) and
- Authorising Officer (AO).

Staff members designated by the AO to verify financial operations are chosen on the grounds of their knowledge, skills and appropriate professional experience.

The S2R JU financial circuits comply with the requirements of the four eyes principle, segregation of duties and the independence of the verifier. In addition, in view of the limited staff, they also provide the flexibility necessary to ensure the continuity of operations.

For the operational expenditure of the JU, S2R JU recognises two different types of transactions: ones solely performed in the ABAC Workflow and ones with the initiation and verification functions outside the ABAC environment in a tool called SYGMA. This tool is also linked to ABAC which allows real time controls over the budget and its implementation.

The nature of the transaction defines the system where the initiation and verification is performed:

- ABAC for all procurement related transactions and
- SYGMA for any transactions related to grant management

In all transactions, whether initiated in SYGMA or ABAC, the AO will give his/her authorisation in ABAC only.

A key element of the ex-ante controls is the *“Guidance Horizon 2020 ex-ante controls on interim & final payments”* adopted by the CSC Steering Board on 15 Dec 2016 and applicable as such to the S2R JU. The main consequence of this simplified ex-ante control approach is that the limited details asked to beneficiaries to be provided in each periodic report do not allow the S2R JU to check most of the conditions for the eligibility of costs. Ex-ante controls in Horizon 2020 are therefore trust-based, focusing on whether:

- the work has been done (as described in the periodic reports)
- the reported effort and use of resources is reasonable and in accordance with the plan
- sufficient explanation and justification are provided for any substantial deviations (see Section 2.5).

In practice, the assessment involves comparing the Description of the Action (DoA) and the budget earmarked with the work actually carried out, as explained in the periodic report, and the costs being claimed in connection with it.

Certain elements (such as risk factors or deviations) are less in evidence when checking interim periodic reports than when assessing final reports. Moreover, since CFS are required only as part of the final reports, ex-ante controls in final periods will be more in-depth. Moreover, officers may take a more flexible approach to ex-ante controls in interim periods by asking beneficiaries for additional clarification in the ensuing reporting period. However, by the time the final payment is made, all outstanding issues should have been dealt with.

4.3. Ex-post Control of Operational Expenditure and Error Rates Identified

Ex-post controls are defined as the controls executed to verify the financial and operational aspects of finalised budgetary transactions in accordance with Article 22 of the S2R JU Financial Rules.

The controls are the last stage of the JU's control strategy in the project life cycle. This stage includes the ex-post audits as well as the recovery/correction of any amounts found to have been paid in excess of the sum due.

Ex-post Control of Operational Expenditure at S2R JU fall under the Horizon 2020 Audit Strategy. The implementation of the Horizon 2020 Audit Strategy will be the responsibility of the Common Audit Service (CAS). The role of the CAS is defined in the Commission Communication of 18 September 2013 establishing the Common Support Centre (CSC)³³. The CAS has been designated as the single entity for implementing the H2020 audit campaign on behalf of the CSC stakeholders such as S2R JU.

The main objective of the Horizon 2020 Audit Strategy is to provide the ED with the necessary elements of assurance in a timely manner on the Horizon 2020 budget for which they are responsible by contributing to:

- assessing the legality and regularity of Horizon 2020 project payments;
- providing an indication of the effectiveness of the related ex-ante controls;
- providing the basis for corrective and recovery mechanisms, if necessary;
- attaining residual error rates at an acceptable level at the closure of Horizon 2020, once the financial impact of all audits, correction and recovery measures has been taken into account³⁴.

The actions identified to realise these objectives include:

- the gradual achievement, in a cost effective-way, of quantitative multi-annual targets in terms of audited participations;
- the closure and communication of audit findings and extension of audit findings to those responsible for their implementation providing the basis for corrective and recovery activities, if necessary.

Different indicators are calculated to provide a comprehensive view of legality and regularity:

Overall Detected Error Rate: this is the error rate derived from the results of all audits, whether audits on a representative sample of beneficiaries or audits implemented for other reasons (large beneficiaries, preventive audits, risk factors, etc.). Its value is cumulative and can be calculated for a specifically to S2R JU or for the whole Research and Innovation Family.

Representative Error Rate for the Framework Programme: this is the error rate derived solely from the results of the CRS on the whole Research and Innovation Family, extrapolated to the overall population and calculated for each FP as a whole. This error rate provides an estimate of the level of error in the given Framework Programme at the time of the audits, but does not factor in the follow-up and corrections/recoveries undertaken by Commission services after the audit, nor does it provide information on the net final financial impact of errors.

Residual Error Rate: the residual error rate, on a multi-annual basis, is the extrapolated level of error remaining after corrections/recoveries undertaken by S2R JU following the audits that have been

³³ Communication on the delegation of the management of the 2014-2020 programmes to Executive Agencies SEC(2013)493 of 18 September 2013, section 5.1.2

³⁴ Legislative Financial Statement as part of the 2011 Commission proposal for the Regulation on H2020 (COM/2011/809) of 30 November 2011, pages 98-102

made. The calculation of the residual error rate is made in accordance with the H2020 Audit Strategy and is based on the following assumptions:

- all errors detected will be corrected;
- all non-audited expenditure is clean from systematic material errors so that the residual error rate can be estimated to be equal to the non-systematic error rate (for expenditure subject to extension of audit findings this is only assumed when the respective extension procedures have been closed).

The residual error rate develops over time and depends on the assumptions set out above. This indicator is reliable and acceptable for the purposes for which it was intended, i.e. as a legality and regularity indicator on the progress made, through its ex-post audit strategy, in dealing with errors over a multi-annual basis. However, it remains an estimate as long as not all cost claims have been received and not all cases of extension of audit findings have been fully implemented yet.

Ex-post controls of the Horizon 2020 programme globally in 2019

Following a review of a sample of ex-post audits and referring to the Commission's methodology for the calculation of the H2020 error rate, the European Court of Auditors observed that *"... ex-post audits aim for maximum coverage of the accepted costs, but rarely cover all the costs. The error rate is calculated as a share of all the accepted costs, instead of the amount actually audited. This means that the denominator in the error calculation is higher, so the error rate is understated. In case the errors found are of a systemic nature, the error is extrapolated which partially compensates for the above-mentioned understatement. However, since extrapolation is not performed for non-systemic errors, the overall error rate is nevertheless understated. The understatement of the error rate cannot be quantified. It is, then, impossible to determine whether the impact of this understatement is significant."* As a result, the Court introduced recommendation 5.3 to address this observation, which was accepted by the Commission. In response, the Commission is re-defining its methodology for calculating the H2020 error rate in line with the Court's observations.

The following error rates for Horizon 2020³⁵ on 31 December 2019 are reported:

- Representative detected error rate: 2.78%³⁶, expected to rise to 3.30% taking into account the results of draft audit reports.
- Cumulative residual error rate for the R&I Family of DGs: 2.15 % (2.24 % for DG R&I), expected to rise to around 2.31 % (2.40 % for DG R&I) when taking into account the results of the draft audit reports.

The above-presented error rates should be treated with caution not only because of the above-

³⁵ The Horizon 2020 audit campaign started in 2016. At this stage, three Common Representative Samples with a total of 467 expected results have been selected. By the end of 2019, cost claims amounting to EUR 16.2 billion have been submitted by the beneficiaries to the services. The audit coverage for Horizon 2020 is presented in annex 10. In addition to the Common Representative Samples, Common Risk Samples and Additional Samples have also been selected. The total of all samples represents 3245 participations. The audits of 2115 participations were finalised by 31/12/2019 (out of which 962 in 2019). This sampling accommodates special needs of certain stakeholders with regard to audit coverage and selection method. In addition, top-ups, which are participations of selected beneficiaries and which are added to the selected participations, are included in the total participations selected.

³⁶ Based on the 298 representative results out of the 467 expected in the three CRS.

mentioned top-up. Since not all results of the three Common Representative Samples are yet available, the error rate is not fully representative of the expenditure being controlled. Moreover, the nature of expenditure in the first years of the programme may not be totally representative of the expenditure across the whole period.

Since Horizon 2020 is a multi-annual programme, the error rates, and especially the residual error rate, should be considered within a time perspective. Specifically, the cleansing effect of audits will tend to increase the difference between the representative detected error rate and the cumulative residual error rate, with the latter finishing at a lower value.

As was the case last year, there is evidence that the simplifications introduced in Horizon 2020, along with the ever-increasing experience acquired by the major beneficiaries, affect positively the number and level of errors. However, beneficiaries still make errors, sometimes because they lack a thorough understanding of the rules, sometimes because they do not respect them.

In conclusion, DG R&I considers that the 2019 cumulative residual error rate for Horizon 2020 will fall within the target range established in the Financial Statement³⁷, and therefore a reservation is not necessary for the Horizon 2020 expenditure

Regarding the future, the Commission will adapt its methodology for the calculation of Horizon 2020 error rate in line to the Court's observations starting with the audits finalised as from January 2020 on.

Ex-post control 2019: S2R JU Specific sample

Given the relatively small share of the S2R JU's budget (less than 1%) compared to the overall H2020 budget, the number of projects selected for ex-post audit by the CAS via the common representative sample is limited. Therefore, S2R JU in line with Annex 1 to the H2020 audit strategy, planned for additional audit sampling (i.e. JU's specific sample) in order to ensure sufficient ex-post audit coverage and allow a representative error rate on S2R JU expenditure to be calculated over time. This is necessary to provide reasonable assurance to the JU's Executive Director in view of his declaration of assurance and the separate discharge procedure for the JU. There were no S2R JU cost claims selected as part of the Common Representative Samples for the H2020 research family, selected by the CAS in years 2016 and 2017. Two risk based audits on S2R JU cost claim have been launched as result of implementing the H2020 Audit Strategy: the first one was finalised in 2018 with zero adjustment; the second audit has not yet been concluded.

In 2017, in addition to the risk based audit detailed above, the JU launched representative audits covering 15 additional cost claims. After launching the representative audits, the total coverage raised into KEUR 1 324 representing 40% of the all cost claims validated in that year.

By 31 December 2018, S2R JU had validated cost claims for a cumulative total of KEUR 32 280 covering 25 projects.

³⁷ The legislative financial statement accompanying the Commission's proposal for the Horizon 2020 regulation states: "The Commission considers therefore that, for research spending under Horizon 2020, a risk of error, on an annual basis, within a **range between 2-5%** is a realistic objective taking into account the costs of controls, the simplification measures proposed to reduce the complexity of rules and the related inherent risk associated to the reimbursement of costs of the research projects. The ultimate aim for the residual level of error at the closure of the programmes after the financial impact of all audits, corrections and recovery measures will have been taken into account is to achieve a level **as close as possible to 2%.**"

By 31 December 2019, S2R validated cost claims for a cumulative total of KEUR 77,556,983.85 covering 80 projects. In 2019, the JU launched 24 additional representative audits on its population as well as one risk-based audit following its own risk assessment. This brought the direct coverage of the S2R JU launched audits into KEUR 7 404 (10%) and in-direct coverage into KEUR 39 96216 757 (52%). The overall status of these audits is shown below.

Batch	Audit launch year	Launched	On-going	Finalised	Of which	
					Representative	Risk-based
1	2017	16	1	15	14	1
2	2018	15	16	9	9	0
3	2019	25	25	0	0	0
Total		56	42	24	23	1

Numbers referenced in terms of cost claims

Total Number of Cost Claims validated at 31/12/2019	930
Total Cost Accepted by S2R JU (cumulative) (A)	77,556,983.85
Total cost audits launched 2019 (B)	7,404,801.00
Total cost Audits finalised 31/12/2019 (C)	2,738,143.30
Direct coverage of total audits (B / A)	10%
Direct audit coverage of the finalised audits (C / A)	4%
In-direct coverage* of the total audits	52%
In-direct audit coverage* of the finalised audits	37%

* taking into account the audited entity's participation on other S2R projects contributing to the sum in (A)

At 31 December 2019, 24 final audit reports from the representative sample were available to the JU. These participations represent 4% of the direct and 37% of in-direct coverage in S2R JU accepted cost claims.

Overall detected error rate based on 28 participations: by applying simple average is 1.56% and by applying weighted average is 1.53 %

Representative Error Rate based on 28 out of 53 participations selected in three representative batches: by applying simple average it is 1.62% and by applying weighted average 1.54%

S2R JU Residual Error Rate: by applying simple average is 0.86% and by applying weighted average is 0.91%

A sufficient audit coverage in finalised audits will be ensured via the selection of the ex-post audits in 2020 and after to be completed and reported in future years. S2R JU recognises that the results available at 31 December may be considered limited in respect of their coverage from the total cost accepted by the JU. The results becoming available after 31.12.2019 will be reported accumulatively in the Annual Activity Report 2020 and after.

S2R JU has reported the respective error rates in terms of both, simple and weighted average. The nature and characteristics of the population determine which one of these two methods provide more representative characteristics of the results. At the cut off 31.12.2019, no material difference was detected between these two approaches. Although the results available may be considered limited in respect their coverage, the error reported is below the targeted threshold of 2%.

European Court of Auditor on CAS assurance

It should be noted that as part of the 2018 Annual Report, the European Court of Auditors concluded that their re-performance audits *“revealed weaknesses in documentation, sampling consistency and reporting, as well as in the quality of the audit procedures in some of the files reviewed. For example, we found ineligible amounts not detected by the auditors due to insufficient testing in their audit, and errors in the calculation of the personnel costs claimed. Although, in some cases, the financial impact was not material, in 10 of the 20 audit files sampled, we were not able to rely on the audit conclusions. Therefore, currently we cannot use the results of the Commission’s audit work”*.³⁸

The Court recommendations request the Commission to address the aforementioned issues, which may also affect the reliability of the assurance provided to the Authorizing Officer.

4.4. Audit of the European Court of Auditors

The European Court of Auditors (ECA) with its mission of December 2019 completed its work which resulted in S2R JU Annual Audit Report for the year 2019, in accordance with the ECA mandate as defined in the TFEU.

During 2019, for the 2018 Financial Year, the European Court of Auditors released the following opinions:

Opinion on the reliability of the accounts

“In our opinion, the accounts of the JU for the year ended 31 December 2019 present fairly, in all material respects, the financial position of the JU at 31 December 2019, the results of its operations, its cash flows, and the changes in net assets for the year then ended, in accordance with its Financial Regulation and with accounting rules adopted by the Commission’s accounting officer. These are based on internationally accepted accounting standards for the public sector.”

Opinion on the legality and regularity of revenue underlying the accounts

“In our opinion, revenue underlying the accounts for the year ended 31 December 2019 is legal and regular in all material respects.”

Opinion on the legality and regularity of payments underlying the accounts

³⁸ https://www.eca.europa.eu/Lists/ECADocuments/annualreports-2018/annualreports-2018_EN.pdf, page 129, points 5.31 and following.

“In our opinion, payments underlying the accounts for the year ended 31 December 2019 are legal and regular in all material respects.”

For the year 2019, the ECA reported no findings for S2R JU in its draft preliminary observations report.

Furthermore, it is confirmed that the corrective actions taken by the S2R JU in response to the Court’s observations from previous years were mostly completed, while the status of two actions is ongoing:

- From year 2017: In response to the recommendations raised by the evaluators, the Joint Undertaking prepared an Action Plan adopted by the Governing Board on 28 June 2018. While not all recommendations raised in the Interim Evaluation will be addressed under the current Financial Framework Programme, some actions included in the Action Plan have already been initiated, while others, in accordance with their nature and the current legal framework, are expected to be implemented in the period 2018 to 2020.
- From year 2018: To improve further the efficiency and effectiveness of the lump sum funding scheme, the JU needs to continue to strengthen the financial data in its beneficiary database and to disclose important financial experts’ comments in the evaluation summary report.

This finding is considered implemented at the end of 2019.

During the course of 2019 the S2R JU took the necessary actions to remedy as much as possible to the main comments of the ECA. At the end of 2019, it is considered that the finding on Lump sum is fully implemented while the other open action will largely depend on the next Programming period of the JU.

The final ECA report is expected to be published at Q4 2020 and will include a consolidated view of the audit and finding for all the Joint Undertakings. Chapter 3 of the report regroups the individual Statements of Assurance for each JU; section 3.8 being the one specific to S2R JU.

4.5. Internal Audit

The Internal Audit Service (IAS) of the EC performs the role of Internal Auditor of the S2R JU and, in this respect, it reports to the S2R GB and the ED indirectly.

The first audit mission consisted in establishing a risk profile of the S2R JU with the objective of establishing a triennial audit plan. The IAS Strategic Internal Audit Plan 2017-2019 had been presented to the S2R GB in June 2017.

In accordance with this audit plan, the IAS performed in 2019 an audit on grant process (from the identification of the call topics to the signature of the grant agreement) in the S2R JU.

In its Final Audit Report of 21 October 2019, the ongoing efforts made by the JU to monitor strictly the duration of the grant preparation phase aiming at ensuring that the H2020 ‘time to grant’ target is respected were recognised.

With regard to the four important recommendations to management and one issue for consideration to address the shortcomings identified the S2R JU started implementing remedial activities, as defined in the Action Plan. The recommendations and corresponding remedial actions can be summarised as follows:

- *Participation of Member representatives as observers in the evaluation process*
S2R Action: The JU provided additional guidance on requirements for observers' participation in a note in January 2020; additional activities are under implementation.
- *Application of evaluation sub-criteria and scoring*
The JU will review the sub-criteria for call evaluation and refined the guidance to evaluators accordingly; considering that 2020 is expected to be the last call of the current JU, no specific sub-criteria have been established to avoid limiting the openness of the call.
- *Reporting on H2020 indicators*
The approach for the retrieval of relevant data on KPIs has been documented in the meantime and additional controls put in place.
- *Call topic development procedure*
The S2R JU has started looking into the process of defining the Call topic development procedure, which will be adapted in a formal way, should a new call be foreseen.
- *Multiannual Action Plan update process (issue for consideration)*

The process for the update of the MAAP is completed and the recommendation will be considered would a new update been required.

In addition, the JU also continued the implementation of actions resulting from the limited review of the implementation of internal control standards in the S2R JU which the IAS had carried out in 2018. By the end of 2019, the JU reported all recommendations as implemented which the IAS confirmed in January 2020.

In 2020, the IAS is planning to perform an in-depth risk assessment in the S2R JU as to develop a new Strategic Internal Audit Plan covering the period 2021-2023.

4.6. Risk management and conflict of interest

The S2R JU implements a risk policy to manage risks and opportunities related to the execution of the S2R Programme. The S2R JU follows the principles of the recognised international standards and aligns to the requirements of the EC as indicated in the Communication SEC (2005) *"Towards an effective and coherent risk management in the Commission services"*.

Risk is defined as *"any event that could occur and adversely impact the achievement of the S2R Joint Undertaking strategic and operational objectives. Lost opportunities are also considered as a risk"*.

The Risk Management system aims at enabling informed decision making with the objective of optimising the ratio between the level of acceptable risk by the S2R JU and the use of the relevant resources by anticipating and proactively identify, analyse, treat, control and monitor risks and opportunities.

With regard to programme specific risk management, the S2R Cooperation Tool as well as the relevant grant agreements related to the different projects provide for the framework to manage both risks and opportunities, with the possibility of escalating them to the proper level of the ED and S2R GB.

For the purpose of implementing the requirements of Article 23 of its constituent act pertaining to the prevention of conflicts of interest, the S2R JU has adopted rules governing conflicts of interest in respect of its members, bodies, staff and seconded staff, as well as its S2R GB members. The responsibility on conflict of interest is within the competencies of the ED.

4.7. Anti-Fraud Implementation and Indicators

During 2019, the JU continued to implement the Shift2Rail Anti-Fraud Strategy 2017-2020³⁹, a tailor-made anti-fraud strategy complementing the Horizon 2020 strategy, including an assessment of its risks and opportunities.

In accordance with the S2R Anti-Fraud Strategy, five indicators are used to report on the results of fraud prevention and detection activities. At the end of 2019, the following results are reported:

	Indicator	Result
1	Number and value of contracts subject to close monitoring or additional controls due to an assessment of a high risk of fraud.	0
2	Number (and trend in number) of files sent to OLAF for investigation.	0
3	Time elapsed between receipt by staff or management of first information on alleged internal fraud and transmission to OLAF.	NA
4	Time elapsed between OLAF requests for information and date when information is provided to OLAF.	NA
5	Time elapsed between receipt of an OLAF report and the decision on recovery or disciplinary sanctions by the S2R JU	NA

The Anti-Fraud Strategy also includes an Action plan designed to implement this strategy, which covers the different stages of the anti-fraud cycle: prevention, detection, investigation and corrective measures. As defined by the strategy, the Action Plan is reviewed on a biannual basis: the first review during 2019 took place at the end of the second quarter, a second review at the end of the fourth quarter. The following measures were adopted during 2019:

- The Memorandum of Understanding between JUs signed in the end of 2018 and establishing an inter-Joint Undertakings Network of Confidential Counsellors was disseminated within the JU. S2R staff received detailed guidance on the Inter-JU network of confidential counsellors.
- Two trainings on the prevention of psychological and sexual harassment were provided in 2019.

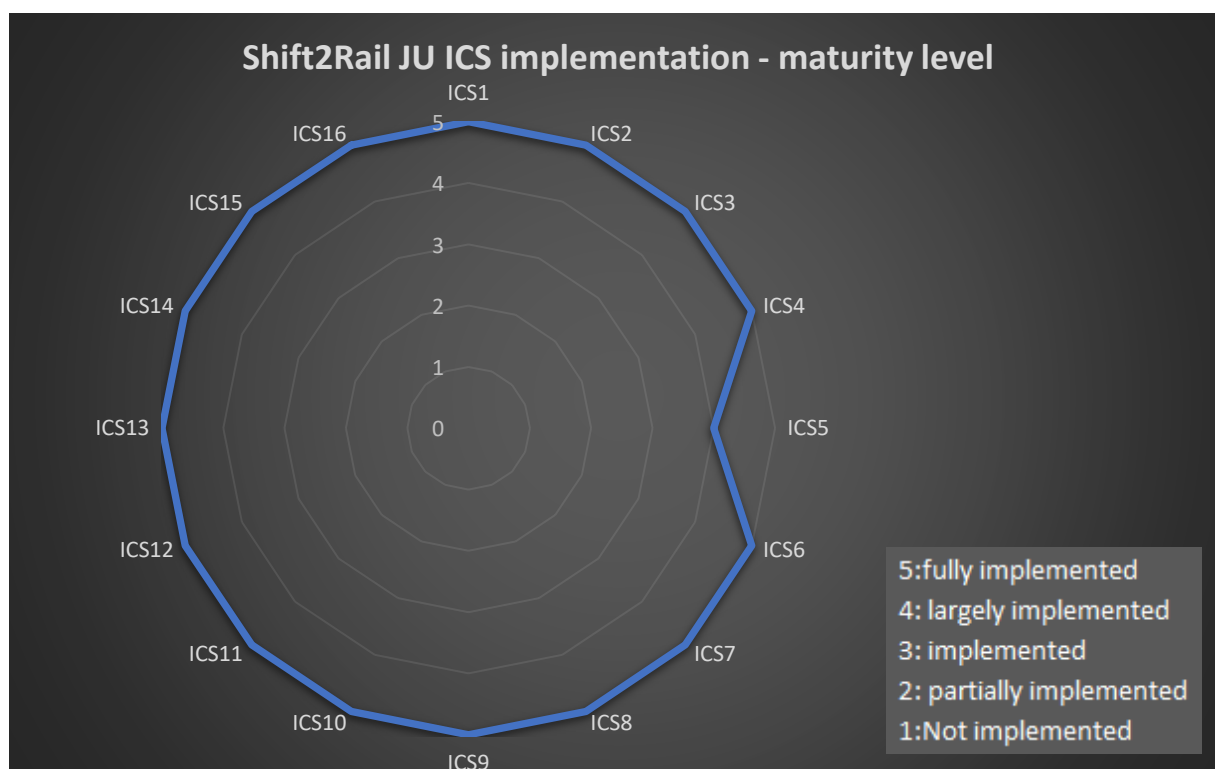
³⁹ <https://shift2rail.org/about-shift2rail/reference-documents/>

4.8. Compliance and effectiveness of Internal Control

The Internal Control Standards (ICS) were adopted in 2016 based on the Commission's ICS and adapted to the context and nature of the S2R JU. Compliance with the standards are continuously monitored. An action plan was established at the end of 2016 and had been progressively implemented to ensure the sound financial management of the S2R Programme.

An internal assessment of the S2R JU's ICS has been performed in order to evaluate the compliance and effectiveness of Internal Control. The internal assessment has been based on reports of the internal and external auditors, the follow up of audit recommendations as well as relevant information available to management.

Its results are summarised in the following graph:



Shift2Rail JU Internal Control assessment 2020 - AAR 2019			
<i>Scale</i> <i>1:Not implemented - 2: partially implemented - 3: implemented - 4: largely implemented - 5:fully implemented</i>			
Internal Control Standard	Definition	Assessment 2020 - AAR 2019	Status
ICS1	Mission	<p>In 2019, action was taken to implement recommendation N° 1 of the IAS Final Audit Report 2018 "Harmonisation of the presentation of the S2R mission statement".</p> <p>The S2R vision and mission statement has been aligned across key official documents: it is visible on the corporate website and has been included in key S2R documents such as the online 2018 Annual Activity Report, the Executive View of the 2018 Annual Activity Report, the Catalogue of Solutions published in October 2019 or the Annual Work Plan for 2020.</p>	5
ICS2	Ethical and organisational values	<p>Decisions on Conflict of Interests are adopted by the Governing Board.</p> <p>In 2018 the JU formalised the rules laying down guidelines on whistleblowing in addition to the organisation of awareness session on anti-fraud and ethic.</p> <p>During 2019, additional action was taken to further implement the S2R JU policy on protecting the dignity of the person and preventing psychological harassment and sexual harassment. This included detailed communication related to the Inter-JU network of confidential counsellors to staff as well as training on these topics.</p>	5
ICS3	Staff allocation and flexibility	<p>In Q3/4 2019, the S2R JU carried out an exercise of including job descriptions in SYSPER following discussions with line managers.</p> <p>The staff turnover remains an important concern generating long term risk for the S2R JU activity (Establishment plan).</p>	5
ICS4	Staff evaluation and development	<p>Staff performance is evaluated against individual annual objectives, which fit with Shift2Rail goals and objectives. The Learning and Development Policy was adopted by the Governing Board and provides the basis of staff development.</p>	5

Shift2Rail JU Internal Control assessment 2020 - AAR 2019			
<i>Scale</i> <i>1:Not implemented - 2: partially implemented - 3: implemented - 4: largely implemented - 5:fully implemented</i>			
Internal Control Standard	Definition	Assessment 2020 - AAR 2019	Status
ICS5	Objective and performance indicators	<p>In 2019, further action was taken to implement recommendation N° 2 of the IAS Final Audit Report 2018 "Finalisation of the KPI model". Following quarterly updates given to the IP/CCA SteCo and the GB, a dedicated GB workshop on KPIs was held. The Release 2.0 of the KPI model was then presented during the meeting of the Government Board in November 2019.</p> <p>The publication of the web-based tool, which is used as communication means to present the Shift2Rail Innovation potentials, is foreseen for 2020 following the completion of some additional work.</p> <p>In addition, an ED Decision 'On a renewed programme governance and change management' was adopted to ensure better the Programme design and implementation within the current legal framework; the advisory support to the Executive Director was formalised with the introduction of a new ED Programme Board.</p>	4
ICS6	Risk management process	<p>The Shift2Rail Risk Management Policy is part of the S2R JU Governance and Process Handbook adopted by Executive Director Decision in 2017. The risk assessment 2019 was carried out in the middle of the year consisting of a follow up of the previous year's exercise which had been implemented with the support of external consultants. The results of the annual risk assessment 2019 have been communicated in the Annual Work Plan (AWP) 2020 and in the Annual Activity Report 2019.</p>	5
ICS7	Operational structure	<p><u>Financial circuits:</u> This part is considered as largely implemented. Effective ex-ante and ex-post controls are in place and in respect of the Financial rules, guidance and procedure.</p> <p><u>Sensitive function:</u> The S2R JU policy on sensitive function was adopted in 2018.</p> <p><u>IT Governance:</u> The current ICT set up which resulted in a private cloud service in place for the overall JUs provides contractually the framework for business continuity addressing one of the major shortcomings of previously having ICT infrastructure in the building.</p>	5

Shift2Rail JU Internal Control assessment 2020 - AAR 2019			
<i>Scale</i> <i>1:Not implemented - 2: partially implemented - 3: implemented - 4: largely implemented - 5:fully implemented</i>			
Internal Control Standard	Definition	Assessment 2020 - AAR 2019	Status
ICS8	Processes and procedures	<p>Since the IAS limited review took place in 2018 resulted in a recommendation to "Strengthen application of the financial manual and checklists" (N° 3 of the IAS Final Audit Report 2018), the JU has strengthened the application of the financial manual by performing quarterly ex-post controls on administrative expenditure. Significant improvement was observed.</p> <p>In 2019, additional focus was given to the following:</p> <ol style="list-style-type: none"> 1. an improved control monitoring on expenditures based on reinforced accounting quality controls together with the S2R JU Accounting Officer and an annual ex-post quality control on administrative expenditure (Q4) with a possible risk assessment on the use of paperless system for administrative expenditure. 2. reinforcing the internal procedures for the operational expenditure (operational tender and grant agreements). 	5
ICS9	Management supervision	<p>The supervisory approach of the activities is reflected in current financial approach and financial rules as well as with the operation of the Programme Handbook since mid-2017. The 'renewed Programme Governance and Change Management' supports management oversight for the overall direction of the programme.</p>	5
ICS10	Business continuity	<p>In 2019, action was taken to further implement Recommendation N°4 of the IAS Final Audit Report 2018: "Awareness raising and testing of the BCP".</p> <p>Tests were performed following business interruption of activities with all JUs the 12 December 2018. In January 2019, an awareness raising session of the BCP was organised for JUs staff. Discussion with staff took place in January 2019 and S2R JU prepared a final report with logbook and lessons learned on BCP monitoring.</p>	5
ICS11	Document management	<p>Following the implementation of the Recommendation N°5 (last one) of the IAS Final Audit Report 2018: "Update the document management policy" during 2018, no specific actions had been foreseen for implementation during 2019. The document management policy is made publically available on the S2R website and revised as necessary.</p>	5
ICS12	Information and communication	<p>Shift2Rail has an external communication strategy to ensure that its external communication is effective, coherent and in line with the JU's key political messages (Communication Strategy adopted by the Executive Director in 2017). Since 2018, a new private cloud contractor has been providing the services. As a consequence, the additional</p>	5

Shift2Rail JU Internal Control assessment 2020 - AAR 2019			
<i>Scale</i> <i>1:Not implemented - 2: partially implemented - 3: implemented - 4: largely implemented - 5:fully implemented</i>			
Internal Control Standard	Definition	Assessment 2020 - AAR 2019	Status
		business security requirement for the JU has been assessed with the chosen solution.	
ICS13	Accounting and financial reporting	Adequate procedures and controls are in place to ensure that accounting data and related information used for preparing the organisation's annual accounts and financial reports are accurate, complete and timely.	5
ICS14	Evaluation activities	Evaluations of expenditure programmes and other non-spending activities are performed to assess the results, impacts and needs that these activities aim to achieve and satisfy.	5
ICS15	Assessment of internal control systems	The JU prepares an annual assessment of the implementation and effectiveness of the internal control system based on the requirements laid down in the decision on the 16 ICS. The JU reported the implementation status of each internal control standard in its AAR 2018, and now in its AAR 2019. During 2019, an action plan was prepared for the implementation of the new Internal Control Framework applicable at European Commission since 2018. The new Internal Control Framework will be implemented in 2020 and provide the basis of the assessment of internal control in the AAR 2020.	5
ICS16	Internal audit function	The Internal Audit Service of the European Commission will perform the function of internal auditor of the S2R JU, in compliance with the relevant international standards. The IAS provides independent, objective assurance and consulting services designed to add value and improve the operations of the S2R JU.	5

The status of the implementation of the S2R Internal Control Framework demonstrates the relevance for the S2R JU to embed risk based management and control systems within its activities to deliver its Programme.

In this respect, in 2019, the S2R JU started the process to implement the new Internal Control Framework proposed by the EC; this will be put in place in 2020 and it will constitute the basis of the JU's internal control self-assessment to be reported in the AAR 2020.

5. MANAGEMENT ASSURANCE

5.1. Assessment of the Annual Activity Report by the Governing Board

The ED submits the draft AAR to the S2R GB for assessment and approval. Once approved by the S2R GB, the AAR is made publicly available. No later than 1 July of each year the AAR together with its assessment shall be sent by the ED to the ECA, to the Commission, to the European Parliament and the Council.

The S2R GB takes note of the results achieved and recommends the JU to continue improving its effectiveness and efficiency with the Members' stronger support.

5.2. Elements supporting assurance

In addition to the specific supervisory activities of the ED, the main elements supporting the assurance are:

- the Certificate of the Accounting officer,
- the information received from the Head of R&I, the Head of Administration and Finance, the Data Protection Officer,
- the results of the audit of the ECA,
- audits performed by the Internal Audit Service,
- the overall risk management performed in 2019 as supervised by the ED,
- the key performance indicators in place,
- the dedicated ex-ante controls of the JU's operational and administrative expenditure,
- the results from ex-post audits carried out by the Commission services,
- the Other Members' reporting of in-kind contributions,
- the follow-up and monitoring of Call process,
- the exceptions reported in the *"exception and non-compliance register"* and the remedial measures put in place.

With regard to the Internal Control Coordinator, the staff member took up duty in the last quarter 2019 and its contribution will be included in the AAR 2020.

5.3. Reservations

The ED is not aware of any element that would bring him to introduce a reservation in the AAR 2019.

5.4. Overall conclusion

Not applicable.

6. DECLARATION OF ASSURANCE

I, the undersigned, Carlo M Borghini, Executive Director of Shift2Rail Joint Undertaking

In my capacity as authorising officer by delegation


Declare that the information contained in this report gives a true and fair view⁴⁰.

State that I have reasonable assurance that the resources assigned to the activities described in this report have been used for their intended purpose and in accordance with the principles of sound financial management, and that the control procedures put in place give the necessary guarantees concerning the legality and regularity of the underlying transactions.

This reasonable assurance is based on my own judgement and on the information at my disposal, such as the results of the self-assessment, ex-post controls, the work of the internal control coordinator, the observations of the Internal Audit Service and the lessons learnt from the reports of the Court of Auditors for years prior to the year of this declaration.

Confirm that I am not aware of anything not reported here which could harm the interests of the Joint Undertaking.

Brussels, 22 June 2020


.....
(signature) 22/06/2020

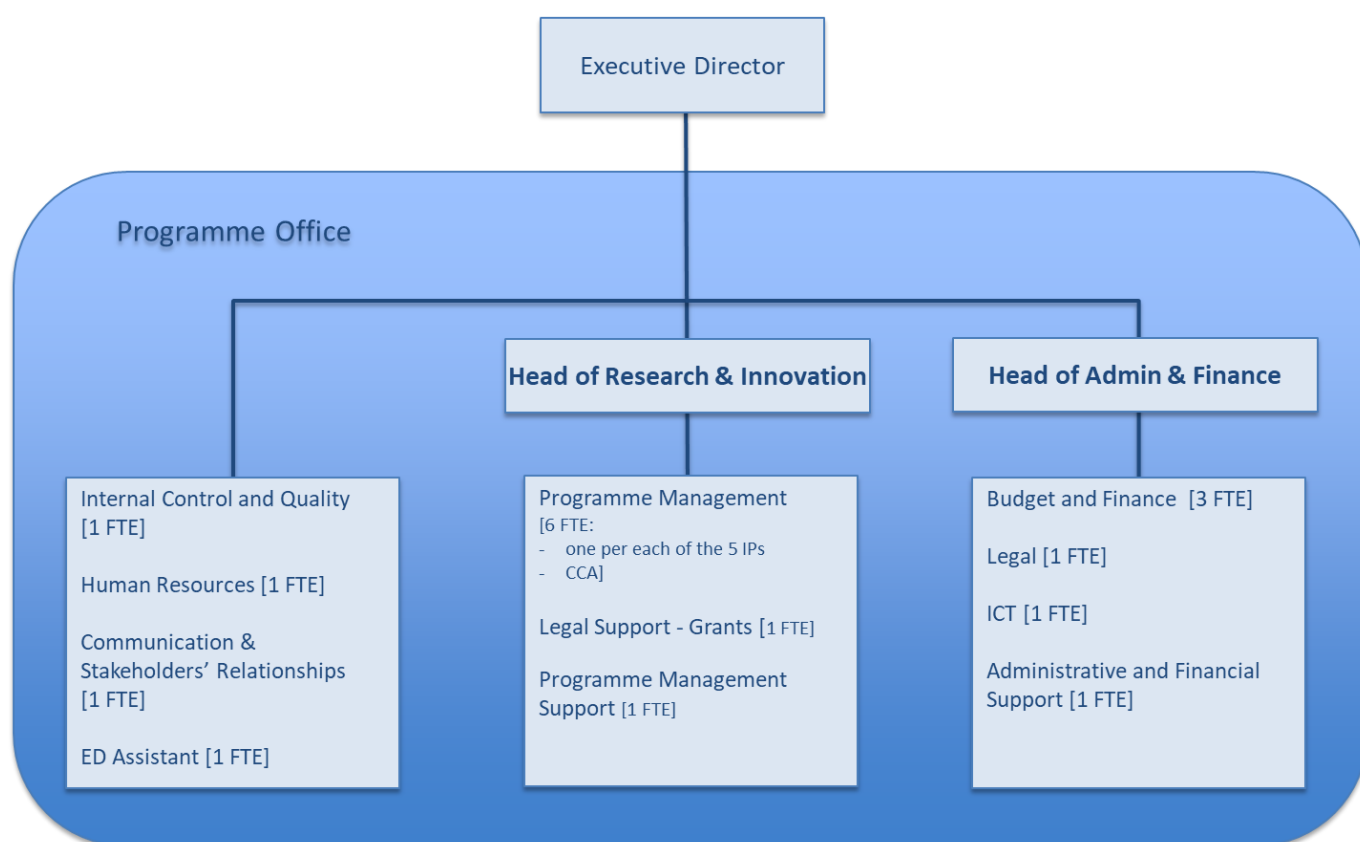
carlo m borghini,
Executive Director

⁴⁰ True and fair in this context means a reliable, complete and correct view on the state of affairs in the Joint Undertaking.

7. ANNEXES⁴¹

⁴¹ It should be noted that the Annexes related to publications from Projects, patents from Projects, materiality criteria are not included considering that the Projects' activities started only 1 September 2016.

ANNEX A Organisational chart of the S2R JU



ANNEX B Establishment plan

Function group and grade	Temporary agents					
	2017		2018		2019	
	Authorised under the EU Budget	Filled as of 31/12/2017	Authorised under the EU Budget	Filled as of 31/12/2018	Authorised under the EU Budget	Filled as of 31/12/2019
	Temporary posts	Temporary posts	Temporary posts	Temporary posts	Temporary posts	Temporary posts
AD 16						
AD 15						
AD 14	1	1	1	1	1	1
AD 13						
AD 12						
AD 11						
AD 10						
AD 9	2	2	2	2	2	2
AD 8			1	1	1	1
AD 7	1	1	1	1	1	1
AD 6	1	1				
AD 5						
AD TOTAL	5	5	5	5	5	5
AST 1-11						
AST TOTAL						
AST/SC 1-6						
AST/SC TOTAL						
TOTAL	5	5	5	5	5	5
GRAND TOTAL	5	5	5	5	5	5

Contract agents	Authorised 2017	Filled as of 31/12/2017	Authorised 2018	Filled as of 31/12/2018	Authorised 2019	Filled as of 31/12/2019
Function Group IV	11	9	11	10	12	13 ⁴²
Function Group III	3	5	3	3	3	3
Function Group II	2	1	2	2	1	1
Function Group I						
TOTAL	16	15	16	15	16	17

⁴² 1 additional FG IV is included for initial period of one year, with possible extension for one additional year. Such recruitment is in accordance with the Staff Regulation and within the budget availability of S2R to replace the activities covered by a TA, absent due to a serious long term sickness leave, with a new contract running from December 2019 to December 2020. It is important to mention that the associated tasks could in no circumstances be wholly or partly allocated to any internal staff (segregation of duties and conflict of interest) nor be covered by an external interim agent or consultant in compliance with the EU Financial Rules.

Seconded National Experts	Authorised 2017	Filled as of 31/12/2017	Authorise d 2018	Filled as of 31/12/2018	Authorised 2019	Filled as of 31/12/2019
TOTAL	2	0	2	3⁴³	2	3⁴⁴

⁴³ Of which 1 SNE replacing two maternity leaves during 2018 and 2019.

⁴⁴ Of which 1 SNE replacing two maternity leaves during 2018 and 2019.

ANNEX C Indicators and Scoreboard of KPIs

TABLE I - Horizon 2020 Key Performance Indicators⁴⁵ common to all JUs

	Correspondence to	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated	Result 2019
INDUSTRIAL LEADERSHIP	12*	SME - Share of participating SMEs introducing innovations new to the company or the market (covering the period of the project plus three years);	Based on Community Innovation Survey (?). Number and % of participating SMEs that have introduced innovations to the company or to the market;	Number of SMEs that have introduced innovations;	H2020 beneficiaries through project reporting	n.a. [new approach under H2020]	50%	Yes	43 %
	13	SME - Growth and job creation in participating SMEs	Turnover of company, number of employees	Turnover of company, number of employees;	H2020 beneficiaries through project reporting	n.a. [new approach under H2020]	to be developed based on FP7 ex-post evaluation and /or first H2020 project results	Yes	N.A.
SOCIETAL CHALLENGES	14*	Publications in peer-reviewed high impact journals in the area of the JU	The percentage of papers published in the top 10% impact ranked journals by subject category.	Publications from relevant funded projects (DOI: Digital Object Identifiers); Journal impact benchmark (ranking) data to be collected by	H2020 beneficiaries through project reporting; Responsible Directorate/Service (via access to	n.a. [new approach under H2020]	[On average, 20 publications per €10 million funding (for all societal challenges)]	Yes	202

⁴⁵ (based on Annex II to Council Decision 2013/743/EU)

	Correspondence to	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated	Result 2019
				commercially available bibliometric databases.	appropriate bibliometric databases)				
	15*	Patent applications and patents awarded in the area of the JU	Number of patent applications by theme; Number of awarded patents by theme	Patent application number	H2020 beneficiaries through project reporting; Responsible Directorate/Service (via worldwide search engines such as ESPACENET, WOPI)	n.a. [new approach under H2020]	On average, 2 per €10 million funding (2014 - 2020) RTD A6	Yes	4
	16*	Number of prototypes testing activities and clinical trials	Number of prototypes, testing (feasibility/demo) activities, clinical trials	Reports on prototypes, and testing activities, clinical trials	H2020 beneficiaries through project reporting	n.a. [new approach under H2020]	[To be developed on the basis of first Horizon 2020 results]	Yes	325
	17*	Number of joint public-private publications in projects	Number and share of joint public-private publications out of all relevant publications.	Properly flagged publications data (DOI) from relevant funded projects	H2020 beneficiaries through project reporting; Responsible Directorate/Service (via DOI and	n.a. [new approach under H2020]	[To be developed on the basis of first Horizon 2020 results]	Yes	19

	Correspondence to	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated	Result 2019
					manual data input-flags)				
	18*	New products, processes, and methods launched into the market	Number of projects with new innovative products, processes, instruments, methods, technologies	Project count and drop down list allowing to choose the type processes, products, instruments, methods, technologies	H2020 beneficiaries through project reporting	n.a. [new approach under H2020]	[To be developed on the basis of first Horizon 2020 results]	Yes	31
EVALUATION	NA	Time to inform (average time in days) <u>all applicants</u> of the outcome of the evaluation of their application from the final date for submission of completed proposals	To provide applicants with high quality and timely evaluation results and feedback after each evaluation step by implementing and monitoring a high scientific level peer reviewed process	Number of days (average)	Joint Undertaking	H2020		Yes	84
	NA	Time to inform (average time in days) <u>successful applicants</u> of the outcome of the evaluation of their application from the final date for submission of completed proposals		Number of days (average)	Joint Undertaking	H2020		Yes	84

	Correspondence to	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated	Result 2019
	NA	Redress after evaluations	To provide applicants with high quality and timely evaluation results and feedback after each evaluation step by implementing and monitoring a high scientific level peer reviewed process	Number of redresses requested	Joint Undertaking	H2020			none
GRANTS	NA	Time to grant measured (average) from call deadline to signature of grants	To minimise the duration of the granting process aiming at ensuring a prompt implementation of the Grant Agreements through a simple and transparent grant preparation process	Cumulatively in days Average under H2020 (days) TTG < 270 days (as %of GAs signed)	Joint Undertaking (automatized)	H2020		Yes	170
	NA	Time for signing grant agreements from the date of informing successful applicants (average values)		Average under H2020 (days)	Joint Undertaking	H2020		Yes	86
AUDITS	NA	Error rate		% of common representative error; % residual error	CAS	H2020		Yes	-Representative detected error rate: 2.78% = Cumulative residual error rate for the R&I Family of DGs: 2.15 % reports.

	Correspondence to	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated	Result 2019
	NA	Implementation of ex-post audit results		Number of cases implemented; in total €million; 'of cases implemented/total cases	CAS	H2020		Yes	o/s

	Correspondence to	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated	Result 2019
PAYMENTS	NA	Time to pay (% made on time) -pre-financing - interim payment -final payment	To optimize the payments circuits, both operational and administrative, including payments to experts	Average number of days for Grants pre-financing, interim payments and final payments; Average number of days for administrative payments; Number of experts appointed	Joint Undertaking	H2020	-pre-financing (30 days) - interim payment (90 days) -final payment ((90days)	Yes	<u>Operational:</u> Pre-financing: 100% Average number of days: 18 Interim/final: 71.9% Average number of days: 78 <u>Administrative:</u> Pre-financing: N/A Interim/final: 97.4% Average number of days: 16 <u>Number of experts appointed:</u> 29

	Correspondence to	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated	Result 2019
HR	NA	Vacancy rate (%)		% of post filled in, composition of the JU staff ⁴⁶	Joint Undertaking	H2020			100%
JU EFFICIENCY	NA	Budget implementation/execution: 1. % CA to total budget 2. % PA to total budget	realistic yearly budget proposal, possibility to monitor and report on its execution, both in commitment (CA) and payments (PA), in line with sound financial management principle	% of CA and PA	Joint Undertaking	H2020	100% in CA and 90% in PA	Yes	<u>100% in CA</u> <u>88% in PA</u>
	NA	Administrative Budget: Number and % of total of late payments	realistic yearly budget proposal, possibility to monitor and report on its execution in line with sound financial management principle	Number of delayed payments % of delayed payments (of the total)	Joint Undertaking		H2020	Yes	<u>22 late payments</u> <u>2.58%</u>

NOTES:

12,14,15,16,17,18*: The upcoming Control Gates (April) and project Reviews could generate improved data for this KPI which is cumulative on the S2R running projects in 2017.

18*: This indicator is not a legally compulsory one, but it covers several additional specific indicators requested for more societal challenges by the services in charge.

⁴⁶ Additional indicators can be proposed/discussed with R.1 and/or DG HR

TABLE II - Indicators for monitoring H2020 Cross-Cutting Issues⁴⁷ common to all JTI JUs

Correspondence in the general	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated	Result 2019
2	Widening the participation	2.1 Total number of participations by EU-28 Member State	Nationality of H2020 applicants & beneficiaries (number of)	H2020 applicants & beneficiaries at the submission and grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes	<p>At the submission:</p> <p>373 Applicants from 22 Member States:</p> <p>19 AT, 17 BE, 1 CR, 15 CZ, 1 EST, 2 FIN, 42 FR, 59 GER, 11 GRE, 5 HUN, 52 IT, 1 LV, 2 LT, 10 NL, 3 PL, 11 PT, 5 ROM, 5 SV, 5 SL, 59 ES, 17 SW, 31 UK</p> <p>In the signed grant agreements:</p> <p>198 beneficiaries from 18 Member States</p> <p>12 AT, 5 BE, 6 CZ, 2 FIN, 23 FR, 1 HU, 38 GER, 4 GRE, 29 IT, 6 NL, 1 PL, 4 PT, 2 ROM, 2 SV, 2 SL, 34 ES, 13 SW, 15 UK</p>
		2.2 Total amount of EU financial contribution by EU-	Nationality of H2020 beneficiaries and corresponding EU financial contribution	H2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes	<p>73.6 M € from 18 Member states :</p> <p>1.3M AT, 938K BE, 1M CZ, 21.9M DE, 635K EL, 13.8M ES, 282K FI, 7M</p>

⁴⁷ (based on Annex III to Council Decision 2013/743/EU)

Correspondence in the general	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated	Result 2019
		28 Member State (EUR millions)						FR, 16K HU, 11.7M IT, 1.7M NL, 200K PL, 557K PT, 150K RO, 5,7M SE, 102K SI, 254K SK, 6M UK
NA		Total number of participations by Associated Countries	Nationality of H2020 applicants & beneficiaries (number of)	H2020 applicants & beneficiaries at the submission and grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes	At the submission: 16 applicants from 3 countries 5 Serbia, 8 Switzerland, 3 Turkey In the signed grant agreements: 5 Beneficiaries from 2 countries 2 Serbia, 3 Switzerland
NA		Total amount of EU financial contribution by Candidate Country (EUR millions)	Nationality of H2020 beneficiaries and corresponding EU financial contribution	H2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes	2 Associated countries beneficiaries 1.1M€ : 771K CH, 375K RS
3	SMEs participation	3.1 Share of EU financial contribution going to SMEs (Enabling & industrial tech and Part III of Horizon 2020)	Number of H2020 beneficiaries flagged as SME; % of EU contribution going to beneficiaries flagged as SME	H2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report		Yes	46 Beneficiaries are SMEs and they benefit of 10.1% of the total contribution
6	Gender	6.1 Percentage of women participants in H2020 projects	Gender of participants in H2020 projects	H2020 Beneficiaries through project reporting		YES	Yes	20.31% of applicants 20.69% among beneficiaries

Correspondence in the general	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated	Result 2019
		6.2 Percentage of women project coordinators in H2020	Gender of MSC fellows, ERC principle investigators and scientific coordinators in other H2020 activities	H2020 beneficiaries at the grant agreement signature stage		YES	Yes	41.18%
		6.3 Percentage of women in EC advisory groups, expert groups, evaluation panels, individual experts, etc.	Gender of memberships in advisory groups, panels, etc.	Compiled by Responsible Directorate/ Service /Joint Undertaking based on existing administrative data made available by the CSC		YES		<ul style="list-style-type: none"> S2R JU Governing Board : 16% of representatives are female in the GB members only and 19% including alternates S2R JU States Representatives Group 33% of representatives are female S2R JU Scientific Committee : 33% of members are female
7	International —	7.1 Share of third-country participants in Horizon 2020	Nationality of H2020 beneficiaries	H2020 beneficiaries at the grant agreement signature stage	JU AAR RTD Monitoring Report	NO	Yes	0%

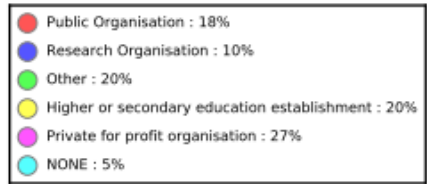
Correspondence in the general	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated	Result 2019
		7.2 Percentage of EU financial contribution attributed to third country participants	Nationality of H2020 beneficiaries and corresponding EU financial contribution	H2020 beneficiaries at the grant agreement signature stage	JU AAR RTD Monitoring Report	NO	Yes	0%
9	Bridging from discovery to market ⁴⁸	9.1 Share of projects and EU financial contribution allocated to Innovation Actions (IAs)	Number of IA projects	Project Office – at GA signature stage he/she will be required to flag on SYGMA. Responsible Directorate/Service (WP coordinator)/Joint Undertaking - via tool CCM2	JU AAR RTD Monitoring Report		Yes	41% (share of projects) 79 % (share of financial contribution)
		9.2 Within the innovation actions, share of EU financial contribution focussed on demonstration and first-of-a-kind activities	Topics properly flagged in the WP; follow-up at grant level	Responsible Directorate/Service (WP coordinator)/Joint Undertaking - via tool CCM2	JU AAR RTD Monitoring Report		Yes	100% follow up as per Grant Agreement

⁴⁸ This indicator (9.2) is initially intended to monitor the Digital Agenda (its applicability could be only partial)

Correspondence in the general issue	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated	Result 2019
NA		Scale of impact of projects (High Technology Readiness Level)	Number of projects addressing TRL ⁴⁹ between...(4-6, 5-7)?	Joint Undertaking	JU AAR RTD Monitoring Report		No	TRL 4-6: 6 TRL 5-7: 11
11	Private sector participation	11.1 Percentage of H2020 beneficiaries from the private for profit sector	Number of and % of the total H2020 beneficiaries classified by type of activity and legal status	H2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report		Yes	151 beneficiaries 55 % of the total beneficiaries
		11.2 Share of EU financial contribution going to private for profit entities (Enabling & industrial tech and Part III of Horizon 2020)	H2020 beneficiaries classified by type of activity; corresponding EU contribution	H2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report		Yes	68%
12	Funding for PPPs	12.1 EU financial contribution for PPP (Art 187)	EU contribution to PPP (Art 187)	Responsible Directorate/Service	JU AAR RTD Monitoring Report		Yes	80.0m€
		12.2 PPPs leverage: total amount of funds leveraged through Art. 187 initiatives, including	Total funding made by private actors involved in PPPs - in-kind contribution already committed by	Joint Undertaking Services	JU AAR RTD Monitoring Report			respectively 126% and 152% , certification process ongoing

⁴⁹ TRL: Technology Readiness Level

Correspondence in the general	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated	Result 2019
		additional activities, divided by the EU contribution	private members in project selected for funding - additional activities (i.e. research expenditures/investment of industry in the sector, compared to previous year)					
13*	Communication and dissemination	13.3 Dissemination and outreach activities other than peer-reviewed publications - [Conferences, workshops, press releases, publications, flyers, exhibitions, trainings, social media, web-sites, communication campaigns (e.g. radio, TV)]	A drop down list allows to choose the type of dissemination activity. Number of events, funding amount and number of persons reached thanks to the dissemination activities	H2020 Beneficiaries through project reporting	JU AAR RTD Monitoring Report	YES	Yes	878 Dissemination and outreach activities other than peer-reviewed publications 264.634 persons reached

Correspondence in the general issue	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated	Result 2019
14	Participation patterns of independent experts	14.2 Proposal evaluators by country	Nationality of proposal evaluators	Responsible Directorate /Service/Joint Undertaking in charge with the management of proposal evaluation				36 experts from 12 Member States : 1 AT, 1 BG, 4 FR, 3 GER, 5 GRE, 4 IRE, 7 IT, 3 NL, 1 PL, 1 PT, 1 RO, 5 SP
		14.3 Proposal evaluators by organisations' type of activity	Type of activity of evaluators' organisations	Responsible Directorate /Service/Joint Undertaking in charge with the management of proposal evaluation				Extract from S2R Experts Pool statistics <div>  <ul style="list-style-type: none"> Public Organisation : 18% Research Organisation : 10% Other : 20% Higher or secondary education establishment : 20% Private for profit organisation : 27% NONE : 5% </div>

Correspondence in the general issue	Cross cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated	Result 2019
sNA	Participation of RTOs and Universities	Participation of RTO ⁵⁰ s and Universities in PPPs (Art 187 initiatives)	Number of participations of RTOs to funded projects and % of the total Number of participations of Universities to funded projects and % of the total % of budget allocated to RTOs and to Universities	H2020 beneficiaries at the grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes	33 participations of RTOs 9% of total 44 participations of universities 11% of total 19% of total budget allocated to RTOs and Universities
NA	Ethics	The objective is ensuring that research projects funded are compliant with provisions on ethics efficiently	% of proposals not granted because non-compliance with ethical rules/proposals invited do grant (target 0%); time to ethics clearance 5target 45 days) ⁵¹	Responsible Directorate /Service/Joint Undertaking	JU AAR RTD Monitoring Report			0%

Notes:

*H2020 applicants - all those who submitted H2020 proposals

*H2020 beneficiaries - all those who have signed a H2020 Grant Agreement

⁵⁰ RTO: Research and Technology Organisation

⁵¹ Data relates to pre-granting ethics review. This time span runs in parallel to granting process.

13*: The upcoming Control Gates (April) and project Reviews could generate improved data for this KPI which is cumulative on the S2R running projects in 2017.

TABLE III - Key Performance Indicators specific for the S2R JU

#	Key Performance Indicator	Objective	Data to be provided by	Baseline at the start of H2020	Target at the end of H2020	Automated	Result 2019
S2R							
1	% reduction in the costs of developing, maintaining, operating and renewing infrastructure and rolling stock and increase energy efficiency compared to "State-of-the-art"	Reduce the life-cycle cost of the railway transport system	JU	"State-of-the-art" 2014	> 50 %	No	See table IV
2	% increase the capacity of railway segments to meet increased demand for passenger and freight railway services compared to "State-of-the-art" 2014	Enhance the capacity of the railway transport system	JU	"State-of-the-art" 2014	100%	No	See table IV
3	% decrease in unreliability and late arrivals compared to "State-of-the-art" 2014	Increase in the quality of rail services	JU	"State-of-the-art" 2014	> 50%	No	See table IV
4	Reduce noise emissions and vibrations linked to rolling stock and respectively infrastructure compared to "State-of-the-art" 2014	Reduce the negative externalities linked to railway transport	JU	"State-of-the-art" 2014	> 3 - 10 dBA	No	-2 dB overall noise limits (FINE1) -4 dB parking operation (FINE1)

#	Key Performance Indicator	Objective	Data to be provided by	Baseline at the start of H2020	Target at the end of H2020	Automated	Result 2019
							<p>Specific examples:</p> <p>-6 dB noise damping mechanical absorption solutions (FR8RAIL)</p> <p>-15-20 dB reduced electromagnetic noise on main transformer (PINTA)</p>
5	Addressing open points in TSIs, compared to "State-of-the-art" 2014	Enhance interoperability of the railway system	JU	"State-of-the-art" 2014		No	One open point of the TSI Infra (tender and IN2TRACK-2)
6	Number of Integrated Technology Demonstrators (ITDs) and System Platform Demonstrations (SPD)	Improve market uptake of innovative railway solutions through large-scale demonstration activities	JU	Multi-Annual Action Plan	4 SPD	No	Updated SPD definition is available (IMPACT-2, deliverable D3.1)
7	Share of the fund allocated to the different Innovation Programmes and to cross-cutting themes	Ensure that funding covers the railway system as a whole	JU	n.a.	> 80%	No	100% of the operational funding

#	Key Performance Indicator	Objective	Data to be provided by	Baseline at the start of H2020	Target at the end of H2020	Automated	Result 2019
8	Percentage of topics resulting in signature of GA	Ensure a sufficiently high call topics success rate	JU	n.a.	> 90%	Yes	94%
9	% of resources consumption versus plan (members only)	WP execution by members - resources	JU	n.a.	> 80%	Yes	o/s
10	% of deliverables available versus plan (members only)	WP execution by members - deliverables	JU	n.a.	> 80%	No	- 85.77% (2015-2019) - 81.82% (2019 only)

TABLE IV – Initial Estimation – Release 2.0 - of the Key Performance Indicators of the Shift2Rail Programme

SPD	LCC		Capacity		Punctuality	S2R KPIs
Target	-50%		+100%		+50%	
High speed	-15%	-18%	69%	74%	29%	19%
Regional	-21%	-24%	57%	49%	51%	15%
Urban	-16%	-18%	23%	28%	n / a	
Freight	-39%	-40%	42%-114%*	91%	78%	71%

*depending on IP2 improvement 0-50%

release 1.0

One of the objectives of the Shift2Rail Joint Undertaking defined in its regulation is to seek developing, integrating, demonstrating and validating innovative technologies and solutions that uphold the strictest safety standards and the value of which can be measured against, inter alia, 3 quantitative Key Performance Indicators (KPIs). The targets defined are the following: reduction of LCC by 50%, improving the reliability & punctuality by 50% and doubling the capacity.

As the railway system is a very interlinked and complex system, it is required to have specific tools and methods to evaluate the effect of technological developments. This question is highly relevant for Shift2Rail as the technologies, which are developed, are to be evaluated with respect to four scenarios called System Platform Demonstrators (SPDs). Hence an approach of estimating the above mentioned KPIs applied on the four generic SPDs based on the market segments high-speed rail, regional rail, metro and freight rail⁵² has been applied which were defined in the S2R Master Plan⁵³.

⁵² IMPACT-1 – D4.1 “Reference Scenario” – 2018, Issue 1

⁵³ Shift2Rail - Shift2Rail Master Plan (MP) – 2015

As some of the Shift2Rail technologies (e.g. Innovation Programme on IT Solutions for Attractive Railway Services) are targeting to increase modal share of rail within the transport sectors by satisfying the customer's travel experience, those innovations cannot be taken directly into account in the three quantitative KPIs, only via an increased load factor. Therefore a dedicated model on the improvement of the attractiveness of the rail system is developed independent from the model discussed here (see also explanations to "demand effect").

In 2019, the Release 2.0 of the KPI model was published. In this version, the Scenarios for the SPDs are continuously stabilised due to a process involving a variety of sources and expertise. Hereby it was identified that the Freight SPD has the highest potential for improvement, among others due to a more flexible operation concept for the SPD.

The cost share within the railway system has a significant influence on LCC-KPI results so e.g. for SPD 1 the reduction of infrastructure maintenance cost is currently estimated to be in the order of 42% while the overall result is about 15%. The LCC improvements for the trains in IP1 are currently conservative estimations based on the estimation of cost for prototypes. Presumably the LCC reduction for the serial production of the end-product will be significantly higher.

The KPI Capacity is the one with the highest complexity of integrated systems which leads to a high sensitivity against minor changes in the input values. The capacity is highly influenced by the number of trains possible hence mainly depending on the signaling system. Especially for the freight scenario, further investigations on the correlations of different effects need to be carried out to ensure a reliable result. Therefore a range depending on the improvement possible by the signalling system is shown in the table.

The improvements in the Punctuality model are mainly caused by a change of the calculation method. The modelling of the Punctuality, which was in the initial model based on a calculation of delayed trains, is now based on a calculation of delay minutes in the scenario. Therefore, not only the number of failures can be taken into account, but also the impact of each type of failure. For the Metro SPD there is no Punctuality result reported, because it was identified that a reasonable data base to do so could neither be found within Shift2Rail nor in any other accessible source.

Key Performance Indicators - KPI

The KPI Life-Cycle-Cost (LCC) is defined as the cost for the railway undertaking over the lifespan of the systems. Hence they are the investment cost, operative cost like maintenance, labour or energy cost and, where applicable, the dismantling cost.

The KPI Capacity is defined as the maximum possible capacity, which is the maximum number of transportable passengers in one peak hour for the passenger transport scenarios and the maximum of tonne-kilometres in 24 hours for freight.

The KPI Reliability and Punctuality is measured as a 50% decrease of late arrivals mainly caused by unreliability of technologies.

System Platform Demonstrators - SPDs

The reference scenarios (state of the art technologies in 2013) described in the deliverable D4.1 “Reference Scenarios” of IMPACT-1 and were further developed in IMPACT-2. The data for this scenarios were collected from various sources whereas usually there could only one source for each certain parameter be found. The coherence check is scheduled for the next iteration of the model.

Further there are aspects for the four different market segments of the SPDs, which need to be kept in mind, when reviewing the result table. Those aspects are due to the inherent structure and specificities of the different market segments:

For the High Speed passenger transport (SPD1), relatively new or constantly upgraded vehicles and lines are taken into account, which are more or less best of class in Europe. Therefore, it is on the one hand a much elaborated basis to start from and on the other hand it can be assumed that effects at less developed railways will show much higher results.

The main relevant KPIs for typically Regional Rail (SPD2) lines are LCC and punctuality. Hence the challenge is here to provide a punctual service at lower cost.

Concerning Metro Rail (SPD3), there are few activities dedicated directly on Metro in direct relation to the specific S2R JU objectives in the short term. Therefore, the results for Metro are mainly based on positive effects of the innovations developed for High Speed or Regional trains as e.g. reduction of energy consumption or improved maintenance. They are not optimised for this special form of rail transport, but can help to reduce LCC and improve capacity.

Because SPD4, Freight rail, is not focussing on passenger transport, but freight transport, it differs in some definitions and focus points from the other three SPDs. Further the modelling has not only to consider technological improvements, but also operational optimisation for rail freight transport. Moreover, as generally the introduction of innovations in freight rail operation takes more time than in passenger transport, the technology level in execution is quite moderate. Taking both into account, the more legacy basis to start from and the technological and operational effects, the achievable benefits are much higher than for the other three SPDs.

Further some innovations cannot show their full potential, because there is only one scenario per market segment. Those scenarios are optimised to show the majority of positive effects, but cannot be set to show every effect of every Shift2Rail innovation.

Demand effect

As already explained in the background, large parts of positive effects especially for the passenger transport (SPD1-3) are not adequately measurable through LCC, capacity and punctuality, e.g. new IT solutions (IP4), effects of other innovations such as noise mitigation, customer oriented services and better quality, increased comfort for the customers, better governance etc. Those will be included in the attractiveness model. Therefore, the increase of demand is not

considered in the results for the passenger SPDs, yet, meaning that for the first results there is no change in the load factor and therefore in the demand included. For the freight SPD, a demand increase could already be considered and therefore also its positive effect of the contribution margin.

ANNEX D Annual accounts

In line with the reporting requirement detail in FR 2018 Article 130.4, the Financial Framework Partnerships >4 years are reported under section 1.6 of this document.

BALANCE SHEET

		EUR '000	
	Note	31.12.2019	31.12.2018
NON-CURRENT ASSETS			
<i>Intangible assets</i>		0	0
<i>Property, plant and equipment</i>	2.1	197	235
<i>Pre-financing</i>	2.2	44 980	41 652
		45 177	41 887
CURRENT ASSETS			
<i>Pre-financing</i>	2.2	33 756	19 240
<i>Exchange receivables and non-exchange recoverables</i>	2.3	26 316	29 757
		60 072	48 998
TOTAL ASSETS		105 249	90 885
CURRENT LIABILITIES			
<i>Payables and other liabilities</i>	2.4	(80 746)	(69 211)
<i>Accrued charges and deferred income</i>	2.5	(36 963)	(24 685)
		(117 710)	(93 896)
TOTAL LIABILITIES		(117 710)	(93 896)
NET ASSETS			
		(12 461)	(3 011)
<i>Contribution from Members</i>	2.6	298 570	187 070
<i>Accumulated deficit</i>		(190 081)	(78 305)
<i>Economic result of the year</i>		(120 950)	(111 776)
NET ASSETS		(12 461)	(3 011)

STATEMENT OF FINANCIAL PERFORMANCE

		EUR '000	
	Note	2019	2018
REVENUE			
Revenue from non-exchange transactions			
<i>Recovery of expenses</i>		30	–
		30	–
Revenue from exchange transactions			
<i>Other</i>		4	–
		4	–
Total revenue		34	–
EXPENSES			
<i>Operating costs</i>	3.1	(117 459)	(108 268)
<i>Staff costs</i>	3.2	(1 684)	(1 547)
<i>Other expenses</i>	3.3	(1 842)	(1 960)
Total expenses		(120 984)	(111 776)
ECONOMIC RESULT OF THE YEAR		(120 950)	(111 776)

CASHFLOW STATEMENT⁵⁴

	EUR '000	
	2019	2018
<i>Economic result of the year</i>	(120 950)	(111 776)
Operating activities		
<i>Depreciation and amortization</i>	53	52
<i>(Increase)/decrease in pre-financing</i>	(17 843)	5 673
<i>(Increase)/decrease in exchange receivables and non-exchange recoverables</i>	3 441	(20 110)
<i>Increase/(decrease) in payables</i>	11 535	32 441
<i>Increase/(decrease) in accrued charges & deferred income</i>	12 278	(4 085)
<i>Increase/(decrease) in financial contributions</i>	64 529	79 165
<i>Increase/(decrease) in in-kind contributions</i>	46 972	18 663
Investing activities		
<i>(Increase)/decrease in intangible assets and property, plant and equipment</i>	(15)	(23)
NET CASHFLOW	–	–
<i>Net increase/(decrease) in cash and cash equivalents</i>	–	–
<i>Cash and cash equivalents at the beginning of the year</i>	–	–
<i>Cash and cash equivalents at year-end</i>	–	–

⁵⁴ Following the appointment of the Accounting Officer of the Commission as the Accounting Officer of S2R JU, the treasury of S2R JU was integrated into the Commission's treasury system. Therefore, S2R JU does not have any bank accounts of its own. All payments and receipts are processed via the Commission's treasury system and registered on intercompany accounts which are presented under the heading exchange receivables.

STATEMENT OF CHANGES IN NET ASSETS

EUR '000				
	Contribution from Members	Accumulated Surplus/ (Deficit)	Economic result of the year	Net Assets
BALANCE AS AT 31.12.2017	89 241	(11 925)	(66 381)	10 936
<i>Allocation 2017 economic result</i>	–	(66 381)	66 381	–
<i>Financial contribution</i>	79 165	–	–	79 165
<i>Contribution in-kind</i>	18 663	–	–	18 663
<i>Economic result of the year</i>	–	–	(111 776)	(111 776)
BALANCE AS AT 31.12.2018	187 070	(78 305)	(111 776)	(3 011)
<i>Allocation 2018 economic result</i>	–	(111 776)	111 776	–
<i>Financial contribution</i>	64 529	–	–	64 529
<i>Contribution in-kind</i>	46 972	–	–	46 972
<i>Economic result of the year</i>	–	–	(120 950)	(120 950)
BALANCE AS AT 31.12.2019	298 570	(190 081)	(120 950)	(12 461)

ANNEX E Overview of publications and events

SHIFT2RAIL 2019 PUBLICATIONS

Title	Publication Date	Link to the Publication
Study on the Use of Fuel Cells and Hydrogen in the Railway Environment	17 May, 2019	https://shift2rail.org/wp-content/uploads/2019/04/Final-version_study-on-the-use-of-fuel-cells-and-hydrogen-in-the-railway-environment.pdf
Human Capital Report Series: Building block for new skills ecosystem	30 July, 2019	https://shift2rail.org/wp-content/uploads/2019/07/Human-Capital-Report-Series_Building-block-for-new-skills-ecosystem.pdf
Human Capital Report Series: Impact Analysis	30 July, 2019	https://shift2rail.org/wp-content/uploads/2019/07/Human-Capital-Report-Series_Impact-Analysis.pdf
Human Capital Report Series: New skills required for the future, skills gap per staff category in the railway sector	30 July, 2019	https://shift2rail.org/wp-content/uploads/2019/07/Human-Capital-Report-Series_New-skills-required.pdf
Human Capital Report Series: Socio-economic aspects of human capital	30 July, 2019	https://shift2rail.org/wp-content/uploads/2019/07/Human-Capital-Report-Series_Socio-economic-aspects.pdf
Human Capital Report Series: Bridging the Skills Gap for the Rail Sector	30 July, 2019	https://shift2rail.org/wp-content/uploads/2019/07/Human-Capital-Report-Series_Bridging-the-skills-gap.pdf
Annual Activity Report 2018: Executive View	30 September, 2019	https://shift2rail.org/wp-content/uploads/2019/09/Shift2rail-Rapport_Annuel-2018_Web.pdf
Catalogue of Solutions	28 October, 2019	https://shift2rail.org/wp-content/uploads/2019/10/Catalogue-of-Solutions-Web.pdf
Shift2Rail Factsheet	26 November, 2019	https://shift2rail.org/wp-content/uploads/2018/12/Shift2Rail-Factsheet-LATEST-VERSION.pdf

SHIFT2RAIL 2019 PRESS RELEASES

Title	Publication Date	Link to the Publication
Memorandum of Understanding signed between Shift2Rail JU and the Ministry of Transport of the Czech Republic	4 January, 2019	https://shift2rail.org/press-releases/memorandum-of-understanding-signed-between-shift2rail-ju-and-the-ministry-of-transport-of-the-czech-republic/
Shift2Rail publishes its new Call for Proposals 2019	16 January, 2019	https://shift2rail.org/press-releases/shift2rail-publishes-its-new-call-for-proposals-2019/
Space for Rail: Bringing the Benefits of Global Satellite Navigation to Railway Customers in Europe and Beyond	18 March, 2019	https://shift2rail.org/press-releases/space-for-rail-bringing-the-benefits-of-global-satellite-navigation-to-

		railway-customers-in-europe-and-beyond/
New study shows good potential for hydrogen-powered trains in Europe	13 May, 2019	https://shift2rail.org/press-releases/new-study-shows-good-potential-for-hydrogen-powered-trains-in-europe/
28% increase in number of applications for Shift2Rail Call for Proposals 2019	24 June, 2019	https://shift2rail.org/press-releases/28-increase-in-number-of-applications-for-shift2rail-call-for-proposals-2019/
Shift2Rail Executive Director to speak at 8th International Railway Summit in New Delhi	12 July, 2019	https://shift2rail.org/press-releases/shift2rail-executive-director-to-speak-at-8th-international-railway-summit-in-new-delhi/
Shift2Rail awards 17 grants for its Call for Proposals 2019	11 September, 2019	https://shift2rail.org/press-releases/shift2rail-awards-17-grants-for-its-call-for-proposals-2019/
Shift2Rail launches its Catalogue of Solutions at the World Congress on Railway Research	28 October, 2019	https://shift2rail.org/press-releases/shift2rail-launches-its-catalogue-of-solutions-at-the-world-congress-on-railway-research/

PRESS ARTICLES ABOUT SHIFT2RAIL PUBLISHED IN 2019

Press outlet	Title	Link to the Publication
BtoBRail	EU-wide Mobility Services	http://www.btobrail.com/btobrail.com/eu-wide_mobility_services.php
CEO magazyn	Run2Rail: 3D printing will help railway enter new tracks	https://ceo.com.pl/branza-kolejowa-wjedzie-na-nowe-tory-pomoze-jej-w-tym-druk-3d-39682
El Diario Vasco	PINTA: a pioneering project for lighter and efficient trains	https://www.diariovasco.com/economia/proyecto-vasco-pionero-tren-20190207161632-nt.html?ref=https%3A%2F%2Fmailchi.mp%2F
El Vigia	The Basque Government will promote railway innovation together with the Shift2Rail consortium	http://elvigia.com/el-gobierno-vasco-promovera-la-innovacion-ferroviaria-junto-al-consorcio-shift2rail/
European Files	European Files: Developing greener rails	https://www.europeanfiles.eu/non-classe/developing-greener-rails-shift2rails-research-innovation-sustainable-infrastructure
European Parliament	Shift to Rail - Research for the EU rail sector	https://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_ATA(2019)64014_7
FerPress	Shift2Rail: a new study shows the good potential of hydrogen trains in Europe	https://www.ferpress.it/shift2rail-un-studio-mostra-buon-potenziale-dei-treni-idrogeno-europa/
	Shift2Rail: The 2019 call received requests for funding for a value of 76.8 million	https://www.ferpress.it/shift2rail-bando-2019-ricevuto-richieste-finanziamento-un-valore-768-mln/
	Shift2Rail: 17 projects worth € 148.6 million will be funded under the 2019 call for proposals	https://www.ferpress.it/shift2rail-17-progetti-un-valore-1486-milioni-euro-saranno-finanziati-nellambito-dellinvito-presentare-proposte-del-2019/

Fuel Cells Works	New Study Shows Good Potential for Hydrogen-Powered Trains in Europe	https://fuelcellsworks.com/news/new-study-shows-good-potential-for-hydrogen-powered-trains-in-europe/
Gasworld	Study shows good potential for hydrogen trains	https://www.gasworld.com/study-shows-good-potential-for-hydrogen-trains/2017216.article
Global Railway Review	PINTA: Improving the acoustic noise prediction	https://www.globalrailwayreview.com/article/75961/acoustic-noise-prediction-train-design/
	Project DESTINATE results	https://www.globalrailwayreview.com/article/75871/cost-efficient-railway-noise-abatement-measures/
	Improving the acoustic noise prediction of future train design (Shift2Rail guest article)	https://www.globalrailwayreview.com/article/75961/acoustic-noise-prediction-train-design/
	Shift2Rail 2019 applications increase by 28 per cent	https://www.globalrailwayreview.com/news/84066/shift2rail/
	25 years in rail: Reflecting on developments and driving forward growth	https://www.globalrailwayreview.com/article/84015/25-years-rail-developements-growth/
	LiTheS: CAF MiiRA's innovative Light Thermo Stable wheel for rail freight	https://www.globalrailwayreview.com/article/83112/lithes-caf-miiras-innovative-light-thermo-stable-wheel-for-rail-freight/
	Shift2Rail awards 17 grants for its Call for Proposals 2019	https://www.globalrailwayreview.com/news/88270/shift2rail-17-grants-2019/
	Women Inspiring Rail: A Q&A with Monique van Wortel, Shift2Rail	https://www.globalrailwayreview.com/article/89134/monique-van-wortel-shift2rail/
	Can space technology be used to transform the future of rail?	https://www.globalrailwayreview.com/pdf/global-railway-review-in-depth-focus-the-future-of-rail/
	Shift2Rail partners with Digital Rail Revolution: A Q&A with S2R Executive Director, Carlo Borghini	https://www.globalrailwayreview.com/article/90248/digital-shift2rail-q-and-a-carlo-borghini/
Hydrogen Fuel News	Shift2Rail launches its first Catalogue of Solutions	https://www.globalrailwayreview.com/news/91836/shift2rail-catalogue-of-solutions/
	New study reveals potential for the European hydrogen railway market to expand	https://www.hydrogenfuelnews.com/new-study-reveals-potential-for-the-european-hydrogen-railway-market-to-expand/8537559/
Interempresas.com	Assets4Rail: computer vision, autonomous vehicles and augmented reality for safer rails	https://www.interempresas.net/Ferrocarril/Articulos/244391-Aplicaran-vision-artificial-vehiculos-autonomos-realidad-aumentada-incrementar-seguridad.html
International Railway Journal	Study finds strong market for hydrogen trains	https://www.railjournal.com/fleet/study-finds-strong-market-for-hydrogen-trains/
	"We need to build metro and suburban lines much faster" Mezghani's rallying cry	https://www.railjournal.com/in_depth/metro-suburban-lines-uitp-global-summit
	Back to the future for spoked wheels	https://www.railjournal.com/in_depth/back-to-the-future-for-spoked-wheels/

	Shift2Rail selects 17 projects from 2019 call for proposals	https://www.railjournal.com/regions/europe/shift2rail-selects-17-projects-from-2019-call-for-proposals/
	The future of intelligence is artificial	https://www.railjournal.com/in_depth/future-intelligence-artificial
	The future of intelligence is artificial	https://mailchi.mp/s2r.europa.eu/shift2rail-october-newsletter
La Stampa	Farewell (or almost) to diesel-powered trains: it's time for hydrogen trains	https://www.lastampa.it/tuttogreen/2019/08/16/news/treni-a-diesel-addio-o-quasi-e-l-ora-dei-convogli-a-idrogeno-1.37342918/amp/
MAFEX magazine	Shift2Rail was established to offer a long-term platform for R&I	http://magazine.mafex.es/en/s2r-ju-se-establecio-para-proporcionar-una-plataforma-para-la-investigacion-e-innovacion-a-largo-plazo/
<i>Metro Rail News</i>	Tackling rapid population growth at global rail event in New Delhi from 20-22 November 2019	https://www.metrorailnews.in/tackling-rapid-population-growth-at-global-rail-event-in-new-delhi-from-20-22-november-2019/
<i>MyNewsDesk- Elmia</i>	Shift2Rail: Integrating Railway Europe	https://www.mynewsdesk.com/se/elmia/news/shift2rail-integrera-jaernvaegseuropa-384192
Parlamentn ilisty	The Ministry of Transport signed a memorandum with Shift2Rail	https://mailchi.mp/s2r.europa.eu/apply-for-our-2019-call-shift2rail-april-newsletter
Phys	Enhancing the competitiveness of the railway sector	https://mailchi.mp/s2r.europa.eu/shift2rail-ju-news-july-288417
Railway Gazette	Competitive Freight Wagon	https://www.railwaygazette.com/news/freight/single-view/view/competitive-freight-wagon-deployment-to-be-planned.html
	Shift2Rail study backs fuel cell train development	https://www.railwaygazette.com/news/news/europe/single-view/view/shift2rail-study-backs-fuel-cell-train-development.html
	Shift2Rail proposals increase	https://www.railwaygazette.com/news/technology/single-view/view/shift2rail-proposals-increase.html
	Freight to be focus of Shift2Rail successor	https://www.railwaygazette.com/technology/freight-to-be-focus-of-shift2rail-successor/54947.article
	Policies needed to maintain EU rail suppliers' global leadership	https://www.railwaygazette.com/policy/policies-needed-to-maintain-eu-rail-suppliers-global-leadership/55022.article

	When an idea creates an ambitious horizon (page 32)	https://online.fliphtml5.com/ylfj/ocaq/#p=35
Railway Pro	Shift2Rail must be included in the next Horizon programme	https://www.railwaypro.com/wp/shift2rail-2-must-be-included-in-the-next-horizon-programme/
	FCH and S2R prove hydrogen trains' market potential in Europe	https://www.railwaypro.com/wp/fch-and-s2r-prove-hydrogen-trains-market-potential-in-europe/
	Shift2Rail and ETSI to facilitate telecommunication standards applications	https://www.railwaypro.com/wp/shift2rail-and-etsi-to-facilitate-telecommunications-standards-applications/
	A 28% increase of number of applications under S2R 2019 Call	https://www.railwaypro.com/wp/a-28-increase-of-number-of-applications-under-s2r-2019-call/
	Shift2Rail granted 17 projects under 2019 calls	https://www.railwaypro.com/wp/shift2rail-granted-17-projects-under-2019-calls/
	Shift2Rail launches its Catalogue of Solutions	https://www.railwaypro.com/wp/shift2rail-launches-its-catalogue-of-solutions/
RailTech.com	Hybrid trains can replace 30 per cent of diesel units by 2030	https://www.railtech.com/rolling-stock/2019/05/21/hybrid-trains-can-replace-30-per-cent-of-diesel-units-by-2030/?gdpr=accept
Railway News	The New European Rail Supply Industry's Vision on Digitalisation	https://railway-news.com/unife-european-rail-supply-industry-digitalisation/
	Henrik Hololei Talks Shift2Rail at Digital Transport Days	https://railway-news.com/henrik-hololei-talks-shift2rail-at-digital-transport-days/
Railway Technology	Timeline: Europe's dream for a single railway, two decades in	https://www.railway-technology.com/features/rail-transport-in-europe/
Raumfahrer.net	Shift2Rail's co-organised event in Vienna: Silk road and satellites	https://www.raumfahrer.net/news/raumfahrt/23032019095220.shtml
Science Business	Cars, 6G and health: A closer look at possible R&D partnerships in Horizon Europe	https://sciencebusiness.net/framework-programmes/news/cars-6g-and-health-closer-look-possible-rd-partnerships-horizon-europe
Spoonpro	UNIFE advocates European platform digitization of the rail sector	https://mailchi.mp/s2r.europa.eu/the-future-of-hydrogen-powered-trains-shift2rail-may-newsletter
	Study: hydrogen train promising alternative to diesel train	https://www.spoorpro.nl/materieel/2019/05/23/studie-waterstofrein-veelbelovend-alternatief-voor-dieseltrein/
	S-CODE project: New point pieces make exchange heating superfluous	https://mailchi.mp/s2r.europa.eu/the-future-of-hydrogen-powered-trains-shift2rail-may-newsletter-281401

	'Vibration and noise prevention starts with good maintenance'	https://www.spoorpro.nl/spoorbouw/2019/10/14/trillingen-en-geluid-voorkomen-begint-met-goed-onderhoud/?gdpr=accept
Trafikverket	Shift2Rail develops the railway of the future	https://www.trafikverket.se/resa-och-trafik/forskning-och-innovation/aktuellt-om-forskning-och-innovation2/2019-09/shift2rail-utvecklar-framtidens-jarnvag/
	Railway research is praised for its impact on society	https://www.trafikverket.se/resa-och-trafik/forskning-och-innovation/aktuellt-om-forskning-och-innovation2/2019-11/jarnvagsforskning-prisas-for-genomslag-i-samhallet/
Transport Information Center of Ukraine	As part of the Shift2Rail initiative, another 17 research and innovation projects will be funded	https://railway-publish.com/pidtemi/11851-v-ramkah-iniciativy-shift2rail-profinansiryut-eshe-17-proektov-issledovanii-i-innovacionnyh-razrabotok.html
TTM	Driverless Wagons - Making Rail as Flexible as Road	https://www.ttm.nl/it/ai/europa-moet-stappen-maken-in-autonoom-vervoer/103941/
Virtual Vehicle Magazine	Shift2Rail as innovation accelerator of market uptake for the railways (page 25)	https://www.v2c2.at/wp-content/uploads/2019/04/VVM_Rail_v05-FINAL_PRINT.pdf

EXTERNAL EVENTS PARTICIPATED TO BY SHIFT2RAIL IN 2019

In 2019, the Shift2Rail JU participated to major events across Europe and beyond, presenting concrete results achieved by Shift2Rail JU Members together with other key stakeholders.

Rail Live! Bilbao – 5-7 March 2019, Bilbao, Spain

The Shift2Rail JU was present at the fair with a stand, where attendees could learn more about the functioning of Shift2Rail and the process to apply for the Call for Proposals 2019. Shift2Rail staff took the opportunity to exchange views with rail undertakings from all over the world and to meet with Spanish network manager ADIF, national operator RENFE, Basque transport regional ministry and various Basque Shift2Rail members. Overall, the event was attended by over 3,000 professionals from across the sector.

Space for Innovation in Rail - 18 March 2019, Vienna, Austria

Working together to satisfy the demands of an increasingly digitalised world, S2R JU teamed up with the European Global Navigation Satellite Systems Agency (GSA) and the European Union Agency for Railways (ERA) to explore the role of satellite technology in future railway systems, in a dedicated event in Vienna. The Austrian Ministry for Transport, Innovation and Technology welcomed an illustrious group of European and international experts counting around 300 participants.

SIFER – 26-28 March 2019, Lille, France

The Shift2Rail JU had a stand at the event enabling visitors to learn about Shift2Rail's Call for Proposals 2019, ask questions and see Shift2Rail's results.

The Shift2Rail Executive Director participated to a UNIFE round-table discussion on Research and Innovation that focused on the role of R&I in helping to maintain the leadership of the European rail supply industry in the face of fierce competition from overseas. Shift2Rail's Executive Director emphasised the work of Shift2Rail that is helping companies to minimise the risk of R&I while supporting them to bring innovative solutions to the market.

The event brought together more than 400 companies from Europe and beyond.

#POLITICOMobility Summit – 8 October 2019, Amsterdam, Netherlands

As a strategic partner of #POLITICOMobility event the Shift2Rail Executive Director participated to a panel discussion focusing on railways, showing how the work of Shift2Rail contributes to the evolvement of the whole mobility sector in Europe. The event brought together policymakers, regulators, disruptors and experts from across the railway sector. As part of this agreement, Shift2Rail's logo was featured on the conference programme and on social media.

12th Congress World Congress on Railway Research – 28 October – 1 November, Tokyo, Japan

The Shift2Rail JU had a 81 sqm stand presenting a selection of Shift2Rail innovations emanating from projects undertaken by our Members and other stakeholders, with a focus on the promising future of a sustainable railway system. The Shift2Rail stand at World Congress on Railway Research was officially opened by Commissioner Violeta Bulc in the presence of Ambassador Patricia Flor, Head of EU Delegation to Japan.

During the opening ceremony Shift2Rail's Executive Director launched the Catalogue of Solutions, publication which brings together the innovative products and approaches, which Shift2Rail has been working on together with Members and key stakeholders to deliver transformed rail systems.

Shift2Rail's Executive Director participated in a panel discussion focusing on R&D for Future Railways on the 31 October.

Scientific papers of 15 Shift2Rail projects were accepted to the conference, and were presented in oral sessions or interactive poster presentations. The "Adaptable Train Communication Systems" paper won one of the nine awards out of 300 papers.

8th International Railway Summit – 20-22 November 2019, New Delhi, India

Shift2Rail's Executive Director gave a keynote speech on where he offered solutions developed within the Shift2Rail R&I programme that help to best manage the growing pressure on capacity. Directly following his keynote titled 'Optimising or redesigning rail? The Executive Director moderated a panel discussion elaborating further on this topic. In addition, the Shift2Rail Executive Director joined a panel discussion to discuss if high-speed rail is worth the big investment it requires together with representatives from our member Siemens, The World Bank and the Indian high-speed rail operators.

As a knowledge partner of the Summit, Shift2Rail helped to enhance networking opportunities by sponsoring a Coffee Lounge where participants had the opportunity to find out more about Shift2Rail's work.

The 8th International Railway Summit brought together many high-level speakers from across the whole sector, including Violeta Bulc, the then European Commissioner for Transport.

In addition to the events explained in more detail above, S2R also participated to the following:

International Railway Summit – 20-22 February 2019, Frankfurt, Germany

At the Summit, Shift2Rail and UNIFE co-organised a data-themed panel discussion moderated by Shift2Rail's Executive Director Carlo Borghini. In addition, Shift2Rail's Executive Director participated to another panel discussion as a speaker focusing on the role of transport in Smart Cities.

Czech and European railway for the 21st century – one single market – 11-12 April 2019, Pardubice, Czech Republic

At the event Shift2Rail's Executive Director gave a keynote speech and participated to a panel discussion on the 4th Railway Package focusing on Research and Innovation.

Staying grounded- Flying less – 19 March 2019, European Parliament, Brussels, Belgium

Shift2Rail's Head of Research and Innovation following the invitation of MEP Lucy Anderson participated to a roundtable discussion presenting how innovations made by S2R will contribute to the goal of creating a real sustainable transport and mobility system, with a shared and multimodal approach S2R is advocating for door to door journeys.

UIC Global FRMCS Conference – 14 May 2019, Paris, France

Shift2Rail's Head of Research and Innovation was key-note speaker in this event attended by rail and telecommunication stakeholders and deliver a vision on how digitalisation and the work done by S2R will affect future rail systems. He also shared a roundtable discussion with other speakers.

7th EcoMotion event – 10-11 June 2019, Tel Aviv, Israel

Shift2Rail's Head of Research and Innovation took part of a roundtable discussion on the future of the rail system in this event dedicated to start-ups innovating on mobility services. Israeli H2020 National Contact Point and S2R State Representative Group member organised a series of meetings between the S2R JU and SMEs/start-ups interested in answering S2R calls.

Unife General Assembly – 12-14 June 2019, Dublin, Ireland

UNIFE General Assembly was attended by Shift2Rail's Executive Director as well as Shift2Rail's Head of Research & Innovation.

International Wheelset Congress – 16-19 June 2019, Venice, Italy

Shift2Rail's Head of Research and Innovation participated to a roundtable discussion on the future of rolling stock. In addition, Shift2Rail had a stand at the venue presenting its R&I work, solutions and programmes working in the area of rolling stock.

EU Transport & Railway Affairs by the European Training Centre for Railways – 8 July 2019, Bruges, Belgium

Shift2Rail's Head of Research and Innovation participated in a panel discussion on Digitalisation of railways contributing to the training organised by ETCR in collaboration with ERA and College of Europe for young engineers.

SmartRail 2019 – 17-19 June 2019, Munich, Germany

SmartRail 2019 was attended by Shift2Rail's Executive Director. In his keynote he focused on the advantages and challenges of standardising the railways.

[IPIC 2019 | 6th International Physical Internet Conference](#) – 9-11 July 2019 London, United Kingdom

At IPIC 2019, Shift2Rail's Executive Director moderated a panel discussion on rail freight innovation and participated to another panel discussion on a hyperconnected transport system. Additionally, Shift2Rail sponsored PhD students by offering them the possibility to participate to the conference where they could also discuss their research ideas with other students and established researchers.

[CENELEC workshop "ICT for RAILWAYS"](#) – 12-13 September 2019, Naples, Italy

Shift2Rail's Executive Director took part in a panel discussion presenting the future innovation strategy for European railways.

[Railway Days 2019 - Club Feroviar Investment Summit](#) – 9 October 2019, Bucharest, Romania

Shift2Rail's Head of Research and Innovation took part in a panel discussion on ERTMS in Central and Eastern Europe.

Information day on Smart, green and integrated transport – 19 October, Rome, Italy

APRE on behalf of the Italian ministry for research and education organised an information day for the H2020 last calls related to the societal challenge on transport. European Commission's, CleanSky2 JU's and other transport related representatives shared the stage with the Shift2Rail's Head of Research and Innovation, who provided a presentation on S2R activities and exhorted participants to apply to future calls.

[Intelligent Transport Systems World Congress](#), – 21-25 October 2019, Singapore

One of Shift2Rail's Programme Managers took part in the Congress by participating to a panel discussion on the challenges for the future integrated mobility. The panel discussion was moderated by Miroslav Haltuf Vice-Chairman of the Shift2Rail States Representative Group.

[Digital Rail Revolution](#) – 7 November 2019, London, United Kingdom

Digital Rail Revolution was attended by Shift2Rail's Executive Director who gave a keynote speech on achieving interoperability in rail. As sponsors of the event, Shift2Rail got high visibility at the event: Shift2Rail's logo was included to the event website, Q&A was published, mention to Shift2Rail was included to event newsletters etc.

[18th Florence Rail Forum](#) – 8 November 2019, Florence, Italy

Shift2Rail's Head of Research and Innovation participated and contributed to an experta panel discussion organised by the European Florence School of Regulation focusing on sustainable freight system in Europe.

[InnoRail 2019](#) – 12-14 November 2019, Budapest, Hungary

Shift2Rail's Executive Director gave a keynote speech on how Shift2Rail is moving from Research and Innovation towards deployment. Vice-Chairman of Shift2Rail's States Representative Group Mr Miroslav Haltuf gave an opening speech on rail sector competitiveness.

AlpinnoCT final Conference – 19 November 2019, Brussels, Belgium

About 80 people from private and public institutions involved in the freight transport at European level participated to this Interreg funded activity and discussed about the most innovative solutions for the modal shift. The S2R Head of Research and Innovation presented the innovative solutions coming out of the S2R R&I Programme and participated to a panel discussion focusing on combined freight transport.

World Bank Vienna Railways Conference – 18-20 November 2019, Vienna, Austria

Shift2Rail's Executive Director participated to a panel discussion on the role of Research and Innovation in European rail integration.

[Intelligent Rail Summit](#) – 20-21 November 2019, Paris, France

Shift2Rail's Head of Research and Innovation participated to the Summit to share how Shift2Rail is digitalising the rail system towards automation and further integration.

[Portugal Railway Summit](#) – 27 November 2019, Almada, Lisbon, Portugal

Shift2Rail's Head of Research and Innovation introduced the research programme of Shift2Rail that helps to transform the Europe's rail system.

[World Rail Festival](#) – 3-5 December 2019, Amsterdam, Netherlands

Shift2Rail's Head of Research and Innovation took part in a panel discussion on how operators, governments and disruptors can work effectively together to shape a future transport mix. As a sponsor of the event, Shift2Rail got high visibility before and during the event. This included logo on the website and marketing materials, social media promotion, inclusion to newsletters and more.

ANNEX F LIST OF ACRONYMS

Abbreviation	
ABAC	Accrual Based Accounting
ADI	Austempered Ductile Iron
AO	Authorising Officer
ATO	Automated Train Operation
AWP	Annual Work Plan
AAR	Annual Activity Report
CA	Commitment Appropriation
CAS	Common Audit Service
CAPEX	Capital Expenditure
CBM	Condition-Based Maintenance
CBTC	Communication Based Train Control
CCA	Cross Cutting Activities
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CFM	Call for Members
CRS	Common Representative Sample
CREL	Core Release
CSA	Coordination and support action
CW	Cloud Wallet
DOI	Digital Object Identifier
DRIMS	Dynamic Railway Information Management System
EC	European Commission
ECA	European Court of Auditors
ED	Executive Director
EDPS	European Data Protection Supervisor
EDV	Electronic Distributor Valve
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EN	European Norm
ERA	European Union Agency for Railways
ERRAC	European Rail Research Advisory Council
ERTMS	European Rail Traffic Management System
ETCS	European Train Controlling System
EU	European Union
EUG	ERTMS Users Group
FACTs	Flexible AC Transmission Systems
FFIS	Form Fit Functional Interface Specifications
FIS	Functional Interface Specifications
FREL	Final Release
GA	Grant Agreement
GDPR	General Data Protection Regulation
GIS	Geographic Information System

GNSS	Global Navigation Satellite System
GoA	Grade of Automation
H2020	Horizon 2020, EU framework programme for Research and Innovation
HST	High-Speed Train
IA	Innovation Action
IAS	Internal Audit Service
LP	Lighthouse Project
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IKA	in-kind contributions to additional activities
IP	Innovation Programme
IPR	Intellectual Property Rights
ISO	International Standardisation Organisation
IT	Information Technology
ITD	Integrated Technology Demonstrator
JTI	Joint Technology Initiative
JU	Joint Undertaking
KPI	Key Performance Indicator
LCC	Life Cycle Cost
LIDAR	Light Detection and Ranging
LTE	Long-Term Evolution (standard for wireless communication)
MAAP	Multi-annual Action Plan
MaaS	Mobility as a Service
MB(S)	Moving block (System)
MC	Mission Critical
MNO	Mobile Network Operator
NaaS	Network as an Asset
NaaS	Network as a Service
NLOS	non-line-of-sight
NTP	Network Time Protocol
OC	Open Call
ODM	Operational Data Management
OMTS	On-board Multimedia and Telematics Services
OPEX	Operating Expenditure
PA	Payment Appropriation
RCA	Railway Command Control and Signalling Architecture
R&I	Research and Innovation
PPP	Public Private Partnership
PRM	Persons with Reduced Mobility
PTC	Positive Train Control
PTI	Platform Train Interface
QoS	Quality of Service
RAL	Unpaid amount
RAMS	Reliability and Maintainability System
RBC	Radio Block Centre

RFID	Radio Frequency Identification
RIA	Research and innovation action
RoI	Return of Investment
S2R	Shift2Rail
SC	Scientific Committee
SDG	Sustainable Development Goals
SETA	Single European Transport Area
SiC	Silicon Carbide
SLA	Service Level Agreement
SME	Small and Medium Enterprise
SNE	Seconded National Expert
SPD	System Platform Demonstration
SRG	States Representatives Group
SWL	Single Wagon Load
TAF	Telematic Application for Freight
TAP	Telematic Application for Passengers
TCMS	Train Control and Monitoring System
TCO	Total Cost of Ownership
TD	Technology Demonstrator
TL	Train Load
TMS	Traffic Management System
TRL	Technology Readiness Level
TSI	Technical Specifications for Interoperability
TSP	Travel Service Provider
UAV	Unmanned Aerial Vehicle
UG	User Group
UN	United Nations
WA	Work Area
WP	Work Package
WSP	Wheel Slide Protection

Founding Members



Associated Members



Virtual Vehicle Austria Consortium (VVAC+)



European Rail Operating community Consortium (EUROC)



Swi'Tracken Consortium



Smart DeMain(SDM) Consortium



AERFITEC



Competitive Freight Wagon Consortium(CFW)



Smart Rail Control (SmartRaCon) consortium





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