

## **Policy Department External Policies**

# **UAVs AND UCAVs: DEVELOPMENTS IN THE EUROPEAN UNION**

**SECURITY AND DEFENCE**

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## **EXECUTIVE SUMMARY**

UAVs have been around since the 1960s. However, since the mid-1980s a number of major technical developments have made UAVs much more effective. As a result they have proliferated tremendously.

Several EU countries have used UAVs for decades, although their operational use in combat situations is limited. The EU has a small industrial capability to develop and produce most types of advanced UAV systems, including actual UAV aircraft, its components, the control system and the sensors. The only fields where the EU industry is not strongly engaged are micro UAVs and large, very long-range UAVs (HALE).

EU members have been unsuccessful in exporting UAVs to non-EU members. Most UAVs in service globally are US or Israeli products. The demand for UAVs is increasing, both in the EU and globally. Much of the current EU demand is met by either by US UAV systems or by hybrid Israeli-EU systems. With US systems, generally the complete UAV system is acquired. In the case of the Israeli-EU systems, the UAV aircraft is acquired or licensed produced from Israel and fitted with European sensors.

Globally UCAVs are currently limited to small numbers of lightly armed versions of ‘normal’ UAVs. None of these is at this moment in service in the EU. Development of UCAV technology demonstrators is ongoing in the EU.

If EU members take part in ESDP missions it is not difficult to find enough UAVs for the mission. But the more important question would be whether the UAVs would be able to provide data quickly to the different national contingents that would comprise an ESDP mission.

While Europe has adopted policies for out-of-area missions, it is still unclear how far these missions go beyond peacekeeping and limited peace-enforcing under UN mandates. While the use of UAV in such operations is demonstrated, it leaves the usefulness of UCAVs in some doubt.

The availability of long-range unmanned strike systems such as UCAVs may lead to a lowering of the threshold for offensive operations that go beyond currently agreed EU policies. However, as demonstrated in Iraq, Afghanistan and Kosovo, an easy victory on the battlefield achieved with high-tech weaponry, does not solve the problem nor limits the necessity of large deployments of vulnerable ground troops.

Since UAVs are generally rather simple systems, needing limited investments, there is room for several producers in the EU.

UCAVs are exponentially more expensive and will, like other large systems such as combat aircraft and air-defence missiles, need significant investments. Cooperating on production within the EU seems unavoidable. However, current efforts within the EU are focused on the development of working concepts. While greater coordination may seem useful, it could be that having several independent projects is actually productive too by providing several initiatives for devising an effective and credible working concept.

# UAVs andUCAVs: Developments in the European Union

## 1. Introduction

The purpose of this study is to provide a short overview of current developments in EU member states in relation to Unmanned Aerial Vehicles (UAVs) and Unmanned Combat Aerial Vehicles (UCAVs). Although UAVs have been deployed by several armed forces since the 1960s, they have experienced a renaissance in the past 20 years. Interest in their acquisition has greatly increased at the same time as the relevant technology has developed. Today UAVs are seen as an integral and indispensable part of modern armed forces.

Most EU members have acquired UAVs or plan to do so soon. Several of them have used UAVs in combat operations since the end of the Cold War, finding them especially useful in missions against guerrilla forces and terrorists. In other words, just the type of adversaries European forces are likely to encounter in the future when engaged in armed peacekeeping and limited peace-enforcement missions.

More recently, UAVs have evolved from a reconnaissance system (a *combat-supporting* system) toUCAVs, an actual combat system. The US has already used lightly-armed UAVs asUCAVs in combat and several countries, including EU member states, are developing similar systems. While UAV technology is mature, the development of real high-performance unmanned combat aircraft –UCAVs – is a new and much more ambitious process. EU member states have already taken their first steps in this process.

## 2. UAVs ANDUCAVs

A UAV is an aircraft with no onboard pilot. Instead, it is remotely-controlled or can fly autonomously based on pre-programmed flight plans or more complex dynamic ‘self-thinking’ systems. While to some extent such unmanned aircraft resemble cruise missiles<sup>1</sup>, they differ in that they return to base for further use once they have fulfilled their mission.

### 2.1 Role of UAVs andUCAVs

The most common roles for UAVs involve combat support. These roles include:

- reconnaissance;
- radar, optical and/or electro-optical sensors;
- intelligence gathering;
- maritime patrol;
- search and rescue (SAR) support;
- survey and mapping;
- non-deadly combat role;
- electronic countermeasures and electronic warfare (mainly the suppression of enemy air defences – SEAD);
- decoy;
- fire control/target designation (with laser designator);

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<sup>1</sup> Cruise missiles, like aircraft (and UAVs), derive their power to stay airborne from lift generated by their wings and/or their body.

- armed combat role (UCAV) – including air-to-ground and air-to-air combat; signal relay;
- target drone

Currently, by far the majority of UAVs perform a reconnaissance role, specifically using optical/electro-optical sensors. Indeed, very few EU UAVs perform any other role. All EU UAVs are land-based systems, as are most such systems globally. The exceptions are those operating from ships, either in a reconnaissance role or to help target anti-ship missiles.

Whereas most sizeable combat ships rely on their on-board helicopters to provide visual observation beyond the horizon and to identify and designate targets for anti-ship missiles, UAVs can perform such a role for those ships without on-board helicopters, such as frigates, corvettes and fast attack craft. With ranges of 50-200km, anti-ship missiles are striking targets far beyond the radar range of the launching ship, making the use of off-board sensors a necessity. Equipping ships with a small UAV helicopter is seen as a solution<sup>2</sup>.

Northrop Grumman (US) has developed the *Fire Scout* for this role and is offering cooperation with Navantia (formerly IZAR: Spain) for use on Spanish F-100 Class frigates<sup>3</sup>. In Europe, several countries are eyeing the Austrian *Camcopter* for this role, and Saab (Sweden) as well as Eurocopter (France) are developing similar vertical take-off and landing (VTOL) UAVs.

Although UAVs started as target drones in the 1920s, today this role is usually performed by much smaller, aircraft-launched decoy missiles, and is not normally a role designated to unmanned aircraft.

If UAVs are used in the armed combat role they would qualify for the UCAV designation. However, generally the UCAV designation is not used for ‘normal’ UAVs carrying a light armament, but is reserved for more advanced combat UAVs. While it is possible to modify UAVs to perform a direct attack role in a one-way ‘suicide’ mission - and this potential misuse should be taken into account when exporting UAVs – technically, the vehicle has been transformed into a cruise missile.

To survive in the often extremely hostile front-line air-defence environment one needs a high-performance aircraft. Acquiring and operating manned reconnaissance aircraft is expensive. Each costs US\$25-35m<sup>4</sup>, and these aircraft need a fully equipped air base as well as large numbers of maintenance technicians. Alternatively, the cost of a UAV to fulfil such missions can be less than US\$1m<sup>5</sup>, with much lower operating costs due to fewer support personnel and no need for major ground-based infrastructure.

Usually, the costs of UAV development and acquisition programmes are small compared to many other military acquisition programmes. Small tactical UAV systems have been developed for a few million US dollars, often using ‘off-the-shelf’ military and civilian components.

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<sup>2</sup> The idea is not new. In the late-1950s/early-1960s the US used an armed UAV helicopter for anti-submarine warfare for use on ships too small to carry a full-sized helicopter. The system (called DASH) failed mainly for technical reasons, however, and was quickly withdrawn.

<sup>3</sup> DEFAEI, 24 July 2002; *Asian Defence Journal*, Oct. 2002.

<sup>4</sup> The price of reconnaissance aircraft is similar to that of combat aircraft – some US\$25-35m for single-engine aircraft such as F-16.

<sup>5</sup> Denmark bought 2 complete Sperwer tactical UAV systems with 12 UAV aircraft for US\$55m; *Defense News*, 23 Jan. 2006, p. 9. The total cost of the British tactical Phoenix UAV programme, which included some 198 UAV aircraft in 8 UAV systems, is estimated to have been £227-260m with each UAV estimated to have cost £0.3m. The Defence Suppliers Directory website, URL <http://www.armedforces.co.uk/army/listings/10101.html>, Federation of American Scientists website, URL <http://www.fas.org/man/dod-101/sys/ac/row/phoenix.htm>.

However, development and acquisition of high-end Medium-Altitude Long Endurance (MALE) and High-Altitude Long Endurance (HALE) systems demands major investments. For Fiscal Year 2007 the US Air Force requested US\$287m for the acquisition of 26 RQ-1 *Predator* UAVs and US\$504m for six *Global Hawk* UAVs. In Fiscal Years 2004, 2005 and 2006 the US spent a total of US\$2.66bn on 295 UAVs of different types<sup>6</sup>.

## 2.2 UAV/UCAV Types

UAVs are often categorized based on performance (linked often to size). There are several categorizations from producers, users and researchers. (These are listed in Appendix I.) UAVs can be classified according to the way their flight is controlled, of which there are three methods: pre-programmed; remote control; self-thinking (which can be combined). Each means of control provides both challenges and opportunities.

- The most basic control is by pre-programmed flight. This is simple, does not need technically difficult and disturbance-sensitive data-links for control, and gives ranges beyond the line-of-sight. However, the system is inflexible. Once airborne the UAV follows a fixed path. It cannot 'take a second look' at something that seems interesting. If the UAV needs to fly as low as possible, it is also dependent on good information of the terrain.
- Remote-control is the most common control system for UAVs. By radio, the operator receives flight data from the UAV and sends flight commands back. The weak points of this system lie in the vulnerability of the continuous radio links, which reveal the positions of both the controller and the UAV, and the fact that radio links limit the UAV's range. More advanced, less vulnerable radio links and indirect radio links (e.g. via satellites or relay UAVs) are a partial solution.
- Self-thinking UAVs are still a futuristic option. The technical challenges to develop a fully autonomous UAV are still insurmountable. Nevertheless, an element of self-thinking has been achieved in as much as UAVs are able to react to threats, for example, when attacked by an air-defence missile.

UAVs and UCAVs are themselves just 'aircraft' with onboard systems. However, they are usually linked to additional equipment outside, such as the remote-control and launching equipment. In addition, UAVs often have an interchangeable 'mission package', which includes the sensors and, if necessary, the link for transferring data collected by the sensors. Together, this equipment forms the UAV system<sup>7</sup>, the main components of which are listed in Appendix II.

## 2.3 UCAV

A UCAV is a sub-category of UAVs. It is basically nothing more than an armed UAV. The border between UAV and UCAV is a thin and grey one. Generally, all UAVs have an inherent combat capacity – one just has to replace a non-deadly payload with a deadly one. The US *Predator* was modified from a reconnaissance UAV to a UCAV by simply adding *Hellfire*

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<sup>6</sup> *The Military Balance 2006*, IISS, p. 20-22 and p. 26 (Routledge, UK, May 2006).

<sup>7</sup> The US uses the term UAS – Unmanned Air System – for the complete package, reserving UAV for the airborne component, the 'aircraft', itself.

missiles. UCAVs have evolved, experimentally, when normal aircraft have been modified to operate without a pilot. Iraq is reported to have modified *L-29* trainer aircraft into remote-controlled chemical weapon sprayers.

The term UCAV, however, is generally used for a high-performance vehicle, capable of high speed, long range and heavy weapon load – more or less the equivalent of a manned ground-attack or bomber aircraft. The armed *Predator*, therefore, would not really count as a UCAV, while the Iraqi *L-29* modification would be a borderline case.

The first successful use of armed UAVs in combat operations was the attacks carried out by the US against ‘terrorist’ targets in Yemen and Afghanistan in 2002 and 2003. These attacks were carried out with *Predator* (MQ-9)<sup>8</sup> reconnaissance UAVs modified to carry one or two *Hellfire* missiles<sup>9</sup>. The use of armed UAVs resulted from the failure of the US to ‘take out’ terrorists, and specifically Osama bin Laden, with cruise missiles. While the cruise missiles worked more or less as advertised, the time lag between identifying a mobile target such as Bin Laden and the actual impact of the missiles was too great.

Ruling out the use of manned reconnaissance and attack systems, the only solution was to combine the detection and surveillance capabilities of a UAV with a weapon. This could either be done by relaying surveillance data to a platform carrying weapons or by adding weapons to the surveillance system. The first option has already been used by Israel in actions against targets in Gaza and Lebanon: UAVs would patrol and identify targets and manned aircraft would fire stand-off guided missiles to attack the target. Since the platform (usually an aircraft) carrying the missile was further away from the target than the UAV, there still remained a gap between target identification and the missile hitting. It also meant that a manned platform would have to be within missile range of the target.

The US, however, chose to arm the UAV itself, thereby further closing the gap between target identification and a missile hitting it, and providing the option to do all this from a distance of up to several hundred kilometres. Adapting a rather large UAV, such as the *Predator*, to carry a light armament did not prove too difficult. The *Predator* was modified, tested and brought into action within months. It gave the US new options to identify and attack time-sensitive targets without having to risk manned aircraft over ‘enemy’ territory or in politically sensitive airspace. The armed *Predator* proved so successful that a new version was ordered almost at once. This much improved version - *Predator-B* (MQ-9B) - is now being acquired, capable of carrying up to 450 kg of missiles or bombs as well as air-to-air missiles to defend itself against interception. This new *Predator* has an endurance of almost two days.

## 2.4 Risks of using UAVs

The obvious advantage of the UAV – the fact that it does not require a human to fly over dangerous ‘enemy’ territory, can easily become a liability if this tempts the owner to intrude into the airspace of another country without permission. Such action could easily trigger conflict. Both Pakistan and India use UAVs along their mutual border and in 2002 violated each other’s airspace several times, while tension was already high. UCAVs add an extra dimension to this

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<sup>8</sup> US systems often have a commercial or military name, such as *Predator* or *Shadow-600*, as well as a military designation, such as MQ-9 or RQ-7. This paper uses the name, giving the military designation in brackets when first used.

<sup>9</sup> The US *Hellfire* is a laser- or radar-guided anti-tank missile developed for use from helicopters. It weighs some 45 kg and has a range of some 5-8 km. The *Hellfire* is used by several EU members, and similar missiles such as *Spike*, *Trigat* or *Brimstone* are in use or being developed by EU members and could be used to arm UAVs.

risk – they may be seen as an excellent method for safe and deniable covert method for targeted attacks on high level ‘enemies’. The use of armed UAVs by the US to assassinate suspected terrorist leaders, even in non-combat areas (e.g. the attack in Yemen) has already raised moral and legal questions.

A second important risk - a lesson learned from UAV use in the Balkans, Iraq and Afghanistan - is the danger of micro-management of combat operations by commanders (both military and political) who are stationed away from the combat zone<sup>10</sup>. Instead of letting their operational and tactical commanders ‘get on’ with the action, top level commanders may now be tempted to think that UAVs and other information gathering systems such as satellites give them the ability to see what is going on in the zone of operations in real time. This may then encourage them to try and micro-command the operation, and lead to rules of engagement that always demand authorization from top level commanders, thereby curtailing the decision-making powers of the lower level commanders. Extensive use of UAVs demands clear doctrines on who is in charge of which levels of operation.

Thirdly, while UAVs are extremely useful, their often slow speed (most have a maximum speed of less than 300km/hour) leaves them vulnerable to enemy action and other attrition<sup>11</sup>. The development of faster UAVs, capable of using defensive measures such as flares, will help to overcome their vulnerability, while the acquisition of larger numbers of UAVs will alleviate the attrition problem.

Lastly, photographs or video images gathered by UAVs for use as evidence in formal legal proceedings (as one might expect in peacekeeping operations) is questionable. This point was made by British officers with experience in Northern Ireland and Kosovo. They maintained that while the UAV imagery was good enough for use in war, it would probably not stand up in court – unlike imagery derived from heavier but better equipment mounted on manned helicopters<sup>12</sup>.

### 3. History of European UAVs

Until the 1960s UAVs were limited in their operations to either pre-programmed flight or to remote radio control. The first option enabled long-range operations, but no flexibility once the UAV was launched, whereas the second option gave flexibility, but severely restricted the range because the controller needed to see the UAV he was steering. In the 1960s developments in data transmission and in electronic miniaturization opened the way for reliable and small sensors to provide live data of sufficient quality to give operators on the ground a chance to see what the UAV’s sensors were seeing and thus to steer the UAV based on these pictures.

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<sup>10</sup> Ripley, T., ‘UAVs over Kosovo – did the earth move?’, *Defence Systems Daily*, 1 Dec. 1999, URL <http://defence-data.com/features/fpage34.htm>; Biass, E. and Braybrook, R., ‘The UAV as sensor platform – from Pioneer to Global Hawk’, *Armada International*, Oct/Nov. 2001, p. 3.

<sup>11</sup> During the 1999 operations in Kosovo, at least 21 and possibly over 27 Allied UAVs were lost. The Canadians had all their four *Sperwers* out of action within a few weeks of the start of their operations in Afghanistan. Of some 30 Pioneer UAVs used by the US forces in the 1990-1991 Gulf War, 13 were out of action by the end of the short war, while 13 had been temporarily out of action due to damage, leaving US forces with a very limited UAV force. Biass, E. and Braybrook, R., ‘The UAV as sensor platform – from Pioneer to Global Hawk’, *Armada International*, Oct/Nov. 2001, pp. 2-3.

<sup>12</sup> Ripley, T., ‘UAVs over Kosovo – did the earth move?’, *Defence Systems Daily*, 1 Dec. 1999, URL <http://defence-data.com/features/fpage34.htm>.

The very first UAV used by a European country was the US MQM-57 used by the UK from the late-1950s<sup>13</sup>. This crude UAV was replaced in the early 1970s by the Canadian CL-89, which also entered service with France, Germany and Italy. Other current EU Member States have been using UAVs on a limited scale. But it was not until the 1990s that European countries first used UAVs in a war zone<sup>14</sup>, or that most other European countries introduced UAVs. Today, the armed forces of almost all of them operate UAVs.

Indeed, the use of UAVs is spreading around the world. They are being deployed even by developing countries like the Philippines (which bought UAVs from Israel in 2001 for use against rebel groups) and Nigeria (which bought them in 2006 for patrolling the Niger Delta).

Today, UAVs range from extremely simple, short-range 'vehicles' for battlefield use, to multi-million dollar 'aircraft' with almost global reach. However, except in respect of the really long-range UAVs, it is not so much the UAV itself that is important, but the payload and the ground station capacities to process and disseminate data. Simple UAVs generally carry little more than a video camera that sends images over limited distances to a ground station that has limited links to other units. Larger UAVs can carry larger or different types of camera, while electronic intelligence systems (ELINT) and ground-surveillance radars are becoming common too. The ground stations are linked into a larger and faster network.

The advantage of UAVs for reconnaissance is obvious: low cost, low visibility and unmanned. Most countries can easily afford them, while the loss of one does not cost much and leaves no pilot to be rescued. Especially against unconventional enemies such as rebel, terrorist and criminal groups, or when used in 'undeclared' wars (e.g. Israeli use of UAVs over Lebanon) the unmanned aspect of UAVs is a clear advantage. The fact that the vehicle does not need to accommodate a pilot makes it possible to keep it small, providing low visibility and enabling a stealthy approach. This means that a target is often unaware of being observed by the UAV (as often happened vis-à-vis Israeli UAVs over Lebanon).

## **4. Current UAV/UCAV developments in the EU**

### **4.1 UAV acquisition and requirements**

Most EU members have either acquired or will soon acquire UAVs (see Table 1 for a comprehensive list). However, the combined EU efforts are small compared to the US acquisitions. As noted earlier, in three years (US Fiscal Years 2004, 2005 and 2006) the US bought 295 UAVs<sup>15</sup>. In the same period EU members bought less than 100. Budget-wise one can compare the US expenditure of US\$2.66bn in just those three years, with the fact that the full UK *Watchkeeper* UAV programme, which covers most of UK UAV acquisitions for the coming decade, will cost about half of that expenditure.

The most urgent requirements are for tactical, MALE and HALE long-range UAVs. Interestingly there seems to be less interest in mini- and micro-UAVs, despite the fact that several EU members are involved in conflicts where the US found a strong need for such systems.

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<sup>13</sup> The MQM-57 was the first US UAV.

<sup>14</sup> The first operational use of a European UAV took place during the 1990-1991 Gulf War, when British forces used the CL-89, almost 20 years after it was first introduced in service. URL < <http://www.sfu.ca/casr/bg-uav-history.htm>>.

<sup>15</sup> *The Military Balance 2006*, IISS, p. 20-22 and p. 26 (Routledge, UK, May 2006).

Many UAVs planned or in service with EU Member States are not of EU origin, even in those states that have an indigenous industry capable of producing them. The strong position of Israeli companies in developing UAVs is obvious. Although they provide many of the UAVs ordered by EU states, often these are ‘disguised’ as a European product, produced at least nominally by a European company. Frequently, the systems are given different designations to further hide their origin. For example, in 1998, Belgium ordered three *B-Hunter* UAV systems with 18 UAVs. They were produced by a consortium specifically set up for the production – Eagle, owned 50 per cent by Sonaca (Belgium), 25 per cent by Thales-Belgium (Belgium) and 25 per cent by IAI (Israel)<sup>16</sup>. It is interesting to note is that only two other UAVs competed for the order: the French *Sperwer* and the Swiss *Ranger*. The latter in reality is another Israeli UAV produced by a European company<sup>17</sup>.

The strong position of the two main Israeli UAV producers, IAI and Elbit, is also reflected in the fact that the UK selected the Elbit *Hermes-450* UAV for its *Watchkeeper* programme (and renaming it *Hermes, WK-450*), and from the fact that France bought *Heron* UAVs from IAI as an ‘interim’ solution for its MALE programme (and renaming *Heron, Eagle*). The *Eagle* will be used by EADS reconnaissance systems<sup>18</sup>. France requires up to 24 MALE UAVs and is most likely to order *Eagle-2* UAVs, developed by IAI and EADS from the *Eagle-1*, which probably means that IAI will deliver a version of its *Heron-2* UAV fitted with EADS sensors.

US producers are also major suppliers to EU countries. While some of the supplies are related to military aid programmes (Poland’s acquisition of US UAVs is financed by US aid), US producers have strong products in the large *Predator* MALE and *Global Hawk* HALE UAVs. European industry has yet to develop such systems.

Among the biggest UAV programme ongoing in the EU is the NATO Alliance Ground Surveillance (AGS) programme. This programme, worth over €3bn, envisages NATO’s acquisition of a long-range airborne ground-surveillance capability based on four large aircraft and four RQ-4B *Global Hawk* UAVs<sup>19</sup>. The most important aspects of the NATO AGS here are: (i) the fact that the AGS will be NATO controlled and thereby will provide EU countries some access to long-range UAVs; (ii) the fact that there was no alternative for the US-produced RQ-4; and (iii) that the cost for the advanced and high-performance ground surveillance radar would be around €200m each.

Germany also wants the *Global Hawk*, but in a SIGINT role – a version called *Euro Hawk* – carrying a European sensor package consisting of COMINT and ELINT equipment (produced respectively by Rohde & Schwarz and by EADS). Germany plans to buy 4-6 UAVs for around €600m to replace manned long-range *Atlantic* SIGINT aircraft<sup>20</sup>. There is a possibility of a second order for *Euro Hawk* UAVs equipped with radar for ground surveillance<sup>21</sup>.

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<sup>16</sup> *AirForces Monthly*, October 2001; *Air & Cosmos*, 31 August 2001.

<sup>17</sup> *Jane’s Defence Weekly*, 23 December 1998. Finland bought the *Ranger* in 1999 via the Swiss company RUAG. Biass, E. and Braybrook, R., ‘The UAV as sensor platform – from Pioneer to Global Hawk’, *Armada International*, Oct/Nov. 2001, p. 7.

<sup>18</sup> The French *Heron/Eagle* acquisition is called SIDM – Système Intermédiaire de Drones Male and is channelled through EADS. *AirForces Monthly*, Nov. 2006, p. 10; *Air & Cosmos*, 16 Sep. 2005, p. 8.

<sup>19</sup> For more on the AGS see the NATO website, URL < <http://www.nato.int/issues/ags/index.html>>. The original plan foresaw equipping the aircraft and the UAV with a ground-surveillance radar, but by mid-2006 the radar for the UAVs was cancelled to save €800m, *Jane’s Defence Weekly*, 16 Aug. 2006, p. 7.

<sup>20</sup> *Air & Cosmos*, 28 Oct. 2005, p. 33; *Soldat und Technik*, July 2004, p. 33.

<sup>21</sup> *AirForces Monthly*, July 2004, p. 11.

## 4.2 European UAV research and development

Research and development (R&D) in EU member states is focused on medium-sized and larger UAVs and their sensors, as well as on UCAVs. A large part of the UAV R&D is financed by private industry and invariably uses existing technology (including civilian technology) for both the UAV aircraft and the sensors. The UAV programmes are generally aimed at producing operational systems. The more complex and expensive UCAV programmes are more dependent on financing by governments. All current UCAV programmes are technology demonstrator programmes aimed at testing instead of producing an operational UCAV.

Research on tactical, mini, micro and super-micro UAVs is ongoing in many places inside EU countries. These range from government-owned research organisations to practical student and private ventures<sup>22</sup>. Cooperation between different companies or countries in the EU is not very strong. The experience of Eurodrone - a 1980 joint venture between Matra (France) and STN Atlas (Germany) to develop a small tactical UAV (called *Brevel* or *KZO*) - seems to sum it all up: brought as a typical French-German cooperative effort, it collapsed when the French pulled out of the project claiming the system was no longer useful, while the Germans went on and finally after 25 years introduced their *KZO* UAV in 2005.

Several MALE UAV systems are being developed by European companies. Two of these are pure European efforts. BAE (UK) is developing the *Herti-IA* MALE based on a Polish powered glider airframe. Dassault (France), Alenia (Italy) and Saab (Sweden) agreed in June 2007 to develop a MALE, based on expertise gained from the Neuron project and probably absorbing Alenia's own Sky-Y MALE technology demonstrator programme. Other European partners are planned and while it is a company initiative, funding from EU governments is sought<sup>23</sup>. It is interesting that the new Dassault/Alenia/Saab programme seems to contradict a 2004 Dassault-EADS agreement whereby Dassault would take responsibility for UCAV and EADS for MALE development<sup>24</sup>. Other programmes are based on Israeli or US technology with different degrees of European input: the French *Eagle* and the British *Watchkeeper* programmes use Israeli UAV aircraft with locally-developed payloads; the RQ-1 is assembled in Italy and carries a US-produced payload.

Most recent are EU efforts to develop a HALE UAV. EADS initiated development of an Advanced UAV in 2005 with support from France and Germany, and in 2007 Spain joined the project. A formal development contract, which includes Thales and Indra, is expected soon and the project is open for additional industrial or country participants<sup>25</sup>.

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<sup>22</sup> E.g. in 2005 students at the University of Delft (Netherlands) developed a 17 gr super micro UAV called Delfly. URL <http://www.flightglobal.com/articles/2005/09/13/201479/dutch-micro-uav-flaps-its-way-to-successful-first-flight.html>. Such micro and mini UAV are not much different from remote-controlled 'toy' aircraft commonly available in almost any toyshop for less than €50.

<sup>23</sup> Alenia is a subsidiary of Finmeccanica (Italy). Dassault press release, 19 June 2007, URL < <http://www.dassault-aviation.com/fr/aviation/presse/press-kits/2007/european-male-agreement.html>>.

<sup>24</sup> US Department of Commerce, 'France to lead UAV development in Europe', *STAT-USA* 15 July 2004, URL <http://strategis.ic.gc.ca/epic/site/imr-ri.nsf/en/gr125937e.html>.

<sup>25</sup> 'Spain signs up for EADS-led Advanced UAV study', *Flight International*, 31 July 2007, URL <http://www.flightglobal.com/articles/2005/09/13/201479/dutch-micro-uav-flaps-its-way-to-successful-first-flight.html>.

### 4.3 European UCAV research and development

Currently, there are no UCAVs (including armed UAVs) either in service or in production in EU countries<sup>26</sup>. However, there is an interest to acquire armed UAVs rather soon. The UK has shown interest in the US *Predator-B* armed UAV, which is currently operating in Iraq and Afghanistan (reportedly with some UK personnel involved). The only EU-developed armed UAV currently under consideration is a French feasibility study ordered from Sagem for an armed version of the *Sperwer-B* UAV<sup>27</sup>. Plans for acquisitions of real UCAVs are still very vague. EU armed forces are not yet clear if and how such real UCAVs fit into their national doctrines. However, several EU governments are sponsoring technology demonstrator programmes to develop the UCAV concept into a working system. All current UCAV programmes are technology demonstrator programmes aimed at testing – rather than producing – an operational UCAV. Different from UAV programmes, the more complex and expensive UCAV programmes are dependent on financing by governments.

There are now several separate ongoing UCAV R&D programmes. France, Italy, Spain, Sweden, Greece, (Belgium may join) and non-EU Switzerland are working on the *Neuron* project: a mainly a French initiative that includes a mix of government and industry funding. The French company Dassault leads the project<sup>28</sup>, but non-French expertise has been sought from the start. The French government has budgeted €300m for the programme. Finmeccanica's subsidiary Alenia is the largest non-French industrial partner and Memoranda of Understanding were signed at the end of 2005 with Sweden (for €75m, including €15m from Saab) and Spain (€35.5 million) for the period 2007-2012<sup>29</sup>. The *Neuron* is a technology demonstrator and should fly around 2010<sup>30</sup>. Its aim is to test concept and technologies for operational UCAVs that may replace the current generation of manned combat aircraft by around 2025-2030<sup>31</sup>.

The UK has launched two programmes, *Taranis* and *Corax* (Raven). BAe Systems, which has financed UAV/UCAV development for the past decade, has been appointed to lead a UK industrial team for the UK-government funded £124m (€185m) *Taranis* development in 2006. *Taranis* is a long range UCAV, the size of a small combat aircraft, powered by a full size turbofan and will have intercontinental range<sup>32</sup>. *Taranis* builds on the experiences of the BAe-developed *Kestrel* and *Corax* UAVs. Currently, *Taranis* is designated a demonstrator

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<sup>26</sup> Spain is reported to have acquired the Harpy, a 'lethal drone' produced by IAI. While very much like a UAV (including the fact that it looks like one, is slow and is designed to loiter for hours before attacking), it is a one-way system and therefore classified here as a missile. Rheinmetall is developing the similar Taifun.

<sup>27</sup> The *Sperwer-B* is an enlarged version of the *Sperwer*, but would not be able to carry an armament heavier than two small missiles. 'Enhanced *Sperwer B* with new operational capabilities', *Asian Defence Journal*, July-August 2006, p.54. Rheinmetall (Germany) has developed the Taifun and TARES, which they label as 'combat UAV'. These operate as normal UAVs but can be also be used to attack targets in a 'suicide' mission. They do not carry any armament. 'Taifun attack drone', *Defence Update*, Vol. 2, 2005, URL <http://www.defense-update.com/products/t/taifun.htm>, and Rheinmetall website, URL <http://www.rheinmetall-detec.de/index.php?fid=1600&lang=3&pdb=1>

<sup>28</sup> Dassault has developed several UAV technology demonstrators (Petit Duc, Moyen Duc, Grand Duc, AVE). Biass, E. and Braybrook, R., 'The UAV as sensor platform – from Pioneer to Global Hawk', *Armada International*, Oct/Nov. 2001, p. 3.

<sup>29</sup> Officially the name is nEUROn. Alenia website, URL < <http://www.alenia-aeronautica.it/Products/neuron.asp>>; US Department of Commerce, 'France to lead UAV development in Europe', *STAT-USA* 15 July 2004, URL <http://strategis.ic.gc.ca/epic/site/imr-ri.nsf/en/gr125937e.html>; 'Madrid dans l'UCAV', *Air & Cosmos*, 6 January 2006, p.24.

<sup>30</sup> Aviation Week & Space Technology, 26 Sep. 2005, p. 13.

<sup>31</sup> US Department of Commerce, 'France to lead UAV development in Europe', *STAT-USA* 15 July 2004, URL <http://strategis.ic.gc.ca/epic/site/imr-ri.nsf/en/gr125937e.html>.

<sup>32</sup> 'Taranis unmanned combat air vehicle (UCAV) demonstrator, United Kingdom', *Air Force Technology*, URL <http://www.airforce-technology.com/projects/tanaris/>.

programme, meant to develop a working UCAV, but not necessarily an operational system. *Corax* is basically a high-end UAV development, using stealth technologies, under development since 2003 and unveiled in 2006. The aircraft is large enough to function as a UCAV. A third programme in which UK with industry involvement is the X-48B, a reduced-size prototype has been built by Cranfield Aerospace for the US company Boeing<sup>33</sup>.

Germany cooperates with Spain in the development of the *Barracuda*, another UAV programme with possibilities to grow into a UCAV. About the same size as the *Taranis*, the *Barracuda* flew first in 2006 and is also meant as a technology demonstrator. Originally envisaged to develop technologies for a long-range reconnaissance UAV - intended to replace the manned *Tornado* aircraft in reconnaissance tasks - it is now also intended to demonstrate armed combat capabilities. EADS leads the development programme, which is funded by the German and Spanish governments. In Italy, Finmeccanica's Alenia has been working on a technology demonstrator called *Sky-X*, which first flew in 2005 as the first European UAV with a weight of over 1,000 kg<sup>34</sup>.

It is clear that UCAVs will not replace manned aircraft in all or even many tasks, not even for some of the most hazardous missions where the loss of aircraft and pilots is likely<sup>35</sup>. However, in some instances UCAVs will be able to offer unmanned alternatives for dangerous missions; often in conjunction with manned aircraft. As yet the roles for the UCAV in Europe are undefined, but are likely to be the basis of future SEAD (Suppression of Enemy Air Defences) forces – attacking enemy radar and air-defence systems, currently one of the most risky tasks for manned combat aircraft<sup>36</sup>.

The one task where UCAVs offer a clear advantage is for covert combat missions, where 'deniability' is a priority: something rendered impossible if and when pilots are lost over 'enemy' territory. The downside is the possibility that having an improved option for conducting deniable covert operations may lower the threshold for carrying them out.

## 5. The role of the EU on the global UAV/UCAV market

The global market for UAVs has grown dramatically in the last 10 years and is expected to maintain high growth rates in the coming decade when existing possessors expand their use of UAVs and when more countries acquire them. This opens up possibilities for EU producers to improve on their previously poor track record and export their products to non-EU countries. As Figure 2 shows (below), only a small proportion of global UAV acquisitions from foreign sources in the last 10 years concerns EU producers exporting to non-EU countries. An estimate for 2006 gave EU producers only a four per cent share of the global market, almost all from national or intra-EU sales. Most of the global export market is covered by the US (in 2006, US producers accounted for some 60 per cent of the total global market - including the huge US market<sup>37</sup>) and Israel (IAI's MALAT division pronounces that it 'leads the market in UAV

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<sup>33</sup> NASA website, 4 May 2006, URL <http://www.nasa.gov/vision/earth/improvingflight/x48b.html>.

<sup>34</sup> Alenia website, URL < <http://www.alenia-aeronautica.it/Products/sky-x.asp>>.

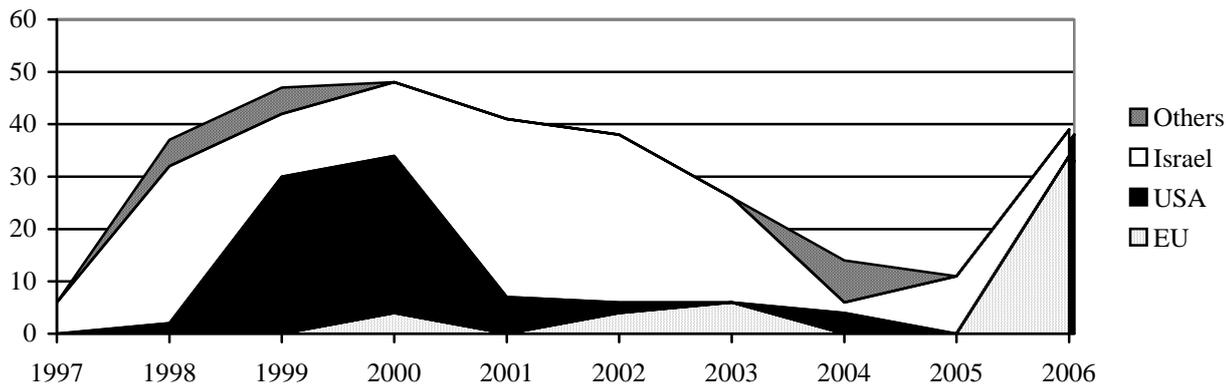
<sup>35</sup> The end of manned combat aircraft has been predicted in the 1950s, 1960, 1970s and 1980s and has then been proven very premature.

<sup>36</sup> Streetly, M., 'Disrupt, disable, destroy' (Briefing: Suppression of enemy air defences), *Jane's Defence Weekly*, 14 December 2005, pp. 24-29.

<sup>37</sup> Dickerson, L., 'UAVs on the rise', *Aviation Week & Space Technology*, 15 January 2007.

**Figure 1: Global exports of UAV 1997-2006**

Figures are number of units (regardless of size, performance or price; excepting micro and mini UAV)



experience, technology and reliability’, and has over 29 customers<sup>38</sup>). No EU producer can claim experiences or success that comes close to that.

Despite this extremely strong position of three US (General Atomics, AAI and Northrop Grumman) and three Israeli companies (IAI, Elbit and Aerostar), the low end of the UAV market is highly competitive. No less than 42 bids were received by Indonesia in 2006 for a small (less than US\$10m) order for a tactical UAV<sup>39</sup>. Most of the demand in markets where international competition is possible (the US market is almost closed for non-US producers) is for tactical and MALE UAVs. The demand for the expensive and technically complicated HALEs derives from some well-developed large, rich countries that either have extensive maritime patrol needs or enjoy ‘regional power’ status, such as Australia, Japan, Turkey and India.

As one of the first non-UAV producers, India has developed as a major market for UAVs since the mid-1990s, ordering TUAVs and MALE USVs worth up to \$1bn from Israel and planning more. Several other Asian countries (Australia, South Korea, Singapore, Thailand, Indonesia) are following suit, with other Asian countries expected to follow soon. Almost without exception, Israeli and US designs have won all competitions in this region, invariably because they were technically superior.

Another future market, and one where Israeli companies are not welcome, is the Middle East. While several Middle Eastern countries have used UAVs for years (e.g. Saudi Arabia has used small and simple UAVs for border surveillance), very few have yet ordered tactical or larger military UAVs. In the years ahead, countries in this volatile region can be expected to spend more on different reconnaissance and intelligence systems, including UAVs.

African and Latin American countries may also become more interested in UAVs. While their markets are not large, many countries here have large territories and long borders to control; and several are experiencing ongoing internal conflicts. UAVs could provide an inexpensive alternative to manned aircraft. For example, UAVs could assume some of the roles of maritime patrol aircraft, which are expensive to buy and to operate (too expensive for many developing

<sup>38</sup> IAI website, URL <<http://www.iai.co.il/Default.aspx?FolderID=17802&lang=en>>.

<sup>39</sup> The IAI (Israel) Searcher-2 was selected. *Air Letter*, 6 November 2006, p. 4.

countries), many of which have extensive EEZs<sup>40</sup> to patrol (Nigeria is one of the first countries adopting UAVs for maritime patrol)<sup>41</sup>. UAVs have also already found use with some developing countries for surveillance missions against rebel forces (e.g. in Sri Lanka, Angola and the Philippines).

An interesting development is the use of UAVs by government agencies other than the military and by civilian users. Here large UAVs are seen as useful for SAR, surveillance of large areas (e.g. forests or fishing grounds), and geographic and geological survey. Smaller, 'tactical' or mini UAVs could well be practical for police forces for area surveillance (e.g. for traffic control), while even the smallest UAVs are already being offered for small scale agricultural use, for example<sup>42</sup>.

All analysts agree the UAV market will still see strong growth in the coming decade. Information from open sources on planned acquisitions globally indicates that most countries currently possessing UAVs will expand their inventory and/or improve sensors on their UAVs. In addition, many new military users of UAVs will emerge. Some predictions have been made about the size of the future global UAV market (for example, one estimate suggests that the market will be worth about US\$13.5bn<sup>43</sup> between 2005 and 2014; another suggests US\$17.5bn<sup>44</sup> between 2003 and 2012), although it is impossible to judge how good these estimates are.

Where open sources provide information about those UAV procurement plans under consideration, it is clear that very few EU companies are involved in the competition. A large part of the expected market is in the US, where EU UAVs have little chance of competing on even terms. The value of expected US orders for *Global Hawk* UAV by 2014 is already US\$3.5bn (or 25 per cent of the total estimated value of the global UAV market). Without resorting to exports, therefore, US producers already have up to 50 per cent of the global market covered<sup>45</sup>.

Another important part of the future market is already locked, with programmes such as the UK *Watchkeeper* or the NATO *AGS* having already been selected but not yet ordered or delivered. Most procurement globally in the next 10 years seems likely to be filled mainly by Israeli and US companies. In 2004 Dassault and EADS suggested that the market segment where they could compete with UAVs and UCAVs was worth some US\$3bn<sup>46</sup>.

The market specific to UCAVs is currently less clear, partly because UCAVs are such a new concept. A tentative estimate of some US\$7.5bn has been given as the value of the UCAV market between 2003 and 2012<sup>47</sup>. Export of UCAVs (excluding armed UAVs) is not foreseen in

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<sup>40</sup> Under the law of the sea, an Exclusive Economic Zone (EEZ) is a sea zone over which a state has special rights over the exploration and use of marine resources.

<sup>41</sup> In 2006 Nigeria bought Israeli UAVs and Unmanned Surface Vehicles (USV – remote controlled boats).

<sup>42</sup> See for example the Canadian company CropCam, which offers a 3 kg camera-equipped micro UAV to 'patrol' farms. CropCam website, URL < <http://cropcam.com/>>.

<sup>43</sup> 'UAV market to top \$13 billion by 2014', Forecast International press release, 21 Oct. 2005.

<sup>44</sup> Frost & Sullivan quoted in US Department of Commerce report dated early 2005, URL [http://commercecan.ic.gc.ca/scdt/bizmap/interface2.nsf/vDownload/ISA\\_1593/\\$file/X\\_2891343.PDF](http://commercecan.ic.gc.ca/scdt/bizmap/interface2.nsf/vDownload/ISA_1593/$file/X_2891343.PDF).

<sup>45</sup> 'UAV market to top \$13 billion by 2014', Forecast International press release, 21 Oct. 2005.

<sup>46</sup> US Department of Commerce, 'France to lead UAV development in Europe', *STAT-USA* 15 July 2004, URL <http://strategis.ic.gc.ca/epic/site/imr-ri.nsf/en/gr125937e.html>

<sup>47</sup> Frost & Sullivan quoted in US Department of Commerce report dated early 2005, URL [http://commercecan.ic.gc.ca/scdt/bizmap/interface2.nsf/vDownload/ISA\\_1593/\\$file/X\\_2891343.PDF](http://commercecan.ic.gc.ca/scdt/bizmap/interface2.nsf/vDownload/ISA_1593/$file/X_2891343.PDF)

the coming decade. Very few countries outside the US and the EU have current plans for (possible) acquisition.

The most successful European UAV on the export market is the *Sperwer*. This was exported to Canada as a 'stopgap' order for immediate use in Afghanistan, and is also used by several EU member states. However, the system is already beginning to become outdated and the operational experience has not been the most rewarding. Denmark has now withdrawn the system because of technical shortcomings and The Netherlands may soon look for a replacement too<sup>48</sup>.

Surprisingly, a small company in Austria, Siebel, may be the most successful exporter of UAVs in the near future. In the spring of 2006 Siebel sold no less than 80 *Camcopter* S-100 UAVs to the United Arab Emirates (UAE), after earlier gaining a small order from Egypt and the interest of the US Navy and Coast Guard. While several other EU and US designs are offered for export or being developed, this sale is significant because the *Camcopter* is basically the first sale of any helicopter-type UAV capable of VTOL operations. It also shows how successful UAV technology does not necessarily come from a larger company with extensive financial and technical resources. The involvement of the emerging UAE arms industry in the deal is also significant – some parts of the *Camcopter* will be produced by the UAE Research and Technology Centre<sup>49</sup>. Unlike the US, Israel has successfully used industrial cooperation and technology transfers as a pillar of its UAV exports and EU countries may want to follow a similar approach.

One important consideration for any future export of UAVs and UCAVs is the fact that such systems – if their payloads and ranges were of sufficient magnitude - would fall within the restrictions imposed by the Missile Technology Control Regime (MTCR). This basically bans exports of complete unmanned airborne systems that could be used as delivery systems for Weapons of Mass Destruction (WMD) - specifically including UAVs and UCAVs and their technology - if the aircraft is capable of carrying a payload of at least 500 kg over a range of at least 300 km. The MTCR also limits the possibility of exporting UAVs and UCAVs with ranges of 300 km or more regardless of the payload capacity<sup>50</sup>.

Another area of concern is protection of technology. Several countries planning UAVs seem to regard the 'newness' of these systems as an opening to get involved in R&D and local production using some imported technology. This could result in a proliferation of independent UAV producers, whose use and misuse of UAVs cannot be controlled.

A third important consideration is, as with all arms acquisition, the dependence on a supplier. This has already been mentioned as an issue for EU countries acquiring UAVs, but for countries with less strong, stable and mutually dependent relations with suppliers of either UAVs or mission equipment, the issue of dependency plays even stronger – certainly for some of the bigger countries like India. Such dependency is often only acceptable when the supplier is reliable and able and willing to support the exported UAV over the many years of its life. This has implications for potential exports: countries with a record of imposing 'embargoes' or limiting access to technology may have less chance to market their products. At the same time,

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<sup>48</sup> Note on Denmark; 'Netherlands prepares for small and mini UAV competitions, flags *Sperwer* upgrade', *Flight International*, 11 Sep. 2006, URL <http://www.flightglobal.com/articles/2006/09/11/208930/netherlands-prepares-for-small-and-mini-uav-competitions-flags-sperwer.html>.

<sup>49</sup> *Jane's Defence Weekly*, 26 Apr. 2006, p. 17.

<sup>50</sup> For more on the MTCR, see the SIPRI website, URL [http://www.sipri.org/contents/expcon/mtrc\\_documents.html](http://www.sipri.org/contents/expcon/mtrc_documents.html).

pressure for exports may limit a country's options to impose embargoes or limit technology access.

## 5.1 Risks of UAV exports

The dangers of exporting UAVs, capable of delivering stand-off weapons or even WMD, are obvious. With UAVs proliferating, it is probably only a matter of time before dangerous governments or terrorists get their hands on them and use them<sup>51</sup>. Such fears gained strength after the discovery of Iraqi programmes to develop UAVs to deliver biological or chemical weapons, and to modify them as cruise missiles with high explosive payloads. For instance, Hezbollah used UAVs (supplied by Iran) in its 2006 war with Israel. At least three were reportedly fitted with a limited (10-50kg) payload of explosives and used as crude cruise missiles<sup>52</sup>. Not only complete UAVs can cause problems: the associated technology for remote-control beyond the line of sight can also be used to modify normal aircraft into precision-guided cruise missiles.

Questions remain as to why terrorists would want to acquire and use UAVs when they have many, much easier, means available. The only advantage for terrorists of a UAV modified to a precision-guided weapon would be when very specific small objects are targeted - sensitive targets normally heavily guarded against more conventional forms of attack, such as specific (parts of) government buildings, targets deep inside a military installation or other sensitive places, or a moving target.

UAVs or UAV technology in the hands of dangerous governments is probably of greater concern. Unarmed UAVs are easily modified through the simple addition of an explosive payload. The result is an inexpensive cruise missile, which, while slow, is also accurate and stealthy. And although they are only able to deliver very limited payloads, this could be a chemical or biological one. Alternatively the control system for a UAV can be used to modify normal aircraft into remote-controlled cruise missiles, capable of carrying a much heavier weapon load. For instance, in the 1980s and 1990s Iraq reportedly modified *Mirach-600* UAVs supplied by Italy into cruise missiles and, as mentioned earlier, modified *L-29* jet trainer aircraft into remote-controlled UAVs for possible use with biological or chemical weapons<sup>53</sup>.

The risks UAVs andUCAVs and their technologies pose vis-à-vis WMD proliferation is recognized internationally. These systems and their associated technologies are covered by the MTCR, to which most EU members are party. Large UAVs and trueUCAVs would exceed the limits of the MTCR agreement<sup>54</sup>, which means that large parts of the world (e.g. Middle East) are basically off-limits for UAV andUCAV exports.

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<sup>51</sup> See for example: Gormley, D. M., 'New developments in unmanned air vehicles and land-attack cruise missiles', *SIPRI Yearbook 2003* (Oxford University Press, Oxford, UK, 2003), pp. 409-432.

<sup>52</sup> None reached their target – two were intercepted and shot down by the Israeli air defences and the third exploded on launch. Wezeman, Siemon T. et al, 'International arms transfers', *SIPRI Yearbook 2007*, (Oxford University Press, Oxford, UK, 2007), p. 411.

<sup>53</sup> Gormley, op. cit., pp. 413-414.

<sup>54</sup> The MTCR limits were until 2002 for example an issue for US export permits for the Predator UAV to European countries. The Predator has a range exceeding the MTCR limits, but its payload is less than the MTCR limit. *Defense News*, 15 Apr. 2002.

## 6. Conclusion

For many countries, UAVs have become important force multipliers. They have gained a permanent place in the military force structure, mainly for reconnaissance purposes: a role of increasing importance. Not only is reconnaissance once more seen as a *sine qua non* for the type of military operations most forces plan for today, but unmanned aircraft are starting to fulfill other roles, including combat roles.

Most EU members have acquired UAVs or plan to do so soon. Several of them have used UAVs in combat operations since the end of the Cold War, finding them especially useful in the type of military operations envisaged in the ESDP. However, the acquisition of UAVs in the EU is generally based on national decisions and often not very coordinated on the EU level. While it is difficult to see if, in order to fulfill ESDP tasks, the EU needs additional UAVs on top of those already in service or planned by EU members, the question of improved coordination in acquisition and operation still arises.

If EU members take part in ESDP missions it is not difficult to find enough UAVs for the mission. But the more important question would be whether the UAVs would be able to provide data quickly to the different national contingents that would comprise an ESDP mission. In other words, the quick dissemination of information may pose a problem, rather than the number of UAVs available. It would be useful for the European EDA to make sure that a UAV 'capability gap' is not developing through lack of means of communication.

The two places where one could see a capability gap is at the high and the extreme low end of the UAV spectrum – in HALE and in the micro and mini UAVs. Although such systems have been developed recently and are now widely deployed by US forces, EU forces have not yet adopted them on a large scale. For HALE, Europe depends on US-controlled platforms. However, since HALE UAVs would be most useful in large-scale operations against far-distant enemies, it seems unlikely that the EU would need a fully independent HALE capability. Mini/micro UAVs, on the other hand, have shown their value in combat operations and would clearly boost the capabilities of EU forces engaged in ESDP missions.

The process of developing the much more complex high-tech UCAVs in Europe is partly following the now 'normal' path of cooperation between a number of European countries. While some coordination between the different EU UCAV programmes would be useful to save R&D funds, it still remains unclear what the role of UCAVs would be, both at national level and in the type of missions that form the core of ESDP focus. It would also still be useful to have several, rather uncoordinated UCAV development efforts proceeding in parallel, since that would give opportunities to develop alternative technologies.

## **Appendix I: Types of UAVs**

Micro-UAV: mostly portable, hand-launched, very short range/low altitude ( $\pm 2\text{km}/600\text{m}$ ) with a simple and payload of less than 1kg (small video camera).

*Aladin ((EMT – Germany); 3.2kg UAV with  $\pm 5\text{km}$  range and 30 minutes endurance; small surveillance camera payload.*

Mini- or Close-UAV: very short range/low altitude (max. 10km/2000m) with a payload of several kg (high resolution large video or thermal camera).

*Bird Eye 400 (IAI – Israel); max. 80 min. + max. 300 m + 10 km range + 4.1 kg payload (large TV or thermal camera).*

Short-range, NATO-type or tactical UAV: short range/low-medium altitude (50-150km/max. 4500m) with a payload of up to 100kg.

*Sperwer (Sagem – France).*

Medium-range or tactical UAV: medium range/medium altitude (200km/6000m) UAV with a payload of up to 150kg.

*Hermes 450 (Elbit – Israel).*

MALE (Medium Altitude, Long Endurance) UAV: long range/medium altitude (200km/10000m) UAV with up to 300kg payload.

*Heron/Eagle (IAI/EADS – Israel/France); over 40 hrs + over 9000 m + over 185 km range + 250 kg payload.*

*Predator (GA – USA).*

HALE (High Altitude, Long endurance) UAV: long range/high altitude (1000+km/10000+m) UAV with over 300kg payload.

*Global Hawk (NG – USA).*

This typology of different UAV types is however not universally agreed. The US armed forces for example use a system of ‘tiers’, which only partly correspond with the typology above. To make matters worse, the different US services use different definitions of their tiers.

## **Appendix II: The main components of UAV systems**

### **Airborne part – aircraft**

Airframe – wings and body.

Engine – most UAVs are powered by a piston (reciprocating) engine driving a propeller. Faster and higher flying UAV use turboprop or jet engines. Electric, battery or fuel-cell powered, engines are becoming usual on micro- and mini-UAVs.

Sensors – radar, photo or video camera, IR scanners or ELINT are most common. Sensors may include a (laser) target designator to provide guidance for stand-off guided missiles and shells.

Control system – used to fly the UAV. Either a two-way data link (radio) for remote control or an onboard computer (generally with GPS navigation) connected to the aircraft control system.

Data link – One-way (radio) link transmitting data collected by sensors.

Recovery system – optional; most modern UAVs land like normal aircraft; earlier UAVs often use a parachute to land.

### **Ground-based part**

Launcher – many UAVs are launched by a catapult-type launcher or with a rocket booster. UAVs with a wheeled undercarriage for take off like a normal aircraft, which is less stressing on the UAVs airframe, is becoming more common.

Control system – used to fly the UAV; this includes a ‘cockpit’ from which the ‘pilot’ on the ground flies the UAVs (if remote-controlled). It is linked by two-way (radio) link to the UAV. The control system may include sub-control systems allowing other operators to take over flight.

Data link – receiver for sensor data transmitted from the UAV. There may be several receivers of data, including some not part of the UAV system.

Transport and maintenance – UAV systems are generally mobile.

### Appendix III - Tables

**Table 1: UAV/UCAV in service or planned by EU members**

The table list all known UAV and UCAV in currently in service or planned by all current 27 EU members. Data are as of June 2007.

Country	Supplier	Type	Name	No.	Year	Comment
Austria		TUAV				Plan since 2000.
Belgium	MBLE – Belgium	TUAV	Epervier			Replaced by B-Hunter.
	IAI – Israel	TUAV	B-Hunter	18	2002	With air force; with 3 systems; chosen over Ranger (Israel/Switzerland) and Sperwer (France).
Bulgaria		TUAV				Possible interest since 2005.
Cyprus	IAI – Israel	TUAV	Searcher-2	2 sys.	2002	With army.
Czech Rep.	Air Force – Czech Rep.	TUAV	Sojka	8	1995	With army.
Denmark	Sagem – France	TUAV	Sperwer	12	2001	With army; with 2 systems; named Tornfalken in Denmark; to be sold 2007 (to Canada) since Denmark unsatisfied with performance.
Finland	IAI – Israel	TUAV	Ranger	(12)	2001	With air force: 1 system ordered 1999 and 1 in 2003; ordered via RUAG (Switzerland).
France	Canadair – Canada	TUAV	CL-89	7 sys.	(1974)	With army; named AN/USD-501 by NATO; replaced by CL-289.
	Canadair – Canada	TUAV	CL-289	50	1992	With army; probably with 8 systems; named AN/USD-502 by NATO; named PIVER by France.
	Sagem	TUAV	Crecelle	2 sys.	1994	With army.
	IAI - Israel	TUAV	Hunter	1 sys.	(1995)	With army; delivered 1995-1997.
	Sagem – France	TUAV	SDTI	18	(2007)	With army; replacing Crécerelle.
	IAI – Israel	MALE	Eagle-1	3	(2007)	With air force; ordered 2001 for delivery 2007-2009; interim acquisition via EADS as ‘SIDM’; won competition from US RQ-1 offered via Sagem (France).
			MALE		12-24	plan
		TUAV			plan	‘DEVIN’ plan for VTOL UAV for army and navy from 2012; possibly EADS Orka-1200.
	Sagem – France	UCAV	Sperwer-B		plan	Feasibility study for armed Sperwer-B UAV.
	Neuron – EU	UCAV	Neuron			Technology demonstrator development project.
Germany		TUAV	CL-289	(50)	1990	With army; named AN/USD-502 by NATO; named AOLOS-289 in Germany.
		TUAV	Luna	(30)	2000	With army.

	STN – Germany	mini TUAV	Aladin KZO	(120) 60	(2004) 2005	With army With army; with 6 systems; originally French-German Eurodrone (Matra and STN Atlas) development from which France pulled out.
	NG – USA	HALE	Global Hawk 4-6		(2009)	With air force; Euro Hawk version; for SIGINT with EADS and R&S equipment; ±EUR600 million order.
	NG – USA	HALE	Global Hawk		(2010)	Possible plan for additional Global Hawk/Euro Hawk with radar to be ordered 2008.
		MALE			plan	Plan 2004 for MALE with air force; RQ-1 (USA) offered with production by Diehl in Germany.
Greece	HAI – Greece	TUAV	Pegasus		(2003)	Modified 2005 to Pegasus-2.
	GD – USA	MALE	RQ-1	6	2002	
	Sagem – France	TUAV	Sperwer	(16)	2004	2 systems delivered 2004-2006 and 2 systems ordered 2006.
	Neuron – EU	UCAV	Neuron		n.a.	Development project.
Ireland		TUAV		2	plan	EUR1 million 2005 plan for 2 small UAV.
Italy	GD – USA	MALE	RQ-1B	4	(2007)	With air force; equipped with el/op sensors and radar; assembled in Italy by Meteor.
		MALE		(2-4)	plan	Plan for additional MALE UAV since 2002; probably RQ-1B.
	Meteor – Italy	TUAV	Mirach-20	5		With army.
	Meteor – Italy	TUAV	Mirach-26	?		With army.
	Meteor – Italy	TUAV	Mirach-150	?		With army.
	Neuron – EU	UCAV	Neuron	-	n.a.	Development project.
	Canadair – Canada	TUAV	CL-89			Replaced by CL-289.
	Canadair – Canada	TUAV	CL-289		2002	Replacing CL-89.
Netherlands	Sagem – France	TUAV	Sperwer	32	2002	With army; with 4 systems.
	EMT – Germany	mini	Aladin	10	2006	With army; bought for use in Afghanistan.
		MALE			plan	Plan for MALE; NLG140 m plan 2001 for delivery 2007-2011; cooperation with France since 2002; possibly Eagle-1 or Eagle-2.
		TUAV		8		Plan for 4 40-70km UAV systems from 2008.
		mini		48		Plan for 24 mini UAV systems from 2009.
Poland	AAIC – USA	MALE	RQ-7B	2 sys	2007	Plan for MALE; original plan for Predator or MQ-5B Hunter replaced by RQ-7B (Shadow-200); Paid with USD73 million US aid.
		MALE			plan	Plan for additional 3-4 MALE systems; probably Shadow-200 (RQ-7B).
Romania	AAIC – USA	TUSV	Shadow-600	(11)	(1999)	With air force; first 6 ordered 1997; 5 more ordered 2000.

Spain		TUAV			plan	Possible plan for UAV for navy frigates; Fire Scout offered by IZAR (Spain) and NG (USA) since 2002.
		TUAV			plan	Plan for medium-altitude UAV with laser designator.
Sweden	Sagem – France	TUAV	Sperwer	(9)	(1999)	With army; with three systems; named Ugglan in Sweden
	EADS - France	MALE	Eagle		plan	Plan since 2000 for MALE; Altus + Predator + Hermes-1500 + Eagle candidate; Eagle found only acceptable; 1 Eagle tested 2002.
	Neuron – EU	UCAV	Neuron		n.a.	Development project.
UK	Canadair – Canada	UAV	CL-89		(1974)	With army; named Midge in UK; replaced by Phoenix
	BAE – UK	TUAV	Phoenix	198	1998	With army; with 8 UAV systems.
	MiTex - ?	Micro	Buster		2005	With army
		Mini	Desert Hawk		(2005)	With army.
	GA – USA	MALE	Predator	3	(2007)	With air force; ‘Project Dabinett’; replacing Canberra PR-9 long-range/high-altitude reconnaissance aircraft (in service since 1960s); with sensor package as also used on Tornado aircraft; Predator-B (as Falcon Prowl) and Eagle (Heron) (EADS/IAI – France/Israel) evaluated 2004-2005 in ‘JUEP’ (Joint UAV Experimental Programme) evaluation programme for long-range UAV.
	Elbit – Israel	MALE	Hermes-450	21		With Watchkeeper system; in service from 2010
NATO	NG – USA	HALE	RQ-4			Part of NATO AGS system; paid by NATO and under NATO control.

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Sources: SIPRI Arms Transfers database and archives; Military Balance 2006 and 2007.

**Table 2: UAV/UCAV produced or in development in EU countries**

The table list all known UAV and UCAV in production or development in all current 27 EU members.

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**National**

Country	Producer	Type	Name	Year	Comment
Austria	Siebel	TUAV	Camcopter		VTOL (helicopter) UAV.
Belgium	MBLE	TUAV	Epervier	1976	Last (Asmodée version) produced 1988; no longer in service.
Czech Rep.	Czech Air force	TUAV	Sojka	1995	Also marketed by AviaTronic (Hungary).
France	Sagem	TUAV	Crecerelle	1994	No longer in production; being replaced by Sperwer.
	Sagem	TUAV	Sperwer		Improved export version of Crecelle; named SDTI in France.
	Sagem	TUAV	Sperwer HV	-	High-speed UAV developed 2001 from Sperwer.
	Sagem	MALE	Sperwer LE	-	Developed 2001 from Sperwer.
	Sagem	mini	TMD-3	-	
	EADS/CAC	TUAV	Fox		Not acquired by France; only for export.
	EADS	MALE	Eagle-1	(2007)	Version of IAI (Israel) Heron UAV with EADS sensors.
	EADS	MALE	Eagle-2		Developed in cooperation with IAI (Israel) from Heron/Eagle-1; probably version of Heron-2 with EADS sensors.
	EADS/Dassault	MALE	EuroMale		Developed in cooperation with IAI (Israel) from IAI Heron.
	EADS/Guimbal	TUAV	Orka-1200		VTOL helicopter UAV based on G-2 Cabri light helicopter.
Germany	EADS	mini	Scorpio-30		VTOL UAV.
	EADS	micro	Scorpio-6		VTOL UAV.
	EMT	TUAV	LUNA	2000	Also named LUNA X-2000
	EMT	Micro	Aladin	(2004)	
	EMT	Micro	Mikado		
	EMT	Micro	Fancopter		VTOL Micro
	EMT	MALE	X-13		Being developed.
	EADS/R&S		Euro Hawk	(2009)	Version of NG (USA) Global Hawk with German SIGINT sensors.
	Diehl	MALE	RQ-1B		Plan for production of GA (USA) RQ-1B Predator in Germany if ordered by German armed forces.
	Rheinmetall	TUAV	KZO	2005	
Rheinmetall	TUAV	Tucan		Designed for export; status uncertain.	
Rheinmetall	UCAV	Taifun		UAV with secondary one-way attack drone; developed from KZO and further developed to TARES	
Rheinmetall	UCAV	TARES		UAV with secondary one-way attack role; being developed.	
Greece	Dornier (EADS)	TUAV	SEAMOS		VTOL UAV; development cancelled.
	HAI/KETA	TUAV	Pegasus	(2003)	
	HAI/KETA	TUAV	Pegasus-2	2005	Modification of Pegasus.
	HAI/Northrop	TUAV	TELAMON	-	Joint development with Northrop (USA); based on US Chickar-3 target drone; development cancelled.
	3 Sigma (EADS)	TUAV	Nearchos		
	3 Sigma (EADS)	TUAV	Iris		
3 Sigma (EADS)	TUAV	Alkyon			
3 Sigma (EADS)	TUAV	Perseas			

Italy	Meteor (Finmeccanica)	TUAV	Mirach-20		Developed from target drone.
	Meteor (Finmeccanica)	TUAV	Mirach-26		
	Meteor (Finmeccanica)	TUAV	Mirach-150		Developed from Mirach-100 target drone.
	Meteor (Finmeccanica)	TUAV	Nibbio		Developed from Mirach-150.
	Meteor (Finmeccanica)	MALE	Mirach-2000		Being developed.
	Galileo (Finmeccanica)	TUAV	Falco		
	Alenia (Finmeccanica)	MALE	Sky-Y		Technology demonstrator; first flown 2007; probably to be integrated in Dassault/Alenia/Saab MALE programme.
	Alenia (Finmeccanica)	HALE	Molynx		In development since 2006.
	Alenia (Finmeccanica)	MALE	Sky-X		Technology demonstrator for MALE/UCAV; also named SkyLynx; first flown 2005.
Netherlands	Private	Micro	Delfly		Technology demonstrator.
Sweden	Saab	TUAV	Skeldar V-150	(2007)	VTOL (helicopter) UAV.
UK	BAE	TUAV	Phoenix	(1995)	No longer in production.
	BAE	MALE	Herti-1A		Developed for military and civilian use; based on (Poland) powered glider airframe.
	BAE	UCAV			
	BAE	UCAV			

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#### Inter-EU

Countries	Producer	Type	Name	Year	Comment
Belgium?/ France/ Spain	Neuron	UCAV	Neuron		Tcehnology demonstrator development programme; Belgium may join.
France/ Germany		TUAV	CL-289	1992	Produced in cooperation with Canadair (Canada); UAV produced in Canada and Germany; sensors produced in France.
France/ Germany/ Spain	EADS	HALE	AUAV		In development.
France/ Italy	EADS	MALE	Surveyor		In development; fast UAV based on Meteor (Italy) Mirach-100 target drone; possibility to act as UCAV.
France/ Italy/ Sweden	Dassault Alenia (Finmeccanica) Saab	MALE	?		Development agreed 2007; based on Neuron.
Germany/ Spain	EADS	UCAV	Barracuda		Technology demonstrator development programme.

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'Type' is; 'Year' is the year when first in service – years in brackets are estimated or planned dates.  
Sources: SIPRI Arms Transfers database and archives.

**Table 3: UAV/UCAV exports from the EU**

The table list all known UAV and UCAV exports from all current 27 EU members to non-EU members.

Country	Supplier	Type	Name	No.	Year	Comment
Austria	Egypt	TUAV	Camcopter	2 sys.	(2002)	Reportedly ordered 2001; 2 systems with probably 4 UAVs; for use on frigates.
	UAE	TUAV	Camcopter	80	2006-	Delivery 2006-2008; including production of components in UAE.
	USA	TUAV	Camcopter			Reportedly ordered for US forces 2006; probably only for evaluation.
France	Indonesia	TUAV	Fox AT-1	4	2005	1 system with 4 UAV.
	Canada	TUAV	Sperwer	(11)		Used in Afghanistan; performance criticised by Canada but more ordered and delivered 2006.
Germany	Pakistan	TUAV	LUNA	(3)	(2007)	3-4 Luna ordered 2006.
Italy	Pakistan	TUAV	Falco	4	2006	

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Sources: SIPRI Arms Transfers database and archives.

**Table 4: Operational use of UAV by EU members**

The table list all known operational use in war zones of UAV and UCAV by all current 27 EU members.

Country	System	Year	Comment
Belgium	B-Hunter	2005	Used in Afghanistan
	B-Hunter	2006-07	Used in DRC (EUFOR mission)
France	CL-289	1999	Used in Kosovo war and aftermath
	Crecerelle	1999	Used in Kosovo war
	Hunter	1999	Probably used in Kosovo war and aftermath
	?	2007	Used in Lebanon (UNIFIL mission)
Germany	CL-289	1999	Used in Kosovo war and aftermath
	LUNA	(1999)	Prototype used in aftermath of Kosovo war
	Aladin	2004-07	Used in Afghanistan
	Luna	2005-07	Used in Afghanistan
Netherlands	Aladin	2006-07	Used in Afghanistan
	Sperwer	2006-07	Used in Afghanistan
UK	CL-89	1990-91	Used in Gulf War
	Phoenix	1999-01	Used in Kosovo war and aftermath
	Phoenix	2003-07	Used in Iraq war and aftermath
	RQ-1 Predator	(2006-07)	UK personnel involved in US Predator operations; possibly loaned by UK from USA.
	Buster	2005-07	Used in Afghanistan
	Raven	2006-07	Cooperation in use of US Raven in Iraq
	Desert Hawk	2006-07	Used in Afghanistan

Sources: SIPRI Arms Transfers database and archives.