Development of UAV Sensors and Information Management

by Steve Roberts

Steve Roberts' experience within the design and evaluation of electronic warfare (EW) systems now extends over a period of 30 years, and he is now Vice President, Capability and Chief Technical Officer (EW) in SELEX Galileo, while also serving as the Industry Co-Chair of the UK MoD's EW Tower of Excellence. In this article he looks at the requirement for sensors, sensor integration and information management, and at the challenges and solutions of integration in unmanned air platforms.

Periodically, a new type of military platform becomes the subject of discussion and debate in both the military and popular press. During the late 19th century, the Torpedo Boat appeared to give smaller nations the ability to challenge the supremacy of armoured battleships. The military response to the Torpedo Boat was the creation of a new class of Torpedo Boat Destroyers, with heavier armament, higher speed and greater endurance than the vessels they were designed to hunt. A similar pattern was seen in the development of aircraft. Initially used to provide reconnaissance for ground forces, they were then used to deliver bombs, which in turn led to the development of fighters and strategic bombers. The current topic of interest is the UAV (or UAS), of which many variants are now in service or development.

The pioneers in the use of UAV were the Israelis, who have been active for some 30 years with a variety of tactical UAV. The USA has developed strategic systems for surveillance and combat, with Global Hawk providing an operational surveillance capability and combat UCAV systems, such as X-45, that could enter service post-2020. Probably the most prominent US capability is General Atomics' Predator, and its weaponised version Reaper, which have seen extensive service in operations. The British Army operated Phoenix in the Balkans; it is being replaced by the Watchkeeper system, in a programme led by Thales. BAE Systems, with UK MoD support and working with other major UK defence companies including SELEX Galileo, have the Mantis programme, aimed at a medium-altitude, long-endurance system, and the Taranis UCAV technology demonstrator programme. In France, the main UAV activities have been as part of European collaborative programmes such as NEURON. In Italy there has been a range of developments ranging from Falco, from SELEX Galileo, to the larger Sky-X and Sky-Y, developed by Alenia. Germany has for a number of years had technology and demonstrator activities related to UAV and UCAV. A similar situation exists in Russia, where there is an enormous variety of UAV platform, mainly seen as prototypes.

Until now, almost all activity on UAV has been for defence applications. Civil applications of UAV need resolution of the issues of flying in controlled airspace (this also constrains more widespread take-up for some defence purposes) and significant programmes have been launched to address the issue of UAV operation in controlled airspace. Currently, the civilian UAV market depends heavily on solutions originally designed for military applications; these tend to be too expensive for the civilian market. This is expected to change once the demand for civilian UAV crosses some threshold, after which solutions will come from civil-orientated development, that are then adapted for military purposes. The parallels with the development of personal communications (e.g. mobile phones) are clear.

Sensor capabilities must deliver imaging and processing capability in complex environments

Mission Capability

From an operational point of view, the capability of UAV systems can be measured in relation to a range of factors, largely determined by the performance of the mission system, sensors and communications systems.

- **Effectiveness:** The capability of sensor and target identification sub-systems to detect and identify the designated mission target, combined with the capability of any associated weapon systems to deliver the required effect on the target. Effectiveness is the primary need of the user. The combat missions currently being conducted by UAV are proving to be effective, with sufficient endurance, interoperability and mission management to fulfil their aims.

- **Interoperability:** The capability to receive command and control data from operators and to provide tactical information and imagery to different users. These capabilities will define the level of coordination that can be achieved between the UAV and other participants in the mission. Clearly, the critical sub-system required to achieve interoperability is the communication sub-system.

- **Endurance:** The capability of the UAV platform to meet the requirements on range and duration of loiter in the mission area. The persistent surveillance capability of UAV addresses some of the limitations of satellites, manned aircraft and submarines.

- **Survivability:** The ability of the UAV platform to perform ingress, fly over the target area (including weapon release and guidance) and egress while being subjected to threats. Survivability may be provided by stealth, manoeuvrability or electronic sub-systems. The nature of most current missions means that survivability against threats is not being tested, although earlier missions indicated that UAV were vulnerable to air and ground attack.

- **Autonomy:** The ability of the UAV for sensing, perceiving, analysing, communicating, planning, decision-making and acting to achieve its goals without intervention by the operator. This concept is often discussed solely in terms of aspects of the air platform, such as take-off, landing and flight plans, while full autonomy would also require control of the sensors, weapons and mission management.

- **Mission Management:** The ability to execute the functions required for controlling, planning, allocating, deploying, coordinating and monitoring the resources participating in a mission. In particular, for the UAV, these tasks are distributed between the Control Station and the airborne Mission Computer, and therefore a key sub-system aspect to be considered is the communication between the ground and the air platform.

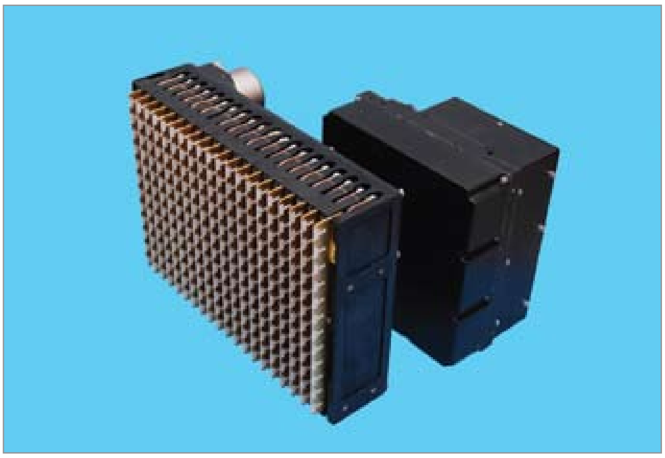
Integrated mission systems incorporating multiple sensors with sensor integration, including data fusion, have been implemented for customers

Mission Payloads

Sensor capabilities must deliver imaging and processing capability in complex environments. They must cope with ambiguity and provide cueing for other electronic sensors and effectors. They must provide forensic capability – identifying traces of activity for intelligence gathering – and extract intelligence value either in real-time or through post-mission analysis by supporting the operators, rather than providing a deluge of information and imagery.

Removing the aircrew from the air vehicle introduces the need to remotely control the air vehicle and its sensor systems. To improve military capability and reduce communication bandwidth requirements the UAV now requires a higher degree of flight autonomy, whereby some decision-making is made onboard the air vehicle. This approach is also relevant to the sensor systems on the UAV, where further work is needed to understand how best to split the mission task execution between the remote operator and the onboard systems. The issue of bandwidth constraint, coupled with the need for the system to develop its own ’situational awareness’ in order to fulfil autonomous distributed sensing, may increasingly result in the need for information exploitation on the platform in order to allow the down-linking of processed information rather than raw data. Linking current and next-generation EO, radar and SIGINT provides great potential for persistent surveillance operations requiring target detection and track maintenance. At a minimum, linking tracks generated by these dissimilar sensors on the same platform will increase the chances of detecting and then maintaining a track on a fleeting and mobile target.

Recent operations highlight the need for net-centric operations: that is, the ability to share information when it is needed, where it is needed, and with those who need it. In essence, net-centricity translates information superiority into effectiveness by effectively linking knowledgeable entities in the battlespace. Cross-sensor fusion technology will therefore also underpin the ability to build an integrated and distributed sensing capability across a number of UAV and land assets. There will therefore be a need to be able to build a system of systems from disparate elements provided by different suppliers and possibly operated by multiple users. This poses serious integration issues, which could be addressed by common solutions for ground station and information management systems, mandated data formats and protocols or through the development of commercial ‘Internet’ technologies to act as interfaces between systems.



The PicoSAR AESA radar provides an unrivalled all-weather capability for unmanned aerial systems, fixed-wing and helicopter platforms. Using many low power, solid state Transmit Receive Modules (TRM) within its array, it is more reliable than conventional radar systems [SELEX Galileo]

UNMANNED VEHICLES

Vixen 500E AESA Fire Control Radar is a compact, lightweight, AESA radar for aircraft. It has been designed to meet the full spectrum of fire control radar operational requirements, detecting, identifying, prioritising and engaging targets, whilst remaining resistant to radar countermeasures [SELEX Galileo]

Seaspray 7500E Multi-Mode Surveillance Radar combines a state-of-the-art AESA with a Commercial Off The Shelf (COTS) processor to deliver a leading-edge capability covering both air-to-surface and air-to-air environments [SELEX Galileo]

Primary Sensors

The primary sensors considered are those required to support ISTAR and Platform Survivability, i.e. Radar, EO and EW. The current generation of sensor fits are very much 'stand alone' and are loosely integrated within the overall avionics architecture; the trend is towards Integrated Sensing solutions which can offer performance and installation advantage. There is pressure to reduce sensor size, weight and power consumption whilst enhancing capability and performance to improve overall platform and system capabilities (range, persistence, weapon carriage). Physical integration, including the sharing of common elements such as processor hardware, power supplies up to and including aperture integration, is a realistic approach.

A common RF aperture supporting radar, EW and communications functionality will also be a feature of future sensor payloads. Traditional independent sensing solutions have both strengths and weaknesses (e.g. range, angular/spatial resolution etc.). By combining data at the point of measurement, the relative functional strength of each sensor attribute can be used to create a more robust, higher-performance sensor sub-system. This leads to an approach based on sharing of common algorithms, and application software and integration of sensor functions, e.g. tracking and identification.

SELEX Galileo has developed the PicoSTAR, a compact, fully integrated RF and EO sensor payload. Compact, multi-function, shared RF apertures are also being developed and demonstrated; they will deliver radar, electronic surveillance, electronic attack and communication functions. Groups of antennas are configured to cover the RF spectrum, with multiple antennas covering the required frequency and

PicoSTAR is designed to provide highly compact, lightweight integrated AESA radar and Electro-Optic (EO) capability for unmanned aerial systems and other small fixed or rotary-wing platforms [SELEX Galileo]

angle coverage. Transmit and receiver signal routing is performed by RF and IF switching matrix supporting sharing of resources and redundancy. A multi-channel RF processor constructed from a set of common RF modules provides the waveform generation and receive functions. Sensor apertures are potentially a significant contributor to the overall platform RCS. A total system design approach to signature management has been employed which considers the array, radome and Frequency Selective Surface (FSS) to achieve low platform RCS.

Integrated sensor sub-systems (with shared apertures, common processing and mission management) are being developed and successfully demonstrated

Sensor Integration

At a ground control station level, SELEX Galileo is also working to develop a new data fusion system, enhancing the net-centric exploitation of data collected by UAV sensors deployed in the battlespace.

SELEX Galileo has a long history of applied research and technology demonstration in the domain of sensor integration, with programmes such as Tandem, Sibling and the Integrated Sensor Demonstration, which demonstrated the benefit of EO and RF sensor integration. Working with its customers in the UK, Italy and the USA, the transition to fully integrated product has been taking place at an increasing pace. Integrated mission systems incorporating multiple sensors with sensor integration, including data fusion, have been implemented for customers including the US Coast Guard, for their C130 upgrade, and the US Border Patrol Cessna Citation; these brought together radar, EO turret, AIS and digital map with a modern man-machine interface. Sensor integration is a key element of the highly regarded ATOS Mission system which supports intelligent sensor management and sensor fusion for a broad range of applications. The fixed-wing examples noted above also have direct relevance to sensor and information management for UAV, since development and proving of capability can be conducted on manned platforms prior to use on UAV.

Summary

UAV are a vital component of current military operations. The capability is provided by the information collected by sensors on the UAV. Despite this, less emphasis is being given to the development of sensors and information management than is being given to the development of platform airframe, autonomous control and flight safety. Integrated sensor sub-systems (with shared apertures, common processing and mission management) are being developed and successfully demonstrated, but exploitation routes on to UAV platforms appear to be limited, possibly due to the view that the most commonly employed full-motion video sensors are commodity items.

But the sensors, information management and concepts of operation do not need to be developed and tested on UAV

Opportunities to develop and demonstrate enhanced sensor capability are perceived to be limited by lack of availability of UAV assets, due to restrictions on use in controlled airspace. But the sensors, information management and concepts of operation do not need to be developed and tested on UAV. Developing and demonstrating sensor capability, in particular, can be undertaken using other manned platforms as 'surrogate UAV' that provide users with the information that would be obtained from UAV platforms in operational situations. This is cost-effective and would maximise the value of investment in capability, since cost-effective provision of sensor capability for a UAV is equally applicable to other air platforms. ■