# 1 Military Roles



## 1.1 Introduction

The military were quick to seize upon the opportunities offered to them by an ability to leave the ground and gain an advantage of height. The initial attempts to make use of this advantage were by using tethered balloons as observation posts, and then as positions from which to direct artillery. The advent of a moving and powered platform allowed guns and, later, bombs to be carried, which led to air war between aircraft, and upon ground troops. Thus, fairly early in the history of the aircraft the main military roles of observation, interception and ground attack had been firmly established. These initial roles increased in sophistication and led to the development of more capable aircraft weapons, aircrew and tactics.

Today the military are called upon to perform a wide variety of aviation roles using fixed-wing and rotary-wing aircraft. The roles largely define the type of aircraft because of the specialist nature of the task; however, there are a number of aircraft types that have been designed as multirole aircraft, or designed to change roles during the prosecution of a mission, the so-called swing-role type.

The military roles that are in place today have emerged over many years of aerial combat experience. The long development timescales of the complex military aircraft have resulted in many types remaining in service long after their original introduction. Consequently, aircraft have adopted new roles as a result of role-fit weapons or mid-life updates. Many of the roles, particularly the intelligence gathering roles, have persisted after combat into the post-war stabilisation period and peacekeeping operations.

The flexibility of weapons and methods of carrying weapons and the adaptability of sensors and avionic systems are what enables this situation to persist. Although many of the 'traditional' roles still exist, there are signs that the changing nature of conflict may lead to new roles or alternative solutions.

To a large extent these new roles and alternative solutions are being driven by advances in the technology of sensors and avionics. Ever more sensitive and effective sensor systems are capable of detecting targets, the use of stealth techniques increases the effectiveness of delivery platforms and the increased capability of on-board computing systems is extending

*Military Avionics Systems* I. Moir and A. Seabridge

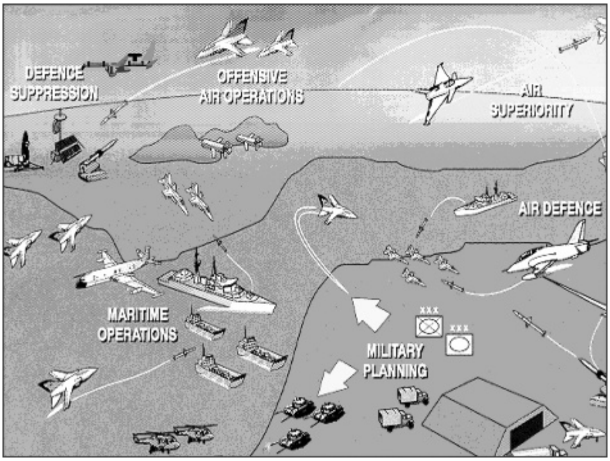


**Figure 1.1** Typical battlefield scenario and the major players.

and speeding up the processing of data. The existence of these advances in the hands of enemies spurs on further development.

This chapter will describe the roles that are required in the military defence environment. Some examples of avionic architectures will be described, along with examples of the types of aircraft in service today that perform the various roles. Other chapters in this book will deal with the detail of a number of military avionic systems.

## 1.2 Air Superiority

### *1.2.1 Role Description*

The primary aim of this role is to deny to an enemy the airspace over the battlefield, thus allowing ground attack aircraft a free rein in destroying ground targets and assisting ground forces, secure in the knowledge that the airborne threat has been suppressed.

The air superiority aircraft is typically designed to enable the pilot to respond rapidly to a deployment call, climb to intercept or loiter on combat air patrol (CAP) and then to engage enemy targets, preferably beyond visual range. The aircraft should also have the capability to engage in close combat, or dogfight, with other aircraft should this prove to be necessary. For this to be successful, an extremely agile machine is necessary with 'carefree handling' capability.

The systems must allow for accurate navigation, accurate identification of targets, prioritisation of targets, accurate weapon aiming capability and the ability to join the tactical communications network.

A typical mission profile is shown in Figure 1.2.

### *1.2.2 Key Performance Characteristics*

The air superiority aircraft is usually a highly manoeuvrable aircraft with a high Mach number capability and rapid climb rate. Many fighters are equipped with afterburning to allow Mach 2 capability, a power to weight ratio greater than 1, allowing acceleration in a climb, and the ability to climb to beyond 60 000 ft. Some types are designed to operate from

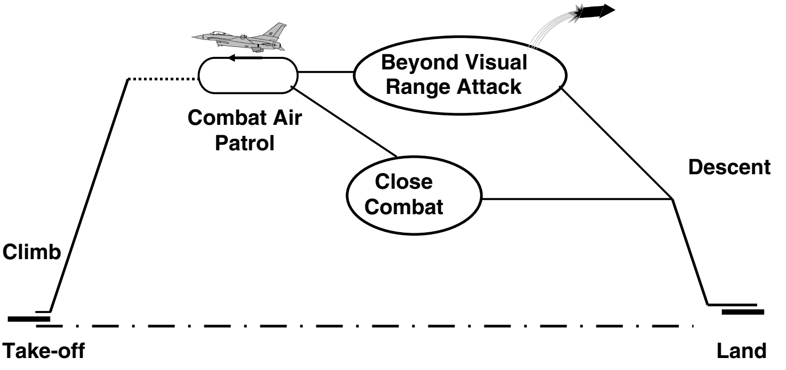


**Figure 1.2** Air superiority mission profile.

carriers and will be equipped for catapult launch and for steep approaches and arrestor wire decelerations.

Many modern fighters are unstable and have full authority flight control systems that are designed to allow the pilot to execute manoeuvres to envelope limits without fear of losing control or damaging the aircraft. This is known as 'carefree handling' capability.

### 1.2.3 Crew Complement

Usually single pilot, but some types employ a pilot and a rear-seat air electronics officer or navigator depending on the role. Trainers or conversion aircraft will have two seats for instructor and student.

### 1.2.4 Systems Architecture

A typical air superiority platform architecture is shown in Figure 1.3. Typical air superiority systems are listed in Table 1.1.

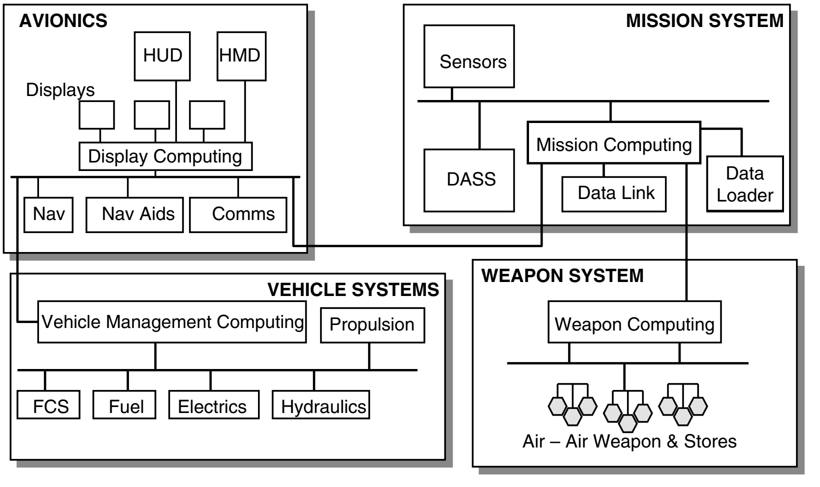


**Figure 1.3** Typical air superiority platform architecture.

**Table 1.1** Typical air superiority systems

| Avionics | Communications | Mission system | Weapons |
|---|---|---|---|
| | VHF | Radar | Air-to-air missile – ASRAAM, AMRAAM |
| Navigation/GPS | UHF | | |
| FMS | HF | ESM | Internal gun |
| Autopilot | SHF SatCom | DASS | |
| ADF | Link 16 | | |
| DME | | | |
| TACAN | | Mission computer | |
| TCAS | | Data loader | |
| Landing aids | | | |
| GPWS | | | |
| LPI RadAlt | | | |
| Air data | | | |
| Digital map | | | |
| MDP | | | |
| Displays and controls | | | |
| Head-Up-display | | | |
| Helmet-mounted display | | | |
| IFF/SSR | | | |
| Avionics data bus | | Mission system data bus | Weapons bus |


**Figure 1.4** Air superiority aircraft types.

### 1.2.5 Air Superiority – Aircraft Types

The various types of air superiority aircraft are as follows (Figure 1.4):

- McDonnell Douglas F-4 Phantom;
- English Electric Lightning;
- Eurofighter Typhoon;
- Panavia Tornado F-3;
- Dassault Rafale;
- Dassault Mirage 2000;
- SAAB Gripen;
- F-15;
- F-16;
- F-18;
- Mig-21 Fishbed;
- Mig-23 Flogger;
- F-117.

## 1.3 Ground Attack

### 1.3.1 Role Description

The ground attack role has been developed to assist the tactical situation on the battlefield. The pilot must be able to identify the right target among the ground clutter and multiplicity of targets and friendly units on the battlefield. The ability to designate targets by laser has enabled precision bombing to be adopted by the use of laser-guided bombs or 'smart' bombs. The role must enable fixed targets such as buildings, radar installations and missile sites, as well as mobile targets such as tanks, guns, convoys, ships and troop formations, to be detected, positively identified and engaged.

This role includes close air support (CAS), where support is given to ground forces, often under their direction, where weapons will be deployed in close proximity to friendly forces.

### 1.3.2 Key Performance Characteristics

Depending on the target and the on-going military situation, the ground attack role may be performed by either fixed-wing or rotary-wing aircraft. A fixed-wing aircraft usually needs very fast, low-level performance with good ride qualities. It should also be reasonably agile to perform attack manoeuvres and take evasive action. Rotary-wing aircraft benefit from extreme low-level nap of the earth penetration, and the ability to loiter in natural ground cover – popping up when required to deliver a weapon.

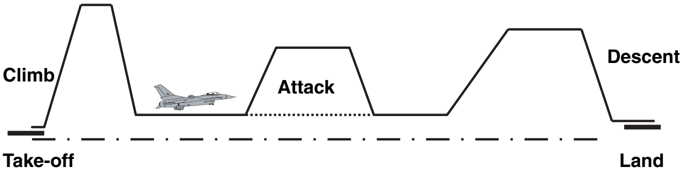


**Figure 1.5** Ground attack mission profile.

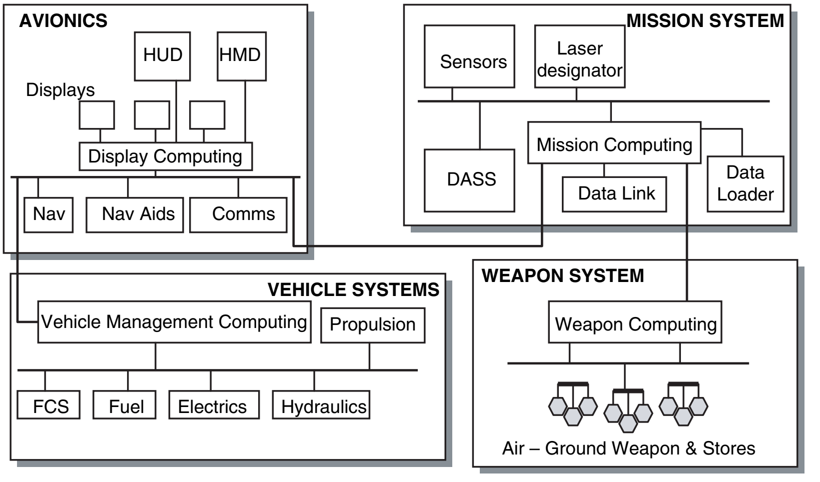


**Figure 1.6** Typical ground attack platform architecture.

### *1.3.3 Crew Complement*

This role is usually conducted by two crew members, a pilot and a crew member to operate the sensors and weapons systems. The advent of smart weapons or cooperative target designation means that the mission can be conducted by a single crew, often a role designated to a fighter aircraft as a secondary role.

### *1.3.4 Systems Architecture*

A typical ground attack platform architecture is shown in Figure 1.6. Typical ground attack systems are listed in Table 1.2.

### *1.3.5 Ground Attack – Aircraft Types*

The various types of ground attack aircraft are as follows (Figure 1.7):

- Sepecat Jaguar;
- Panavia Tornado GR4;
- Fairchild A-10 Thunderbolt;
- Apache;
- Sukhoi Su-24 Fencer.

## 1.4 Strategic Bomber

### *1.4.1 Role Description*

The role of the strategic bomber is to penetrate deep into enemy territory and to carry out strikes that will weaken defences and undermine the morale of the troops. The strategic

**Table 1.2** Typical ground attack systems

| Avionics | Communications | Mission system | Weapons |
|---|---|---|---|
| | VHF | Radar | Air-to-ground missiles |
| Navigation/GPS | UHF | Electrooptics | |
| FMS | HF | ESM | Free-fall bombs |
| Autopilot | SHF SatCom | DASS | Laser-guided bombs |
| ADF | Link 16 | Laser designator | Airfield denial |
| DME | | | Internal gun |
| TACAN | | Mission recording | gun pod |
| TCAS | | Data loader | Rockets |
| Landing aids | | Cameras | |
| GPWS | | | |
| LPI RadAlt | | | |
| Air data | | | |
| Digital map | | | |
| MDP | | | |
| Displays and controls | | | |
| Head-Up display | | | |
| Helmet-mounted display | | | |
| IFF/SSR | | | |
| Avionics data bus | | Mission system data bus | Weapons bus |

bomber was usually a very high-flying aircraft capable of carrying a large load of bombs which were released in a 'carpet bombing' pattern. The modern aircraft may choose to fly low and fast and rely on stealth to evade enemy radar defences. Different weapons may also be employed such as Cruise missiles and joint direct attack munition (JDAM).

**Lockheed F-16 (Lockheed Martin)**

**A-10 (US Department of Defence)**

**Harrier GR7 (BAE SYSTEMS)**

**Figure 1.7** Ground attack aircraft types.

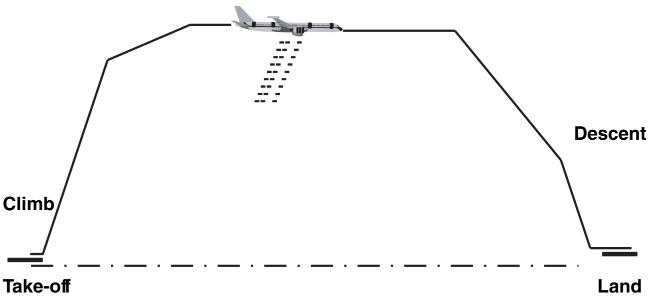


**Figure 1.8** Strategic bomber mission profile.

### *1.4.2 Key Performance Characteristics*

Strategic bomber aircraft attributes include high altitude cruise, long range and high payload capacity.

### *1.4.3 Crew Complement*

The crew includes pilots, a navigator, an engineer and specialist mission crew. For very long missions a relief crew may be provided.

### *1.4.4 Systems Architecture*

A typical strategic bomber platform architecture is shown in Figure 1.9. Typical strategic bomber systems are listed in Table 1.3.

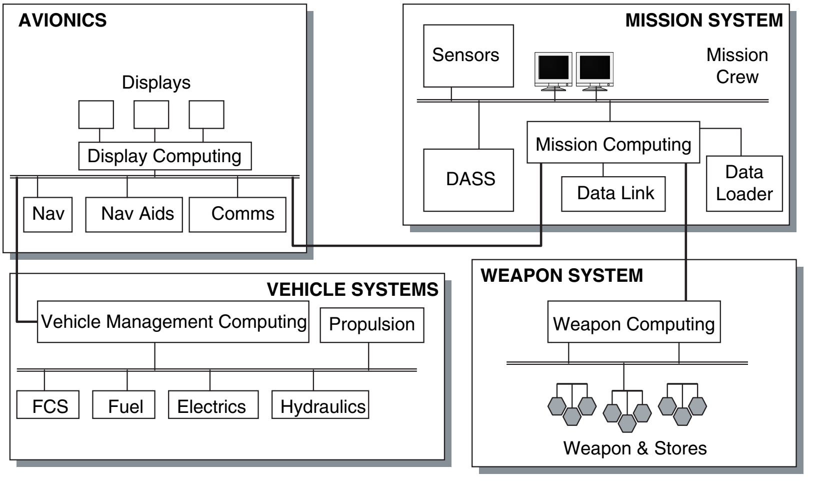


**Figure 1.9** Typical strategic bomber platform architecture.

**Table 1.3** Typical strategic bomber systems

| Avionics | Communications | Mission system | Weapons |
|---|---|---|---|
| | VHF | Radar | Air-to-ground missiles |
| Navigation/GPS | UHF | Electrooptics | Free-fall bombs |
| FMS | HF | ESM | Laser-guided bombs |
| Autopilot | SHF SatCom | DASS | Airfield denial |
| ADF | Link 16 | MAD | Cruise missiles |
| DME | | | |
| TACAN | | Mission recording | |
| TCAS | | Data loader | |
| Landing aids | | Cameras | |
| GPWS | | | |
| LPI RadAlt | | | |
| Air data | | | |
| Digital map | | | |
| MDP | | | |
| Displays and Controls | | | |
| IFF/SSR | | | |
| Avionics data bus | | Mission system data bus | Weapons bus |

### *1.4.5 Strategic Bomber – Aircraft Types*

The various types of strategic bomber aircraft are as follows (Figure 1.10):

- Boeing B-52;
- AVRO Vulcan;

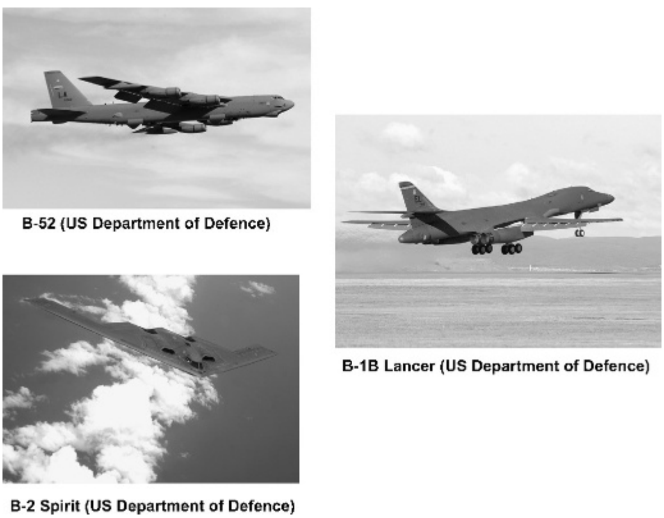


**Figure 1.10** Strategic bomber aircraft types.

- Northrop B-2;
- Tupolev Tu-22M Backfire;
- Tupolev TU-160 Blackjack;
- General Dynamics F-111.

## 1.5 Maritime Patrol

Over 60% of the earth's surface is covered by oceans – a natural resource that is exploited by many means: as a medium for transportation of cargo, as a source of food, as a means of deploying naval assets such as capital ships and submarines and for movement of men and materiel. It is also used for pleasure and for criminal purposes such as the smuggling of drugs, liquor, tobacco and illegal aliens. It is not surprising, therefore, that surveillance of the ocean's surface is of importance to military and paramilitary forces.

The most practical way of carrying out surveillance or reconnaissance is by air, and the flexibility of the fixed-wing aircraft with its comparatively high speed, long range and excellent detection capability from high altitude made it an excellent complement to surface vessels in carrying out naval or policing duties.

Over 90 years of development have led to the emergence of the maritime patrol aircraft (MPA) as one of the most complex of systems aircraft with a demanding role embracing a broad spectrum of tactical and strategic tasks, as well as support for civilian and humanitarian activities.

The general MPA specification that has evolved calls for the ability to transit at high speed to a distant patrol area of interest, and then to remain in that area for a long time, carrying out searches for surface, subsurface or both types of activity. Operational requirements typically ask for an ability to fly over 800 miles to an area, remain on task for over 7 h, return to base and have sufficient fuel remaining to carry out a bad weather diversion. To perform such a task requires an aircraft weighing up to 100 t, a crew of 12 or more and a suite of electronic sensors and communication systems.

### *1.5.1 Role Description*

The typical tasks that an MPA is called upon to perform include:

*Anti-surface unit warfare (ASuW)*
- Reconnaissance;
- Shadowing;
- Strike against surface vessels;
- Tactical support of maritime strike aircraft;
- Over-the-horizon targeting for friendly vessels;
- Intelligence collection;
- Communications relay;
- Limited airborne early warning capability.

*Anti-submarine warfare (ASW)*
- Close air support to task forces and convoys;
- Open ocean searches;
- Extended tracking of submerged targets;

- Deterrence of hostile submarines;
- Cooperation with friendly submarines;
- Intelligence collection.

*Search and rescue (SAR)*
- Location of survivors;
- Dropping of survival equipment;
- Scene-of-action commander for rescue operations;
- Escort to rescue helicopters;
- Cooperation with rescue services;
- Escort of aircraft in difficulties.

*Exclusive economic zone protection*
- Oil rig surveillance;
- Fishery protection;
- Pollution detection and dispersal.

*Customs and excise cooperation*
- Anti-illegal immigration;
- Anti-gun running;
- Anti-terrorist operations;
- Anti-drug smuggling.

### 1.5.2 Anti-surface Unit Warfare (ASuW) Role

MPAs take part in all aspects of the war at sea. In the role of anti-surface unit warfare, the MPA may carry out autonomous strikes against surface targets using free-fall bombs or stand-off weapons. Alternatively, it may be used to search, identify and shadow surface forces, remaining in contact but out of range of a surface ship's weapons for long periods of time. This can be performed overtly using the integral radar of the MPA to detect, classify and track targets, or covertly using passive electronic support measure systems to detect the ship's radars while remaining outside the ship's maximum radar detection range.

Frequently it is necessary to shadow naval forces for days using a number of MPAs, each handing over the task to a relief aircraft at the end of its endurance on task. If there is then a requirement for specialist strike aircraft to carry out attacks against the ships under surveillance, then a cooperative attack is planned. The MPA can guide the attacking force accurately to suitable attack positions using its own radar, while the attacking aircraft can approach covertly under any defensive radar screen, only being detected by the air defence radar of the target at very short range. During the attack the MPA can carry out jamming of radar and communications to distract the surface ship's defensive tactics.

The MPA can also use similar tactics to cooperate with attack helicopters, or to provide over-the-horizon targeting for surface missiles launched from friendly naval ships.

### 1.5.3 Anti-submarine Warfare (ASW) Role

Traditionally, submarines have waged strategic warfare by effectively blockading enemy countries, preventing military supplies, reinforcements and essential food and medical supplies from arriving by sea. The counter to the submarine campaigns was to regulate shipping by organising it into strictly disciplined convoys and concentrating naval forces to protect the convoys. However, as submarines became more effective and became organised into ‘wolf packs’, the escort ships found themselves outperformed and sometimes outnumbered.

Furthermore, as detection ranges from improved sensors increased, surface ships did not have the speed necessary to exploit the detections and to supply a secure cordon around the enemy.

The use of the aircraft in general reconnaissance of the sea surface was a natural evolution of its role in war. However, it was not until significant performance improvements in sensors, weapons, aircraft range and endurance and communications that the MPA could play its full part in integrated close support of surface forces.

The MPA can often put itself at risk of friendly fire when joining a force. An unexpected aircraft contact in the war situation of jammed communications and strict emission control policies is often seen as a potential threat. As a result, complex joining procedures are adopted before closing within range of the defensive missile engagement zone of a friendly force.

While on task, the tactics of the MPA are likely to involve searching at low altitude using a constant radar policy to force down submarines that may have closed the force and are attempting to get periscope ranging for an attack solution. The maritime radar is optimised to detect small contacts against a backgound of reflections or ‘clutter’ from the sea. Although the submarine will prefer to operate submerged, there are situations in which it must expose itself above the surface. For example, there are surface-to-surface anti-ship missiles that may require the submarine to surface partially in order to fire the missile, providing opportunities for detection by the MPA radar, leading to engagement by mines, torpedo or anti-ship missile.

Sonobuoys are also used to create barriers across a perceived threat axis, allowing the MPA to listen to noises that are characteristic of different submarine types. The experienced acoustic operator can distinguish between different types and between different operating states, and can detect noises from a submarine at rest on the sea bottom. Electronic support measures are used to detect the slightest transmission from an extended communications mast, and the maritime radar can detect a fleeting extension of a communications mast or a diesel air inlet mast. A contact is confirmed by overflying the contact and using the magnetic anomaly detector to distinguish a metallic mass from a shoal of fish or other natural phenomena.

The MPA crew work closely together with their individual sensors, while the tactical commander uses fused sensor data to view the whole surface picture. The MPA works closely with other assets to detect, locate, track and prosecute an attack over many days or weeks of continuous operation. Search patterns similar to those described in the next section are routinely used to conduct an efficient open ocean search.

### *1.5.4 Search and Rescue (SAR) Role*

Search and rescue is the public and humanitarian aspect of military maritime patrol. The extension of the lifeboat service has grown from the original requirement for the military to provide a rescue capability for military aircrew who are forced to make emergency landings in the sea. The task fell to maritime patrol aircraft, rather than a specialist aircraft, for economic reasons, particularly in peacetime when the number of available aircraft is low. The requirements for an effective SAR aircraft have much in common with a maritime patrol aircraft and include:

- Long range and endurance;
- High transit speed and long loiter time;
- All-weather operations capability;
- Precise navigation system;
- Comprehensive communications;
- Extensive sensor suite;
- Good visual platform;
- Large crew complement;
- Displays for tactical control for scene-of-action command;
- Ability to carry large quantities of air-dropped survival equipment.

A military base may keep at least one aircraft and crew on SAR standby 24 h a day, 365 days of the year. The aircraft is normally capable of taking to the air in response to a call for assistance within 2 h. As soon as the SAR aircraft is airborne, a new aircraft and crew are readied to provide cover for any subsequent calls for help.

#### *1.5.4.1 Datum Searches*

Where the distressed person or vessel has been able to pass a message to an emergency service, it is likely that a reasonably accurate datum is available and a number of datum search patterns can be used. Some example patterns are shown in Figure 1.11.

If a very accurate position is obtained and the searching aircraft is able to arrive on the scene quickly after the incident, it is possible that the cloverleaf search pattern can be used. This is often the case when military aircrew are forced to eject from their aircraft which

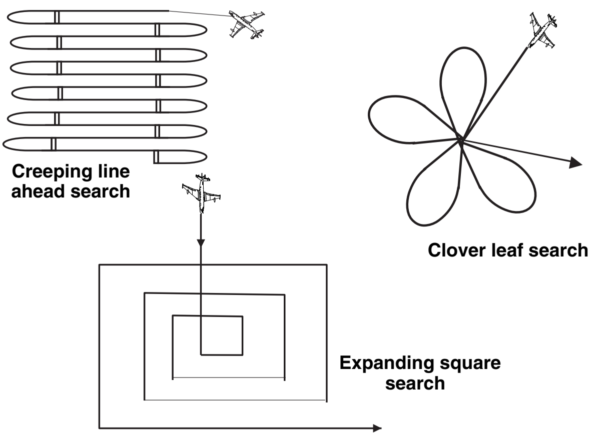


**Figure 1.11** Search pattern examples.

has been tracked by a surveillance radar. The fact that the SAR aircraft has arrived shortly after the ejection means that the survivors will not have drifted far from the last known position.

However, if the SAR aircraft is delayed and the position of the datum is not so accurately defined, then there will be a need for the MPA to search out to a greater range. A more suitable search pattern would be the expanding square search, covering an area calculated by the SAR crew to enclose any inaccuracies in position or drift as a result of prevailing weather conditions. If the survivors are equipped with a personal locator beacon (PLB), then the aircraft will use its direction finding (DF) and homing systems to fly straight to the survivor's position.

#### *1.5.4.2 Area Searches*

It often happens that notification of an incident is received hours or even days after its occurrence. This usually happens when an aircraft or ship fails to make its scheduled position report. In these circumstances the SAR aircraft is likely to have to search a very large area for survivors or wreckage. Frequently the MPA would be one of a number of cooperating aircraft, helicopters, lifeboats, naval vessels and surface ships involved in the search. The procedure used for organisation, command and control are well tried and tested, and subject to international agreement and standardisation. Specific SAR radio frequencies are available, as are call signs and communication procedures that allow effective integration of civilian and military resources.

The tactics employed by an MPA to search a very large area depend on all the factors described above. If the incident involves a missing military aircraft, the MPA will normally make a number of medium- to high-altitude passes over the area allocated for search. This is firstly to establish a shipping density using radar, and secondly to determine whether any survivors are using PLBs. In the event that no PLB signals are received, the MPA will descend to an altitude suitable for visual and radar search. The type of search will frequently be creeping line ahead (CLA), with track spacing determined by the calculation $1.5 \times$ estimated visibility. Where the track spacing is very short, in poor visibility, for example, the MPA will have difficulty in maintaining the integrity of the search because of the tight turning circles at the end of each loop. A modified creeping line ahead pattern can be used to compensate for this.

#### *1.5.4.3 Scene-of-Action Commander*

One aspect of the SAR operation where a modern MPA excels is as a scene-of-action commander (SAC). A typical example of this was the Piper Alpha oil platform disaster in the North Sea. A serious explosion and fire occurred and rescue forces were mobilised. There was no shortage of ships and helicopters to carry out rescue work, but, owing to poor visibility, burning oil on the sea surface and poor communications, there was a distinct danger of the rescue craft hampering or colliding with each other. A Nimrod MR2 from RAF Kinloss was directed to the scene and was able to establish firm control of all rescue forces using radar to deconflict the various helicopters, direct firefighting ships and keep the rescue control centre fully informed of developments. Each ship and helicopter was electronically tagged and displayed on the tactical display, while the area around the rig was divided into small search boxes and allocated to specific ships or helicopters.

### 1.5.5 Exclusive Economic Zone Protection

#### 1.5.5.1 Oil and Gas Rig Patrols

Many countries have a requirement to police their territorial waters, particularly those declared to be an economic exclusion zone (EEZ) and containing vital national resources such as oil, natural gas and fishing grounds. This task requires regular patrols over large areas of coastal waters by specialist aircraft cooperating with surface vessels to ensure the security of oil and gas installations which may be potential targets for terrorist action.

#### 1.5.5.2 Anti-pollution

There is a requirement for early detection of pollution of the sea, whether by accidental discharge from ships or installations, or by illegal washing of tanks and bilges by merchant vessels. This is an ideal task for aerial surveillance with specially designed sideways looking radar (SLAR) and electrooptical devices using ultraviolet (UV) and infrared (IR) techniques to detect and measure the density and area of oil slicks at sea.

#### 1.5.5.3 Fishery Protection

Fishing represents an increasingly important element of national economies, and there has been a growing tendency for fishing fleets to ignore international agreements for control and licensing of fishing within territorial waters. If a nation is to protect its own fishing rights, it must be capable of demonstrating a capability of detecting and apprehending any vessels fishing illegally within its EEZ. To achieve the very large-scale surveillance task effectively and in an acceptable timeframe dictates the use of an aircraft. There are obvious difficulties if an illegal fishing vessel detected by a fixed-wing aircraft needs to be arrested and brought before a court of law.

Current tactics involve very close cooperation between aircraft and surface vessels, with the aircraft locating the offender, and the ships performing the arrest. However, there is often a delay of some hours before the surface ship can transit to the offender's position, who will no doubt have got rid of any evidence of illegal fishing and possible even have sailed out of the area. It is, therefore, incumbent on the EEZ patrol aircraft to obtain sufficient evidence to allow a reliable case to be brought before an international court, if the offender escapes immediate arrest.

To have a good chance of winning a case in court, the aircraft must catch the offender in the act and obtain high-quality photography of the time and position at which each offence took place. The film needs to have a superimposed image of latitude, longitude, date and time to be used as secure evidence.

#### 1.5.5.4 Customs and Excise Cooperation

Customs and excise operations are usually inshore, and a large military MPA may not be best suited to this kind of role. An alternative is a small twin-turboprop aircraft fitted with a minimum sensor set operating from a civilian airfield by a police or customs crew. This type of aircraft would not normally be armed, its role being surveillance and recording. However, the long-range aircraft will be called upon if a target vessel needs to be tracked over the high seas.

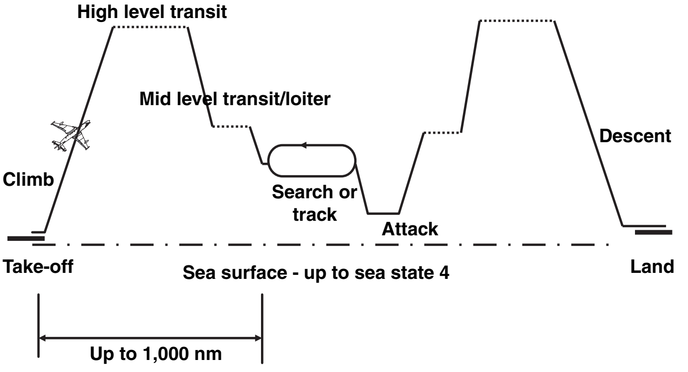


**Figure 1.12** Maritime patrol aircraft mission profile.

### *1.5.6 Key Performance Characteristics*

The key performance characteristics are:

- Long endurance;
- Long range.

### *1.5.7 Crew Complement*

The flight deck crew consists of two pilots who may alternate the roles of flying pilot and second officer throughout a long-duration mission in order to maintain vigilance. Some types may carry an engineer who will operate the general systems and usually acts as a monitor for height. On types expected to perform very long-duration missions, for example, with air-to-air refuelling this may be in excess of 20 h, a supernumerary pilot may be carried.

The mission crew will be sized to operate the sensors and conduct the tactical mission. Crew sizes for a long-range maritime patrol and anti-submarine aircraft may exceed 10.

### *1.5.8 Systems Architecture*

A typical maritime patrol aircraft platform architecture is shown in Figure 1.13. Typical MPA systems are listed in Table 1.4.

### *1.5.9 MPA Aircraft Types*

The various types of MPA aircraft are as follows (Figure 1.14):

- Shackleton;
- BAE SYSTEMS Nimrod MR2;
- BAE SYSTEMS MRA4;

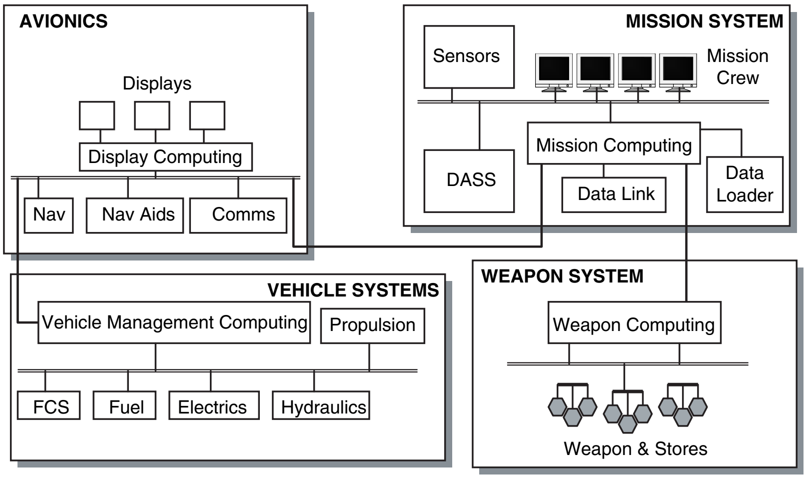


**Figure 1.13** Typical maritime patrol aircraft platform architecture.

- Lockheed P-3C;
- Lockheed S-3 Viking;
- Dassault Atlantic;
- Tupolev Tu-20;
- Westland Sea King.

**Table 1.4** Typical MPA systems

| Avionics | Communications | Mission system | Weapons |
|---|---|---|---|
| | VHF | Maritime radar | Anti-ship missiles |
| Navigation/GPS | UHF | Electrooptics turret | Torpedos |
| FMS | HF | ESM | Free-fall bombs |
| Autopilot | SHF SatCom | DASS | ASR kit |
| ADF | Link 16 | MAD | Flares |
| DME | Link 11 | Acoustic system | Smoke markers |
| TACAN | Marine band | Mission recording | Sonobuoys |
| TCAS | Shortwave | Data loader | Mines |
| Landing aids | | Cameras | |
| GPWS | | Oceanographic database | |
| LPI RadAlt | | Mission computing | |
| Air data | | Mission crew workstations | |
| Digital map | | Intelligence databases | |
| Homing | | | |
| Direction finding | | | |
| MDP | | | |
| Displays and controls | | | |
| IFF/SSR | | | |
| Avionics data bus | | Mission system data bus | Weapons bus |

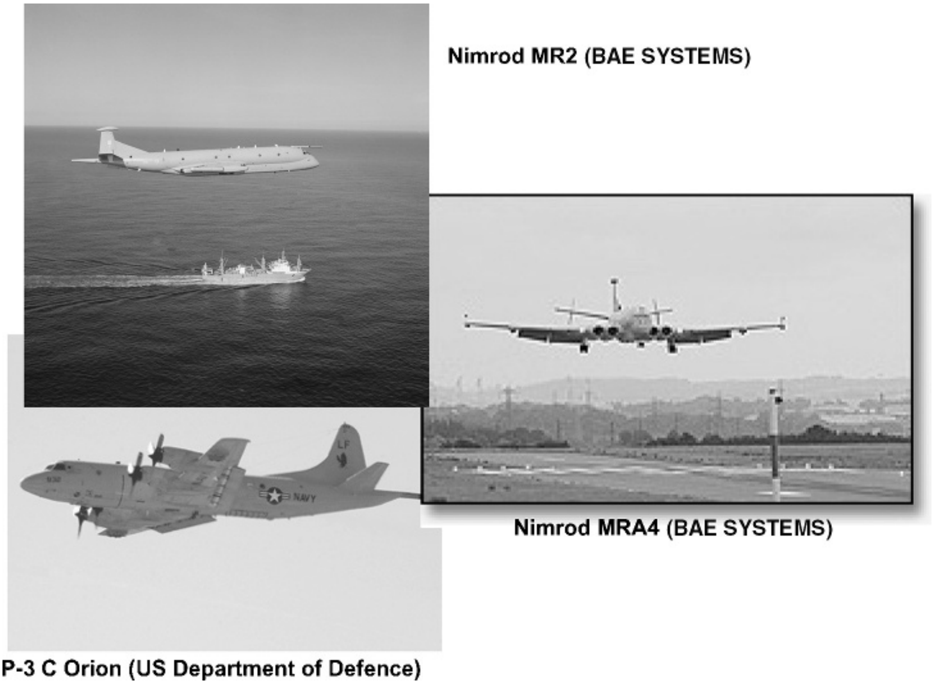


**Figure 1.14** Maritime patrol aircraft types.

## 1.6 Battlefield Surveillance

Detailed knowledge of the tactical scenario on the battlefield is of importance to military commanders and planners who need real-time intelligence of enemy and friendly force disposition, size and movement. Many commercial aircraft types have been converted to perform this role to complement specifically designed military types. The aircraft are equipped with a radar located on the upper or lower surface of the airframe that is designed to look obliquely at the ground. The aircraft flies a fixed pattern at a distance outside the range of enemy defences and detects fixed and moving contacts. These contacts are confirmed by using intelligence from other sensors or from remote intelligence databases to build up a picture of the battlefield and the disposition of enemy and friendly forces. The mission crew operate as a team to build up a surface picture, and can operate as an airborne command centre to direct operations such as air or ground strikes.

### *1.6.1 Role Description*

A battlefield surveillance mission profile is shown in Figure 1.15.

### *1.6.2 Key Performance Characteristics*

The key performance characteristics are high altitude, long range and a stable platform often based on a commercial airliner airframe.

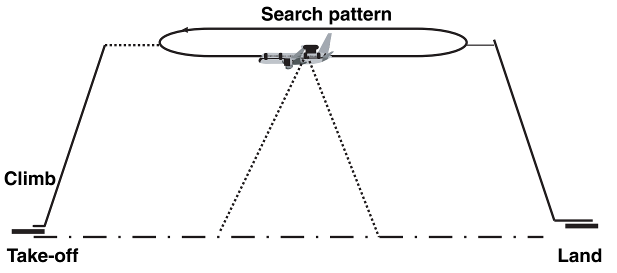


**Figure 1.15** Battlefield surveillance mission profile.

### 1.6.3 Crew Complement

The flight deck crew consists of two pilots who may alternate the roles of flying pilot and second officer throughout a long-duration mission in order to maintain vigilance. Some types may carry an engineer who will operate the general systems and usually acts as a monitor for height. On types expected to perform very long-duration missions, for example, with air-to-air refuelling this may be in excess of 20 h, a supernumerary pilot may be carried.

The mission crew will be sized to operate the sensors and conduct the tactical mission. Crew sizes for a long-range, long-duration mission may exceed 10.

### 1.6.4 Systems Architecture

A typical battlefield surveillance platform architecture is shown in Figure 1.16. Typical battlefield surveillance systems are listed in Table 1.5.

### 1.6.5 Battlefield Surveillance Aircraft Types

The various types of battlefield surveillance aircraft are shown in Figure 1.17.

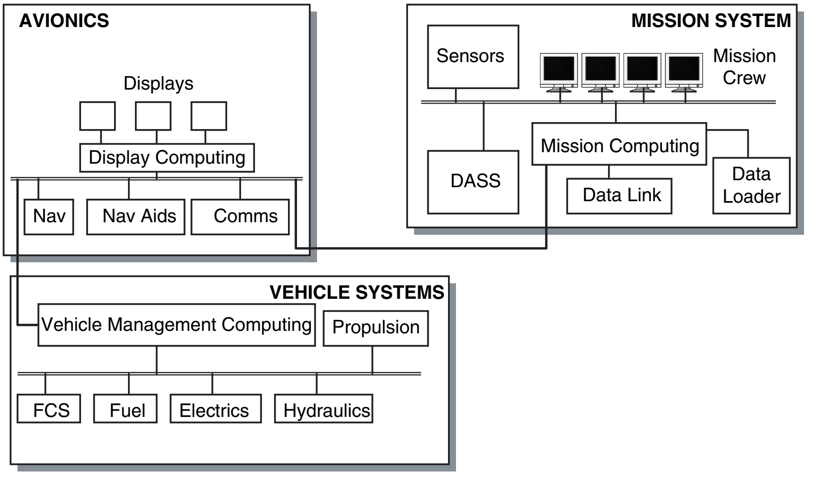


**Figure 1.16** Typical battlefield surveillance platform architecture.

**Table 1.5** Typical battlefield surveillance systems

| Avionics | Communications | Mission system | Weapons |
|---|---|---|---|
| | VHF | Radar | |
| Navigation/GPS | UHF | Electrooptics | |
| FMS | HF | ESM | |
| Autopilot | SHF SatCom | DASS | |
| ADF | Link 16 | Moving target indicator | |
| DME | | | |
| TACAN | | Mission recording | |
| TCAS | | Data loader | |
| Landing aids | | Cameras | |
| GPWS | | Mission computer | |
| LPI RadAlt | | Mission crew workstations | |
| Air data | | Intelligence databases | |
| Digital map | | | |
| MDP | | | |
| Displays and controls | | | |
| IFF/SSR | | | |
| Avionics data bus | | Mission system data bus | |

## 1.7 Airborne Early Warning

### *1.7.1 Role Description*

Early detection and warning of airborne attack is important to give air superiority and defensive forces sufficient time to prepare a sound defence. It is also important to alert ground and naval forces of impending attack to allow for suitable defence, evasion or countermeasures action.

E-8 JSTARS (US Department of Defence)

ASTOR (Raytheon)

**Figure 1.17** Battlefield surveillance aircraft types.

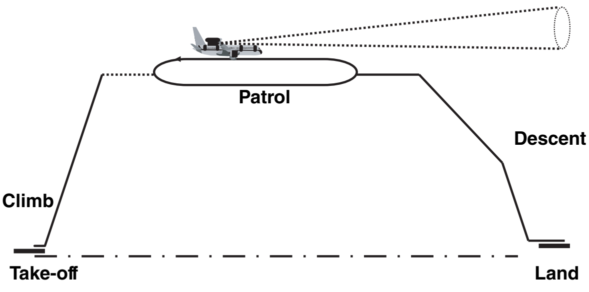


**Figure 1.18** Airborne early warning mission profile.

Operating from high altitude gives the airborne early warning (AEW) aircraft an advantage of detecting hostile aircraft at longer range than surface radar, which gives vital seconds for ground defence forces.

### 1.7.2 Key Performance Characteristics

A long-range, long-endurance aircraft enables a patrol pattern to be set up to cover a widesector area from which attack is most likely. A radar with a 360° scan, and a capability to look down and look up, provides detection of incoming low-level and high-altitude attack. The radar will usually be integrated with an interrogator to enable friendly aircraft to be positively identified. The aircraft will also act as an airborne command post, controlling all airborne movements in the tactical area, compiling intelligence and providing near real-time displays of the tactical situation to both local forces and remote headquarters.

### 1.7.3 Crew Complement

The flight deck crew consists of two pilots who may alternate the roles of flying pilot and second officer throughout a long-duration mission in order to maintain vigilance. Somevtypes may carry an engineer who will operate the general systems and usually acts as a monitor for height. On types expected to perform very long-duration missions, for example, with air-to-air refuelling this may be in excess of 20 h, a supernumerary pilot may be carried.

The mission crew will be sized to operate the sensors and conduct the tactical mission. Crew sizes for a long-range, long-duration mission may exceed 10.

### 1.7.4 Systems Architecture

A typical airborne early warning platform architecture is shown in Figure 1.19. Typical AEW systems are listed in Table 1.6.

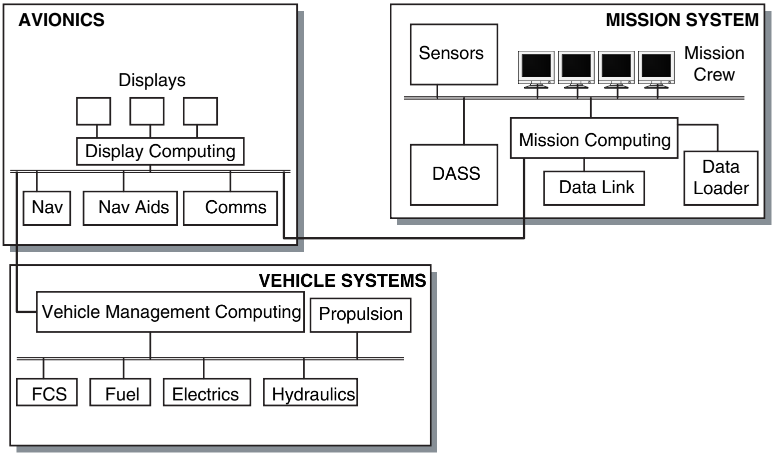


**Figure 1.19** Typical airborne early warning platform architecture.

### *1.7.5 AEW Aircraft Types*

The various types of AEW aircraft are as follows (Figure 1.20):

- Grumman E-2 Hawkeye;
- Boeing E-3 Sentry;
- Lockheed P-3 AEW;
- Tupolev Tu-126 AEW;
- Westland Sea King.

**Table 1.6** Typical AEW systems

| Avionics | Communications | Mission system | Weapons |
|---|---|---|---|
| | VHF | AEW radar | |
| Navigation/GPS | UHF | | |
| FMS | HF | ESM | |
| Autopilot | SHF SatCom | DASS | |
| ADF | Link 16 | | |
| DME | | | |
| TACAN | | Mission recording | |
| TCAS | | Data loader | |
| Landing aids | | Mission computer | |
| GPWS | | Mission crew workstations | |
| LPI RadAlt | | Intelligence databases | |
| Air data | | | |
| Digital map | | | |
| MDP | | | |
| Displays and controls | | | |
| IFF/SSR | | | |
| Avionics data bus | | Mission system data bus | |

E-3 Sentry (US Department of Defence)

P-3 AEW (Lockheed Martin)

**Figure 1.20** Airborne early warning aircraft types.

## 1.8 Electronic Warfare

### *1.8.1 Role Description*

Electronic warfare (EW) refers to a number of related subjects across a wide spectrum of activities:

- Electronic countermeasures (ECM);
- Electronic support measures (ESM);
- Signals intelligence (SIGINT);
- Electronic counter-countermeasures (ECCM).

### *1.8.2 Electronic Countermeasures*

Electronic countermeasures or jamming are a commonly used form of electronic warfare used to disrupt communications or defence radars. In noise jamming, radio frequency at the same frequency as a target emitter/receiver is modulated and transmitted at the target. Depending on the transmitted power level, it is capable of denying range information to the target or degrading communications to an unacceptable level. As the jamming power increases, or the range between the jammer and the receiver reduces, the jamming can become sufficiently strong to break down the directional properties of the target antenna. In this case both range and directional information can be denied.

Deception jamming is a more subtle form of countermeasure, where the intention is to confuse the enemy as to the correct bearing, range and number of targets. It has major implications in the countering of weapon guidance systems, where the technique of range gate or velocity gate stealing can be particularly effective.

Chaff is a passive ECM application, in which the transmitter energy of a threat radar is reflected to create false targets. Chaff can be used in a distraction sense by dispensing small discrete bundles to create an impression of specific small targets to confuse a radar or seduce a missile guidance system. Large clouds of chaff can be dispensed in a confusion sense completely to obscure one's own position.

Jamming is a key tactical role on the battlefield and is often carried out by fast jets equipped with jamming equipment. These aircraft are known in the United States as Wild Weasel squadrons.

### 1.8.3 Electronic Support Measures

Electronic support measures (ESM) comprise the division of electronic warfare involving actions taken to intercept, locate, record and analyse radiated electromagnetic energy for the purpose of gaining tactical advantage. An important advantage of ESM when used as a sensor is that they are completely passive. They also provide the potential for detecting enemy radars at much greater ranges than the detection ranges of these radars. Signals of ESM interest are usually radar systems. However, they can also include communications, guidance or navigational emissions in the radio-frequency spectrum, as well as laser emissions and infrared radiation in the electrooptics field.

Electronic intelligence information is required for both short- and medium-term planning and also for immediate tactical use in support of offensive and defensive EW operations. ESM are primarily used to support activities such as:

1. Threat warning – the short-term or tactical activity of ESM concerned with detecting transmissions that pose a physical threat. A typical example is the use of radar warning receivers (RWR) to provide an indication of impending attack by fighter or surface-to-air missiles.
2. Target acquisition – the presence of radar systems can indicate the existence of a target, or can assist in the identification of a radar-defended target. An example of this is a maritime patrol aircraft detecting and classifying surface ships by ESM.
3. Homing – an attack radar homing passively onto land or naval base radar-defended targets.

### 1.8.4 Signals Intelligence (SIGINT)

Signals intelligence consists of a number of different but related activities that are usually complementary in their employment and results. SIGINT is acknowledged as being used by most military forces and governments. Security surrounds its exact operational deployment and the degree of capability available to governments. SIGINT consists of three major activities:

1. Communications intelligence (COMINT) which is achieved by the interception of communication signals of all types – telegraphy, voice or data – and obtaining intelligence on a prospective enemy's intentions, capabilities and military preparedness. Frequently, the text of messages is enciphered and cannot be read immediately. However, there is still a great deal of intelligence to be derived from signals traffic analysis and direction finding which can provide both tactical and strategic advantages. Patterns of communication can be used to identify the state of readiness and location of participants.

Sudden communication activity may indicate battle readiness or changes of plan. Silence can indicate departure of forces from an area, or deliberate radio silence prior to an attack. A database of such communications activity is useful in establishing a potential enemy's radio discipline and movements. Selective or broad band jamming can be deployed to restrict useful communications.

2. Radar intelligence (RADINT) which uses standard or special-purpose radar systems to obtain intelligence on an enemy's capabilities, deployments and intentions. These radar systems may be space, air, sea or land based. RADINT is collected by an electronic support measures (ESM) system employing a number of sensitive antennas that are able to detect radar signals in different bands. As well as detecting the signal, the ESM also establishes a precise direction of arrival of the signal. Analysis of the signal characteristics such as frequency, pulse duration, amplitude and the spacing of main power lobes and side lobes will identify a particular type of radar. Continued collection of analysed data mapped onto the types of platform carrying different radar systems enables an experienced EW operator to identify a particular ship, aircraft or land-based system type. There are claims that experienced operators can even identify an individual platform by its radar transmitter characteristics. A successfully managed EW campaign can identify radar types and their exact locations for subsequent database update or for selective jamming. This technique is known as 'fingerprinting' and it requires some very clever waveform analysis equipment.
3. ELINT Electronic Intelligence involves the interception and analysis of non-communication radio-frequency signals, usually radar, to obtain many aspects of a nation's intentions and capabilities such as technological progress, military preparedness, orders of battle, military competence, intentions etc.

### 1.8.5 Key Performance Characteristics

For high-altitude, long-duration intelligence gathering, a high-altitude stable platform is required. For cooperative 'Wild Weasel' support, a fast, low-level aircraft is required.

### 1.8.6 Crew Complement

The flight deck crew consists of two pilots who may alternate the roles of flying pilot and second officer throughout a long-duration mission in order to maintain vigilance. Some

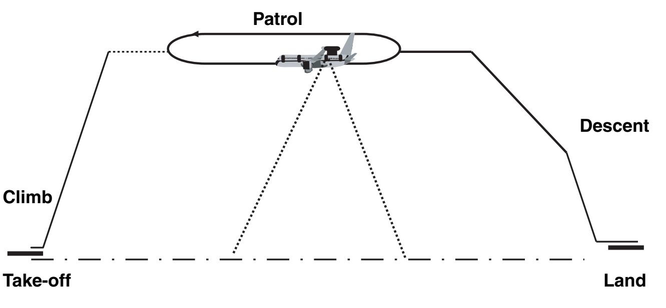


**Figure 1.21** Electronic warfare mission profile.

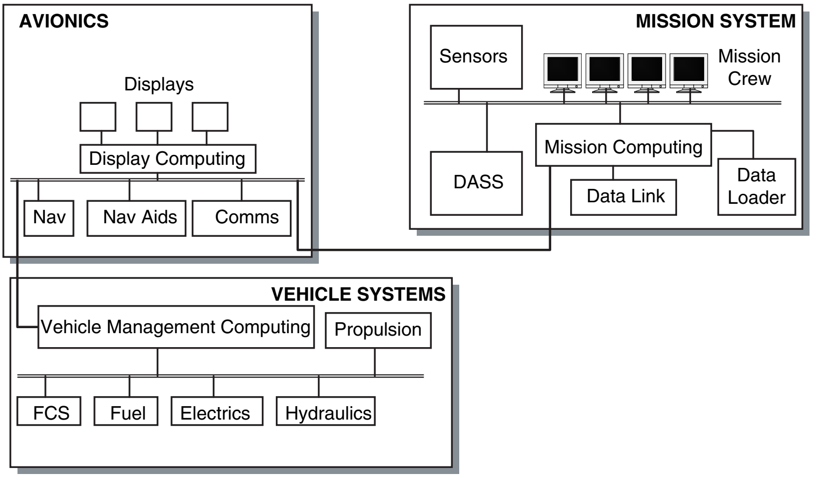


**Figure 1.22** Typical electronic warfare platform architecture.

types may carry an engineer who will operate the general systems and usually acts as a monitor for height. On types expected to perform very long-duration missions, for example, with air-to-air refuelling this may be in excess of 20 h, a supernumerary pilot may be carried.

The mission crew will be sized to operate the sensors and conduct the tactical mission. Crew sizes for a long-range, long-duration mission may exceed 10. A typical wild weasel aircraft will have a one- or two-person crew.

### 1.8.7 Systems Architecture

A typical electronic warfare platform architecture is shown in Figure 1.22. Typical EW systems are listed in Table 1.7.

### 1.8.8 Example Aircraft Types

Various types of electronic warfare aircraft are shown in Figure 1.23.

## 1.9 Photographic Reconnaissance

### 1.9.1 Role Description

Photographic imagery (IMINT) can be used to confirm SIGINT intelligence by providing a high-resolution permanent image using ground-mapping cameras. Such images can be analysed by specialists and used to confirm the types identified by SIGINT. The images may provide further intelligence by providing numbers, groups and battalion identification marks, as well as the deployment of troops.

Although often obtained from satellite imaging systems, IMINT can also be collected by high- and low-altitude fixed-wing aircraft overflying the battlespace in wartime, or by

**Table 1.7** Typical EW systems

| Avionics | Communications | Mission system | Weapons |
|---|---|---|---|
| | VHF | Maritime radar | |
| Navigation/GPS | UHF | Electrooptics turret | |
| FMS | HF | ESM | |
| Autopilot | SHF SatCom | DASS | |
| ADF | Link 16 | Active jamming | |
| DME | | | |
| TACAN | | Mission recording | |
| TCAS | | Data loader | |
| Landing aids | | Mission computer | |
| GPWS | | Mission crew workstations | |
| LPI RadAlt | | Intelligence databases | |
| Air data | | | |
| Digital map | | | |
| Displays and controls | | | |
| IFF/SSR | | | |
| Avionics data bus | | Mission system data bus | |

overflying territory in peacetime. This activity is risky, leading to loss of aircraft from missile attack, or leading to diplomatic incidents. An example of this is the loss of the US U-2 aircraft in 1960 by surface-to-air missile over the Soviet Union, and over Cuba in 1962.

Cameras mounted in the fuselage or in a pod provide forward, rearward, downward and oblique looking views. Oblique cameras provide the opportunity to film territory without the need to conduct direct overflights – a necessity to prevent diplomatic incidents. The mission computer determines the best rate of height and speed to optimise the film frame rate and varies lens aperture to match light conditions. High-speed focal plane shutters reduce the

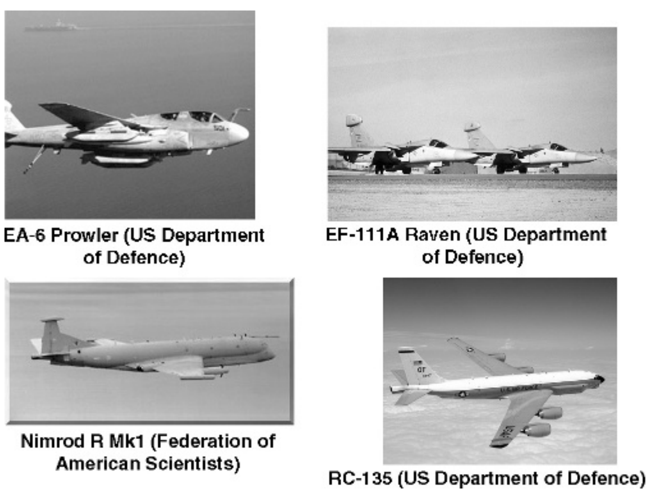


**Figure 1.23** Electronic warfare aircraft types.

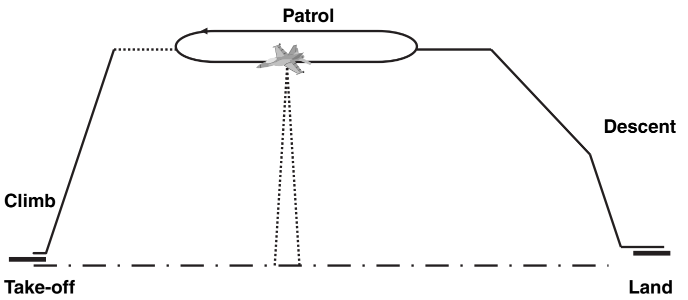


**Figure 1.24** Photographic reconnaissance mission profile.

effect of vibration. A window in the airframe or pod is heated to prevent icing or condensation. Wet-film and digital cameras are often complemented by sideways looking synthetic aperture radar and infrared cameras. The reconnaissance pod fitted to Jaguar contained both wet-film and IR cameras, and the Tornado Raptor pod provides real-time high-resolution images from its CCD camera.

Low-altitude, high-speed passes over terrain by fast jets using cameras installed in underwing pods can obtain tactical information at very short notice, and this can be used in conjunction with gun and head-up display (HUD) cameras to provide an instant battlefield picture and confirmation of inflicted damage.

### 1.9.2 Key Performance Characteristics

Often a very high-altitude aircraft to allow enemy territory overflights beyond radar detection and missile engagement range. To enable large areas of terrain to be covered, extremely high speed is an advantage. To obtain pictures of battlefield damage, low-level high-speed flights may be used.

### 1.9.3 Crew Complement

Usually a single crew, although aircraft carrying out long-duration precision mapping type photography may carry camera operators and film processors.

### 1.9.4 Systems Architecture

A typical photographic reconnaissance platform architecture is shown in Figure 1.25. Typical photographic reconnaissance systems are listed in Table 1.8.

### 1.9.5 Typical Aircraft Types

Typical photographic reconnaissance aircraft types are as follows (Figure 1.26):

- Lockheed U2;
- Lockheed SR71 Blackbird;

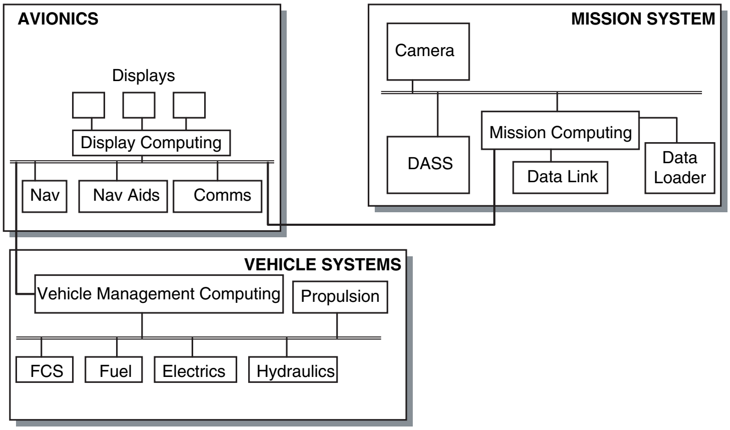


**Figure 1.25** Typical photographic reconnaissance platform architecture.

- Canberra PR9;
- Jaguar GR1;
- Tornado GR4.

## 1.10 Air-to-Air Refuelling

### *1.10.1 Role Description*

Military aircraft of nearly all types find it necessary to extend their range or endurance. This may be the result of the global nature of conflict which is giving rise to long-range missions

**Table 1.8** Typical photo reconnaissance systems

| Avionics | Communications | Mission system | Weapons |
|---|---|---|---|
| | VHF | High-resolution cameras | |
| Navigation/GPS | UHF | Film storage | |
| FMS | HF | Film processing | |
| Autopilot | SHF SatCom | Infrared cameras | |
| ADF | Link 16 | Optional FLIR | |
| DME | | Optional SAR | |
| TACAN | | | |
| TCAS | | | |
| Landing aids | | | |
| GPWS | | | |
| Air data | | | |
| Digital map | | | |
| MDP | | | |
| Displays and controls | | | |
| IFF/SSR | | | |
| Avionics data bus | | | |


**Figure 1.26** Photographic reconnaissance aircraft types.

or long ferry flights over large oceanic distances, such as the United Kingdom to Falklands flights. This is especially true for large military aircraft which may be sent to an area to establish a presence or force projection as a diplomatic move. If there are no intermediate airfields available, or no airfields readily accessible in friendly nations, then air-to-air refuelling becomes a necessity.

Air superiority aircraft or aircraft on combat air patrol are better refuelled close to their CAP, rather than returning to base to refuel. Not only are time and fuel saved, but so is the need constantly to send replacement aircraft to ensure a continuous presence on patrol.

Incidentally, aircraft companies have extended the duration of their test missions by the use of air-to-air refuelling, extending test flights from a nominal 1 h to up to 8 h.

Most tankers in operation today are conversions of well established commercial aircraft types such as the Boeing 707, Lockheed L1011 Tristar and the BAE SYSTEMS (Vickers) VC10. Military types have also been used, such as the Boeing C-17 and the Handley Page Victor.

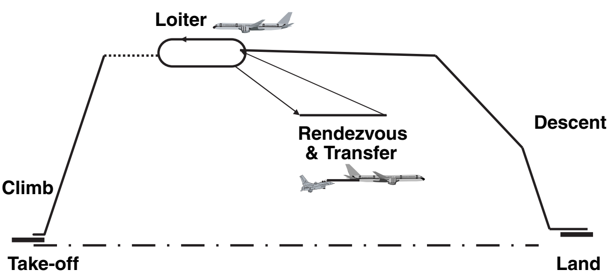


**Figure 1.27** Air-to-air tanker mission profile.

There are two types of refuelling method in widespread use:

1. The probe and drogue method is widely used by most air forces. The tanker aircraft deploys and trails one or more hoses, each with a ‘basket’ at the end. The receiving aircraft homes on to the tanker, extends its refuelling probe and engages the probe tip in the basket. When positive contact is made, refuelling commences, the aircraft matching their speed – a tricky manoeuvre with the tanker becoming lighter and the receiver heavier as fuel is transferred. It is possible to refuel up to three receivers simultaneously.
2. Most US Air Force tanker aircraft are fitted with a boom that is deployed from the tanker. The receiver aircraft homes on to the tanker and flies close. The tanker boom operator engages the boom tip into a receptacle on the aircraft.

### *1.10.2 Key Performance Characteristics*

Long range, capable of carrying a large fuel load and the ability to fly a stable refuelling pattern. Often a converted commercial airliner equipped with additional fuel tanks and loading equipment.

### *1.10.3 Crew Complement*

Flight deck crew and boom operators.

### *1.10.4 Systems Architecture*

A typical air-to-air tanker platform architecture is shown in Figure 1.28. Typical tanker systems are listed in Table 1.9.

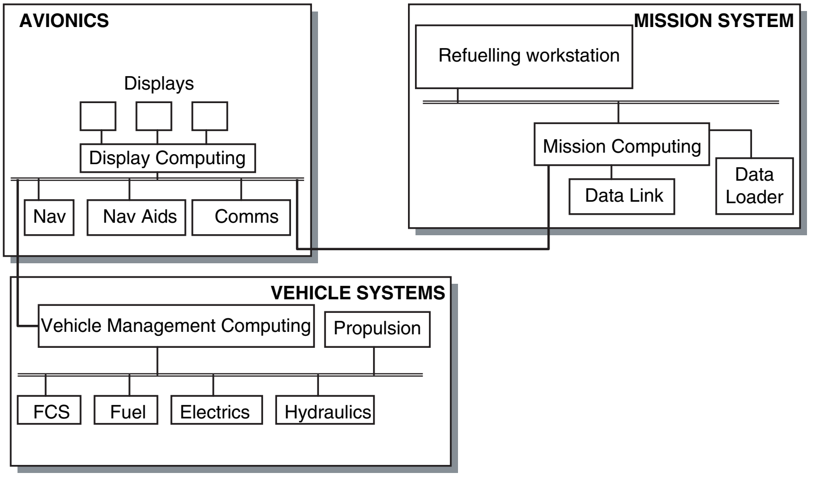


**Figure 1.28** Typical air-to-air tanker platform architecture.

**Table 1.9** Typical tanker systems

| Avionics | Communications | Mission system | Weapons |
|---|---|---|---|
| | VHF | Radar | |
| Navigation/GPS | UHF | | |
| FMS | HF | ESM | |
| Autopilot | SHF SatCom | DASS | |
| ADF | Link 16 | | |
| DME | | | |
| TACAN | | Mission recording | |
| TCAS | | Data loader | |
| Landing aids | | | |
| GPWS | | Refuelling equipment | |
| LPI RadAlt | | | |
| Air data | | | |
| Digital map | | | |
| MDP | | | |
| Displays and controls | | | |
| IFF/SSR | | | |
| Avionics data bus | | Mission system data bus | |

### *1.10.5 Aircraft Types*

The various types of air-to-air tanker aircraft are as follows (Figure 1.29):

- KC 135;
- KC-10 (DC-10 militarised version);
- Lockheed L-1011 Tristar;
- VC10.

VC-10 (BAE SYSTEMS)

KC-135 (US Department of Defence)

**Figure 1.29** Air-to-air tanker aircraft types.

## 1.11 Troop/Materiel Transport

### *1.11.1 Role Description*

The global nature of conflict and peacekeeping operations demands the movement of troops and materiel to remote theatres of operation. While the bulk of the task is performed by marine vessels, rapid deployment in order to establish a military position requires fast aerial transport. This is often seen by the military as force projection – the ability to establish a rapid presence in times of tension.

Troops can be carried with their personal arms and equipment by fixed-wing or rotary-wing aircraft, disembarking from a landed platform or by parachute. Stores, ammunition and light vehicles can be carried by the same types and either unloaded on the ground or dropped on pallets during a low-speed, very low-height transit. They may also be dropped by parachute if the terrain or the defences do not permit a low-speed pass.

Larger and heavier items of equipment such as artillery, trucks, personnel carriers or helicopters are unloaded from large short take-off and landing (STOL) transport aircraft.

Transport aircraft are used to assist in evacuations from battlefields and also to assist in humanitarian operations by carrying foodstuffs and relief supplies, as well as evacuating refugees.

### *1.11.2 Key Performance Characteristics*

A large volume of cargo-carrying space with secure stowage and a rapid deployment ramp is required, combined with the ability to lift heavy loads from short poorly prepared strips. Long-range transit with air-to-air refuelling if necessary. Good accurate navigation and the ability to operate with mobile landing aids into new designated landing areas. The ability to operate in poor weather conditions and from ill-prepared airstrips.

### *1.11.3 Crew Complement*

Flight deck crew of pilots and flight engineer, with crew to provide loading, unloading and paratroop deployment services.

### *1.11.4 Systems Architecture*

A typical troop/material transport platform architecture is shown in Figure 1.31. Typical transport systems are listed in Table 1.10.

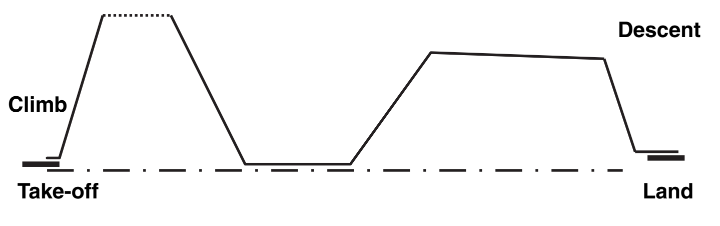


**Figure 1.30** Troop/materiel transport mission profile.

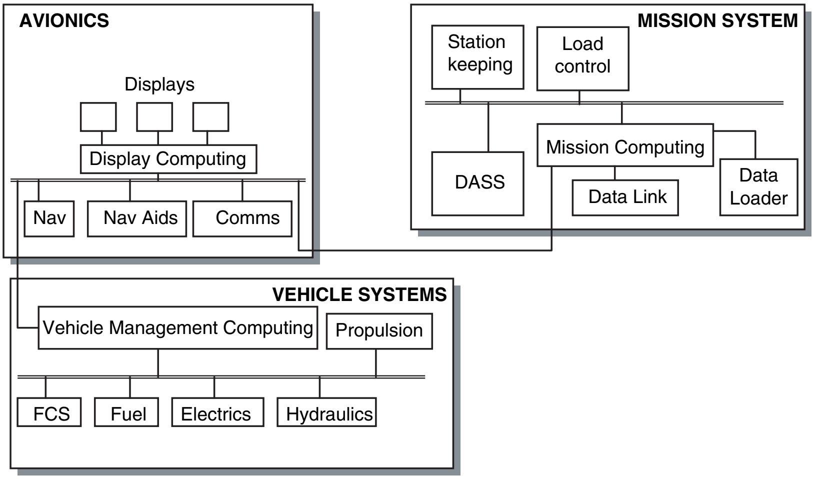


**Figure 1.31** Typical troop/materiel transport platform architecture.

### *1.11.5 Typical Aircraft Types*

Typical types of troop/materiel transport aircraft are as follows (Figure 1.32):

- Lockheed C-130;
- Boeing C-17;
- Lockheed C-5 Galaxy;
- Antonov An-124 Condor;

**Table 1.10** Typical transport systems

| Avionics | Communications | Mission system | Weapons |
|---|---|---|---|
| | VHF | Radar | |
| Navigation/GPS | UHF | Electrooptics turret | |
| FMS | HF | ESM | |
| Autopilot | SHF SatCom | DASS | |
| ADF | Link 16 | | |
| DME | | | |
| TACAN | | | |
| TCAS | | Data loader | |
| Landing aids | | | |
| GPWS | | Station keeping | |
| LPI RadAlt | | Materiel deployment | |
| Air data | | Paratroop deployment | |
| Digital map | | | |
| MDP | | | |
| Displays and controls | | | |
| IFF/SSR | | | |
| Avionics data bus | | | |

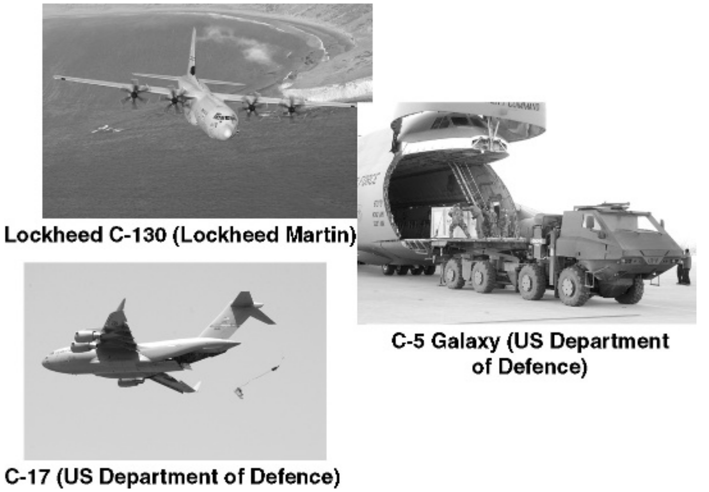


**Figure 1.32** Troop/materiel transport aircraft types.

- Transall C-16;
- Fiat G-222;
- Chinook;
- Puma;

## 1.12 Unmanned Air Vehicles

Many aircraft have evolved to perform the roles described in the previous paragraphs, with ever-increasing performance and sophistication. Aircraft, sensors and systems have become more capable, as have the crews who perform the flying and sensor management tasks. This has led to the situation where the cost of an individual aircraft is very high – tens or even hundreds of millions of dollars per copy, and the value of the crew in terms of training time and experience is also very high. A need to operate over the battlefield without risking human life or expensive assets has led to the development of unmanned aircraft.

Unmanned air vehicles [or uninhabited aerial vehicles (UAVs)] have been used for some time as pilotless target drones. Often these were obsolete aircraft converted for use as an aerial target. Aircraft such as Meteor, Sea Vixen and Canberrra have been used in the United Kingdom and F4 Phantom in the United States. Special-purpose drones were constructed using aircraft parts or designed specifically for the task. Most UAVs today are designed specifically to fulfil a particular role. Without the need to carry a crew, the vehicle can be relatively small and simple, hence reducing cost. The reduced mass also leads to vehicles that can operate for very long duration and at high altitudes. There are examples of UAVs that can operate for over 50 h continuously at altitudes in excess of 70 000 ft.

Some UAVs are small, and careful low-observability design makes them extremely difficult to detect on radar.

An ideal role for the unmanned air vehicle is aerial observation and intelligence gathering. Optical sensors using infrared or TV are used to transmit information to a relay for visual image intelligence (IMINT) to record enemy asset deployment or bomb damage assessment, while antennas are used to obtain communications intelligence (COMINT) or signals intelligence (SIGINT). Some UAVs carry wetfilm cameras, the film being processed on return to base.

Some simple UAVs are used as decoys to entice defence radars to illuminate them as targets. This enables a force to test the alertness of the defensive screen, and also positively to identify the radar type, and hence defence weapon, in order to deploy suitable countermeasures.

All UAVs require a ground station for operators and mission planners, with associated data links for control and data communication. The human factor elements of the traditional cockpit design must be incorporated into the ground station control panels.

Some UAVs can operate autonomously for large portions of a mission without ground station intervention. It is anticipated, as technology evolves, that many of the roles and missions described in the previous paragraphs will be subsumed by role-specific UAVs. Current-generation cruise missiles are an example of a capable UAV, although they are expendable.

Some examples of UAVs are listed in Table 1.11 and shown in Figure 1.33. Unmanned combat air vehicles (UCAVs) are now emerging that are capable of carrying out offensive operations. This covers the delivery of air-launched weapons to attack ground targets, or a capability of engaging fighter aircraft and launching air-to-air missiles.

**Table 1.11** Examples of unmanned air vehicles

| Type | Manufacturer | Country of origin | Typical use |
|---|---|---|---|
| Jindivik | | Australia | Target drone |
| Firebee | Teledyne Ryan | USA | Reconnaissance |
| Phoenix | BAE SYSTEMS | UK | Battlefield surveillance |
| Pioneer | Israeli Aircraft Industries | Israel | |
| Predator | General Atomics | USA | Surveillance, COMINT |
| Mirach 26 | Meteor | Italy | |
| Seeker | Kentron | South Africa | |
| Banshee | Flight Refuelling | UK | Target drone |
| CL227 Sentinel | Canadair | Canada | Maritime surveillance |
| Yak 60 | Yakovlev | Russia | Surveillance |
| TU141 Strizh | Tupolev | Russia | Surveillance |
| D4 | Xian ASN | China | Surveillance |
| Skoja III | Ominpol | Czech Republic/ Hungary | Surveillance |
| Fox AT1/4 | CAC | France | Surveillance |
| Brevel | STN Atlas | France/Germany | Surveillance |
| Global Hawk | Teledyne Ryan | USA | Surveillance |
| Raven | Flight Refuelling | UK | Surveillance |
| Storm Shadow | | | |

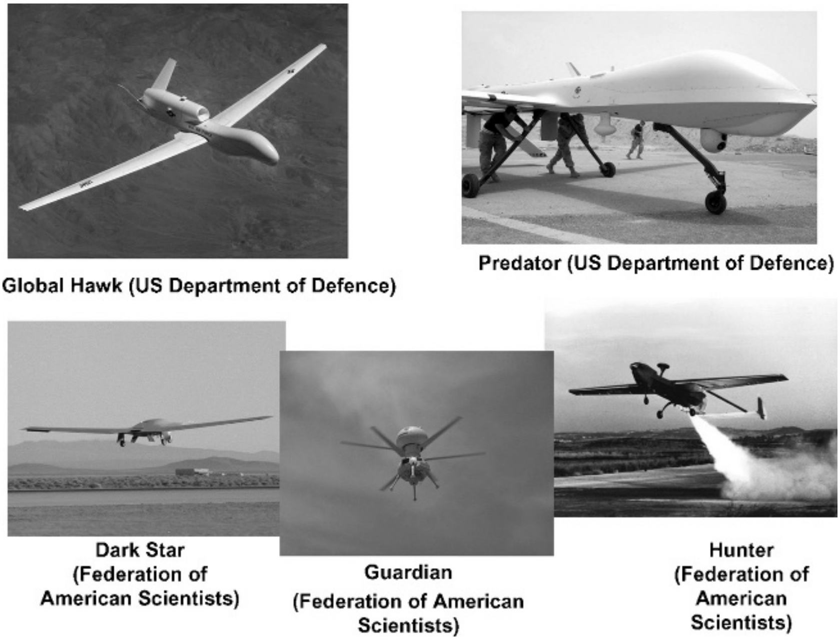


**Figure 1.33** Examples of unmanned air vehicles.

Further developments include the design of micro-UAVs that act in flocks to provide a multiple redundant sensor system capability. These devices can be programmed to mimic bird flocking behaviour so that a number of UAVs will follow a leader.

## 1.13 Training

Training of aircrew is an important task, from primary training through conversion to type to refresher training to maintain combat readiness. Training is accomplished by a variety of means. Initial training (*ab initio*) is usually carried out using a dynamic simulator to gain familiarisation before transferring to a single-engine light aircraft and then to a single-engine jet trainer. Conversion to an operational type again uses a simulator before transferring to a two-seat version, and then to solo. This is usually carried out on an operational conversion unit (OCU), a squadron staffed by qualified flying instructors.

Routine mission and tactics training can be performed on dynamic simulators, designed to have a high degree of fidelity in six degrees of motion and an outside world real-time picture. However, realism is an important aspect of training, and nations have designated areas of their territory for low-level or combat training. While this includes ranges in restricted areas for very high-speed flight, live weapons delivery and electronic warfare training, much flying takes place in airspace that conflicts with other users such as the general public, private flying, commercial helicopters and leisure flying of balloons, hang-gliding and microlights. Training in these circumstances is essential for combat readiness but requires delicate handling to maintain public sympathy. For this reason, many air forces have resident public liaison officers to deal with public complaints.

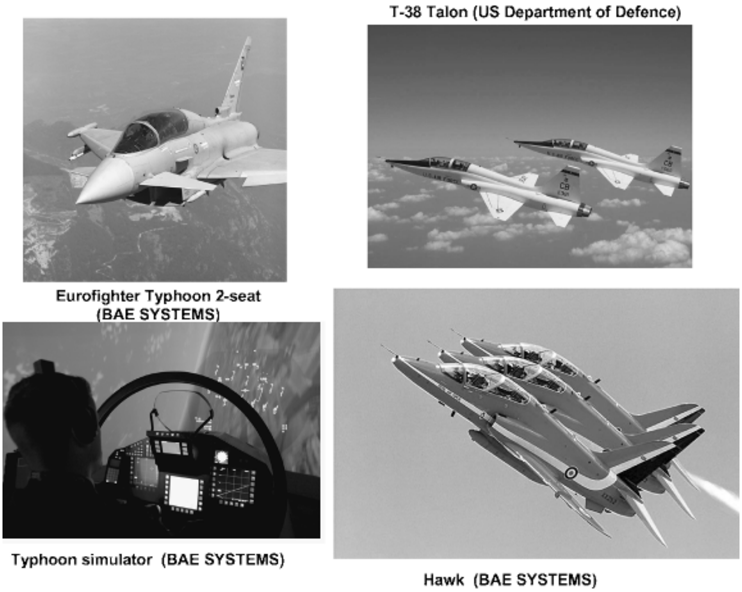


**Figure 1.34** Training system aircraft types.

Simpler simulations of parts of the mission task are often undertaken in classrooms, especially for cockpit familiarisation or for mission systems crews to practise team tasks such as MPA or AEW. These are known as part task trainers. In this situation, real missions can be replayed and unexpected scenarios generated. Occasionally, flying classrooms using modified business aircraft to seat a number of trainees at workstations are used.

The training role also includes the provision of aerial targets. These may be implemented as remotely piloted drones such as converted obsolete aircraft or specially designed target vehicles. Banner targets can be towed by converted operational aircraft for air-to-air gunnery


**Figure 1.35** Examples of special role types.

practice. Converted small business jets have been used to carry underwing pods equipped with radio-frequency transmitters for use in a simulated EW environment.

### 1.13.1 Typical Aircraft Types

Typical types of aircraft as follows:

- BAE SYSTEMS Hawk;
- Aermacchi MB339;
- Aermacchi MB326;
- Dassault/Dornier Alphajet;
- Embraer EMB-312Tucano;
- Pilatus/BAE SYSTEMS PC-9;
- Fairchild-Republic T-46;
- -endNorthrop T-38 Talon.

## 1.14 Special Roles

Military aircraft are often called on to perform roles beyond their original design intention. This may be for research and development of sensors and systems, development of new tactics, for intelligence gathering or for peaceful information-gathering missions. Conversion to these roles may be by major modification to the type or by adding payload internally or externally – such as under-wing pods.

Many of these special roles are, of course, so special that their existence is not revealed to the general public.

### 1.14.1 Examples of Special Roles

Examples of special roles are as follows:

- Gunship;
- Air ambulance;
- Arctic survey;
- Nuclear contamination detection;
- Biological/chemical sensing;
- Meteorological research;
- Covert troop deployments;
- Remotely piloted vehicle (RPV) aerial launch.

## 1.15 Summary

This list of roles is by no means exhaustive, the roles may also be known by other titles in different nations and different air forces. The nature of the roles and the system solutions to enable them to be fulfilled will also vary according to the perceived threat, the prevailing defence policy, local politics and the national air force inventory.

What they have in common is a comprehensive system and sensor solution that will include the following elementes:

- Communications and navigation;
- Mission sensors;
- Mission computing and data communications;
- Weapons and stores carriage and release;
- Man-machine interface.

The following chapters will describe the elements and will provide some examples of typical practical implementations.

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