Introduction

Evolution of Avionics

Avionics is a word coined in the late 1930s to provide a generic name for the increasingly diverse functions being provided by AVIation electrONICS. World War II and subsequent Cold War years provided the stimulus for much scientific research and technology development which, in turn, led to enormous growth in the avionic content of military aircraft. Today, avionics systems account for up to 50% of the fly-away cost of an airborne military platform and are key components of manned aircraft, unmanned aircraft, missiles and weapons. It is the military avionics of an aircraft that allow it to perform defensive, offensive and surveillance missions.

A brief chronology of military avionics development illustrates the advances that have been made from the first airborne radio experiments in 1910 and the first autopilot experiments a few years later. The 1930s saw the introduction of the first electronic aids to assure good operational reliability such as blind flying panels, radio ranging, non-directional beacons, ground-based surveillance radar, and the single-axis autopilot. The 1940s saw developments in VHF communications, identification friend or foe (IFF), gyro compass, attitude and heading reference systems, airborne intercept radar, early electronic warfare systems, military long-range precision radio navigation aids, and the two-axis autopilot. Many of these development were stimulated by events leading up to World War II and during the war years.

The 1950s saw the introduction of tactical air navigation (TACAN), airborne intercept radar with tracking capability and Doppler radar, medium pulse repetition frequency (PRF) airborne intercept radar, digital mission computers and inertial navigation systems. The 1960s saw the introduction of integrated electronic warfare systems, fully automated weapon release, terrain-following radar, automatic terrain following, the head-up display laser target marketing technology and the early digital mission computer.

Over the years, as specialist military operational roles and missions have evolved, they have often driven the development of role-specific platforms and avionics. Looking across the range of today’s airborne military platforms, it is possible to identify categories of
avionics at system, subsystem and equipment levels that perform functions common to all platforms, or indeed perform unique mission-specific functions.

Technology improvements in domestic markets have driven development in both commercial and military systems, and the modern military aircraft is likely to contain avionic systems that have gained benefit from domestic computing applications, especially in the IT world, and from the commercial aircraft field. This has brought its own challenges in qualifying such development for use in the harsh military environment, and the challenge of meeting the rapid turnround of technology which leads to early obsolescence.

Avionics as a Total System

An avionics system is a collection of subsystems that display the typical characteristics of any system as shown in Figure I.1. The total system may be considered to comprise a number of major subsystems, each of which interacts to provide the overall system function. Major subsystems themselves may be divided into minor subsystems or equipment which in turn need to operate and interact to support the overall system. Each of these minor subsystems is supported by components or modules whose correct functional operation supports the overall system. The overall effect may be likened to a pyramid where the total system depends upon all the lower tiers.

Avionics systems may be represented at a number of different levels as described below:

1. A major military task force may comprise a large number of differing cooperating platforms, each of which contributes to the successful accomplishment of the task force.

Figure I.1  Avionics as a ‘system of systems’.
mission. Within this context an individual strike aircraft or surveillance platform avionics system may represent one component of many within the task force.

2. At the individual platform or aircraft level, a collection of subsystems and components or modules operate to support the successful completion of the primary role of the platform, be it reconnaissance, strike, support or surveillance.

3. The individual equipment that supports the overall system of the platform is a collection of units or modules, control panels and displays, each of which has to operate correctly to support subsystem and overall system operation.

4. Finally, the electronic modules that form the individual components of the aircraft avionics systems may be regarded as systems within their own right, with their own performance requirements and hardware and software elements.

In general within this book, most discussion is centred upon the aircraft-level avionics system and upon the major subsystems and minor subsystems or equipment that support it. Passing reference to the higher-level system is made during brief coverage of network centric operations. In some cases the detailed operation of some components such as data buses is addressed in order that the reader may understand the contribution that these elements have made to advances in the overall integration of platform avionics assets.

The product breakdown structure of a military aircraft system is shown in Figure I.2.

### Increasing Complexity of Functional Integration

As avionics systems have evolved, particularly over the past two or three decades, the level of functional integration has increased dramatically. The nature of this increase and the accompanying increase in complexity is portrayed in Figure I.3.

In the early stages, the major avionics subsystems such as radar, communications, navigation and identification (CNI), displays, weapons and the platform vehicle could be
considered as discrete subsystems, the function of which could be easily understood. The performance requirements could be relatively easily specified and captured, and, although there were information interchanges between them, each could stand alone and the boundaries of each subsystem was ‘hard’ in the sense that it was unlikely to be affected by the performance of a neighbouring subsystem.

As time progressed, the functionality of each subsystem increased and some boundaries blurred and functions began to overlap. Also, the number of subsystems began to increase owing to the imposition of more complex mission requirements and because of the technology developments that furnished new sensors. Improved data processing and higher bandwidth data buses also contributed to providing much higher data processing capabilities and the means to allow the whole system to become more integrated.

Further technology developments added another spiral to this trend, resulting in greater functionality, further increasing integration and with a blurring of functional boundaries as subsystems became able to share ever greater quantities of data. This evolution has been a continual process, although it is portrayed in three stages in Figure I.3 for reasons of simplicity.

The outcome of this evolution has been to **increase**: performance; sensor types; functionality; cost; integration; complexity; supportability (reuse); software programs in terms of executable code; memory requirements; throughput; reliability; data handling; data links; and obsolescence.

The result has been to **decrease**: size; weight; power consumption; and technology windows.

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**Figure I.3** Increase in functional integration over time.
Organisation of the Book

This book is organised to help the reader to comprehend the overarching avionics systems issues but also to focus on specific functional areas. Figure I.4 shows how the various chapters relate to the various different major functional subsystems.

The book provides a military avionics overview aimed at students and practitioners in the field of military avionics.

Chapter 1 lists and describes the roles that military air forces typically need to perform. It is the understanding of these roles that defines the requirements for a particular suite of avionics, sensors and weapons for different platforms.

Chapter 2 examines the technology that has led to different types of system architecture. This technology has resulted in sophisticated information processing structures to transfer high volumes of data at high rates, and has resulted in greatly increased functional integration.

The subject of radar is covered in Chapter 3 which describes radar basic principles, while Chapter 4 explains some of the advanced features that characterise different types of radar used for specific tasks.

Chapter 5 deals with electrooptical (EO) sensors and their use in passive search, detection and tracking applications. This includes a description of the integration of EO sensor applications in turrets and pods, as well as personal night vision goggles.

Chapter 6 looks at the sensitive, and often highly classified, field of electronic warfare and the gathering of intelligence by aircraft using sophisticated receiving equipment and processing techniques.

Figure I.4  Military avionics functional subsystems.
Chapter 7 is concerned with communications and identification; this describes the mechanisms by which an aircraft is identified to other stakeholders such as air traffic control and to friendly forces, as well as the different form of communications available for speech and encrypted data.

Chapter 8 covers the subject of navigation and the means by which pilots are able to navigate precisely to their engagement zones, understand their location during and after an engagement and return safely to home base. This makes maximum use of military and civilian navigation aids, using state-of-the-art on-board systems.

Chapter 9 addresses the subject of weapons carriage and guidance to give an understanding of the integrated weapon system. Individual weapons types are described, together with the systems required to ensure that they can be aimed and released to maximum effect.

Chapter 10 deals with the vehicle management system; those systems that provide the platform with power, energy and management of basic platform control functions. Although provided as a separate control system today, it is inevitable that these functions will be absorbed into mission system processing in the future.

Chapter 11 covers part of the human–machine interface – the displays in the cockpit and the mission crew areas that enable the crew to prosecute the operational mission. This chapter deals with the technology of displays and provides numerous examples of display systems in military applications.

The authors believe that this volume will complete the set of companion volumes that describe the aircraft general, avionic and mission systems, as well as the way in which they are developed. This series provides a guide to the interested public, to students and to practitioners in the aerospace field. It should be recognised that this book, like its companion volumes, only scratches the surface of a series of complex topics. Within the book we have provided a comprehensive bibliography as a guide to specialised volumes dealing in detail with the topics outlined here, and it is to be hoped that the reader will continue to read on to understand aviation electronic systems.