SPACE AVIONICS - 2024/5

Module code: EEEM059

Module Overview

Expected Prior Learning: Module EEE3040 Space Systems Design, or equivalent module.

Module Purpose: Through a series of lectures and a design assignment, the module aims to give an introduction to the engineering design principles, requirements and solutions for satellite avionics.

This module builds on from many Electronic Engineering modules at undergraduate level in the topics of RF/Communications (EEE3033), Processor Design (EEE3027), and C coding Software (EEE1035 and EEE2047).

Module provider

Computer Science and Electronic Eng

Module Leader

BRIDGES Christopher (Maths & Phys)

Number of Credits: 15

ECTS Credits: 7.5

Framework: FHEQ Level 7

Module cap (Maximum number of students): 45

Overall student workload

Independent Learning Hours: 90

Lecture Hours: 22

Laboratory Hours: 22

Guided Learning: 6

Captured Content: 11

Module Availability

Semester 1

Prerequisites / Co-requisites

Open Rule: Given satellite avionics is primarily electronics and software based, an undergraduate level understanding of Electrical / Electronic Engineering and C Programming Language is required. Students from other disciplines are welcome but additional study from the Reading List would be recommended.

Module content

Indicative content includes the following:

TELECOMMAND, TELEMETRY & CONTROL (TT&C)

1. Design function of TT&C system: launch and early operation phase (LEOP), end-of-life operations.
2. Communications Link: TT&C frequencies, Doppler curve - AOS, LOS TCA; link design: carrier-to-noise ratio, Eb/No, signal quality.
3. Tracking and ranging methods, worked examples.
4. Telemetry systems, formatting and synchronization, validation and authorization.
5. Packet Radio: HDLC and AX.25 packet formats, existing alternatives in packet radio.
6. Software Defined Radios: gnuradio introduction, common equipment and design philosophy to single chip solutions, the FUNcube Dongle and DVB tuners.
7. Ground-station design, Mission Operations Control Centre (MOCC), ground-support equipment, use during AIT and LEOP, orbit determination.
8. Tour of Surrey's MOCC and Groundstation.

DATA SYSTEMS

9. Common design practices: OBCs, OBDH, mission and risk tradeoffs
10. Processors: key design considerations, heritage controllers, SSTL and SSC examples.
11. Configurable Systems: FPGAs and logic cells, radiation tolerant design, IP cores, LEON3 processor and worked examples, on-chip triple modular redundancy.
12. Bus systems and performance: Topologies, ESA Bus, control area network (CAN-SU), I2C, FlexRay.
13. Radiation effects and mitigation - SEEs and total dose damage, example systems.
14. Sensor interfacing, ADC/DAC conversion.
15. Payload requirements: solid-state memories and buffering in store-and-forward operations.
16. Harnessing: key interfacing considerations, materials, existing specifications.

SOFTWARE

17. OSI Layer Stack: reduced design layers, common open-source tools.

18. Software standards: CCSDS, SOIS, PlugNPlay (PnP).

19. Real time aspects and Runtime Kernels: RTEMS, embedded Linux, FreeRTOS.

20. Software security and integrity: design rules, scrubbing, error detection and control.

21. Autonomous software: bootloader, non-volatile to volatile operations.

22. Common AOCS, sensors, propulsion control loop.

23. Methods and Tools: Requirements, design, coding, integration and test, revision control.

24. Simulation, in-circuit testing and debugging.

Assessment pattern

Assessment type	Unit of assessment	Weighting
Coursework	GROUP DESIGN EXERCISE	20
Coursework	INDIVIDUAL CODING EXERCISE	20
Examination	2 HR INVIGILATED EXAM	60

Alternative Assessment

Alternative assessment for the Group Design Exercise is an individual design assignment.

Assessment Strategy

The assessment strategy for this module is designed to provide students with the opportunity to demonstrate an understanding of principles, technologies and operation of a spacecraft's core avionics and how they are driven by both the space environment and the mission requirements.

Thus, the summative assessment for this module consists of the following.

- Assignment 1 - Group Design Exercise of a Low-Cost Platform. Together given mission and data requirements, the students are to research technologies on how to build and interface a platform to various sensors and buses. A paper study is required into justifying robust decisions in solving space avionics problems as hardware or software functions the following requirements: fault-tolerant memory storage, ADC/DAC, EDAC, and any radiation mitigation techniques. This is designed to allow students to fully appreciate spacecraft requirements and their importance.

- Assignment 2 - Individual Coding Exercise - Implementation of Low-Cost On-Board Computer (OBC) Functions: Using existing software and hardware tools, the student is to programme, test and verify common space avionics design features in a lab environment. Additional flight computers will be made available as alternatives. This assignment is designed to allow students to explore their own expertise in avionics and in handling representative flight hardware.

- Final exam to assess all module learning outcomes

These are appropriate in marks and length to give the opportunity to demonstrate knowledge at an examination level and also in ‘hands-on’ experiences.

Any deadline given here is indicative. For confirmation of exact dates and times, please check the Departmental assessment calendar issued to you.

Formative assessment and feedback

For the module, students will receive formative assessment/feedback in the following ways.

- During lectures, by question and answer sessions
- By means of unassessed problem sheets (with answers/model solutions)
- During supervised laboratory sessions
- Via the marking of written reports
- Via assessed coursework

Module aims

- This module aims to introduce the student to the operating principles, design and operation of spacecraft avionics systems able to support a wide variety of spacecraft missions – primarily in Earth orbit.
- The module also aims to provide opportunities for students to learn about the Surrey Pillars listed below.

Learning outcomes

Ref		Attributes Developed	
001	By the end of the module, the student should have a good understanding of the principles, technology and operation of a spacecraft's key avionics or platform systems and how the space and mission environments constrain these.	KC	M1, M6
002	The student should be capable of applying this knowledge the produce a preliminary design of a spacecraft on-board computer to interface to particular subsystems in a robust manner. The student should be able to analyse and evaluate the performance of key systems of the spacecraft.	KC	M2, M5
003	The assignments will allow the student to emulate data, utilising existing databases or simulated sources, in order to understand the data requirements and design to evaluate its performance. The student will then produce a succinct and clear report describing this analysis.	CPT	M4, M10, M12, M16, M17

Attributes Developed

C - Cognitive/analytical

K - Subject knowledge

T - Transferable skills

P - Professional/Practical skills

Methods of Teaching / Learning

The **learning and teaching strategy** aims to facilitate student’s learning through direct application of knowledge with real software and hardware tools in a laboratory environment using and expanding on industrial examples.

Learning and teaching methods include the following.

- Lectures and in-class discussion of teaching material and its applications
- Practical laboratory sessions providing students with opportunities to gain experience avionics tools and the associated software so students gain an appreciation of the key blocks in spacecraft avionics
- Designed in-class problems with associated discussions
- Two assignments in the form of requirements group work and individual coding exercise with associated reports
- Timetabled summary revision classes also demonstrate the principles of the theory

Indicated Lecture Hours (which may also include seminars, tutorials, workshops and other contact time) are approximate and may include in-class tests where one or more of these are an assessment on the module. In-class tests are scheduled/organised separately to taught content and will be published on to student personal timetables, where they apply to taken modules, as soon as they are finalised by central administration. This will usually be after the initial publication of the teaching timetable for the relevant semester.

Reading list

https://readinglists.surrey.ac.uk
Upon accessing the reading list, please search for the module using the module code: **EEEM059**

Other information

University Pillars

• **Sustainability** – This module discusses low power and efficient RF, electronics and software systems for all space missions where power is a major driver in avionics decision.

• **Global and Cultural Intelligence** – We discusses differences in design between US and EU design strategies and the role of regulators in the real geopolitical world.

• **Digital Capabilities** – This entire module is focussed on industry relevant and highly transferable digital skills in RF, OBDH, and software for space missions.

• **Employability** – This avionics module is unique across the whole sector in practical real-world skills. Such practical skills ensure employability as detailed by evidence from students, employers, accreditors, external examiners and governments.

Programmes this module appears in

Programme	Semester	Classification	Qualifying conditions
Electrical and Electronic Engineering MEng	1	Optional	A weighted aggregate mark of 50% is required to pass the module
Electronic Engineering MEng	1	Optional	A weighted aggregate mark of 50% is required to pass the module
Electronic Engineering with Space Systems MEng	1	Optional	A weighted aggregate mark of 50% is required to pass the module
Satellite Communications Engineering MSc	1	Optional	A weighted aggregate mark of 50% is required to pass the module
Space Engineering MSc	1	Optional	A weighted aggregate mark of 50% is required to pass the module

Please note that the information detailed within this record is accurate at the time of publishing and may be subject to change. This record contains information for the most up to date version of the programme / module for the 2024/5 academic year.