SPACE ENVIRONMENT AND PROTECTION - 2024/5

Module code: EEEM057

Module Overview

Expected prior learning: Knowledge equivalent to BEng/BSc in physics or engineering, or equivalent learning.

Module purpose: Engineers and scientists in the space industry need a sound appreciation of the hostile and challenging space environment which includes electromagnetic and particle radiation, space weather, plasmas, ultra-high vacuum, particulates (inc. debris) and thermal extremes. This module provides a comprehensive and detailed understanding of the space environment and its impacts in an engineering context and goes into more detail than is possible in the 'Space System Design' module: it is especially complementary with 'Space Avionics' which provides further methods to protect microelectronics and computers in particular. Through a series of lectures and exercises, and making use of numerous global digital resources including global space environment models, space weather data streams, and international tools for calculations of effects and impacts, describes the impacts on engineering systems (especially to electronics and materials) and how to protect against them. This in turn enables students to design and create reliable space infrastructure leading to the sustainable and economic use of space in the long term by minimising space debris and avoiding wasted resources. In order to illustrate the industrial and employment perspective, realistic examples and exercises based on past scenarios are studied in detail also use is made of real-time space weather events as they develop as well as the forecasts provided via various global digital sources. Guest lectures by specialist practitioners in the field, for example, from the European Space Agency, Airbus, SSTL and OHB are normally provided.

Student journey The module follows on naturally from the 'Space System Design' module which necessarily can give only a brief summary of the space environment but does put in context the broad range of missions, orbits and environments that can be encountered and summarises top-level impacts. EEEM057 looks in considerably more detail at the space environment and especially those aspects relevant to the performance and reliability of space-electronics and -avionics and protection measures. For these reasons the module is especially complementary with the 'Space Avionics' module, part of which looks at the design of avionics and on-board computers and further techniques to mitigate radiation impacts.

Module provider

Computer Science and Electronic Eng

Module Leader

RYDEN Keith (Maths & Phys)

Number of Credits: 15

ECTS Credits: 7.5

Framework: FHEQ Level 7

Module cap (Maximum number of students): N/A

Overall student workload

Independent Learning Hours: 91

Lecture Hours: 11

Tutorial Hours: 11

Guided Learning: 10

Captured Content: 27

Module Availability

Semester 2

Prerequisites / Co-requisites

None.

Module content

Indicative content includes the following.

- Overview of the module
- Space environment
  - Discovery of the space environment
  - Cosmic rays, solar radiation, trapped particles (Van Allen belts), space plasma
  - Space weather, solar flares, energetic particle events, coronal mass ejections, fast wind streams
  - Past space weather scenarios and extreme events
  - Real time space weather data and forecasts
  - Electromagnetic radiation in space – gamma, X-rays, UV, visible, infra-red
  - Vacuum
  - Orbit dependence
  - Exo-atmospheric nuclear detonations
- Space science, instruments and measurements
  - Environment and plasma missions, X-ray astronomy.
  - X-ray and gamma-ray detection, imaging and spectroscopic techniques: telescopes (e.g. Wolter type), Bragg spectrometers.
  - Particle detection e.g. particle telescopes

    - Other planets (e.g. Jupiter)

- Thermal effects and design
    - Solar radiation
    - Black body radiation
    - Absorptivity and reflectivity
    - Thermal equilibrium and transients
    - Calculation and modelling methods, view factors, tools
    - Thermal control (MLI, heaters, paints, louvres, phase change etc)

- Radiation effects (on electronics and materials)
    - Ionising dose
    - Displacement Damage (including optical components such as CCDs)
    - Single Event Effects (SEE)
    - Electrostatic charging (surface and internal)
    - Effects on materials and components
    - Instrument noise
    - Engineering implications

- Radiation protection engineering
    - Radiation transport and shielding
    - Radiation testing and facilities
    - Materials selection
    - Electronic component test and selection
    - Design margins

    - Circuit design approaches
    - Error detection and correction
    - Voting

- Global/international tools for radiation modelling
    - Dose-depth curves and usage
    - Sector shielding
    - 3D modelling dose modelling
    - Charging tools (e.g. DICTAT, SPIS)
    - On-line tools e.g. Spenvis, CRÈME-96/MC

- Global/international standards and methods
    - Systematic approaches
    - International standards
    - Satellite anomaly investigation
    - Web-based digital resources

- Guest Lectures: e.g. ESA, SSTL, Airbus.

Assessment pattern

Assessment type	Unit of assessment	Weighting
Examination	Open book invigilated exam of 2hrs duration	100

Alternative Assessment

N/A

Assessment Strategy

The **assessment strategy** for this module is designed to provide students with the opportunity to demonstrate that they have achieved the intended learning outcomes. A written open-book exam will be undertaken and questions will be set to assess:

· the student's overall comprehension of space environment and protection,

· analytical skills when presented with space environment information or data,

· problem-solving skills in the field and with unseen scenarios to test resilience and resourcefulness

· ability to propose and design protection solutions and justify their choice

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

· an invigilated open-book examination.

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

· During tutorials/tutorial classes

· By means of unassessed tutorial problem sheets (with answers/model solutions)

Module aims

- To provide the student with a comprehensive and detailed understanding of the space environment in an engineering context and how it is specified using global digital models and how it is measured and monitored via global collaborative initiatives.
- To provide a comprehensive and detailed understanding of space environmental effects on engineering systems and how to evaluate the risks and impacts, including use of using digital tools
- To provide an appreciation of what mitigation methods can enable reliable design and ultimately ensure sustainable use of space;
- To promote the student's ability to apply this knowledge to realistic and practical situations, so developing student resourcefulness, resilience and employability aligned to the Surrey Pillars listed below.

Learning outcomes

Ref		Attributes Developed	
001	To understand the space environment and its effects and how to implement protection measures against these effects.	KC	M1, M2

Ref		Attributes Developed	
002	Analyse the space environment specification provided in satellite and equipment specifications	KCPT	M6, M7
003	Analyse and calculate the effects of space environments	KC	M2
004	Select and use suitable methodologies e.g. analytical and computer tools to model complex problems	KCPT	M3, M4
005	Design appropriate mitigation approaches and demonstrate their validity	PT	M9

Attributes Developed

C - Cognitive/analytical

K - Subject knowledge

T - Transferable skills

P - Professional/Practical skills

Methods of Teaching / Learning

The learning and teaching strategy is designed to achieve the following aims.

1. Learning through regular lectures. These lectures will include problem solving exercises, enquiry based learning, research-led teaching and in-class discussions.
2. Provision of lectures notes.
3. Provision of case studies and associated discussion.
4. Prepare for summative assessment through intensive in-class revision session.

Digital resource will be used through-out as described above in other information).

Learning and teaching methods include the following.

Teaching is by lectures and tutorials. Learning takes place through lectures, tutorials, and exercises.

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: **EEEM057**

Other information

Digital Capabilities Students on this module will access their course materials via the Surrey digital portal for learning (currently SurreyLearn) including lecture slides, lecture recordings, class examples, past exam questions and answers and also digital media items such as videos from external (public domain) sources where appropriate e.g. imagery and digital data collected by satellites to illustrate space environments and impacts. Students are shown how to use a wide range of on-line and stand-alone digitally-enabled and industry-standard tools and portals which provide information on space weather in the past (archives), the present (real-time data) and the future (forecasts). Students are also shown how to use a further range digital tools/portals which enable running of the key international space environment models and the formulation of mission specifications: such tool are also used for determination of the impacts and effects of these environments for engineering purposes: these tools may also be required to be used in module assessments. The module discusses and illustrates the vulnerability of digital services to the environments being studied and how protection can be provided. Since real-time space weather alerts are distributed via e-mail, text messages, WhatsApp and various other media, student are encouraged to use these to become closely connected to current space weather events and learn about the sequences of events and then join in discussions of recent space weather at weekly live or remote (Zoom, Teams) sessions.

Employability This module provides underpinning learning on the unfamiliar and harsh space environment, its impacts and how to protect against it, all of which are critical for any space-system or mission: hence this module is of direct importance (as part of the wider, balanced MSc and BEng/MEng programmes) to student employability all across the space industry. Students are shown how to use a wide range of industry-standard tools, methods and terminology and so can immediately join industry teams and be rapidly effective. Examples based on real past experience (e.g. from the activities of the European Space Agency, NASA or new entrants such as Space-X) are used and interactive class examples are provided such that students can participate in collective and individua data analysis and solution development. In assessments students are expected to propose their own approaches to understanding and manipulating previously unseen data and scenarios and are expected to develop solutions and provide advice as if working in the space industry.

Global and cultural capabilities Space is an inherently global and internationally-collaborative endeavour and the knowledge, models, instruments and tools used in this module have been developed with a vast array of inputs and contributions from virtually all space-faring (and indeed non space-faring) nations since the start of the space age. Students on the module also usually come from a very wide range of nationalities and cultural backgrounds and since the focus is on the common issue of understanding the space environment and how to protect against it, this enables the cohort to work together with relative ease (e.g. to tackle the hazards of future Moon or Mars bases) and this will naturally promote collaboration during their future careers. It is emphasised throughout the module how even small-scale initiatives (e.g. additional measurements) often contribute to the global understanding of the space environment and its effects and hence small- or developing-countries, groups and even individual citizens can fully participate. Extreme space weather is a global threat and the module emphasises the need for preparedness through understanding of vulnerability so that, in particular, developing nations can maximise protection in their new infrastructure by appropriate design.

Resourcefulness and resilience The module actively encourages the use of a very wide range of globally-developed resources and tools (as described above) which are coupled with learning of how to apply and combine them together to make accurate assessments of a situation and to provide good engineering advice and decisions. Developing the ability to proceed with best-available assessments, decisions and forecasts via scenario-based examples and exercises is incorporated into the module via exercises using partial or restricted sets information (which in real life is always the case anyway) and this promotes the student's resourcefulness and resilience. These skills are often tested in the assessments where scenarios will have some information withheld or may be they may be unusual in nature and outside the scope of past examples.

Sustainability Defunct satellites create space debris and can be a waste of the resources devoted to placing them in orbit: this module will enable students to develop reliable space systems which will ultimately lead to a sustainable space eco-system. Also our ever-increasing and vital space infrastructure devoted to Earth sustainability (e.g remote sensing missions measuring global warming) must themselves be made robust against malfunction, damage and errors (e.g. in space weather events) and the module will enable students to achieve this goal through appropriate design solutions and methods.

Programmes this module appears in

Programme	Semester	Classification	Qualifying conditions
Electrical and Electronic Engineering MEng	2	Optional	A weighted aggregate mark of 50% is required to pass the module

Programme	Semester	Classification	Qualifying conditions
Electronic Engineering with Space Systems MEng	2	Optional	A weighted aggregate mark of 50% is required to pass the module
Space Engineering MSc	2	Optional	A weighted aggregate mark of 50% is required to pass the module