ELEC9764
The Ground Segment and Space Operations

Course Outline – Semester 2, 2016

Never Stand Still | Faculty of Engineering | School of Electrical Engineering and Telecommunications

Course Staff

Course Convener: Prof. Andrew Dempster, Room MSEB 618, a.dempster@unsw.edu.au
Lecturers: Dr. Barnaby Osborne, Room MSEB 619, barnaby.osborne@unsw.edu.au
Dr. Elias Aboutanios, Room MSEB 702, elias@unsw.edu.au

Consultations: You are encouraged to ask questions on the course material, after the lecture class times in the first instance, rather than via email. Lecturer consultation times will be advised during lectures. You are welcome to email the tutor or laboratory demonstrator, who can answer your questions on this course and can also provide you with consultation times. ALL email enquiries should be made from your student email address with ELEC9764 in the subject line, otherwise they will not be answered.

Keeping Informed: Announcements may be made during classes, via email (to your student email address) and/or via online learning and teaching platforms – in this course, we will use Moodle https://moodle.telt.unsw.edu.au/login/index.php. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Course Summary

Contact Hours

The course is delivered in block mode course due to run in the week commencing 19th September, 2015. Teaching will occur between 9am and 5pm, Monday to Friday of that week.

Context and Aims

This course is intended to deliver to the student a deeper understanding of the requirements and functions of the ground segment of a satellite system. To achieve this this course will cover three main aspects of the ground segment design and two aspects of spacecraft operations:

1. Ground segment management,
2. Ground segment engineering, including communications design, data management, ground segment equipment, ground segment infrastructure and operational software,
3. Applications of the ground segment, incorporating examples from real space missions,
4. Space operational architectures and activities,
5. Mission operation phases and activities.

Indicative Lecture Schedule

Day	Summary of Lecture Program
Day 1	Introduction to the Module Ground segment elements and role in a space mission Earth station design process
Day 2	Earth station locations Satellite communications
Day 3	Earth station internet working principles Earth station hardware
Day 4	Space operations architectures and activities Space mission operational phases and examples
Day 5	Group activities and assignment time

Assessment

Mid-Semester Exam	10%
Assignment	30%
Final Exam (3 hours)	60%

Course Details

Credits

The University defines a UoC as requiring 25 hours of total learning effort per semester, spread over lectures, tutorials, labs, and the student's own study time (see https://my.unsw.edu.au/student/atoz/UnitsOfCredit.html). Therefore, it is expected that 150 hours will be allocated to this course. For a Master's course, the only expected formal contact hours are the lectures, which accounts for about 32-40 hours out of this total. The students should then allocate around 110 hours of additional private hours to the subject over the semester.

Relationship to Other Courses

The ground segment and space operations course is a core specialisation course within the Masters of Engineering Science Extended - Satellite Systems Engineering program (ELECSS 8539). It is a recommended elective which can be taken in either the first or second year of the program, although It is intended (though not required) that this be taken early in the Satellite Systems Engineering Masters program.

Pre-requisites and Assumed Knowledge

There are no prerequisite courses leading into this course, however it is expected that enrolling students will have completed a 4 year Bachelor's in Engineering and have prior undergraduate learning in Mechanics, Mathematics and Physics.

Learning outcomes

After successful completion of this course, you should be able to:

1. Understand the role of the ground segment in the context of the overall space mission and the space system operation.
2. Cite specific design requirements for earth stations for different satellite applications.

3. Explain the principle factors that govern earth station site selection.
4. Understand and apply basic satellite tracking techniques employed in ground stations.
5. Describe and contrast different earth station architectures as used in a variety of satellite applications.
6. Design simple satellite communication links, and perform detailed link budget analysis of a satellite links.
7. Analyse basic hardware options for earth station components and infrastructure, citing relevant factors such as performance, support, and economic cost.
8. Describe the basic principles of operations and maintenance of satellite earth stations.
9. Describe the common mission operation architectures
10. List the main operational activities
11. Describe the operational requirements for the mission phases

This course is designed to provide the above learning outcomes which arise from targeted graduate capabilities listed in ***Appendix A***. The targeted graduate capabilities broadly support the UNSW and Faculty of Engineering graduate capabilities (listed in ***Appendix B***). This course also addresses the Engineers Australia (National Accreditation Body) Stage I competency standard as outlined in ***Appendix C***.

Syllabus

This course covers, in detail, the types and applications of ground segment and space operations used in space missions. It is intended to give the student a deeper understanding of the requirements and functions of the ground segment and operations.

To achieve this, this course covers aspects of the ground segment design including ground segment management; mission planning; client/end-user requirements; flight operations requirements; payload data segment requirements; and ground segment system designs.

Aspects of ground segment engineering are also covered, including ground based communications design, data processing, data relaying, mission operating equipment, payload ground support, instrument operation and calibration and satellite simulation

Applications of the ground segment are covered including, data downlinking, uplinking, relaying, tracking and ranging. Examples of current and past ground segments of space missions are used to illustrate the design process and design implementation. Where appropriate, theory associated with the preliminary analysis of the operation and performance of the ground segment is also presented.

To cover the operations of spacecraft, topics including Space operational architectures and activities, mission operation phases and activities will be presented.

This course delivers to the student a broad overview of the engineering principles involved with the management, design, development, testing and implementation of the ground segment of a space mission.

Teaching Strategies

Delivery Mode

The teaching in this course aims at establishing a good fundamental understanding of the areas covered using:

- Formal face-to-face lectures, which provide you with a focus on the core analytical material in the course, together with qualitative, alternative explanations to aid your understanding;
- In-class Tutorials, which allow for exercises in problem solving and allow time for you to resolve problems in understanding of lecture material;

Learning in this course

You are expected to attend all lectures, tutorials, and mid-semester exams in order to maximise learning. You must prepare well for your laboratory classes and your lab work will be assessed. In addition to the lecture notes/video, you should read relevant sections of the recommended text. Reading additional texts will further enhance your learning experience. Group learning is also encouraged. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending face-to-face classes throughout the course.

Tutorial classes

You should attempt all of your problem sheet questions in advance of attending the tutorial classes. The importance of adequate preparation prior to each tutorial cannot be overemphasized, as the effectiveness and usefulness of the tutorial depends to a large extent on this preparation. Group learning is encouraged. Answers for these questions will be discussed during the tutorial class and the tutor will cover the more complex questions in the tutorial class. In addition, during the tutorial class, 1-2 new questions that are not in your notes may be provided by the tutor, for you to try in class. These questions and solutions may not be made available on the web, so it is worthwhile for you to attend your tutorial classes to gain maximum benefit from this course.

Assessment

The assessment scheme in this course reflects the intention to assess your learning progress through the semester. Ongoing assessment occurs through the lab checkpoints (see lab manual), lab exams and the mid-semester exam.

Mid-Semester Exam

The mid-session examination tests your general understanding of the course material, and is designed to give you feedback on your progress through the analytical components of the course. Questions may be drawn from any course material. Marks will be assigned according to the correctness of the responses.

Assignment

The assignment allows self-directed study leading to the solution of partly structured problems. Marks will be assigned according to how completely and correctly the problems have been addressed, the quality of the code written for the assignment (must be attached to the report), and the understanding of the course material demonstrated by the report.

The assignment report will be due on the Friday in Week 11. *Late reports will attract a penalty of 10% per day* (including weekends).

Final Exam

The exam in this course is a standard closed-book 2 hour written examination, comprising five compulsory questions. University approved calculators are allowed. The examination tests analytical and critical thinking and general understanding of the course material in a controlled fashion. Questions may be drawn from any aspect of the course (including laboratory), unless specifically indicated otherwise by the lecturer. Marks will be assigned

according to the correctness of the responses. *Please note that you must pass the final exam in order to pass the course.*

Relationship of Assessment Methods to Learning Outcomes

	Learning outcomes										
Assessment	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Mid-semester exam	☐	-	☐	☐	☐	-	-	☐	☐	☐	☐
Assignment	☐	-	-	☐	-	☐	☐	-	-	-	-
Final exam	☐	☐	☐	☐	☐	-	-	☐	☐	☐	☐

Course Resources

Textbooks

Reference books

- B. Ackroyd, World Satellite Communications and Earth Station Design; BSP Professional, 1990.
- P. Fortescue, J. Stark, & G. Swinard, Satellite Systems Engineering, 3rd Ed., John Wiley & Sons, 2003.
- B. Elbert, The Satellite Communication Ground Segment and Earth Station handbook; Artech House, 2001.
- J Wertz et al., ”Space Mission Engineering : The New SMAD” ; Microcosm Press, 2011.

On-line resources

Moodle

As a part of the teaching component, Moodle will be used to disseminate teaching materials, host forums and occasionally quizzes. Assessment marks will also be made available via Moodle: https://moodle.telt.unsw.edu.au/login/index.php.

Mailing list

Announcements concerning course information will be given in the lectures and/or on Moodle and/or via email (which will be sent to your student email address).

Other Matters

Academic Honesty and Plagiarism

Plagiarism is the unacknowledged use of other people’s work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a form of academic misconduct, and the University has very strict rules that include some severe penalties. For UNSW policies, penalties and information to help you avoid plagiarism, see http://www.lc.unsw.edu.au/plagiarism. To find out if you understand plagiarism correctly, try this short quiz: https://student.unsw.edu.au/plagiarism-quiz.

Student Responsibilities and Conduct

Students are expected to be familiar with and adhere to all UNSW policies (see https://my.unsw.edu.au/student/atoz/ABC.html), and particular attention is drawn to the following:

Workload

It is expected that you will spend at least **ten to twelve hours per week** studying a 6 UoC course, from Week 1 until the final assessment, including both face-to-face classes and *independent, self-directed study*. In periods where you need to need to complete assignments or prepare for examinations, the workload may be greater. Over-commitment has been a common source of failure for many students. You should take the required workload into account when planning how to balance study with employment and other activities.

Attendance

Regular and punctual attendance at all classes is expected. UNSW regulations state that if students attend less than 80% of scheduled classes they may be refused final assessment.

General Conduct and Behaviour

Consideration and respect for the needs of your fellow students and teaching staff is an expectation. Conduct which unduly disrupts or interferes with a class is not acceptable and students may be asked to leave the class.

Work Health and Safety

UNSW policy requires each person to work safely and responsibly, in order to avoid personal injury and to protect the safety of others.

Special Consideration and Supplementary Examinations

You must submit all assignments and attend all examinations scheduled for your course. You should seek assistance early if you suffer illness or misadventure which affects your course progress. All applications for special consideration must be **lodged online through myUNSW within 3 working days of the assessment**, not to course or school staff. For more detail, consult https://my.unsw.edu.au/student/atoz/SpecialConsideration.html.

Continual Course Improvement

This course is under constant revision in order to improve the learning outcomes for all students. Please forward any feedback (positive or negative) on the course to the course convener or via the Course and Teaching Evaluation and Improvement Process. You can also provide feedback to ELSOC who will raise your concerns at student focus group meetings. As a result of previous feedback obtained for this course and in our efforts to provide a rich and meaningful learning experience, we have continued to evaluate and modify our delivery and assessment methods.

Administrative Matters

On issues and procedures regarding such matters as special needs, equity and diversity, occupational health and safety, enrolment, rights, and general expectations of students, please refer to the School and UNSW policies:
http://www.engineering.unsw.edu.au/electrical-engineering/policies-and-procedures
https://my.unsw.edu.au/student/atoz/ABC.html

Appendix A: Targeted Graduate Capabilities

Electrical Engineering and Telecommunications programs are designed to address the following targeted capabilities which were developed by the school in conjunction with the requirements of professional and industry bodies:

- The ability to apply knowledge of basic science and fundamental technologies;
- The skills to communicate effectively, not only with engineers but also with the wider community;
- The capability to undertake challenging analysis and design problems and find optimal solutions;
- Expertise in decomposing a problem into its constituent parts, and in defining the scope of each part;
- A working knowledge of how to locate required information and use information resources to their maximum advantage;
- Proficiency in developing and implementing project plans, investigating alternative solutions, and critically evaluating differing strategies;
- An understanding of the social, cultural and global responsibilities of the professional engineer;
- The ability to work effectively as an individual or in a team;
- An understanding of professional and ethical responsibilities;
- The ability to engage in lifelong independent and reflective learning.

Appendix B: UNSW Graduate Capabilities

The course delivery methods and course content directly or indirectly addresses a number of core UNSW graduate capabilities, as follows:

- Developing scholars who have a deep understanding of their discipline, through lectures and solution of analytical problems in tutorials and assessed by assignments and written examinations.
- Developing rigorous analysis, critique, and reflection, and ability to apply knowledge and skills to solving problems. These will be achieved by the laboratory experiments and interactive checkpoint assessments and lab exams during the labs.
- Developing ethical practitioners who are collaborative and effective team workers, through group activities, seminars and tutorials.
- Developing independent, self-directed professionals who are enterprising, innovative, creative and responsive to change, through challenging design and project tasks.

Appendix C: Engineers Australia (EA) Professional

Engineer Competency Standard

	Program Intended Learning Outcomes	
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals	□
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing	□
	PE1.3 In-depth understanding of specialist bodies of knowledge	□
	PE1.4 Discernment of knowledge development and research directions	
	PE1.5 Knowledge of engineering design practice	□
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice	
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving	□
	PE2.2 Fluent application of engineering techniques, tools and resources	□
	PE2.3 Application of systematic engineering synthesis and design processes	
	PE2.4 Application of systematic approaches to the conduct and management of engineering projects	
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability	
	PE3.2 Effective oral and written communication (professional and lay domains)	□
	PE3.3 Creative, innovative and pro-active demeanour	□
	PE3.4 Professional use and management of information	□
	PE3.5 Orderly management of self, and professional conduct	
	PE3.6 Effective team membership and team leadership	□