Department of Aeronautics and Astronautics
School of Engineering
Massachusetts Institute of Technology

Graduate Program (S.M., Ph.D., Sc.D.)

Field: Communications and Networks
Date: September 4, 2007

1. Introduction and Purpose

The graduate program in the Department of Aeronautics and Astronautics at M.I.T. provides educational opportunities in a wide variety of aerospace-related topics through academic subjects and research. The purpose of this document is to provide incoming masters and doctoral level students guidance in planning the subjects they will take during their graduate program. The suggestions outlined here are to be understood as guidance and not as a mandatory, rigid framework. The final decision as to which subjects are taken and in what sequence is to be decided between each student and their academic advisor and/or doctoral committee. In addition to these recommendations, the official S.M. and doctoral degree completion requirements must be taken into account during the design of a graduate program[1].

2. Aerospace Communications and Networks

The increasing reliance on information technology in aerospace makes communications a critical element of most modern air and space operations. In many instances communication resources and networks are essential for delivering mission critical information. Moreover, in many locations lacking in a terrestrial communication infrastructure, satellite-based networks are the only viable mechanism for providing needed communication services.

While the field of communications and networks is rapidly advancing due to the increased popularity of the Internet, air and space communication systems are at a much more immature state of development. Certain attributes of the open air and satellite channels make techniques previously developed for terrestrial networks unsuitable. For example, satellite systems often have longer propagation delays and higher bit error rates than their terrestrial counterparts; and the open-air interface for satellite channels lends itself to the concept of dynamic sharing of resources. In addition, space based systems involve additional issues such as spacecraft technologies and complex system characteristics that are intertwined and complicate the design of communication systems.

[1] Refer to the S.M., Ph.D. and Sc.D. degree requirements in Aeronautics and Astronautics section of the MIT Bulletin, or to http://web.mit.edu/aeroastro/academics/grad/index.html

The unique attributes of aerospace networks lead to a number of research challenges including: a) the design of architectures and protocols for satellite communications systems including satellite constellation design, efficient resource allocation algorithms, and physical and link layer protocols for dealing with special properties of space systems; b) Hybrid space-terrestrial network architectures including the design of space-ground network architectures and interfaces, and the design of protocols for internetworking over heterogeneous networks that are efficient, reliable and able to provide quality of service assurance; c) Space to ground communications link technologies including bandwidth and power efficient link designs and efficient channel sharing mechanisms; d) high-reliability networks for intra aircraft/spacecraft communications; and e) network architectures and protocols for air vehicle systems including architectures for reliable communications between autonomous air vehicles (e.g., UAV's) for the purpose of delivering time-critical control information.

3. Faculty and staff with interest in Aerospace Communications and Networks

Professor Eytan Modiano (Modiano@mit.edu)

Please consult the Communications and Networks Research Group's Web page for more information about Professor Modiano's research activities in the area of communication networks.

Professor Moe Win (moewin@mit.edu)

Please consult the Wireless Communications Research Group's Web page for more information about Professor's Win research activities in wireless communications.

4. Suggested classes and typical programs of study in Communications and Networks

Students interested in communications and networking typically will take 3 or 4 of the following courses; depending on their research interests. Communications Systems engineering is a good introductory course to both communications and networking and is available for G-level credit to graduate students (please contact Professor Modiano for more information). Students whose interest is in the networking area will typically follow with Data Networks (16.37), while those interested in Communications at the physical layer will typically follow with Principles of Digital Communications (6.450).

16.36	Communication Systems Engineering
16.37/6.263	Data Networks
6.441	Transmission of Information

6.450	Principles of Digital Communications I
6.451	Principles of Digital Communications II
16.???/6.???	Spread Spectrum Systems
16.???/6.???	Space Communications and Networks

In addition to the above core communications and networking classes, students who are doing research in this area are likely to take classes from the following areas:

Algorithms:

6.046J/18.410J	Introduction to Algorithms
6.852J/18.437J	Distributed Algorithm
6.854J/18.415J	Advanced Algorithms
6.856J/18.416J	Randomized Algorithms

Optimization:

6.255/2.098/15.093	Optimization Methods
6.231	Dynamic Programming and Stochastic Control
6.252/15.084	Nonlinear Programming
6.253	Convex Analysis and Optimization
6.254	Game Theory with Engineering Applications
16.321/6.251	Mathematical Programming
6.855/15.082/ESD.78	Network Optimization
6.859/15.083	Integer Programming and Combinatorial Optimization

Mathematics:

6.262	Discrete Stochastic Processes
6.264/15.072	Queues: Theory and Applications
6.435	System Identification
6.041/6.431	Probabilistic System Analysis
6.436/15.085	Fundamentals of Probability
16.391/6.434	Statistics for Engineers & Scientists
18.100 B	Analysis

A. Typical program of study for an S.M. degree

A typical masters student would take two of the header classes (either 16.36 and 16.37 or 16.37 and 6.450). In addition, they may take two math courses and two courses on optimization and algorithms.

Header courses in communications and networks:

16.36 – Communications Systems Engineering (G-level)
16.37 – Data Networks

6.450 – Digital Communications

Math courses:

6.262 – Discrete Stochastic Processes
6.441 – Transmission of Information

Two introductory courses in optimization and algorithms: e.g.,

6.231 – Dynamic Programming
16.321 – Mathematical Programming
6.046 - Algorithms

B. Typical program of study for a Ph.D. degree

A Doctoral student would typically take about four additional courses depending on the particular focus of the student. Outlined below are example courses for people with a communications focus and networking focus.

Communications focus:

6.451 – Digital Communications II (coding theory)
16.** - Space Communications and Networks or Spread Spectrum Communications
18.100 – Analysis
16.391 – Statistics
6.435 – System Identification

Networking Focus:

6.252 or 6.253 – optimization
18.415 or 18.416 – Advanced algorithms
6.435 or 6.436 – advanced probability
16.** - Space Communications and Networks