Discover Viterbi: Astronautical Engineering

Professor Mike Gruntman
Program Director, M.S. in Astronautical Engineering

Meghan Balding
Graduate & Professional Programs

November 17, 2015
<table>
<thead>
<tr>
<th>WebEx Quick Facts</th>
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<tbody>
<tr>
<td><strong>Will I be able to get a copy of the slides after the presentation?</strong></td>
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<tr>
<td><strong>YES!</strong></td>
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<tr>
<td><strong>How can I ask a question during the info session?</strong></td>
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<tr>
<td>1. Use the Q&amp;A panel to the right of this presentation.</td>
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<tr>
<td>2. Type your question in the box.</td>
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<tr>
<td>3. An USC representative will answer your question as soon as they are able.</td>
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Today’s Program

- The University of Southern California
- Viterbi School of Engineering
- Master of Science in Astronautical Engineering
  - Program Overview
  - Application Criteria
- DEN@Viterbi
- Tuition & Fees
- Q&A
University of Southern California
University of Southern California

- Oldest private university in western U.S. – founded in 1880
- 43,000 Students: 19,000 Undergrads | 24,000 Graduates
- 3,900+ full-time faculty
- Diverse student population
A Dynamic Location: Los Angeles, California

Principal world center for aerospace, communications, biotech R&D, commerce, entertainment and the arts

Los Angeles provides a setting for numerous cultural, educational and career opportunities

California offers rich opportunities for internships and careers, with Silicon Valley to the north; the hub of biotech activity in San Diego, to the south; and Silicon Beach to the west - right in our back yard.
Viterbi School at a Glance

- **Academic Departments**
  - 8 Academic Departments

- **Faculty**
  - 180 tenure-track faculty
  - 22 NAE
  - 60+ NSF CAREER, Nat’l & Presidential Young Investigator

- **Student population**
  - 2,600 Undergraduate
  - 5,200 Graduate students

- **Alumni**
  - More than 60,000+

- **Research**
  - Leader in funded research 45+ Research Centers

- **More than 60,000+**

- **Leader in funded research 45+ Research Centers**
Recent Announcements

• Top Ranked Graduate Engineering Program

• Ranked #1 in Online Computer Information Technology Program (Computer Science)
• Top 3 Ranked Online Graduate Engineering Program

• Ranked #1 Online Computer Information Technology for Veterans
• Ranked #2 Online Graduate Engineering for Veterans
Viterbi School: Points of Distinction

- International Reputation for Excellence
- World Class Faculty & Research
  - NSF Career Awardees
  - Sol Golomb, Nat’l Medal of Science
  - MIT TR35 Faculty Distinctions
- Trojan Family Network
- Complete range of programs
  - Ph.D., Master’s & Bachelor’s Programs
  - Graduate Certificates
  - Continuing Education Short Courses
  - Custom Programs
Viterbi School is a consistent leader in funded research in the U.S.

- highly interdisciplinary research environment
- diverse research areas as robotics, software engineering, sensor networks, vision sciences, automated construction and photonics
- over 45 research centers
- industrial partnerships and collaboration
Course Delivery Methods

Methods of Course Delivery

❖ On-campus, full time
  o 3 classes per semester
  o 1.5-2 years to complete degree

❖ Online delivery via DEN@Viterbi
  o 1-2 classes per semester
  o 2 ½ - 3 years to complete degree
Distance Education Network (DEN@Viterbi)

More than 40 years of distance education expertise

Online delivery makes earning an MS degree practical and flexible for working professionals

DEN@Viterbi students:

• View the same lectures as on-campus students, with fresh content every semester
• Participate in highly interactive discussions with professors and peers
• Submit homework electronically
• Take exams at proctored testing centers near their home or work (or at USC if in the Los Angeles area)
## Distance Education Network (DEN@Viterbi)

<table>
<thead>
<tr>
<th></th>
<th>DEN@Viterbi Student</th>
<th>On-Campus Student</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Program Admission</strong></td>
<td>USC Graduate Application &amp; required materials</td>
<td>USC Graduate Application &amp; required materials</td>
</tr>
<tr>
<td><strong>Weekly Course Lectures</strong></td>
<td>Online with Interactivity</td>
<td>On USC’s Campus</td>
</tr>
<tr>
<td><strong>Online Course Archives</strong></td>
<td></td>
<td>✅</td>
</tr>
<tr>
<td><em>(Lectures &amp; Course Documents)</em></td>
<td></td>
<td>✅ *</td>
</tr>
<tr>
<td><strong>Assignments</strong></td>
<td>Submit electronically via email or fax</td>
<td>Submit during lecture or lab according to course deadlines</td>
</tr>
<tr>
<td><strong>Exams</strong></td>
<td>Proctored location</td>
<td>USC’s campus</td>
</tr>
<tr>
<td><strong>Courses per Semester</strong></td>
<td>1-2</td>
<td>3-4</td>
</tr>
<tr>
<td><em>(Average)</em></td>
<td></td>
<td></td>
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<tr>
<td><strong>Degree Completion Requirements</strong></td>
<td>27-34 units with a 3.0 GPA or above</td>
<td>27-34 units with a 3.0 GPA or above</td>
</tr>
<tr>
<td><strong>USC Diploma</strong></td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td><em>(No Distinction)</em></td>
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</tbody>
</table>

*DEN@Viterbi sections only.
Schematic of deflagration

- Reaction zone
- Direction of propagation: Speed relative to unburned gas = $S_L$
- Temperature
- Reactant concentration
- Convection-diffusion zone
- Distance from reaction zone
- Flame thickness ($\delta$) ~ $\alpha/S_L$

Turbulent premixed flame experiment in a fan-stirred chamber (http://www.mech-eng.leeds.ac.uk/res-group/combustion/activities/Bomb.htm)

Videos can be streamed or downloaded at high resolutions.
DEN@Viterbi’s E-Learning System

DEN@Viterbi Classroom on USC’s Campus
Limited Status

- Allows strong candidates to begin coursework before formal admission.
- Courses *(maximum of 12 units)* can be applied toward degree program once admitted but *limited status does not guarantee admission*.
- Get Started: [http://gapp.usc.edu/graduate-programs/den/getting-started](http://gapp.usc.edu/graduate-programs/den/getting-started)

Tuition Deferment Program

- Students supported by company can defer “up front” payment of tuition until after the semester is over.
- Company must pay 75-100% of tuition to be eligible for program.
- For additional information: [http://gapp.usc.edu/tuitiondeferment](http://gapp.usc.edu/tuitiondeferment)
Tuition & Fees for M.S. Students

<table>
<thead>
<tr>
<th>PER-COURSE TUITION</th>
<th>Tuition for 3-Unit Course</th>
<th>Tuition for 4-Unit Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>500/600 level course: $1,774 per unit</td>
<td>$5,322</td>
<td>$7,096</td>
</tr>
</tbody>
</table>

• Degree Programs are 27-34 units (9-11 courses)

• For an overview of additional fees, please visit: https://gapp.usc.edu/graduate-programs/graduate-funding/masters/tuition
General Application

Deadlines

FALL – January 15
  ❖ For on-campus students: Apply by December 15 for funding consideration

SPRING – September 15

Apply Online
  ❖ http://www.usc.edu/admission/graduate/apply
Getting Started

For those interested in taking classes on campus:
  ❖ Visit USC campus
  ❖ Start your application:
    http://www.usc.edu/admission/graduate/apply

For those interested in DEN@Viterbi delivery
  ❖ Start as Limited Student next semester or apply for admission at the link above
Meet Professor Mike Gruntman

Mike Gruntman
Professor of Astronautics
USC Viterbi School of Engineering

Research Interests:
Astronautics, spacecraft and space mission design, space physics, space instrumentation and space sensors, space exploration, rocketry, spacecraft technologies, space education, and space and rocket history
Master of Science in Astronautical Engineering

Mike Gruntman
Program Director
Master of Science in Astronautical Engineering

November 17, 2015
Agenda

- Department of Astronautical Engineering
- Faculty
- Research Areas, Collaborations
- Degree: *Master of Science in Astronautical Engineering*
- Students
- Coursework
- Criteria for MS Applicants
- Contact info

About the program – article in *Acta Astronautica*, 2014

MS ASTE at your fingertips
Department of Astronautical Engineering

• Established as Astronautics and Space Technology Division in 2004 “to take full advantage of growing opportunities in space”
  – founding Chairman (2004–2007) Prof. Mike Gruntman

• Operated as a department from 2004
• Built upon astronautical specialization, started in 1995
• Followed standard process in building a new department in a university (degree approval, course development, ABET accreditation, student affairs, ...)
• Responsible for programs in space engineering in USC
• Established a full set of degrees, including a large nationally-prominent Master’s degree program
• **Department of Astronautical Engineering** since July 2010
Department of Astronautical Engineering

- Unique pure-space-engineering department
- Offers the full set of degrees in Astronautical Engineering (ASTE)
  - Bachelor of Science
  - Bachelor of Science Minor
  - Master of Science
  - Engineer
  - PhD
  - Graduate Certificate
- Among largest national programs in space engineering
- Mission: to provide forefront research and education in astronautical (space) engineering
Faculty, Adjunct Faculty, and Lecturers

**Faculty**
- Prof. Daniel A. Erwin (Chairman)
- Prof. Mike Gruntman (Director, Master of Science Program)
- Prof. Joseph A. Kunc (PhD Adviser)
- Prof. Azad Madni
- Prof. E. Phillip Muntz
- Prof. Stan Settles (joint appt.; ISE/SAE)
- Prof. Joseph Wang

**Research Faculty**
- Prof. Elliot Axelband
- Prof. David Barnhart
- Prof. Sergei Gimelshein
- Prof. Jo Ann Lane
- Prof. Herb Schorr (joint appt.; ISI)
- Prof. Peter Will (joint appt.; ISI)

**Adjunct Faculty and Lecturers (grad courses)**
- Dr. Mohamed Abid (JPL)
- Dr. Oscar Alvarez-Salazar (JPL)
- Dr. Azam Arastu (Boeing)
- Dr. Kirstie Bellman (Aerospace Corp.)
- Prof. Robert Brodsky (ret., TRW)
- Dr. Douglas Buettner (Aerospace Corp.)
- Prof. Bruce Cordell (21st Century Waves)
- Prof. Don Edberg (Cal Poly Pomona)
- Dr. Anthony Freeman (JPL)
- Dr. Michael Gabor (TASC)
- Dr. Keith Goodfellow (Aerojet Rocketdyne)
- Dr. Troy Goodson (JPL)
- Prof. Gerald Hintz (ret., JPL, Aerospace Corp.)
- Prof. Michael Kezirian (Boeing)
- Dr. Johnny Kwok (JPL)
- Dr. Steve Matousek (JPL)
- Dr. Leila Meshkat (RAND)
- Dr. Ryan Park (JPL)
- Dr. Robert Parker (ret.; Northrop-Grumman)
- Dr. G.P. Purohit (Aerospace Corp.)
- Dr. Madhu Thangavelu (AAA Visioneering)
- Prof. Kent Tobiska (Space Environm. Techn.)
- Prof. James Wertz (Microcosm)
- Dr. Bret Williams (Raytheon)
- Dr. Sydney Yuan (Aerospace Corp.)
Books by Faculty and Lecturers
Research Areas

- Astronautics
- Space environment and spacecraft interactions
- Space science
- Space instrumentation and sensors
- Spacecraft propulsion
- Space mission and spacecraft design
- Non-equilibrium processes in gases and plasmas
- Computational physics and high performance computing

- Faculty are PI’s and Co-I’s on programs supported by NASA, Air Force, Navy, NSF, industry
- Science team member/investigator/development: Pioneer 10/11, SOHO, Deep Space 1, IMAGE, Dawn
- Current NASA missions Co-I: TWINS and IBEX

- Student (undergraduate) projects
  - Sounding rocket
  - Lunar lander
  - Student microsatellite
  - International Student Satellite
Interdisciplinary Collaborations

- Interdisciplinary collaborations with other USC departments/schools
  - Systems Architecting and Engineering
  - Electrical Engineering
  - Mechanical Engineering
  - Information Sciences Institute (ISI), VSOE
  - Physics and Astronomy

- External collaborations
  - U.S. Universities (Harvard, UC Berkeley, U of Arizona, BU, …)
  - NASA centers (JPL, Goddard)
  - DoE National Labs (Los Alamos)
  - R&D centers (Applied Physics Laboratory; Southwest Research Institute, …)
  - Industry (Northrop-Grumman, Lockheed-Martin, Boeing, …)
  - Foreign R&D centers and universities (Germany, Japan, …)
Master of Science Program in Astronautical Engineering

• Degree in the highly dynamic and technologically advanced area of astronauts and space technology

• Program designed for those with **B.S. degrees in science and engineering** who work or wish to work in the space sector of the space/defense/aerospace industry, government research and development centers and laboratories, and academia

• Combines science and engineering fundamentals with specialized courses

• VSOE Astronautics faculty and adjunct faculty and lecturers from leading space companies and government space R&D centers (Boeing, Lockheed-Martin, Northrop-Grumman, Aerospace Corporation, NASA Jet Propulsion Laboratory, Raytheon, Aerojet Rocketdyne, Microcosm, Space Environment Technologies, …)
Students

- Students pursuing MS in Astronautical Engineering
  - Full-time on-campus students – 20-30%
  - Working full-time and studying part-time students (through Distance Education Network of the Viterbi School – DEN@Viterbi) – 70-80%
  - Active duty military (Air Force, Army, Navy, Marine Corp)
  - Student background (BS and MS degrees)
    - Astronautical engineering
    - Mechanical Engineering
    - Electrical engineering
    - Aerospace engineering
    - Other areas (chemical, computer, systems, etc) of engineering
    - Physics and Astronomy
    - Other areas of science (including medical doctors)
    - Planning apply for astronaut training
  - Pathway to positions in system engineering of space systems (especially important for engineers with BS and MS in EE, ME, etc.)
## Master of Science Program in Astronautical Engineering

### Students

- National statistics (American Society of Engineering Education – ASEE) combines students in astronautical, aeronautical, and aerospace, engineering in one broad group (>50 departments in the United States)
- In **AY 2011-2012**, USC MS ASTE program accounted for **2.7%** of national enrollment in this broad aerospace/astronautical/aeronautical group

### Astronautics M.S. Students

- Among students working full-time and studying part-time in **AY 2011-2012**, USC MS ASTE program accounted for **6.6%** of national enrollment of astronautical/aeronautical/aerospace students

### National Reach (through Distance Education Network DEN@Viterbi)

- Students pursuing MS ASTE through DEN in 2005–2014
- Also in Canada (Ontario and Quebec) and various military installations abroad

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November 17, 2015

USC Astronautics
Master of Science Program in Astronautical Engineering

Astronautics M.S. Students
M.S. Degrees Awarded: annually 38+ (average) during the last 8 years
3.3% nationally awarded Master’s degrees in astronautical/aeronautical/aerospace engineering

USC/VSOE Master of Science in Astronautical Engineering (ASTE)

Number of MS ASTE Graduates

04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14

Academic Year

Students

USC Astronautics

November 17, 2015
Community of Alumni, Students, and Supporters

USC Astronautics

networking group launched in April 2009

>600 members (as of Jul 2015)

http://astronauticsnow.com/astrousc_linkedin/
Coursework

Master of Science in Astronautical Engineering coursework requirement: total of 27 units or 9 courses (one course is usually 3 units)

- **4 required astronautics courses**
  - Spacecraft Systems Design
  - Space Environment and Spacecraft Interactions
  - Spacecraft Propulsion
  - Orbital Mechanics

- **3 core elective courses** from the list of astronautics core courses

- **2 technical elective courses** selected from courses in astronautical engineering and/or from other science/engineering graduate courses
  - MS Program in Astronautical Engineering never limits choice of technical elective courses to those offered by the home department but rather encourages students to choose engineering and science graduate courses best meeting their educational objectives

- **MS Thesis is optional (possible but not required)**
<table>
<thead>
<tr>
<th>Coursework</th>
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<tbody>
<tr>
<td>❑ Spacecraft System Design</td>
<td>❑ Space Launch Vehicle Design</td>
</tr>
<tr>
<td>❑ Space Environment and Spacecraft Interactions</td>
<td>❑ Design of Low Cost Space Missions</td>
</tr>
<tr>
<td>❑ Orbital Mechanics I, II</td>
<td>❑ Space Studio Architected</td>
</tr>
<tr>
<td>❑ Space Navigation: Principles and Practice</td>
<td>❑ Spacecraft Power Systems</td>
</tr>
<tr>
<td>❑ Spacecraft Attitude Dynamics</td>
<td>❑ Spacecraft Thermal Control</td>
</tr>
<tr>
<td>❑ Spacecraft Attitude Control</td>
<td>❑ Systems for Remote Sensing from Space</td>
</tr>
<tr>
<td>❑ Spacecraft Structural Dynamics</td>
<td>❑ Spacecraft Sensors</td>
</tr>
<tr>
<td>❑ Spacecraft Structural Strength and Materials</td>
<td>❑ Safety of Space Systems and Missions</td>
</tr>
<tr>
<td>❑ Spacecraft Propulsion</td>
<td>❑ Human Spaceflight</td>
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<tr>
<td>❑ Liquid Rocket Propulsion</td>
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</tr>
<tr>
<td>❑ Advanced Spacecraft Propulsion</td>
<td>➢ Continuously developing and introducing new coursework</td>
</tr>
<tr>
<td>❑ Physical Gas Dynamics I, II</td>
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Master of Science Program in Astronautical Engineering

Criteria for Applicants

• Candidates for formal admission to the Master of Science in Astronautical Engineering program require:
  - Bachelor of Science degree in engineering or science from a regionally-accredited institution
  - Minimum cumulative grade point average [GPA] of 3.0 on a 4.0 scale
  - General portion of the Graduate Record Examination [GRE]
  - Two letters of recommendation

• Department application deadlines:
  1 June for fall; 1 November for spring; 1 March for summer

• It is possible to begin studies prior to formal admission to the program as a limited student. You need to apply to Distance Education Network (DEN@Viterbi) for enrollment as a limited student. After your limited-student application is processed, DEN will allow you to enroll in the classes.
### Master of Science Program in Astronautical Engineering

#### Common Questions

- **Typical time to complete the program**
  - Full-time students: 1.5 years
  - Part-time student: 3 – 4 years (1 – 2 courses per semester)

- **Course sequence (e.g., required before electives?)**
  - Course sequence is entirely up to students. Advisors help as needed. Few exceptions: space navigation requires orbital mechanics; advanced propulsion requires propulsion, ...

- **Waiver of required courses – yes**
  - Required courses waived if a student had similar level courses elsewhere.

- **Technical electives from other departments – yes**
  - Almost any graduate science and engineering course approved

- **System engineering**
  - Pathway to system engineering of space systems, especially for engineers with BS and MS in EE and ME

- **Attending classes on campus by distance students – welcome!**

- **Difference between programs in Astronautical and Aerospace Engineering**

- **Industry interest**
  - Enrollment and graduation dynamics prove: we meet the real demand of the industry/gov’t
Contact Us

Department of Astronautical Engineering

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ASTE Chairman
Prof. Daniel A. Erwin
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tel. 213–740–5536

MS ASTE Faculty Advisor & Program Director
Prof. Mike Gruntman
mikeg@usc.edu
tel. 213–740–5536

About the program – article in Acta Astronautica, 2014

MS ASTE at your fingertips

Frequently Asked Questions
http://astronauticsnow.com/msaste/
CONTACT US

USC Viterbi School of Engineering
Graduate and Professional Programs

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Email (DEN@Viterbi): DEN@Viterbi.usc.edu

Phone: 213.740.4488

Web: http://viterbi.usc.edu/msdegrees