ESS 265
Instrumentation, Data Processing and Data Analysis in Space Physics

Lecture 1: Overview; Access to Space

C.T. Russell

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Content, Grade

- **ESS 265: Instrumentation, Data Processing and Data Analysis in Space Physics:**
- **Course ID 578-390-200**
- Catalogue Description:
  Principles, testing and operations of magnetometers and other instruments. Data processing, display and archiving. Time series analysis techniques, including filtering. Fourier series, eigen analysis and power spectra. Units 4.
- Room 4677 Geology; Monday, Wednesday, 9:30-11:00 AM, and occasionally Friday. See detailed schedule.
- Course grade will be assigned by consultation between the two lecturers: C. T. Russell and V. Angelopoulos.
- Grading A/B/C preferred; S/U possible
- Textbook: None required.
- The grades for the course will be based on the performance on assignments during the quarter. There is no final exam scheduled. The weighting for the final grade will be as follows:

  Written assignment 50%
  Data analysis assignments 50%

The Assignment

- Written Assignment
- Select a class of instrumentation used on space missions of a type not described in the class notes. Read about the different ways that this class of instruments has been implemented on different missions. Prepare a written report describing the operating principles, the strengths and limitations of this approach, e.g. accuracy and precision obtained. Describe the nature of the differences in various implementations. Include diagrams and instrument specifications such as dimensions, mass, power, data rates etc. Assignment will be due on May 7. This draft will be commented on and returned to the students. The final copy will be due on May 30.
- See online book list for some helpful references.
- A number of software packages developed for both educational and research purposes may be useful for this class.
- We will maintain a set of lecture notes for this class online. Some of these from previous years will not be used but are maintained for background reading. Often links from earlier times get broken. Please let the instructors know when you find a broken link.

On-line Material

Chapter 1. Access to Space
Chapter 2. Mission Design
Chapter 3. Past, Present, and Future Missions
Chapter 4. Magnetometers (*A History of Vector Magnetometry in Space* by Bob Snare)
Chapter 5. Ionospheric Instrumentation
Chapter 6. Deep Space Instrumentation
Chapter 7. Time Series Analysis Techniques in Space Physics
Chapter 8. Fourier Wavelet Analysis
Chapter 9. Correlation and Regression

- Classical Error Analysis
- Bootstrap, Autoregression, and Model Selection
- Linear Prediction Filtering and Neural Networks

Chapter 10. Simulations
Chapter 11. Distributed Information System

Previous Lectures

Ray Walker lessons available @ http:lucid.igpp.ucla.edu/lessons/ess265/2005
McPherron first five (2001) lectures: http://www.igpp.ucla.edu/lucid/lessons/ess265/
McPherron programs and data files can be found at
ftp://ftp.igpp.ucla.edu/rmcpherr/teaching/ess265_spring_2001/

Website for ESS 265 Class Material

http://www-ssc.igpp.ucla.edu/personnel/russell/ESS265/ESS265_Instrumentation.html

Useful Books

- General Space Physics
  - Introduction to Space Physics, (Edited by M.G. Kivelson and C.T. Russell) Cambridge University Press, 1995.
- Analysis Techniques
  - Analysis Methods for Multispacecraft Data, (Edited by G. Paschmann and P.W. Daly), ESA Publications, 1998.
  - Time Series Analysis and Inverse Theory, D.A. Gubbins, Cambridge, 2004.
- Measurement Techniques
  - Measurement Techniques in Space Plasmas: Fields
  - Measurement Techniques in Space Plasmas: Particles, (Edited by R.F. Pfaff, J.E. Borovsky, and D.T. Young), American Geophysical Union, 1998.

Mission and Payload Descriptions

- The Galileo Mission, (Edited by C.T. Russell), Kluwer, 1992.
- The Global Geospace Mission, (Edited by C.T. Russell), Kluwer, 1992.
- The Cluster and Phoenix Missions, (Edited by C.P. Escoubet, C.T. Russell, and R. Schmidt), Kluwer, 1997.
- The Near Earth Asteroid Mission, (Edited by C.T. Russell), Kluwer, 1997.
- The Advanced Composition Explorer Mission, (Edited by C.T. Russell, R.A. Mewaldt, and T.T. Von Rosenvinge), Kluwer, 1998.
- The Genesis Mission, (Edited by C.T. Russell), Kluwer, 2004.
- 2001 Mars Odyssey, (Edited by C.T. Russell), Kluwer, 2004.
- The Cassini/Huygens Mission Vols. 1, 2, 3, (Edited by C.T. Russell), Kluwer, 2003, 2004.
- The IMS Source Book, (Edited by C.T. Russell and D.J. Southwood), American Geophysical Union, 1982.

Agencies Responsible for Undertaking Space Science Research

- In US
  - National Aeronautics and Space Administration (NASA)
    - HQ – Washington, D.C.
  - National Science Foundation (NSF)
    - HQ – Alexandria, VA
- In Europe
  - European Space Agency (ESA)
    - HQ – Paris
  - National Agencies – DLR, ASI, etc.
- In Japan
  - Japanese Exploration Agency (JAXA)
- Also Russia, India, others?

NASA

- Administrator: M. Griffin
- Science Mission Directorate: E. Weiler (interim)
  - Heliophysics: R. Fisher
  - Solar System Exploration: J. Green
  - Astrophysics
  - Earth Science
- Exploration Directorate
  - Exploration to the directorate means humans in space
- Several other Directorates of lesser importance to science
- Work is carried out at Centers
  - Goddard, JPL, Ames, Glenn, Langley, Marshall, Kennedy, Johnson, others

Physical Structure

- Headquarters: Washington, D.C.
  - Planning
  - Administration
- Goddard Space Flight Center: Greenbelt, MD
  - Space Physics
  - Astrophysics
  - Earth Science
  - NSSDC
- Marshall Space Flight Center, Huntsville, AL
  - Rockets
  - Space lab operations
- Ames Research Center: Mountain View, CA
  - Aeronautics
  - Pioneer Venus
- Jet Propulsion Laboratory: Pasadena, CA
  - Planetary
  - Deep Space Network
- Johnson Space Center: Houston, TX
  - Manned Space Flight
  - Lunar Studies
- Glenn Research Center: Cleveland, OH
  - Propulsion
- Kennedy Space Center
  - Launch Facility
- Others

Old Way of Doing Business

- Competition within and between disciplines for new start opportunities
- Biggest, most ambitious program always won
  - Better than competition
  - Limited number of new starts
  - Increased NASA's budget
- Problems
  - Hard to manage small number of big programs
  - Big projects are complex and therefore risky
  - Cost non-linearly related to size
  - Pressure to use space shuttle

New Way of Doing Business

- Fewer ambitious projects
  - Decreased emphasis on Great Observatories and outer planets (but Pluto Flyby)
  - Small Explorers (SAMPEX, FAST)
  - Discovery spacecraft (NEAR, MARS Pathfinder, others)
  - Smaller launch vehicles
  - New technology

Obtaining Funding

- NASA releases Announcements of Opportunity “AOs” for mission participation
  - Information on opportunities can be found on the NSPIRES website
  - Funding for data analysis, modeling is under the line “Research Opportunities for Space and Earth Sciences (ROSES)”
- NSF does not usually issue AOs but does have dates for proposal evaluation
  - Space Physics is under the Geosciences Directorate under Atmospheric Science Programs
  - Code ATM funds Aeronomy, Magnetospheric Physics and Solar Terrestrial Research
  - These three areas have programs that sponsor annual meetings CEDAR, GEM, and SHINE

Advisory Process: National Research Council

- National Academy of Science (and of Engineering) run the National Research Council that conducts independent studies for the government including NASA.
- Studies require funding so that advice is generally given only in areas in which the agencies request it.
- NSF receives advice from a standing committee: Committee on Solar Terrestrial Research
  - Top level advice from National Science Board (internal)
- NASA obtains advice from the Space Studies Board and its committees
  - Committee for Solar and Space Physics
  - Committee for Planetary and Lunar Exploration
  - Others
- NRC runs Decadal Studies/Surveys that advise both NSF and NASA
  - Solar and space physics
  - Planetary Exploration
  - Astrophysics
  - Earth Science
- NASA now has only one internal science advisory committee, the NASA Advisory Council (NAC), that has three subcommittees of science. There are no web links to NAC.

NASA Planning Process

- Based on the top level advice given by the NRC and the NAC and following its top level Strategic Plan, NASA develops planning documents or roadmaps that address specific objectives in the Strategic Plan.
- Roadmaps are developed in Heliophysics as solar and space physics is now called by NASA, Solar System Exploration and in Astrophysics
- When a mission from a Roadmap is selected for development, it undergoes further planning by a Science Design Team. When the SDT is disbanded, the mission is completed (instruments selected) and more planning takes place in Phase A of the mission.
- In a PI-led mission, science planning is generally completed as part of the selection process.

Mission Categories

- Announcements of Opportunities (AOs) allow the submittal for proposing a PI-led mission or an investigation on a mission.
- Heliophysics and astrophysics have SMEX (~$150M) and MidEx (~$250M) missions.
- Planetary has Discovery and Scout (~$450 M) and New Frontiers (~$750M) missions.
- Larger missions are required to be center-led: Solar Terrestrial Probes and Living with a Star missions for example [STEREO, Magnetosphere Multiscale, Radiation Belt Storm Probes, Solar Sentinels]
- Cosmic Vision is the latest large program line in Europe.
- Japan has Geotail (part of ISTP); Venus Climate Orbiter (alone); Bepi Colombo with ESA

Selection Process: Obtaining Congressional Approval

- Year N-2 -Prepare budget request for Office of Management and Budget
  -Send request to OMB in Fall
  -In December OMB tells NASA what it accepts
  -NASA makes a reclama to get more funds
- Year N-1 -In February, President sends budget to congress
  -House and Senate debate authorization bill
  -Joint committee resolves differences
  -House and Senate debate appropriation bill which allows NASA to spend money
  -Joint committee resolves differences
  -Ideally money is available on October 1
  -Recently no agreement and continuing resolution at last year's budget

Selection Process: Grants

- AO appears
- Submit notice and intent to propose
- Write proposal and submit
- NASA sends proposals to reviewers
- Reviewers send NASA their opinions
- Panel assembles reviews and adds their opinions
- NASA tells proposer if funding will be made available

Selection Process: Missions

- Draft proposal published and comments accepted
- AO published and 90 days given for proposal to be submitted
- Proposal review takes about 6 months: Science panel and TMCO
- Panels look for major weaknesses, minor weaknesses, major strengths and minor strengths in many areas
- Several missions selected for competitive study – Concept Study Report
- After several months of study, new, very detailed reports submitted
- Panel reviews them, makes a long list of hard questions and gives them to proposers a couple of days before a site visit
- After further deliberation a winner is announced

Mission Development Phases

Phase A - Concept Study Report or Initial Planning (Feasibility) Phase

Phase B - Planning or Formulation Phase

Preliminary Design Review - Allows project to proceed to next phase

Phase C - Building or Implementation Phase

Critical Design Review - Allows project to order parts and build

Phase D - Assembly, Integration, Test and Launch Operations (ATLO)

Pre-ship Review - Allows project to ship to launch site

Phase E - Post-launch operations

Phase F - Closing the books.