AOSS STRATEGY

Integrated study of air and space – where science and engineering merge

This is a living document that describes the goals of the Atmospheric, Oceanic, and Space Sciences (AOSS) Department at the University of Michigan, Ann Arbor. This document in strategic in nature; it defines and clarifies the goals with the primary activities in which the faculty and staff AOSS participate. It also describes future directions in which the department would like to move.

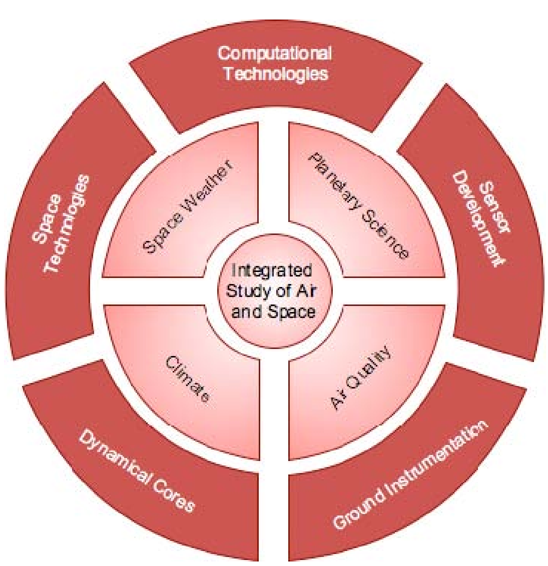
RESEARCH GOALS

The goals of AOSS are

- To establish a vigorous Earth systems science research program to meet national and global needs.
- To revitalize our space science and engineering program, by building a vigorous program leading from basic research in the space environment of the solar system to applied knowledge for Government and industry.
- To maintain traditional strengths in planetary exploration and in air quality research, with application to environmental studies.

We embrace our department's unique position within the College of Engineering emphasizing the design and use of new instruments and models to explore our complex space and Earth systems.

These goals are so broad that no single department or even College can span its entire range. The AOSS vision for the coming years is to perform research that focuses on the integrated study of the atmosphere and of the space environment of Earth and planets. It recognizes that these are systems with disparate physical and chemical processes. The processes and domains have highly non-linear interactions and feedbacks that have major impact on the system as a whole. Therefore, our primary focus is the investigation of multiple components or aspects of the system that are also important to the mean state and variance of the system as a whole.



It is our vision that AOSS will focus on four interrelated science areas: climate, space weather, planetary science, and air quality. These areas are interrelated and their study employs several common methodologies and technologies: computational technologies, dynamical cores of global numerical models, sensor developments, ground instrumentation and space technologies.

It is a direct consequence of our focus on integrated system science that we expect our faculty to have broad interests, preferably covering two or more science areas and several underlying methodologies or technologies. It is our goal that our atmospheric and Space science faculty develop and use shared methods and technologies and thus pioneer an integrated approach to the integrated study of air and space – the future of our planet. As we will discuss below initial steps have already been made in this direction. Our challenge is to strengthen our crosscutting efforts and develop a hiring strategy that is consistent with this vision.

2 Education Goals

It is the goal of AOSS to have a viable undergraduate program, a world class Ph.D. program in both atmospheric and space sciences, and a strong and unique SGUS/MEng program in space engineering. In the last few years we completely “reinvented” our undergraduate program.

The new Earth System Science and Engineering program is successful and in three years we accomplished our five-year goal of 50 ESSE majors. The program still need some fine-tuning, but it is on track. The undergraduate courses are fairly general (including the lab courses) and it can be taught with the broad-based faculty of AOSS.

Our Ph.D. program is of very high quality and it does not need major changes. The space and planetary science program is stable and very successful. The atmospheric science program is also strong, but it needs more faculty to teach specialized graduate courses. This need can be met by the research agenda driven tenure-track faculty hiring plan (to be discussed below).

One of our main education focus areas is the SGUS/MEng in Space Engineering. This program presently has about 20 students enrolled, and our goal is to grow it to an enrollment of about 30. The crucial emphasis here is on hands-on work of students of multiple engineering disciplines. Such work could be encouraged in a classroom setting, as well as an independent project setting. The courses in this program can be taken by students from throughout the College, and contribute to our growth in Student Credit Hours.

AOSS also needs to focus on increasing our student credit hours, especially in the CoE. The service courses we teach in LS&A should be critically evaluated. Presently only AOSS-102 (Extreme Weather) and AOSS-105 (Changing Atmosphere) have large enough enrollments to justify teaching them (we teach these courses both in the Fall and Winter terms). We should suspend teaching all other service courses in other Schools and Colleges. Simultaneously, we should teach at least 2 sections of the high enrollment introductory engineering courses (ENG100 and ENG-101). Our goal is to reach 5000 SCH a year. This would be close to the CoE average per T&TT faculty.

3 IMPLEMENTATION

3.1 Criteria for a Successful Strategy

The following are a set of four criteria for success against which the strategy should be judged.

1. **The opportunities for success are available and our entry is not severely handicappedby the dominance of some other organization.** The purpose of this strategy is to excel. We will be unlikely to excel by copying what others, such as CU and UCB, are doing. Similarly,

it would be foolish to compete head on with NCAR, GFDL, or Livermore.

2. **The opportunities for recognition are available**; in particular adequate funding is available. In today's environment, this requires diversification from NASA funding sources.

3. **Support and encouragement is available from the College of Engineering and the University of Michigan**. Our educational and research missions have to satisfy the College's needs, and our activities need to be recognized and rewarded by the University.

4. **Specific strategic elements need to be compatible with the global departmental goals.** Such compatibility enables cross-disciplinary collaborations across the diversity of the Department. The Department's mission is understandable if the various approaches are common.

3.2 Atmospheric Science

The proposed atmospheric science strategy has three components, leading from basic research to applied knowledge:

1. **Fundamental research to understand the changing climate of the Earth.** The purpose of this task is to develop breakthrough research to enhance our understanding of the fundamental physics of the climate system. Success criteria are given by publication and citation records, and the amount of paradigm-shifting knowledge obtained. Such breakthroughs can happen through observations, data analysis, and theory/modeling.

2. **Integrate this research into a system-level understanding of the climate system.** Large models play a crucial role for this second part. This integration task should take advantage of computational technologies developed in AOSS and other CoE departments.

3. **Apply this knowledge to support policy and mitigate societal impact.** The purpose of this aspect is to respond directly to engineering needs arising from climate change, taking full advantage of the CoE environment. Success criteria should be defined by the usefulness of our approaches to customer needs, patentable technologies, and spin-off technologies.

The accompanying educational thrust is:

4. **Focus education on excellence in the ESSE PhD program and student design and experimental work**. The crucial emphasis here is on hands-on work of students of multiple engineering disciplines. Such work could be encouraged in a classroom setting, as well as an independent project setting. This emphasis also enhances the AOSS undergraduate program and does not preclude participation through classroom teaching and experimental classes.

Climate science requires coordinated study that combines observations, theory, and prediction. Theory and prediction are often expressed by models of the climate system or its primary elements, the atmosphere, the ocean, the land, and the cryosphere. These elements encompass, tacitly, composition and chemistry, radiative transfer, clouds and aerosols, and biological process. Both natural and anthropogenic causes of variability will be investigated. We recognize the fundamental role of observations and emphasize the use of information from observations to evaluate model performance and to contribute to model development. We seek to investigate and quantify the underlying physical and chemical processes of the climate system and to isolate and predict variability from both natural and anthropogenic causes.

The atmospheric science component of AOSS will perform their research as partners and collaborators in the national and international community. In particular, we are committed to work with the major federal modeling centers, for example, the National Center for Atmospheric Research, the Geophysical Fluid Dynamics Laboratory, the National Aeronautics and Space Administration, and the Department of Energy. Model development will, often, contribute directly to these modeling activities. Therefore, model development will, most often, focus on particular components or sub-processes of key importance to the performance of these national models.

The importance of the investigation of the climate system has moved out of the realms of physical and natural sciences. We recognizes the importance of climate science to many other schools and departments in the University. Additionally, a measure of success of AOSS scientists is the use of AOSS research and researchers in national and international assessment activities. Given the growing requirements for the incorporation of climate science into the research of other disciplines, we seek to participate with, and when appropriate lead, research activities that span these many fields. Of special interest to the university community are issues of sustainability, natural resources, energy, transportation, and adaptation to climate change. We will advance the concept of using knowledge of the climate system to inform these other activities and improve the environmental security of the nation.

3.3 Space Science

The proposed space science strategy has three components, leading from basic research to applied knowledge:

1 **Fundamental research to understand the space environment of the Earth, the planets,and elsewhere.** The purpose of this task is to develop breakthrough research to enhance our understanding of the fundamental physics of the environments in question. Success criteria are given by publication and citation records, and the amount of paradigm-shifting knowledge obtained. Such breakthroughs can happen through experimental work, data analysis, and theory/modeling.

2 **Integrate this research into a system-level understanding with the goal of developing prediction capability.** Large models play a crucial role for this second part. This integration task should take advantage of computational technologies developed in AOSS and other CoE departments.

3 **Apply this knowledge to flight programs by NASA, DOD, and the U.S. aerospaceindustry.** The purpose of this aspect is to respond directly to engineering needs arising from space flight or other industrial challenges, taking full advantage of the CoE environment. Success criteria should be defined by the usefulness of our approaches to customer needs, patentable technologies, and spin-off technologies.

The accompanying educational thrust is:

4. **Focus education on excellence in the PhD program, the Space Engineering Mastersprogram, and student design and experimental work**. The crucial emphasis here is on

hands-on work of students of multiple engineering disciplines. Such work could be encouraged in a classroom setting, as well as an independent project setting. This emphasis also enhances the AOSS undergraduate program and does not preclude participation through classroom teaching and experimental classes.

The application-motivated themes put forward in topic (3), and also (2), are not found at other Universities. It takes advantage of the CoE environment and its breakthrough technologies. It focuses on environments and their relation to engineering in the relevant environments. These drivers are needed for space missions, near-Earth spacecraft from all agencies and industry, communications effects from space weather, and many more applications. Our major competitors have a science focus exclusively, perhaps with the exception of the Air Force Academy, which has a very different purpose.

Looking for new opportunities does not preclude the funding sources we have now. Moreover, it broadens our scope sufficiently to attract interest from DOD, NOAA, and the aerospace industry. In addition to traditional science disciplines, we can compete for funds that are focused on technology. This diversity has precedents, of course. The programs currently most successful in AOSS have that character, including work by the space environment modeling group. A strategic underpinning of these developments would enhance their impact and breadth. A stronger technology focus will also increase the likelihood for major wins of space instrumentation; a situation that is not currently likely in the absence of a strong technology effort.

The direction of the CoE can only be assessed once we understand the change of leadership in the College and the strategy the University of Michigan is planning to implement. There are good reasons to assume, however, that the CoE would be enthusiastic about our goals. First, it links AOSS closer to traditional engineering disciplines. Second, AOSS would take leadership in design and systems of interest to the broader industry and government labs. The educational role stressed in the strategy has an important history in AOSS through successful classes, such as AOSS 450 (JPL, Aerospace Corporation), AOSS 582 (GOOGLE, JPL), and AOSS 381 (S3FL, ICARUS).

4 Hiring Strategy

The following tactical steps are to illustrate the implementation of the strategy. The strategic imperatives could be pursued through other possible tactics:

4.1 FY06 Hires

In FY06 AOSS has two open T&TT positions, one in space science and one in atmospheric science. Our FY06 hiring strategy is the following:

- Hire one position at 50% T&TT level with the task to develop and run a Space Weather center similar to the SEC/NOAA, with focus on real-time weather forecasting. Encourage through modest startup funds to develop a distributed array of FPIs to analyze global space-environment characterization. (The split position will be accommodated with expected retirements.)

- Hire one position at 50% T&TT level to develop near-Earth radiation analysis and test laboratory, with the task to develop models and tests for radiation environments. Focus on breakthrough radiation-belt physics, and the Mars environment. (The split position will be accommodated with expected retirements.)

- Hire a climate/radiation scientist at 100% T&TT level (Assistant Professor) with the task to work with our emerging climate group and complement our existing capabilities.

4.2 FY07 Hires

In FY07 we expect to have two authorized searches. One anticipated position will be to replace Hunter Waite, and the other anticipated position will be to hire one more climate related scientist.

- For Hunter’s replacement we will conduct an open search with the emphasis on hardware and space technology.
- For the climate position we will look for observers who are developing instruments and/or are members of large climate research teams.

4.3 Future Hires

In the next decade we anticipate that over half of our present T&TT faculty will retire. We will continuously update this plan so that at any given time we have a well defined plan for the next three years or so. At the same time we recognize that the world is rapidly changing and we need to be extremely flexible and adjust our plans as the circumstances change.