SELF-STUDY
AND
2013-2017 STRATEGIC PLAN

Department of Earth Sciences
Millersville University
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I. Introduction

This is the Department of Earth Sciences’ (DES) self-study and strategic plan for 2013–2017. It results from input from the faculty and staff during department meetings and a dedicated retreat, and has been informed by university administrators, external reviewers, students, and alumni. This is meant to be an actionable plan, in that it will direct the investments of efforts and resources in the DES, the School of Science and Mathematics (SCMA), and Millersville University (MU) during the next several years, and the department will judge its progress and success against the elements of this plan. It is also a living plan, so that although it looks forward on a five-year timescale, it is intended that it will be revisited and renewed through that period as necessary. Throughout this document, the department strives to maintain alignment with the MU mission and strategic directions, while forging into new initiatives that it hopes will help steer the school and university in a direction that will help bring greater recognition and distinction to all.

The overarching theme guiding our strategic direction is Integration and Transformation, and this theme will be applied to all focus areas and guide the goals and initiatives that the department will pursue over the next several years. The strategic plan involves six focus areas, three required by the university for all program reviews, and three selected by the department from a list provided by the MU Office of Planning, Assessment and Analysis.

Required Focus Areas:
   I. Curriculum
   II. Student success
   III. Integrated planning

Selected Focus Areas:
   1. Faculty accomplishments
   2. Pedagogy (from the perspective of integration and transformation)
   3. Integration and transformation across and curriculum

II. Mission centrality

The mission is the keystone of a university. The DES takes seriously the alignment of its mission with the university mission, and understands that there should be a clear mapping between them.

University mission statement

*Millersville University recognizes excellence in teaching and learning as its reason for being and is committed to offering students a high quality, comprehensive university experience of exceptional value. Dedicated to providing nationally recognized programs that embrace the liberal arts, the University*
provides academic opportunities which are supported by outstanding faculty who are also accomplished scholars, artists and practitioners and are supported by a talented and dedicated professional staff.

The University provides an extensive range of academic and professional programs to meet the interests and needs of both undergraduate and graduate students. To better prepare students for a diverse society and workforce, the University embraces diversity of people, cultures, ideas and viewpoints. By balancing traditional and innovative learning environments both inside and outside of the classroom, this inclusive campus community enhances learning outcomes and better equips students for their chosen professions.

By preparing students to become well-rounded individuals for productive roles as civic and community engaged leaders and citizens, Millersville University contributes to the public good. The University stimulates intellectual and creative energy that fosters the growth of our students, faculty and staff and contributes to the social, political and economic advancement of the Commonwealth and the wider world. The Millersville University community pledges itself to academic freedom and encourages imagination and curiosity, unfettered discourse, the exchange of divergent and controversial opinion, and multicultural awareness and understanding within an environment of civility, mutual respect and cooperation.¹

University vision statement

The Millersville University experience will empower students to make a significant difference in the communities where they will live and work. Millersville will be a premier comprehensive public university.

Department of Earth Sciences mission statement

The mission of the Department of Earth Sciences is to provide a rich, authentic, challenging, and integrated learning experience for every student, both major and non-major. We strive to achieve a transformative environment through enlightened and comprehensive curricula, attentiveness to emerging trends, modern facilities and equipment, and meaningful opportunities for students to engage in undergraduate research and other co-curricular and trans-disciplinary activities.

Department of Earth Sciences vision statement

The vision of the Department of Earth Sciences is to provide an integrative learning experience in the Earth Sciences disciplines that is second to none.

¹ Approved by the President’s Cabinet on May 13, 2008 and the Council of Trustees on June 18, 2008.
² Alternate Assignments are charged either in-load (i.e. as part of the 24 contact-hour load) or as additional summer complement; dual appointments refer to duties that are additional to and concurrent with an individual’s full-time
Department values and traits
The DES faculty, staff, and students are committed to the following values and traits as we carry out the business of the department and our interactions between ourselves and with others:

We value:

1. The diversity of our staff, in perspective, gender, ethnicity and background, recognizing that this diversity is important to our organizational strength and excellence;
2. A working environment that supports excellence, transparency, flexibility, academic freedom, and the virtues of a healthy work-life balance;
3. Open and honest communication, respecting diverse perspectives, and striving to make organizational decisions that are consensus-driven and inclusive;
4. Teamwork, and demonstrating mutual respect within an atmosphere of collegiality;
5. Creativity that broadens our opportunities for success and humor that enlivens our workplace.

We will:

1. Conduct ourselves in a manner that is supportive of each other, respectful, tolerant of differences, and responsive to both individual and collective needs;
2. Carry out our responsibilities with a commitment to excellence and dedication to organizational goals and commitments;

By adhering to our mission, the DES has forged high quality programs of national and regional distinction. DES is one of a few departments to have achieved “flagship” status at MU, and faculty and staff are routinely called upon to offer guidance to the organization and community at-large on matters of innovation, transformation, and discipline-related expertise.

III. The Department of Earth Sciences
The Department of Earth Sciences is one of seven departments in the School of Science and Mathematics (SCMA). The DES offers five undergraduate majors: 1) geology, 2) meteorology, 3) ocean sciences and coastal studies, 4) ocean sciences and coastal studies-physical oceanography, and 5) earth sciences education with certification in secondary education. In addition, DES offers two BA degrees—earth sciences and earth sciences–environmental geology. The human resource serving these programs includes:
1. Ten full-time faculty members (seven tenured; three tenure-track). Nine department faculty have
doctorate degrees in their respective scientific disciplines and support the core programs in geology (3
faculty), meteorology (4 faculty), and ocean sciences and coastal studies (2 faculty), and share
responsibility for the B.A. and B.S.Ed. programs. A tenth faculty member with an earned Juris
doctorate (JD) was hired in fall 2012 to support the M.S. in emergency management (MSEM) and the
B.S. in emergency management (in development). One meteorology faculty member has a half-time
alternate assignment as director of the Center for Disaster Research and Education (3 c.h.) and
program coordinator of the MSEM (3 c.h.). Another meteorology faculty has a half-time alternate
assignment/semester as the DES chair in accordance with the Collective Bargaining Agreement
(CBA). Together these alternate assignments reduce the FTEs dedicated to meteorology by the
equivalent of one full-time faculty member. A geology faculty member has a half-time alternative
assignment to serve as Chair of the General Education Review Committee.

2. Two support staff: 1) the director of the Millersville University Weather Information Center who has
a dual appointment as a temporary part-time faculty member (TPTF) in DES, and 2) the department
secretary.

3. One computer/network support person with an M.S. in atmospheric science is assigned to the
department for 80% of his time from the Division of Information Technology. His office is located in
the meteorology facility and the DES chair serves as co-supervisor and takes part in his annual
evaluation. [The DES is responsible for approximately 80% of the campus Internet throughput.] He
also has a dual appointment as a TPTF in DES and teaches computer programming courses in
FORTRAN and Perl and shell scripting.

4. Nine TPTF (adjuncts) serving DES and the MSEM program.

The Center for Disaster Research and Education (CDRE), which hosts the MSEM program, became part
of School of Science and Mathematics in 2011 after several years as part of the School of Humanities and
Social Sciences. The CDRE director and MSEM program coordinator now report to the SCMA Dean.
With CDRE and its MSEM in SCMA, there is considerably more opportunity for synergistic activities
and integration. The MSEM program coordinator is an atmospheric scientists with assignments shared
between DES and CDRE. The new faculty hire in MSEM is part of the DES complement and brings an
expertise in business law and emergency management, areas that will serve DES well as we continue to
build the fledgling M.S. in Integrated Scientific Applications (MSISA) program. Approved by the
PASSHE Board of Governors in July 2011, the new MSISA program is the only graduate program solely

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2 Alternate Assignments are charged either in-load (i.e. as part of the 24 contact-hour load) or as additional summer complement; dual appointments refer to duties that are additional to and concurrent with an individual’s full-time responsibilities, and for which the individual is additionally compensated via a separate contract.
under the auspices of DES. The program coordinator reports to the SCMA Dean, and has a separate funding stream from DES, including current funding for two graduate assistantships. The MSISA is an inherently multidisciplinary program with four specializations (see mville.us/msisa), and has developed strong ties to several departments at MU and at Shippensburg University that offer courses that are relevant to the MSISA curriculum (e.g., economics, geography, and business administration), as well as the Extended Studies Program in Business at Shippensburg University. The organizational structure for DES is shown in Figure 1. **Error! Reference source not found.**

The department typically operates as a committee-of-the-whole, as in the case of this program review. Tenured faculty members serve on the DES evaluation committee for the purpose of reappointments, tenure, and promotion of non-tenured faculty members, and promotion and periodic (5-year) performance reviews for tenured faculty. The department chair is elected by the faculty for a three year term. The department also has representatives on faculty senate standing committees, the SCMA Curriculum Committee, SCMA Safety Committee, and the local collective bargaining council (APSCUF Meet-and-Discuss). In addition, faculty members serve as liaisons to the university library and to the School of Education for the B.S.Ed. in earth sciences education.

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**Figure 1: Organization and Management Structure for the Department of Earth Sciences**
**DES Faculty**

Faculty credentials (See Appendix J for Biographical information):

Regular full-time tenured or tenure-track faculty

**Clark, Richard D.**, Ph.D. (University of Wyoming, 1987), Chair, Department of Earth Sciences; Professor of Meteorology; Program Coordinator for the M.S. in Integrated Scientific Applications. Research interests: boundary layers and turbulence; atmospheric chemistry; airborne and balloon-borne atmospheric research; new learning environments for science education.
http://www.millersville.edu/esci/facultypages/r_clark.php

**DeCaria, Alex J.**, Ph.D. (University of Maryland, 2000), Professor of Meteorology. Research interests: Application of the Python programming language and the SciPy and NumPy libraries for scientific programming, data analysis and visualization.
http://www.millersville.edu/esci/facultypages/a_decaria.php

**Earman, Samuel**, Ph.D. (New Mexico Institute of Mining and Technology, 2004). Assistant Professor of Geology. Research interests: climate change impacts on water resources; snowmelt contribution to groundwater recharge; groundwater recharge and movement in mountains; basin-scale evolution of groundwater chemistry; natural tracer applications to investigations of groundwater systems; geophysical applications to investigations of groundwater systems.
http://www.millersville.edu/esci/facultypages/s_earman.php

**Hagelgans, Duane**, J.D. (Widener University School of Law, 2003). Assistant Professor of Emergency Management. Research interests: homeland security; mass distribution and medical countermeasures; regional preparedness; multi-agency coordination.
http://www.millersville.edu/cdre/faculty/duane-hagelgans.php

**Kumar, Ajoy**, Ph.D. (Old Dominion University, 1996), Associate Professor of Ocean Sciences and Coastal Studies. Research interests: Coastal Oceanography, Satellite Remote Sensing, air-sea interaction.
http://www.millersville.edu/esci/facultypages/a_kumar.php

http://www.millersville.edu/esci/facultypages/l_marquez.php

http://www.millersville.edu/esci/facultypages/j_price.php

**Sikora, Todd D.**, Ph.D. (Pennsylvania State University, 1996), Professor of Meteorology. Research interests: Marine meteorology, synthetic aperture radar, air-sea interaction.
http://www.millersville.edu/esci/facultypages/t_sikora.php

**Vaillancourt, Robert D.**, Ph.D. (University of Rhode Island, 1996), Assistant Professor of Ocean Sciences and Coastal Studies. Research interests: biological-physical interactions in the ocean;
polar oceanography; primary productivity; bio-optics and phytoplankton photosynthesis. http://www.millersville.edu/esci/facultypages/r_vaillancourt.php

Yalda, Sepideh, Ph.D. (Saint Louis University, 1997), Professor of Meteorology, Director, Center for Disaster Research and Education; Program Coordinator for the M.S. in Emergency Management. Research interests: Mesoscale climate statistics & Mesoscale modeling; climate dynamics and regional climate change; science education, and the development of new tools and technologies to improve science education at all levels, including computer-based immersion learning environments.
http://www.millersville.edu/esci/facultypages/s_yalda.php
http://www.millersville.edu/cdre/faculty/yalda_s.php

Temporary Part-time Faculty (adjuncts)
1. Joe Calhoun (Meteorology)
2. Eric Hörst (Meteorology)
3. David Fitzgerald (Meteorology)
4. Jay Parrish, Ph.D. (Geology)
5. Mary Ann Schlegel (Oceanography)
6. Edith Gallagher (Oceanography)
7. Tim Severson (EMGT)
8. Greg Zarus (EMGT)
9. Paul Charp (EMGT)

Faculty accomplishments: a selected self-study focus area
The DES annual reports (Appendix A) provide the details that portray faculty and staff who are driven to high professional productivity and engaged in service to their professional communities. Also contained in Appendix A are the faculty/staff key performance indicators for professional development, which provide a tally of the number of activities that faculty have engaged in over the past five years. When viewed in the context of our teaching load (24 contact-hours/year in accordance with our Collective Bargaining Agreement (CBA)), it tells a story of the level of commitment to a highly productive professional environment consistent with our aspiration of national distinction. The short list below provides a sampling of some of these accomplishments (Data taken from the Key Indicators, 2008-2012).

- Faculty presented 95 papers at national or international meetings; Students presented 32 papers or posters
- Faculty published 39 articles in refereed journals
- Faculty were elected or appointed to 31 leadership positions, including as (co)editors of journals, chairs of scientific and technical advisory committees, member of the Council of the American Meteorological Society (AMS) and trustee of the University Corporation for Atmospheric
Research (UCAR), the board of the Marine Science Consortium, UCAR Governance Task Group, and various AMS and UCAR committees

- Faculty and staff were awarded over $2.1 million in grants and contracts from 2009-2012
- Faculty were recipients of two major professional awards: the AMS Teaching Excellence Award (2008) and AMS Fellow (2012)

**Faculty collaborations**
One of the strengths of the DES is the rich collaboration with colleagues and allied partners on several fronts. Our faculty and staff collaborate internally within the department, across the SCMA, and with other MU departments. There is formal collaboration between organizational entities such as CDRE, the MSEM, and the new MSISA program, with DES faculty serving as program coordinators and/or as instructional faculty, or on the curriculum and internal advisory committees. The Wallops Island Marine Science Consortium (MSC) adds another dimension to our collaborative efforts. In addition, DES has established formal partnerships with the PA Department of Transportation for winter weather forecasting, regional environmental consulting firms, and others. We are initiating a major thrust into building partner relationships with private sector firms through our MSISA program. A full list of collaborations is found in Appendix B: Faculty and Staff Collaborations.

**Faculty diversity**
Women represent 20% (2/10) of the DES faculty; URM represent 10% (1/10) of the DES faculty. In a department with a relatively small number of faculty, replacement of one by another faculty can have a significant impact on URM and gender representation. When recruiting new faculty, we make every effort as an EE/AO institution to attract URM and women to the applicant pool. A 2007 study by Marcy Towns, “Where Are the Women of Color? Data on African American, Hispanic, and Native American Faculty in STEM,” documents the ubiquitous nature of the problem; in all of earth sciences only 4% of faculty are URMs, and only 16% are women. Much still needs to be done to increase the input in the STEM pipeline and incentivize against the loss of women and URM faculty in early and mid-careers.

**The DES student**

**Student success: a required self-study focus area**
As a department with two baccalaureate degrees, and over 200 students in five majors, our paramount imperative must be the success of our students; and it is and will continue to be. Our annual reports (Appendix A) are replete with examples of student achievements from independent research to the number of students that secure jobs or go on to advanced degree programs upon completion of the degree. The DES expresses this commitment not only in the
classroom, but in support of cocurricular activities; some of which require considerable funding support from our operating budget in order to make happen. [In 1988, we made a promise to take the seniors to the AMS annual meeting. This was at a time when our seniors numbered in the single digits. We have honored that commitment for 25 years as our enrollment has increased. Today, the budget for travel for 25–30 senior meteorology majors to attend the AMS annual meetings is close to $20,000. Even after receiving generous contributions from the Dean, the MU Student AMS Chapter, and the AMS Student Assistance Program, the DES outlay of funds is considerable. But we will continue to make this happen. The Millersville student contingent is often the largest undergraduate group attending the annual meeting of any single school in the U.S.] This vignette tells of just one of several trips that we fund each year for students to attend their respective disciplinary conferences; in all, the DES spends over $10K per year (~ 1/3 of our operating budget) on defraying the cost of student travel; the total of which is upward of $30K.

Many changes take place—emotional, intellectual, physical—from the time students enter college as “wet-behind-the-ears” high school graduates to their graduation as fledgling scientists ready to embark on careers or to continue advanced studies elsewhere. The rate of metamorphosis varies for each individual, but it is the faculty responsibility, one that we explicitly state in our mission, to ensure that each major is challenged and given adequate resources and opportunities to grow. Undergraduate research is a vital for student acceptance into advanced degree programs. Internships are the bridge to professional careers or graduate school. Academic minors provide breadth and greater marketability. Student clubs (AMS Chapter; Ocean Sciences Club, and Geology Club) meld the social with the professional and build camaraderie. The DES living-learning community ensures that students in our department can live and work together during their first year, and enhance their probability of success by feeling part of a community striving toward a common goal. Moreover, DES instills a strong sense of community between faculty and students and within the student population. For instance, the MU Student Chapter of the AMS created a Met-Mentor program about five years ago where juniors and seniors volunteer as mentors for incoming freshmen (see http://snowball.millersville.edu/~ams/outreach/mmp.html). They have a full agenda of activities throughout the first semester. The impact on retention in the major has been profound, rising from the historic persistence of **50% to 75%–85% today** (See Figure 2.). While details of
student success can be found in the DES annual reports in Appendix A and A.1, the following have been called out to highlight some of their activities from 2008–2012.

- 103 students participated in undergraduate research projects
- 72 students participated in internships
- 176 students attended national or regional conferences
- 50% of graduates have secured a career move upon graduation
- On the average, about 20 students per year receive awards, including the Ernest Hollings Scholarship, UCAR SOARS program scholarships, AMS scholarships, state, university, and department awards, student research grants

![Figure 2: Retention in Meteorology as a percentage of sophomore/freshmen for 2003-2011. The Met-Mentor Program was initiated in 2003.](image)

**Student diversity**
Race and gender diversity continue to be important recruitment issues. Gender diversity has remained nearly constant with a 5-year average of 35.5 ± 1.1%. Racial diversity has doubled from 4% to 8.3% over the same 5-year period. An NSF study of the number of underrepresented minority degrees as a percentage of total undergraduate degrees in the geosciences reports an increase from 4% to 7% from
1996–2005. DES mirrors the national statistics in both annual percentage and multi-year trend. Table 1 below provides additional detail on racial and gender diversity in DES.

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The DES curriculum: a required self-study focus area

The Department of Earth Sciences continues to take a progressive stance on curricular revisions to accommodate emerging trends, workforce demands, and student access. Our current curriculum is deep in the core discipline and broadened by electives, minors, and double majors. The meteorology curriculum conforms to the American Meteorological Society (AMS) Guidelines for a B.S. in Meteorology/Atmospheric Science and the GS-1340 civil service requirements. Our geology program provides the skills needed to become a professional licensed geologist. Our recently revised ocean sciences and coastal studies curriculum immerses students in hands-on experience at the Wallops Island MSC. We are pleased with the number of meteorology majors who have declared OSCS with the option in physical oceanography as a double major. These students gain a fuller understanding of the relationship and interaction between the atmosphere and oceans, and graduates are receiving advanced degrees in
oceanography and related fields with preparation strengthened by the meteorology curriculum. Meteorology majors are required to take two computer-programming courses (FORTRAN, and either Python or IDL), and all DES students can take skills\[3\] courses to build proficiencies in related areas. Many students are electing to stay an additional semester or year to broaden their academic portfolios with minors and second majors; one reason for 4-year graduation rates being lower than the university mean while 5-year rates are considerably higher than the university 5-year mean.

The OSCS program has recently undergone significant change as we moved away from the four traditional ocean silos (BIO, CHEM, PHYS and GEOL) to a focus on coastal environments, wetlands, and ecosystem ocean sciences. However, we retain a strong but integrated emphasis in biological oceanography ocean optics, and oceanographic observation and data analysis. In addition, we have strengthened our physical oceanography option and its prerequisites for students interested in pursuing advanced degrees in oceanography.

It has been a challenge to make changes to the major requirements due to the large number of requirements in the liberal arts core (51 c.h./120 c.h.). While we fully support a strong liberal arts education, we are also pleased that MU has recently taken steps to reduce the number of general education requirements or to make modifications to the requirements that will allow some courses in the major to be cross-counted in general education. This has the potential to make available nine additional credits that can and will be used in the major requirements. These changes provide greater flexibility in the major curriculum, which is needed to address areas where added proficiency is critical for today’s students. Integration across DES plays a central role is transforming the DES curriculum. Efforts on several fronts are already underway with 1) a proposal to designate ESCI 350 History of Meteorology as a diversity\[4\] (D) course, 2) offering ESCI 421, Advanced Geology, which integrates geology subdisciplines under a senior capstone experience, and ESCI 281, GIS applications for the earth sciences. The annual reports in APPENDIX A provide a more detailed description of the curricular changes to date. Our main thrusts have been in the areas of 1) Distance learning courses to provide greater student access and flexibility; 2) Course and curriculum changes that better align programs with emerging trends and workforce needs, or the needs of the university for general education offerings; and 3) new “skills”

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3 Skills courses provide students with specializations in areas of desired proficiencies. They are taken for credit but do not count in the major sequence, as electives, or required-related courses. Skills courses include: Perl and shell scripting; GIS applications; advanced weather analysis and forecasting; broadcast meteorology, and others.

4 A course with a D designation is intercultural and/or cross-cultural, with culture being a worldview that reflects beliefs, customs, values, politics, and experiences as shaped by age, economics, education, gender, geography, language, nationality, occupation, physical ability, race and ethnicity, religious affiliation, and/or sexual orientation among other factors.
courses that allow students to gain specific proficiencies in computer programming, GIS, or advanced forecasting methods.

**Learning resources**

Technology plays an ever-increasing role in student learning and scholarly activity. DES has been a leader at MU in acquiring and extracting information from the copious volumes of data through the use of Internet data distribution systems [DES acquires about 100 GB/day of environmental data via Unidata’s Internet Data Distribution (IDD) system, which is used in the classroom, for co-curricular projects, independent studies, and to support research activities]. The trend toward virtual servers/machines (VMs), large data clouds, and other storage repositories challenges universities to maintain current hardware, technical support, and requisite training. Students expect and pay for state-of-the-art technology, and this will continue to be a recruitment tool for institutions. [We frequently hear of colleges and universities giving free iPads and laptops to entice prospective students. See for example, http://www.setonhill.edu/ipad/] At the same time, most earth sciences disciplines use sophisticated, RAM-intensive software (e.g., The Integrated Data Viewer (IDV) developed at the Unidata Program Center (http://www.unidata.edu) or Kingdom geoscience software that provides integration for geological, microseismic, and seismic interpretation, and geophysical numerical modeling systems (e.g., the Weather Research and Forecasting Modeling System). In addition, imagery from satellites and weather radar—which already represent 99% of the data ingested and distributed—will, in the near future, significantly increase in data volume as weather radar are upgraded to dual polarization capabilities and next generation hyperspectral imaging satellite systems are deployed. Nearly half of the funds allocated by DES for software licenses and maintenance is used for a single satellite data rendering and imaging package (IDV/ENVI).

The flip side of the technology coin is instrumentation. DES has substantial assets in facilities, equipment, and instrumentation for environmental observations. We believe in students doing science as scientists do science. To achieve this goal students need not only an understanding in the conceptual aspects of radiative transfer, but the operational procedures as well, including basic- to intermediate-level electronics, signal processing, and hands-on experience in using a device. DES, through extramural and internal funding, has established itself as a go-to place for authentic observational research. The Millersville University Atmospheric Boundary Layer (MABL) facility includes a rawinsonde system, multiple tethered balloons, acoustic sodar/RASS, micropulse LiDAR, and surface flux tower and suite of trace gas and aerosol analyzers on which over 60 students have received research training over the last several years through NASA, NSF, and EPA funding (see Figure 3).
Our leadership in and close association with the Marine Science Consortium (MSC) at Wallops Island, Virginia, provides students with opportunities to explore the coastline and Chesapeake Bay using instrumentation onboard a research vessel such as the R.V. Parker and skimmers. In the geology laboratory, students examine minerals through a research grade petrographic microscope or search for evidence of fault lines in the field. Each is a rich experience for students that expose them to a wide array of instruments, hands-on data collection, and data analysis and interpretation.

What the collage in Figure 3 does not depict is the challenge of storing equipment when it is idle. Most of this equipment is confined to a shed, or put in boxes and not available to students in a classroom setting where they could receive authentic experience. Caputo 403 is largely unusable as a classroom because of equipment storage.

Pedagogy: a selected self-study focus area

The DES is forging new and innovative approaches in the way our students learn. From “flipping the classroom” to 3-D real-world computer generated immersion environments blended with traditional didactic approaches, we strive to engage students by varying styles of learning. Many of the DES faculty members have been using personal response systems (clickers) for several years, especially in large enrollment (80 – 150) introductory survey courses for non-science majors. Each course, major or non-major, fully online, blended, or face-to-face (f2f) formats, has a virtual presence via the online learning management system, Desire2Learn (D2L). Some faculty incorporate the Field Learning Assessment Guide (FLAG) techniques into their pedagogy using conceptual diagnostic tests, minute papers, and other classroom assessment techniques (CATs) in their assessment of student performance. Others allow
students to work in teams, notably in upper level courses, in order to prepared them for the multifaceted interactions that they will encounter in the workplace.

In certain courses such as the upper level meteorology elective *Satellite Meteorology*, the traditional f2f format has been completely upgraded and revamped into a fully online delivery format. The course is complemented by an all-day hands-on workshop on McIDAS-V, focused case studies and the use of derived products. The students will also get a tour of the NOAA Office of Systems Development. In *History of Meteorology*, each student is assigned a unique book and students lead weekly discussions online on their individual topic and its relevance to other books and course materials in addition to responding to postings made by others. In *Introduction to Earth Sciences*, freshman students are introduced to critical elements related to the understanding of the relationship amongst the various components of the earth system, relationship between the earth sciences and mathematical and physical sciences, role of technology in earth sciences, the importance of observational studies and exploration, role of teamwork and collaboration, and the need for strong communications skills. Students are introduced to these elements through collaborative projects, demonstrations, group discussions, hands-on experiments and introduction to instruments and tools of analysis. In *Radar Meteorology*, students collaborated with design students in the Art Department on case studies focused on the application and display of data. This provided a unique setting where students in an upper-level meteorology course worked with students in an upper-level design course. The final projects were presented to the entire group at the end of the semester.

Data analysis plays a central role in classroom activities. In OSCS courses, data from buoys and platforms around the world are presented to student for analysis, and the Ocean Data View (ODV) software is used to teach global ocean circulation. Demonstrations and experiments are vital to elevating student interest. The DES partnered with the Massachusetts Institute of Technology (MIT) to employ a rotating tank to demonstrate atmospheric and oceanic circulations. DES has two tanks: one portable and a large fixed tank in which to demonstrate geophysical fluid systems under conditions of differential heating and rotation. We have contributed to the development of experiments that are posted on MIT’s “Weather in a Tank” web site ([http://paoc.mit.edu/labguide/index.html](http://paoc.mit.edu/labguide/index.html)).

*Geospatial Information Systems* (GIS) is offered as a technical applications course in the department. Programming courses in FORTRAN, Python, IDL, Perl and Shell Scripting are all standalone courses in their own right, but are also integrated into other courses such as *Statistical Meteorology*, *Ocean Data Analysis and Presentation*, *Numerical Modeling of Oceans and Atmospheres*, *Remote Sensing and Image*
Interpretation, and Boundary Layers and Turbulence. Similarly, a student-developed online tutorial in MatLab is used across the DES curriculum.

Students in all majors gain hands-on experience in the use of research-grade instrumentation. In Atmospheric Thermodynamics, students use the DES Vaisala rawinsonde to launch and track a balloon, collect the data, and plot it on a skew T-log p diagram. In OSCS, students travel to the Marine Science Consortium where they deploy a CTD profiler onboard the R.V. Parker, or explore wave dynamics using the DES wave tank. Students install, operating, and gather data for analysis from the micropulse MPL4 LiDAR and surface flux tower, and operate, calibrate, and maintain a suite of criteria gas analyzers. Geology students have ready access to a research-grade petrographic microscope, and routinely take field trips to various outcroppings and formations. All this expands the pedagogical style of learning.

Technology plays a vital role in the more innovative pedagogical approaches and contributes in meaningful ways to cocurricular learning experiences. Meteorology students can present the short-term forecast using a screenwriter and streaming video (http://www.atmos.millersville.edu/~wic/videos.html). Student-led initiatives such as MU WeatherWatch (http://muweatherwatch.com/) have generated considerable interest among students. The use of COMET modules as supplements to learning.

The new GEOpod graphical user interface provides a navigable immersion environment that allows a user to fly through a data volume and actuate virtual devices to explore the atmosphere and discover relationships. Funded through an NSF grant and built on top of Unidata’s Integrated Data Viewer (IDV) software through collaboration between the Millersville University Departments of Earth Sciences and Computer Sciences, provide a new 3-D perspective of the atmosphere. As screen shot of the GEOpod is shown in Figure 4.
Figure 4: A screen shot of the GEOpod interface with virtual device actuated. GEOpod used Unidata's IDV to select model data and GEOpod controls the navigation and geo-referencing in IDV.

Our approach is based on the notion that students learn science by doing science, and there are many ways of doing science.

**Facilities and budgetary resources**

The DES operating budget (Appendix C) sustained a university-wide reduction of 4.9% in 2009 in response to a statewide economic turndown, and since has remained at that reduced level. With many expenditures being fixed (e.g., subscriptions, membership dues, and software licenses and maintenance fees), budget reductions primarily affect our ability to support travel for students, faculty professional development, and educational supplies. The total annual DES revenue of approximately $100K includes university transfers for our MSC membership dues (~$52K), and in 2011-12, a one-time transfer of about $18K to cover the cost of a new trailer for the Millersville University Atmospheric Boundary layer (MABL) facility. We remain committed to supporting travel for students to attend professional conferences, training workshops, and other visits. Overall, DES has contributed between 35% and 45% of its base operating budget for students to attend, and for about 1/3 to present their research at national venues, including: the annual meetings of the American Meteorological Society (AMS), the Ocean Sciences Meetings, the Geological Society of America (GSA) and the Space Weather Workshop at the
Space Weather Prediction Center, and the Northeast Storms Conference sponsored by Lyndon State College. In addition, we have supported students attending MatLab workshops, National Acid Deposition Program (NADP) training workshops, geology field trips, Ocean science field trips to Wallops Island Marine Science Consortium with research cruises, and trips to the National Centers for Environmental Prediction, Smithsonian Museum, and Warning and Forecast Offices in State College and Mt Holly, PA, and Sterling, VA. The Annual Reports in Appendix A include a detailed list of professional activities in which students participated.

Our formula for supporting faculty professional development is that we try to defray most if not all the personal cost to a faculty member, especially if the faculty member is presenting or serving in some professional role that represents her/his scientific community. Faculty can apply for small university grants for travel ($500 max), and request support from the Dean (typically $300). Faculty with indirect costs from extramural grants will often apply some monies to their travel. The department tries to cover the balance, and we have been routinely successful at that and are still able to end the FY with a small carry-over on the order of hundreds of dollars.

The DES also has a relatively healthy student wage budget ($14,200/yr), although we regularly exceed it and optimistically rely on the university pool of finds for student wages to remove the year-end deficit. These wages are used to compensate students for their service to the MU Campus Weather Service, clerical assistants in the department office, research and data analysis in a post-funding period, and sundry other duties. In some cases, such as with the Pennsylvania Department of Transportation contract for an eight-county winter weather forecasts and the precipitation collection for the NADP, students are paid from the grants and contracts.

In addition to the DES operating budget, the university has an annual base equipment budget allocation. Until the economic downturn in 2008, the School of Science and Mathematics was allocated slightly more than $100K per year to be distributed in a prioritized fashion among seven departments. Since then, our base equipment budget is approximately $65K, which is insufficient to cover large-ticket items. Fortunately, the student technology fee budget has provided adequate funds to cover some of the more expensive equipment items that cannot be obtained through grants such as the NSF Transforming Undergraduate Education in Science (TUES) (formerly CCLI). Through the “tech fee” allocation, the DES has been able to acquire some high-cost equipment. However, a significant quantity of the equipment in our inventory has been acquired through TUES/CCLI, NSF-Major Research Instrumentation, and direct line items in grants.
The most pressing challenge that affects day-to-day activities in the department, and impacts students and faculty as an obstacle to integrated planning is that earth sciences faculty, staff, and students are physically separated between four buildings within the Argires Science Complex. The department offices are located in Nichols House, along with one oceanographer and the remote sensing lab. Brossman Hall is home to the geology faculty and the second oceanographer and a geology lab and oceanography lab, but geology classrooms and other laboratories occupy part of Roddy Hall. The meteorologists occupy the fourth floor of Caputo Hall. Our attempt to integrate faculty and programs with the CDRE and the MSEM program are stymied by the location of CDRE in Luzerne House, a building where the 2nd floor has been condemned. This physical separation is counter-productive and makes intradepartmental interaction, synergy, integration, and optimization of resources cumbersome, if not ineffectual. In addition, as pointed out above, the department lacks space to deploy several important pieces of equipment in the classroom for the purpose of education and research training for all students. Each of the areas the department occupies was built based on enrollments at the time of design, so that even the most recent construction for meteorology in Caputo Hall was based on enrollments in 1998 when we had about half the number of students. More importantly, students realize very little in terms of interaction between disciplines; rarely do geology, meteorology, and ocean sciences majors cross paths, except during the biweekly seminars offered by the department. Students sense only cursory departmental integration and interaction, which runs counter to what they will encounter in the workplace. This physical separation represents our greatest obstruction to many of the integrative and transformative ideas that we describe in the new strategic plan, and its resolution in the form of a new building is our most pressing imperative going forward.

Environmental scan

The Department of Earth Sciences (DES) had experienced remarkable (yet unsustainable) growth during the period 1997–2006, nearly doubling (125 to 240) the number of matriculated majors. Since 2007, the total number of undergraduates has leveled off, and has started to relax slightly in recent years. Figure 5 depicts how departmental enrollment parallels the number of meteorology majors (which are about 60% of departmental majors). Other majors have shown slight increases in recent years as a consequence of targeted recruitment and programmatic curricular enhancements, goals that were implemented as part of our 2007–2012 strategic directives. The decline in majors across all degree programs, in part, reflects the decline in students from an all-time high in meteorology and B.S.E. majors in 2007. We speculate that the persistence of low fall B.S.E. enrollments is a consequence of the political climate and corresponding teacher lay-offs. The relaxation in the number of meteorology majors has relieved some of the stress of having to add a second section to some of the 300- and 400-level meteorology courses, avoiding the
adverse attendant resource implications. Still, our single section course enrollments equal or exceed maximum classroom capacity. MU meteorology remains one of the largest undergraduate meteorology programs in the U.S., and is drawing increasing numbers of out-of-state students into the major even in light of nascent meteorology programs at universities in adjacent states (e.g., Maryland and Virginia).

**Figure 5: Earth Sciences fall undergraduate enrollments by major (cumulative options) and total for the period 2006–2012.**

Within the SCMA, DES ranks 3rd overall (after Biology rank 1 and Math rank 2) in the number of degrees conferred; 1st in the physical sciences; and accounts for an average of 15% of the total SCMA degrees with 10% of the SCMA faculty complement. Figure 6 provides a synopsis of the degrees conferred by major from 2005-2010. Meteorology accounts for an average of 52 ± 12% of total degrees conferred over that period.
Within SCMA, DES consistently produces the highest student-faculty ratios (FTES/FTEF = 25.6), which is $1.74\sigma$ greater than the mean of the seven SCMA departments (17.7) and a close second only to the economics department university-wide (see Table 2).

**Table 2: Student: Faculty Ratio (FTES/FTEF) by Department and Academic Year**

<table>
<thead>
<tr>
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<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SCMA</td>
<td>Biology</td>
<td>15.2</td>
<td>15.8</td>
<td>15.6</td>
<td>15.8</td>
<td>16.3</td>
</tr>
<tr>
<td></td>
<td>Chemistry</td>
<td>14.8</td>
<td>14.7</td>
<td>14.8</td>
<td>14.8</td>
<td>15.4</td>
</tr>
<tr>
<td></td>
<td>Computer Science</td>
<td>15.0</td>
<td>15.4</td>
<td>14.8</td>
<td>15.2</td>
<td>15.5</td>
</tr>
<tr>
<td></td>
<td>Earth Sciences Total</td>
<td>24.2</td>
<td>23.2</td>
<td>22.1</td>
<td>24.6</td>
<td>25.6</td>
</tr>
<tr>
<td></td>
<td>Mathematics</td>
<td>20.7</td>
<td>20.4</td>
<td>20.4</td>
<td>21.3</td>
<td>21.8</td>
</tr>
<tr>
<td></td>
<td>Nursing</td>
<td>10.0</td>
<td>11.4</td>
<td>10.3</td>
<td>11.8</td>
<td>12.0</td>
</tr>
<tr>
<td></td>
<td>Physics</td>
<td>14.8</td>
<td>15.8</td>
<td>15.4</td>
<td>16.0</td>
<td>17.2</td>
</tr>
<tr>
<td></td>
<td>SCMA Total</td>
<td>17.4</td>
<td>17.5</td>
<td>17.1</td>
<td>17.9</td>
<td>18.6</td>
</tr>
<tr>
<td></td>
<td>University Total</td>
<td>18.1</td>
<td>18.1</td>
<td>18.3</td>
<td>19.1</td>
<td>19.6</td>
</tr>
</tbody>
</table>
DES is the third largest department in SCMA in terms of fall enrollments in the major. Retention and graduation rates for full-time fall freshmen in both URM and non-URM groups significantly exceed the university rates for years 5 and 6. [4-year graduation rates are slightly lower than the University rates (DES 12.5% versus MU 14.9%) due mainly to inadequate math preparation of incoming freshman meteorology majors and the need for them to complete MATH 101 and MATH 160 before starting the required meteorology math sequence.] Graduation rates are found in Table 3 below.

DES also has the highest productivity in SCMA as measured by annualized credit hours per FTEF (767 AY c.h./FTEF; 1.7σ above the SCMA mean of 526 AY c.h./FTEF) based on institutional research data for academic years 2006–2007 to 2010–2011. DES has enrolled 13,503 students in courses offered by the department from 2006–2011 with 78% (10,519) in courses that serve the University’s general education liberal arts core requirements. Another productivity metric is instructional cost per credit hour; DES has one of the lowest (~$150) in SCMA, second only to the mathematics department (Note: The following reports will be available for the 2012–13 academic year, pending the completion of the 2011 Delaware Study, and were not available from Institutional Research at the time of this writing.)

Table 3. Retention and Graduation Rates of New, Full-Time, Fall Freshmen

<table>
<thead>
<tr>
<th>Group*</th>
<th>Retention</th>
<th>Graduating from University</th>
<th>Graduating from Original Department</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-year</td>
<td>2-year</td>
<td>4-year</td>
</tr>
<tr>
<td>URM</td>
<td>85.7%</td>
<td>75.0%</td>
<td>12.5%</td>
</tr>
<tr>
<td>N</td>
<td>7</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Non-URM</td>
<td>86.1%</td>
<td>78.5%</td>
<td>37.9%</td>
</tr>
<tr>
<td>N</td>
<td>209</td>
<td>223</td>
<td>232</td>
</tr>
<tr>
<td>Total</td>
<td>86.1%</td>
<td>78.4%</td>
<td>37.1%</td>
</tr>
<tr>
<td>N</td>
<td>216</td>
<td>231</td>
<td>240</td>
</tr>
</tbody>
</table>

* URM (Under-Represented Minority) is defined as all African-American and Hispanic students

Table 3. Retention and Graduation Rates of New, Full-Time, Fall Freshmen

<table>
<thead>
<tr>
<th>Group*</th>
<th>Retention</th>
<th>Graduating from University</th>
<th>Graduating from Original Department</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-year</td>
<td>2-year</td>
<td>4-year</td>
</tr>
<tr>
<td>URM</td>
<td>72.5%</td>
<td>55.3%</td>
<td>14.9%</td>
</tr>
<tr>
<td>N</td>
<td>904</td>
<td>895</td>
<td>870</td>
</tr>
<tr>
<td>Non-URM</td>
<td>83.0%</td>
<td>73.3%</td>
<td>40.2%</td>
</tr>
<tr>
<td>N</td>
<td>5662</td>
<td>5665</td>
<td>5792</td>
</tr>
<tr>
<td>Total</td>
<td>81.5%</td>
<td>70.9%</td>
<td>36.9%</td>
</tr>
<tr>
<td>N</td>
<td>6566</td>
<td>6560</td>
<td>6662</td>
</tr>
</tbody>
</table>

* URM (Under-Represented Minority) is defined as all African-American and Hispanic students
Within the SCMA, DES ranks 3rd overall (after Biology rank 1 and Math rank 2) in the number of degrees conferred; 1st in the physical sciences; and accounts for an average of 15% of the total SCMA degrees with 10% of the SCMA faculty complement. Figure 4 above provides a synopsis of the degrees conferred by major from 2005-2010. Meteorology accounts for an average of 52 ± 12% of total degrees conferred over that period.

The DES Data Summary Form is shown in Table 4. Noteworthy is the consistency from year to year over the previous five years of all data elements. Since 2008, while the department’s budget increased from $1.37M to $1.51M, or 10%, mainly as a result of faculty promotions to higher ranks, our annualized FTES increased by 15%. The student fall headcount has remained just over 200, except for an anomalous bubble in 2007-08 in meteorology enrollments; a condition that exacerbated an already crowded meteorology facility and required opening two sections of upper-level courses for the first time in the department’s history. Over this same 5-year period, faculty brought in over $2M in extramural funding in support of research and education. In each of the elements contributing to the cost of running this department and its programs, there is evidence that DES continues on the path of being the most productive department in SCMA, and one of the most productive across the university in spite of it being a science program with its attendant higher costs.

<table>
<thead>
<tr>
<th>Earth Sciences</th>
<th>Academic Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2006-07</td>
</tr>
<tr>
<td>Student Enrollment – Annualized FTES</td>
<td>293.0</td>
</tr>
<tr>
<td>Program Budget /Cost* (FY personnel, operating, equipment)</td>
<td>$1,414,558</td>
</tr>
<tr>
<td>Program Cost/FTES</td>
<td>$4,828</td>
</tr>
<tr>
<td>Faculty FTEs</td>
<td>12.1</td>
</tr>
<tr>
<td>Majors Enrolled – Fall Headcount</td>
<td>228</td>
</tr>
<tr>
<td>Program Graduates</td>
<td>27</td>
</tr>
</tbody>
</table>

*Either reflect the portion of the department’s budget (personnel, operating, and equipment) associated with this program, or reflect the Common Cost Accounting costs associated with this program.
In addition, DES continues to bring in more extramural funding in the form of grants and contracts than any other department at MU, with much of this funding directed to supporting student participation in research (see Appendix A: Annual Reports).

Appendix A.1: Key Indicator Data Summaries). On the basis of these and several other metrics, DES continues to be one of the most productive departments on campus.

**Demand for earth scientists**

We expect career opportunities in the earth sciences to remain strong through this decade and beyond. College majors in geological and geophysical engineering, atmospheric science and meteorology, and ocean sciences are in the top 11 out of 173 highest employment rates in the U.S., and enjoy median incomes well above the average. (Wall Street Journal, Nov 8, 2011: Data from the Georgetown Center on Education and the Workforce. [http://graphicsweb.wsj.com/documents/NILF1111/#term](http://graphicsweb.wsj.com/documents/NILF1111/#term)). The challenges of the 21st century demand professionals with knowledge of theory, technical and computing skills, models (physical, mathematical, and conceptual), and critical thinking ability, who can collaborate across allied disciplines. In particular, there is significant informational content in geo-referenced data that requires a knowledgeable workforce to garner value. Moreover, there is an urgent need for individuals with technical proficiencies who can manage, mine, model, analyze, visualize, and interpret data structures and extract information that can be incorporated into decision support and risk management systems. Specifically, nearly half of the U.S. GDP comes from industries that are sensitive to environmental hazards—the *de facto* ‘business’ of the earth sciences. The private weather and climate sector is a growth enterprise that is expanding into nontraditional areas such as energy, manufacturing, retail, life/health science, insurance, forensics, road information systems, climate services, and customer services. Hydraulic fracturing, depletion of water resources and soil erosion, and the quality and quantity of groundwater ensure the need for geologists and geophysicists. With the Ocean Observatories Initiative coming online in 2014, and with MU a member of the Mid-Atlantic Regional Association for Coastal Ocean Observing Systems (MARACOOS) and the only PASSHE institution that offers a degree program in ocean sciences, we anticipate a significant increase in students interested in majoring in this discipline.

Concomitant with the demand for individuals steeped in their discipline is the need for curricular breadth. The Congressional Research Service Report for Congress (March 2008) is one of several national reports that expresses the growing concern that the U.S. is not preparing a sufficient number of practitioners in science, technology, engineering, and mathematics (STEM). Additionally, the market trends indicate the
growing, if not urgent, need for a technical workforce prepared beyond the baccalaureate degree with a broader set of skills that will be needed to collaborate across disciplines to tackle complex problems and arrive at holistic solutions. Climate change, floods, droughts, coastal erosion, high impact weather including space weather threats, and aerosols and air- and water-borne pollutants are but a few of the key issues facing society that demand an integrated and holistic approach to mitigating these problems. Today’s students must be attuned to these winds of change. As tomorrow’s earth scientists, they will be part of this paradigm of collaboration between oceanographers, meteorologists, geologists, space scientists, environmentalists, computer scientists and information technologists, sociologists, economists, business leaders, and educators, and will play a vital role in adding value to the decision-making process. To excite a future generation of inquiring minds, it is imperative that we forge the path of change while not compromising our core attributes.

IV. 2007-2012 Program review progress report

The previous program review, conducted in 2007, resulted in the 2007–2012 strategic plan, which focused on the following goals:

1. Improve facilities and expand the equipment inventory and educational resources for education and research. A broad spectrum of initiatives was planned including a new facility for DES; a 10th faculty position; pursuit of grants for equipment; and expansion of endowments for equipment.

2. Preparation and preparedness for lifelong careers in earth sciences. The plan emphasized curriculum, creative thinking, problem-solving/computational skills across the disciplines, with a special emphasis on strengthening the B.S.E. program.

3. Ocean sciences and coastal studies program enhancement: The plan targeted improving recruitment/retention in the program, making connections with regional and national research and educational initiatives, in particular with the MSC at Wallops Island, Virginia.

As we reflect on the 2007–2012 strategic plan, we take pride in achieving many of the goals that were established, but we remain challenged to bring others to fruition. Below is a summary of the departmental progress toward these goals.
The department has expanded its equipment inventory for education and research by a considerable amount through funding from the base equipment budget, student technology fees, one-time allocations, and through extramural grants and contracts (see Appendix A: Annual Reports).

1. Appendix A.1: Key Indicator Data Summaries). The distribution of equipment/instrument allocations has been equitable across the three primary disciplines: geology, meteorology, and OSCS. At the department level, the number of majors in each discipline does not factor into base equipment budget allocations. However, criteria for access to the student technology fee are, in part, contingent on the number of students who will benefit by the equipment’s acquisition. As a result, the OSCS program and, to a lesser degree, the geology program, are challenged to compete against requests from other departments in SCMA. Consequently, the equipment inventory in OSCS is wanting of several large items.

In 2012, we completed a successful search for a 10th faculty position in earth sciences and hired Dr. Duane Hagelgans (J.D., CSP). His responsibilities are primarily to the MSEM, but he will broaden the initiatives offered by DES. The department still needs a new faculty complement who has a terminal degree or conducted post-doctoral work, or has had considerable experience in cross-cutting disciplinary themes such as earth system science, land-air-sea exchanges, and the like. One of the primary imperatives of the previous strategic plan was to move the University forward on the construction of a dedicated building for the earth sciences and related programs. While we are encouraged that plans for a new building are now formally part of the University Master Plan – Stage 2, and that Stage 1 is moving forward, we remain challenged by many factors that a new building would go far toward ameliorating. A new building is the primary imperative of the 2013–2017 strategic plan, as outlined in the section, DES 2017.

We have made significant changes to the curriculum in each of the three major disciplines, including developing new courses, retiring courses that have been subsumed by others or have become less relevant, and changing prerequisites to strengthen student preparedness (see Appendix A: Annual Reports).

2. Appendix A.1: Key Indicator Data Summaries). We have introduced skills courses for students to develop specific proficiencies (e.g., GIS, Python, Perl and shell scripting). We have targeted the B.S.Ed. program for strengthening and recruitment and were very successful early in our five-year plan. But more recently, mainly due to the acrid political environment nationally and statewide, we are experiencing a decline in B.S.E. enrollments as would-be teachers choose other career tracks. We believe this to be largely beyond our control as this point, but the B.S.E.
program remains in our sights even if it is not called out specifically in the next five-year plan. Increasing B.S.E. enrollments has little adverse affect on existing resources and faculty teaching load.

3. The OSCS program has undergone a major overhaul with several new courses and courses that better align with trends, workforce needs, and faculty expertise. The relationship between the University and the MSC is robust. MU is a full senior partner in the MSC, which involves contributing significant funds to sustain and maintain MSC’s infrastructure. Our connection with regional and national initiatives has strengthened through our membership in MARACOOS and our potential participation in the NSF-funded Ocean Observatories Initiative, which is managed and coordinated through the Consortium for Ocean Leadership. These partnerships promote, enhance, and sustain long-term relationships with the ocean sciences communities.

Although the University has the only ocean sciences/oceanography program in PASSHE, our landlocked location creates a recruitment challenge. Prospective students simply do not look first to MU for ocean sciences and coastal studies (OSCS). One major success is the number of meteorology majors who choose to dual major in OSCS, which tends to significantly enhance and broaden their skill sets and portfolios. Several have chosen an oceanography career path upon graduation and some have been accepted to top-ranked graduate programs in ocean sciences or oceanography. Still, recruitment remains an ongoing challenge, and we cannot rely solely on the double major pathway to build enrollment in OSCS. Our implicit goal was to raise enrollments in OSCS to approximately 20 majors, and we seem to be approaching that number, albeit slowly (see Figure 4). An interesting observation is the increase in the enrollment in OSCS with an option in physical oceanography, which is a manifestation of well-prepared meteorology majors opting for the more rigorous and graduate-school-aligned option.

Marketing efforts tout our relationship with MSC and NASA Wallops Island, the field program, and courses that bring students to the MSC for a “hands-on, feet-wet” authentic experience. This year (summer 2012), Dr. Ajoy Kumar offered a section of ESCI 104, The World Ocean, at the MSC as a means of recruiting exploratory freshmen. We do not yet know the outcome of this effort on recruitment, but already one student from this class has declared OSCS as a major.
Figure 7: Majors in ocean sciences and coastal studies 2008-2012: all OSCS majors in blue; OSCS majors with physical oceanography option in red.

V. Composition of the review teams

Internal: Department faculty and staff

Dr. Richard Clark (Professor), meteorology. Dept. Chair (2002-Present); Program Coordinator for the MSISA program; Chair of the Program Review Team

Dr. Alex DeCaria (Professor), meteorology

Dr. Sam Earman (Assistant Professor), geology

Dr. Duane Hagelgans (Assistant Professor), emergency management

Dr. Ajoy Kumar (Associate Professor), ocean sciences and coastal studies

Dr. Lynn Marquez (Professor), geology

Dr. Jason Price (Associate Professor), geology

Dr. Todd Sikora (Professor), meteorology

Dr. Robert Vaillancourt (Assistant Professor), ocean sciences and coastal studies

Dr. Sepideh Yalda (Professor), meteorology. Director of CDRE; Program Coordinator for the MSEM program

Mr. Eric Hörst (B.S. meteorology), staff meteorologist, Director of the Weather Information Center, TPTF lab instructor

Mr. David Fitzgerald (M.S. atmospheric science), distributed systems specialist II, TPTF instructor for FORTRAN, Perl and shell scripting, and large enrollment survey course (ESCI 107)

Mrs. Martha Devlin, clerical typist III, department secretary
**Internal: Representatives from outside the DES**

Dr. Jeff Adams, Associate Provost, Millersville University

Mr. Thomas Renkevens, Deputy Division Chief, NOAA/NESDIS/OSPO Satellite Products and Services Division; Millersville alumnus (1992, meteorology)

**External review team**

Three external reviewers were invited to review the department as a whole, but also to concentrate on specific programs that fall within their areas of expertise. The three external reviewers, their affiliations, and their concentrations are listed below.

Dr. Eileen Hofmann, Department of Ocean, Earth and Atmospheric Sciences, Old Dominion University; ocean sciences and coastal studies

Dr. Gary Lackmann, Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University; meteorology

Dr. Laura Toran, Department of Earth and Environmental Science, Temple University; geology
DES 2017

Strategic Directions for the Department of Earth Sciences

The Department of Earth Sciences (DES) was created in the late 1960s as an academic amalgam of faculty having interest and credentials in geology, meteorology, and oceanography. Today, with over 200 majors, DES is a Millersville University flagship department offering majors in three core disciplines—geology, meteorology, and ocean sciences and coastal studies—a general major earth sciences, and a major in earth sciences education leading to a certificate in secondary education. Some DES programs have received national or regional distinction. According to many institutional metrics, DES is one of the most productive organizations on campus.

DES faculty are vigilant for new opportunities and emerging trends that will continue to set us apart as a touchstone for undergraduate earth sciences programs nationwide. We pay close attention to feedback from our recent graduates who go on to jobs in government, private, or academic sectors and report back on their degree of preparedness and expected skills, and we use this feedback to refresh our curriculum, enhance and expand co-curricular activities, and test new pedagogical learning and assessment methodologies. Undergraduate research has been and will continue to be one of the primary ways in which we engage students in authentic learning, and it will continue to be a carrot for student recruitment.

In order to remain competitive, we will continue to seek new and challenging opportunities, both internal and external, that will help our students develop the skills that they will need to find successful and fulfilling careers, and be prepared for the unavoidable re-tooling that will be needed to keep pace with changing workforce demands. While our graduates continue to be successful at finding employment that is meaningful with wages and benefits that are generally financially acceptable, or go on to earn advanced degrees in their core disciplines before entering the workforce, the most interesting problems, those that call for holistic and complex solutions, are going on at the interdisciplinary boundaries.

DES has taken steps to broaden its curriculum without compromising its core disciplines, but much more needs to be done to more effectively integrate salient areas that will prepare our graduates for the 21st century workplace and the complex and transdisciplinary scientific questions that will face their generation. To accomplish this requires integration and transformation across the earth sciences disciplines, collaboration with existing allied partners and new partners, and finding new or repurposing present resources to address this theme.

The DES faculty selected Integration and Transformation as our overarching theme to guide our strategic direction. This theme will be applied to our focus areas and steer the imperatives and frontiers that we will pursue over the coming years.

The Imperatives

Imperatives are the initiatives that we believe are essential to maintaining the health, vitality, quality, integrity, and growth of the earth sciences programs.
Imperative 1: Ensuring student success

Foremost among our imperatives is our investment in students, from recruiting not just the best and brightest but those with insatiable passion and stalwart work ethic to providing a nurturing and enriching environment that will cultivate graduates of deep, broad, and diverse perspective, who will challenge traditional thinking, work collaboratively, and participate in addressing the scientific and socioeconomic challenges of this century. Technology is transforming the way students learn, driving faculty to assimilate or create new pedagogical constructs for the classroom (e.g., *Flip Your Classroom: Reach Every Student in Every Class Every Day* by Jonathan Bergmann and Aaron Sams).

We will accomplish this through a set of actionable and living goals that we will use to guide us. These goals will be evaluated and, if necessary, refined each year during the development of our annual report.

Goals for student success

1. Success in the earth sciences is built on scientific competency, steeped in mathematics appropriate to the discipline, and infused with current technology. *We will strive to achieve a challenging and transformative environment through an enlightened and comprehensive curriculum in each of the majors.*

2. Students are preparing for careers that may not yet exist. Through our collaborations, participation in venues across the enterprise, and thoughtful planning, *we will remain attentive to emerging trends and create opportunities for our students to engage and broaden their skill sets and portfolios in these areas.*

3. Undergraduate research, as the example in Figure 8 depicts, will continue to play a central role in defining the successful student. DES has a long history of providing challenging and meritorious opportunities for students to engage in research of the highest quality and to present their findings at professional venues. DES already brings in more grant funding than any other department on campus, and *we will continue to sustain, if not increase, the number of research opportunities and the number of students who seek them out.*

4. Cocurricular activities are many and varied and all offer opportunities to get involved and stay engaged outside the classroom and allow each student to continue to nurture their passion for their chosen field. From traditional internships and NSF-funded Research Experiences for Undergraduates (REUs) to membership in discipline-centric campus clubs, institutional evidence, as well as anecdotes,
continues to point to a higher probability of success for students that get involved outside the classroom. *We will remain steadfast in effort to increase retention rates well above the national average and the university and school averages by encouraging students to get involved in cocurricular activities.*

5. The curriculum in each discipline is deep and comprehensive. Yet, to be successful in the 21st century workplace, it is imperative that our students broaden their knowledge base, proficiencies, and skills. We strongly encourage our majors to declare minors by their junior year, and we have developed for our students a set of congruent minors, and in some cases specifically tailored in consultation with the department offering the minor.

### Minors Earned by students in DES

1. Internal minors in geology, ocean science and coastal studies, and meteorology
2. Mathematics
3. Chemistry
4. Physics
5. Heliophysics and space weather (new)
6. Computer science
7. Environmental hazards and emergency management
8. Government and political affairs
9. Communications option (for broadcast meteorology)
10. Public policy with science and technology policy focus
11. Quantitative methods in environmental sciences
12. Environmental policy and regulation

The combination of a major in the core earth sciences discipline and a minor in another field has been very effective in sustaining high employment rates and acceptance to advanced degree programs after graduation, because the breadth of opportunities is expanded by the minor. The minors also serve the purpose of addressing emerging trends across the earth sciences enterprise without unduly taxing the complement of the department (e.g., heliophysics and space weather), which is largely needed to support the major disciplines. *We will continue to encourage the declaration of minors and anticipate adding additional earth sciences tailored minors in hydrology, economics, GIS, and business management.*

### Imperative 2: Providing a modern, integrated curriculum

The curriculum provides the educational foundation for a meaningful and fulfilling career, and satisfying its requirements is a robust measure of student success. *The imperative related to the curriculum is that it remains strong, integral to the intended learning outcomes, sequential in its conceptual development,*
contextual in its intra- and interrelationships, and able to accommodate change resulting from feedback from outcomes assessments as well as emerging trends.

With sufficient modifications to the structure of the general education curriculum, we plan to achieve the following goals.

**Curriculum goals**

**Departmental**

1. Convert the 2-credit ESCI 110, *Introduction to Earth Sciences Programs*, currently required in the major, to a 3-credit, multiple section, UNIV 103 with the proposed title *Earth System Science* and a capacity to accommodate freshmen in DES, and with seats not taken by majors to be open to students outside the department enrolling in the freshman year inquiry (FYI). This course serves to jump-start the process of intellectual inquiry for freshmen, bringing together students in all majors to explore the earth system qualitatively.

2. Create an integrated capstone course for seniors of all DES majors using climate change as a central context for a quantitative analysis of overarching topics related to climate change (e.g., climate and energy; climate and water resources; climate and extreme events). The course would be team-taught and students would be organized into peer groups.

3. Develop a cross-cutting minor in water resources, which would build on faculty expertise in hydrology, groundwater geology, coastal oceanography, climate-induced precipitation modification, droughts, floods, and erosion.

**Program Curricular Goals**

Because the geology and OSCS programs have recently undergone significant transformation, we anticipate only nudges to the curriculum as we receive student feedback or as emerging trends necessitate.

In geology, one emphasis has been to strengthen prerequisites in ESCI 221 to make the course more robust and meaningful for geology majors—the course also serves as a very popular general education courses (G2, L) and for recruitment in geology as well as the B.A. in earth sciences with an option in environmental geology. Geology remains the only lab science discipline at MU with a ‘single-tier’ lab system in which the general-education lab courses taken by the majors are the same courses taken by non-majors (in all other lab sciences, there is at least one G2, L course that does not count toward the major, and is thus focused on non-majors). Adding a lab component to an existing 100-level G2 geology course would allow one lab course to focus on non-majors, and allow ESCI 221 to be directed more to the needs of majors than it currently is. A second focus has been the development and approval of ESCI 421, *Advanced Geology*, which is a senior level capstone course for geology majors that examines, in-depth, current geological research from multiple subdisciplines. The course is designed to foster the synthesis and integration of knowledge through student-led exploration of current developments in geology, with students responsible for interpreting and discussing pertinent geological research, including the role of science in society.

The OSCS program has seen significant program-wide transformation aimed at better alignment with faculty expertise, programmatic resources, new and emerging trends, affiliation with and expanded use
of the Wallops Island MSC, and student recruitment. Like geology, we do not see a need to make further substantial revisions to the program curriculum at this time. But there are imperatives that loom large. Excluding the B.A. in earth sciences, OSCS suffers from under-capacity in the major—the current number of majors is approximately 20 with approximately 30%–40% meteorology students earning double majors. The consequence is that even though the curriculum is modern and forward thinking, certain upper-level courses occasionally have insufficient enrollment and are withdrawn from the schedule to make more effective use of faculty complement. At times, this can leave students scrambling for substitute courses, which interrupts the curricular sequence and erodes student satisfaction with the program.

We recognize that, to increase enrollment, we must engage in targeted recruitment. Our recruitment effort for OSCS should begin internally with the ever-popular courses ESCI 104/105 *The World Ocean* and ESCI 261 *Introduction to Oceanography*, which are both general education courses with laboratory components (G2, L), and have had a throughput of 2,786 students from 2006–2011. Oceans remain a largely unexplored frontier, and the subject continues to attract curious students. Coastal areas are vulnerable to a wide range of natural and human-induced hazards, from sea level rise to coastal erosion and wetland degradation to overdevelopment, and will appeal to the next ‘gener’ who desire careers that have an aspect of societal improvement and are more personally meaningful. These courses, with their “captive audience,” offer an excellent opportunity to recruit students to the major. In addition, we have an excellent opportunity to recruit by way of a sustained marketing effort that spotlights the program’s link to the MSC at Wallops Island. Our first effort occurred in summer 2012 with the offering of ESCI 104 at MSC, an initiative that we will continue to promote and expand. We also attempted to offer a 2012 summer camp at MSC across all the disciplines including OSCS, and expended costs on a marketing campaign, but could not attract sufficient participants to offer it. This has not dissuaded us in our commitment to the concept of a summer camp as a recruiting tool, and we will try another all-discipline approach in summer 2013. We believe the summer camp can be a hook for prospective students interested in careers in the earth sciences.

Another opportunity for the OSCS program comes through the Ocean Observatories Initiative and our membership in the regional observing station through MARACOOS. We expect our participation to bring greater recognition to MU and the OSCS program, while providing an entirely new and exciting data stream for students enrolled in the major.

The positive impact of university-wide changes to the general education requirements for the liberal arts core is likely to affect the meteorology program the most. By freeing up credit hours that students can use in the major, we can develop a new 200-level (sophomore) course in meteorological analysis. This new course will introduce
students to practical techniques that serve as an undergirding for all courses in the major. The course, tentatively titled ESCI 240, *Analytical Techniques in Meteorology*, will serve as a counterpart to the existing ESCI 241, *Meteorology*. Students will be able to enroll in ESCI 240 or 241 depending on their prerequisites. Not only will this course fill a knowledge gap in our curriculum, it will provide students with an option to start their meteorology requirements while fulfilling prerequisites that they will need for the more quantitative ESCI 241. For years, transfer students matriculating in meteorology without the necessary math prerequisites either had to be granted special permission to enroll in ESCI 241 or wait a full year until it was offered again before taking their first meteorology course. We anticipate an improvement in our 4-year graduation rate as a result of these changes.

**Imperative 3: The need for a new facility for integrated science**

From Figure 1, it is apparent that DES is part of an organizational structure that has synergies with the Integrated Scientific Applications and Emergency Management programs. Since the department’s founding in 1968 through several program reviews and strategic outlooks, we have and continue to strive to create actionable plans that stay true to maintaining solid programs in the majors while seeking opportunities to keep pace with the changing landscape of the science and the workforce. We are committed to our vision to offer programs that are truly second to none. But we have outgrown the existing facility and we are the only department in SCMA with facilities that are distributed across every building in the Argires Science Complex. We presently occupy four buildings: Caputo Hall (Meteorology), Brossman Hall (Geology and OSCS), Roddy Hall (Geology), and Nichols House (OSCS and department secretarial offices). Moreover, faculty offices are separated from labs and classrooms; rarely do meteorology students (and faculty) interact with their counterparts in geology and OSCS, and our equipment assets are stored in closets or sheds, complicating quick deployment for hands-on learning. We have no space for staging equipment operations prior to field deployment. This situation severely limits our ability in three fundamental areas: 1) moving forward on interdisciplinary fronts and new initiatives with the core disciplines in research and education; 2) creating synergies between the undergraduate programs, between graduate and undergraduate programs, and between organizational entities, and 3) having adequate space for using equipment for hands-on education and research. An adequate facility will fire the impetus for transformation and integration so that we can achieve more and redefine our potential based on the new organizational structure.

*Integration and Transformation* is the theme of our strategic plan. The department sees a new multipurpose facility as key to our mission, integral to student success, and as central to an actionable plan that must be accomplished by 2017.

**Facilities goals**

1. Any major construction venture must begin with a commitment on the part of all stakeholders. The concept of a new facility for DES and its related entities is not new. It was part of our 2007–2012 strategic plan, and threaded its way into the University Master Plan – stage 2; we are currently finishing stage 1 with the Ganser Library renovation and the completion of the Charles R. and Anita B. Winter Visual and Performing Arts Center. However, with the expanding breadth of our disciplines, the growth of the M.S. in Emergency Management program, and the addition of the new M.S. in Integrated Scientific Applications, the need for a new facility is more urgent than ever. This cannot wait for the next strategic plan. *DES will work with the University Administration and the*
School of Science and Mathematics to seek “bricks and mortar” funding by 2015, in full or as a challenge grant, in order to realize the construction of this facility within the period of this strategic plan (2013-2017).

2. Related to the first goal, we envision a LEED-Certified Center for Earth and Hazards Sciences and Solutions, which will serve as the hub for DES, CDRE, and its MSEM program and the Emergency Operations Center (EOC), home of the MSISA program, the Weather Information Center, and the MU Center for Environmental Sciences. We have a unique opportunity to create an integrated facility that broadens the student experience, spaws deeper learning through involvement in authentic, skills-based activities, and empowers new modes of transdisciplinary inquiry in a market that exhibits workforce need.

**Imperative 4: The need for new complement**

Two of the most important metrics for department productivity at MU are student-faculty ratio and extramural (grant) funding. The DES 2010–2011 student-faculty ratio (FTES/FTEF) is second highest at the University and first across the seven departments in SCMA. In fact, Figure 9 shows that for the 2006–2011 average FTES/FTEF, the DES is consistently and significantly (1.7σ) above the school mean (DES = 23.9 versus SCMA = 16.8), and even 0.7σ above the Department of Mathematics, which has the second highest FTES/FTEF (20.6) in SCMA.

Moreover, the meteorology program has four regular full-time meteorologists, however, the chair and the MSEM program coordinator each have half-time teaching load reduction for these alternative assignments. So meteorology effectively has three full-time teaching faculty to cover the major sequence of courses. In addition, the program coordinator for the MSISA program currently has no load reduction for this effort. Similarly, the OSCS program has two regular full-time faculty, and although the number of majors is less than 20, it is difficult to expand the breadth of ocean sciences to address emerging initiatives on a bare-bones complement. Across the DES, faculty load is so prescribed by the courses in the major and large-enrollment introductory courses, that there is little that remains for cross-pollination and transdisciplinary interactions and collaborations.

It is worthwhile to consider the effect that one additional complement in DES would have on the FTES/FTEF. An additional faculty complement in DES would reduce the FTES/FTEF from a 5-year average of 23.9 to 23.8, the latter accounting for the increase in the annualized student credit hours (~700) generated by the additional faculty member. DES would retain its status as one of the most productive departments on campus. The benefit to the department, on the other hand, would be enormous. Adding one position with an interdisciplinary expertise (e.g., earth system science, climate science/modeling with a cross disciplinary research portfolio, or land-air-ocean exchange processes) could serve as a keystone to
bridging the current major disciplines and help bring convergence to the theme of this strategic plan: Integration and Transformation.

**Complement goal**

Add a faculty member to the DES complement with an expertise in earth system science, or climate science/modeling with a cross-disciplinary research portfolio that could include societal impacts or mitigation and adaptation, or a geoscientist with expertise in land-air-ocean exchange processes.

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Appendix A.1: Key Indicator Data Summaries
Appendix B: Faculty and Staff Collaborations
Appendix C: DES Budget Information
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