Engaging MSU Students in NASA Mission Related Research

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Outline of Presentation

- Introduction
- MSU Engineering Undergraduate Program Overview and Graduate Curricula with Focus on Applied Research Projects from Industry and Governmental Agency Sponsored Research, especially NASA Related/Interested Research Projects
- MSU Collaboration with NASA
- Highlight of Recent Collaboration with NASA and MDSGC-Supported Projects
- Outcome Assessment On MSU Graduate Students Who Participate In NSF S-STEM Grants
- Concluding Remarks
- Acknowledgement

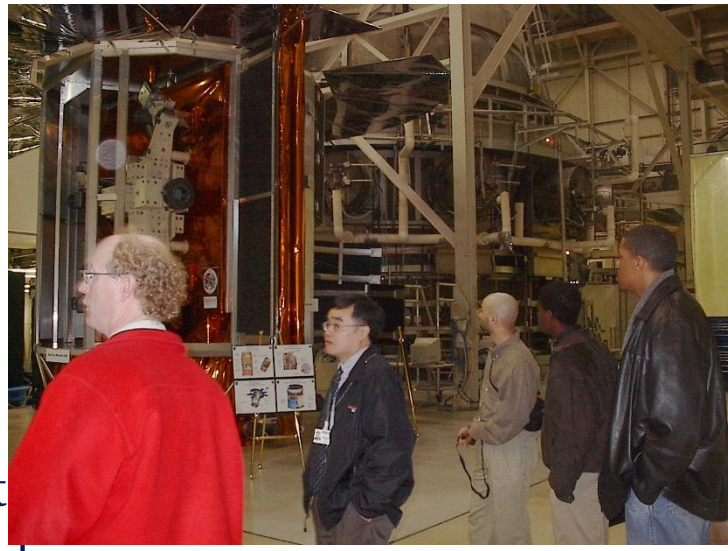
Introduction

- Science, Technology, Engineering and Mathematics (STEM) fields play an important role as an economic engine.
- Competitiveness in STEM fields is basically a benchmark for the country's global competitiveness.
- Federal Government has set up policies and set aside funds to support STEM workforce development to maintain American economic competitiveness and leading role in the world.
- The workforce development in engineering is especially important in dealing with the significant global competition from fast-growing economies.
- Participation opportunity in funded research is an important factor in attracting talented engineering students.

Introduction - Continued

- Through ASEE/NASA Summer Faculty Fellowship Programs in 1999/2000 and an NASA Administrator Fellowship Program, Dr. Chen has established a good relationship with the NASA engineers at GSFC.
- Since then, every year several MSU engineering students are engaged in real NASA research projects.
- The students participated in the research with NASA project teams.
- Sponsored by NASA engineers and program managers, students received the badges to actually work at NASA facilities of GSFC.
- Students benefited significantly from this type of experience and their interests in STEM area are inspired.

Introduction - continued



- Graduate study provides a passion and a pathway for advanced education or career advancement.
- Many MSU graduate students come from economically disadvantageous families and have very limited financial support for their full-time graduate study.
- NSF S-STEM scholarships, NASA research grant and other Federal research grants provide financial supports for these students, which also allow student's involvement in applied research in the federal laboratories such as NASA GSFC.
- The grant support from MDSGC also allowed us to support one or two engineering students to conduct research with NASA engineers at GSFC every year for the past eight years.

Morgan State University (MSU) is

- Historically Black College/University (HBCU),
- Advocate of diverse STEM workforce pipeline development.
- Classified as a doctoral/research university (DRU) under the Carnegie classification system.
- MSU has developed a ten-year strategic plan that includes a vision to propel the University from the current DRU Carnegie classification to RU/H Research University (high research activity).
- MSU President brought a motto “Grow the Future, Lead the World” to the university.

MSU Engineering Program Overview

- MSU School of Engineering contains four departments: Electrical and Computer Engineering; Industrial and Systems Engineering; Civil Engineering; Transportation Studies
- The School offers ABET-accredited B.S. degree in each department, also M.Eng degree and D.Eng degree.
- B.S. degree needs about 133 credits, now in a transition process to 120 credits, including a senior design project
- M.Eng needs 33 credits, including a research project.
- D.Eng needs 30-credit course work beyond master's degree, plus a dissertation focusing on an applied research problem.

MSU Engineering Graduate Curricula

MSU School of Engineering offers the Doctor of Engineering (D.E.N.) and Master of Engineering (M.E.N.) degrees, which focus on applied and interdisciplinary research topics for graduate dissertations and theses. The graduate curricula in Engineering have a focus on

- ✓ encouraging graduate students to conduct an applied research project with industry or Federal laboratories, or research centers.
- ✓ Master's degree candidates need to complete an applied research project of four semester-credit hours (Research Project I & II) in 1 - 1.5 years.
- ✓ doctoral candidates need to complete a dissertation focusing on applied research in 1.5 - 3 years.
- ✓ A total of minimal 33 semester credits are required for the Master's graduate student (courses and projects).
- ✓ Master's graduate student must complete more than 10 semester credits of coursework before starting Research Project.

Applied Research Projects

- Similar to the setting for doctoral dissertation, most master-level graduate students are required to make a professional presentation on the research proposal in Research Project I.
- The student will spend one more semester or even more than one year to conduct the research, and then make a professional presentation on the completed research project to summarize the research findings.
- These presentations are open to public and the students are interrogated by challenging questions from faculty, industrial sponsors and colleague students.
- Through this process, the graduate students can significantly enhance their hands-on capabilities and applied research-oriented critical thinking. Their communication skills through presentations can also be significantly improved.

MSU Collaboration with NASA

- Since about twenty years ago, MSU engineering school has conducted many collaborated projects with NASA, including several major NASA grants.
- Such as in the past several years, Dr. Chen was involved in “Center of Excellence in Systems Engineering for Space Exploration”, “Maryland Elite Researcher In Training”, etc.
- Nearly a hundred of MSU engineering students had a chance to work with NASA engineers at GSFC. Many of them were hired by NASA and defense industry later after their graduation.
- Dr. Chen’s collaboration with NASA are mainly in reliability engineering, systems engineering and manufacturing cost reduction of aerospace products


National Aeronautics and Space Administration

Presents the

Silver Achievement Medal

to

NASA & Morgan State University Collaboratio
Team

For outstanding leadership in NASA’s core value of teamwork by championing collaborations with Morgan State University.

Guangming Chen

Signed and Sealed at Washington, DC
this twenty-eighth day of August
Two Thousand Twelve

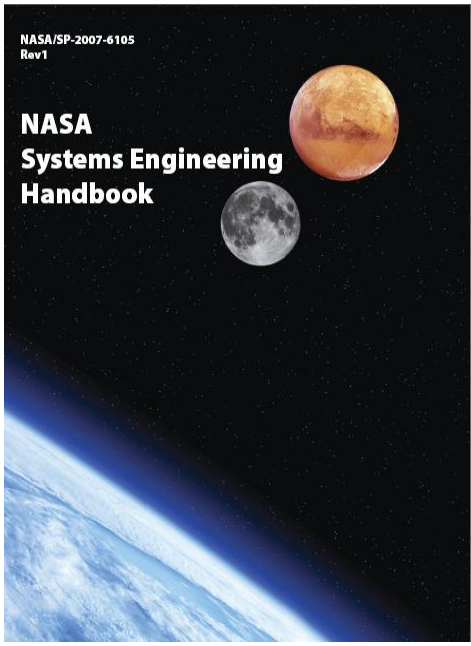
Administrator, NASA

Recent Collaboration with NASA and MDSGC-Supported Projects

- Systems Engineering – There is an increasing demand for systems engineering skills and talents in NASA and aerospace industry in the past decade. MSU engineering students were involved in cost reduction and cost prediction for multiple production runs of small satellites and aerospace products, and trained and guided by NASA systems engineers to function as a systems engineer for a university team.
- Reliability study for antenna systems in the remote sites, such as McMurdo station in Antarctica
- SOARS Database Improvement

Systems Engineering

- The main guidelines were drawn from
  - NASA Systems Engineering Handbook;
  - NASA Requirement Protocol;
  - Criteria for Flight and Flight Support Systems Lifecycle Reviews by NASA.
- NASA Systems Engineering Handbook: Systems Engineering is an interdisciplinary approach for the design, realization, technical management, operations, and retirement of a system



Systems Engineering - continued

Systems Engineering (SE) is a kind of interdisciplinary approach to allow the fulfillment of successful systems, with focuses on

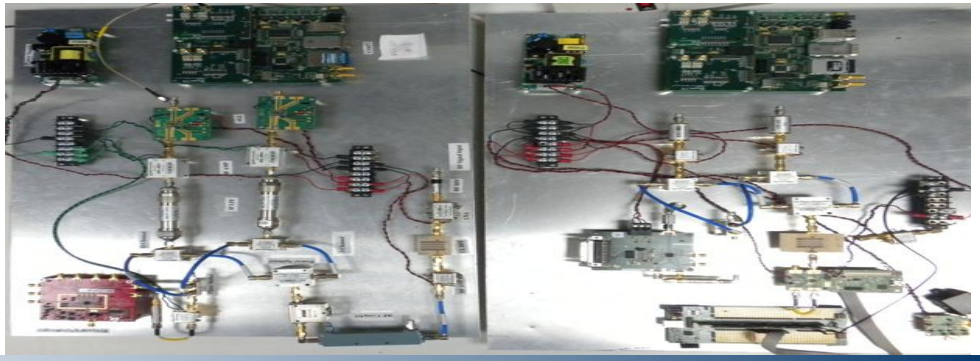
- the needs of customers or clients, and the needed functionality early in the development stage.
- This involves cataloging requirements, creating a design synthesis, along with the system confirmation.
- The task may involve scheduling and cost, operations, training and support, performance, test, manufacturing and disposal.
- Basically, System Engineering deals with both technical and business needs of all customers with the purpose of bringing up a high-quality product more efficiently.

Systems Engineering Application to Software Defined Radio (SDR) Technology Development

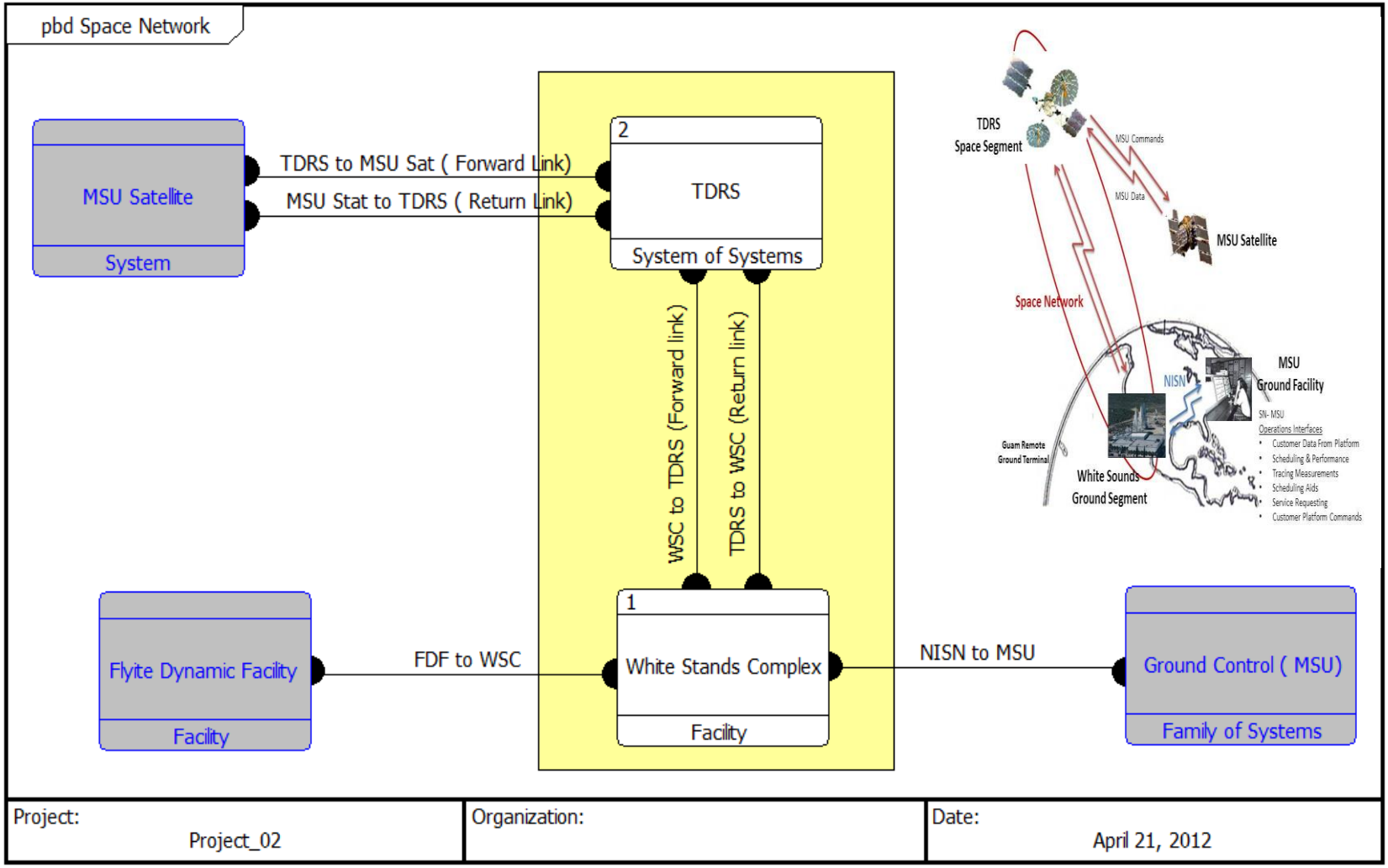
- SDR is a type of radio communication system where the functions of many hardware components (amplifiers, modulators, mixers, filters etc.) are replaced by software in a personal computer or other types of embedded computing devices.
- It also serves as a type of modem that modulates and demodulates the incoming Radio Frequency (RF) signals. The main goal of this SDR project at MSU is to discover alternative solutions to advance in SDR applications.
- The MSU System Engineering and Management Institute (SEMI) was established to collaborate with the electrical engineering student researchers and industrial engineering student researchers to apply systems engineering in the SDR project.

Systems Engineering Application to Software Defined Radio Technology Development- continued

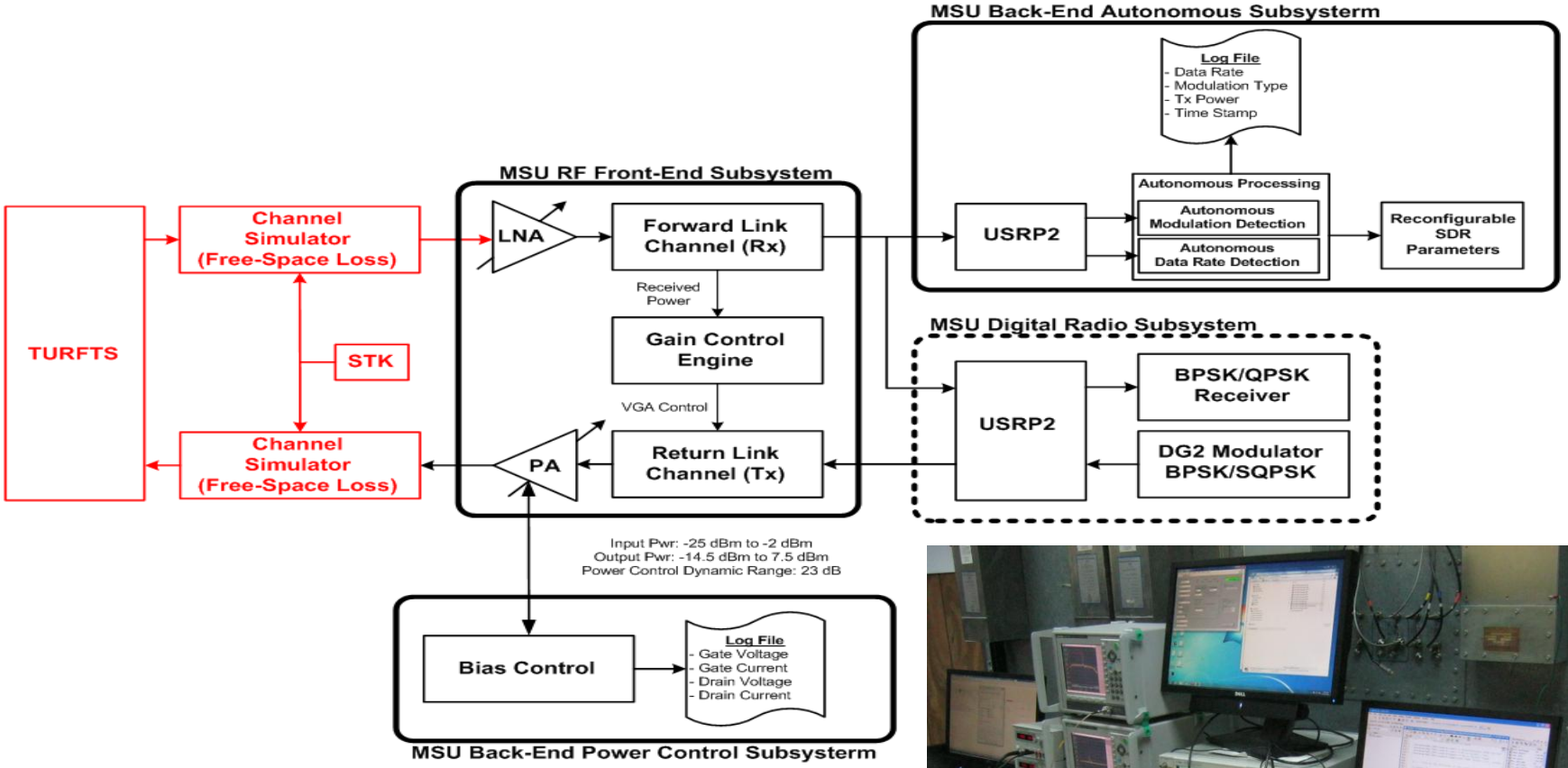
- The MSU electrical engineering team fabricated the technologies that are befitting to the SDR platform on an unmanned cargo supply spacecraft ("MSU-Sat") that brings provisions and equipment to the ISS in a hypothetical scenario.
- The following slide gives the illustration on the SDR system architecture and demonstration or context diagram.
- A context diagram is a useful tool for grasping the system to be built. The diagram shows the general structure. The MSU team makes the system as three subsystems:
  - Front-end Subsystem
  - Back-end subsystems
  - Digital Radio subsystem

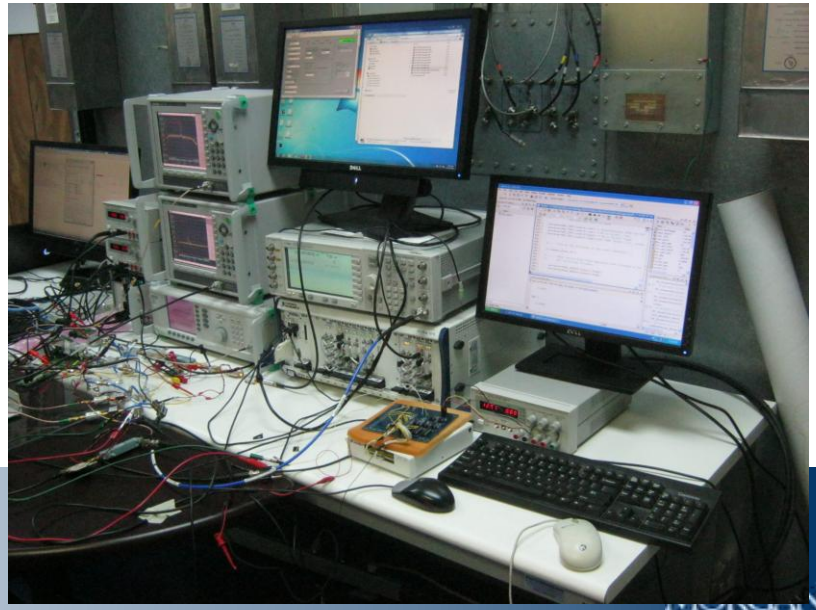


Space Network



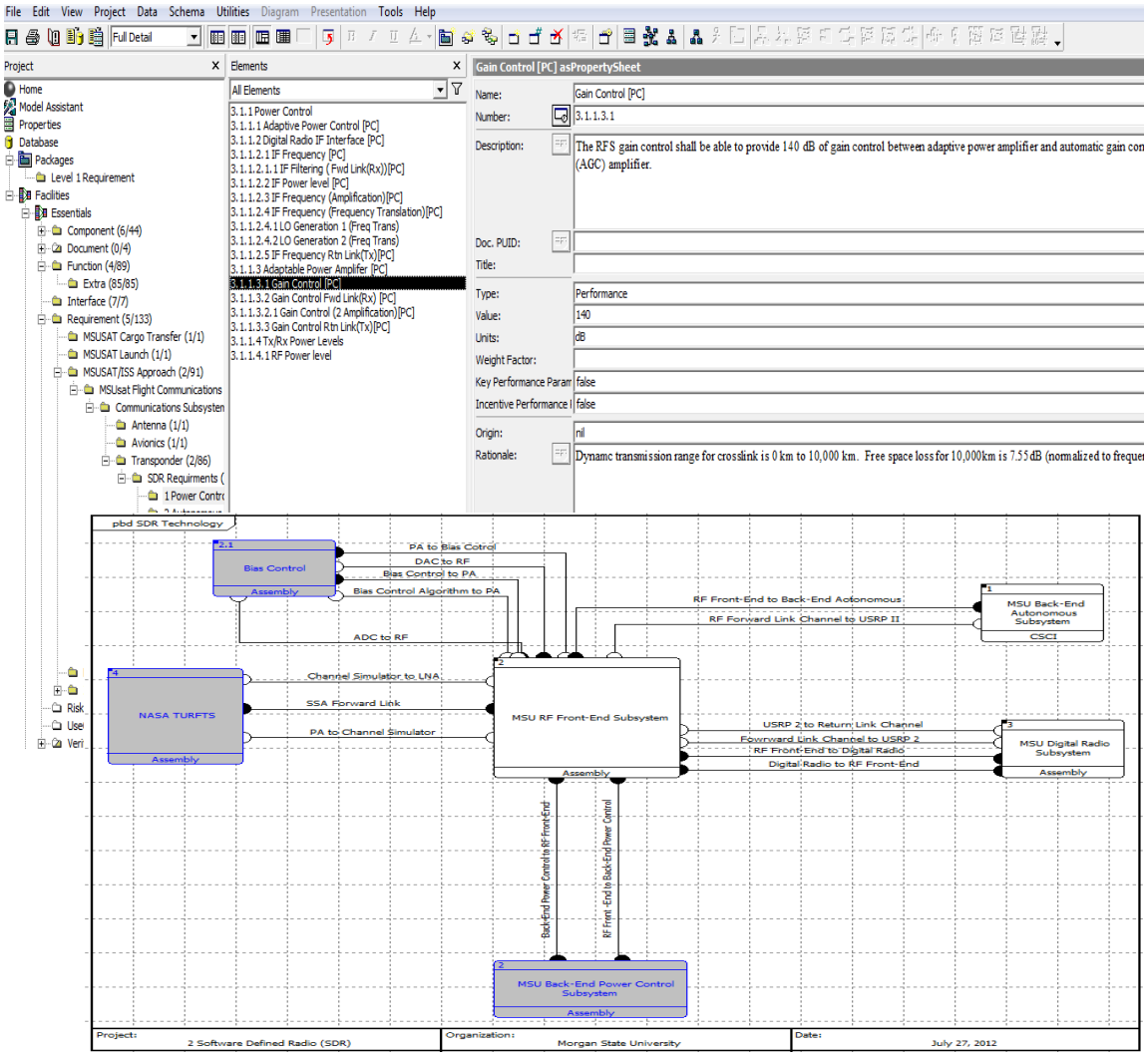
Systems Engineering Application to Software Defined Radio Technology Development- continued





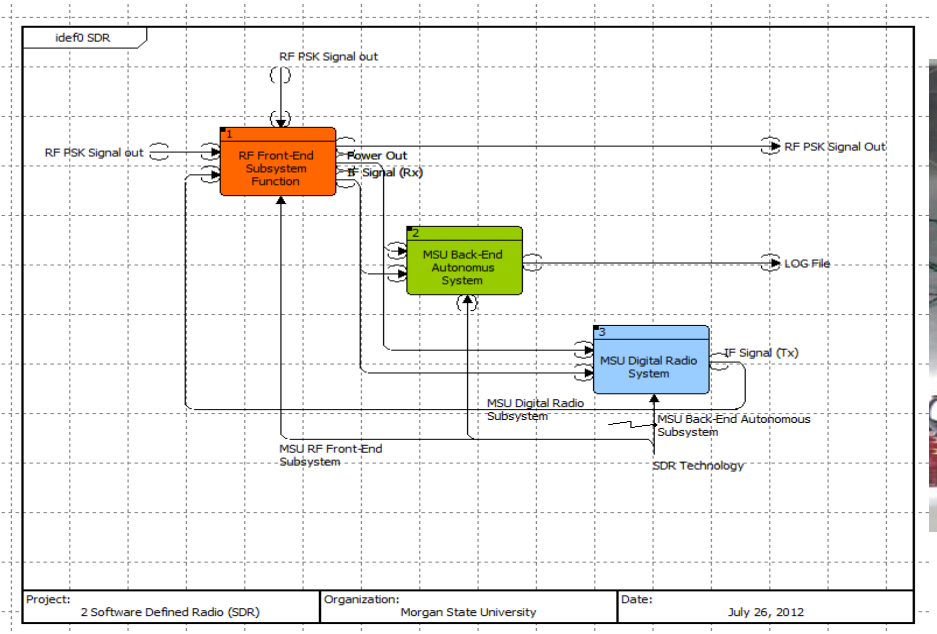
The part in red is NASA's facilities, including the TDRSS (Tracking and Data Relay Satellite System). The part in black is developed by the MSU team. It includes all the main components of the back end, front end, and digital radio subsystems.

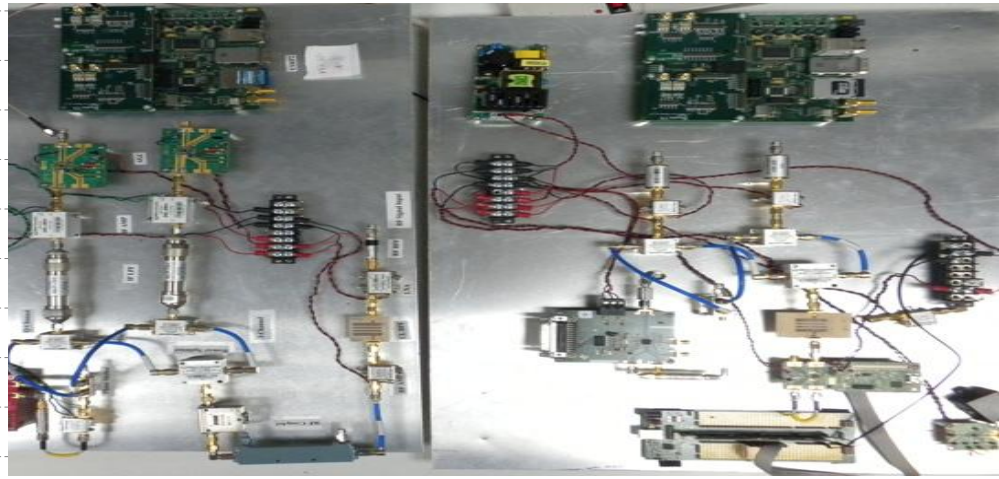
CORE Software

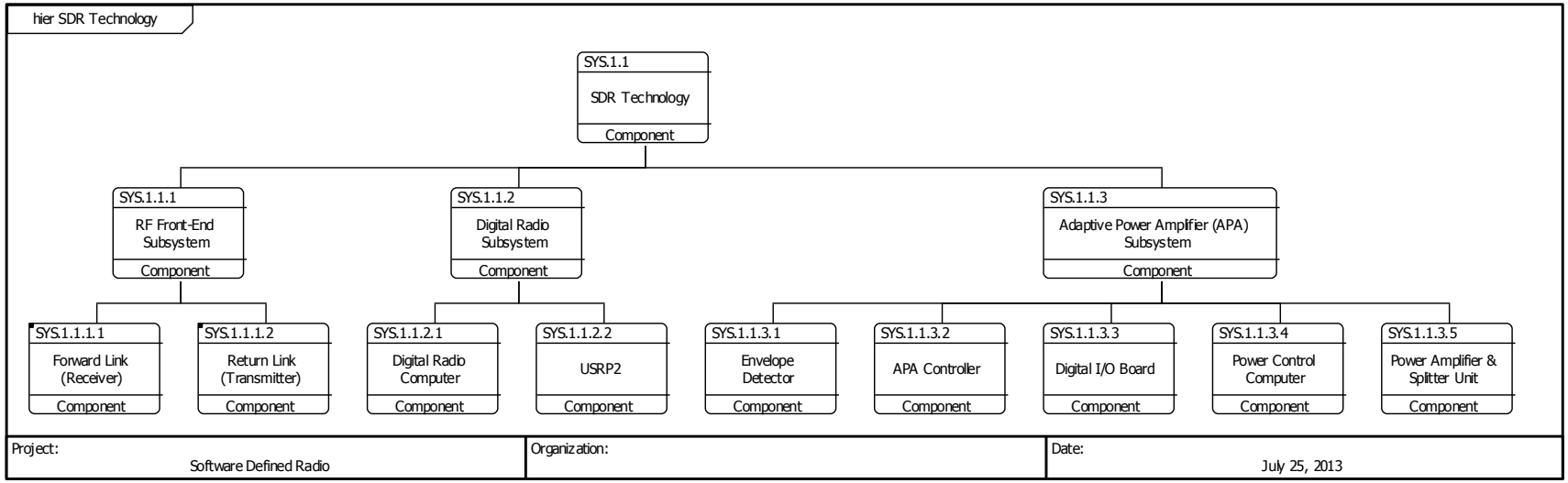


input the requirements of specific components dealing with the SDR. Such as an originating requirement is Power Control, and it is broken down into its different components (elements). Here you can see the elements. (The elements represent a "thing" that can be uniquely identified.) The system name is located towards the top and underneath that comes is number designation. Immediately after that comes the description of the component. At the bottom, the relationships can be created. For instance, it can be refined by something or it refines another item.

Some Diagram and Component Hierarchy Diagram Generated by CORE for SDR at MSU





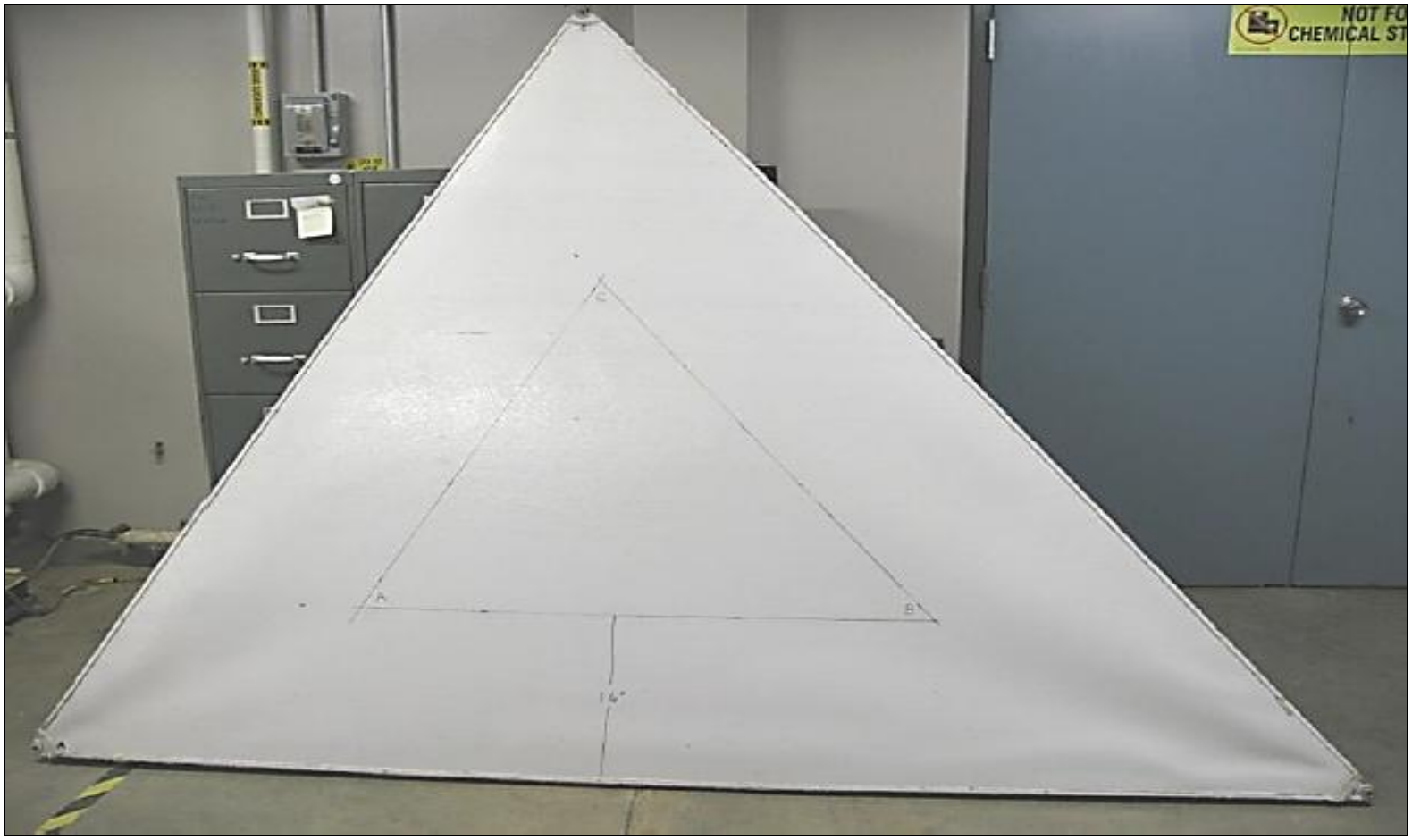


Reliability Study for Antenna Systems at Remote Sites

MSU engineering students participated in the applied research projects, collaborated with NASA engineers at Goddard Space Flight Center (GSFC), on Reliability Study for Antenna Systems at Remote Sites

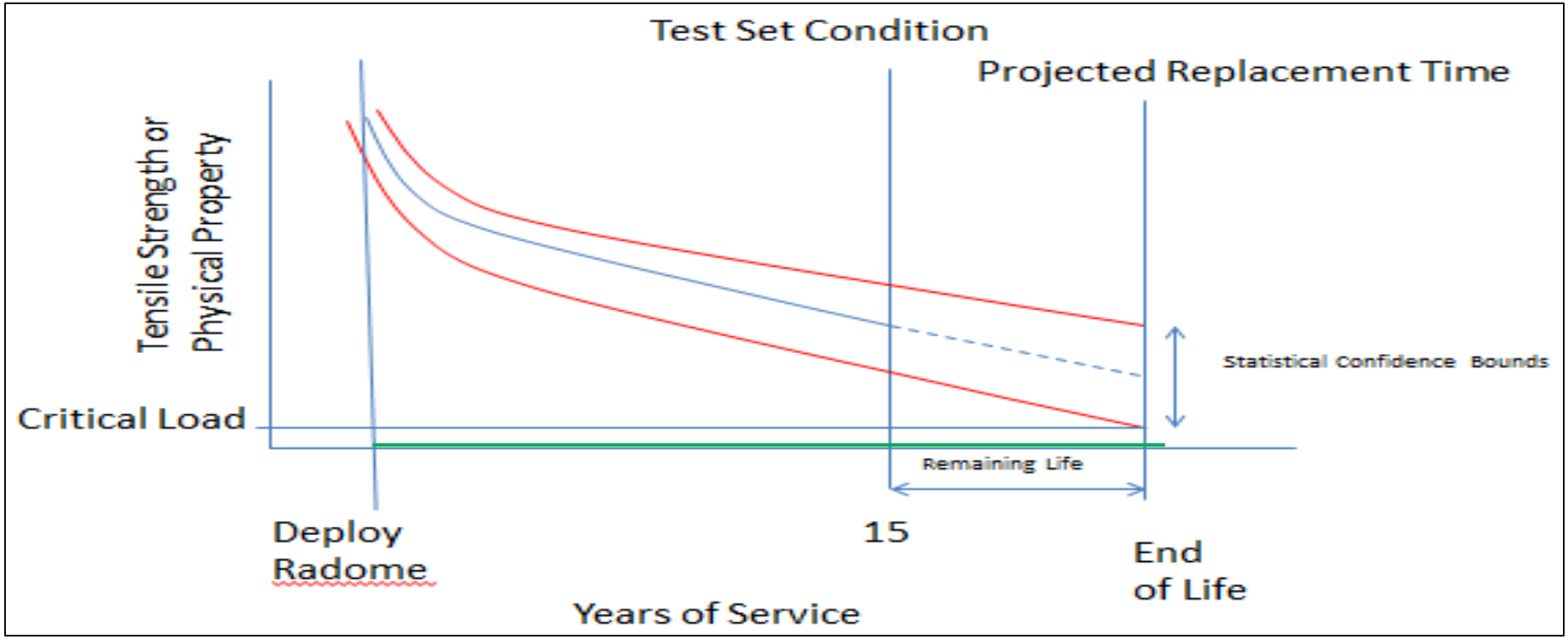
- Radome Availability and Maintainability Study – to study the degradation of Radome panel materials under the extreme weather conditions, such as McMurdo station in Antarctic or Guam
- Reliability and maintainability study for McMurdo antenna system

Redome Panels - Center Area that Experiences Greatest Wind Loading Marked on Panel



Reliability Study for Antenna Systems at Remote Sit- Continued

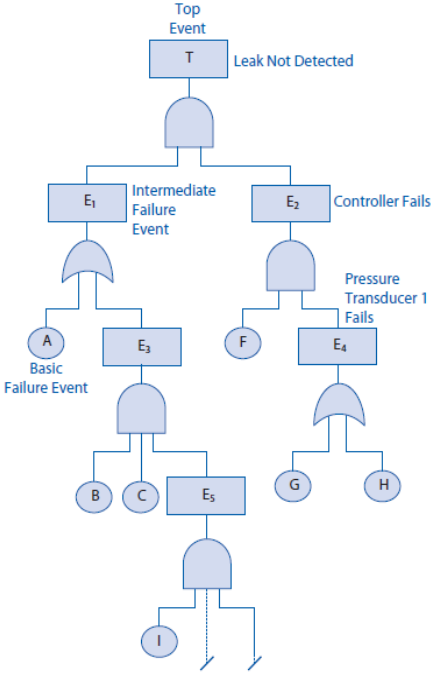
The student's experience in working with NASA engineers or industry can significantly benefit the students and enhance their future employability. For instance, after conducting Master's research project on reliability with NASA engineer, an M.E.N. graduate received several job offers as reliability engineer from Zodiac Aerospace, BGE and a consulting firm.



Categorizing the Database of Spacecraft Orbital Anomaly Report System (SOARS)

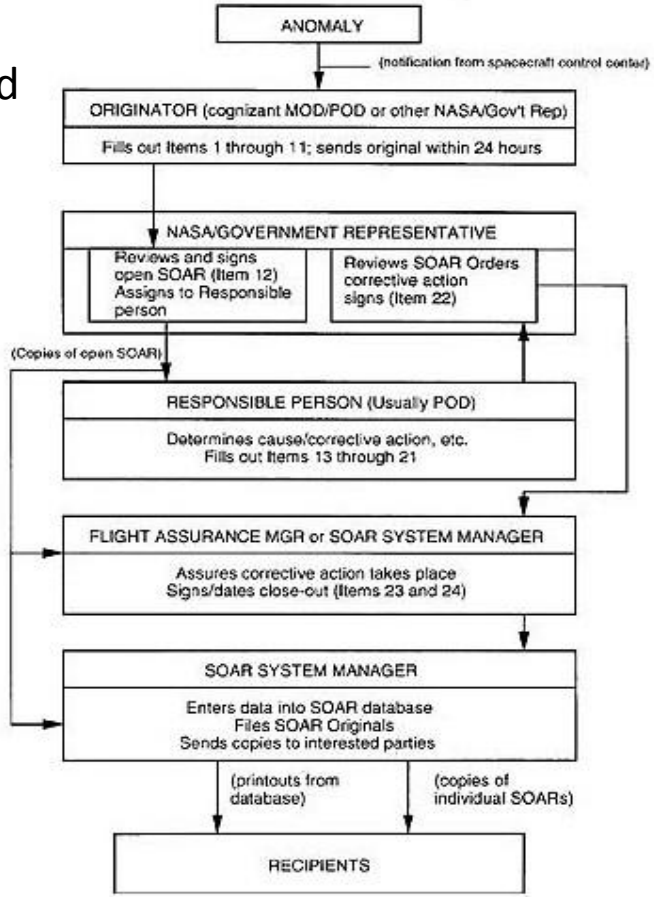
Learn from unexpected outcomes or failures, and properly understand consistent operational successes.

- SOARS database has recorded all operational anomalies of spacecraft/subsystems related to GSFC missions since 1972
- SOARS provides a single uniform, effective, and efficient computer database for in-orbit reliability studies to identify performance trends for use in design reviews, flight readiness reviews, and in the evaluation of test, reliability, and quality assurance policies.
- To increase the safety of the future space missions, it is important to enhance the reliability and risk analysis.
- It can help the accuracy and convenience of the future reliability and risk analysis if MSU students can collaborate with the engineers at GSFC in categorizing the anomaly data according to failure cause and mode, relating the anomaly data to the proximate cause of the failure for reliability analysis purposes.
- The failure mode and effects analysis (FMEA) and fault tree are used to link the original causes to the anomaly operation events.



Categorizing the Database of Spacecraft Orbital Anomaly Report System (SOARS) - Continued

- The goal of SOAR is to report anomaly operation immediately after the occurrence of an anomaly.
- Valuable data given as schematic data, numerical data, and text data.
- Categorizing these data for probabilistic modeling.
- MSU students will conduct this task, according to the failure cause and mode, relating the anomaly to the proximate cause of the failure.
- Student's exposure to the real NASA project environment.
- Students received training on the use of SOARS database.
- Their technical tasks include:
  - Organizing data into vectors suitable for input into statistical modeling software.
  - Performance Benchmarking of competing statistical models and parameter estimation methods.
  - Reporting and Analysis of Benchmark Results
  - Assistance in preparing scholarly papers in referred journals, conferences



SOARS Flow Diagram

Outcome Assessment on MSU Graduate Students Participating in NSF S-STEM Grants

Doctoral Scholars in Engineering (DSiE), funded by National Science Foundation, allow us to increase the financial support to engineering graduate students. Several graduate students supported by this grant have worked on NASA related projects. The objectives of the scholarship:

1) Increasing access to the doctorate, especially for underrepresented minority students;
2) Improving doctoral degree completion and time to degree by relieving participants from full-time off-campus employment;
3) Improving support programs for doctoral students in the School of Engineering;
4) Increasing the preparation for and placement of doctoral students in academic and research careers.

Outcome Assessment on MSU Graduate Students Participating in NSF S-STEM Grants

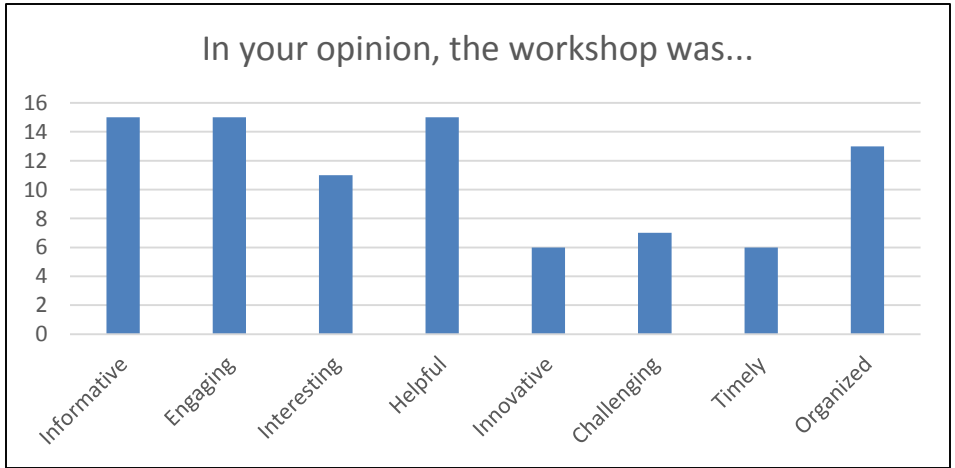
Table 1 below shows the results of initial recruitment and participant selection in the first semester.

Table 1: Applicant recruitment and selections (Year 1)					
		Fall 2013		Spring 2014	
		Applicants	Selected Participants	Applicants	Selected Participants
Applicants	Female	5	3	2	2
	Male	13	4	7	1
Cumulative GPA		3.73	3.73	3.55	3.61
US Citizens		83%	100%	44%	33%
Current Doctoral Students		94%	100%	100%	100%
African American		78%	57%	89%	100%

	Gender		**Ethnicity**	
	Male	Female	Black	White
DSiE Scholars	50%	50%	70%	30%
Engineering (Doctoral)	72%	28%	62%	5%
Morgan State (Doctoral)	38%	61%	74%	10%

Outcome Assessment on MSU Graduate Students Participating in NSF S-STEM Grants

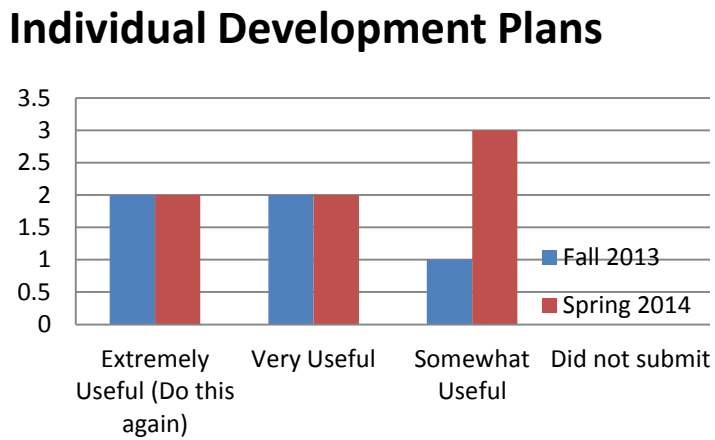
- The DSiE community utilizes existing student support structures in the School of Engineering while creating new opportunities for students to develop professionally.
- Students were provided with professional development opportunities, including several seminars and a workshop.
- The use of an Individual Development Plan has been shown to improve career outcomes for doctoral students and is promoted by many professional societies and funding agencies.
- Participants developed their own IDP using the tool at *www.myidp.sciencecareers.org*.
- This strategic planning tool allows students to use their skills, interests and values to set goals and identify career paths.



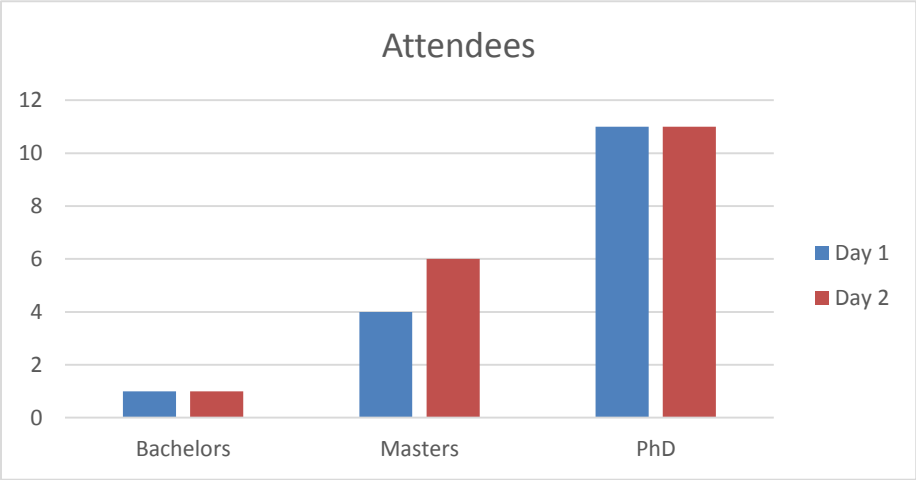
Outcome Assessment on MSU Graduate Students Participating in NSF S-STEM Grants

During Spring Break 2014, the DSiE team hosted a two-day hands-on research and communication workshop modeled Workshop participants developed a research roadmap (Day 1), research plan (Day 1), presentation storyboard (Day 2), and research elevator speech (Day 2).

There were 21 attendees and the breakdown by academic classification is shown in Figure on right. Feedback about this workshop was overwhelmingly positive as shown in Figure on right.



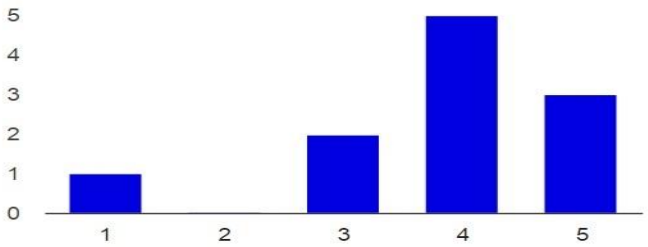
Students ratings on the usefulness of preparing IDPs.



Workshop attendees by level.

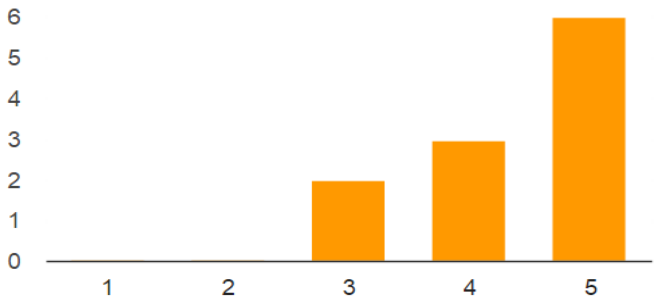
MERIT Program Outcome Assessment

I am more interested in the STEM fields since participating in MERIT.



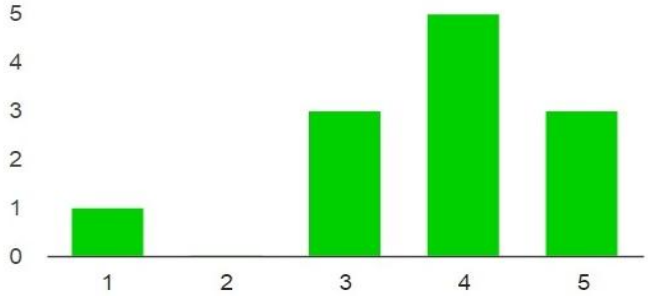
Strongly Disagree: 1	**1**	9.1%
2	**0**	0%
3	**2**	18.2%
4	**5**	45.5%
Strongly Agree: 5	**3**	27.3%

I am comfortable with my coursework



Strongly Disagree: 1	**0**	0%
2	**0**	0%
3	**2**	18.2%
4	**3**	27.3%
Strongly Agree: 5	**6**	54.5%

My technology skill has been enhanced by my experience in the MERIT program



Strongly Disagree: 1	**1**	8.3%
2	**0**	0%
3	**3**	25%
4	**5**	41.7%
Strongly Agree: 5	**3**	25%

Concluding Remarks

- The ability to conduct applied research project is an important factor for the career development of engineering students.
- Participation in an applied research project especially in NASA related Projects can effectively retain student's vigorous interests and enthusiasm in STEM areas and enhance their problem-solving capability.
- Engaging students in NASA related research projects can significantly improve their teamwork skills and offer a better future employability on job market.
- Our experience in engineering education at MSU convinces us that this education setting can benefit these students in their career-building path.
- After SE research was conducted on the SDR project, multiple vital problems were found by our students from systems engineering perspective.
- Through engaging several engineering students, the students were able to create concept of operation, product breakdown structure, a context diagram, and master schedule by using CORE. The software can also help prepare these future systems engineers.
- A 370-page Systems Engineering Report was submitted to NASA.

Acknowledgement

Our effort to engage students in NASA related research is supported in part, by

- Maryland Space Grant Consortium,
- Several other NASA grants,
- NASA reliability engineering branch and systems engineering division at GSFC.
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Thanks!