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Multidisciplinary Engineering Technology: Addressing the Change in Industry Workforce Needs

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Introduction

Over the past ten years, industry that hires engineering and engineering technology graduates has placed increasing emphasis on undergraduate education that crosses the boundaries of traditional technical or stovepipe curricula. For example, in the aerospace, automotive and oil/gas industries, there is a growing need for new hires that have expertise in integrating electrical and mechanical systems to create, operate, develop and maintain intelligent electromechanical systems. To this end, the Engineering Technology and Industrial Distribution Department at Texas A&M University is proposing a new program entitled "Multidisciplinary Engineering Technology."

The new program, which will reside in the Dwight Look College of Engineering, will be based on a strong engineering technology core curriculum that incorporates fundamentals in mechanics, thermodynamics, materials, electronics, programming, instrumentation, project management and product development. The students can then customize their degree through faculty-designed, twenty-nine credit hour emphases that are based on technical areas identified through industry/faculty collaboration. In this way, the program will be versatile and able to respond to changing industry needs. For example, the first emphasis will be in mechatronic systems where the students will augment their core knowledge with courses in embedded systems, control systems, fluid power systems, and mechanical/electronic system design. The mechatronics emphasis was identified through multiple sources including industrial advisory committee meetings, industry visits and specific industry requests.

Currently the program is going through the university request-for-approval process and will officially begin in Fall 2016. In the interim, the faculty is developing the new courses required in mechatronics and is working with industry to identify at least two additional emphasis areas. Because of the structure of the program and the fact that it leverages existing coursework, it will not require a substantial investment of resources in the beginning. Finally, it is envisioned that the new program will be accredited through ASEE based on the general engineering technology criteria. This paper will discuss the details of the new Multidisciplinary Engineering Technology curriculum, the efforts made to create emphasis areas, the approval process, and the recruitment of the first class of students.

Need

Industry

The Occupational Outlook Handbook of US Bureau of Labor Statistics does not have a separate category for Multidisciplinary Engineering Technology. However, considering that a proposed program includes fundamental courses in mechanical engineering technology and electronic systems engineering technology which includes embedded electronic hardware and control software, it is reasonable to say that graduates from a multidisciplinary engineering technology program can be hired to work in many of the areas covered by these fields, especially where the specialties intersect and require capabilities in multiple disciplines.

Although detailed statistics specific to careers in engineering technology are not available, in general these careers will closely follow those of similar-focused engineering careers. Table 1 shows the growth outlook in USA from 2012-2022, for jobs in mechanical engineering, electrical/electronics engineering, and software development. These same types of growth rates should be expected in the associated engineering technology career fields.

Table 1. USA Engineering Employment Growth Outlook 2012-2022 [1]

Occupation	Growth rate	Annual Pay	# of jobs in 2022
Mechanical Engineers (BS)	5%	$80,580	269,700
Electrical & Electronics Engineers (BS)	4%	$89,630	318,700
Software Developers	22%	$93,350	1,240,600

Source: http://www.bls.gov/ooh/architecture-and-engineering/home.htm

The data indicate there will be many job openings with high annual pay for graduates from a multidisciplinary engineering technology program and is the justification for the first focus area to be mechatronics. In addition, graduates from the multidisciplinary engineering technology program will have the flexibility of finding employment in any of these occupational areas. Companies like Tenaris in the oil &gas industry segment are quick to see the value of an employee in their manufacturing facilities who has educational experience in mechanical systems, electronic systems, embedded intelligence systems and control systems. This provides more flexibility in employment and a less likelihood of being impacted by an unexpected downturn in a specific engineering field.

The Texas Job outlook for 2012-2022 (Table 2) shows much stronger demands than the national averages in similar fields with higher pay. The overall trend for Texas jobs is the same as that for the United States. There will be many job openings with high annual pay for graduates from the Look College of Engineering multidisciplinary engineering technology program.

According to US Department of Labor, among 4-year B.S. degrees, all four relevant occupations, Mechanical Engineers, Electrical Engineers, Electronics Engineers, and Software Developers (application), rank in the top 50 occupations with most openings: 22nd, 41st, 46th, and 9th respectively. These four occupations also ranked among the top 50 for highest paying jobs (ME: 45th, Electrical Engineers: 33rd, Electronics Engineers: 25th, Software Developers: 14th) [1]. In Texas, these four occupations also ranked among the top 50 with most openings (22nd, 41st, 46th, and 9th respectively) and the top 50 highest paying (38th, 30th, 31st, and 27th, respectively) Hence, the short-term and long-term outlook for students with a multidisciplinary engineering technology degree with a focus in mechatronics is very good.

Table 2. Texas Long-Term Employment Projections (2012-2022) [2]

Occupation	Growth rate	Annual Pay	Annual average job opening
Electrical Engineers	20.8%	$101,126	580
Electronics Engineers, Ex. Computer	22.2%	$100,002	485
Mechanical Engineers	20.0%	$99,073	990
Software Developer, Applications	25.1%	$97,035	1,540

Source: http://www.tracer2.com/publication.asp?PUBLICATIONID=826

The 2014 federal Workforce Innovation and Opportunity Act (WIOA) places renewed emphasis on education and training for workforce needs. Government, employers, and other key stakeholders in Texas have raised concerns as well that the current pool of graduates are not meeting workforce needs and have emphasized a need for greater alignment between workforce needs and education [3]. According to [3], engineering and engineering technology are in "high-demand, medium-supply" cells that needs special attention when considering new degree programs.

Students

According to the Texas Higher Education Coordinating Board, there will be an average of 6.3% increase in enrollment of all Texas higher education institutions from 2015 to 2020 [4]. The Dwight Look College of Engineering at Texas A&M University is in the process of expanding the engineering and engineering technology programs so that the total enrollment will be increased to 25000 by 2025[5]. In addition to increasing the enrollment in the existing engineering/engineering technology programs, the College of Engineering will need to create more options for students. Many students want to work in both the mechanical and electronic areas. With the significant increase in design and analytical tools for these two disciplines, more students want to combine elements of both domains as part of their undergraduate education. However, these students may not be able to get into mechanical engineering, electrical engineering or the associated engineering technology program due to capacity limits for these departments/programs. The new multidisciplinary engineering technology program will provide these students an exciting and rewarding alternative.

Another source of students are transfer students from existing electromechanical engineering associate degree programs. Table 3 shows that there were 185 students in 2014 who graduated from associate degree level electromechanical engineering programs from 10 junior colleges in the state of Texas. We also expect that there will be some high school graduates who would choose to enroll in the multidisciplinary engineering technology program with a mechatronics focus as incoming students. There may also be interests among the engineering students to pursue a minor in mechatronics. Additionally, there may be individuals in the current workforce with associate degrees who choose to advance their career by returning to Texas A&M to complete their BS degree in mechatronics.

Opportunity

Initial feedback from industrial partners indicated very strong support. There is a need for graduates with multidisciplinary educational experiences, especially with a focus in the field of mechatronics. While the market need for entry level BS-degreed graduates with multidisciplinary capabilities is clearly there, why are not more universities offering multidisciplinary engineering technology programs focused on mechatronics with BS degrees? One of the reasons could be the interdisciplinary nature of mechatronics. In general, it requires multiple departments or programs, including mechanical and electrical, to be involved. The ETID Department is unique in that there are two Engineering Technology programs within the department – Electronic Systems Engineering Technology (ESET) and Manufacturing and Mechanical Engineering Technology (MMET) – that can provide the building blocks for a new multidisciplinary program.

Table 3. Electromechanical Associate Degree Graduates in Texas, 2014 [6]

Institution	Total Graduates
Amarillo College	17
Angelina College	14
Clarendon College	2
Midland College	10
Paris Junior College	7
Texas State Technical College-Harlingen	20
Texas State Technical College-Waco	68
Texas State Technical College-West Texas	19
Tyler Junior College	28
Statewide	**185**

The multidisciplinary engineering technology program with a focus in mechatronics proposed by ETID will be a seamless integration of the two programs with two additional new courses specifically in mechatronics. This new program will address the job market need primarily in Texas, as well as be competitive nationwide. The unique structure of ETID will keep the cost of creating the new degree at a reasonable level. In the State of Texas, there is no multidisciplinary engineering technology program with an emphasis in mechatronics at the BS level. We will have no competition and do not foresee any competition in the near future.

Curriculum

Overview

As shown in Figure 1, the Multidisciplinary Engineering Technology (MXET) program will be composed of 127 hours which encompasses a University Core, a Math and Science Core,

a MXET Core (including Freshman Engineering and two Directed Technical Electives) and a Focus Area of study. The intent of the degree program is to provide undergraduate students more opportunities for a customized experiential learning opportunity than is typically provided in programs that are more discipline specific, i.e. stove-piped. A number of Focus Areas are possible and could be developed in the future based on documented need and student interest. The first, Mechatronics - also known as electromechanical engineering technology, is an engineering technology discipline that prepares individuals to apply mathematical and scientific principles to the design, development and operational evaluation and maintenance of complex computer controlled electro-mechanical systems and products with embedded electronics, sensors, and actuators [7, 8].

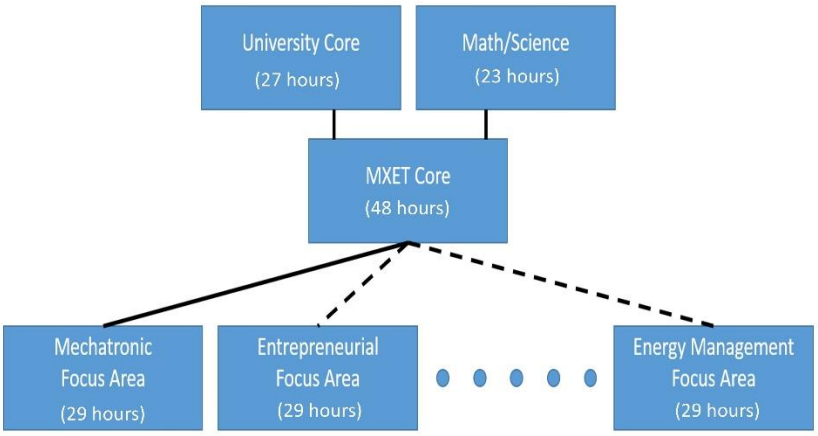

Figure 1. MXET Program Block Diagram (127 hours).

Examples of other Focus Areas that represent the breadth and cross-disciplinary aspects of the MXET program include Entrepreneurial New Product Development, Energy Management, and Instrumentation. This Entrepreneurial Product Development Focus Area, which is geared towards the inclusion of business-related concepts and aspects of starting a new venture in a high tech industry segment, will be used to demonstrate how new areas of interest can be achieved when demand and support are available.

The diagram contained in Figure 2 shows the interdisciplinary nature of the Multidisciplinary Engineering Technology program with a mechatronics focus area. Graduates from multidisciplinary engineering technology programs have a unique skill set that allows them to engage in product development and commercialization from a systems perspective.

Table 4 is a summary of the proposed degree requirements for the MXET program with a mechatronics focus area. These requirements are subdivided into major categories and a justification for exceeding the State of Texas imposed maximum cap of 120 hours is provided. The General Education Core includes the University Core curriculum (27 hours) and required Math and Science courses (23 hours). Required MXET Core Courses (44 hours) include 40 hours of coursework from the ESET and MMET programs and the Freshman Engineering courses (ENGR 111/112). The Mechatronics Focus (29 hours) includes two new mechatronics courses and other selected ESET and MMET courses. Four hours of directed technical electives is also included in the multidisciplinary/mechatronics engineering technology program.

Similarly, the MXET program with an entrepreneurial new product development focus will also have 127 hours defined.

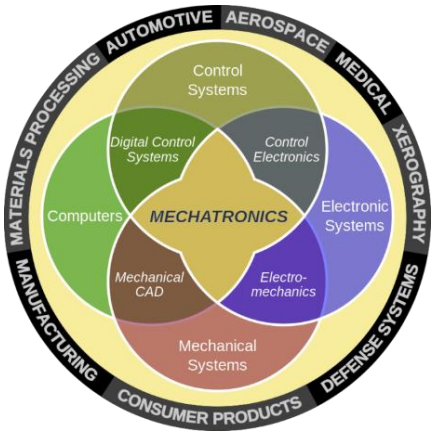

Figure 2. Multidisciplinary Engineering Technology with Mechatronics Focus.

Core Curriculum

The MXET curriculum is broken into two areas, the core curriculum (98 hours) and the emphasis curriculum (29 hours). To design the core curriculum, several requirements were first put in place. First, it obviously had to meet the University's core curriculum requirement. Second, it had to align with the College's new first common year philosophy that is required of all freshman engineering students. Third, it needed to leverage courses from the existing electronics and manufacturing programs ensuring that all MXET graduates have a strong multidisciplinary underpinning of electronics and mechanical concepts. The core curriculum for the MXET program can be seen in Table 5.

Table 4. Curriculum Summary

Category	Semester Credit Hours
General Education Core Curriculum *(bachelor's degree only)*	50
Required Courses MXET Core Mechatronics Focus	 29 44
Prescribed Electives	4
Free Electives	0
Other *(Specify, e.g., internships, clinical work)*	(if not included above)
TOTAL	127*

* 127 Semester Credit Hours is minimum requirement to achieve ABET/ETAC accreditation for Mechatronics Program.

Table 5. Required Courses for the BS MXET degree.

Required Courses	SCH
Composition	3
History	3
History	3
Government	3
Government	3
Communications	3
Creative Arts	3
Social and Behavioral Science	3
Engineering Ethics	3
Total University Core	**27**
Engineering Calculus I	4
Engineering Calculus II	4
Math Elective	3
Engineering Chemistry	4
Mechanics	4
Electricity and Optics	4
Total Math and Science	**23**
Freshman Engineering I	2
Freshman Engineering II	2
Circuit Analysis	4
Digital Electronics	4
Embedded Programming in C	3
Electronics	4
Instrumentation Systems	4
Metallic Materials	3
Mechanics for Technologists	3
Dynamics	3
Applications I	3
Thermodynamics for Technologists	4
Capstone I	3
Capstone II	2
Technical Elective	2
Technical Elective	2
Total MXET Core Courses	**48**
Total MXET Focus Area (See Table 7 and 8)	**29**
Total Required Courses	**127**

Emphasis Areas

Two different focus areas are presented as viable examples of the breadth of the MXET program in supporting multidisciplinary undergraduate experiential learning opportunities. The first focus area planned for implementation will be mechatronics. Based on industry support and student interest, once the mechatronics focus area is stood up and operational, the entrepreneurial new product development focus area will be created. Other focus areas which would also be considered for future expansion of the program include energy/building management, manufacturing automation, and instrumentation. The MXET Program focus area curricula for mechatronics and entrepreneurial product development are contained in Tables 6 and 7, respectively. All core requirements are the same with 29 hours defining each focus area.

Table 6. Required Courses for Mechatronics Emphasis Area

Required Courses	SCH
Microcontroller Architecture	4
Embedded Systems Software	4
Control Systems	4
Fluid Mechanics and Power	4
Product Design and Solid Modeling	3
Strengths of Materials	4
Mechatronics I	3
Mechatronics II	3
Total Mechatronics Focus	**29**

Table 7. Example of Future Focus Area - Entrepreneurial Product Development.

Required Courses	SCH
Leadership	3
Six Sigma	3
Product Development	3
Computer Architecture	4
Quality Assurance	3
Product Design and Solid Modeling	3
Strengths of Materials	4
Purchasing Application in Distribution	3
Distribution Operations and Financial Management	3
Total Entrepreneurial New Product Focus	**29**

Program Educational Objectives and Student Outcomes

In preparation for future ABET accreditation, preliminary program educational objectives and student outcomes have been created for the new MXET program. The educational objectives of the BS MXET degree program are to produce graduate who:

- Possess and demonstrate technical knowledge of the design, manufacture, sales, and service of complex systems that span multiple engineering technology disciplines.
- Demonstrate increasing level of leadership and responsibility.
- Exhibit productivity in a dynamic work environment through a commitment to lifelong learning.
- Exhibit a commitment to professional ethics in their professional career.

In addition, the MXET student outcomes have been design to align with both ABET outcomes as well as the outcomes of the other two existing engineering technology programs:

a) An appropriate mastery of the knowledge, techniques, skills and modern tools of complex systems that span multiple engineering technology disciplines.
b) An ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering and technology.
c) An ability to conduct standard tests and measurements; to conduct, analyze and interpret experiments, and to apply experimental results to improve processes.
d) An ability to apply creativity in the design of complex systems that span multiple engineering technology disciplines.
e) An ability to function effectively on teams.
f) An ability to identify, analyze and solve technical problems.
g) An ability to apply written, oral, and graphical communication in both technical and non-technical environments; and an ability to identify and use appropriate technical literature.
h) An understanding of the need for and an ability to engage in self-directed continuing professional development.
i) An ability to understand professional, ethical and social responsibilities.
j) A respect for diversity and knowledge of contemporary professional, societal and global issues.
k) A commitment to quality, timeliness, and continuous improvement.

Current Status

Existing ET Programs

Currently, the department's two existing engineering technology programs, Electronic Systems Engineering Technology (ESET) and Manufacturing and Mechanical Engineering Technology (MMET), are both successful and thriving programs. The ESET program has an enrollment of 220 students while the MMET program has an enrollment of 370 students. Both programs have greater than ninety percent placement and the graduates have starting salaries that are comparable with their respective engineering program counterparts. Because a large part of the new multidisciplinary MXET curriculum is "borrowed" from the two existing programs, the majority of the MXET courses are already created and being taught on a regular basis. Thus, once approval for the new program is granted, students recruited into the MXET program will be able to begin their curriculum immediately. In addition, because the current programs have multiple technical electives, development of some of the new courses necessary to implement the Mechatronics track are being developed today. In fact, the Mechatronics I course was developed during the Fall 2015 semester with support of a mechanical engineering graduate student paid for through internal departmental funds. The course is being taught for the first time during the Spring 2016 semester and students from the ESET program are taking the course as one of their

two technical electives. Finally, in order to ensure that the new MXET program is ready to accept students once it is approved, an interim program coordinator has been appointed.

College Approval

During the Spring and Summer of 2015, a team of faculty members researched potential models for the new MXET program and visited multiple industry partners to analyze the need. It was quickly determined that the new program's focus area should be in mechatronics. During the Fall 2015 semester, the new program request was drafted and submitted for College review. It was through this process that the new program was broadened to a more general Multidisciplinary Engineering Technology degree. This was done for two primary reasons. First, the College had recently created a new Interdisciplinary Engineering degree designed to support students interested in a broader degree that merged two or more traditional disciplines. The new MXET degree was seen an opportunity to develop a parallel engineering technology degree. The second reason was driven by the College's and University's interest in developing new satellite campuses in the State of Texas. By having a more general Multidisciplinary Engineering Technology degree on the main campus, new targeted degrees can be custom designed for the satellite campuses based on regional need. After multiple refinements of the new program proposal, it was submitted to the College's curriculum committee for a vote where it passed unanimously.

University and State of Texas Approval

With the new program proposal approved by the College, it was then submitted for approval by the University Curriculum committee in December of 2015. It passed both this committee as well as the Faculty Senate. With all of the internal voting completed successfully, the new proposal was submitted Board of Regents where it is currently on the agenda for a vote by the Board in February 2016. To prepare for this vote, the faculty team worked with the Provost's and President's office to ensure that all of the paperwork required for a new program request was complete. It is anticipated that if the new program is approved by the Board of Regents, it will be a matter of paperwork to have the new program listed in University's list of approved programs. Thus, the department is on target to start offering the MXET program in the Fall 2016.

Recruiting

To prepare for the likely opening of the new MXET program in the Fall of 2016, the interim MXET Program Coordinator in conjunction with the departmental advising office is currently developing recruiting strategies and materials. The primary strategy involves the College of Engineering's new entry-to-major program. Starting in the Fall of 2015, the College began admitting all freshmen into a first-year general engineering program. The concept is that all new students would participate in a common, first-year program that consists of math, science, core curriculum and a sequence of two introductory engineering courses. During that time period, students learn about all of the engineering disciplines through videos, informational sessions, and modules in their engineering courses allowing them to make a more informed decision about which program to pursue. Then in their second semester, they can begin applying for admission to one or more of the engineering/engineering technology programs based on their interests.

During the first year of the entry-to-major program, an interesting issue arose when approximately a quarter of the freshman class expressed an interest in applying to the Mechanical Engineering program. From this it became clear that programs that involved mechanical design concepts were in high demand. This has positioned the new MXET program in a unique recruiting position. Based on the obvious interests of freshman students, it is clear that the goal of growing the enrollment of the new program to 125 students over the first five years is readily achievable. Thus, new recruiting materials are being created to tout the uniqueness of mechatronics as an area of study and career path. These will then be disseminated to the approximately 3000 students in the freshman engineering courses. In addition, industry has offered to participate by offering focused evening informational sessions on potential careers for students who can cross the boundaries between mechanical and electrical systems.

The second area of focused recruiting will be with transfer students. Traditionally, a significant number of students enter the engineering technology programs as transfer students from two-year regional schools. Thus, recruiting strategies and materials are being developed to ensure that students at two-year schools are aware of the new MXET program as a choice when they apply to Texas A&M University.

Next Steps

As the review and approval process moves forward, the ETID Department is actively working in parallel to ready itself for a potential start date of Fall 2016 for the new program and its mechatronics focus. Specifically, an interim program coordinator has been named and one new tenure-track faculty member has been hired with expertise and interests in developing courses and laboratories for the new program. In addition, the program coordinator is actively involved in engaging the private sector to continue the refinement of the educational curriculum, seeking funding for new resources and equipment, establishing interest in defining internships, procuring new equipment and developing one of the two mechatronics-specific senior-level courses.

With industry input and an eye towards managing costs, the ETID Department has selected the National Instrument Real-time Input-Output technology as the underpinning of its two new courses. Mechatronics I will focus on the integration of embedded intelligence, algorithm development and implementation for mechanical monitoring and control. This course development will be led by ESET faculty members. The Mechatronics II course and associated laboratory will be led by the MMET faculty members and will focus on mechatronics from a production/manufacturing perspective.

The NI RIO technology clearly spans these disparate areas of mechatronics and for this reason was selected as a platform for both courses/laboratories. Because the ESET-led Mechatronics I course will utilize the second generation of its Articulated Suspension Evaluation

Platform (ASEP II) robot shown in Figure 3 as the focus for learning about electro-mechanical systems with embedded electronics and control software, the myRIO has been selected and procured. Each student will be issued a myRIO and teams of two students will share an NI mechatronics kit. These resources will be used throughout the course and its associated laboratories. One of the reason this embedded system was selected was its ease of use, ability to be programmed using the LabVIEW graphical programming environment and its ability to communicate wirelessly to a laptop or computer acting as a base station. In addition, the myRIO can support the integration of video/image information and process these data for situational awareness and control.

Figure 3. ASEP II Robot.

To leverage the knowledge and experience the students take from Mechatronics I as they move into Mechatronics II, the ETID Department has chosen the compactRIO (cRIO) for the modular system monitoring and control of industrial production machines and robots. In addition to being able to work with the same hardware architecture, the choice of cRIO will also allow the students to extend their capabilities in using the LabVIEW programming environment for real-time industrial applications. The cRIO architecture also allows the integration of specialty modules thus creating feature-rich controller that are configured to the specific application.

The ESET Program took advantage of a need to provide a technical elective course to their senior-level students during the Spring 2016 semester to begin development of the Mechatronics I course. Although satisfying the elective requirement of the ESET Program, the course is also being implemented and delivered to meet all current requirements of the Multidisciplinary Engineering Technology curriculum with the mechatronics option.

To provide a "mission" for the Mechatronics I course and lab, the ESET faculty invited a former NASA program manager to attend during the first week of the course. The program manager presented a mission brief on Lunar Exploration using Humans and Robots. The Mechatronics I course has now generated a course objective to develop a number of ASEP II-based autonomous robots by the two-student teams and then have teams work together to develop the follow-me capability extracted from the NASA mission requirements. Finally, individual students will select some other aspect of the robot mission requirements to investigate and present their solution recommendations to the class.

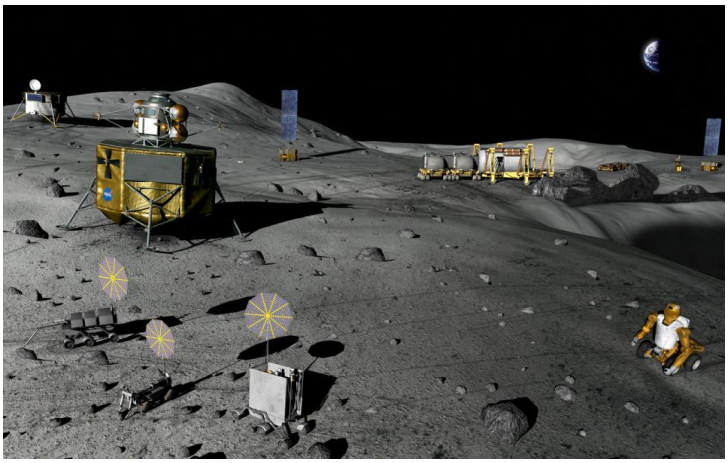
Figure 4. NASA Lunar Exploration Mission.

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