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CAPE CANAVERAL - A MAIN CAMPUS FOR THE UNIVERSITY OF SPACE

by

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ABSTRACT

Predicted in space commercialization studies of the 1970s, anchored in the Cape Canaveral area by the Space Technology graduate program at Florida Institute of Technology, and nurtured by inputs from other universities and industries throughout the United States, the world's first UNIVERSITY OF SPACE is now well on its way to becoming a distinct educational facility for the next millennium! This paper describes the highly innovative graduate program in Space Technology that has been developed over the last decade at the Florida Institute of Technology to satisfy the evolving educational needs of scientists and engineers who work in America's space program in the Cape Canaveral region. This unique FIT graduate curriculum involves 48 credit hours of instruction (quarter system) including courses on the U.S. Space Transportation System, space stations and their applications, remote sensing of the Earth, space power and propulsion systems, the human role in space, and space commercialization. This paper also describes how the essential features of FIT's graduate program in Space Technology are now being introduced into the graduate curricula at other universities to form an educational infrastructure that can rapidly be fused into our planet's first UNIVERSITY OF SPACE with proper industrial support. With the opening of a joint, mutually-beneficial academic-industrial spaceport teaching facility, possibly as part of a NASA-sponsored Center for the Commercial Development of Space, the Cape Canaveral/Kennedy Space Center area can become the main campus for this UNIVERSITY OF SPACE within a few years.

INTRODUCTION

The French writer and science prophet, Jules Verne, wrote De la terra a la lune (From the Earth to the Moon) in 1865. This, then science fiction, now fact account of a manned voyage to the Moon originated from a Floridian launch site near a place called "Tampa Town". A little over one hundred years later, directly across the state from the modern city of Tampa, the once isolated regions of the east central Florida coast shook to the mighty roar of a Saturn V rocket. The crew of Apollo 11 had embarked from the Earth and man was to walk for the first time on the surface of the Moon.

Reportedly discovered by the 16th century Spanish explorer and adventurer, Ponce de Leon, the patch of coastal scrubland that makes up Cape Canaveral has now become one of the most famous pieces of real estate on this planet. When the first military missile launches were conducted at the Cape during the early 1950s, few persons then realized that within a generation, man would not only orbit his own planet successfully in a spacecraft, but would also explore in person an alien world. By analogy, few persons today realize that the founders of humanity's extraterrestrial civilization are now enrolled in colleges and universities throughout the world, including, of course, graduate students in the Space Technology program at the Florida Institute of Technology! Rich in technical tradition, it is only fitting that the Cape Canaveral region become the training ground for the scientists, engineers, and commercial entrepreneurs

who will cross the "vertical frontier" in pursuit of knowledge, adventure, and wealth.

As we enter the next millennium, human development will be highlighted by the creation of mankind's extraterrestrial civilization (1-5). Table 1 summarizes some of the major developments in space technology that could occur in the next hundred years or so, while Figure 1 is a montage of artist renderings of "things to come". Depicted here in clockwise fashion starting with the upper left illustration are advanced robotic devices in space, the construction of large structures on orbit, the initial lunar base, and a large space settlement (under construction). In the projected sequence of technical events displayed in Table 1, we first learn how to permanently occupy near-Earth space and then expand human activities throughout cislunar space. As the commercial use of space continues to grow in the 21st century, a subtle but very significant transition point will eventually be reached. A portion of the human race will eventually achieve full self-sufficiency in cislunar space-- that is, individuals living in space habitats and on the surface of the Moon will no longer depend on the Earth for the materials and energy supplies necessary for their survival. From that very historic moment on, humanity will possess two very distinct social subsets: terran and nonterran or extraterrestrial.

Humanity has now developed the technical tools needed to initiate the next major phase of planetary development - expansion of the human resource base off-planet into our Solar System (1,2,6,7). Space technology allows us to accept our cosmic challenge and to initiate the first steps in the creation of our extraterrestrial civilization. Complementary advances in aerospace education, especially those advances involving the timely and profitable application of the unique and valuable properties, conditions, and resources of outer space, will greatly accelerate the overall process by which men and women come to feel at home in the Universe.

AN INNOVATIVE SPACE TECHNOLOGY PROGRAM

The word "technology" may be defined as the application of scientific and technical knowledge to improve the overall human condition. "Space technology", consequently, involves the application of the unique properties, conditions and resources found in outer space to improve the quality of life for all here on Earth. What are some of these unique properties and conditions found in outer space? They include: microgravity, hard vacuum, a synoptic view of the Earth, and physical isolation from the terrestrial biosphere.

The Florida Institute of Technology (FIT) was founded in 1958 in close companionship with the emerging United States space program. The original mission of the institution was to offer continuing educational opportunities to the scientists, engineers, and technicians who were gathering at what is now the Kennedy Space Center to work toward putting American astronauts on the Moon. Both faculty and students worked during the day in the space program and then labored in the classroom at night. That unique, highly productive learning environment exists today in the Cape Canaveral/Kennedy Space Center area in the Shuttle Era. It will continue well into the next century as first the space station, then the lunar base provide engineers, scientists, and entrepreneurs with an expanding extraterrestrial frontier.

The Florida Institute of Technology is an accredited, coeducational, independently controlled and supported university. Its faculty members are committed to the pursuit of academic excellence in teaching and research in the sciences, engineering, technology, management and related disciplines. Approximately 7,000 full- and part-time students are now enrolled in all university programs. These programs include eight that culminate in the earning of the doctorate and twenty-five that lead to a master's degree. One of these degree programs, the Master of Science in Space Technology, involves a highly innovative, rapidly evolving curriculum that is intimately linked to the contemporary U.S. space program. This particular graduate degree program has been developed by the Department of Physics and Space Sciences for the engineer or scientist who desires a broader knowledge of many aspects of the ongoing and

future U.S. space program. The graduate degree in Space Technology requires 48 credit hours of instruction (quarter system) including: 10 space technology courses, 2 computer science courses, 2 management science courses, and two technical electives approved by the ST Program Chairman. A comprehensive written examination is given to the degree candidates, usually in their last quarter of instruction. Admission to the program requires a bachelor's degree in a recognized field of engineering or physical science.

FII's unique Space Technology curriculum includes courses on the U.S. Space Transportation System (i.e. the Space Shuttle), the remote sensing of Earth, space stations and their numerous applications, space power and propulsion systems (including nuclear), spacebased astronomy, satellite data processing, large structures in space, and the development and mission planning for scientific and engineering payloads. Table 2 provides a brief summary of selected Space Technology courses. Many of these courses are not currently offered in any other graduate program in the United States. Space Technology faculty members frequently develop state-of-the-art level information packages and textbooks to support their classroom instruction. For example, the book, Space Nuclear Power by J. Angelo and D. Buden (5) was developed in conjunction with the very contemporary course: ST 5014 Space Nuclear Power, the syllabus for which appears in Table 3. This particular course has given rise to similar graduate courses at the University of New Mexico and the University of Arizona.

A major Space Technology growth area planned for the next few years will be the creation and operation of a small payloads handling facility or spaceport teaching facility in the Cape Canaveral area. This future facility, a cornerstone in the creative use of outer space by universities and private industry, will emerge by one of the following pathways: (1) an FIT-aerospace industry interactive agreement; (2) an FIT-other universities interactive agreement (e.g. an academic consortium dedicated to advances in space technology and space applications); or (3) as part of a NASA-sponsored academic-industrial Center for the Commercial Development of Space (CCDS) (8). By whatever management and fiscal route this spaceport teaching facility is ultimately established, it will represent a very major step forward in aerospace education. Here, for example, students enrolled in such FIT courses as ST 5010, 5011 (Introduction to Space Technology I & II), ST 5041 (Scientific Payloads and Missions), and ST 5042 (Experimental Packages and Instrumentation) will interact with actual space-qualified hardware and will assist in the design, construction, buildup, checkout, processing, ground flow, and post-flight evaluation of highly innovative small payloads (from other universities and nonaerospace industrial firms) that will be flown on the Space Shuttle and then the space station.

Typical small payloads will include NASA's Getaway Special (GAS) program hardware, space-qualified equipment for in-cabin use onboard the Space Shuttle or space station, and NASA's Hitchhiker program hardware. Many highly innovative small payloads can be serviced through such a spaceport teaching facility and not all the hardware need be developed at FIT. Instead, FIT Space Technology program faculty and students in close professional cooperation with other academic-industrial teams will be able to explore basic scientific phenomena, develop important engineering and systems performance data, and closely support emerging space commercialization opportunities. Within the next few years, such an FIT spaceport teaching facility could easily evolve into the major terrestrial node for something we can call: THE UNIVERSITY OF SPACE. This valuable spaceport teaching facility would represent a portal to outer space for a large number of university and industrial "small payloads" - each pursuing different areas of scientific inquiry, engineering development, or commercial exploitation but all bound by the common discipline of Space Technology. Without such a spaceport teaching facility, specializing in the development and handling of pioneering small payloads, a large number of universities and industrial firms would find it extremely difficult to maintain a continuous, effective technical presence in America's expanding space program. The students at this spaceport teaching facility, either FIT graduate degree candidate or professional seminar attendees, would obtain a truly unique educational experience and find a ready market for their newly acquired space technology/applications talents.

A SPACEPORT FOR A CAMPUS

FIT's Space Technology program classes are currently offered in the evenings at convenient locations on the Kennedy Space Center (KSC) and Patrick Air Force Base (PAFB). Perhaps the most exciting and innovative feature of this graduate program is that it introduces the students to the overall concept of mankind's extraterrestrial civilization and the essential role that they themselves are playing (as professionals in the aerospace industry) in helping people now move into and use outer space on a more or less routine basis. This educational approach provides a unique, highly motivating, continuously evolving central theme around which the detailed technical curriculum can be presented. Classroom discussions provide an enriched learning environment, since both faculty and students are actively involved in the contemporary U.S. space program. The phrase: "Out to launch" is a frequently given reason for a late homework assignment or a class absence.

NASA's John F. Kennedy Space Center is located on the east central coast of Florida and serves as America's Spaceport. It is the major NASA launch organization for manned and unmanned space missions. As the lead center within NASA for the development of launch procedures, technology and facilities, KSC personnel launch unmanned interplanetary spacecraft, and scientific, weather, and communications satellites. KSC also serves as the launch and landing facility for the Space Shuttle. The KSC mission includes: assembly of space vehicles; preflight preparation of space vehicles and their payloads; test and checkout of launch vehicles, spacecraft, and facilities; coordination of tracking and data acquisition requirements; countdown and launch operations; and landing operations and refurbishment of the Space Shuttle for future missions.

With the development of a permanent space station and, in time, a lunar base, the Kennedy Space Center will become one of the world's most important ports. In the upcoming decades, goods and travellers will routinely flow through KSC on their way to help build our extraterrestrial civilization. Unique space-manufactured products and interesting objects found on alien worlds will flow back through this spaceport into the mainstream of terrestrial civilization in a manner quite similar to the way the riches and discoveries found on the American continents (the then New World) flowed back through major port cities in Europe in the 16th, 17th and 18th centuries. A bustling spaceport is an ideal terrestrial location for a major university dealing with space technology and the application of space.

THE UNIVERSITY OF SPACE

Space commercialization studies of the 1970s have already identified in-space education as a potential candidate applications goal (8,9). Such in-space classes would take direct advantage of the unique conditions and properties found there for teaching science or for such global subjects as geography and environmental monitoring. Either in situ laboratory demonstrations would be broadcast to Earth from space or a very few fortunate individuals would receive a portion of their graduate education on orbit.

The essential features of FIT's Space Technology program are now being shared with other universities (e.g. the University of Arizona and the University of North Dakota) and fused into an informal, but nonetheless distinctive, academic infrastructure that can easily evolve into our planet's first real UNIVERSITY OF SPACE. The campus for this future academic institution will not only include many terrestrial locations at universities throughout the United States, but will also include dedicated academic-industrial facilities in the vicinity of America's Spaceport. Through these "extended campus" locations University of Space faculty and students will perform the fundamental research and development activities that herald the creation of our extraterrestrial civilization.

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FIGURE 1

TABLE 1. POSSIBLE STEPS IN THE CREATION OF HUMANITY'S
EXTRATERRESTRIAL CIVILIZATION.

STEP 1: Permanent Occupancy of Near-Earth Space

- o Space Station (6 - 12 persons)
- o Space Base (50 - 200 persons)
- o Orbiting Propellant & Service Depot

STEP 2: Permanent Occupancy of Cislunar Space

- o Initial Lunar Base (6 - 12 persons)
- o Manned Space Platform at GEO (6 - 20 persons)
- o Large Powerplants (Nuclear) at GEO (megawatt range)
- o Permanent Lunar Settlements (200 - 300 persons)

STEP 3: Full Self-Sufficiency in Cislunar Space

- o Space Communities in Earth Orbit
- o Space City-States
- o Extensive Lunar Settlements
- o Use of Apollo/Amor Asteroids

STEP 4: Permanent Occupancy of Heliocentric Space

- o Manned Expedition To Mars
- o Initial Martian Base
- o Permanent Martian Settlements
- o Main Asteroid Belt Exploration
- o Bases On Selected Moons of Outer Planets (e.g. Europa, Titan)
- o Manmade Planetoids in Heliocentric Space
- o First Interstellar Probes (robotic)
- o First Interstellar Missions (manned)

TABLE 2. FIT SPACE TECHNOLOGY PROGRAM (SELECTED COURSE DESCRIPTIONS)

ST 5010, 5011 INTRODUCTION TO SPACE TECHNOLOGY I & II

a survey of modern space technology that covers the following topics: space structure and materials; guidance and flight control; propulsion systems; life support systems; launch operations; secondary power systems; communication systems; data handling; space commercialization; spacebased manufacturing; and the fundamentals of space law.

ST 5021 SPACE APPLICATIONS

an introduction to the Space Transportation System, including: the Orbiter vehicle; Spacelab; Long Duration Exposure Facility (LDEF); Multimission Modular Spacecraft (MMS). User applications including payload management and interfacing, launch, landing and turnaround procedures.

ST 5022 MANNED SPACE TECHNOLOGY

the role of people in space. Shuttle crew training. Space Stations, permanent space habitats, lunar bases, and expansion into heliocentric space.

ST 5014 SPACE NUCLEAR POWER

space nuclear power technology. The use of radioisotopes and nuclear reactors in space power systems. An introduction to nuclear reactor theory and operational principles. The design and operation of radioisotope thermoelectric generators (RTGs). Contemporary space nuclear power system applications in both manned and unmanned missions. Aerospace nuclear safety.

ST 5015 SPACE NUCLEAR PROPULSION

the use of nuclear energy for propulsion applications in space. Fission reactor rockets, fusion rockets, radioisotope propulsion systems. Aerospace nuclear safety. Advanced propulsion system requirements for interplanetary and interstellar flight.

ST 5041 SCIENTIFIC PAYLOADS AND MISSIONS

review of past and present scientific experiments in both manned and unmanned spacecraft with emphasis on instrumentation and data handling. Survey of instrumentation required for next decade of planned scientific missions.

ST 5042 EXPERIMENTAL PACKAGES AND INSTRUMENTATION

planning and design of space experiments from original concept through operational phase, including orbit considerations, power, heating and cooling, pointing accuracy, telemetry, data storage, package volume and shape, structural considerations, launch and re-entry accelerations and vibrations, and operation under exposure to the space environment.

TABLE 3. SYLLABUS FOR ST 5014 SPACE NUCLEAR POWER

Text: Space Nuclear Power by J. Angelo & D. Buden, Orbit Books, 1985.

Course Description: Space nuclear power technology. The use of radioisotopes and nuclear reactors in space power systems. An introduction to nuclear reactor theory and operational principles. The design and operation of radioisotope thermoelectric generators (RTGs). Contemporary space power system designs and applications. Aerospace nuclear safety.

Lesson #	Topic (s)
1	Space Nuclear Power Systems; Radioactivity
2	Radiation Interaction With Matter
3, 4	Radioisotope Thermoelectric Generators; Aerospace Nuclear Safety
5	Nuclear Reactor Theory
6	MidTerm Examination
7	Uranium-Zirconium Hydride Reactor Power Plants
8	Alternate Space Reactor Concepts
9	Contemporary Space Nuclear Electric Power Systems.
10	Space Nuclear Power Plant Design Considerations.
11	Final Examination