Wisconsin engineer. Volume 93, No. 2 December 1988

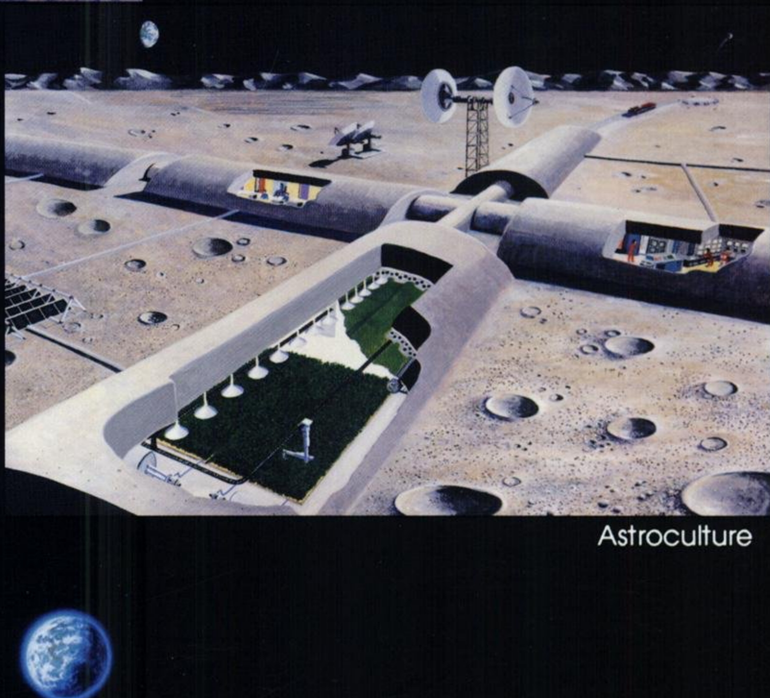
Madison, Wisconsin: Wisconsin Engineering Journal Association, [s.d.]

https://digital.library.wisc.edu/1711.dl/7P3DBZ6M5SIJV8I

Volume 93, No. 2 December 1988

wisconsin engineer

Astrobotics



Astroculture

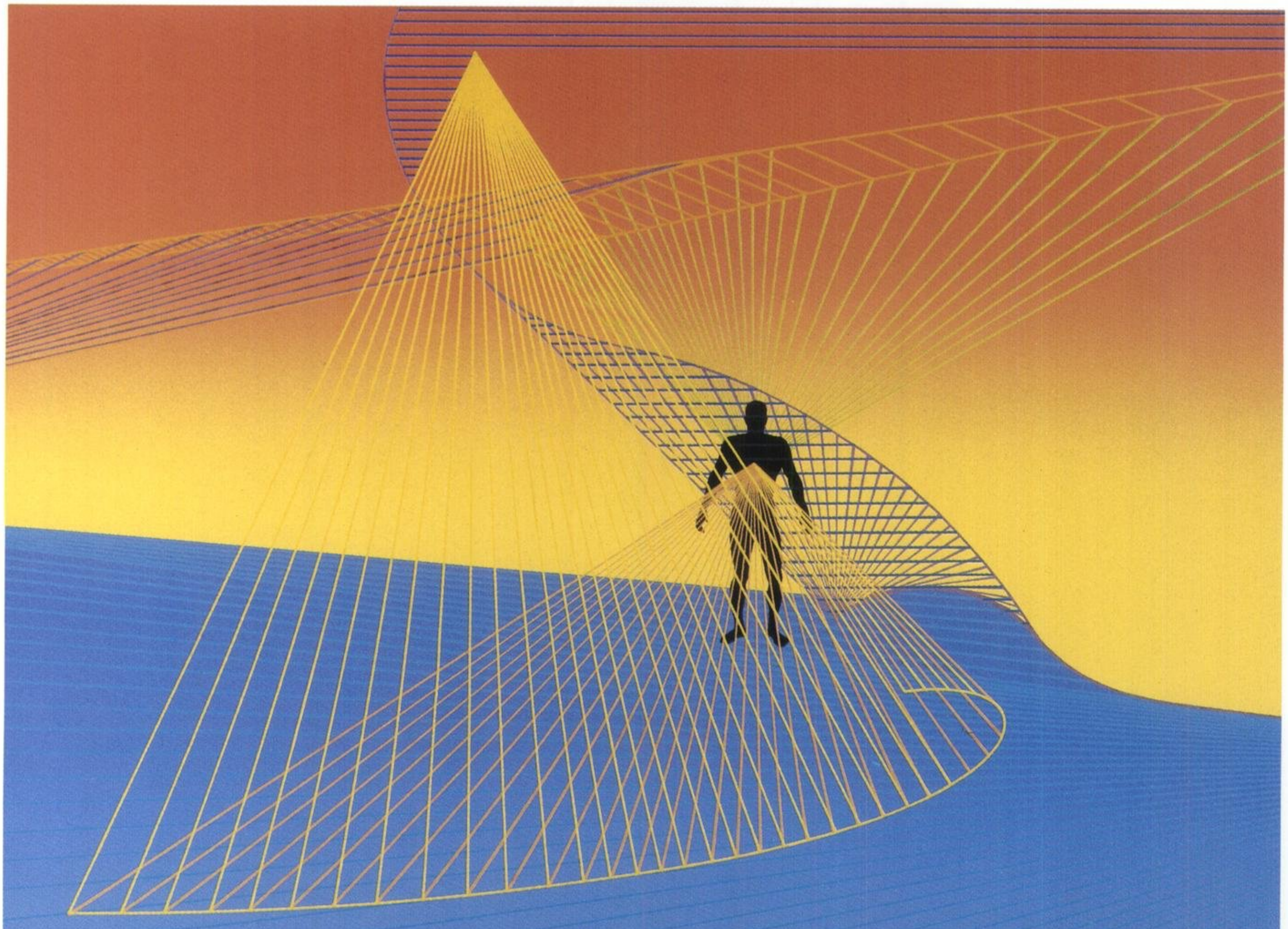
In This Issue:

- Working in Space
- The Ozone Layer
- The Space Shuttle

Astrofuel

Wisconsin Engineer Magazine
Mechanical Engineering Building
Madison, WI 53706

Nonprofit Organization
U.S. Postage
PAID
Madison, Wisconsin
Permit No. 658



wisconsin engineer

PUBLISHED BY THE STUDENTS OF THE UNIVERSITY OF WISCONSIN-MADISON, DECEMBER 1988

Editors
Barbara Angermann
Shelly Hoffland

Managing Editor
Brian Lindahl

Business Manager
John Ulman

Student Advisor
Lisa Peschel

Ad Staff
Jennifer Barber
Troy Clemens
Mike Gallistel
Ethan Johnson
John Stangler
Tony Wolfram

Writers
Sharon Chen
Nick Denissen
Craig Fieschko
Peter Holmi
Nancy Hromadka
Don Korjenek
Chris Lindell
Lisa Peschel
Winnie Teng

Photography
Brian Fischer
Jeff Roork

Layout/Graphics
Mike Bashel
Ethan Johnson

Circulation
Mike Bashel

On the cover 1) Astrobotics: creating robotic technologies capable of enhancing mankind's ability to live, travel, and explore in space, 2) **Astroculture**: developing automated plant growth facilities for space, 3) **Astrofuel**: mining and processing of helium-3, an extremely valuable source of safe, clean, reliable fusion fuel

TABLE OF CONTENTS

Board of Directors: Michael Corradini, Gerald Duchon, David Malkus, Evelyn Malkus, Richard Moll, Tom Murray, Kenneth Potter, Thatcher Root.
Faculty Advisor: Don Woolston
The *Wisconsin Engineer* magazine, a charter member of the Engineering College Magazines Association, is published by and for engineering students at UW-Madison. Philosophies and opinions expressed in this magazine do not necessarily reflect those of the College of Engineering. All interested students have an equal opportunity to contribute to this publication.
Publisher's Representative: Littel-Murray-Barnhill, Inc., P.O. Box 1405, Morristown, NJ 07960-1405.
Publisher: Community Publications
ECMA Chairperson: Lynn Nystrom, Virginia Polytechnic Institute.
Correspondence: *Wisconsin Engineer* magazine, 1527 University Avenue, Madison, WI 53706. Phone (608) 262-3494. The *Wisconsin Engineer* is published five times yearly in October, December, February, April, and July by the Wisconsin Engineering Journal Association. Subscription is $10.00 per year.

Editorial

Have you ever been outside on a crisp, clear night only to look up and see a falling star streak across the black sky? It lasts only one or two seconds, but a world of thought can pass through your mind as you watch. I saw one a few nights ago. The sight forced me to consciously question space. What else is really out there? Our future is in space, so say modern scientists. I believe them. Where else can we go? There seems nothing else to explore. I wonder what questions will be answered in my lifetime. I wonder also if we are doing the best research to discover the truth about space.

At quick glance it appears that space research is booming. Consider the scope of articles in this issue of the *Wisconsin Engineer*. Moon mining? What an incredible concept. The space shuttle program is back on track with the recent and successful Discovery launch. Certainly the nations of the world spend billions of dollars annually on such research. It is not a waste of time or money, as we profit from even the smallest discoveries.

But also consider recent headlines. A former head of the Soviet space agency declared that the world is conducting twenty first century space exploration in the twentieth century: the world simply is not prepared for or wise enough to conduct the current exploration. He feels that because of such haste we *are* wasting time and money.

So why the haste? Are we really so eager to learn more about space, and in turn our future, that we plan missions that are beyond the true capabilities of current technology? It's possible. Not twenty years ago an American astronaut took the first moon walk. This month a Soviet cosmonaut returns to earth after living for one year on a space station. Despite such progress the world is at a very early stage of space exploration. It is understandable that mistakes will occur. Lack of knowledge accounts for that. But could some of the mistakes be the result of unnecessary haste — haste that is not an eagerness to learn?

No one can dismiss the tragedy of the explosion of the Space Shuttle Challenger on January 28, 1986 as simply a mistake. Roger Boisjoly, a former Morton-Thiokol engineer who helped develop the booster rockets used in the Challenger launch, explained in a lecture that he gave at UW-Madison last spring the events prior to the launch of the Challenger. In 1985 he discovered that primary seals eroded and never sealed during two shuttle flights. He feared that the same problems would occur during the cold weather launch of the Challenger. Morton-Thiokol initially told NASA not to launch but, as Boisjoly claims, his managers ignored the protests of top engineers who felt that a launch was not safe and gave in to NASA pressures to find data sufficient for a launch. The world was awaiting the first teacher in space. Would NASA be embarrassed? Certainly any delay in this single launch could not have jeopardized the space program the way the explosion did. What was at stake for NASA if the launch couldn't go on?

I wish I had a sure answer to that question. In light of other recent "mistakes" in space a thought comes to mind. At about the same time Discovery boosted America's space program a Soviet spaceship experienced a near tragedy when onboard computers failed and two cosmonauts were nearly stranded in space because they could not fix them. Was it an avoidable error?

With space as our "last frontier" are the countries of the world more concerned with "who gets there first" rather than how effectively we get there at all? It's a thought that concerns me. It seems rather silly that such national competition could *really* pressure us to make poor judgments in a field as important to our future as space exploration. Perhaps in the future America and the Soviet Union will realize the possible knowledge to be gained if we combine forces and explore space as a united team. *That* could be mankind's greatest step of all time.

Shelly

Shelly Hoffland,
Co-Editor

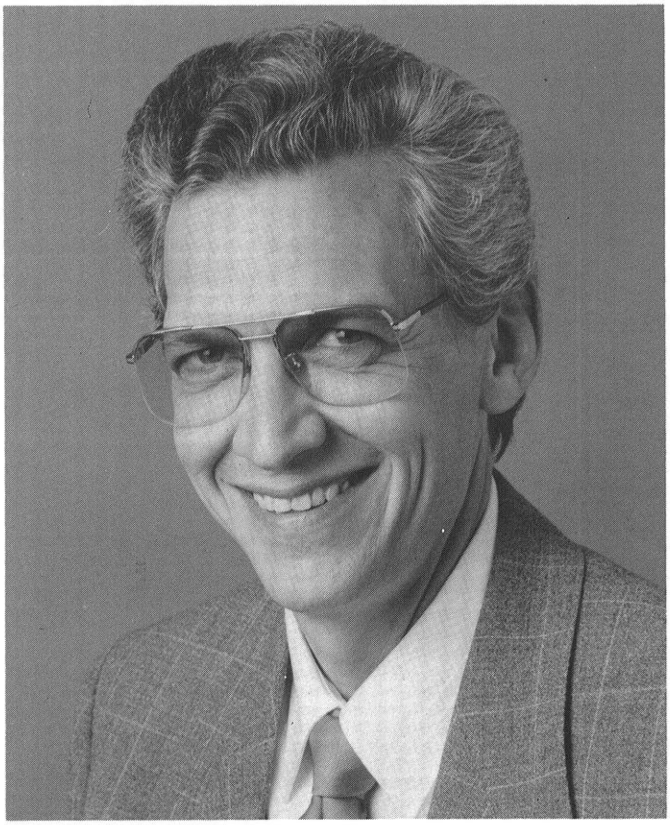
Dean's Corner

The mission statement of the UW-Madison College of Engineering pledges that college administration, faculty, staff, and students join to:

- provide the highest quality engineering education at the undergraduate, graduate, and continuing education levels;
- conduct scholarly research at the frontiers of science and technology; and
- make the unique facilities and expertise of the college available to industry and government.

These commitments parallel the general expectations that the university has responsibilities in three broad areas: teaching, research, and public service. In effect, these are the three legs on which all of the nation's great public and private universities stand. Although you may have heard these words before, and perhaps even repeated them yourself, I know it is sometimes difficult for undergraduates to see how our research and public service missions affect you or directly enhance your education. But they do affect you, and they enhance your education in more ways than I can list in this short column. Let me give a few examples, though, to illustrate why universities have been given a three-fold mission, rather than the single mission of "lecturing" which is the simplest and most obvious example, though not necessarily the most effective method, of "teaching."

The first issue any teacher faces is that of course content: what to teach, which topics to emphasize, which topics were taught last year that can now be dropped to make room for new material, etc. College-level teaching (especially in upper division courses) demands constant renewal of a sort that can only be accomplished by a teacher who is actively involved as a practitioner or researcher in the field: someone who is personally seeking answers to important questions or solutions to important unsolved problems. By the time a textbook is available in the bookstores,



the material is at least two to three years old — old enough to be slipping into obsolescence in some engineering fields! If your instructor knows no more about the subject than what is in the book, who will provide the critical evaluation for you? More importantly, if university engineering faculty are not actively seeking to push back the frontiers of what is known, how will engineering and engineering education progress beyond what is known and taught today? No one seriously believes that we already have all the answers we will ever need, or even that everything in today's textbooks is correct!

"That sounds very fine," you say, "but it's all pretty abstract. How does it affect me in my courses this semester?" I invite all of you to look at the College of Engineering budget for last year, as recently published in our 1988 Annual Report. The total budget for the college was $59,037,000. That budget covers all College expenditures: faculty and staff salaries, TA salaries, lab course supplies and expenses, fellowships, scholarships, new computers, pencils, paperclips, . . . everything. You (through tuition and fees) and the State of Wisconsin (through taxes) provide, respectively, 16% and 20% of that total. Where does the rest come from? Mostly from outside research funding.

More than half of the budget ($32,139,188) was research funding, and 91% of that was obtained competitively from sources other than the state or university budgets. Even without knowing any more details, it is obvious that the college you are attending is much bigger and more diverse than it would be without our research programs. Much of the equipment you use in lab courses is borrowed from or was originally purchased by research programs. Our faculty, staff, and student body are larger and better than we could ever afford without active research programs. The professor you will be taking a course from next semester may be in Japan this semester, learning about their progress on "fifth-generation computers"; or working at GM on advanced automation; or participating in a National Academy of Engineering study; or on leave at the National Science Foundation; or writing the text (notes) you will learn from. These activities translate directly into enhanced educational opportunities for you on a daily basis.

Outside the classroom, too, you benefit (or have the opportunity to benefit) from our research programs. We bring to campus a steady stream of distinguished visitors from other universities, national laboratories, and industry, and from all around the world. Dozens of seminars (many of which are sufficiently general for nonspecialists) are announced every week and are open to the public. You may never again be in an intellectually richer environment, and you will certainly never again have learning and self-improvement as your main responsibility. Take advantage of it!

Many of you undertake special independent study projects in our research labs, or work as hourly laboratory assistants. These are outstanding opportunities to work closely with faculty and graduate students and get some of the "flavor" of research. Many students who avail themselves of such opportunities decide to go on to graduate school themselves. Graduate school is not for everyone, but it is an option that every student should at least consider.

As Associate Dean for Research, I naturally emphasize the contributions our research programs make to your education. Our faculty and staff are also engaged in many public service, outreach, and consulting activities that make similarly strong contributions to our teaching programs. Many of the "real-world" examples that faculty bring to the classroom, for instance, arose during consulting or public service activities.

Finally, there is an intangible, but very real, benefit that you will receive with your degree from UW-Madison: your degree will have come from one of the best-known and most prestigious universities in the country. The reputation of the university derives from all of our activities, but especially from the major "breakthroughs" and advances that bring the national spotlight on our research programs, and from the outstanding faculty, staff, and students that these programs enable us to attract and retain. This is a distinction you will be proud of for the rest of your life. ▮

J. D. Wiley, Associate Dean-Research, College of Engineering

WORKING IN SPACE

The Wisconsin Center for Space Automation and Robotics (WCSAR) is committed to encouraging private industry to develop space ventures. It was established in 1986 with a $5 million grant from NASA and is a joint effort of industry and UW-Madison, UW-Milwaukee, Marquette University, and Milwaukee School of Engineering. WCSAR is dedicated to develop technology for commercialization of technology that will play a vital role in enabling us to explore the space frontier.

Three programs are under research by WCSAR. They are Astrobotics, Astroculture and Astrofuel. The goal of Astrobotics is to develop automation and robotic technology to assist us to work in the hazardous environment of space. Providing the necessary life support requirements for our survival in the space environment is the primary goal of Astroculture. The goal of Astrofuel is to develop the technology that will enable us to recover He-3 and other valuable volatile materials from the moon for use in space and on earth.

ASTROBOTICS

by Lisa Peschel

John Zik slid his hand into the small labyrinth of gears and wires on the table until his fingers fit snugly in a matrix of small bars. Streamers of bright ribbon cable led from this "glove" to a personal computer, and from the computer to a robot arm standing a few feet away. He pressed a key on the computer and said, "When I flex my hand, watch the fingers of the robot." As he curled his fingers around a tennis ball, jointed metal fingers mimicked his movements, clutching an imaginary tennis ball of their own.

Zik is a staff engineer involved in the astrobotics research program at the Wisconsin Center for Space Automation and Robotics. The robotics system he is working with consists of components built by engineers at UW-Madison and industrial partners of WCSAR, along with some standard "off the shelf" robot parts. It demonstrates some of the technologies WCSAR is developing for eventual use by the National Aeronautics and Space Administration, which funds the center. NASA considers robotics an important technology for the exploration and eventual commercial development of space. According to Zik, WCSAR's work supplements NASA's research: "We are now working to augment state-of-the-art telerobotics."

Research at WCSAR in astrobotics emcompasses two major directions: improving the dexterity of the robot, and enabling the operator to actually sense, instead of merely see, what a robot hand is doing.

Two-fingered robot hands have been used for more than 20 years to work in dangerous enviroments such as the core of a nuclear reactor. As an operator watches the robot arm through a window or on a television monitor, he controls the hand by moving a sliding switch. The two metal fingers slide closer to each other or farther apart on the "wrist" so they can grasp objects and pick them up.

The robot astrobotics is currently developing consists of an arm with an elbow joint, a wrist that can be bent and rotated, and a hand. The arm and wrist are nothing new; they were taken from a standard industrial robot. But the hand, three-fingered with one finger acting as an opposing thumb, represents a major improvement in robotics technology. "Three fingers is really the minimum needed for dexterous manipulation," said Zik. With three fingers, the robot can grasp even oddly shaped objects securely and manipulate them much more finely than two-fingered robots can.

The controlling mechanism, called the "master," is also much more sophisticated than that of earlier robots. The master is constructed like a smaller model of the robot itself. At the end of the master's jointed arm is a ring that represents the wrist of the robot. The operator's hand slides through this ring to reach the most complex part of the master: the mechanism that controls the hand.

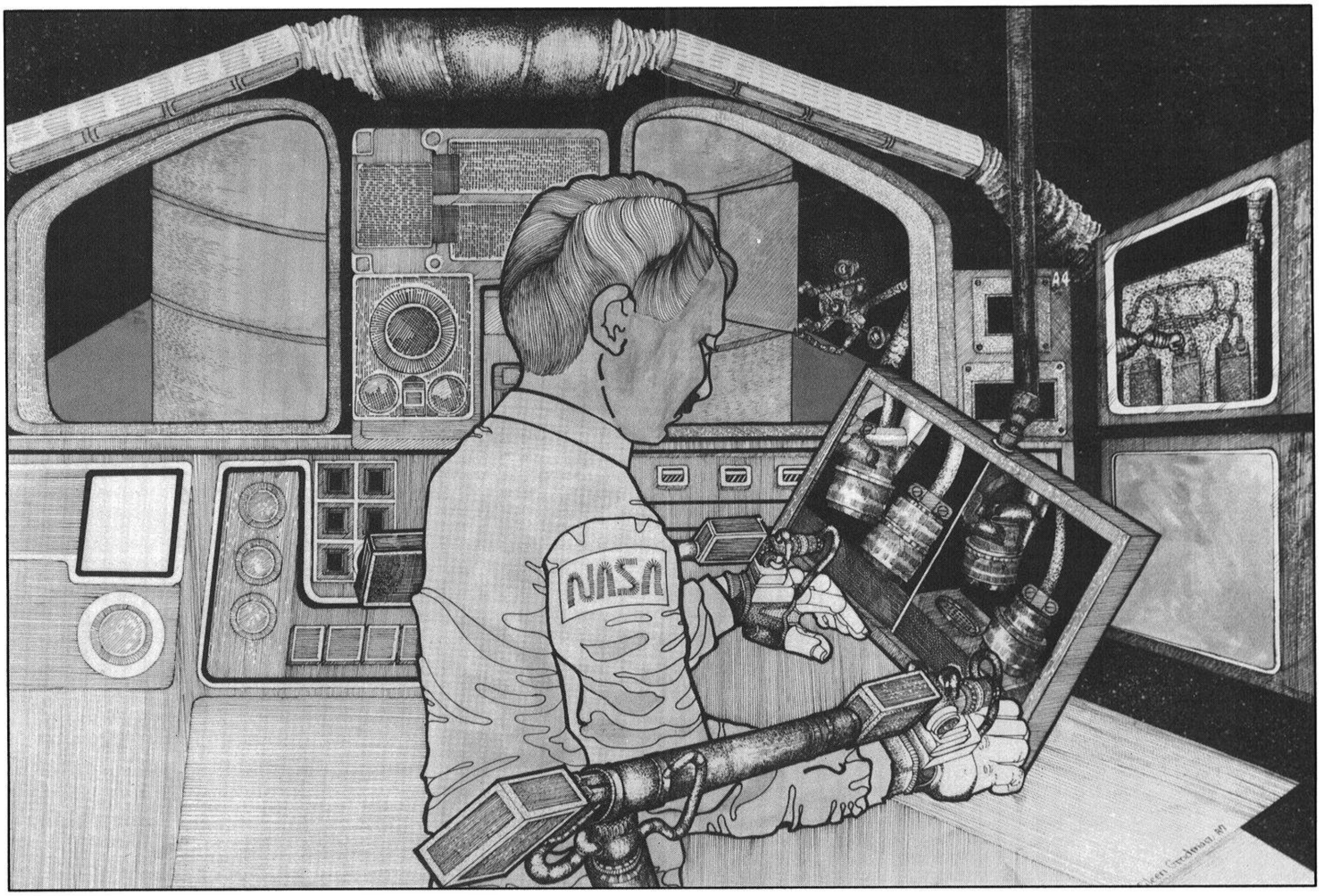
Inside this mechanism, the operator's thumb and two fingers, held in place by small bars, fit closely underneath metal fingers with plastic joints. The parts of the master's fingers correspond exactly to the parts of the robot hand.

As the operator twists his wrist and moves his arm and fingers, the master moves with him. Small sensors on the joints of the master determine their positions and transmit this information through a cable to the computer. The computer processes this information and sends it on to the robot, which adjusts its joints until it assumes a position identical to that of the master. According to Zik, "The sensors determine the position of the joints about 1,000 times a second, so the robot adjusts almost instantly as the operator moves."

But the operator of this robot has no way to know how much force the robot is exerting on an object it is grasping, or if it is touching anything at all, unless he is looking right at the robot. The robot could easily pop a tennis ball or crack anything it picks up. That's where the concept of telepresence comes in.

"The goal of telepresence," said Zik, " is to let the operator project himself into the task area — to feel like he's really there." To accomplish this goal, WCSAR researchers are working on two techniques: the ablility to feel force, and the ability to sense touch.

A few fairly basic techniques for force sensing are already used in



Concept of a telerobotic device for use in space

industry, but WCSAR researchers wanted something more sophisticated — something that would transmit the actual sensation of force from the robot to the operator. The method they are now exploring relies on the piezoelectric material. Piezen is a Greek word meaning "to squeeze," and whenever piezoelectric material is squeezed, or any other type of force is appled to it, it emits an electrical signal that varies according to the strength of the force.

The researchers plan to put a force sensor on the end of each of the robot's three fingers. The fingertip is made of silicon rubber, and small strips of piezoelectric material are embedded in the tip. The force information will be transferred back to the operator's hand so that when he grasps something with the robot hand, he will not need to see the object to know whether to tighten or relax his grip.

The present arrangement has its limitations. For example, with the force sensors only on the tips of the fingers, the robot will not be able to transfer force sensations when it grips something that is not in contact with the fingertips. But, according to Zik, this problem can be solved by placing some other type of sensor on the inside surface of the robot fingers.

Another possibility for the WCSAR group is the development of a robotic sense of touch. One idea involves constructing a tiny matrix of sensors on the robot fingers and palm. By coordinating and interpreting the separate signals each sensor gives off, an operator will be able to tell when the robot has touched something, and perhaps the texture and shape of the object.

The signals can be transmitted through wires from the robot to the operator. Oddly, the human hand is not the best place to send the information on what the robot hand is feeling. According to Zik, "There is simply not enough 'real estate' on the hands; they are not big enough to have the large electrodes we now use attached to them." Electrodes also function better on a flat, stable area such as the stomach or back.

However, this restriction does not hinder touch sensation. As Zik learned from researchers at the UW Clinical Science Center, "It doesn't matter how the information gets into the body; once it's there, the brain can be taught to interpret it in any way it needs." After training, an operator can feel the sense of touch in his fingers, even though the signal is being transmitted to another part of his body.

Zik estimates that, in five to ten years, robots with dexterous three-fingered hands and the ability to transmit a sense of touch and force to their operators will be ready to work. When NASA has developed the technology to send these robots into space, humans will be able to explore the universe anywhere they can send their machines. ▮▮▮

Astroculture

by Winnie Teng

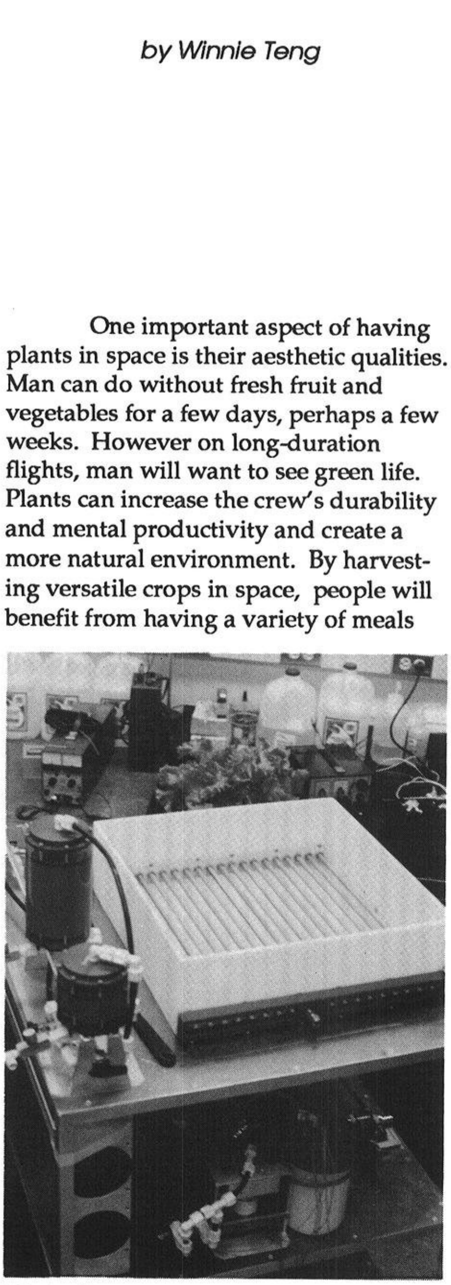
If you have ever gone camping in the woods for a whole week with just the barest necessities, then you know what it feels like to live on an extremely basic meal plan. However, on a month-long camping trip, your diet would definitely undergo major culture shock if you were to eat the same prefab "camping" food again and again. In addition to the lack of decent meals, the burden of carrying a heavy load of food would most likely discourage anyone from embarking on such a journey. By the same token, a trip out into space follows restricted living conditions.

The focus of the Wisconsin Center for Space Automation and Robotics (WCSAR) Astroculture project is the development of technology for a space-based plant growth unit which will serve as a major component of Controlled Ecological Life Support Systems (CELSS). NASA is proposing to launch a low earth orbit (LEO) space station within the next decade, to set up a lunar base early in the 21st century, and eventually, to build a Mars base in about 40 years. It is clear that a superior form of life support, designed for long-duration or permanently manned flight expeditions in space, needs to be developed. A major concern for the advancement of our space frontier is maintaining an environment similar to the earth's in order for man to function well.

Currently, the space program utilizes physiochemical processes to create a controlled environment for its astronauts. Machinery for such processes and storage of a crew's entire dietary supply both contribute to the exorbitantly high launch costs. With one crew member's daily food requirements weighing approximately 14 pounds and estimated launch costs of $2000 per pound, a six- month mission for four people would mean a great financial burden and an extremely heavy payload.

A solution to this problem would be to use a bioregenerative system which could eliminate heavy environmental machinery and space-consuming food storage. The general concept behind this self-supporting system is the interdependence between plants and humans. The plants provide food and oxygen to the crew, and the crew, in turn, supplies carbon dioxide and waste nutrients to the plants. The four components of a bioregenerative cycle includes plant production, food processing, human interaction, and waste processing. Plants in space would reduce the need for water purifying and oxygen to carbon dioxide conversion devices while efficiently keeping the crew alive. Although the research and development at WCSAR is concerned with the plant production subsystem, the entire system makes up a large portion of their research efforts.

One important aspect of having plants in space is their aesthetic qualities. Man can do without fresh fruit and vegetables for a few days, perhaps a few weeks. However on long-duration flights, man will want to see green life. Plants can increase the crew's durability and mental productivity and create a more natural environment. By harvesting versatile crops in space, people will benefit from having a variety of meals



The 1 m^2 prototype of a potato -growing container and nutrient supply system that look and taste like their earth-grown counterparts.

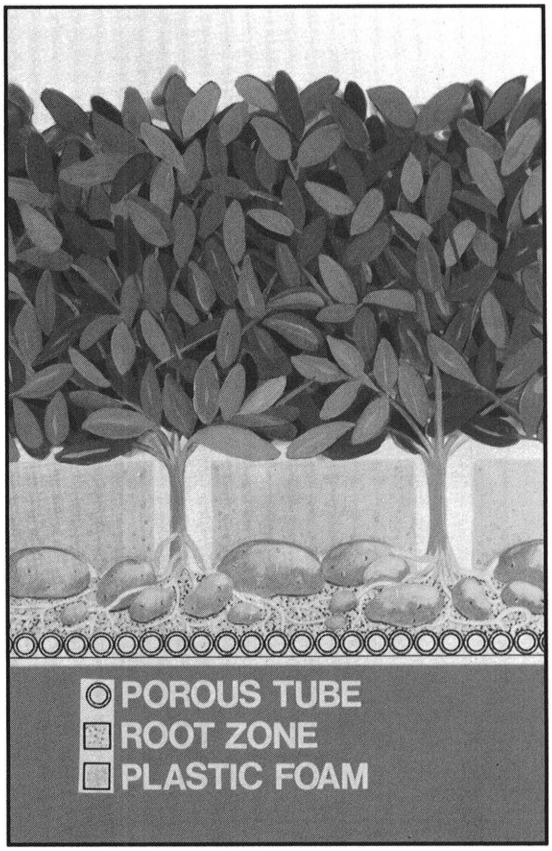
Requirements for ideal crop production in space had to be identified before candidate food crops could be chosen. The edible crop yield and production rate of a plant must be maximized. It is also necessary for the plant volume and ratio of waste to edible material be minimized. Most importantly, the production of the crop should be easy to automate, considering the fact that a crew's time should be reserved for higher priority tasks.

Several crop plants identified for space applications include wheat, soy beans, sweet potatoes, lettuce, white potatoes, rice, peanuts, and sugar beats. These crops are a vital source of bulk. The food plant which WCSAR has chosen to use is the potato crop. The potato is ideal in that it has a high productivity rate of digestible food and a high harvest index, is a good source of carbohydrates and proteins, is easily propagated in sterile culture, and requires little or no processing. Not only are potatoes a widely accepted food, but they are also versatile in terms of culinary forms.

During the first year of the AR-2 project, biological requirements for plant growth have been outlined as follows: irradiation, temperature, water, oxygen, carbon dioxide, atmospheric pressure, gaseous contaminants, and nutrients. Cultural needs consist of a growing container, nutrient supply, and microbial supply. From these specifications, the concept of a plant growth unit has materialized.

A space-based plant growth unit is composed of the following individualized subsystems: plant culture (container and nutrient supply), irradiation, water control, automation and robotics, temperature control, atmosphere control, sanitation, and inedible waste management.

For the first three subsystems, much research and many concept designs have been achieved because their terrestrial analogues are already well developed. The last five subsystems remain to be researched as soon as WCSAR acquires more resources.



A cross-sectional view of the plant culture system

Plant Culture

A cultural container was designed with attention to the low-gravity or weightless conditions under which plant growth could occur. A rooting medium made of arcillite, a compound similar to kitty litter, would provide support to the root area while allowing growth without much resistance. On top, open-cell plastic foam material would support the plant stem and prevent the rooting medium from flying around. Under weightlessness, water and nutrients cannot be supplied from the upper surface of the plant cavity. Instead, an unsaturated solution is piped through porous stainless steel tubing underneath the rooting medium. A pump provides suction of the solution, thus letting water and nutrients move through the pores and into the rooting medium by capillary action. A similar plant growth container has been developed at the Kennedy Space Center using membranes rather than a rooting medium for the transferal of nutrients. However, the rooting medium is by far a better design in that it insures a greater contact area and a back-up system, by holding in nutrients, in the case of a system shut-down.

Through this suction method, the problem with the loss of free-flying water is prevented. Separate reservoirs of water and nutrients, regulated by pressure and electrical conductivity sensors, lead to a mixing chamber. The water pressure sensor, set so that the roots receive the required amount of water, compensates for the transpirational loss of water into the "atmosphere."

From the mixing chamber, the nutrient solution is pumped and recirculated through a nutrient buffer system. This system is a column of ion-exchange materials which does three jobs at once. It purifies the water, adjusts the pH level of the solution, and balances the ion concentrations. The ion-exchange system proves to be superior to traditional hydroponics where chromatography and spectroscopy are used to determine and regulate ion ratios. Not only would specific ion analysis equipment be expensive and bulky but this method would not be able to accomplish the complex task of varying the ion ratio requirements for a system containing more than one crop species. For the ion exchange system, stock nutrient solution is added and low-level indicators and conductivity meters take care of the balancing act.

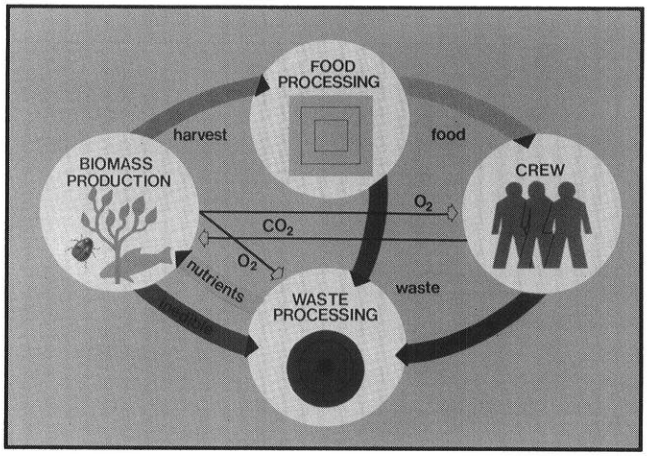
Evaluation of the plant culture is minimal so far. A small prototype of about one square meter in size has been tested for "proof of concept." Dr. Robert Morrow, an AR-2 research assistant, experimented with lettuce plants and produced some fresh salad from the prototype in 28 days. Data taken from this small model can be scaled up to working size. It is estimated that 10 square meters of growing area can provide half the caloric requirement of one person. Such a design is convenient: as the number of crew members increases, the unit can expand without much change to the design.

Humidity Control

Another matter of concern for growing plants in a closed environment is the control of moisture. The addition and removal of water in a plant growth unit will be regulated by machines similar to the humidifiers and dehumidifiers used on earth. As of now, WCSAR is in the midst of having these machines patented. By eliminating free (dripping) water through suction similar to the reverse of the nutrient supply method, water can be conserved. Dehumidification is a practical means of collecting pure drinking water. Thus, humidity control serves two functions: it supports both plants and humans.

Irradiation

Three sources of light for plants have been identified: the sun, lamps, and a combination of both. Getting light from the sun would be the most ideal means of cost crunching, but the drawbacks are numerous. Solar light is lost through light pipes positioned outside the culture system to direct light to the plants. Another disadvantage to the reliance upon solar energy is that light and dark cycles in LEO do not promote efficient production of plants. In orbit, the light cycle lasts 60 minutes and the dark 30 minutes. On earth, cycles are 16 hours of light and 8 hours of darkness. Although the light/dark ratios are the same on earth and in orbit, biomass



The Bioregenerative cycle

production in simulated LEO light/dark conditions resulted in a yield 50% less than earth-grown yield. Another trouble with solar light is having to use large collectors which can cause shading on parts of the growing areas. Also, most of the sunlight must be filtered to remove heat and UV light. The disadvantages for use of solar light seem to favor the artificial means of irradiation.

High intensity discharge (HID) and fluorescent lamps can reduce the power requirement for producing radiant energy which a plant could use. Both halide gas and high pressure sodium lamps are worthy of being used as growing lamps. Undergoing a patenting process is the concept of optoelectric devices which will select a tight wave band (approximately 650-680 nanometers) of light most needed by plants. By specifying the wave bands necessary for photosysnthesis, overall efficiency of lamps can be increased by 30-40% — compared to a meager 3% for solar light.

Incomplete Subsystems

Significant technology needed to develop the following subsystems are not available. However, a few requirements have been established.

SANITATION

The sanitation subsystem will be designed to "wash the dishes" for the plant growth unit. In addition to removing debris, it will eliminate microbial populations and other plant diseases (once they are defined). Such diseases must be monitored and destroyed because they can easily be spread through the nutrient supply system. A single microorganism, once in the system, could wipe out an entire crop in one blow.

AUTOMATION and ROBOTICS

The functions of an automated plant growing system include planting, harvesting, and storage. The robotic mechanisms must be sensitive to the light and fragile plants. Common robotics, used primarily for larger and heavier items must be redesigned. Development of AR-2 automation and robotics can begin only after AR-1 (Astrobotics) progresses in technology.

ATMOSPHERE CONTROL

Two concerns for a regulated growing atmosphere are the gaseous make-up and the identification/control of gaseous contaminants. A pressure balance of oxygen, carbon dioxide, and other necessary gases must be maintained. Research is being carried out pertaining to the concentrations of each gas required for efficient growth. Types of gaseous contaminants may be in the form of organic releases (normal physiology of plants themselves), microbial breakdown, and "outgassing" from structural materials (i.e. plastics). The latter two, being potentially volatile forms of gases, must be identified in order for proper control to be carried out. It is important that all conditions involved in a closed environment system be accounted for to insure risk-free food production.

INEDIBLE WASTE MANAGEMENT

As with any space-conscious effort, management of waste which can accumulate quickly must be established. Adequate data taken from space-grown (actual or simulated) crops is needed in order to calculate waste yield and composition. Only after researchers become comfortable with the actual space crop production, and determine exactly the percentages of waste and food, will they be able to research further the treatment of inedible plant material.

Resources

The Biotron, a UW-Madison facility which provides growing/testing chambers tailored to specified variables, plant care services, and reliable control systems, is an important resource for WCSAR researchers. At the Biotron, WCSAR is able to run experiments on plant-environment relationships which aid their understanding on how to integrate terrestrial requirements into space crop production.

The McDonnell Douglas Corporation is contracted to WCSAR for assistance in their program also involving bioregenerative support systems. They have already developed computer simulations of physiochemical and environmental control/life support systems for the space shuttle. Now they want to branch off simulation concepts for these machine-based systems to test a plant-based one. WCSAR's main duty is to provide estimated parameters for plant growth, such as amounts of required oxygen, carbon dioxide, nutrients, and inedible material. In return, WCSAR will gain "experimental" results of plant growth in space generated from computer simulation.

Limits on AR-2

Dr. Raymond J. Bula, project coordinator at WCSAR, comments that what is holding back much of the conceptual development for the plant growth unit and its subsystems is the significant amount of unavailable technology at the moment. Of the technology that exists, most is based on terrestrial environmental conditions. Bula sees future limitations. In order to validate space crop production, flight evaluations must be made. Unfortunately waiting for (scarce) flight opportunities to run tests may cause delay. Beyond the next three years, AR-2 directors plan for the construction of a demonstrational plant growth unit, after having completed subsystem tests. The finished product must be efficient and dependable day after day. Although it will most likely take a few decades for a potato growing unit to evolve into a life support system, mechanically and biologically perfect, the result—aesthetic meals for space-bound travelers—will be worth the wait. ▮▮▮

ASTROFUEL

by Peter Holmi

As exotic as it may seem, the world's future energy needs may be supplied by a special element only found in large quantities on the moon.

The element is known as astrofuel. This substance has the potential of providing the world with power for many years as well as powering some of the most exotic space ships to cruise through the galaxy.

Research at the University of Wisconsin - Madison campus is taking place under the Fusion Technology Institute. Jerry Kulzinski, director of the program, and Roxy Engelstad, professor of mechanical engineering, are studying astrofuel and some of the technical problems associated with its applications.

Technically, astrofuel is helium-3. Normal helium which is used to fill balloons is actually helium-4. The difference between the 3 and the 4 makes the balloon variety inert while the other applicable in a whole host of subjects and a prime candidate for nuclear fusion.

Without adequate supplies, all this research would be next to useless. Fortunately, the moon has vast supplies of astrofuel. Potentially, the amount of helium-3 on the moon could power fusion reactors for several centuries, hopefully starting as early as the 21 century. Unfortunately, only minute quantities exist on earth.

The helium-3 on the moon is a by-product released from the sun's fusion reaction. After leaving the sun, the helium-3 flies through the universe until it collides with something. As a result, the Earth's moon, along with other planets, is constantly bombarded by helium-3.

Unfortunately, the earth receives only small quantities of the helium-3 from the sun because the earth's outer atmosphere effectively blocks most of the helium-3.

This leaves the moon as the closest source of helium-3. The Fusion Technology Institute hopes to install surface mining machinery on the moon's surface to gather helium-3 for export to the earth in the space shuttle.

Since helium-3 only penetrates an extremely thin outer layer of the moon's surface, the element can be mined over large flat sections of the moon with an unmanned vehicle.

However, surface mining the moon for helium-3 requires the separation of helium-3 from the other elements and rocks. A cheap and effective method needs to be developed for the vehicle.

Fusion is the process of releasing energy by combining two small elements into one large one. Today's nuclear power comes from a fission reaction which is the process of breaking one large element into two smaller ones.

In contrast to fission, fusion offers a direct method of producing power. After breaking apart a large element, fission releases energy by a two step process. The reaction first heats water and then the heated water is used to produce energy. This is also the same method used for fossil fuel power. On the other hand, energy from fusion can be obtained directly. This translates to substantially higher efficiencies approaching 70 to 80%, or approximately twice the percentage for fission reactors or fossil fuel power plants.

Astrofuel fusion offers a clean source of fuel when compared to fission. The fusion by-product is simply normal helium used to fill balloons rather than a radioactive isotope that releases harmful radiation for hundreds of years.

Although the technical problems are substantial, the actual process of converting astrofuel to energy is very simple. This translates to small reactors that are relatively inexpensive.

Traditional fission power plants are located in remote areas in the event that the reactor releases radiation into the environment. Since astrofuel fusion does not have the severe radioactive by-products, the power plants can be located close to major power consuming areas eliminating some long distance power transfer.

Why not some other form of energy for the 21st century?

Currently, the world consumes the equivalent of about 50 billion barrels of oil in fossil fuels per year which includes oil, natural gas, and coal. Economically recoverable fossil fuels are a finite quantity with the equivalent of approximately 5000 - 7500 billion barrels of oil. As the population of the world continues to increase, world consumption of fossil fuels continue to rise and is estimated to reach a consumption rate equivalent to 100 to 150 billion barrels of oil per year.

In addition, burning fossil fuels adds to problems such as acid rain and the "greenhouse" effect and their use is no longer limited to energy production but to a whole spectrum of products designed to improve the quality of life.

Finally, since astrofuel fusion is more efficient and releases so much more energy compared to fossil fuel power, only several dozen tons of astrofuel per year could provide the world with its yearly energy requirements.

The moon is estimated to have enough helium-3 loosely distributed on it's surface to provide a continuous source of helium-3 energy for several centuries at the estimated consumption rate.

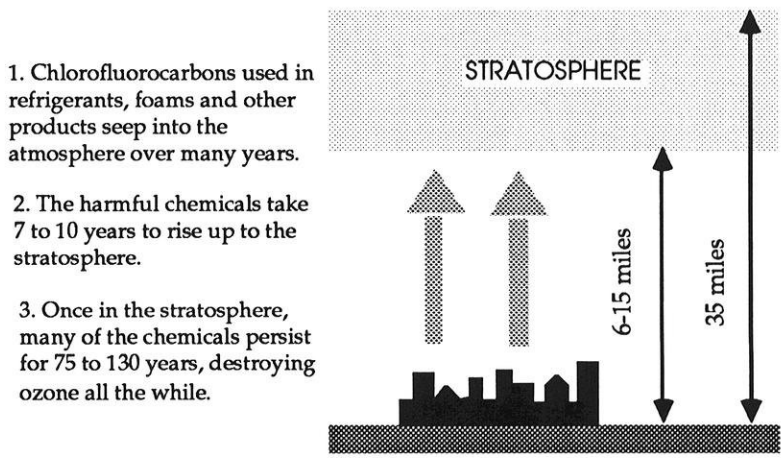
The Wisconsin Engineer would like to thank WCSAR for their cooperation with the research of these articles and for their contribution of the photographs.

The Light May Be Stronger Than You Think

by Craig Fleschko

It appears that the earth faces another series of tough environmental questions, and just like the problem of the Greenhouse Effect, there are no easy solutions

The Theory of Today's Pollution

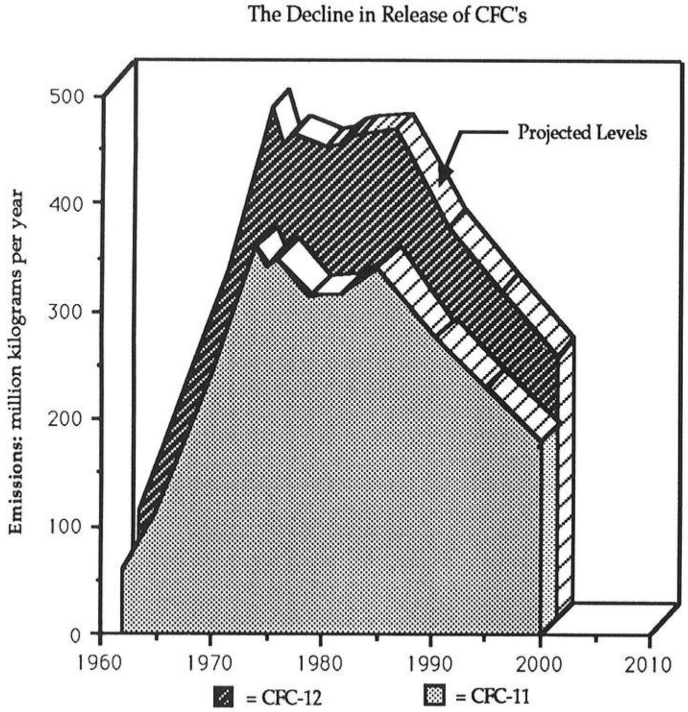


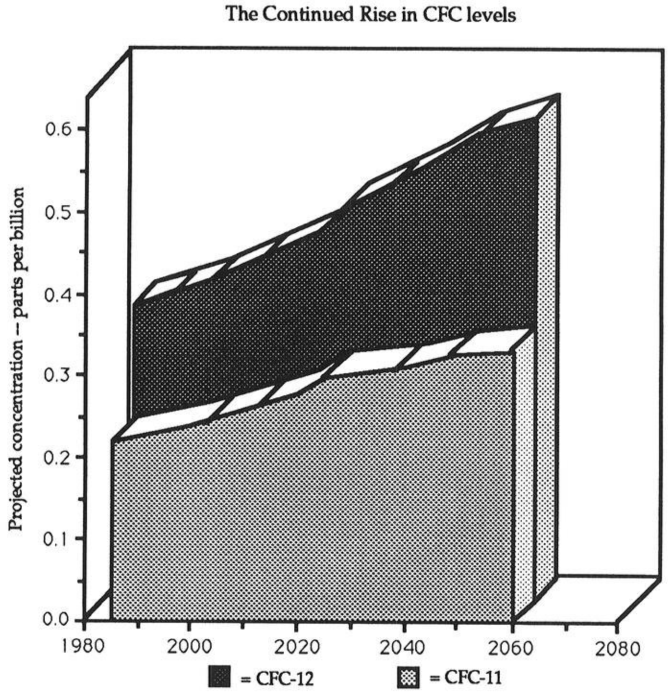
Source: The New York Times

Ozone is a triatomic oxygen molecule with a bluish color and pungent odor. Ozone can be produced by a large electrical discharge in the air; this is why most people associate the smell of ozone with the fresh, clean odor of the air after a thunderstorm with a lot of lightning. Ozone can also be created in the upper atmosphere when air is exposed to solar ultraviolet radiation. This is how the earth's ozone layer, which protects us from the shorter, more harmful wavelengths of solar ultraviolet radiation, is produced.

Chlorine is a pungent smelling, poisonous greenish-yellow gas which is used by the public and in industry in bleaches, disinfectants, and water purification systems. Chlorine is responsible for the present destruction of over 2% of the earth's ozone layer, which is projected to cause thousands of new cases of cancer and possible environmental catastrophe.

If you haven't already heard about the problems with the ozone layer, you should have. The media first started publicizing the deterioration of the ozone layer in 1974, when chemists F. Sherwood Roland and Mario Molina found that chlorine compounds known as chlorofluorocarbons combine with and break down ozone. The chlorofluorocarbons (or CFC's) are produced by man for use in refrigerators, plastics, propellants, and solvents, and when released into the atmosphere they rise until they reach the ozone layer, where they mix with ozone and destroy it. This presents a problem because the ozone layer is the earth's defense against ultraviolet radiation, which can cause cancer, mutations, and a host of other health problems in man and other organisms. Due to the worry over the destruction of the ozone layer, CFC's were banned for use in the United States as aerosol propellants in 1978. The CFC problem wasn't entirely solved by the ban, however, because CFC's were (and still are) commonly used as plastic additives, solvents, and refrigerants in the U.S. and other countries, and they are still used as aerosol propellants in other countries. A complete ban on CFC's for any and all uses wouldn't solve the problem either, because CFC's are very durable — they can last for over a century before they are finally broken down to the point where they are no longer harmful. Even if CFC production was to be totally halted tomorrow, the CFC's that are in the atmosphere now will still continue to eat away at the ozone layer. It appears that the earth





* Source: The New York Times

faces another series of tough environmental questions, and just like the problem of the Greenhouse Effect, there are no easy solutions.

The recent concern with CFC's started almost a decade after the U.S. ban on CFC propellants. In early 1988, University of Illinois researchers found that satellite data showed a 5% decrease in worldwide ozone levels. Scientists had noted in 1985 that a hole was developing and growing in the ozone layer over Antarctica, and ozone levels had dropped by as much as 50% over the entire Antarctic continent. The Antarctic hole was believed to occur because the ozone layer is strengthened by a chemical reaction triggered by sunlight. Thus, the polar regions would be very susceptible to ozone destruction in the winter months, when relatively little sunlight reaches these areas. Data collected by Canadian weather balloons showed a similar loss of ozone in the north polar region, but the ozone drop was less due to the different weather patterns in the northern hemisphere. The loss of ozone over the poles was surprise enough; no one had expected that such a sharp ozone drop would be found worldwide, ranging from a huge 40% average loss in the polar regions, a loss of 6% in the middle latitudes, and a relatively low loss at the equator. This confused many scientists whose previous calculations had indicated that such a loss was decades away, which apparently meant that the damaging effects of CFC's had been greatly underestimated. At first, scientists considered the possibility that the Nimbus weather satellites that collected the ozone data might have developed calibration problems and delivered inaccurate ozone readings. Unfortunately, even versions of the satellite data corrected for calibration errors showed a sharp drop in ozone, and the adjusted amount of worldwide ozone destruction was only reduced to around 2%. Since a 1% decrease in ozone corresponds to a 2% increase in ultraviolet radiation reaching the earth's surface, even a 2% decrease in ozone could still cause thousands of new cases of skin cancer. The future projections look much worse - some computer models predict that the amount of ultraviolet radiation reaching the earth could rise by 5 - 20% by early in the next century.

...some computer models predict that the amount of ultraviolet radiation reaching the earth could rise by 5 - 20% by early in the next century

What can be done about it? Very little. CFC's take seven to ten years to reach the stratosphere, and one chlorine molecule can stay in the stratosphere to break down thousands of ozone molecules for over a century, so recent ozone readings are actually based on past CFC's that were released years ago. CFC use rose throughout the world in the seventies and eighties, so there are also these past CFC's from the seventies and eighties that have yet to register an effect. Even if present CFC use were to discontinue entirely, there are still enough CFC's in refrigerators and plastic foams to have a significant impact after the products are discarded and the CFC's escape. There is also the problem of future CFC's; thirty-one nations signed an accord in Montreal in early 1988 that pledged that they would gradually reduce their production of CFC's to 50% of their 1986 levels, and negotiating this great of a reduction between the countries was considered to be a victory. A victory? Under the Montreal accord, an Environmental Defense Fund report estimates that the next century would see the present ozone depletion increase by a factor of three. Some manufacturers realized that a 50% reduction in CFC production wasn't enough and decided to move out of CFC production entirely, which may help in the long run. This move was spearheaded by DuPont, the producer of 25% of the world's CFC's, and was soon followed by several other companies. However, even if CFC production was to halt entirely, there would be a lag period of ten years or so before we'd notice any effects, so it may be a case of too little, too late.

Another cause for worry is that nobody really knows all of the effects of increased ultraviolet radiation. The link between increased ultraviolet radiation and human skin cancer is not yet fully understood, and UV is suspected to cause other health problems as well. Evidence indicates that UV can affect the human immune system and weaken the body's resistance to parasites, viruses, and foreign substances. The effects of UV on other organisms is less researched and even more of an unknown. What is known doesn't look good; ultraviolet has been found to be deadly to microorganisms such as plankton, which forms a significant link in the ecological food chain. Dr. Donat Haber of the University of Marburg, West Germany, states that "our data say that these organisms are already under very drastic ultraviolet stress right now. Most of them are incredibly sensitive. When you expose a population of these organisms, they will die within a few hours... When you go through the food chain, the effects multiply, and eventually we will be losing millions of tons of fish protein." Biologists are also concerned about the impact on crops and other plants. Thomas Coohill, the president of the American Society of Photobiology, says that "on a global scale, the most significant thing is the destruction of plants... If you start tampering with the layer of ozone that quickly, you don't have time to evolve protective mechanisms."

Evidence indicates that UV can affect the human immune system and weaken the body's resistance to parasites, viruses, and foreign substances

The ozone depletion could also cause an escalation in global warming, or the greenhouse effect, if the phytoplankton and algae begin to die. Since these organisms convert carbon dioxide to oxygen, their destruction by the increasing ultraviolet radiation will result in the the earth not being able to efficiently replace carbon dioxide, and more global warming will result.

So ultraviolet radiation levels are continuing to rise. The hole in the polar ozone layer is growing every year, and has now reached populated areas of South America. Human health and the safety of the ecosystem are in jeopardy, and most people don't even realize it. Many do not understand the problem, and ironically enough, it is difficult to get people to take the problem seriously. As Dr. Irving Mintzer of the World Resources Institute puts it, "it's not a Chicken Little problem — we don't all die by the end of the week. We're asking people to reduce the risk of an invisible, odorless, colorless gas because we perceive that there will be a risk of destruction of an invisible shield, allowing the penetration of invisible rays." The Reagan administration suggested the simplistic solution of wearing sunglasses and sunscreen lotion, the infamous "Rayban Plan" that made scientists cringe — and Reagan himself had cancerous skin removed from his nose. So the next time you go lie out to get a tan, remember — the light may be stronger than you think. ▮

College of Engineering Photo Contest

The College of Engineering is holding a photo contest for graduate students, undergraduates, faculty and staff. Anyone having a connection to College of Engineering projects or programs is eligible to enter, including non-engineering students supervised by engineering faculty or employed in engineering programs.

The photographs may represent microscopic views of engineered objects or engineering materials, computer-generated or computer processed images that have some engineering meaning (not purely "computer art"), or other visually interesting photographs. Some other examples are infrared, x-ray, high-speed, or other novel views of common "everyday" objects.

A $300 cash prize will be awarded to the 1st-place winner and a $200 cash prize to the 2nd-place winner in both categories of black & white and color. In addition, up to five $100 prize winners will be selected from each of the two categories (14 winners in all).

The deadline for entry is February 1, 1989. Deliver entries to Associate Dean John Wiley in 411 ERB. The primary selection criterion will be visual and artistic impact rather than technical or scientific significance. Subject variety, technical significance, and relation to important college projects will be used as secondary or tie-breaking criteria.

Evening With Industry

As the excitement has mounted, the Evening With Industry Committee has been hard at work on this year's rapidly approaching event. Evening With Industry, the annual banquet sponsored by the Society of Women Engineers, brings engineering students and practicing engineers together. In the past, companies such as Proctor and Gamble, Rockwell International, and Honeywell have helped make this event a proven success. Students enjoy learning more about present-day industry and existing career options from leading professionals. Companies appreciate this opportunity to gain exposure on campus and advertise possible job openings. The evening will include hors d'oeuvres, dinner, a guest speaker, and an awards presentation. This event is free to all S.W.E. members and is $12 for non-members. Note, S.W.E. membership is $10 and is open to all engineering students. Mark February 15 on your calenders now. Deadline for reservations is December 22. Pick up forms on the S.W.E. board and return them to the S.W.E. mailbox, both are in the ME Lobby. For additional information, contact Lori Tatsuguchi at 255-6621.

OOPS!!!

The Wisconsin Engineer unintentionally omitted Gregory Lillegard's name from the "Letters from Japan" article in our last issue. Lillegard is one of the three students from UW-Madison studying engineering in Japan this year. We apologize for the error.

COLLEGE CENTENNIAL

The College of Engineering will be celebrating its one hundredth anniversary in 1989. The College will hold a wide variety of events to celebrate the Centennial. Plans include special seminars, lectures, and programs, as well as a centennial "birthday party" on February 25 at (Eliot) Union South. Seminars are scheduled weekly for Spring semester 1988-1989 and Fall semester 1989-1990. They will feature outstanding indiviuals of society and can be taken for one credit each semester. The seminars are open to the public. The *Wisconsin Engineer* will highlight the College of Engineering Centennial in a

Engineering Briefs

Williston Award to be Presented by ASME

The American Society of Mechanical Engineers is sponsoring the 1989 Arthur L. Williston Award Contest. The Williston Award is presented annually to the student engineer or recent graduate who authors the best acceptable paper in the area of civic service. This year's topic is International Technology Exchange. The contest is open to ASME student members and associate members who received baccalaureate degrees not more than two years before March 1, 1989. The deadline for entries is March 1, 1989. For more information contact: Professor Bill Feiereisen at 262-7888.

EXPO '89

EXPO '89, the University of Wisconsin-Madison 1989 Engineering Exposition, will take place April 7,8, and 9, 1989. EXPO is a non-profit, student run and organized event that introduces students and the public to developments in the College of Engineering and the industrial sector. Exhibits include engineering related displays created by UW students and by corporations throughout the country. Special Exhibits for EXPO '89 feature health and engineering. For more information about EXPO '89 contact the EXPO office at 262-5137.

HAPPY BIRTHDAY!

The staff of the Wisconsin Engineer wishes our faculty advisor, **Don Woolston**, a very happy 24th anniversary of his 16th birday.

He hit the big 40 on Dec. 9.

wisconsin engineer

spring 1989 issue.

Events that will take place on February 25, 1989 at Union South will include:

6:00 p.m.	Social Hour (with live background music), free beer, soft drinks, and snacks.
6:30 p.m.	Buffet Dinner (with live background music)
7:30 p.m.	Cake Cutting and Cake Contest Prize Ceremony
8:30 p.m.	Dance Band
	Dag Hammarskjold Room (Older people)
	DJ Entertainment in Diversions Einstein Room (Younger people)
12:00 p.m.	Adjourn

Concurrent with above will be free admission to bowling, video games, pool, etc. in the game room, and historical artifacts will be on display. Ticket price: With dinner $10.00
Student with dinner $5.00
Without dinner $4.00

Tickets will be sold before the event and at the door. Reservations must be made if attending the dinner. Every person attending will receive a gift valued at $4.00.

Questions Remain Despite Shuttle's Success

by Don Korjenek

On September 29th the U.S. finally got its space program back off the ground following the 32 month post-Challenger disaster layoff. On the same day, the U.S. signed an agreement with 11 other countries to build the next major space project, a permanently manned space station to orbit the earth by the 21st century. Few would argue that there was a great deal more riding on the Discovery's flight than a group of nervous astronauts.

Few would argue that there was a great deal more riding on the Discovery's flight than a group of nervous astronauts

Since the Discovery flight was a success, many people feel that NASA and our space program are back on track. However, just as one accident should not cripple an entire program, nor should one success earn NASA the proverbial pat on the back. NASA still suffers from several major problems, most of which are not directly connected to the Challenger accident. Without focused long term goals, secure funding, and added versatility NASA may see its role as a powerful government agency reduced.

Goals

The immediate future for NASA is fairly simple. The large number of proposed shuttle launchings that were put on hold following the Challenger accident are to be carried out. This however does not constitute long term planning. There is a necessity for the space program to provide such objectives, but NASA has yet to do so. In fact, this has been the case since the start of the space race in the late 1950's. NASA has a history of spurting ahead to reach specific goals, then relaxing. Originally, the goal was simply to beat the Soviet Union to space. Today, the shuttle program seems more like a means without an end.

Aside from the shuttle, NASA's next major project is the planned orbiting space station. Presumably, it would serve as a low-gravity laboratory and a stepping-stone to further explore the solar system. While this project would certainly give NASA something to do, its goals beyond actually building the station are unclear. Most of the proposed missions for such a space station can be done by the existing shuttle fleet, satellites, and space platforms. Other possible long range goals of NASA include: a more ambitious exploration of the solar system with robotic craft, an expanded effort to monitor the earth's threatened environment from space, a permanent base on the moon, and human exploration of Mars. These general proposals do not solve NASA's problem of a lack of coherent, specific goals. Without specific goals, NASA will also have problems obtaining funding for future projects.

Finance

Obtaining the necessary money for such projects as the space station will be difficult at best for NASA. Although President-Elect Bush has expressed support, Congress has been rather lukewarm about the idea. NASA hopes to use the shuttle to build the proposed space station, but since the Challenger exploded the costs of each shuttle mission have dramatically increased. These costs were not just from the loss of such an expensive craft and the subsequent redesign, but from a reorganization of NASA itself. Now more safety precautions and testing go into each launch. Furthermore, NASA competes with other U.S. government agencies for money. Figure 1 shows how the space budget of the Defense Department has increased while NASA's has decreased since the Apollo moon missions.

If NASA's goals are unclear then it's future funding is in serious doubt. Many people feel that it is not appropriate to fund NASA simply for the sake of sustaining the organization. With $200 billion budget deficits, the U.S. can not afford to spend money on unwise programs.

Many people feel that it is not appropriate to fund NASA simply for the sake of sustaining the organization

Versatility

Most of NASA's current problems stem from a lack of versatility. That is, the reliance on the shuttle program as its single most important project since its conception. There is great debate today over the need for manned space flight. Much of the scientific community contends that its experiments can be conducted by unmanned rockets, which are much cheaper to operate. Also, NASA faces stiff competition for commercial flight business from foreign countries and private firms. Small companies like E-Prime Aerospace with 25 employees as well as General Dynamics and McDonnell Douglas are all getting into the business of unmanned space travel. This leaves NASA with all of its eggs in one basket—the space shuttle.

As the Challenger accident showed, relying only on manned space flight is dangerous. No matter how improved the safety measures are, accidents can still happen if flights continue. Those supporting unmanned, non-reusable rockets insist that accidents with these rockets could never cripple the entire space program as the Challenger wreck did. On the other hand, the bureaucrats and contractors who are the main proponents of the shuttle, insist that glamorous manned flights are necessary for public support.

Despite the Discovery's recent flight, the debate continues on. NASA may find it necessary to diversify it's operations in the future. If not, a continued reliance on the shuttle will require more specific program goals. This would greatly help to reduce the pressure NASA feels today.

The hub of NASA's problem is that it has an expensive space transportation system and not a whole lot to do with it. In the future there is sure to be a strong incentive to fund new missions in order to rationalize the giant investment already sunk into the shuttle. If NASA is to continue into the next century it will need more focused long term goals. A sense of mission is what is needed. Most of NASA's problems date back to the decision to rely on the shuttle program and manned flight, without specific goals. Obviously, NASA has done wonders for American pride. More justification may be required, however, to build a $30 billion space station and continue on with road-to-nowhere programs.

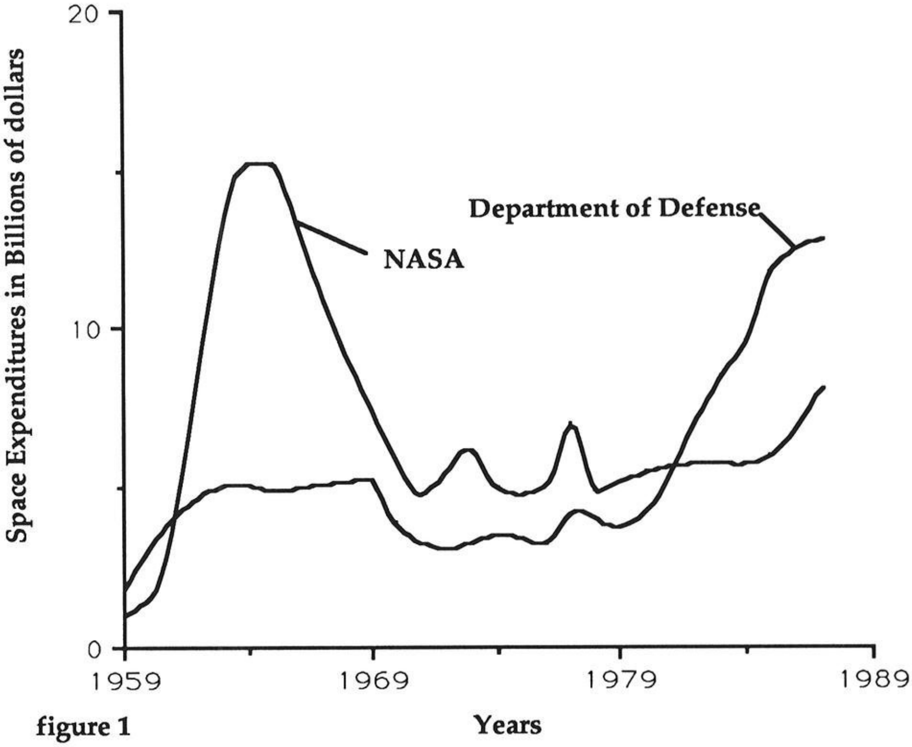
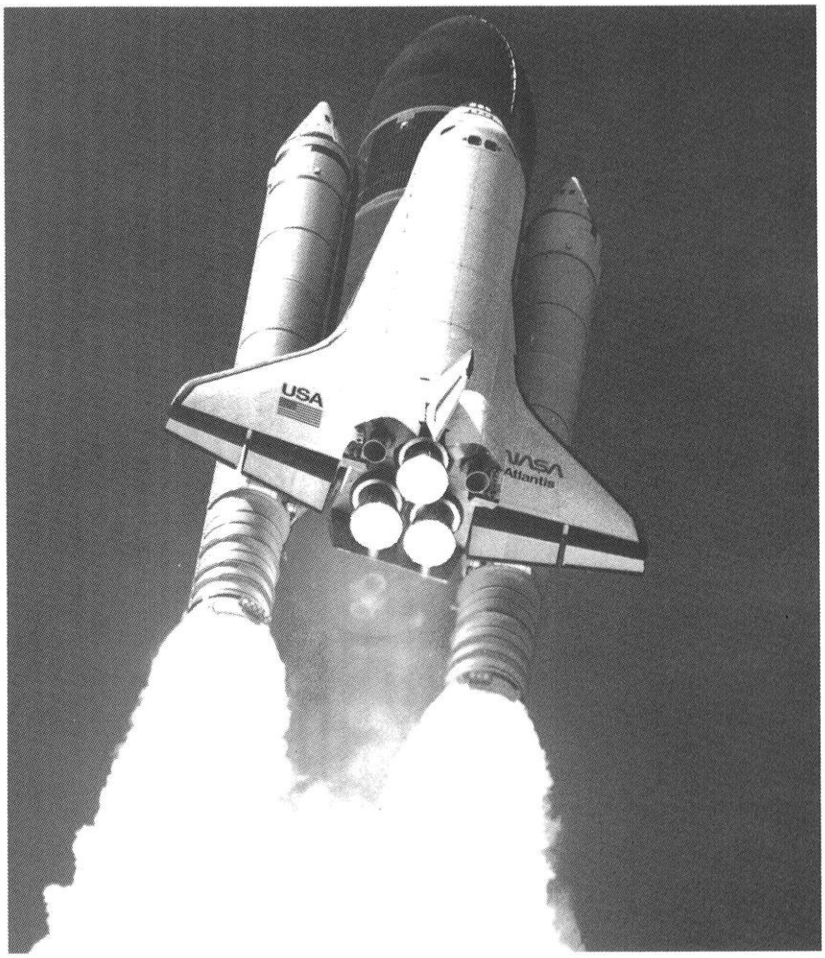


figure 1



Accreditation Board for Engineering and Technology

by Nancy Hromadka

A little over two months ago, the University of Wisconsin-Madison's College of Engineering underwent an examination by the Accreditation Board for Engineering and Technology (ABET) to verify that the College of Engineering is maintaining the standards necessary to achieve status as an ABET accredited school.

ABET, a federation of 26 engineering societies, is the major accrediting agency used to evaluate engineering programs in the United States. The organization was formed in 1933 as the Engineers' Council for Professional Development (ECPD) and later changed to its current title with the primary purpose of standardizing engineering degree requirements and institutions throughout the country. ABET identifies programs that meet minimum criteria for evaluation and provides guidance for the improvement of existing engineering programs.

Within ABET there are several committees, such as the Engineering Accreditation Commission (EAC) which is responsible for administering policies, procedures, and criteria previously drafted and approved by the ABET Board of Directors. The EAC consists of engineering professionals from throughout the country representing both industry and academics. Each member of the EAC has been nominated and elected by a professional society to serve as an active member on the committee for a five-year term. The EAC's members represent all disciplines of engineering including aeronautical, agricultural, chemical, civil, electrical, industrial, metallurgical, and nuclear.

From this large and diverse group of engineers, smaller evaluating teams known as Ad Hoc Visitors' Boards, which actually visit the schools and make accreditation recommendations, are formed. Each visiting team consists of approximately 10-15 people and includes one type of engineer for every program within a school to be evaluated. Every member of the EAC is expected to serve on one such visiting team during each year of his or her term.

The actual evaluation of an engineering school involves a two-day visit and an extensive personal examination of the school by each team member prior to the visit.

Every year, 45-50 schools are visited and evaluated. Generally, individual schools must request an ABET evaluation before their current accreditation expires. For example, in the case of UW-Madison, Chancellor Donna Shalala made a formal request in January inviting ABET to send a visiting team to evaluate ten programs in the College of Engineering.

As a follow-up to such a request and in preparation for the evaluation, each school prepares a self-analysis, known as a Self-Study Questionnaire, sometime between February and May. Associate Dean Donald Dietmeyer was responsible for composing UW-Madison's self-analysis which consisted of three large volumes.

The first volume, typical of one prepared at any school, dealt with the college of engineering as a whole, evaluating in detail the faculty, curricula, administration, facilities, budget, commitment, and students. It identified areas the college viewed as its strengths and weaknesses, and offered suggestions for improving any such weaknesses.

The second volume of the self-analysis consisted of multiple parts with a separate section prepared for each program to be evaluated. The ten programs covered in UW-Madison's latest evaluation were Agricultural Engineering, Chemical Engineering, Civil Engineering, Civil Engineering Survey Option, Electrical Engineering, Engineering Mechanics, Industrial Engineering, Mechanical Engineering, Metallurgical Engineering, and Nuclear Engineering.

The third volume illustrated the numerous pamphlets, brochures, and informational packets put out by the College of Engineering to publicize its programs.

A copy of this kind of self-analysis is then sent to each member of the visiting team and used as background information to familiarize members with the school prior to the visit.

A typical visit takes two days, beginning on a Sunday evening with an initial meeting of the team members and ending on the following Tuesday afternoon in a final meeting with the school's chancellor. During the two days on campus, team members speak with

Associate Dean Donald Dietmeyer

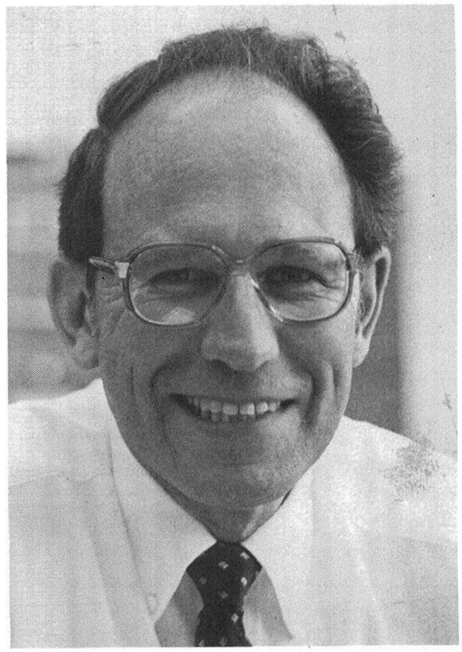
the dean of the college and department chairmen, interview the faculty and students, examine the laboratories and support departments, and review the displays of student homework papers, text books, and graded exams.

Following the visit, each team member submits a report, summarizing his or her evaluation of the school and suggesting a final recommendation, to the team chairman, who then relays the opinions of his team back to the ABET Board of Directors.

Five possible recommendations may be made by each team member. These ratings, given to specific programs, are as follows: 6V-six years and a visit, the best rating that can be achieved, indicating a maximum period of accreditation; 3R-three years and a report, indicating the need for minor changes which, when implemented and documented in a report submitted to ABET in three years, may result in an additional three-year accreditation; 3V-three years and a visit, indicating the need for additional changes which, when implemented in three years and accompanied by another visitors' evaluation, may result in an additional three-year accreditation; SC-show cause, indicating that a program is found to be deficient, in which case the school is given three years to make necessary corrections and "show cause" for being accredited; NTA-not to accredit, a rating earned only after failure to "show cause," indicating program may no longer claim ABET accreditation.

In January, after all schools for a given year have been visited and evaluated, preliminary statements are sent to each school. From February to May, the schools are then given an opportunity to respond to the statements, and from May to June, schools are expected to carry out suggestions made in reports by the Ad Hoc Visitors' Boards. The final recommendations for each program in the schools evaluated that year are then discussed in a July meeting with the team chairmen and the ABET Board of Directors. The official rating of each program is determined here. According to these time frames, the preliminary statement focusing on the results of UW-Madison's most recent evaluation will not be available until January of 1989, and the final, complete results will not arrive until sometime in August.

Inside ABET With Professor Ferrel Stremler



Presently, only one member of UW-Madison's Engineering faculty is actively serving on the EAC. Professor Ferrel G. Stremler, of the electrical and computer engineering department, represents the Institute of Electrical and Electronics Engineers (IEEE) on the EAC. He recently visited the University of California at Davis for an evaluation of their electrical engineering program. Professor Stremler said that he enjoys being a part of the EAC and serving on the Ad Hoc Visitors' Boards because he has the opportunity to "see what schools are doing in a completely different part of the country."

Having visited schools on both the east and west coasts, as well as in the southern part of the country, Professor Stremler explained, "I like to see how other schools are doing. Every visit I've been on has been very interesting." Part of ABET's plan to insure accurate and unbiased evaluations involves bringing in team members from other parts of the country.

Although evaluating a particular engineering program requires long hours of processing information and preparing a final report, as well as two intense days of actual visitation, the position of an Ad Hoc Visitors' Board member is strictly voluntary, receiving no compensation. Every year, professional engineering societies ask for nominations of their members to serve on the EAC. Nominees are asked to submit resumes, and the best-qualified members are elected. Professor Stremler said that the IEEE generally receives from five to six times more resumes than what it elects. Regarding his position, he noted, "It's an honor to be chosen." The reward, according to Professor Stremler, comes from "knowing you've accomplished something and have helped people. As a visitor, I find deficiencies and suggest ways of solving them; I always find that worthwhile."

Explaining his favorite part of an evaluation, Professor Stremler related his experience of interviewing students, "This is the best part of the trip. For the first 15 minutes, everyone is quiet; then, for the next half-hour, conversation picks up, and during the last 15 minutes, I can't stop the discussion!" He has interviewed juniors and seniors and noted, that along with some unavoidable complaints, "Often, they come up with some very positive statements which are very supportive of what's being done."

The Hubble Space Telescope

by Chris Lindell

The Hubble Space Telescope to be launched in the space shuttle in late 1989 or early 1990 will not be the first space-based telescope, nor will it be the first telescope that the University of Wisconsin-Madison has had a major role in developing. However, it will be the most powerful, most useful, and most capable telescope ever built—and not just because it will be in space.

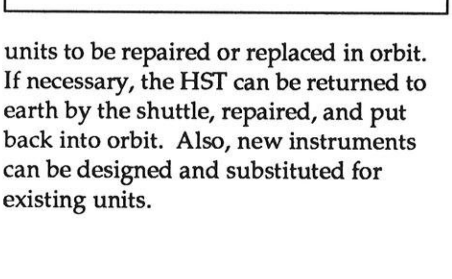
The Hubble Space Telescope (HST) is unique in that it is the only space telescope that takes advantage of three benefits of being outside of the earth's atmosphere: the sky is darker, there is no partial absorption of non-visible wavelengths due to the atmosphere, and there is no blurring of the image by varying atmospheric refraction. Professor Arthur Code of the Astronomy Department likens this variation in refraction of the earth's atmosphere to looking through a swimiming pool to see the bottom. The Hubble takes advantage of its sophisticated optics, that other space-based telescopes and earth-based telescopes can't match, to see images more clearly.

The capabilities of the HST will be incredible. It will be able to see objects ten times farther and 50 times fainter than the best earth-based telescopes. Additionally, the pointing accuracy and angular resolution will be much improved, allowing the HST to distinguish details and separations between objects ten times more clearly than telescopes on the earth. The HST could see the light of a candle at the distance of the moon, and the separation between a car's headlights from 2,000 miles.

"It is the best telescope ever made," says Professor Code. After looking at its capabilities, one can't help but to agree.

The HST consists of a 2.4 meter mirror, a Ritchey-Chretien type of Cassegrain optical system, five on board instruments, including the High Speed Photometer, two solar panels, star trackers, a rate gyro assembly, and antennae. The whole package weighs about 25,000 pounds and will fill the entire Space Shuttle bay.

Once in orbit, the HST is intended to have a lifetime of decades. The complete design is modular, allowing



units to be repaired or replaced in orbit. If necessary, the HST can be returned to earth by the shuttle, repaired, and put back into orbit. Also, new instruments can be designed and substituted for existing units.

Tracking Data Relay Satellites (TDRS) and a Scientific Operation are both integral parts of the complete Hubble System. The TDRSs will be placed in geosynchronous orbits, in

It will be able to see objects ten times farther an 50 times fainter than the best earth-based telescopes

which their positions are stationary with respect to a point on the earth's surface, and will allow constant communications with the HST. The Space Telescope Science Institute at Johns Hopkins University will run the Scientific Operation. The operation will be based on proposals submitted by interested scientists to determine usage times in order to maximize the HST's potential.

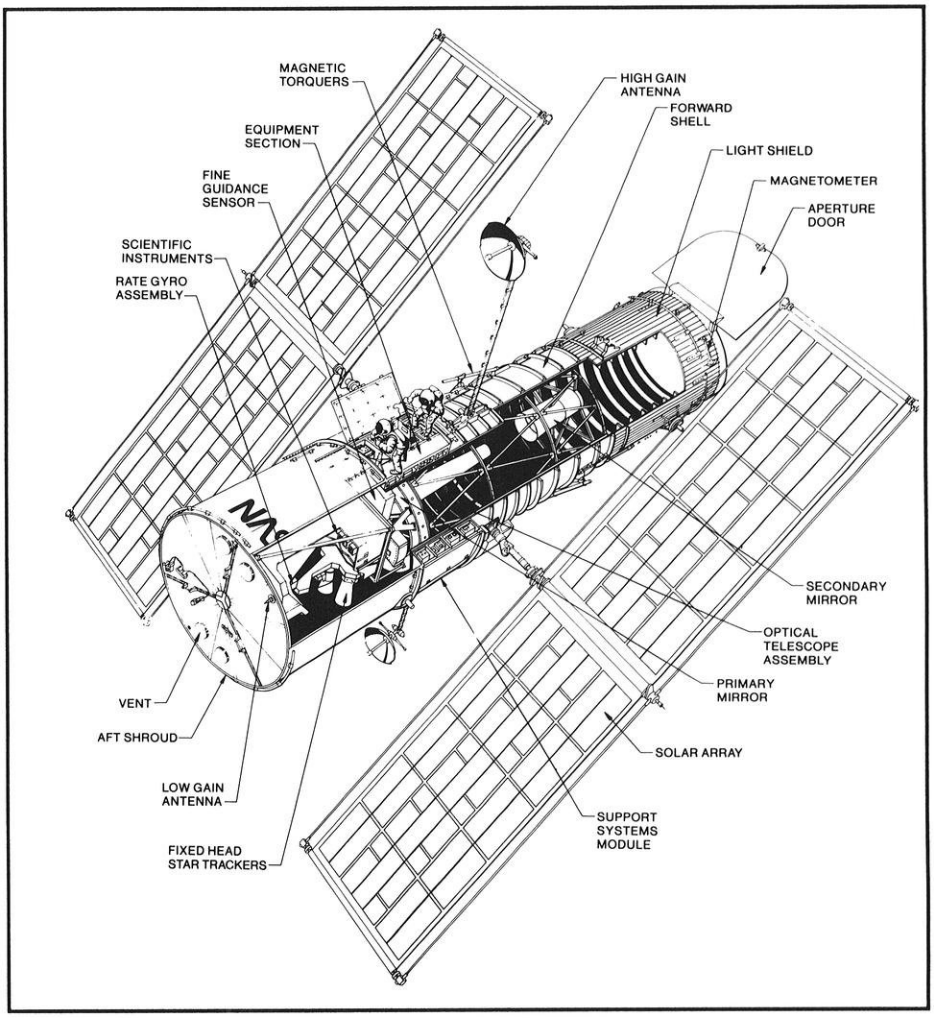
The University of Wisconsin has many people working on the telescope. UW researchers have been involved with three of the five instruments on board, including designing and making the High Speed Photometer, the only part of the telescope that was made at a university. Professor Robert Bless of the Astronomy Department is the Principal Investigator for this project. Additionally, Professor Code is working on the wide-field and planetary camera in conjunction with the California Institute of Technology, and Astronomy Professor Blair Savage has been involved in the development of the high resolution spectrograph. Numerous others in the Astronomy and Engineering Departments have also been involved, including many students.

Along with the amazing capabilities of the HST comes high expectations, many of them contingent on the UW's contributions to the project. For instance, the photometer will allow observers to see quick changes in a star's brightness that were previously undetectable. This will allow scientists to analyze pulsating stars and neutron stars, and to possibly supply more proof that black holes exist. Also, in binary star systems where the mass of the stars are known, the size of the stars can be determined using the photometer. This information could confirm or disprove the existence of high density matter implicit in present star evolution theories.

By seeing farther into space, the HST will be able to see farther back in time, looking at galaxies as they existed as long as 14 billion years ago

Perhaps the most interesting information that scientists hope to obtain is that which pertains the most to American astronmer Edwin P. Hubble (1889-1953) himself. He discovered that the universe is expanding, consistent with the concept of the "Big Bang" theory. By seeing farther into space, the HST will be able to see farther back in time, looking at galaxies as they existed as long as 14 billion years ago. Astronomers hope to gain insight on the order of creation of stars and galaxies. Another dilemma that astronomers hope to solve is whether the universe is open or closed. If the universe is an open system, it will expand forever, but if it is closed all matter will once again collapse to the center of the universe, perhaps to explode again in another "Big Bang".

Professor Code sees the HST as possessing all of these capabilities and more. "The HST will lead to a better understanding of the world we live in. A true scientist," he says, "knows something that no one else in the world knows, even if just for a second—that is the real satisfaction." ▮▮▮



* *Illustrations courtesy of University Research Program, UW-Madison*

ADVANCED SIMULATION FOR SPACE AUTOMATION

by Nicholas C. Denissen

Many hazards must be overcome if man is to conquer space. Most hazards are caused by the extremely harsh environment of outer space. It is already accepted that robotics can distance humans from these dangers.

The development of robotics for use in space, however, presents many problems. First, the requirements for robots in space are unique; they are unlike any that have so far been encountered on earth. For example, it is not feasible to use an industrial robot, such as an Asea IRB2000, to unload the space shuttle; even if the kinematic requirements were met by the robot for this task. The physical construction of the robot

It is not enough to merely posses this advanced technology; it is important for us to effectively apply this technology to various areas.

does not permit it to function in space. Thus, it is necessary for us to design completely new robots that are suited for our space applications. Secondly, the conventional programming of robots brings various detrimental factors into play; the time and costs involved in on-line programming of a robot in space would be astronomical. Time and cost effectiveness could be achieved through off-line programming the robots from earth. The main basic asset that overcomes all these problems is technology.

Working in this space environment demands the most of our technology. It is not enough to merely possess this advanced technology: it is important for us to effectively apply it to various areas.

McDonnell Douglas is one company which has effectively applied its technological resources to create a product that can help us overcome the hazards of space by overcoming the problems of robotics. The product, PLACE, has been a leader in the dynamic subset of the CAD/CAM market: robotics simulation systems. Graphical simulation systems, such as McDonnell Douglas' PLACE, are a large step toward conquering these hazards.

For demonstration purposes let us examine a project that is currently being undertaken by the United States; the development and implementation of an orbiting space station. By examining the work that is involved in bringing this project to fruition and by analyzing problems that might arise during its execution and implementation we can demonstrate that simulation is an invaluable tool.

Analyzing the complete project would be beyond the scope of the article, so for demonstration purposes divide the project into small key groups; design, construction, implementation, and support. These four groups will be briefly studied and the application of simulation will be evaluated.

To simplify the analyzation and thus make it more effective, I will draw an analogy to a manufacturing process here on earth; the manufacturing of an automobile. This process involves the same four key groups mentioned above; design, construction, implementation, and support. Since many automobile manufacturers use a simulation system to assist them in manufacturing, it will prove effective to draw analogies to the "manufacturing" of the space station. We will see how automobile manufacturers overcome problems in the four areas and thus will be able to predict how we can overcome the similar problems that arise with the space station.

The first step is designing the space station. The design process is

The larger the project and the more groups involved, the more important effective and efficient communication becomes.

tedious and lengthy. It is further complicated by the fact that NASA is working with companies, such as McDonnell Douglas and Astronautics, as well as with universities and institutions, including the Wisconsin Center for Space Automation and Robotics (WCSAR) at the University of Wisconsin. The classic problem that arises is the lack of sufficient communication. The larger the project and the more groups involved, the more important effective and efficient communication becomes.

Let us say, for example, that a certain concept of the space station exists. Various groups and teams have worked together to create a theoretical model of the space station– what it is and how it will work. The model consists of a complex array of information; mechanical, kinematic, material, and so on. It is represented by various formulas and parameters that were combined from the various groups and teams. Now let us assume that a particular group has discovered a better alternative for their part of the project. They wish to implement their improvement in the accepted space station model. By conventional methods this would mean writing a report on the change, distributing the report, and having the change implemented. The main problems that would now arise would be:

• time loss, and hence financial loss, due to writing, distributing, and implementing reports

• inconsistency due to timing; some groups implement the change in their models quicker that other groups. We would have various groups working with different models at the same time.

These problems could be overcome by implementing a simulation system that is linked to a database. A database system, such as the commercially available Oracle, would link all the information of the various groups and teams into one universally accepted model. Then if a group altered any of its data, the change would be immediately universally implemented.

The effectiveness of such a concept, known also as Computer Integrated Manufacturing or Manufacturing and Process Planning, has proven itself in industry already. A company I worked with in France, AutoCoussin, manufactures car seats. They supply the French automobile market as well as BMW AGand Adam Opel AG in West Germany. Through the implementation of networking, CAD systems, databases, and McDonnell Douglas' simulation system PLACE, they are able to alter their product and implement changes within a matter of hours. It would be impossible to achieve this flexibility through the conventional means mentioned before.

After the decisions on the design have been reached, the construction and the implementation processes begin. Although it is a one-time construction, it is very complex, with time and money playing important roles. The space station is not something we can completely build on earth and send up in a Delta rocket.

It has already been decided that when the building of the space station begins, it will be built in smaller units, then transported into space and assembled there. Questions immediately come to mind. How many units? How many trips? What is the duration of each trip? Answering these questions is difficult but important. The answers not only determine how the construction and implementation will occur, but also affect the design. First, all the relevant information has to be collected. We studied the problems that arise if this information is collected through conventional methods. Now we will concentrate on how to use the information to develop a construction plan.

If we used a simulation system we would be able to test various methods and plans of construction under various conditions. We would be able to study how design changes might affect construction without any significant time loss or financial expenditure. Having a visual representation of the plans would also greatly assist in conveying ideas. The simulation would be based on technical information so there should be no difficulties for the engineers and scientists to communicate. In addition, the visual representation of the model would allow the technical people to present their work to the United States government and the taxpayers who fund the projects. This is a very important aspect of a graphic simulation system. If the support ceases, inevitably the project ceases.

The ability of a simulation system such as PLACE to provide the functions required to formulate a construction plan and test various construction methods has already been proven in the automotive industry. Adam Opel AG has successfully used PLACE to test various methods of "constructing" the left-hand side of the Omega 2000. The simulation allowed Opel to test different robot models and variations. Once the best method and combination was chosen, the construction plan was implemented. Opel noted advantages of using a simulation system rather than conventional methods. The main advantages were savings in time and cost and the ability to convey highly technical information to nontechnical decision makers through the graphical abilities of the simulation system.

It is clear that distinct advantages exist with the simulation system. Numerous problems that until recently were inherent in conventional robotics can be overcome. By examining the application of such a system to the space station project, we saw how robotics can be developed for space and implemented into the space environment. This is only a part of the function of a simulation system.

Space robotics projects will require an enormous amount of support after they have been implemented. It would be invaluable to have a simulation model of the various robots, tools, work cells, and so on. This would allow for more productive use of our robotics resources, since with little time investment and practically no financial investment, one would be able to try various ways of completing tasks with the different robots and other equipment. The importance of being able to effectively evaluate programming alternatives will also increase. The flexibility that the simulation system introduces would allow our space robotics to evolve.

It is clear that distinct advantages exist with the simulation system.

The University of Wisconsin has also realized the importance of such simulation systems. It started to develop a system named STAR (Simulation Tool for Autocad and Robotics) in 1985. Currently, under a NASA grant, STAR is undergoing further development with the intention of it becoming an integral part of the NASA space program.

Simulation systems such as PLACE and STAR will become invaluable tools in our future space ventures. They help us design and control space automation, which in turn distances us from the hazards of space. ■

Just One More

University Parking Enforcement Gets Tough

The University of Wisconsin-Madison Parking Enforcement (UW-MPE) unveiled its latest vehicle in lot 14 on the engineering campus last week.

The new machine, named "Ogre" by officials at UW-MPE, demonstrated the University's new policy on habitual overtime parkers.

The event drew quite a curious crowd. One bystander, who refused to give his name, said, "Whoah. Next time I try to park on campus, I'll make sure I have enough change for the meter."

Just One More tried to contact the UW-MPE for comment. Officials there explained that with the shortage of parking on campus overtime parking and parking without a permit simply will no longer be tolerated.

One insider, however, claimed that the UW-MPE was just bored. "They were sick of hearing violators complain about the $10 tickets so they are giving them something to really moan about." ❑

Spanky® Says:

Spank' Wants:

YOU

TO

Subscribe Now

By subscribing to the *Wisconsin Engineer* you will be able to have the *Wisconsin Engineer* delievered directly to your home. That way you won't have to miss one single issue of the *Wisconsin Engineer*. You will be able to keep up with all of the lastest technologies and innovations that the world of engineering has to offer. A one year subscription to the *Wisconsin Engineer* is only $10.00, a three year subscription is a deal at $25.00 and a lifetime subscription (Your's not ours, we've been around for 94 years!) is a steal at $175.00. To subscribe, just make out a check payable to:

The *Wisconsin Engineer*
Mechanical Engineering Bldg.
1513 University Avenue
Madison, Wisconsin 53706

If you have any questions or comments, give us a call at **(608) 262-3494.**

wisconsin engineer

Mary Blue doesn't rest until every part is perfect.

Mary Blue expects a lot from herself. A software engineer at GE Aircraft Engines, she helps develop new manufacturing methods for the engine parts that power commercial and military aircraft. Quality is her absolute top priority.

Mary also expects a lot from the company she works for. As a member of GE's Manufacturing Management Program, she's found the environment that lets her achieve, and excel. Her support system includes CAD/CAM, robotics, new materials, and all the leading-edge technologies. Plus interaction with the best minds in her field.

Talented engineers like Mary Blue are handed real responsibility on high priority projects from the day they join GE. Which is why only the most demanding, self-motivated people can be selected.

Behind the truly successful engineer, there's a standout company.

The mark of a leader.

An equal opportunity employer.