Drama in space: GRO gets much-needed boost

After two years of unsuccessful maneuvers and anxious analyses, NASA engineers last month boosted the Compton Gamma Ray Observatory (GRO) back to a higher-altitude Earth orbit, averting a potential disaster. Had the craft continued to descend, the space agency would have lost control of it this April, forfeiting the ability to determine where large chunks of the 17-ton observatory would have struck Earth early next summer, NASA scientists say.

Long before NASA launched GRO in April 1991, the agency knew that the craft — the heaviest science payload ever launched by a space shuttle — would require a boost to counter the effects of solar activity, which gradually push the satellite into a lower orbit. The boost had to occur before the craft descended below 290 kilometers. At that altitude, GRO would lose stability and plunge uncontrollably into Earth's atmosphere, increasing the risk that GRO debris not burned up in the atmosphere would fall on populated areas.

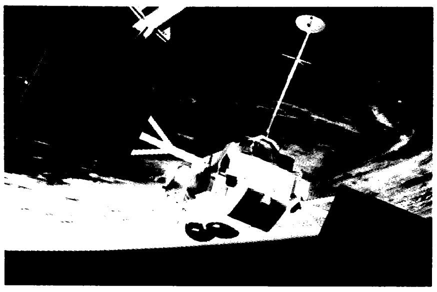
Engineers at NASA and TRW Systems of Redondo Beach, Calif., the company that built GRO, believed that the boost would go smoothly. But they hadn't fully accounted for the complexities of GRO's propulsion system, which features long, wide-diameter fuel lines that can accelerate fuel to high velocity and sometimes give rise to surges in pressure.

"What it amounts to is this: Something was overlooked in the design of the [propulsion] system," says Joseph A. Wonsever, a NASA program manager for flight assurance in Washington, D.C., who participated in a review of the GRO difficulties. "We hadn't [launched] any spacecraft of that size, and therefore we didn't have a history of a spacecraft with long propulsion lines."

A key problem emerged soon after the observatory's launch, notes Thomas LaVigna of NASA's Goddard Space Flight Center in Greenbelt, Md., who supervised efforts to boost GRO. After ground controllers commanded the craft to inject high-pressure propellant from a fuel tank into a pipe leading to the observatory's thrusters, they noticed several things amiss. Two valves in the fuel line flipped positions, and a device to measure pressure went off the scale.

It appeared that a high-pressure surge had damaged the valves. Studies indicated that the seeds of this problem may have been sown during inadequate ground testing, says Dennis I. Asato of the Goddard Space Flight Center. Scientists believe that just before launch, large bubbles of nitrogen gas became trapped in the lower-pressure fuel downstream of the fuel tanks. These gas pockets would create an empty space for the rushing propellant to fill, fostering the pressure surge.

Concerned about damage to that fuel line, engineers turned to GRO's redundant fuel line and set of thrusters to raise the craft's orbit. To avoid another pressure surge, engineers devised a method of opening fuel valves for just a few hundredths of a second at a time, allowing the high-pressure fuel to trickle down the pipe. That strategy proved a success, but another problem soon developed. During an attempted orbital boost in June 1993, one of the smaller thrusters failed to fire reliably, causing the observatory to tumble.


NASA

Compton Gamma Ray Observatory.

Engineers quickly regained control of the craft and, by firing GRO's large thrusters only for short intervals, circumvented the need for the stabilizing force of the small thrusters. On Dec. 17, NASA completed the operation, taking GRO to an orbit 452 kilometers above Earth and lengthening the craft's life by an estimated five years. Well before the craft descends to 290 kilometers, ground controllers will take steps to ensure that debris from the observatory strikes uninhabited parts of Earth, LaVigna says.

Wonsever says he knows of no other NASA spacecraft that are likely to suffer similar propulsion problems. Nonetheless, propulsion systems may continue to fuel headlines. Next week, the space agency plans to release a report on the loss of the Mars Observer spacecraft. The report's contents are not known, but some scientists have speculated that the fuel system aboard the Observer — though markedly different from the one on GRO — may have played a role in the craft's demise (SN: 9/4/93, p.149).

— R. Cowen

Gun blasts naked-DNA vaccine into cells

After a decade of ever more elaborate genetic engineering procedures — snipping, stitching, and packaging DNA — some vaccine researchers are finding that the simplest method works best. Just administer plain DNA to mice, they recommend, and the animals will muster an immune response strong enough to protect them from an otherwise lethal virus.

A research team led by Harriet Robinson of the University of Massachusetts Medical School in Worcester inoculated mice with purified DNA, which encodes a protein of the influenza virus. Between 67 and 95 percent of these test animals developed flu symptoms and then recovered, whereas 87 percent of the control animals, which had not been vaccinated, died.

Five different routes of inoculation conferred immunity, but by far the most efficient was to shoot DNA into the mice's skin with a gene gun. The scientists describe their study in the Dec. 15 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

"I think this is a powerful new technique," Robinson says. "It will allow us to make vaccines for diseases that we did not previously have vaccines for."

"It is a revolutionary approach in the sense of using DNA as a vaccine," comments Dominick Iacuzio, who directs the influenza program at the National Institute for Allergy and Infectious Diseases in Bethesda, Md.

At this time, though, the technique remains an experimental concept, both researchers caution. "It's promising but too early to tell how these animal results will relate to a possible vaccine for humans," Iacuzio says.

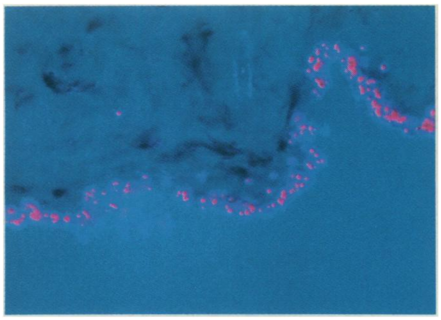
A vaccine provokes the body's immune system to prepare for a later attack of a pathogen. Traditional vaccines consist of live, weakened viruses, dead viruses, or purified proteins. Live viruses carry the risk of reverting to a more active form, and dead viruses and proteins do not always achieve lasting immunity. With pure DNA, however, "you get the advantages of a [weakened] virus without the risk of [that] virus actually growing out," Robinson says.

That was not the mainstream opinion until now. "The whole idea of injecting DNA as a vaccine is contrary to anything that was previously envisioned or even allowed by the Food and Drug Administration," Iacuzio explains.

Besides safety concerns, researchers doubted whether DNA could enter cells in amounts sufficient to trigger a strong immune reaction.

Host cells take up very little DNA, Robinson acknowledges, but she suggests that immunity depends on quality, not quantity. Cells read the DNA and produce proteins that touch off a cascade of cellular interactions leading to stable immunity. The technique is so effective because the immune system recognizes a viral protein manufactured by the body much better than one made outside, she adds.

Moreover, the skin and the linings of the nose and trachea possess unique patrol systems of lymphoid cells that detect foreign proteins when they enter the body and promptly inform the im-



Louis Savas, Robinson

Vaccine-coated gold particles (red) have penetrated the outer skin. Underneath lie lymphoid cells (black) that set off an immune response.

mune system of the invasion.

All of the five routes of inoculation tested by Robinson's team conferred immunity: nose drops, injections — into muscle, veins, and under the skin — and a "shotgun" application to the skin. "We show for the first time that all these multiple routes work," Robinson says.

Tissues differ in DNA uptake and efficacy, the researchers noticed. The skin proved by far the most effective route. So rather than inject DNA and hope that enough of it would sneak into cells, Robinson's co-workers used a gene gun to blast DNA-covered gold particles into outer skin cells.

Thanks to the gun and the nearby lymphoid cells, the amount of DNA needed to immunize mice through the skin dwindled to 0.4 microgram, roughly one-thousandth the amount required by the other routes. "As the method gets more refined, we will need to apply even less DNA," Robinson predicts.

"The technique has tremendous implications, most immediately for the generation of new vaccines. As it outgrows its infancy, however, you will see it made into drug-delivery regimens," says David B. Weiner, an immunologist at the University of Pennsylvania School of Medicine in Philadelphia.

Using a similar approach, Weiner and his colleagues elicited an immune response against a type of human immunodeficiency virus (HIV) in macaques, they report in the Nov. 9 DNA AND CELL BIOLOGY.

The researchers inoculated monkeys with DNA of gp160, a coat protein of HIV, the virus that causes AIDS. In response, the monkeys' immune system made antibodies that blocked HIV infection in laboratory-cultured cells. After four inoculations, 95 to 100 percent of the macaques exhibited that response. The team has yet to infect these monkeys with HIV to test whether they are truly immune.

"Our study is the first to demonstrate a successful vaccination of nonhuman primates using a DNA vaccine," Weiner says. Others may quickly follow suit. Several research teams are devising similar tests in monkeys. *— G. Strobel*

Probing a computer productivity paradox

Information technology pervades the service sector of the economy. A loan officer uses a computer to process an application for a mortgage. A lawyer relies on the same technology to assemble a will, as does a travel agent to make an airline reservation or a sales clerk to prepare a bill.

During the 1980s, banks, airlines, and other U.S. service companies spent more than $750 billion on computer and communications equipment, along with additional billions on software. Yet, conventional measures of economic prowess showed only a 0.7 percent average annual increase in productivity in these industries.

Now, a report from a committee of the National Research Council in Washington, D.C., suggests that this apparent paradox stems in part from the inability of traditional productivity measures to reflect adequately the impact of information technology on the performance of the service sector.

"Productivity data do not capture important elements of service output," says James B. Quinn of Dartmouth College in Hanover, N.H., who chaired the panel. "Key among these are the capacities to handle increased complexity and to provide improved timeliness, flexibility, response times, reliability, or safety for employees, customers, and the general public."

Taking into account these and other factors, "there is little doubt that information technology has had a dramatic impact on service-sector performance," he concludes.

The committee's report, "Information Technology in the Service Society," also recognizes that service companies have not adopted information technology with uniform success. It notes that most problems in achieving payoffs from investments in information technology have arisen from inadequate planning and implementation — including failures to provide adequate training for workers, to pay sufficient attention to customer needs, and to rethink how businesses should operate.

The report, however, does not address some of the problems associated with the tremendous growth of information technology. These concerns range from serious shortcomings in computer security (SN: 12/15/90, p.373; 10/30/93, p.282) and system safety and reliability (SN: 2/16/91, p.104) to the impact of rapid change and increased complexity on companies and their customers and employees. *— I. Peterson*

Beef quality: Ultrasound makes the grade

Meat inspectors today grade carcasses on the basis of how much intramuscular fat, or marbling, they see. However, any two inspectors may eye things differently, especially when distinguishing between "select" cuts (marbling with just 4 percent fat) and "choice" meats (having 5 percent fat). Such differences have important economic consequences: Retailers and consumers pay a premium for more marbled — and presumably tastier, tenderer — cuts of meat.

Now, two researchers at Iowa State University in Ames believe they have a sound means of reducing the subjectivity in grading: acoustical scanning.

Using a hand-held ultrasound pulse generator coupled to a laptop computer, Doyle Wilson and Gene Rouse have scanned the rib-muscle tissue of some 1,200 head of cattle prior to slaughter over the past five years. Then the animal scientists correlated patterns in the resulting black-and-white images with a precise measurement of intramuscular fat that was chemically extracted from a one-quarter-inch-thick rib-eye portion of each carcass. With these data, the researchers developed a computerized image-processing system that can quantify marbling from gray-scale patterns in rib-tissue ultrasound images.

Last year, the Iowa State researchers modified the computer algorithms to evaluate marbling based on ultrasound pictures of about 500 carcasses. When they tested the grading system in an Iowa meat-packing plant recently, they found that 75 percent of the time, human inspectors assigned meat a lower marbling grade than the ultrasound scanning system.

Because of its greater accuracy, "[ultrasound] and other objective instrumentation will eventually replace the current meat-grading system," Wilson predicts. Indeed, later this winter, one Iowa meat packer expects to test such on-line grading of meat. In preliminary tests, "we kept up with a packing line running at 100 carcasses per hour," Wilson says. However, he adds, the device could keep up with double that pace if necessary.

The system, however, may pay more immediate dividends to livestock breeders seeking to develop lean animals with well-marbled muscle. "There's no way you can assess [marbling] by looking at a live animal," Wilson points out. But with ultrasound scanning, he says, breeders can begin reliably identifying those live animals that preferentially lay down desirable amounts of intramuscular fat. *— J. Raloff*