Your basic, off-the-shelf satellite

Standardized, plug-in components
promise large savings
as the Space Age discovers the Model T

BY JONATHAN EBERHART

"They're re-inventing the wheel." This epithet, commonly heard among engineering types, is not a compliment on the fundamental significance of some new development. It's more of an insult, suggesting that the perpetrators are ignoring foundations that have already been laid, wasting money, time and experience by starting from scratch when there was no need to do so.

In the nearly two decades since the Space Age began, the wheel has been re-invented countless times. A series of, say, weather satellites may follow much the same pattern, but when work begins on something such as an Orbiting Astronomical Observatory, the designers go back to square one (or perhaps square two). The scientific instruments related to the mission are not the only items to change. Virtually everything goes: power supplies, communications, attitude-control, data-processing, right down to the frame it all hangs on. The result, multiplied by the scores of different satellite types now in orbit, is long development times and, more to the point, high costs.

The National Aeronautics and Space Administration is at last working on a solution: a versatile, standardized "basic satellite" with a set of interchangeable "housekeeping" modules that can be used to suit a wide range of diverse missions, leaving only the scientific instrumentation to be developed anew. It marks a radical, fundamental change in satellite design—indeed, in the whole approach to high technology—yet it almost seems so obvious that it ought to have happened years ago. But just as it took years of car-building to lay the foundation from which Henry Ford began punching out your basic Model T, it has taken years of satellite-building to standardize the common needs of satellites (prompted by rising costs) into what NASA calls the Multimission Modular Spacecraft, or MMS.

The first satellite scheduled to use the MMS design, a 1979 solar-studies probe introduced in NASA's latest budget request (SN: 1/24/76, p. 53), is to be launched by a conventional Delta rocket. But the MMS concept is tightly linked with the reusable space shuttle. The shuttle is touted as a big money-saver, since it won't be thrown away after use, but some NASA officials believe that this alone is not enough to justify its soaring development costs. An equal or greater saving is anticipated from the fact that the craft is designed as a space-going service truck, capable of salvaging multimillion-dollar satellites that have malfunctioned from trivial ills. And that's where the MMS fits in.

It's like those "works-in-a-drawer" television sets. If a microcircuit blows in the communications equipment that links a satellite with earth, the whole probe is as good as dead. With the shuttle, however, the satellite can be retrieved and the offending part replaced. This would still be a problem with today's satellites, since everything is fully integrated into a unified package, but with MMS, it becomes a matter of simply unplugging the faulty component and plugging in a new one. On Jan. 29, for example, the Atmosphere Explorer D satellite stopped working, apparently due to nothing more than a short circuit in its power supply. An MMS version, serviced by the shuttle, could easily receive a whole new unit.

The heart of the MMS is its frame, which resembles the skeleton of a hexagonal hatbox. The standardized modules for power, communications and attitude control are evenly spaced around three of the six sides, with a propulsion system on the bottom. An indication of the design's versatility is that the simple structure, four feet on a side and four feet high, is being considered as the basis for satellites with payloads ranging from as small as a cubic foot to the size of a large bus.

At present, NASA is studying 41 missions embodying 21 completely different MMS-based designs. They run the gamut

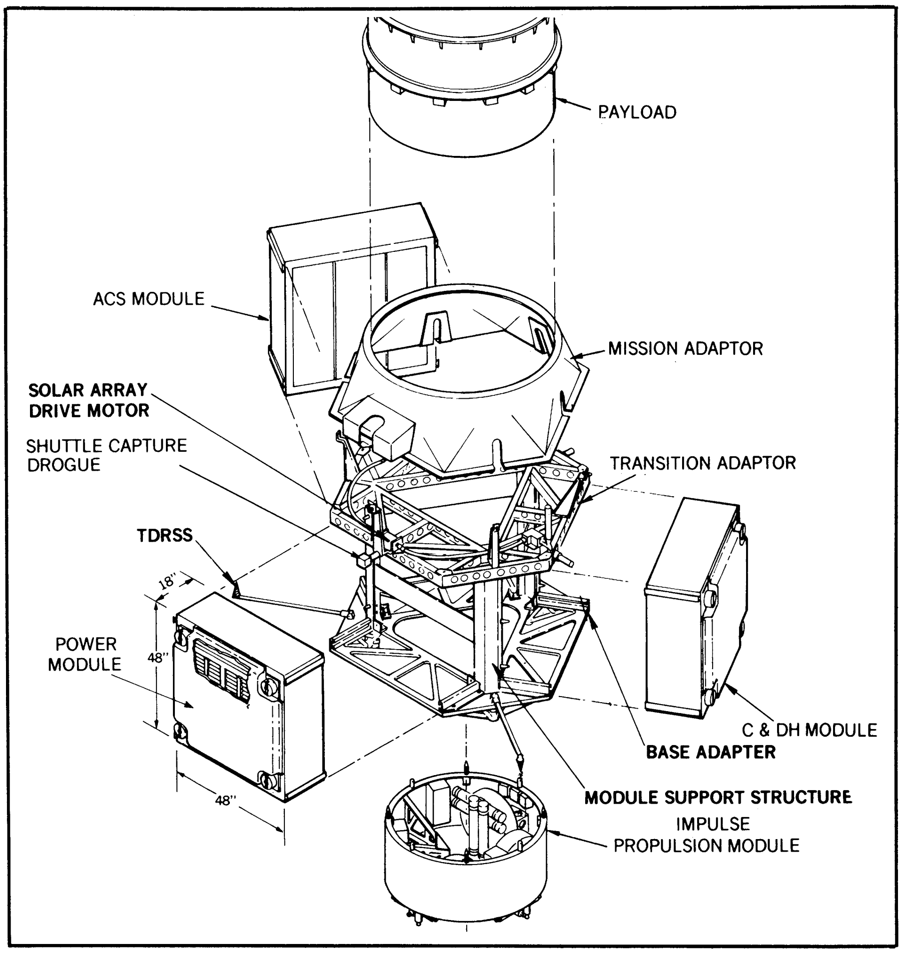
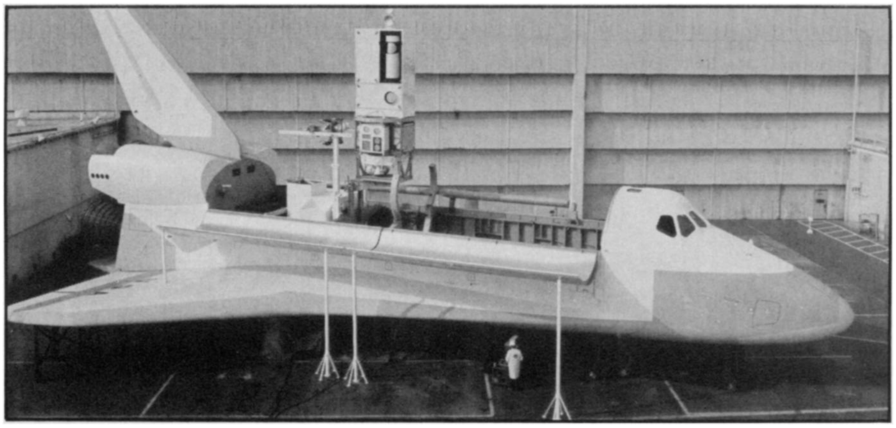


Diagram of MMS shows plug-in modules designed for easy replacement from the shuttle.



Life-size mockup shows model MMS in cargo bay, mounted on refurbishment jig.

in almost every department, from the 200-pound, weather-watching Stormsat to the four tons of the proposed second-generation High Energy Astronomy Observatory. Power requirements range from 50 watts for a tiny International Ultraviolet Explorer to 800 watts or more for Seasat B. The various probes have planned lifetimes from as little as nine months for a Technology Demonstration Satellite that will check out new instrumentation to five years for a magnetosphere probe called Geopause. There is even BESS, a Biomedical-Experiment Scientific Satellite to sustain life-forms as large as primates in orbit for up to six months. Yet all would use the same frame design, the same option list of standardized black boxes—again like a line of automobiles.

The possibilities for saving money are numerous. The most obvious is the chance for bulk purchasing of the frames and black boxes, since the payload designers will all be choosing from what amounts to the same catalog, but this would require a change in the way satellite programs are funded, so it may have to wait a few years until the idea's cost-cutting ability is proven. A bigger advantage is the saving from not having to pay for new research and development, even if the modules are bought one at a time. The biggest potential, however, is in the saving on basic design costs when a whole new satellite program is initiated, points out John Taber of TRW, Inc., one of several companies which have studied the concept for NASA. The effort—and funding—could be concentrated on scientific goals, rather than on the need for designing the entire probe from the ground up. A side-bonus would be that those planning experiments could aim toward an existing design instead of having to shuttle back and forth in the lengthy, laborious and expensive process of overall satellite integration. Added to it all is the ability to go up and fix something when it breaks.

Since the whole point is to cut down the staggering costs of space hardware, what is the cheapest way to make repairs? The obvious way, given the shuttle, is to do it in orbit: fly up, snag the sattelite, swap boxes and let it go again. Planners at NASA already know how they want to do that, using a remotely controlled (from the shuttle cockpit) maneuvering arm to pick up the probe and attach it to a ladder-like device, pivoted at the base, which will rotate the satellite past a shelf full of spare modules and automatically make the switch. (Grabbing a satellite on the fly is harder than it seems, even at matched orbital speeds, since even a weightless probe retains all the momentum of its spinning, tumbling or other motions. Starting in May, NASA researchers at Johnson Space Center in Houston plan to try it out, using helium-filled balloons as targets for the maneuvering-arm operators.)

The other method is to bring the satellite down and fix it on earth. At first look, this seems outlandish by comparison. But some maintain that there may be good reason, depending upon how NASA resolves the presently thorny problem of how to charge users for the shuttle's services. If weight is the controlling factor rather than volume, launch-window constraints or other variables, it might be cheaper for a relatively lightweight probe to be brought down from its orbit and relaunched than to send up the heavy automatic-repair apparatus. But Frank J. Cepollina, who is the MMS manager at NASA's Goddard Space Flight Center and who has been shepherding the idea through about $5 million worth of studies since 1968, disagrees. If a satellite is brought back to earth, he says, even if it only needs a single part replaced, the vibration and possible contamination during the ordeal will require that the whole satellite be requalified for flight, an expensive checkout procedure. Furthermore, he adds, in low orbits, where the shuttle's lifting capability is greatest, the repair jig will take up only about three percent of the vehicle's available payload weight.

Though it may seem like the most trivial of nuts-and-bolts issues, NASA's choice of a basis for billing the shuttle's launch service users will be an important factor in making the multibillion-dollar project the cost saver it is supposed to be. Weight percentage is only one option. Another could be volume, or a reduced charge for bringing a satellite down, since the shuttle would presumably be carrying something else up anyway. Or there might be a premium charged for launches such as Defense Department sky-spies that are urgent enough, even with the possibility of shuttle flights every two or three weeks, to require rescheduling a takeoff. The users will have to know, well in advance, at least the formula if not the actual price.

How much can the MMS really save? It will not be all things to all users. It will be too heavy for a communications satellite, says Cepollina, since the people who fly them want to use most of the available weight per unit volume for talk channels, even though the shuttle will mean an easing of the severe weight limitations that have been around since the earliest satellite launches. The MMS is not spin-stabilized, so certain kinds of scientific probes are out, and its aerodynamics and lack of space for a large "kick motor" make it useless as a stratospheric density probe such as the deep-dipping Atmosphere Explorers. But it will suit a variety of astronomical, earth-resources and other missions. Cepollina estimates that over a 10-year span, with the present number of NASA launches per year, the MMS could save as much as $1 billion to $2 billion, most of it in reduced research and development and in prolonged satellite lifetimes thanks to plug-in refurbishment by the shuttle.

The first MMS mission was originally to have been a gamma-ray astronomy probe, but that has been postponed in favor of sending a cluster of spectrometers and other instruments to study the sun from earth orbit during a time of maximum solar activity. This Solar Maximum Mission will be launched from a conventional rocket, however. The first MMS satellite to be launched and refurbished by the shuttle is likely to be the little Technology Demonstration Satellite, now being considered for the shuttle's sixth test flight, scheduled for 1980. After the various shuttle tests had been completed, the crew would go through a variety of servicing and module-change demonstrations with the satellite, finally releasing it into a circular orbit about 350 miles above the earth. Four to six months later it would be retrieved during another shuttle flight, taking advantage of a mission in which the shuttle would be carrying a different payload into orbit and returning otherwise empty.

Although the shuttle will carry a number of tailor-made large payloads such as the European Spacelab workshop, it is still basically an economic tool. To be really effective, however, it will need all the help it can get. The Multimission Modular Spacecraft can be such a help, a dramatic departure from its two decades of predecessors. Its basic principles of modularity, standardization and reusability can—and will, if they fulfill their promise—be the key to a technological revolution in the Space Age. □