NASA Rethinks the Space Station

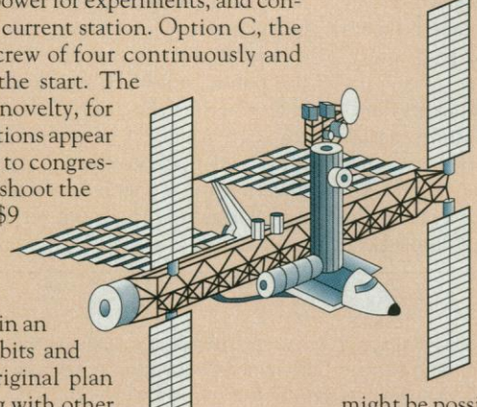
As a frenzied review of the space station nears its end, supporters fear that new plans for a bargain-basement facility will mean the project's demise

As engineers at the National Aeronautics and Space Administration (NASA) raced to come up with designs for a cut-price space station last week, supporters of the program were growing more panicked by the hour. President Clinton has ordered NASA to set aside current plans for the $30 billion space station and produce a design and operating plan costing about half as much, in a flat 90 days. The deadline—7 June—is fast approaching, and NASA is homing in on three candidate designs (see below). But even before the work is done, one of the station's most loyal supporters, House Science Committee chairman George Brown (D–CA), called a press conference to warn that none of these options will fly politically. None, Brown said, will get his backing because none can "carry the support of the House."

Brown and his fellow committee members all have a stake in the station's survival; their districts contain federal space facilities or major aerospace plants. But they're not the only space station constituents who have come to believe that the redesign will doom the station. The station's international partners are unnerved, and scientists who were planning to use the station for research worry that the redesign options won't accommodate their projects. To Alex McPherson, a biochemist at the University of California, Riverside, it all suggests a setup to get the station killed. McPherson, who studies protein crystals grown in space and chairs a science advisory group for NASA, thinks once the Administration picks a plan that

Could These Cut-Rate Stations Be Contenders?

With days to go before the 7 June deadline, the National Aeronautics and Space Administration (NASA) redesign team led by engineer Bryan O'Connor has narrowed its options for a cheaper space station to three main candidates. It's still too early to make out all the details, but some striking differences in overall strategy are evident. Two of the designs—Options A and B—attempt to solve the cost problem by letting NASA start small. Both options aim to give NASA a working station sooner, after fewer shuttle flights than the current design. Eventually, depending on funding and demand, these rudimentary stations could be scaled up. But at first, they would provide correspondingly less of everything—less crew time, less power for experiments, and consequently less science—than the current station. Option C, the third possibility, could house a crew of four continuously and provide adequate power from the start. The Achilles' heel of Option C is its novelty, for the design is untested. And all options appear to share one fatal flaw, according to congressional aides: They appear to overshoot the White House budget target of $9 billion by $3 billion to $6 billion.



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Option A

This choice is a mystery wrapped in an enigma. The structure includes bits and pieces cannibalized from the original plan for Space Station Freedom, along with other off-the-shelf technology intended to permit a gradual, "modular" approach to construction. At its heart, in one variation, would be a mysterious device known as "Bus-1," a spacecraft designed and built by the Lockheed Corp. as a secret project for the Pentagon in the 1980s. Bus-1, which has already gone into space on a test flight, has "power and data on it...and ability to move around in space," says Daniel Hastings, aeronautics and astronautics professor at the Massachusetts Institute of Technology, who is evaluating the impact of the redesign for the space station advisory committee. Not much else is known, but when NASA invited people to submit new ideas for the station, Lockheed brought Bus-1 out of the shadows.

The station that would take shape around Bus-1 would be the smallest of the three options, and it would do without the complex joints that rotate the solar panels in the original design. Initially, Option A would rely on an attached shuttle orbiter to house the crew. Later, additional laboratory and habitation modules could be added, if funds permitted, to create a complete international station.

Option A's dependence on an attached shuttle in the early stages would restrict crew time, however. Medical guidelines now limit U.S. astronauts to spending no more than 20 days in space, partly because they must pilot the shuttle back to Earth and no one knows how long-term space flight would affect flying skills that depend on the inner ear. And because the solar panels couldn't be rotated, the entire station would have to be reoriented every 2 to 3 months to catch the sun's rays. Materials research, for example, would be interrupted regularly. Even if projects could be automated (a costly alternative), many might not run longer than 60 days because of these motions.

According to Bonnie Dunbar, coordinator for science on the NASA redesign team, the motions could affect research on solidifying and crystallizing materials: "If you lose orientation, you induce convection in the melt—exactly what you were trying to eliminate" by going into space in the first place. It might be possible to compensate by adding motors that, as the station turned, would rotate the research furnaces in the opposite direction, but "that just adds a degree of complexity." In addition, because the movement would reorient external sensors, data on the thin gases and debris in low Earth orbit would no longer be continuous. Again, Dunbar says, NASA is looking at a technical fix such as adding additional controllers. But that, too, adds complexity.

Option B

If stability and predictability are your goals, Option B may be your choice. But that's not saying much, considering the chaotic 9-year history of the station program. Called the "Freedom-derived" design,

cuts back on research, "all the scientists like me will say, 'We can't do science on it any more.'" Then, he predicts, "Congress will say, 'Well, if they can't do science on it any more, it's a waste of money....' And then Congress will kill it."

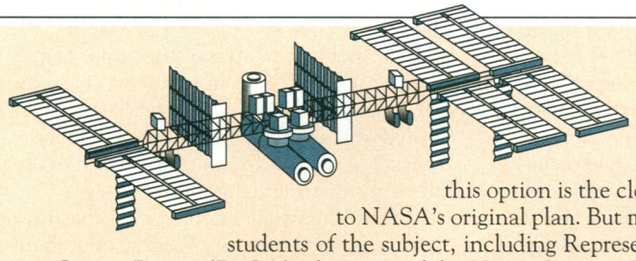
McPherson and other station backers agree with Brown that the station can be kept alive politically by less radical surgery —by "scaling back" the existing plan, as NASA has done many times before. Indeed, when the Administration's proposal reaches Congress, it's likely to be met by Brown's counterproposal, to limit annual spending on the station to $1.9 billion through 1999, delay its launch by 1 year, and save several billion dollars through management changes.

But to Daniel Goldin, NASA's administrator, starting over from scratch is the best, perhaps the only hope of salvaging the 9-year-old project. NASA had been asked to cut $24 billion from its entire spending plan over the next 5 years and to put back in about $8 billion of new technology development projects such as remotely piloted research vehicles. As Goldin explained in an interview with *Science* last week, the only way to do that is to redesign the station, which had become, in Goldin's words, a "30-year entitlement program." Besides being downsized, he said, the station needs a focused, 10-year mission, and it must be a lot better managed. As if to drive home the point, presidential science adviser Jack Gibbons said last week, "Our work to date confirms that funding Space Station Freedom as it was planned would have made it impossible for us to move ahead with critical programs within NASA...crucial to the U.S. economy or our environmental challenges."

RICK KOZAK

A fresh look. Goldin and the station that was.

Goldin's agenda for delivering the goods is a tough one. By 7 June the NASA engineering teams must hand over a redesign re-



this option is the closest to NASA's original plan. But many students of the subject, including Representative George Brown (D–CA), chairman of the House Science Committee, say that even this version is too little understood at present.

The basic plan, as outlined at a public meeting on 3 May by NASA chief engineer Michael Griffin, would be to start with half the original design and allow the station to grow to full size as the budget permits. The first half of this station would offer a lot less than Freedom. Onboard data storage and total lab space available to researchers would be better than in Option A, but crew would have to spend far more time doing routine maintenance of the system. According to a comparison released on 3 May, for example, Option B would require astronauts to do 125 man-hours of external maintenance work each year, in contrast to 72 hours for Option A and 50 hours for Option C.

Like Option A, Option B in its initial phase would rely on an attached shuttle to provide housing for the crew. That would limit astronauts to visits of 20 days—too little time to get anything worthwhile accomplished, many scientists think. Hastings of MIT says: "Just going up for [a few] days and coming back...is nothing but shuttle-plus. It wouldn't be worth the money to do that." To accommodate longer stays, NASA would have to build the other half of the Option B structure, which would require a total of 10 shuttle flights (costing upwards of $60 million each) and an additional 60 hours of external assembly work by astronauts.

But it's not clear at what point the extra labor and cost of building up the structure would pay off in additional research capacity. Dunbar adds that the quality of the data management system—even on this Freedom-derived design—remains uncertain. "Some of the areas we'd like to assess are difficult, because [the redesign engineers] haven't got to that level of detail" yet, she says.

Option C

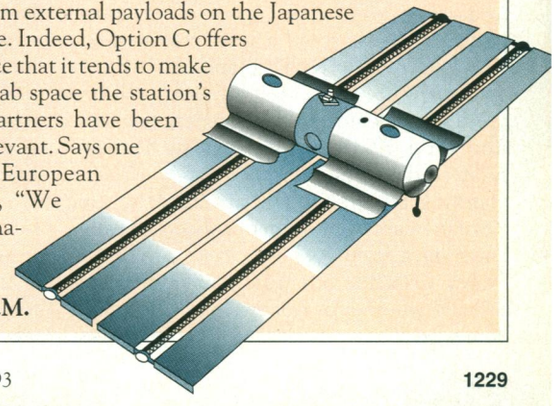
The big can, as it's called, is a radically new design that looks like a clean and easy solution to NASA's problems. It would go up in one piece and require little maintenance. But Hastings says Option C is actually "a very high-risk venture," because it puts "all your eggs in one basket." The reason: This design must be developed from scratch and tested in a short time, and it would rely on a new launch vehicle that would have to work on its maiden voyage. If the launcher failed, Hastings says, "you'd lose everything."

The layout of the big can is straightforward: a 92-foot-long cylinder with six large viewing windows on its sides, divided internally into seven decks connected by a central passageway. This design would give researchers even more lab area and, in one configuration, more power than the current design for Space Station Freedom. The whole device is designed to mate with the solid rockets and liquid engines that power the shuttle, replacing the orbiter and piggybacking on the giant tank that holds the shuttle's fuel. The aim would be to have it operating as an independent station on its first launch, serviced by the shuttle.

Option C could sustain a crew of up to four continuously, without an attached shuttle. On the down side, the design and launch system are untested, although NASA designer Chester Vaughan says many parts of the plan to combine the shuttle's rockets and boosters have been tested since the mid-1980s as part of a transport project known as "Shuttle-C."

Another disadvantage is that the spacecraft would have to rotate to keep its solar panels facing the sun and generate maximum power. As with Option A, this motion could render some microgravity experiments useless. Designers think it might be possible to suspend the motion for, say, 6 months of the year to accommodate microgravity research, but during that period the power would vary.

The third big drawback: The configuration would block observations from external payloads on the Japanese attached module. Indeed, Option C offers so much lab space that it tends to make all the add-on lab space the station's international partners have been developing irrelevant. Says one expert at the European Space Agency, "We view this alternative with great suspicion."



–E.M.

Redesign Creates Consternation Abroad

While U.S. space station supporters fear that NASA's crash program to redesign the craft may mean the end of the station itself (see main story), the United States' international partners are worrying about their own stakes in the enterprise. Whatever redesign option is chosen, the partners will face increased costs in adapting their laboratory modules and equipment to fit. At worst, they may be frozen out altogether. "We're not happy," says an official of the European Space Agency (ESA).

On 13 May, the space agencies of Europe, Japan, and Canada took the unprecedented step of calling a meeting of the four partners in the Freedom project at the U.S. State Department to voice their concerns about the redesign, and have scheduled another meeting there for 11 June. Most of the unhappiness at the May meeting focused on the most radical of the three possibilities, Option C. Option C would require both ESA and the Japanese space agency, NASDA, to redesign the electrical, thermal control, and data management systems of their laboratory modules—if they could be accommodated at all. With the add-on modules, a complete Option C station would include 136 experiment racks—nearly three times as many as in the original station and far more than could be supported by the station's power supply. In addition, the solar arrays in Option C would block some experiments in the Japanese lab. Option C and a second redesign candidate, Option A, would also require only part of the mobile servicing arm being developed by the Canadian Space Agency.

The best of a bad lot, as far as the international partners are concerned, is Option B, because it deviates least from the current design. But whichever option is chosen, both ESA and NASDA are concerned that NASA, as part of the redesign, may adopt a more highly inclined orbit than originally planned, at an angle of 51.6 degrees to the Equator rather than 28.5 degrees. The higher angle would permit the Russians to reach the station and deliver a Soyuz capsule as a life raft in case of an accident. But it would require the shuttle to burn more fuel and hence reduce its payload. Not only would this necessitate more assembly launches, but at least until NASA developed a new, lighter fuel tank and more powerful rocket boosters for the shuttle, it would mean that the heavy European and Japanese modules could not be launched at all.

–Daniel Clery

port to a "blue-ribbon panel" of independent experts, chaired by Charles Vest, president of the Massachusetts Institute of Technology (MIT). This report will be a decision matrix, according to Goldin, laying out data on three different options, three funding levels, and at least two stopping points for each station. It will also consider putting the station in a high-angle orbit (51.6 degrees rather than the usual 28.5 degrees) so that Russian spacecraft could reach it.

Three days after the Vest committee receives the data from NASA—on 10 June—it's supposed to pick a winner and forward a recommendation to President Clinton. The international partners are planning to meet the next day in Washington to review the report themselves. The White House is scheduled to send its final decision to Capitol Hill on 15 June, to be included in the 1994 appropriation bill for NASA. The fast pace leaves almost no time for the international partners to get into the act, says one European science attaché. "To whom do we take our comments after 15 June," he asks, "to Congress?" This is just one of many issues that trouble Canada, Japan, and the European Space Agency (see sidebar on this page).

Scientists planning to use the station for research, meanwhile, are trying to figure out how much room for science will be left in the redesigned station. The signs aren't encouraging. Bonnie Dunbar, a NASA microgravity science official leading the scientific assessment of the new options, says, "We are cutting capabilities...to the users in all cases." Perhaps the biggest threat to science, says Daniel Hastings, professor of aeronautics and astronautics at MIT and chair of a space station advisory group, will be the inability of two of the three candidate designs to sustain a crew in space for more than 20 days, at least at first. That would restrict researchers' ability to do long-term (6-month) experiments or even to run shorter experiments properly.

Many scientists are concerned that they may not get answers to questions about crew, power, and communications in time to comment on the new proposals before they go to the president. "It's a moving target," says one. That's been true of the space station for the past 9 years, say NASA watchers. But the target only seems to speed up as time goes by. "For someone like me who's watched [NASA] closely for over two decades," says John Logsdon, director of the Space Policy Institute at George Washington University, "it's never been this crazy."

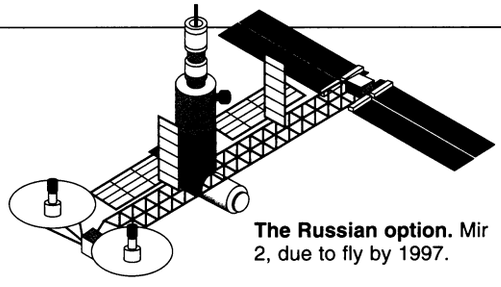
–Eliot Marshall

SPACE SCIENCE

NASA Researchers Eye Mir

Last week, several crystallographers met at the National Aeronautics and Space Administration's (NASA) George C. Marshall Space Flight Center in Huntsville, Alabama to discuss plans for an experiment to grow protein crystals aboard a space station next year. No, they weren't talking about Freedom, the U.S. Space Station that's still on the drawing boards and being redesigned (see story on p. 1228). These scientists had just received the go-ahead from NASA to begin planning an experiment aboard Mir, the Russian Space Station that has been orbiting Earth since 1986.

For years the scientific community has debated whether or not space station Freedom's price tag—currently $30 billion—is justified by the kinds of scientific studies that NASA hopes to conduct aboard it. Fueling the debate has been an argument advanced by some scientists that NASA could do the same work aboard Mir, or on Mir 2, a successor space station that the Russian firm NPO Energia is building and plans to launch in late 1996 or early 1997. Several scientists have approached NASA's life sciences advisory subcommittee, recalls Francis Haddy, a cardiovascular physiologist at the Uniformed University of the Health Sciences who chaired the subcommittee until last November, asking, "Gee, why don't we use Mir?"



The Russian option. Mir 2, due to fly by 1997.

While insisting that research on Freedom would be better, NASA nevertheless has responded to Mir's advocates: Last fall it sent a delegation to Moscow armed with a wish list of joint research projects that might be done aboard Mir, as part of a scientific exchange signed by the United States and Russia last July that will also see a cosmonaut fly on the shuttle this November. After assessing Mir's capabilities, NASA officials have decided in the past few weeks to go ahead with several joint projects, including the protein crystallization