research by those who do not participate in it in a direct manner has always proved to be difficult and in the long run, unrewarding. At the same time, constructive criticism and advice are of high value.

The SDI efforts proceed under exceptionally difficult circumstances. The present leader of the project, Lt.-Gen. James Abrahamson, is eminently suited for this task both in his technical knowledge and in his organizational efforts. His performance is without parallel in my four-and-one-half decades of experience in such matters.

## Obsolescence of aggression

Our government has taken the initiative to collaborate on defense with our friends and allies. The President has stated that the end results should be shared even with the Soviet Union.

The purpose of rendering weapons of mass destruction "impotent and obsolete" can be accomplished by international cooperation which is directed in general against aggression, and at the moment, more specifically against the launching of aggressive rockets, particularly when great numbers of rockets are launched at the same time. We are beginning to succeed in finding methods of defense against such instruments.

Our flexibility in seeking cooperation from other nations in any form in which we can obtain it is both unprecedented and encouraging. . . .

At this time, the Soviet Union enjoys a monopoly in defensive weapons and also in most of the research leading to such weapons. They do not intend to lose this monopoly; hence, their opposition to SDI and their lack of interest in sharing information.

As we make progress toward realistic and effective methods of defense and as we gain participation of more and more nations in this effort, the interest of the Soviet leaders will increase.
table. They proved in the past to be flexible and also open to accept reasonable peaceful compromises where such can be had without danger to themselves.

Due to the open discussion generated by the democratic process at home and abroad, it is becoming perfectly clear that the purpose of SDI is not to isolate America, not to obtain superiority over the Soviet Union, but to preserve peace for ourselves and for everybody else. This was the announced purpose of our President on the 23rd of March 1983. It should be a nonpartisan issue.

During the Second World War, I participated in practically all phases of the Manhattan Project, which was an effort to avert the most terrible consequences to which this war might have led. The challenge today is to avert a third world war. I believe this deserves the full support of Congress. The large majority of the American people have already demonstrated their support.

# Need goal-oriented space program

by Robert Gallagher

The quickest way to get America back into space, is to orient the program around the three national space goals set by the President and by his Commission on Space: deployment of a strategic defense sometime in the 1990s, and the establishment of a permanent manned space station by 1994, and of a manned base on the Moon early in the 21st century. A review of even these modest commitments of the Reagan administration is mind-boggling when compared to existing launch capabilities.

Defense and space programs, and satellite launches for U.S. corporations and our allies, will require a national space launch capacity equivalent to a fleet of at least eight Space Shuttles by 1992, according to a tabulation of NASA, Defense Department, and other estimates carried out by the Fusion Energy Foundation. By 1992, NASA must be deploying the space station if it is to meet President Reagan's date of early 1994 for initial operation; according to official estimates, this will require 8-10 dedicated Shuttle missions per year. (The shuttle payload capacity is rated at 65,000 pounds.) Also in 1992, the SDI program should move into the development stage, according to a conservative timetable proposed by Strategic Defense Initiative director Lt.-Gen. James Abrahamson—an effort that he estimates will require the equivalent of five full Shuttle payloads (called "Shuttle-equivalent payloads") launched per year. These NASA and SDI needs themselves require the launch capacity of at least three Shuttle orbiters flying five missions per year each. However, national security requires that SDI be accelerated toward deployment around 1992, an effort that SDIO estimates will require 25 to 40 Shuttle-equivalent payloads launched per year.

The So

## Launch backlog grows

Even before the Challenger explosion, a backlog of national and allied defense, commercial, and other missions, beyond the capability of the Shuttle, NASA, and Air Force expendable rockets and Europe's Ariane, was growing with alarming speed. The Shuttle fleet was expected to carry out at best 14 missions in 1986, whereas demands on U.S. launch systems are for the equivalent of about 18-19 missions (see **Table 1**).

TABLE 1

## Estimated U.S. annual launch requirements in Shuttle-equivalent payloads

| Program | 1986 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96-99 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DoD (non-SDI) | 9 | 9 | 9 | 9 | 11 | 11 | 11 | 11 | 11 | 12 | 12 |
| Space station | | | | | | 8 | 8 | 9 | 8-10 | 8-10 | 8-10 |
| Planetary and other | 3 | 5 | 6 | 8 | 8 | 8 | 8 | 8 | 12 | 12 | 12 |
| NASA Moon-Mars | | | | | | | | | | 5 | 5 |
| Sub-total | 12 | 14 | 15 | 17 | 19 | 27 | 27 | 28 | 32 | 38 | 38 |
| SDI plan A | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 5 | 5 | 5 | 24-40 |
| Sub-total A | 13 | 15 | 16 | 18 | 20 | 28 | 32 | 33 | 37 | 43 | 62-78 |
| SDI plan B | 2 | 2 | 2 | 5 | 6 | 9 | 24-40 | 24-40 | 24-40 | 24-40 | 24-40 |
| Sub-total B | 14 | 16 | 17 | 22 | 25 | 36 | 51-67 | 52-68 | 56-72 | 62-78 | 62-78 |
| Commercial | 5-6 | 5-6 | 5-6 | 5-6 | 5-6 | 5-6 | 5-6 | 5-6 | 5-6 | 5-6 | 5-6 |
| Total A | 18 | 20 | 21 | 23 | 25 | 33 | 37 | 38 | 42 | 48 | 67-83 |
| Total B | 19 | 21 | 22 | 27 | 30 | 41 | 56-72 | 57-73 | 57-73 | 67-83 | 67-83 |
| **Orbiter fleet equivalent**[1] | | | | | | | | | | | |
| Total A | 4 | 4 | 5 | 5 | 5 | 7 | 8 | 8 | 9 | 10 | 14-17 |
| Total B | 4 | 5 | 5 | 6 | 6 | 9 | 12-15 | 12-15 | 12-16 | 14-17 | 14-17 |
| **Shuttle flight rates** | | | | | | | | | | | |
| Pre-accident[2] | | | | | | | | | | | |
| (4 orbiters) | 10 | 17 | 18 | 24 | 24 | | | | | | |
| Post-accident | | | | | | | | | | | |
| (3 orbiters)[3] | 0 | 6-7 | 9-11 | 12-13 | 15 | | | | | | |

[1]The size of the shuttle orbiter fleet required to fulfill requirements of Plans A and B.
[2]Congressional Budget Office, "Budget Effects of the Challenger Accident," March 1986.
[3]According to May 1986 testimony of NASA Space Flight director Vice-Adm. Richard Truly.

TABLE 2

## Payload capability of inventory of expendable rockets

| Launcher | To LEO[1] (lbs.) | Inventory | Total capacity[2] |
|---|---|---|---|
| Delta | 5,000 | 3 | 15,000 |
| Atlas Centaur | 8,000 | 15 | 120,000 |
| Titan 34D | 10,000 | 6 | 60,000 |
| Total | | | 195,000 |
| In addition, under development are: | | | |
| Titan II to polar orbit | 2,000-5,000 | 13 being refurbished | |
| Titan 34D7 to geosynchronous orbit | 10,000 | 10 ordered 1985<br>10 ordered 1986 | |

Now, in the wake of the Challenger, Titan, and Delta failures, the national launch schedule has been scrubbed. Brig.-Gen. Donald Kutyna, Air Force director of space systems, told the annual meeting of the American Institute of Aeronautics and Astronautics:

> The Nation now faces a serious problem with the grounding of the Shuttle and Titan fleets. In the near-term, with the consideration of national priorities, a 12-month downtime of the Shuttle fleet results in an average DOD launch date slip of 10 months. These mission slips and a reduced-orbiter fleet cause an alarming backlog of payloads waiting to be launched. This problem becomes apparent when the Nation's Shuttle launch requirements and capabilities are compared. Assuming the NASA-planned flight rate of 18 flights per year with three orbiters, this significant backlog of payloads evolves. By 1992, payloads filling a total of 45 Shuttle bays are waiting for a way to get

on-orbit. This takes on added significance when you realize that, on top of these missions, deployment of the space station and SDI could begin. It is important to note that if six flights per year per orbiter is not achievable, which is a possibility in the post-Challenger era, the Nation could face a far more serious situation.

Shortly after General Kutyna made these remarks, NASA director for Space Flight, Vice-Adm. Richard Truly announced that the space agency regarded five flights per year as the capacity of a Shuttle vehicle.

Because the Shuttle is our principal launch system, all projects measure their launch requirements in terms of "Shuttle-equivalent payloads."

## SDI looks at mass production of rockets

Even were the presently grounded U.S. fleet of expendable Titan, Atlas, and Delta rockets available, the entire inventory of expendables could only orbit as much payload as three to four Shuttle flights, less than the annual capacity of the Challenger (see **Table 2**). However, the addition of 13 Titan II ICBMs and 10 new Titan 34D7s, available in late 1988 under current production schedules, will increase this "single-shot" capacity to the equivalent of about 6-7 Shuttle launches.

Behind the scenes, Air Force and SDIO officials were already developing plans to expand national launch capabilities for SDI development and deployment, before the loss of Challenger. *Space Business News* reported April 21:

> The Air Force Rocket Propulsion Laboratory [RPL] is exploring the use of robotics and automated processes for Shuttle-equivalent SRB [solid rocket booster] manufacture, assembly and launch operations. RPL hopes that automation will significantly reduce the overall cost of space launch vehicles. RPL says that a new SRB plant will probably be constructed at or near the launch site, presumably USAF Space Launch Complex 6 at Vandenberg AFB, Calif. RPL hopes to have the plant on line in 1997-2000, with 40-150 boosters manufactured each year for ten years. The capacity to produce enough SRBs to launch up to 75 Shuttles and Shuttle-derived vehicles by the turn of the century would probably cover the Defense Department's anticipated launch needs for SDI deployment. A "baseline architecture" established by the SDI Organization calls for deployment of 58 million pounds of SDI systems over a 23-year period.

Some of this expected launch requirement may include one or more manned DOD space stations.

It is not necessary to meet the launch requirements tabulated in Table 1 by only building more Shuttles. Former NASA administrator James Beggs proposed in 1984 the development of a family of unmanned heavy-lift and other launch vehicles based on the Shuttle solid-rocket boosters and main engines to solve the need for cargo transport to space. It is estimated that one such vehicle could lift over 200,000 pounds to low-Earth orbit (or more than three times that of the Shuttle). The launch system would be at least in part reusable. According to NASA, this vehicle could be available in three years.

A simpler proposed vehicle could be composed of one or more Shuttle solid rocket boosters. Since production facilities already exist, development of these vehicles may be the fastest way to meet future launch needs. Air Force Secretary Edward Aldridge endorsed Beggs' concept before the National Aviation and Space Writers Association May 13.

In addition, Edward Teller proposed May 9 the development of a reusable unmanned transatmospheric vehicle for cargo transport to and from low-Earth orbit.

An approach to improved technology mass production of space launch vehicles was outlined by Lieutenant-General Abrahamson in an interview with the *New York Times*. Responding to charges from SDI opponents that the cost of the program would be enormous, Abrahamson stated: "They 'cost' those things by using today's systems. . . . Nobody's going to accept" a system that would be built with current production methods. He added: "That's my responsibility, not to accept that kind of nonsense. That's why we talk of cost goals. . . . The cost of space transport has to be at least one-tenth of the current prices. That's an arbitrary goal, but at least it's a goal." General Abrahamson has created a committee on costs which he said "will take a look at an item and how producible that item is and ask whether there are some automatic machine techniques that can be adapted for production."

The present launch crisis should teach some lessons to the President's economic advisers. The Carter administration's decision to abandon development of new, expendable launch vehicles and only fund the Shuttle, and the Reagan administration's drive to "privatize" production and launch of existing NASA and Air Force expendables, has yielded a situation where production lines for the Delta and the Atlas Centaur are shut down, with the last of six Titan 34Ds scheduled to come off the line in September, when, unexpectedly, the nation's principal launch system—the Shuttle—is grounded until mid-1987.

Redundancy must be built into a launch fleet if it is to at least partially spring back from a crisis like the current one. With the Shuttle grounded, we are left with a set of 25-year-old ballistic missiles (the Atlas, the Titan, and the Thor-derived Delta launch vehicle), whose capability has been improved with solid rocket boosters originally designed for the Polaris and Minuteman missile programs and upper stage rockets like the Centaur.

we should reopen the production line for the Delta and the Atlas, if only until the Shuttle-derived launch vehicles are available.

In other words, the Air Force was right when it insisted on development of some complementary launch vehicle to

be available if anything ever happened to the Shuttle. Unfortunately, the decision to develop this vehicle was not made until 1984. The new Titan 34D7 will not be ready under present production schedules until late 1988. However, if the methods used in the original development of the Titan, Atlas, and Thor from 1955-59 in the ballistic missile program were used, the new vehicle could possibly be ready within half that time. This method compresses development by working on the various components of the vehicle concurrently, not in series.

Secondly, the practice of engineering payloads so that they are compatible with only one launch vehicle, should be abandoned. For complete redundancy, all payloads should be able to be launched by any vehicle that can lift them to orbit.

## Estimates

The estimates in Table 1 on launch requirements were put together in the following way. Estimates on Defense Department launch requirements (excluding requirements for SDI) are taken from remarks of Brigadier-General Kutyna as quoted in *Defense Daily*, July 26, 1985. The same source cites Lieutenant-General Abrahamson stating that: Once the decision to develop the SDI is made, the program will require "roughly" 5 Shuttle missions per year. Deployment will require, he said, at least 24 missions per year. And according to *Space Business News*, April 21, 1986, "A 'baseline architecture' established by the SDI Organization, calls for deployment of 58 million pounds of SDI system over a 23-year period," for an annual average of 40 flights.

In Plan A, development begins in 1992, as suggested by Abrahamson. We estimate that development under a conventional timetable would last four years, then be followed by deployment. Initial SDI deployment in 1996 was also suggested by then-Air Force Undersecretary Edward Aldridge in July 1985 (*Defense Daily*, Aug. 1, 1985).

SDI Plan B is simply a more rapid timetable. It projects development to begin in 1989, followed by deployment in 1992, within a decade of President Reagan's March 23, 1983 speech announcing the program.

Estimates for space-station launch requirements are based on 1) President Reagan's call for initial operating capability by 1994 in his 1984 State of the Union address, and 2) NASA estimates of what would be required to build the station and then supply it afterwards. John Hodge, NASA acting associate administrator for the space station, told the Senate Space Subcommittee (*Defense Daily*, April 24, 1986) that 25 Shuttle flights would be required to orbit the IOC space station (19 for the U.S. portion and 6 for the foreign elements). Thereafter, the program will require 8-10 launches per year. As we go to press, Dr. Hodge has announced that budget cuts have forced a "scale-back" in the U.S. portion of the station, from four to two modules, a change that he states will reduce the launch requirement for the U.S. portion, to 14 Shuttle missions.

# Making sure we get back into space

by Marsha Freeman

Both the military and civilian space programs of the United States are facing the most serious challenges in their histories. The Titan, Shuttle, and Delta rockets will not fly again until the cause of their recent failures is known, their security is enhanced to prevent opportunities for any future sabotage, and engineering changes are made to increase their reliability.

But the real challenge to the space program now is not technical, but political. In the dark hour of the post-Sputnik U.S. launch failures, this nation was able to both close the "missile gap" through the ICBM program under Gen. Bernard Schriever, and begin the manned space program that took us to the Moon. After the 1967 fire in the Apollo 1 command module which caused the death of the first three Apollo astronauts, a thorough NASA investigation led to a safer program that produced breathtaking accomplishments. And even in the budget dog-days of the early 1970s post-Apollo period, NASA was able to tackle the formidable task of developing the world's first reusable space ship.

Today, however, a combination of fanatical Gramm-Rudman budget cutters, the *New York Times* and much of the media, and the interference of the Rogers Commission with NASA's ability to make the changes necessary to get back in business, threaten to overwhelm the civilian and military space programs.

From the standpoint of economic security, the United States cannot afford to cede its commercial payloads to China or the Soviet Union, which is where the U.S. launch market may well go. On May 11, China announced that it would launch two U.S. commercial communications satellites by the end of this year. Dr. Fred d'Allest, who heads the Ariane program, announced that the Europeans will not increase their Ariane flights to absorb what the Shuttle would have carried.

There is no reason to put obstacles in the way of getting our expendable rockets and the Shuttle flying as soon as possible. Yet, that is exactly what is happening.

## Stalling at the White House

It is now nearly four months since the loss of the Challenger, yet there has been no definitive statement from the White House on whether the lost orbiter will be replaced. Minimally, work must begin to build an orbiter, expand the number and quality of expendable vehicles, fund the fix that