STATEMENT OF
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BEFORE THE
SUBCOMMITTEE ON SPACE AND AERONAUTICS
COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES

Mr. Chairman and Members of the subcommittee on Space and Aeronautics:

I appreciate the opportunity to share with you some of my thoughts on the ongoing space station and shuttle programs at NASA. My discussion will be primarily related to the shuttle as I have been associated with that program since its inception. On the other hand, I retired from NASA prior to the beginning of the space station program. However, I believe that great improvements have been made in the space station program under the leadership of Dan Goldin. Both the contracting structure and NASA's management organization have been significantly simplified and improved during the last few years. Consequently, it is reasonable to believe that International Space Station Alpha ("ISSA") will be a successful program.

In my opinion, the space shuttle is one of the great achievements in aerospace history. Although it's not completely reusable, it clearly has demonstrated the feasibility of completely reusable vehicles. This is most important since truly low cost transportation to and from space will only be achievable if we reuse our transportation hardware. However, since the shuttle is the first vehicle of its kind it should not be surprising that some of the goals of the program, particularly low cost operation, were not met. During the next decade the shuttle's primary mission will be to launch and service the various elements of the space station. And as a matter of fact it is the capabilities inherent in the shuttle that really make the space station program feasible.

During the last few years NASA has managed to make significant progress in reducing the cost of shuttle operation. However, still further reduction in operation costs are achievable and should be vigorously pursued. This, of course, must be done without any additional compromise to safety. However, in looking at some of the missions that the shuttle must perform in launching various elements of ISSA it is clear that as presently configured, the shuttle is lacking in performance. Therein lies the rub. More performance, lower operation costs, continued safe and reliable operation -- these three goals are normally in conflict with one another, i.e. performance is usually achieved by increasing cost and/or compromising reliability, and so forth.

In reviewing the ongoing safety effort at NASA one cannot help wonder just how effective the excessively large number of people involved in safety are in reducing the hazards of the mission. I cannot help but wonder whether or not many of these people are mostly involved in coordinating the safety effort with one another rather than being in the position and having the talents to recognize and correct real problems. Furthermore, there are only so many failures of such a critical nature to cause a catastrophe. It is my belief that 95% of the catastrophic failures will occur during the launch phase of the flight (approximately the first 8 minutes). During this period the shuttle is flying through the atmosphere and is being propelled both by the solid rockets as well as its main propulsion system. I might also mention that it is during this period that the shuttle is most highly stressed and consequently some form of accident has the greatest probability. Regardless of the organization, ultimately we must rely on the experienced hands-on experts within the NASA and contractor organizations that really understand the various facets of rocket-propelled flight such as flight control, structural loads, rocket propulsion, etc. Overlaying the judgement of these people at present are numerous reviews, excessive paper trails, etc. which may only serve to distract these experts from concentrating on their task of preparing the shuttle for a safe mission.

When the shuttle was originally designed, one of the primary design objectives was to reduce operation costs. To this end it was planned to install sufficient redundancy in the many individual subsystems, where possible, so that it would be practical to proceed with the launch even with a failed component in one or more of the subsystems. This was done by providing a redundancy level of four rather than the normally acceptable three which had been used in previous manned space flight hardware. As a consequence, if a component were to fail prior to launch the desired redundancy level of three would have still existed. However, during the first few flights it was naturally desirable to have all the hardware operational since we were then dealing with an untried system. Unfortunately, this high level of precaution was never abandoned. After the Challenger accident with a new emphasis on safety demanded and implemented, a strengthened and more extensive safety organization was created and a policy of planned launches with a failed component never implemented. Consequently, designing in four levels of redundancy in order to reduce operation costs has completely backfired, and now instead of assuring that a shuttle with only three levels is faultlessly ready for flight, the extra effort must be made to assure that the added fourth level is equally ready. The fourth level of redundancy also increases the chance of a failed component showing up during the final countdown resulting in costly launch delays while trouble-shooting the problem and correcting it. I do not wish to recommend any reduction in safety. However, I believe that some acceptable compromise can be made in reducing the number of safety related personnel and in easing the launch criteria to accept some reduction in available redundancy. Obviously this must be done by careful scrutiny of the implications of such changes, remembering that clear identification of responsibility will more than compensate for reduction in redundant personnel.

Earlier I mentioned that the shuttle will be used to provide launch services for ISSA. With ISSA flying at much higher inclination that originally envisioned, the shuttle's performance will have to be upgraded in order to be able to deliver some of the heavier elements of ISSA. This extra cargo weight can only be achieved by reducing the weight of the shuttle components (external tank, the orbiter, or the solid rocket boosters) or by increasing the thrust of the space shuttle main engines (" SSME's"). Most of the weight decreases envisioned represent decreasing structural weight. Structural weight decrease is usually accompanied by higher stress which may compromise safety and cost money to implement. Furthermore, any increase in concern about safety will inevitably cost more money during operations as additional analysis and overview will most likely be required. NASA has been developing a modified version of the SSME's. This modified version should improve reliability by increasing the size of the nozzle throat. The large throat nozzles are designed to reduce temperatures, pressures and stresses in the SSME and thereby decrease the chance of catastrophic failure. However, the large throats can alternately be used to increase the thrust if the present level of turbine temperatures and stresses are maintained. This is the approach that NASA is now planning for the large throat SSME's. However, this would only provide about 1/3 of the needed additional performance.

The SSME is a very high performance engine. Without the extremely high specific impulse and thrust-to-weight provided by the SSME's the Shuttle would not have been feasible. However, this was done at a price. The SSME's were originally specified to be able to operate for 7.5 hours (27000 seconds) between overhauls. This was specified with the idea of keeping operations cost to a practical minimum. It also represented at that time an achievable goal for contemporary work-horse engines such as the F-1 used on the Saturn. Presently the SSME's are normally operated .56 hours between overhauls. This number should be compared to 3600 hours for a general aviation jet engine and 1600 for a piston engine. An Indianapolis race car engine is expected to last the 500 miles (a little less than 2 hours). There should be no doubt that the expected probability of catastrophic failure and time between needed overhauls are related. Serious problems with the SSME's have been successfully dealt with by an extensive program of thorough inspections and, as often needed, repairs after each mission. The technicians and engineers involved represent a high degree of dedication, skill and expertise. They, and most probably they alone, make the SSME's safe to operate.

There is no doubt that any future compromise in safety will only result in increased operational costs as additional attention to detail and analysis will be required in order to avoid a catastrophe. It is my firm belief that rather than trying to reduce the weight of structural components in the space shuttle and continuing to maintain the high stresses in the SSME, that flying the shuttle without a crew would achieve the requisite performance for those missions that require large weight components. If there were no crew aboard much installed equipment could be removed from the orbiter and the mission could be flown with lower expendable reserves. This includes maneuvering propellant, reactants for the fuel cells and food, water, and personal equipment for the crew. It is conservatively estimated that with one of the orbiters permanently reconfigured to fly unmanned that, at a minimum, 12,000 extra pounds of cargo could be carried. This would allow NASA to continue to improve both safety and operation costs for their manned flight program using presently configured shuttles with the modified, more reliable large throat SSME's.

Finally, I would like to make a few remarks as to the direction in which the country's launch vehicle program should evolve. With the successful development and operation of the shuttle, our country is in a marvelous position to develop completely reusable launch systems. We should continue to operate the space shuttle so that we can better understand how cost can be minimized with future reusable systems. It must be understood that a reusable system has the potential to not only save money by the avoiding the cost of manufacturing new hardware every flight, but also should save a great amount of money in pre-launch operations wherein the vehicle is made ready for the next flight. The latter is so because if the data obtained from the previous flight indicates little or no problem, very little should be needed to make the vehicle ready to fly again. This is exactly how we operate aircraft. Unfortunately, very little advantage of this situation is achieved in our present space flight operations. We must also learn to operate the shuttle unmanned. This will not only provide a useful unmanned launcher adjunct to the present capability but will also provide an improved insight into how an unmanned, fully reusable system can be operated. Our first fully reusable launch vehicle should be unmanned.

A fully reusable system will be most cost effective if the design is extremely conservative. This means that highly stressed components and structures are avoided. It is my belief that this can only be achieved using a two stage system. Two stages provides a great relief from the need for extremely high performance and will make a truly conservative design a possibility. The present effort that NASA has invested in developing the technology for a single stage to orbit should be continued. This is because most of that technology would be directly applicable to the second stage of the two stage system. However, I would recommend that NASA cease to identify the development of the single stage to orbit as a goal since such a goal, in my sincere belief, is contrary to achievement of the practical low cost launch vehicle system.

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