Written Testimony of

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Chairman Nelson, Ranking Member Vitter, and Members of the Subcommittee, I am honored to be invited to appear before you today to testify on the matter of crew safety in human spaceflight. In the wake of the Augustine Committee report and now the President's 2011 Budget, it is imperative that this Congress should carefully consider and understand all of the potential ramifications of the proposed changes to be made to the programs that NASA has pursued and that the Congress has approved for more than four years for human spaceflight.

Before proceeding to answer your questions, I would like to make a few observations concerning the Augustine Committee report.

The most important observation of that Committee, and the underlying concern in all deliberations on the future of U.S. Human Spaceflight, is that it has been inadequately funded for many years now. The budget projection for NASA in the next decade and beyond is inadequate to accomplish the core objectives with which NASA has been charged. The funding is inadequate to build a timely replacement for the Space Shuttle, to transport our astronauts and other international partner nations' crews to and from the International Space Station to the Earth. The Augustine Committee pointed out that a heavy lift launch vehicle would be required to have flexibility to visit the moon, near-Earth asteroids, and to develop the technology and systems required for the first human voyages to Mars.

The plan that NASA had proposed and that has been approved by the Congress is a program offering the strategic vision for human spaceflight that was demanded by Adm. Gehman and the Columbia Accident Investigation Board. It is a program worthy of our nation. The Augustine Committee notes that at least three billion dollars per year must be added to NASA's appropriation to accomplish the mission. Even more importantly, the Committee notes that there is no other worthwhile program of human spaceflight which could be accomplished for the amount of money presently planned for NASA. Also of interest, is that the Augustine Committee stated that Mars is the ultimate destination for human exploration to the inner Solar System, but not the best first destination. Visiting the "Moon First" and following the "Flexible Path" are both viable exploration strategies and the two are not necessarily mutually exclusive before traveling to Mars. I certainly agree with these findings of the Committee.

The choice is now plain: either we will provide the funding necessary to accomplish worthy objectives in space, or this nation will cede its leadership on the space frontier to others. I wish to add my voice to those who say that this leadership, the result of five decades of effort purchased at the cost of nearly a trillion of today's dollars and many lives, some of them given by close friends of mine, must not be allowed simply to drift away. As a nation, as a people, we must be better than that.

I want to acknowledge the work performed by the Augustine Committee to cover these broad based subjects in such a relatively short period of time. After extensive examination of the Committee's report, I strongly agree with the majority of their findings and recommendations. However, on some of the Committee's findings, I have a different opinion.

I am not familiar with all of the aspects of the President's proposed 2011 budget nor all of the aspects of NASA's response. I agree with the Committee's recommendation that the remaining Space Shuttle flights should be launched on a schedule that is compatible with the normal procedures used for safe check out test and launch operations, which may extend the flights into 2011. We presently have a Shuttle at KSC on standby to launch on short notice, as was determined by the CAIB. If funding were available this Shuttle could easily provide cargo delivery that would certainly enhance the viability of the ISS six-person crew capability.

The Committee wisely recommends the extension of the International Space Station past 2015 to at least the year 2020. However, the ISS will never be fully and effectively utilized unless researchers of all of the ISS partner nations have the confidence that it will be supported and sustained as long as it is operationally viable and technically useful.

To have and to use this great international laboratory requires a guaranteed space transportation capability to be available as soon as possible after Space Shuttle retirement. The Committee recommends that this responsibility be removed from NASA and offered to commercial providers. Today, approximately 88-89% of NASA budget flows on to commercial entities.

I would like to differentiate the two subjects, Potential Commercial Cargo delivery to the ISS and Potential Commercial Government Crew delivery to the ISS. NASA has incentivized and selected two contractors to provide commercial cargo delivery to the ISS. For commercial cargo delivery, the first issue is the development of a reliable booster to low earth orbit under the COTS program, which is yet to be demonstrated. The second issue is to develop an autonomous transfer vehicle to transport cargo from the booster in low earth orbit (LEO) to the ISS in a safe manner that would meet the stated ISS visiting spacecraft requirements that were complied with by the European Space Agency's ATV and Japan's HTV. The development of this type of a transfer vehicle is in itself certainly is a major challenge. The European Space Agency recently delivered their first ATV payload several years later than their initial target delivery date. Japan delivered their HTV some two years later than their initial target date. Both government entities used considerable resources to develop their individual transfer vehicles. I certainly wish the two United States entities success in meeting their NASA milestones for cargo delivery since the ISS is dependent upon a continued supply of cargo deliveries by the partners.

With respect to commercial crew launch delivery to the ISS, I would like to recall my own experience. I have flown two Gemini missions on a modified TITAN II, ICBM, booster and two Apollo missions, one on the Saturn IB and one on the giant Saturn V. Over the period of thirteen years at NASA, I experienced and participated in the development of high reliability boosters, spacecraft, and launch abort systems. I was a back-up pilot for the first manned Gemini spacecraft and spent many months in the factory and countless hours of testing in the spacecraft as it was being built and tested. I was then pilot of Gemini VI, the world's first rendezvous mission. On that mission, the TITAN II first stage engines ignited and then shutdown at T=0. Wally Schira and I had the lift off signals and a fire broke out below the base of the booster. The emergency detection system and modifications that had been installed in the TITAN II helped us to resolve the two critical failures that we experienced in that extremely short period of time. There were several black areas of the launch trajectory of the Titan II Gemini. They would not be acceptable today. The Titan Gemini program was a high risk demonstration program.

I was the back-up commander for the second Block I Apollo flight and had my crew performing a similar test, in the sister spacecraft, at the same time that the Apollo I accident occurred and the crew died in the spacecraft fire on the launch pad. I was then back-up commander of the first Block II Apollo spacecraft, Apollo VII, and again spent considerable time in the command module which was being built and tested. There were also numerous NASA engineers, inspectors and support technicians at the factory to facilitate this effort. This support effort was similar to the Gemini program, where numerous NASA engineers, inspectors and support technicians participated in the manufacturing and test at the factory. I was then the Commander of Apollo X, the first flight of the Lunar module to the moon. Again, I spent an inordinate amount of time in performing test and check-out in the command module and the lunar module.

My fourth mission, I was commander of Apollo for the Apollo-Soyuz Test Program. Again, I spent considerable time for the test and check out of the Apollo spacecraft and a brief time in the Soyuz spacecraft. These flights, both as a prime and as a backup crew member were accompanied with hundreds of hours of training for each mission in different types of spacecraft simulators and mockups where numerous emergency and normal situations were simulated and resolved.

Therefore, safe reliable delivery of a government crew to the ISS involves the human rating of the launch vehicle, the spacecraft, and the launch abort system, and the successful integration of all three elements. The safety goal for the Apollo Saturn was from launch to LEO and safe return to the Earth 0.9999. The process of requirements, design, and construction all begin with the NASA safety and mission assurance requirements. There also has to be a process where there is not an excessive creep in requirements that would result in cost increases and launch schedule delays of the vehicles. Unfortunately, the Augustine Committee report only gave just a very brief mention of crew safety for launch, orbital, and recovery operations. Regrettably , there were no in-depth discussions of this vital issue of safe launch to orbit and return to earth of government crews.

It may be that the complexity of developing a new government crew space transportation capability, and the difficulty of conducting spaceflight operations safely and reliably, it is not fully appreciated by those who are recommending the cancellation of the present system being developed by NASA, and the early adaptation of the presently non-existent commercial government crew delivery alternatives. There seems to be some belief that if NASA would "step aside", private alternatives would rapidly emerge to offer inexpensive, safe, reliable, dependable government crew delivery space transportation at an earlier date.

Human spaceflight is the most technically challenging enterprise of our time. No other activity is so rigorously demanding across such a wide range of disciplines, while at the same time holding out such harsh consequences for minor performance shortfalls. Aerodynamics, aerospace medicine, combustion, cryogenics, guidance, and navigation, human factors, manufacturing technology, materials science, structural design and analysis – these disciplines and many more are pushed to their current limits to make it possible and just barely possible at that, to fly in space. Flight in space is very, very hard to achieve.

We've learned a lot about human spaceflight in the last five decades, but not yet nearly enough to make it "routine" in any meaningful sense of the word. As Adm. Gehman and the CAIB outlined, these flights in the past have been developmental flights and the relatively small number in the future will be the same. Thus far, it has been a government enterprise with only three nations yet to have accomplished it. Of the three, it is important to note that only the United States, where NASA set requirements had oversight with the design and development of vehicles, and commercial entities built all of the hardware and software. In the other two countries, it is government owned entities that built all of the hardware and software for their capabilities. Development of new systems is very costly, operational risks are extremely high, and commercial profitable activities are elusive. It may not always be this way, but it is that way at present.

Apart from questions of technical and operational complexity and risk, there are business issues to be considered if the U.S. is to rely upon commercial providers for government crew access to space. It is not that industry is incapable of building space systems. Far from it. It is American industry which actually constructs all of our nation's space systems today, and carries out most of the day-to-day tasks to implement flight operations, subject to the government supervision and control which is required in managing the expenditure of public funds.

So the question is not whether industry can eventually develop government crew delivery systems and procedures to fly in low Earth orbit. It can. The relevant questions in connection with doing so commercially are much broader than that of the relatively simple matter of whether it is possible. Let us consider a few of those questions.

Absent significant government backing, will industry provide the sustained investment necessary to carry out the multi-year development of new commercial government crew delivery systems to LEO? Will industry undertake to develop such products with only one presently known customer, the U.S. Government? What happens if, midway through the effort, stockholders or boards of directors conclude that such activities are ultimately not in the best interests of the corporation?

What happens if, during development or flight operations, an accident occurs with collateral damages exceeding the net worth of the company which is the responsible party? A key lesson from the development of human spaceflight is that safety is expensive, and the failure to attain it is even more expensive. Apollo 1, Challenger, and Columbia have shown that spaceflight accidents generate billions of dollars in direct and collateral liabilities. Who will bear this risk in "commercial" space operations? If the company, how much insurance will be required, where will it be obtained, and at what cost? If government indemnification is expected, upon what legal basis will it be granted, and if the government is bearing the risk, in what sense will the operation then be "commercial"?

When commercial government crew delivery space transportation does come about, other questions will arise. Will there be competition in this new sector, or will there be a monopoly supplier? If NASA is to contract with the first, or only, commercial government crew space transportation supplier, and if there is no price ceiling established by a government alternative, how do we ensure a fair price for the taxpayer in a market environment in which the government is the only customer for the products of a single provider? And how is a space operation "commercial" if the government is both regulatory agency and sole customer?

Leaving aside technical, operation, and business concerns, there is the matter of the schedule by which these new commercial systems are expected to come into being. The Augustine Committee has been particularly pointed in its clams that, with suitable government backing, such systems can be made before the comparable Constellation systems, Ares 1 and Orion, could be ready. Page 71 of their report offers such a claim. It further goes on to say Committee recognizes that the development of commercial services to transport crews come with significant problematic risks. Among these are that the development of this capability will distract current potential providers from the near term goal of the successfully developing commercial cargo capability. Second, the comm. Community may fail to deliver a true capability in mid-program and the program would revert to NASA "Now, how could it revert to N when the team has been dismissed and laid off with this exercise?" It would be a disaster for our country's Human Space Flight program both technically and politically.

Are such claims optimistic? Any launch system and crew vehicle that can transport a half-dozen people to and from the ISS, and loiter on-orbit for a six-month crew rotation period while serving as an emergency crew return vehicle, is necessarily on the same order of complexity as that of the old Saturn 1 and the Apollo systems. The Saturn 1 conducted its first test flight, with a dummy upper stage, in October 1961, and finally carried a crew for the first time in October 1968. The Apollo VII spacecraft which carried that crew, of which I served as back-up Commander, began its own development in 1962. Thus, the Earth-orbital segment of the Apollo system architecture required a half-dozen years and more to complete. These developments were carried out by highly experienced teams with virtually unlimited development funds in the cause of a great national priority.

If, in the fashion of airline travel, NASA is buying a ride rather than a spacecraft, then how, by whom, and to what standards will the company's equipment and operation be certified? How is NASA to determine that the system is truly ready to fly? Does the government merely

accept the claims of a self-interested provider, on the basis of possibly very limited flight experience by company pilots? We certainly do not do that for military aircraft, and even less so is this the case for civilian transport aircraft. Extensive development and hundreds or even thousands of hours of flight testing followed by operational test and evaluation by the government is required before a new military aircraft is released into operational service; I have participated in and managed this type of testing. Similarly, new civilian aircraft are subject to extensive testing involving certification of systems and subsystem, and hundreds of flights to exact certification standards before they are allowed to be put in passenger service. Will we accept less for new, "commercial" space systems which carry government astronauts, or those of our international partners? In my opinion, the Congress should certainly not accept less.

Yet, today, we do not even know what standards should exist for the certification of commercial spacecraft to carry government crew members into orbit. What entity other than NASA can establish and verify appropriate standards for human spaceflight? I will tell you that from my perspective and from the history that I have lived, these standards, like airworthiness standards, are written in other people's blood. Some of that blood was shed by friends of mine. We don't know enough, yet, about human spaceflight to relax the hard-learned standards by which we do it. And we certainly do not yet know enough to make the assumption that new and untried teams can accomplish it on a schedule that is better than was achieved during Apollo.

This takes me to another point. Some of you may recall that, a few years back, I chaired the Task Force on International Space Station Operational Readiness. This task force was charged with making an independent assessment of our readiness to put crew on the ISS, and to sustain it with the transportation systems, Russian and American, which were necessary for cargo delivery and crew rotation. We did not take this matter lightly. The ISS was new, and much smaller. We did not then have the years of experience we have since accumulated in building the ISS and flying on it. Our then-recent long-duration spaceflight experience had mostly been accumulated during the Shuttle-Mir program, and Russian experience in resupplying the Mir and the earlier Salyut space stations was not unblemished. Numerous docking failures had occurred over the lifetimes of these programs, resulting not only in cargo which went undelivered but also, in one case, the collision of an unmanned Progress resupply vehicle with the Mir. An in another instance there had been a fire on Mir itself and the first crew to visit their first very small space station Salyut died after performing the D orbit maneuver to reenter the atmosphere.

These incidents and accidents gave us pause. Not because we doubted the capability of the team; the Shuttle had been flying for over fifteen years by that time, and the Russians had accumulated decades of experience in long-duration spaceflight. I've flown with them; I know how capable they are. No, our concerns were heightened by our awareness of just how careful one has to be in this most demanding of enterprises. We cannot afford to relax that vigilance today as we go forward into a new era of ISS utilization, and as we prepare once again to hopefully voyage outward from Earth, first to the moon or the asteroids and then beyond. There is a place in these plans for the contributions of commercial government crew space transportation, but not yet demonstrated, and not to the exclusion of NASA's own safety and mission requirements.

I have asked many questions in this testimony, questions which I believe must be answered if commercial government crew human spaceflight is to become viable. I believe that these questions and others yet to come can and will be answered at some date. However, America's continued leadership in space should not depend upon the nature and timing of those answers. When commercial entities have demonstrated that they can provide dependable reliable transportation to LEO, the U.S government crews as well as partner nation crews, the government should buy it. But until that time, there should be an assured government capability to accomplish the task.

Thank you.