Remarks to Conference on Quality in the Space and Defense Industries
Cape Canaveral, Florida
Rex Geveden
NASA Associate Administrator
March 26, 2007

Thank you Rob (Rob Ellison, KSC) for that generous introduction and good morning ladies and gentlemen.

It pleases me to be here back at the Cape to kick off the nation's pre-eminent aerospace quality conference. I've spent almost exactly half of my life, which turns out to be 23 years, in the aerospace business. The first six of those were in strategic space and the last 17 in civil space with NASA. And, as an engineer, project manager, program manager, and institutional manager, I've worked closely with your community, the quality community, in every single one of those years. So, I count you as friends, and I hope the feeling is mutual. I doubt it, but I hope it.

By the way, you picked a perfect setting for the conference. A few miles north of here, on Banana Creek at Launch Complex 39, is the place where America's space exploration dreams come true.

Occasionally, I'm called upon to deliver guest briefings in connection with our Shuttle launches, and I always remind people that this is only one of three spaceports on planet Earth from which humans have been launched into orbit. And Launch Complex 39 is the only site from which humans have departed Earth for another heavenly body.

In our business, there is a strong bond between the astronauts who take personal risks to explore the unknown and those of us who support their missions from the ground. (For the record, I like it on the ground.) It is partially from this bond that we derive our commitment to quality in the space business.

With your indulgence, I would like to put this topic of quality in perspective, by recalling how far we’ve come in the first half century of the space age, and by discussing the challenges we will face in the next fifty years as we send pioneering crews back to the moon, and then on to Mars and other interesting destinations in the solar system.

Our Administrator, Mike Griffin, has compared the current state of human space flight capability to that of marine navigation and exploration at the time of Magellan. At the time Magellan first circumnavigated the globe about 500 years ago, it was a feat barely within human capability. Such is the case with human spaceflight today.

By the time Magellan’s crew returned to Spain in 1522, almost three years after departing, there were only 18 survivors from the original crew of about 230. Magellan, who was killed in the Philippines, was not one of them.

The significance of this analogy is that nations persisted in their quest to master the seas despite the risks and costs, just as we will persist in our attempts to master space. We will persist in order to bring the resources of the solar system into our economic sphere, to use the words of the President’s Science Advisor Jack Marburger. And I believe we will persist because our survival as a species ultimately depends upon our migration off the planet.

There are those who question why we take risks of this magnitude and nature, why we expend the resources necessary to execute projects of this scale and complexity. My answer is because the commitment to great challenges, such as space exploration, is what makes great nations. Great nations are always on the physical and intellectual frontiers of their time; because doing what is required to solve the very hard problems develops capability. Very few nations can put sophisticated scientific satellites into space; and as I noted earlier, even fewer can put humans there.

Why is it such a rare capability? It is rare because the barriers to entry are high. Space exploration is something that wealthy nations do on the margins of their economies. Doing it requires the expenditure of human and financial capital; requires the creation of new industries and systems for managing processes and products—systems for parts and configuration control, environmental testing, requirements management, and of course, quality control. These systems, and the people that manage and understand them, are difficult to attain, develop, and improve.

But other nations know what having such capabilities says to the rest of the world about their global stature. This is why the Chinese, the Indians, the Iranians, and others are making investments in space today. They desire to succeed in space, because they understand what the possession of such strategic capabilities communicates to others and presumably they understand the inherent value of the capability. I have often quoted my friend John Horack who once wrote that for those nations that can afford it and have the desire to do it, "…exploring space remunerates positively toward greater security and survivability on one's own terms."

Returning briefly to Magellan—another reason I find this analogy attractive is that in Magellan's case, just as in space exploration, there is very little margin for error. And it is my strongly held conviction that when you are attempting to operate highly complex systems in extreme environments—human spacecraft, nuclear reactors, warfighting vehicles for example, in other words, systems with little margin for error—then quality can make the difference.

Even a perfect design will not translate into a workable system unless there is a highly skilled and dedicated quality community contributing to the product. We didn't always understand that, but some unfortunate lessons borne of failure led to an early understanding that success in the space business would require an uncompromising commitment to discipline, in particular to quality management.

So, let's talk about some of the hard lessons we learned. Despite America's great post World War II capability and faith in science and technology, history tells us that the first satellite to orbit the Earth was launched not from the Cape, but rather from the steppes of Kazakhstan at the Baikonur Cosmodrome at four minutes to midnight on

October, 4th, 1957. As a somewhat regular visitor to Baikonur in recent years, I can tell you it is truly impressive to see the complex launch infrastructure out there in the middle of nowhere.

The Soviet Union's launch of Sputnik punctured our national ego, prompting then-Senate majority leader Lyndon Johnson to warn, "The Roman Empire controlled the world because it could build roads. Later—when moved to the sea—the British Empire was dominant because it had ships. In the air age, we were powerful because we had airplanes. Now the Communists have established a foothold in outer space. It is not very reassuring to be told that next year we will put a better satellite into the air. Perhaps it will also have chrome trim and automatic windshield wipers."

To compete in the space race, the U.S. rushed to get our Vanguard rocket into orbit on December 6th of that eventful year, in America’s first nationally televised countdown.

Pulitzer Prize nominee William Burrows describes that countdown in his book—This New Ocean—as follows: “The engine blasted a torrent of flame and smoke into the pit. Vanguard, the focus of thousands of lenses and millions of eyes, began its tenuous climb to the sky. It took two seconds to reach its maximum altitude: four feet. Then there was an explosion accompanied by a sight that was already painfully familiar to everyone who worked with rockets: a fat, boiling, angry cloud of oily fire; an inferno that seemed to be held together by a spider web of dirty black veins and globs of rocket blood: its propellant. The beautiful cylinder, its nose cone shaken loose from the upper stage like a wobbly drunk losing his footing, slowly disappeared into the orange-and-black cloud. There were gasps of horror on the beach and sickening disappointment inside the blockhouse and the White

House." The San Francisco News ran a headline calling the explosion a "Cold War Pearl Harbor."

And Vanguard wasn't an isolated failure. Steven Johnson's Book, *The Secret of Apollo*, chronicles the advent of systems management, which came to be applied very successfully to the Apollo program. Systems management, which Johnson defines as "a set of organizational structures and processes used to develop a novel but dependable technological artifact within a predictable budget," was a cold war innovation. It was driven into existence by the need to manage the development of systems of unprecedented complexity and interdependency. But I believe it gained grudging acceptance only after repeated, costly test failures left no other reasonable alternative.

NASA lost the first six Ranger spacecraft, which were lunar robotic precursor missions to Apollo. In the meantime, the Air Force was losing roughly one-half of the Titan intercontinental ballistic missiles. A little later, the European Launch Development Organization utterly failed in their attempts to develop a launch system.

What were the problems? You can guess—interface problems, parts quality, environmental failures, and so on. And because configuration management was not a well developed discipline—at least not in the space business—understanding and correcting test and mission failures was doubly challenging. And these problems occurred within programs that had other serious programmatic issues such as horrendous cost overruns.

Our collective industrial response was to develop systems management—documentation, interface control, parts control, quality assurance, environmental testing, and even project management—at least as we know it today. Apollo, and all its success, was preceded by stark, recurring failure. And there can be no doubt that Apollo owes much of its success to the evolution and practice of the aforementioned disciplines.

There are many in the aerospace field today who didn't benefit from that history or aren't aware of it. And they are, of course, the first to question these seemingly bureaucratic and arcane practices. "Why do we need quality control?" they might ask. "Engineers should be responsible for quality. After all, who wants their designs to work more than they do?" You've heard it before, I'm sure.

It is for this reason that this conference, CQSDI, is so important. We need to promulgate the hard lessons learned in this business and ensure they aren't forgotten as we go forward in developing even more complex systems performing more demanding missions with higher consequences of failure.

To that end, let's talk about some of the unique challenges we face in flying our remaining shuttle missions and transitioning to our new Constellation systems.

Today, no activity is more important to NASA and the future of the space program than that of safely launching and landing our Space Shuttle flights. First off, completing the International Space Station and retiring the Shuttle by 2010 are the cornerstones of the national exploration policy, which was made the law of the land with the passage of NASA's 2006 Authorization Act. But in more concrete terms, we know that losing another Shuttle mission would severely damage if not terminate the human spaceflight program in this nation.

I am immensely proud of the performance of the entire NASA team on the missions we've conducted since our return to flight in July, 2005. Our teams have demonstrated the technical excellence and dedication to mission we strive for as an organization. With the two most recent shuttle flights, STS-115 and STS-116, the Shuttle team has conducted some of the most complex and difficult space assembly missions ever attempted. But, as we have all learned form hard experience, we must remain vigilant.

Our task is made even more daunting by the fact that a many of our engineers are nearing retirement age, and many of our more talented younger engineers are eager to get started on the Constellation Systems—the new Orion crew exploration vehicle, the Ares 1 launch vehicle and Ares V cargo vehicle.

Accordingly, a key component of our strategy to maintain quality and safety on our remaining shuttle flights is to encourage senior engineers to stay with the program through its conclusion. We are also attempting to keep a solid core of talented young engineers working on the shuttle program.

We just can't permit our Shuttle workforce to diminish to the extent that we no longer have the people who know instinctively what problems to look for. So we're having discussions with our contractors to make sure we retain the right people until that final Shuttle mission touches down.

Yet another challenge we face is the aging of the Shuttle fleet and the component parts of the Shuttle system. We are on the lookout for parts that are in danger of becoming obsolete and working assiduously to prevent the introduction of counterfeit parts into the system.

In order to make our Quality Management System more robust NASA is following the lead of private industry and has formally adopted the AS9100 quality system which is targeted to critical and complex aerospace products and processes.

It is important to note that NASA's entire approach to quality is risk-based. Our policies and procedures require the identification of risks from which quality plans and efforts can be appropriately tailored. This is, in fact, consistent with our heritage—which is to use risk-based inspection and processing, wherever that is feasible. And by risk, I am referring to the intersection of failure likelihood and failure consequence.

It is interesting to note that NASA's risk-based approach to quality flows from federal regulations that mandate quality assurance by government and contractors appropriate to the criticality and complexity of the product and service in use.

An important example of this risk based approach is what we hope to do with the new human-rated systems being developed by our Exploration Systems Mission Directorate. During the Shuttle era, maintenance was based on worst case failure scenarios. Accordingly, we inspected parts between every flight regardless of whether there was any serious likelihood that the part had degraded below design criteria.

In the future we are looking at a maintenance philosophy that incorporates the likelihood of product degradation. We've done benchmarking with other agencies such as the Navy to learn from their best practices in this regard.

These, of course, are just a few of the challenges we will face in assuring quality when we embark on constructing bases on the moon and sending crews to Mars. We are considering now how to create tools, *in situ*, that astronauts will need to fix vital equipment on the moon.

It is simply too expensive to take along every possibly required tool, so we are examining innovative solutions to that problem.

We know now that we will need systems to provide integrated launch vehicle system health monitoring. Today, when a fighter pilot pushes a button to fire an air-to-air missile, the missile executes an automatic, built-in-test to inform the airplane's fire control system about its readiness to be fired. And it does it in milliseconds.

And if it isn't ready, it automatically delegates to the next missile in line so the pilot doesn't have to think about it. We don't have that capability yet with NASA launch vehicles, although an air-to-air missile has the same subsystems we employ in launch vehicles. So, we will need to develop it, and it is obviously possible given the existence proof of air-to-air missiles. Other alternatives are too operationally expensive. And we simply can't afford to do business the way we process and launch Space Shuttles.

Until now, we have structured our space program to ensure that Mission Control in Houston is able to respond in real-time to mission contingencies. In the future, when crews are stationed on the moon for weeks and months at a time, or are on Mars, where it takes eight minutes to half an hour for a round trip message from Earth, our crews will not have the luxury to wait for Houston or any other center to solve problems in real time.

It's imperative that we move away from the mindset of "mission control" and move into a new era where our centers on the ground providing "mission support" to our crews and their ships. And this will require us to rethink traditional notions of quality.

Our emphasis in the future will be on greater adaptability, flexibility and resilience and less so on roles, procedures and control dictated from the ground. And our technical communities will have to adapt to these requirements in their designs. Our ships will need to be smarter, and must work in tandem with their human crews.

The good news is that this community, through your commitment to excellence, is well positioned to take on these and the many other challenges we will face as the second half century of space flight gets underway.

So, I'll close by offering this thought to you. This business of quality management has consequence; it matters. It is vitally important. The consequences of failure are usually terrible and yet the rewards for success are tremendous. So, we persist in the design and operation of these complex systems with the belief that we will succeed. And with your help and commitment, I think we will. Thank you for the invitation to speak and for giving me your attention today.