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NASA Exploration Plans: Where We've Been and Where We're Going

Chairman Cruz, Ranking Member Sinema, and Members of the Subcommittees, thank you for the opportunity to appear before you today to discuss NASA's early and future human spaceflight programs.

This is an exciting time for NASA and the space industry as we celebrate one of our Nation's greatest technical achievements – landing two American astronauts on the Moon and returning them safely back to Earth on the Apollo XI mission.

I was tremendously fortunate to be a part of the team and that great endeavor. Growing up, I could have never imagined I would serve in such a role. As a young boy, all I wanted to do was fly airplanes – that was my dream. I grew up during the depression, my father was a World War I veteran and died when I was only seven. We lived near the American Legion and, to support her three children, my mother opened a boarding house for military personnel. The influence of these military servicemen really sparked my drive to become a naval aviator.

On the path to becoming an aviator, I learned resilience, very early. I received an appointment to the U.S. Naval Academy but, unfortunately, failed the entrance physical and believed my dream was gone. Other than this appointment, there were no other scholarships pursued and we certainly didn't have the financial means. But an angel in my life, Sister Mary Mark, one of the nuns at Central Catholic High School in Toledo, found an Elks scholarship for Parks College of Saint Louis University. I earned a degree in Aeronautical Engineering and an ROTC commission in 1954. I flew the first three mass produced jet fighters, the F-80, F-86, and the F-100. After a tour in Korea, I selected reserve status and in 1958 was assigned as a civilian Flight Test Engineer on the B-52 at Holloman AFB.

At the completion of the flight test program, I applied to NASA and was selected to join the Space Task Group at Langley in 1960, serving under Christopher Kraft, as the assistant flight director for John Glenn's Mercury mission. Having never met him before, our initial introduction was short and to the point – he tapped me on the shoulder and stated, "I'm Chris Kraft, you work for me, I want you to go down to the Cape and write a countdown and some mission rules. When you're ready, give me a call, and we'll come down and launch." This was our first Redstone launch.

While the space missions became more challenging and the stakes higher, we grew into a stronger, more unified, and capable team. During this period, we developed a set of cultural values which guided our operations over 50 years ago and throughout the decades to come. These steadfast values still apply to our space programs, today.

For the past several weeks, I have done dozens of interviews for local, national, and global media. Besides the typica l questions, "how do you feel about the 50th anniversary and what do you think about the Apollo Mission Control Center restoration?" Nearly all the reporters have followed with questions about our current space initiatives. Should the U.S. go back to the Moon? Should we go to Mars and skip the Moon? Can we do it again and why haven't we already?

My answer to the question, "should we go back to the Moon" is simply – yes. There are tremendous opportunities lunar missions can provide our space industry from redeveloping the capability and honing the spaceflight experience for missions beyond the Moon, as well as commercial development and utilization of the resources. The benefits go well-beyond the time available today and there are plenty of scientists and entrepreneurs who can expound on the economic benefits.

To answer the question, "Can we do it again and why haven't we already," is much more complex. But that's why I am here today, to offer my perspectives based on my experience from having been one of many, key NASA leaders and part of the spaceflight team which accomplished President Kennedy's,1961 mandate, "to land a man on the Moon and return him safely to Earth before the decade was out."

The 1960's were not dissimilar to where our Nation is today relative to geopolitics, domestic turmoil, and patriotism. President Kennedy faced a confident Soviet Union and a sleeping giant in the Peoples Republic of China. We were at the beginning of the Vietnam War and domestic turmoil over civil rights was building. President Kennedy's challenge was a timely, masterful distraction, it utilized the challenge of space exploration to unify our Nation and demonstrated the technical prowess of the United States.

Today, we have many of the same issues. However, unity, was essential to our success in the 60's – one goal, one team.

However, I believe the most critical element we lack today is unity – across our country, our government, and within the space industry.

We have an Administration which is strongly supportive of space, clearly stated directives to align with the goals, and a willingness to provide the resources. We have a capable workforce and industrial base which are engaged in various aspects of the industry, they are anxious to explore, but philosophically divided in their business and technical paradigms. We have infinitely more technological capability than we had in the early programs, but there seems to be a lack of focus and prioritization of those what are explicitly needed to accomplish the mission. We have a Congress divided

primarily down partisan lines on just about everything but, individually, have a passion for space and a desire to see our Nation continuing to explore.

It is my understanding that the objective of today's hearing is to address those qualities that were contributors to the success of the Apollo Program. Many papers have been written on this topic so my comments should not be new.

What made Apollo a success? The Leadership. The Unity. The Team.

The Mercury and Gemini Programs provided the experience base for the Apollo, Shuttle, and subsequent programs.

The Mercury Program provided the initial understanding of the manned flight mission environment, the involved mission tasks, facility requirements and capabilities, training and the nature of the personnel most suited for the critical, high risk aspects of mission control.

The Gemini Program introduced the critical new space technologies; computers, fuel cells, maneuvering and attitude control systems, and the ability to accomplish rendezvous, docking, and support extravehicular operations. Computers, satellite communications, and improvements in display technology in Mission Control combined with effective simulation training established the relationship between the mission control team and crew needed for complex space operations. Possibly the most important was that it provided the training ground and mission experience required for making risk-based decisions during pre-mission and mission operations.

Developing our Team and Our Values

The Space Task Group was an enterprise, with three unique components. The foundation was provided by a small group of classical aeronautical engineers from the Langley Research Center. This group had the hands**-on** knowledge and experience from their work in the design and test of the breakthrough aircraft during and after World War II. The second group was composed of aeronautical engineers and flight test personnel from the Avro Arrow project in Canada. The cancellation of the AVRO Arrow project by the Canadian government made key engineers and flight test personnel available to the fledgling Space Task Group. The third component was comprised of a mixture of young engineers recruited from America's colleges, former military personnel, and a small group experienced in early scientific satellite programs.

Each of these groups brought with them a unique organizational chemistry. The Langley group brought a classical aeronautical engineering skill to the Mercury Program. The Arrow group brought an incremental flight test approach. The third, younger group, brought a highly energetic and impatient, "let's get going" approach. The interaction of these three groups created an organizational chemistry that was greater than the sum of its parts that I believe led to developing the incredible and gifted leadership that provided success during the early programs.

As the programs evolved and we came face-to-face with various challenges and failures, we truly began to solidify our team core values of discipline, competence, confidence, responsibility, and teamwork (ref. Foundations of Mission Control). Toughness, emerged as a core value, learned the hard way, after the Apollo 1 fire and the loss of the crew. Toughness, meaning, we are forever accountable for our actions, what we do, or, in the case of Apollo 1, what we failed to do (ref. Kranz Dictum).

The organizational structure for future space programs must consider the relationship between Headquarters personnel and those assigned to mission leadership. From Gemini through the early Shuttle Program a highly professional, personal, and friendly relationship existed to address issues on a variety of issues before they became problems.

Leadership

The leadership inherited from the Langley and Arrow groups recognized that for an organization to function, leadership must exist in all segments and at every level. There must be individuals capable of taking leader-like actions to make their piece work, leaders with confidence in their ability to send word back up the line that design, plans and policies needed amendment or reversal. There was a universal recognition that every member of the Space Task Group was responsible to develop the next generation of leaders. During the Shuttle Program, many organizational “fads” originated. Awards were given for “flattening organizations,” essentially eliminating mid-level supervisors. I believe this was detrimental, mid-level positions provide the primary training ground for higher level positions.

Teamwork and Unity

One mission, one team, one voice was present in every aspect of our work from the formation of the Space Task Group through all subsequent programs. There was so much to be learned, and work to be done that unification of both NASA and contractor organizations in every activity was universally recognized as essential to the program success. The unity I had seen through the early Shuttle Program began to shatter, reaching crescendo on the Space Station Program in the period after the Space Shuttle Challenger accident resulting in lost opportunities, schedule and cost impacts, and many good leaders deciding it was time to retire.

Policy

The three basic elements that contributed to the success of the Apollo Program are: spacecraft hardware that is the most reliable, flight missions that are extremely well planned and executed, and flight crews that are superbly trained and skilled. These policies have guided me and my teams in all programs. NASA document SP-287, What Made Apollo a Success, provides many of the specifics related to the Apollo Program. This report addresses spacecraft development, mission development, flexible yet

disciplined mission planning and execution, flight crew training, and trajectory control techniques.

A key area I consider pertinent to system design is related to safety. NASA has six decades of experience in manned space flight, has written numerous papers related **to** design criteria, materials, fault tolerance, propellants, testing, and many other space systems design elements.

From the start of Gemini and for subsequent programs, the NASA astronauts, safety engineers, design engineers, and operational personal were embedded in the space systems design and change control process at program initiation. I had direct communications with the prime contractors' design and test organizations. This assured timely operational inputs to the space system design, development of flight procedures and plans, and the configuration of mission facilities and trainers. My controllers were some of the best systems engineers in the world. Astronaut John Young assured the mission control cadre participated in every major accident review and contributed to the redesign when needed

In today's "Commercial Crew and Commercial Cargo," NASA gets to see what is designed after the fact and often too late to make any critical changes." I have asked NASA personnel on several occasions who is accountable for providing oversight to the commercial crew space systems design, test, and operations. The answers I received were not specific.

The day I retired, I left a memo for Dave Leestma, Chief of the Astronaut Office, containing testimony by Admiral Rickover on accountability.

The Rickover memo described the lack of accountability for the 1963 submarine Thresher loss during a diving test with all crew aboard. This was the environment I experienced in the post-Challenger and early Space Station period.

"During the six years of the submarines design, the Portsmouth Naval shipyard had three shipyard commanders, three production officers and five planning officers.

The Bureau of Ships during this period had two Chiefs of Bureau, five or six chiefs of the design division and three heads of the Submarine Type desk."

I closed my memo to Leestma with these words, "With the emphasis on concurrent engineering and reinventing NASA, we must assure that individual responsibility is not forever lost. When the dust finally settles on the trials and tribulations of our programs, we must have individuals accountable for design, development, and operations."

If a crew is lost on a commercial crew mission, who will be held accountable?

While the world has changed dramatically since Apollo, and in the Space Program since my retirement in 1994, the one constant essential to success, is unchanged, it is leadership.

John Gardner, in the preference to his excellent book “On Leadership” states, “In order for an organization to function, leadership must be dispersed throughout all segments, and at every level there must be individuals capable of taking leader like actions to make their piece work. Men and women who are not afraid to send word back up the line that newly announced plans and policies need amendment or reversal.”

Gardner then comments on the large numbers of people who are torn loose from values they may have held previously, what he calls the divergence of value systems. “Leaders are always seeking the common ground that will make concerted action possible. *It is impossible to exercise leadership if shared values have disintegrated.”*

In conclusion, I believe the book, “*Apollo the Race to the Moon”* by Charles Murray and Catherine Bly Cox, provides an in-depth perspective of the programmatic, engineering, and operational elements responsible for the success of the Apollo Program. I would recommend that this book is made “required reading” for those who would assume future leadership and programmatic functions.

Today, our National leadership and the NASA industry team are at a critical, “go, no-go” point. “Now is the time to take longer strides…time for this Nation to take a clearly leading role in space achievement which, in many ways, may hold the key to our future on Earth.” President John F. Kennedy

Thank you for the opportunity to testify. I look forward to answering your questions.

Foundations of Mission Control

- **To instill within ourselves these qualities essential to professional excellence:**

  Discipline – Being able to follow as well as to lead, knowing that we must master ourselves before we can master our task.

  Competence – There being no substitute for total preparation and complete dedication, for space will not tolerate the careless or indifferent.

  Confidence – Believing in ourselves as well as others, knowing that we must master fear and hesitation before we can succeed.

  Responsibility – Realizing that it cannot be shifted to others, for it belongs to each of us; we must answer for what we do, or fail to do.

  Toughness – Taking a stand when we must; to try again, and again, even if it means following a more difficult path.

  Teamwork – Respecting and utilizing the abilities of others, realizing that we work toward a common goal, for success depends upon the efforts of all.

  Vigilance – Always attentive to the dangers of spaceflight; Never accepting success as a substitute for rigor in everything we do.

- **To always be aware that suddenly and unexpectedly we may find ourselves in a role where our performance has ultimate consequences.**

- **To recognize that the greatest error is not to have tried and failed, but that in the trying we do not give it our best effort.**

The Kranz Dictum

(speech to the control team after the Apollo I fire)

Spaceflight will never tolerate carelessness, incapacity, and neglect. Somewhere, somehow, we screwed up. It could have been in design, build, or test. Whatever it was, we should have caught it. We were too gung-ho about the schedule and we locked out all of the problems we saw each day in our work. Every element of the program was in trouble and so were we. The simulators were not working, Mission Control was behind in virtually every area, and the flight and test procedures changed daily. Nothing we did had any shelf life. Not one of us stood up and said, 'Dammit, stop!' I don't know what Thompson's committee will find as the cause, but I know what I find. We are the cause! We were not ready! We did not do our job. We were rolling the dice, hoping that things would come together by launch day, when in our hearts we knew it would take a miracle. We were pushing the schedule and betting that the Cape would slip before we did.

From this day forward, Flight Control will be known by two words: 'Tough' and 'Competent.' Tough means we are forever accountable for what we do or what we fail to do. We will never again compromise our responsibilities. Every time we walk into Mission Control we will know what we stand for. Competent means we will never take anything for granted. We will never be found short in our knowledge and in our skills. Mission Control will be perfect. When you leave this meeting today you will go to your office and the first thing you will do there is to write 'Tough and Competent' on your blackboards. It will never be erased. Each day when you enter the room these words will remind you of the price paid by Grissom, White, and Chaffee. These words are the price of admission to the ranks of Mission Control.