Transcript of

REVIEW OF U.S. HUMAN SPACE FLIGHT PLANS COMMITTEE

Public Meeting ■ Huntsville
July 29, 2009
8:00 A.M.

Committee Members

- Norman Augustine, Chairman, former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
- Phil McAlister, Executive Director, Designated Federal Official (DFO)

Members – Listed Alphabetically

- Wanda M. Austin, Ph.D.
- Bohdan Bejmuk, Chairman, NASA Constellation Program Standing Review Board
- Leroy Chiao, Ph.D.
- Christopher Chyba, Ph. D, National Academy of Sciences Committee
- Steve Cook, Project Manager, NASA Marshal Space Flight Center, Project Ares
- Edward F. Crawley, Ph.D.
- Steve Creech, Ares V Integration Manager
- Daniel J. Davis, Upper Stage Manager, NASA Marshall Space Flight Center, Project Ares
- Stephan Davis, Deputy Manager Ares I-X – Mission Management Office
- Bret Drake, NASA Lunar and Mars Integration
- Joe Fragola, Vice President, Valador Inc.
- Jeffrey Greason, Co-Founder of XCOR Aerospace
- Jeffrey Hanley, Program Manager, NASA Constellation Program
- Dr. John Hutt, Ares I Vehicle Integration - Chief Engineer
- Charles Kennel, Former Director of Scripps Institution of Oceanography
- Mike Kynard, Upper Stage Engine Manager, NASA Marshall Space Flight Center, Project Ares
- Robert Lightfoot, Deputy Director, NASA's Marshall Space Flight Center
- General (ret) Lester L. Lyles, National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program, Chairman
- Alex Priskos, First Stage Manager, NASA Marshall Space Flight Center, Project Ares
- Gary Pulliam, Vice President of Civil and Commercial Operations, The Aerospace Corporation
- Sally K. Ride, Ph.D., Former Astronaut

Public Commentary Section – Speakers Listed Alphabetically

- Tommy Battle – Huntsville City Mayor
- Dr. Barbara Cohen – Planetary Scientist
- Ronda Cox – High School Math Teacher
- Shar Hendrick – Vice Chairman Tennessee Valley NASA Advocacy Committee
- Homer Hickam – NASA Engineer (ret.) & Author
- Steve McKamy – NASA Contractor
- Michael Milling - Masten Space Systems
- Ray Moses – Retired Space Engineer
- Tim Pickens – Orion Propulsion – President
- David Ward – Space Camp Counselor
- Andy Welton – University of Tennessee – Physics Major
- Dave Williams – University of Alabama, Huntsville – President
- Dennis Wingo – NASA, DoD, DARPA & Author

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Presentation

Phil McAlister, Executive Director, Designated Federal Official (DFO)
Good morning everybody and welcome to the third public meeting of the review of U.S. Human Space Flight Plans Committee. I am Phil McAlister, I am the Executive Director of the committee and we are happy to be in Huntsville this morning. I say that just to remind us that we are in Huntsville because we've got several meetings in several cities and sometimes we lose track.

This is a public meeting. It is governed by the Federal Advisory Committee Act which means that among other things that the discussion, the presentations, and the comments today are all on the record. There will be a public comment period at the end of the day. We ask that people come up to the mics at that period. It is at the end of the day. We ask that you don't ask questions for the committee. There is a Q&A portion of the website for that. We would like to get as many comments as possible from the public so we are going to ask that everybody keep their comments to about a two minute period. And for members of the media, there will be a half-hour session at the end of the day today with Norman Augustine so your questions can be asked then. So again let's try to keep the public comment period to public comments.

In addition, if we don't get to everybody and we probably will. We have at every meeting so far, but if we don't get to everybody the committee is essentially available 24x7 via the website. It is http://hsf.nasa.gov. You can ask questions, provide comments, upload documents and thousands of people have taken advantage of that feature and we recommend that you do that as well.

Please do not interrupt the presentations today or the committee deliberations or discussions. Again, we are going to try and keep the public comment period to that session.

Please mute your cell phones. It is just like the movie theaters. Also transcripts for today's session will be available on the website as well as a video stream as soon as we can get that up there, probably sometime early next week. So with that I will turn it over to the Committee Chair, Norman Augustine.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you Phil and good morning everyone. Not only those of who are in the room but those of who are joining us on television this morning. We are very happy to be here. We've been working very hard on our project and you can be assured that we take very seriously the responsibility that has been placed upon us.

We have had an outpouring of comments, guidance, and advice from the public from members of NASA, from others, extremely helpful. All these, strongly held views of four dedicated people and unfortunately usually contradictory. That's the challenge that I think we face, perhaps our principal challenge. We have a very full agenda today. As you have heard there will be time for public comments at the end and we treasure that time so we'll protect it. I'm not going to introduce my colleagues or myself to save time, but we have our name tags in front of us here and on the website I think there are some biographies if you have any interest in looking.

We do have a website. We welcome as you have heard your comments. We receive e-mails, we twitter, we do almost anything we can to make it possible to get input from the public, the folks at NASA, and others who care; contractors and so forth.

We have been given 90 days for our task, which is a rather minimal time for a task of this complexity. The reason for the 90 days is that the White House would like to match the budget schedule and in order to do that we have to be finished by August 31st, which means I will remind my colleagues that we now have 34 days left to work. Yesterday you were told that it was 35, not surprisingly.

We have divided ourselves into four task groups, if you will. The first task group is addressing issues associated with the current systems, namely the shuttle and the ISS. That task group under Sally Ride, reported to us yesterday and today we will hear from two other task groups. The other three task groups that we have, I should say one is dealing with transportation from Earth to Low Earth orbit, which of course is one of the major cost drivers of whatever we do in space. The third group is dealing with beyond LEO and the fourth group is dealing with integration with any number inputs, particularly focusing on international aspects on work for other government agencies on commercial launch, if you will, and various other important issues including, for example, maintenance of a skill base for space.

We have been holding a number of preparatory meetings in addition to this particular meeting to do our homework and it is that homework that you will hear a part report of this morning.

I think that is probably all I want to say to keep us on schedule here. I would like to add just one caution to those who are in the room and those who are on television who are listening and that is that our group style is to ask difficult questions. We sometimes take a position that we really don't believe in in order to just draw out facts and test for the strength of various viewpoints so please don't interpret anything we might say as suggesting a conclusion that any one of us might have drawn or that we might have drawn as a group. As a group we have drawn no conclusions we're precluded by law from doing that until later-on. I could also tell you that the process of learning, even though many of us have been in this business for a few years, many of us are changing our views as we get more and more information. So please don't interpret anything you hear as a final view or is indicative of a final view because you will be trying to read the minds of someone who hasn't made up their minds. And with that caution again thank you for your presence and your interest and we will return to the first item on the agenda. I should warn my colleagues here, if you haven't heard, this is a push to talk system so you will be like the little boy with his finger in the dyke. The first thing that we do want to do is hear from Robert Lightfoot and get an update on the perspective of NASA here and it has been my privilege to be here many years from time to time. Robert, you need no introduction so we'll just turn it over the floor to you.

Robert Lightfoot - Deputy Director - NASA's Marshall Space Flight Center

And panel members and thank you for what you are doing for the country. I think this is an important endeavor. I was listening to some of the deliberations yesterday. You have quite a challenge on your hands. Maybe we can help you with it; maybe we'll add to your challenge. I don't know. We will see how the day goes.

Welcome to Huntsville. Welcome to North Alabama. We appreciate you guys coming back. Several of you were here with us last month and got to see the site.

I was telling my wife this morning that this is kind of like a concert tour for a young guy, right, from my younger days. And you guys you need to just sell shirts, right, as you go on this trip around the country. So we appreciate you making Alabama your second stop on your three day tour coming through here. So, we will see if ya'll are selling t-shirts afterwards so to help us out.

I intend to give you a little bit of our review of where we are and what we do here and what we think our roles are from a Marshall perspective and then talk about our capabilities a little bit. I am going to close with a perspective that I think you guys have asked for from the Center Director's….. the Center Director's spot. Next chart please.

So these are the roles we feel like we have at Marshall. We are responsible for lifting from Earth, living and working in space and understanding our world and beyond. I am going to touch on each of those as we go through and we make contributions in each of those areas.

Next chart please. Here as you see from Marshall you can see and most people know, you can see it hanging out here in the Davidson Center with the Saturn V we started back in the Apollo days. We are currently working the shuttle, as you guys know, and that is not that long bar that says shuttle, recognize that there have been a lot of improvements and a lot of work done during that time in development activities; block 1 engine, block 2 engine, updates to the RSRM and our super light-weight tank efforts and of course the foam efforts that we've been through after Columbia.

We also have spent a lot of time on the future transportation systems development that you guys have probably see a lot of the acronyms as we call them, but those have actually provided us quite a bit of technology development as we've gone along. We have factored all that in as we've gone forward. That's most of the roles we've been playing in and then finally of course we've been working ARES I and ARES V and you are going to hear more about that today from Steve and his team as we go forward.

Next chart please. The other thing that we do that probably isn't as obvious to the outside world since most people think "Rocket City" that we do rockets is that we do a lot of living and working in space activities. I think the important piece to know is we started that kind with Skylab and all along we have been very big in the development of payloads, payload operations, and payload racks. We do a lot with space flight. We work with them to do that. Today for space station we're supporting them with the oxygen generation system, the water recovery system that's up there now, and it allows us to get involved with how to live and work there. I will talk about that a little bit when we talk about the capabilities. Some of you saw our ecosystem, our Ecolab when you were here before. Those guys are doing some really interesting stuff that will allow us to kind of extend this venture past low earth orbit. We also provide the microgravity research rack that goes on the station where we do all the science and the material science research rack as well. So I think that combination is a bunch of skills we have at Marshall that folks don't realize and the support that we do there.

The other thing that I'll point out is we've done a lot with the nodes. We've managed those. It's not just doing the work; it's also the program management that comes with it. And then finally we have the Payload Operations Center here 24x7 all the payloads on the station come through Marshall Space Flight Center to get the work done and that's recently cranked up from two or three countries to about fifteen with the addition of the Columbus module and the JAXA Kibo module on the station. So our payload operation center is very busy. They are also the back up

control center for Houston and after hurricane Ike last year we had about 35 of our colleagues from mission ops in Houston come over and run the station from here. So it was a good check out for us.

Next slide please. So another piece of this that I won't spend a lot of time on, I just want to point out as we do a lot of the work and science and a lot of folks don't realize we managed Hubble and Chandra, two of the greatest observatories in my opinion everywhere you go. The important piece that I want to point out that relates to Human Space Flight is when you look at Hinode and the Lunar Precursor Robotics Program; this is how science can work to help Human Space Flight. Hinode is helping us understand the sun. It's a Japanese mission, but we have a principal investigator here. The things that we are learning about the sun will help us as we get out past lower earth orbit and start dealing with affects of the radiation from the sun on humans. The Lunar Precursor Robotics Program, the two missions that AMES and Goddard have put together are going to help us understand where we might want to go on the moon when we go there. So that's what those guys are doing.

Next chart. So that is kind of our roles and in those roles lead us to what we consider a set of capabilities. So I'm going to talk about each of these a little bit. The lifting from Earth of course that means we have to develop the transportation and propulsion systems and development of the integration of large complex systems for living and working in space and then of course the science side of it, understanding our world and beyond.

Next chart please. So for the transportation and propulsion systems I think the important thing here is that these capabilities that we have here start at the program project management level, that's critical. I mean we can't do anything if we are not managing the projects appropriately. Systems engineering and integration, if you look at every one of these systems is a complex system, you have got to have the integration piece and we do that here very well. I think we have an organization dedicated to that in our engineering department and we have an integration group in each of our project offices that we have here that are responsible for that.

The propulsion systems and components work that we do, if you look at our propulsion lab in engineering, it is a group of folks that goes all the way from the valves, lines and ducts, all the way to the turbo machinery and combustion devices and the Full-up system. When you look at propellant management delivery we have teams that do tankage, they do main propulsion system work and have been doing it for years. They are the folks that do most of this for NASA in terms of getting that ready to go.

The other piece that is important is modeling and simulation. You saw some of that I think. Those of you who visited with us before when we went to our Cedar room where we talked about how the modeling and simulation plays into the design process and how those tools have become very helpful in the design process to kind of give us some early warning of some issues that we may have.

And then finally in the manufacturing area, we're doing a lot of things that are pushing that envelope on manufacturing at least for space materials. And the guys I think say "well have you seen it"? It's not just the manufacturing and materials pieces; it's the processes that go with it. Laying out the manufacturing flow, the things that we've got to do on the shop floor to actually put these things together in the right way. I think you saw some of that with the friction stir weld work

and also with the work on the common bulkhead that we showed you when you were here before. Those are the kind of things that are going to push us to the next level.

Next chart please. So in the large complex systems, again, it's the program project management area that we've got and systems integration engineering, those could go across everything. Another piece that we do is the regenerative ECLSS. If you look, you guys, some of you saw it, some of you actually drank the water from our system. Our team was really excited by the way. I've got to tell you that when you guys picked the water up and some of you started drinking it they were "wow". I laughed at Leroy because Leroy said I'd drink it if I had to. But he didn't pick up a bottle. But anyway, the team was very excited to show you what they are doing. Right now they have gotten to the point we have got a water recovery system on orbit, an oxygen generation system as well, that's part of the pieces that allowed us to go to six crew on station. We had to have that to be able to do that. So the team put that together. That lab, the work they are doing now will certainly be something we can morph toward any surface systems or any habitation work we want to do down the road. That's what we have got to have.

The vast concepts work that we do and architectures you guys, some of you have had Reggie Alexander and his team brief you. That team does an awesome job. They can take any scenario that you can throw at them and putting the trappings around it and they have some good tools and ability to model that out.

And then one of the bigger things that we have is this tremendous testing capability that we have at Marshall. We showed some of you the stuff that we're doing for thrust oscillation related to lock stamping in one of our structural test facilities. Those are the kinds of things that you have to have. The Software integration lab where we do all of the full-up hardware and the loop software integration and other stuff that is very important for us to be able to get through this. And then the propulsion testing and the big dynamics' testing that we do will allow us to… it's just the capability that we have here that it's hard to match.

We are also working technology maturation stuff. We are working with ETDP for ESMD. We are doing some things related to the descent engine, descent engine technologies for a lander and our teams are working that plus some RAD hardening for the electronics they have got to get out into space.

Next chart please. Then on the science side, again this is just kind of a list of some of the science stuff that we do. The one thing that I will point out that I think that is important for the Human Space Flight piece is the bullet next to the bottom there is the in space propellent propulsion and surface power systems. We do a lot of work with Glenn Research Center. In this area, with the surface power systems, we've got some nuclear capability. I hear that it allows us simulation, or I should say simulated nuclear capability that allows us to test potential systems that will allow us to survive on the moon. We are also doing some in space propulsion work with Glenn and then the cryogenic fluid management and things that we're going to have to do on orbit once we get to that point. It's an area we've been working on for years here.

Next chart. So we kind of feel like we've got the lifecycle capabilities and we think that the full lifecycle is important.

If you will hit the next chart for me. It starts with the advanced concepts. I've showed you guys this, some of you this before and I just want to get it as part of the record. The advanced concepts are important. That's where you kind of lay out what you are doing.

Next chart. Then you go into technology development where you take, what am I going to need, where are my technology items and that's the area that we do here, especially in the manufacturing arena.

Next chart. Then we start the design and analysis process and it is very iterative at this point where we go back and forth between these two so the teams are all there to do that.

The next one is of course manufacturing. The important piece about manufacturing I didn't point out earlier, Michoud Assembly Facility belongs to Marshall Space Flight Center. It is one of our satellite spots. A couple of you went down there with us to see that site. What we do here at Marshall is we kind of develop the one-offs and how we are going to make these things work and we send them to Michoud as part of the production, to start to begin to integrate what we learn here down there. I think when you guys saw the friction stir welding that we did for one of the domes, you recognized that the Boeing guys were there, the Michoud guys were there, everybody was there that was going to take that down.

Next chart. Of course you have got to integrate all of this into an assembly and test it. We've got the capability to do that. We have a software integration lab; we have full-up ISTA and Integrated Systems Test Article that is going to have the upper stage in the J2 test set for the first time. That will all be done on test stands that are sitting here left over from the Apollo days. And then, of course the last piece is the operations and sustainment. I think it is really important to recognize that you have to kind of be tied into the operation's piece to know what to fix in the design cycle. So, Marshall has got that and that is what we think the system's engineering does for us. But I tell you we don't do this alone. This is not something that just Marshall does by itself. We are just a key part of the agency with these capabilities that allows us to bring to bear what we bring to the Human Space Flight story.

Next chart. What I want to touch on here a little bit because you guys asked about this or have it in your charter is the industrial base. I think a lot of people when we talk industrial base they get just a commercial or an industry piece of that and I think when you look at Marshall, Kennedy, Johnson, and Stennis from a Human Space Flight perspective we are part of that industrial base. We are part of the national capability. We have a lot of agreements in place as you see, 70+ Space Act Agreements and these are agreements where people come in and use our capabilities, our people, our facilities, to do things they might not be able to do in their own company and I think that is an important thing to recognize. We are not the only ones that do this by the way. Most of the centers do this. I think we have a history of sharing those capabilities with the industry and I am going to talk about that a little bit when I give my perspective because I think that is an important piece. So when you guys think industrial base I hope you recognize that NASA sites are part of that industrial base that allows us to do Human Space Flight.

That's kind of what I wanted to show you from a, next chart please, from a perspective of capabilities, a real high level of course. The intent of that was just to kind of give you an idea that the extent of the Human Space Flight capabilities here, but also the fact that they are a part of a much larger capability that the agency has and frankly that the county has from an industrial base perspective. It is a little bit of a…I don't know.. you've got kind of a… it's not an exciting

presentation right. There's not any videos. They asked me earlier if I had embedded videos. I'm going "Oh God no, I can't do that". Only my buddy Steve can do that.

But what I want to point out from my perspective is that this is not a time to be passive about our future. Okay. I think from my place and you asked for the Center Director's perspective and from my perspective I think we are kind of at a crossroads for Human Space Flight. I think it hangs in the balance a little bit and I think that if I sat here and just gave you that pitch you just saw it would almost be as if I was silent or indifferent to what you guys have on your plate and what you have in front of you. And I wouldn't be representing my team at Marshall or this community that has probably invested most of their time in Human Space Flight over their careers. So you asked for challenges, we've got a bunch of challenges. There's a lot of challenges. We will always have technical, we will always have workforce, and we will always have infrastructure and resources. It will always be there. It is part of this business. Anybody that has been in it for a while, I don't think I have ever had a budget that was good enough. Okay. I mean that is just the way it has been since I have been here.

That said, for me the biggest challenge is maintaining the capabilities that we need for the future during this gap. I heard you guys talking about the gap yesterday. We have gone through a really strong process to establish what Constellation needs that we have today, that the shuttle is carrying. So I think we have got a good feel on the what, the question is the when they need it and that is when it sometimes becomes problematic because they may not need it for three or four years so what do we do. That kicks off a whole another process for us. So that is a big challenge, but I want to be really clear. It's not the facilities and the infrastructure that I'm worried about, it is the people. Because the people we have is where intellectual capability is and the folks that work at Marshall, Johnson and Kennedy, they are a national asset period and I hope you guys take that away. So I think that is probably the biggest challenge, there is a lot of challenges, but I think that is the biggest one. I didn't want to overload your plate. I heard you talk yesterday and I think you know some of the other challenges that are out there.

As for perspective on Human Space Flight, perhaps the events of the past week summed it up for me the best with the 40th Anniversary of Apollo. You know the focus last week was on the people and I think if you all take a little bit of time and think about Human Space Flight, think about the images you have kind of etched in your brain when it comes to Human Space Flight. For me it's obviously Neil Armstrong and Buzz Aldrin walking on the moon. It's John Young pumping his arms when he was walking around the Columbia after the first landing. So excited about what we've done. Its John Grunsfeld hanging on the end of the robotic arm silhouetted against the Hubble Space Telescope. The best example of Human Space Flight and science together and then it is Pamela Melroy and Peggy Whitson sharing an embrace when 120 has joined the station for the first time to show that we had both a female shuttle commander and a female station commander. Each one of those represents an incredible, technical achievement. I mean I could tell you the technical piece of all of those but what is interesting is the human piece and the piece how that relates to us and how we as humans can take that and grab our attention. You know, we are driven by the natures of our successes and failures and sometimes cynicism can run kind of high in this 24x7 world that we live in. It's pretty easy to get everything out in the public eye so quickly. I sometimes wondered today if we would have continued Apollo with the early launch failure that we saw if they were so public. And I wonder if we would continue with the shuttle. I remember test engines blowing up in test stands early on too. It is part of the process. I think our memories forget that forging this new frontier is hard. It's full of challenges. So why do we choose to explore with humans. I had to be reminded of my own reason for pursuing a career in

Human Space Flight business and frankly I had to peel back some of that cynicism and scar tissue that gets built up over the years to be reminded. And it was standing, when this rocket that was out here was outside I was standing at the end of it looking at the F1 engines, just had taken a propulsion class in college, had no idea what a rocket engine was but boy I could do the math, no problem. But to see that F1 engine I thought "Wow, this is pretty cool. This is actually what I have been studying". And it drove me to get interested in engines and engine testing. I followed on and became a specialist engine test conductor and just loved it. That was my favorite time in my life was running tests and trying to make the improvements to the engine that we needed to make to get to be a better engine. It gets in your blood. You know it kind of gets in there and you can't get it out of there. Even today when we get done here I'm going down to Stennis. If you don't think transition is real today is the last planned SSME test at Stennis Space Center. Now I probably won't make it in time for the test unless they have some lightning, which I'm kind of pulling for, but I will at least get down there and see who I really want to see which is the team; my peers, my buddies, the folks that really were part of my career and have been part of my career all along.

The point is that when you think about that piece of it, for me it wasn't the rocket engine down at this end that intrigued me as much as it was that little bitty capsule at the other end carrying the three people and what we needed to do to make that better. It is no different than when we had the shuttle crews come to Marshall Space Flight Center and recant their missions. You got Sally and Leroy have done that I know. When they come into recant their missions we always invite at least two or three elementary school classes to come. They can bring all the pictures they want but without them sharing their thoughts, their perspective, it's just a book. They allow us to put the human part of that is what grabs our attention.

I spent some time with our younger folks here last week. I just had got lucky. I got real lucky. Actually I had a meeting with them. They were presenting some things on actually retraining and retaining talent. How do we keep them interested here at Marshall? So knowing I was coming here I said "hey I've got a job for you". I handed him my index cards and said tell me why NASA because these are some sharp folks. Man they are sharp. Why NASA and why Human Space Flight? And needless to say they threw my index cards away and they sent me emails. So I didn't get any index cards but I did get a lot of input. The funny thing is that when they left that room they went back and they kind of started their own little network of "hey, Mr. Lightfoot asked us a question, what are we going to go do"? Well, I got a ton of emails. So what I want to do is just share some of these. This is very inspiring to me and it gives me great hope for the future when I hear what these folks said.

Why NASA? "NASA is my dream job". Another one said "I want to be a part of making the greatest discoveries ever made". Another one, "my desire to work for NASA has been my motivation to succeed my entire life". "I want to be part of a team that makes the impossible possible". Some of those guys are here today. I asked them what about why Human Space Flight? You've got to realize these folks are probably about 20 years old, 22, 23 maybe the max. Why Human Space Flight? "Exploration and the challenges of the unknown provide the opportunities that an individual in society need to fulfill their potential". "Great challenges precede great results; Human Space Flight is such a challenge". Another one, "We're the first and maybe only species that has the ability to potentially extend our biosphere beyond the confines of one world. It would be a shame to waste that potential". "When we left Earth's orbit we crossed a line and there is no going back. Stopping now would be like Christopher Columbus stopping in the middle of the Atlantic". And then the final one I picked up, "To me there are two main factors that

drive us to explore our solar system; natural curiosity and concern for our future. The first of these factors makes further exploration inevitable. The second dictates that exploration occur in a timely and thoughtful manner. The only question in my mind is how much we want to invest in this inevitable venture. How much do we desire to remain at the forefront of this frontier and how long will it be until myself or my children experience the sense of global unity that resonated around the globe when man first set foot on the moon". Twenty-year-olds, I think we've got a good future. I think we are okay.

With all of our background in recognizing that we at this agency implement policy and don't set it. I would like to share with you from my prospective since you asked for it. The outcomes I must wish from your efforts.

First, I think we need to extend the International Space Station. We continue to learn from this magnificent platform how to live and work from space. Whether it's studying the effects of long term exposure on the human body or whether it's learning how to fix a carbon dioxide removal assembly that we did this weekend. That is what we are learning. That will all help us to go longer distances and spend longer time in space.

Second, we need to get out of low earth orbit. I believe the Constellation architecture is one of the possibilities to do this and we are making progress every day. You are going to see that later. However you frame it, we need a heavy lift capability. And no matter what options, I had recommendations there, but I was reminded you are making options not recommendations, but out of all the options you provide I certainly hope that you will set an expectation that there are going to be bumps along the road and there are going to be surprises. That's the nature of this business.

I think third, as you think about, as you read through all the way back to your 1990 Commission all the way up to the one that just came out from General Lyles. There is a common theme in there that no matter what policy comes out of the options you guys present, I certainly hope that we will be reminded, or you will remind them that the policy has to come with the resources to get the job done.

Fourth, I think there is, I kind of categorize this one as collaboration. I think there is huge opportunity for collaboration. We have fallen, in my opinion, into the trap of the tyranny of the "or" verses the power of the "and". We have made it commercial or NASA instead of commercial and NASA. We have made it. That is something we have got to fix because if you look at the capabilities I presented and you look at the Space Act Agreements and you look at the things we can do sharing the capabilities, to me that is an important thing to do. And that's not just commercial, that's us working with international partners. I sat in the HTV review last week for the Japanese transfer vehicle and that is one of the neatest reviews I have ever been in because you had the Canadian Space Agency, you had JAXA, and you had the U.S. side talking about how we are going to actually capture this free flyer HTV and we are going to use the Canadian Arm and go grab it. We wouldn't be doing this. We wouldn't be doing this if it wasn't for that opportunity. That international collaboration is really important and they do bring things to the table that we can use. No doubt.

And the final piece of the collaboration that I will talk about is I think General Lyles has this as his sub-team so I will just pile on that the collaboration between us and other government agencies is something that I think we can take advantage of.

Today we did it in little bitty pieces. We are helping the Air Force with their RS68. They are using our propulsion engineers in some of our facilities to do some improvements on the main injector that they are looking at for the RS68. That's the one way.

We use the Army here and locally. Not as much as we should, but we use the Army locally to help us with some of our satellite motors that they pour for us. Some of the smaller satellites that we use and then we test them over on the Marshall's side. So I think there is room there to go do that and frankly it is the power of "and", not the tyranny of "or". When you are in a resource-driven world like we are I think that is what you have got to look for is ways to get there.

Finally I guess I would hope that each of you will kind of step back and think what got you interested in Human Space Flight. Just for a minute. I know you can't do this very long. Step away from the architectures, the scenarios, the resources, and ask yourself why Human Space Flight. I believe a section in your report should be dedicated to why Human Space Flight not assuming that people believe in it. A section in your report; dedicated to Human Space Flight and why presented to the President from this Board, this chosen Board and a very respected group in our Industry, a highly respected group in our Industry, would be a powerful message indeed.

A lot of us grounded explorers live our experiences of Human Space Flight through folks like Dr. Ride and Dr. Chiao and why we can't share their same feelings; I think we can share the sense of accomplishment of turning that impossible into the possible. It will inspire the next generation. I think you heard what our folks said and I didn't even bring 10% of what I got. It provides a place of leadership for this country and we have given that away in a lot of areas. It does provide us that leadership and it also provides technical and economic benefits that I cannot even begin to predict. Everybody has asked me. All I know if we don't do it we won't get those benefits and we won't learn. So I do believe we stand at a crossroads for Human Space Flight and I think you have direction from the most powerful man in the world, the President of the United States to provide guidance for the future for our endeavor. You have asked for input from a lot of folks including me, a small town kid who didn't know what an engineer was when he went off school and certainly never thought I would be standing here talking to a Presidential Commission on Human Space Flight. But my input is pretty simple for you guys and I will tell you what I told my folks when the Commission was first formed. Recognizing that I am from the University of Alabama and it is almost football season, so football kind of comes into play here. I told everybody that the Augustine team is going to throw a pass. They are going to throw it to this new administrator or the new administration and our new administrator and our new administrator is ready to catch it. If you haven't noticed he is pretty passionate about this stuff. He is ready to catch it. All I ask is that you throw a pass that they can run with and when you do this team at Marshall Space Flight Center and this community is ready to support any way that we can to continue this endeavor of Human Space Flight.

Thank you. I will take questions if you have got any.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you very much. Your comments were not only very informative, very inspiring. Perspective of time, I would like to ask two things that I'm going to ask my colleagues if they will bear with me and we'll just ask those two things of you. We will have chances to visit with you at other times.

The first is do you think the people on your staff who raise all the logistics for us they have done a terrific job. More to the point, you made some comments that nonetheless probably are sympathetic to one of which is if we are having Human Space Flight Program it ought to have goals that are exciting and motivate people.

Secondly you make a point that we certainly agree with is let's match the goals to the budget. Let's don't tell people to go do things and then not give them a budget to do them. We feel strongly about that.

But when you put those two things together, you can see where I'm headed, the National Budget challenges, there is a danger that the decision maker, whoever that might be, may just say okay we take you at your word we are going to have to shut down. We can't do this. Are you prepared to take that kind of a risk?

Robert Lightfoot - Deputy Director - NASA's Marshall Space Flight Center
I think that personally I worry about a program that isn't, if we have a program that is not fully funded is kind of a dream and we will just get in a mode where we are not making the progress we need and we can get into the mode where we do things unsafe. My personal opinion. Okay. I think Mike Coates said it yesterday. He said there are no shortcuts. I recognize the challenge. Don't get me wrong. I certainly recognize the challenge. I heard it loud and clear yesterday and I kind of knew it beforehand but you guys presented some data that actually I had not seen yet, but I believe that if the country is going to do it, we need to do it. I told some of my staff the other day that this is kind of one of those big toe or all in. I don't think we can get by with just putting our big toe in the water. I think we have to go all in.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you very very much. Unless any of my colleagues has something that is urgent to ask now I think we will march on. Again, I appreciate your comments, you leadership, and all that you and your team do.

Robert Lightfoot - Deputy Director - NASA's Marshall Space Flight Center
Thank you for your time and again thanks for what you guys are doing. You have a good challenge ahead.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
You bet.
We will turn ahead then to the next item on the agenda. As I mentioned earlier our team is divided into four sub-teams, if you will, to address various problems. Today, as I mentioned you will hear from two of them, the first will be the one that's been dealing with the issue of access to LEO, which is a major cost driver. It has a lot of complexities. That group has not had a chance to debrief all of us so you will be hearing along with us for the first time the findings of that group and we will be talking about it. Bo is going to make the presentation. Bo do you know how use the podium so you don't have to keep your finger on.... on this darned microphone the whole time. I probably should caution you about Bo. For those of you who don't know him, he tends to be very subtle so you will have to look for nuisances of what he says.

[Laughter]

Bo are you ready?

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair
Does this mic work? Can you hear me? Well, good morning. When I began my career in the aerospace business in Huntsville, believe it or not, I was a Rockwell guy assigned to…

Sorry.. you are not turned on.

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair
How is this? Is this better? I began my career here on Mated Ground Vibration Test of the Space Shuttle and I remember I was a new engineer in aerospace business and for the first time I experienced the hospitality and warmth of the Huntsville people. And I was working on a program that was questioned. Shuttle was questioned. The value was questioned. It this a right course for America? In retrospect, now that I am now 69 years of age and I look back when I was a young guy working on the program, I feel privileged that I was working on a program that was actually finished. This country had enough stamina and was willing to fund this program and see it through its conclusion. Shuttle was not the perfect solution for anything but, as you know, we took it on, we finished it, we proved it to ourselves and to others that we, Americans, can do something difficult and do it well. And I hope whatever we come out in the future that we will have a chance to finish something.

Going back to what I'm really supposed to be doing here is briefing you on the LEO access. As Norm mentioned, we are divided into groups; Sally actually briefed yesterday her portion which has to do with flying out Shuttle and with addressing the issue of an international space station. I will talk to you about LEO access and of course, General Lyles will talk you about the international and the integration arena and tomorrow, Ed Crawley is going to address beyond LEO. And if you look at this division, it maybe is not all that perfect, but it was trying to get these chores to a manageable level. But you can also see that they all need to be integrated between them. You cannot do LEO access without addressing beyond LEO. You can't do LEO access without addressing station and shuttle questions. So we are in a process of actually doing this integration. Because you can't really pick, you can fall in love with a launch vehicle and you should not really optimize a launch vehicle because that launch vehicle has to be driven by what Sally and Ed feel in terms of their scenarios. So what you will see today is how far we got so far and that job isn't finished because there is still that element of integration between the other two teams.

So let's see how do I change charts here. I'm sure there is something I (can) press. A little bit about that charter. We were to examine and evaluate existing and proposed and some of us called it affectionately paper systems and, of course, including Ares I and Ares V and propose the best support to the beyond LEO and ISS and sub teams. And I'm stressing that thing because you try to match a launch vehicle to what its need is. You don't look at the launch vehicle and select it because of its individual virtues and this shows a membership of our sub team, myself, Dr. Sally Ride, Dr. Wanda Austin, and Dr. Ed Crawley. I'm the only guy who was too lazy to get a Ph.D., as you can see from this chart.

Okay. Our approach has been to identify the broad range of this government and commercial launch vehicles and to make the choice sort of a little bit organized, we have and I'll now show you how we have done it. We have segregated it into the classes by their launch capability and we have received a lot of briefings and we will receive briefings from the Constellation folks, from other NASA entities, and from out… from industry. There are a lot of proponents of their systems. And of course, we have received the whole bunch of briefings about Constellation and some of us call it program of record. So we… and it was a part of the management job was to manage all the information that we receive and sort out things that we… one of them is how believable they are, how credible they are, and to help us with that chore, we have asked Aerospace to provide us some technical evaluation because we have a short time to do this and there are a lot of data to look at and we don't have the staff. This is it. Commission is what you see us here plus a few people who help us move around and set up these meetings. So we have asked Aerospace to provide us an independent evaluation and for me, personally, it is very important to do it in a level playing field. Use the same criteria. I was a party to setting the criteria to make sure that like everybody gets a fair shake with when we start looking at these alternate systems.

We have also asked to Aerospace to provide an evaluation, independent evaluation, of Constellation. And you can see the logic for that. It would not be appropriate to ask NASA to give me an independent evaluation of your work so we went to Aerospace, they are credible, they do this by the way all the time for NASA and well as DoD. So armed with these briefings that we received from the industry with the help from our friends in Aerospace, what we have ahead of us is to take a look and we are in the process of doing this. Take the scenarios that were developed by Dr. Crawley and Dr. Ride and see how we can match these launch vehicles that we have identified with those scenarios. And so we are using all the data and believe me, I have a stack of data which is probably 4 or 5 feet tall. I don't think I will be ever to go through all of that, but we try to get to what is of substance. We will apply results from Aerospace's independent evaluation. We have to consider the NASA budget constraints and, of course, safety and human rating will be important drivers. So I'm just trying to present to you a little bit of the logic of how we are going to arrive at proposing the launch vehicle which will best match the scenarios that Sally and Ed are coming up with. And we will try to favor systems that encourage commercial and international participation particularly with those that end with a mission to low earth orbit, either ISS or other low earth orbit.

We feel… NASA has been doing some wonderful things for a long time. NASA is good at it. I personally feel that NASA should relinquish some of those tasks which the industry can do, open the door to the new commerce. NASA has opened the door via a COTS program. They should do more of that and allow the new commerce to come and do some of these chores that NASA does not have to do because NASA has done it over and over and have NASA sides turn to more lofty goals that like going or returning to the moon, going to Mars, going to other heavenly objects. So, we will try to promote a little bit of this additional participation by commercial and when we are through with this integration using these criteria, I will be prepared to present recommendations of the launch vehicle selection that best fits their scenarios in the DC open meeting that is coming up.

Let me just show you a little bit of these classes of launch vehicle. You can see that we are not discriminating. From little tiny rockets to your Ares V and those by the way are numbers of equivalent capability to low earth orbit and you can see that there is a huge range of things and one thing that I have learned over my rather lengthy career is to try to find a right tool for the job.

If you want to do something between the surface of earth and LEO, you have a different set of launch vehicles to look at. If you have a massive trip ahead of you, maybe you want a bigger vehicle. So this shows a broad range of things to select from.

Just a little bit about logic… how to select… the committee has a set of goals. They are very broad goals and you can see the two teams. Sally is on the left and Ed is on the right and those two people and their team will select the scenarios that fit their overall goals. My job is to take those scenarios and this line essentially, I call it filters because I wasn't sure how else to call it, but it's a means of segregating or picking the best launch vehicles that match those scenarios and again, we'll use the briefings that we have received, Aerospace evaluations results, and our own judgment and judgment is important here because you hear people's briefing and sometimes you have to put your own little filter on it and by the way, we are not on this committee, I hope only for… because of our good looks, hopefully we'll bring something that we can call judgment.

So what I'll do now, I'll turn it over to my colleague from Aerospace, Gary Pulliam. I can't see him because lights are in my eyes. He is here and he is to walk you through a couple of their products. One was this launch system independent evaluation. We're looking at a broad range of the systems from Ares I to Ares V to Little Taurus and using the presentation that we have receive and data that they have received from these promoters of these systems, we were given an independent… approach how we are arriving at this independent evaluation. He will also give you the cost schedule and technical evaluation of Constellation and I'll come back a little later and wrap it up. So Gary, let me turn it over to you.

Gary Pulliam – The Aerospace Corporation – Vice President of Civil and Commercial Operations

I was told that… I mean as I stand next to you you'd need this.

Good morning, Mr. Chairman and the members of the committee. It's my privilege today to share with you some of the work of The Aerospace Corporation has done in support of the committee's work. Today, we'll talk specifically about two of our studies; we've done several. We'll talk specifically about our look at alternative launch concepts and our assessment of the Constellation program.

Before we begin that, I'd like to put these studies into some context for you and I have taken them here in reverse order in which I will present them later.

First, let's talk about our assessment of the Constellation program. Here, we have an existing government program of record. Detailed data exists in all elements of that program so far and I would point out that NASA has been entirely cooperative and gracious in supplying us all the data that we could use and digest in the short period of time we had to do this study. We did not and we're not able to do detail cost analysis, independent cost estimates, and those kinds of things that would have been useful. Those efforts generally are in the several months category rather than the two- to three-week category that we had in support of you. But they did give us data. We did use it and we did try to assess that data in our findings today.

When you have a program that is a government program and is reasonably far along in its development, you understand the risks and the challenges more deeply and more thoroughly than you might for some other systems and we'll talk more in a few moments about how we looked at those risks but that's an important factor.

And importantly, for a government program of record, it either conforms to or it doesn't conform to the existing funding profiles that that agency has and I'll show you in a moment how important that element is. But all of these kinds of things go into an assessment of a government program of record so it is as detailed as time allows and as the program has to date with its own progress.

Then secondarily, you look at our request to assess alternative launch concepts and note the differences here. Here we have systems that are at various levels of maturity from, as Bo said, design studies to vehicles and systems that are attempting to get into a test flight to systems that have flown and other configurations perhaps than the one that would be required for Constellation.

Believe it or not, we find that when you look at purely commercial systems with the limited historical data we have that getting to a full mature reliable initial operational capability might even in fact take longer than a government program, so those things have to be considered in a historical context.

We realized that for these systems limited data exist, more data on some programs than others, but in all cases, more limited for our purposes and our evaluation than that which we got from the Constellation program.

We know that challenges exist with these programs so when a provider suggests that he might be able to accomplish a part of the Constellation mission, many other questions must be asked. Are you going to integrate the Orion? Are you going to integrate the EDS? What are you doing about Altair and other configurations? Have you contemplated in your proposals of when you can get your launch vehicle ready? Have you contemplated these integrations? Do you understand those challenges? And even for some programs who say, "I'm not going to use those elements of the existing architecture. I will develop my own." then that brings a whole new set of challenges, too. Many of those, at least to us, are reasonably or at least are comparatively unknown with regard to the kind of things we see in the Constellation program.

We recognize the importance of COTS. We recognize that progress is being made there. We congratulate NASA and the providers for that. We wish them success and it accomplishes an important mission, but it is a complement to exploration. It does not accomplish the exploration mission in terms of the medium-lift vehicle and the heavy-lift vehicle and getting out of low earth orbit as both speakers have said before me. And really importantly, we did not have time and perhaps it is not knowable at this point but the conformance would be the budget profiles. And that is critically important. Someone might say that they can develop a program in a certain period of time for a certain amount of money but a lot of detail work has to be done before you would see how that fits and the funds that are available to that program.

So I just like for us to keep those comparisons in mind as we go because there is this tendency on all our parts to take the results of one study and apply them and compare them to the results of the other study and it is my personal view that that would be a disservice to both studies if we did that. They are different. They approached it differently and they were for different opinions.

In fact, my view of our assessment of alternative launch concepts was as Bo said, to provide a level playing field for a comparison among those systems and that class of vehicles. Which one of these guys look better or worse and who is trying to do what mission to take the results of those and apply them directly to our detailed analysis of Constellation, I think, can create some problems.

So what did we do? We were asked to do a comparative assessment on the alternative launch vehicle assessment for these systems. We spent some time figuring out how to this because we recognize, as I've said before, some systems are flying, some systems are in design. Systems have various claims. They are attempting to do various missions. So we developed an assessment methodology by using metrics to assess these alternative launch concepts. We shared those metrics with all the providers of the various systems. We told them what our task was and how we were going about it and how we were going to assess or grade their systems. We offered them the opportunity to share with us anything they chose either in person or by delivery and all of the systems either did come in and brief Aerospace for a half day at a time or provide data to us as they saw fit. So we took that data that they provided us and tried to come up with an assessment.

Everybody knows and you saw chart that Bo showed a moment ago and I'll show it again in a moment that these systems are of various capabilities at least when looking at mass to orbit. They are attempting to do different parts of the mission. They have varying levels of claims of what they are trying to do. We try to look at these systems with regard to cost and schedule and performance and clearly safety and human rating. Are these systems human ratable? What do we see about maturity? What do we see about design factors that we understand NASA is applying to the Ares I program. How would we see those flowing down? Do we believe the offerers have assessed those as they would need to, to incorporate human reliability? What about ascent trajectories? What about G-loading? So we try to interpret those kinds of things as much as we could because we realize that safety in human rating is pervasive and most important as you look at alternative options for doing a part of this mission.

In looking at the Constellation mission, we categorized these offerers into these four classes. As you can see here, crew to ISS and cargo to ISS, and then crew and cargo to the Low Earth Orbit lunar rendezvous point by attempting to show who is attempting to do what? It was important for us to set up a metric process where a person who is claiming and offering to take humans to ISS and Lunar Rendezvous Orbit is not penalized because he can't do the heavy cargo mission. So we had to find a way to give, as Bo requested of us, a level playing field against what these systems are proposing to do and claiming to do and how that fits into the system.

You saw that chart earlier just a reminder to us as we go through that systems are of various capabilities and various sizes and that's important to the committee as you consider the kinds of systems that you would anticipate or contemplate putting into an architecture and your recommendations. So we recognize we have folks from Taurus on one end to the big guy, Ares V, on the other end and how does that fit into the mission that you're trying to accomplish?

We also have charted these offerers as they claimed to us against the parts of this mission that they were trying to accomplish and you can see that here. No surprises here but it's a reminder to us to keep in mind as we evaluate various systems, what is it that they are offering to do and what is it that they're claiming to do?

The way Aerospace approached this problem, as I said, was to receive data from these companies. Now, Mr. Chairman and the committee, as you well know, every page of every piece of that data came to Aerospace stamped company proprietary and we took that data and assessed it and rolled it in to a massive presentation that many of you have already received, some of you more than once. It's about a three-hour presentation when we are hurrying. But that data, even as we've assessed it, we hold as still being proprietary. There's not time today in this public session to give you individual assessments of these alternate launch vehicle systems nor did we have the time honestly to go back to each of those companies and have them go through a detailed analysis of whether or not they would consider what we said about their information to be proprietary or not.

So with your permission today in this study, I'm going to show how we went about it recognizing that the committee has the data that we've given you in your fact finding sessions and in great detail and in each of the areas but I think it's important for the committee and the public to understand how we approached this problem. We did look at system claims from the offerers and everybody has claims about cross performance schedule and how human ratable they are if they're offering to do that mission. So everybody was consistent in making claims around those metrics. But there also other metrics that we felt were important that weren't necessarily claimed by the offerer. Some of them were, some of weren't. Some offerers didn't have much to say about infrastructure, many didn't have much to say about the NASA workforce. Clearly, it is important as you've heard already from Marshall. It is important to consider the workforce. So we tried to assess the effects with these metrics that I categorize as not necessarily claimed by the system, yet we wanted to see what we thought about their claims in these areas.

And then finally, we had over 70 secondary metrics that we use to inform these primary metrics. So beyond each of these is more and more and more detail of how we came to our view on performance or operability or any of those factors.

We began by creating a quad chart for each of the systems we looked at and this is just a sample and example, the only one I will show, where we try to list what the offerers were claiming for their performance capabilities in your upper left and in the lower left, we try to write down what we felt the strengths and weaknesses were of that system as offered and proposed to us. In the upper right, you can see that we assessed those systems against those primary metrics that I displayed on the previous slide and gave them a grade and a color coding with green being better and yellow and red being worse and you can see in this particular case, blank spots because this particular system isn't offering to do crew to ISS. It's the cargo carrier. So we did this kind of individual system assessment against the four missions for each of the systems. And in the lower right section, we attempted to list critical assumptions. Those in the top dark blue box, those are critical assumptions as given to us by the offerers, things that they understand are important to the success of their program, and then the light bluer section is Aerospace's independent thoughts about this system and those critical assessments. So the committee has that detail at the proprietary level for each one of these systems.

Next chart please. Then we've rolled all these data up by these four mission classes as I've described to you and gave a ranking against each metric for each class of system, for each one of the systems, and here I've been required to make more generic the top labels for… I've called them system 1 to system N. These would be the individual offerers across the top of that so that you can get a snap shot if you're concentrating on crew to ISS. You can get in this snapshot how we look at each of those systems. We did two ratings here because it was important for us to do

that. We gave a rating of how we felt and our assessment was of the offer made by this particular system against this particular mission and then we felt obliged to give it an uncertainty rating. And what that means to us is system A could say I can take humans from Low Earth Orbit during this time, for this money, and on this schedule and with this master orbit and we make an assessment about that and we might be very sure about our assessment which would be a high confidence factor or we might not be very sure about or assessment. There's just not enough data for us to know. So the committee as many of you already know have to look at what Aerospace said about it and how certain we were about what we said about it and that we apologize for that fuzziness but in the time we had, we felt it was only honorable for us to make that statement to you that in some cases we are surer of our statements than in other cases.

The next thing we did which we thought would be important to Bo's work and the committee's work was to make a comparative assessment, again, against these mission classes. Given the mission class and all of the offerers, who appears to be the best of class, who appears to be the worst of class, and who's in the middle? So you get the assessment of each individual system, you get the assessment of all systems against the mission, and then you get an assessment that shows how do we see them ranking among each other as we go through the various assessments by mission.

Now we turn to what do we say, how do we approach for the committee our view of claims of costs and schedule which are so dramatically important. Well, every offerer made some claim about cost and schedule and we represent those in this generic chart as a green ball. This is what they are claiming to us they can do. In this period of time, the best product Aerospace could produce in this regard was to bound those claims and our best knowledge of historical evidence. And that you see by the blue bars and the red bars. So depending on what the system is offering, we could apply a historical factor that says we understand how this is done and has normally been done pretty quickly. It may be as a modified vehicle or in some of the bars perhaps it's a brand new vehicle and that applies a different set of historical data. So Aerospace pulled together for these bars every piece of historical information we have in the history of the company and every piece of historical information we could get our hands on in order to give you some sense of simply with regard to history, what does the claim the offerer is making look like with regard to history? Again, I would point out that while informative to the committee, I trust, this is still a very different assessment than looking at a program of record and going specifically to the thousands of program elements and making assessments about those. So it is what we did for cost and the committee has that data. Again, for each system it's a proprietary level.

Next please.

Same thing with schedule, we did the same technique. We took their schedule claims, we bounded them by history, you'll notice just by example on the first one if you're talking about a medium launch vehicle capability system, you might have an existing system, a new system, or a modified system and those all bring with them various historical perspective as well. So we did that in the schedule part for each system. We tried to show you whether we felt it was a new development or a modification, or in fact, an existing system that was already being built to those kind of performance parameters what that historical bound looks like, what the offerer is claiming for cost, and what our view is of an initial launch capability and initial operating capability, and the committee gets some perspective, simply with regard to history, what these claims… how these claims are falling into that spectrum.

So to complete the view of our look at the alternative launch vehicle assessment summary, again, I reiterate that the COTS providers are moving along. They're progressing. This is an important element of Constellation and the overall mission it's doing, but when one looks at the COTS and we have done other studies for the committee about the importance of COTS to station resupply and how that fits with ATV and HTV and we all recognize the importance of that program but it still isn't a plug and play change for the kinds of missions that NASA has as its direction right now.

We recognize in that chart that showed you the various capabilities of mission offerings with regard to capability to orbit that if, as was said previously, you need to get out of Low Earth Orbit and you need a big rocket to do that you got to get up into that heavy… super heavy lift capability among these offerers to be able to accomplish what NASA maintains is this two launch solution to get that kind of capability out of Low Earth Orbit.

Obviously, not all systems satisfy all system requirements. That was not a problem and we hope that our methodology gave you a way of looking at that so that no one is penalized at all if they can do one mission but cannot do another or not offering to do another. So we recognize that right up front. We will point out that there are options for each of these classes of missions among these offerers. The determination now becomes what do we know about those systems, how much more detail would we need to know before we will begin to hold that as a true alternative to the program of record.

I will point once again that certainty gets greater the farther along a program is and certainty is certainly greater for programs of record than it is for programs where the offerers says I can do this in these months for this amount of dollars and we're trying to put some historical assessment around that.

We recognize that some systems omitted things from their offering to us that we felt were critical. Some folks didn't think enough about the infrastructure in our view and some folks didn't think enough about what it really takes to get a reliable, mature, human-rated system in our view. So we recognize that folks are making offerings but they may not have considered in their offer what the government and what NASA would consider to be important in terms of an overall architecture. Aerospace did not make architecture assessments in this study, but we hope that our work will inform the architecture work that does need to go forward.

We intended our work with Bo's directions as we started to be a guide to the committee. We intended this work to give you some view of how these systems are progressing, where they are in their development, how one might look at them with regard to performance or schedule or cost on a level comparative basis, and we hope and believe we've done that. It is our view and I don't know how this plays in the reality of time, but it would be our view that as the committee deliberates these alternative options and determines that some of them are more desirable or interesting than others that more detailed work needs to be done to find out what's really in those programs and where they are and what their budget profiles would look like and what their real detail design scheme is for human rating or to accomplish these missions. So we're proud to have done this work; it was fast, in about three weeks. We hope that it's useful to the committee as we've delivered it to you so far and that summarizes that part of it.

Now we'll move then to the second part of my presentation which came in a different way. In fact, came from the chair for us to provide an independent assessment of the Constellation program of

record. Not to whine but to inform, this too was a very compressed time schedule. We did this work in about three weeks. You would expect that a detailed independent assessment of a program of this magnitude would be perhaps a several-month effort but that was not the case. So we were not able to do detailed design reviews. We were not able to do independent cost estimates in the traditional way that aerospace is accustomed to doing that. We had to assessments about the data provided to us. We did use the data NASA gave us as I've mentioned, PMR09 data to IOC, and NASA was gracious in providing us insight into their integrated risk management analysis database which is very informative into the program as we tried to assess it.

As we looked at the Constellation program of record, we tried to look at the effects of the budget, what we thought and felt and believed about the technical risks as we saw them, what it would look like if the ISS were extended from 2016 to 2020, and then within that study, look at the Orion not only as the part of the overall Constellation IOC but as a standalone piece because the committee needed that if they wanted to see how the Orion might fit on some other alternative capability, what does the IOC look on a critical path perspective for the Orion as well. So we did all that work in this study.

You've seen this chart before, I believe. In my view, no pun intended, this is the money chart. When you look at what has happened to NASA, regardless of your perspective of any of those lines, when you look what NASA believed it had and said it, desired, and what has happened to NASA and the '09 budget and the '10 budget, it should not surprise anyone that problems exist. I will say it again in my conclusion, Aerospace believes that NASA is not properly funded to accomplish its current program of record. So we should not be surprised that Aerospace is going to say we think it will take more money. We should not be surprised that Aerospace says we think the schedule is going too slow. These things happen. When programs don't have enough funding and have to compress, push things out, and move them along. We understand that everybody knows that and we've heard before it is… nobody ever has enough money, but it is really critical in our view to recognize that as we look at a program, which we will tell you in a moment, we believe is slipping to the right that they didn't have the money they requested to execute their program as they went along so things began to happen. We believe that the effect of budget reductions alone, as we see them in the FY'10 budget, could result in up to a year-and-a-half delay in the Constellation Ares I/Orion IOC. Others can have different views of that but as we look at the effects of things that are being moved and shifted around, that is Aerospace's opinion that those budget reductions will cost a year-and-a-half from the program of record IOC of early 2015.

Next chart.

Then we moved in to the technical risk assessment and here's where it gets interesting and one needs to be very careful about comparisons to the previous study. We looked at thousands of elements in the integrated risk management assessment. We looked at them with regard to what is the risk? How is it categorized? How is it resourced? How is it scheduled? And not surprisingly in many cases, some cases at least, Aerospace believed that some risks were underrepresented. We believed it was going to take longer than that or we believed it was going to cost more than that. So when you begin to look at thousands of these risks and you whittle them down to the few hundred that you think are really important and you have assessments about many of these and they begin to aggregate up in a collective way to an increased schedule. So that shouldn't surprise anyone. We looked at mitigation plans. We made assessments as the

committee asked us to do about whether those mitigation plans were reasonable and thorough and complex enough and whether again there was enough schedule against them and cost against them as we saw them.

We noticed that the risks were more detailed. When you looked at the face of the system you are in now and the rest were a bit less detailed as you looked farther out. Not surprising. That shouldn't really alarm anyone only to say that those risks that are in the database for future years are going to come to pass, too, and one has to understand whether or not they will result… they will certainly result in challenges. Whether or not they will result in more cost and schedule strains remains to be seen, but one has to understand that there are challenges, as we said previously, all throughout a program.

We looked at our final risk element ratings and we tied to those to modify our S-curves and I certainly won't get in to the necessary long discussion about S-curves but we all understand them. What is the confidence level? Is the curve too steep in our opinion? Should it tilt more to the right? And then in many cases, we felt that the confidence curves were a bit more tilted than in the program basis of record and we felt that when you move the confidence factor up, as I know NASA is attempting to do, of course, that impacts cost and schedule as well.

And then finally, we tried to do an affordability analysis. Again, this is such an important part of the overall assessment of the current program and alternative programs. What is the confidence factor you are seeking to achieve, what mission are you seeking to achieve, and how does that fit in to the funding that is available for these programs or, on the converse, what funding is necessary if we are going to execute this program? When we looked at the cost, schedule, technical risk, interaction assessment, we believed that that could result in up to a two-year delay in the Constellation IOC.

We recognize and fully accept that there are other opinions about that. We recognize that this was a fast look at Aerospace. We stand behind the rationale that brought us to this conclusion. We recognize that the risk can be mitigated and worked through without a schedule delay. We realize that the interaction of schedule and cost can be mitigated by funding returns or more robustness in the funding, but we didn't caveat all those things. We simply said, "As we see the risk and as we roll up these hundreds maybe thousands of risk elements, we do see those collecting up to as much as a two-year delay in the program."

Inside this assessment, in fact, it began after we had started the Constellation program assessment, we were asked about a weekend to do this individual Orion assessment primarily with regard to critical path elements, meaning if we need to look at this, we presume that the Orion IOC assessment is umbrellaed in the Constellation assessment and that is the case, but if we needed to look at Orion as a standalone thing in an architecture with another system, what would that look like? So we did a quick assessment of Orion looking at critical path schedule and we did notice that the schedule appears to be a bit backend loaded. That should not be a surprise and again, the program manager can tell us his opinion about that as well, but as funding is not as robust as one might think, sometimes things slide a bit to the right. Sometimes they get a bit more compressed and we noticed that there was some compression going on. The critical path still works but in our opinion there was not a lot of slack in it. And as things happen then that often results in schedule change as well.

We tried to look at the technical risk around these uncertainties again in this particular assessment with regard to how they might affect things on the critical path thereby affecting the end of the program and again we tried to envelop this in a historical perspective and I'll give you a couple of examples of that here and some of which are more informative than others are, honestly, but these are the data we had. So you can see two bar charts here as we try to compare Orion development to other human space flight mission development programs. The top one, PDR through systems start and the bottom one, systems start through launch. You get varying levels of information out of this. You can see in the bottom one that Orion is decently on par with Apollo but half the time of shuttle and everybody would have an opinion about why that is the case. The national will behind one program, the inherent difficulties that start perhaps in the other. So there's not a lot of data to inform this but nevertheless, that's how the Orion schedule fits into that historical perspective.

So well, let's then look at something more recent. So we looked at in comparison to a reason study Aerospace had done of 77 nonhuman space flight missions and we noticed that the Orion development was a bit shy of those developments even for nonhuman space flight programs so when you take the two of those together, you can make some assessment on the committee's behalf of whether or not the historical evidence of the development of a vehicle such as this fits within historical perspectives or are perhaps just a little aggressive given the program of record IOC of 2015 and what our view is of the confidence of that.

We also took a look at the extension of the ISS and the effects on human lunar return, ISS extension from 2016 to 2020. We believe just from a perspective of needing to keep the station flying and in the presence of the budget profiles that was our baseline, that is the FY10 budget, we believe the extension of ISS to 2010 would result in another six months delay. One could say, "We're not going to do it that way. We're going to make sure that Ares I and Orion don't suffer that." Well, then something else has got to give and that was outside our purview but with any exploration budget if you keep the station running and it consumes more budget during those years then that has a negative effect on the funding capability for Orion and Ares I.

There has been a lot of debate about that second bullet but given our assessment of 2010 budget and what we believe about cost and schedule, we just simply said, there is not enough money in this budget in the near term to do the human lunar return. There are those who disagree with that, there are mitigation plans, but our view is if you can get it started and Aerospace is now doing that study, I think tasked just late last week, what does a robust human lunar return program look like with regard to time and schedule? What this assessment was given all these constraints on this budget, what do you say for human lunar return and we essentially said, "We can't see it closing at this point.

So that there has to be some work done there and again that was the flat line budget, OMB numbers up to about 2015 and a flat line budget after that which may or may not be the case but those were the best assumptions we could get and we did not attempt to do content reduction. We recognize that there are things the agency can do to conform better to the budget it has and the mission given it. We were not asked to do those trades of can you do something different with the Ares I? Can you do an incremental build with the Ares V? Can you get humans to ISS sooner with a capability that will be improved along the way? We did not do those studies. We recognize it, they are there. We simply were assessing the program of record. And again we believe that the FY10 budget just as a stand-alone document requires a real re-look at the human lander program to see where that money is and when it gets started and then you have a better

idea of when you might be able to get that program. So this rolls it all up for you. The top bar simply says that Aerospace's view of just the budgeting facts without having gone into our technical risk analysis indicates almost a year-and-a-half slip just solely due to budget reductions but the more important bar is the bottom one and this is the depiction of what I have said before. We see the budget as costing about a year-and-a-half. We see technical risk as up to two more years and if you extend at ISS, we see that as another six months. So that is where is that aerospace statement of three-and-a-half to four years comes from. I will point out, however, that not all of these things have to happen. The committee can be influential in helping NASA restore some of that budget. That red bar would diminish dramatically in our view. NASA can be successful more so than our assessment predicted on the management mitigation by down of those technical risks. We hope they are but our assessment was as you see here. So it is important to note than when Aerospace gives this overall number, which the committee asked us to do that it does comprise these three elements, each of which can be managed and mitigated separately to help this program come in more closely to its program of IOC as it stands now.

So the assessment of this that Aerospace sees the collective cumulative effect of these factors on the constellation program as reducing or increasing the IOC time as I've displayed there. It is a combined effect and it is a function of the FY10 budget, I just can't stress that enough that things begin to happen when budgets get reduced. Our Orion quick look says that on the critical path that we begin that Orion could slip up to 18 months based again on schedule and critical path and things that we believe are probable or have a probability of occurring in the later more compressed part of the program schedule. Again, we hope and believe that NASA will have mitigation plans that go against those that are successful in the future.

And then finally, as I try to make sense of both our studies for the committee, and attempt to take this podium to tell you what I think they mean. When we look back at history and you look at the inception of the Constellation program, it was doable, it was within what we see as historical bounds and it was often running as I said in my public session to the committee last time, it is an architecture. It behaves like an architecture. Certain elements feed other elements and that was all designed on purpose and it was doable. But things happened. Budgets began to get reduced and that has a dramatic effect. Technical challenges occurred but they always do. We were certainly not naïve enough to believe that in order to be successful, you don't have technical challenges which may stretch your budget. We understand those and we understand they happen every program but when you start reducing budgets and start creating, cascading effects, things get moved, risks perhaps are not managed as thoroughly as you would have liked had you more money and things begin to ripple and you get into our assessment of a program that looks like it's stretching as a result of these things.

As I said before and I'll say it finally here, we don't think there's enough money in the budget to execute this program as it is currently formulated with these capabilities and these IOCs. We don't think that can happen. I will then go on to say that there might not be enough money in this NASA budget to execute any of these programs. We don't know that because we haven't done the kind of detailed analysis of all these alternative offerers to find out what's really in there. So before we take anybody's suggestion that I can do this within the budget, again we think analysis and details are required there to make sure we don't trade one insufficiently-funded program for another insufficiently-funded program.

And then finally realizing it's provocative but there may not be a commercial solution to this whole thing. One may decide that a government program designed it the way it is, that it's on its way

and is experiencing the kind of challenges that programs experience is the right way to go. COTS is important. It should be continued and I agree with Bo, we need to stimulate commercial and international cooperations. But as I talk to colleagues at NASA and as I talk to my own colleagues at Aerospace, when you contemplate putting humans on a completely commercially developed launch vehicle and capsule, that's a big change. And we need to really, really understand that. It is dramatic. All the way to do we understand maturity and reliability and operability to what do we know about these systems when something goes wrong and we get into the necessary position of needing to repair and redesign and fix and you find yourself beginning to think about government program oversight again so I would just suggest to all of us as we hear folks who say, "I can take humans earlier," just requires our very careful look about what it means to move in that direction.

Mr. Chairman that completes my quicker review of these two studies that Aerospace has done for the committee. As I said many, many hours of detail exists much of which has been briefed to Bo and Dr. Ride's Committee and we stand ready to continue to provide that detailed information as the committee desires.

Before we take questions.

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair

Let me just wrap it up. I have got only like three comments.
Okay. Gary, described to you one of our tools that you used to match these proposed and existing run systems to the scenarios. Remember, I mentioned to you we got a bunch of materials, briefings, data, and talking of which, you know, this is a very small team, so I am grateful to the NASA guys, Jeff, your team, Ralph Moore's team who is I don't see Ralph, who are very instrumental towards getting knowledge, getting up to speak quickly. I am grateful for that. One chart that Gary showed to you that showed us potential impacts to IOC from three different areas, why we're seeing insufficient budget. That probably is not in your control Jeff. To somebody higher salary, here at NASA or beyond has to work that. There was another one, ISS extension. That also may not be on your plate to decide but there is one area that was very significant and that is technical risks. That one is on your plate, Jeff, so… But there is one that you can exercise most of control and that is the one that is your ability to control those risks were not necessarily affected in Gary's pitch because he just see those risks, that's what they mean statistically to your IOC but you can improve that one. So let me quickly go and I have to say we still have one more briefing from Ed, to go, tomorrow which will paint as boundary of scenarios but trying to get the ready for him, we have done a little bit of looking and say, "How would you match one or two launch vehicles so that they can start serving his scenarios enough to have some idea where he is heading?" So for example first you look at the program of record, there Ares I and Ares V and you know comments that I don't want to say. I really could have had budget/cost. I could have budget. Budget problem created your cost problem. The second one is a potential, is dual launch that most of you guys have heard of and this is something of the order of Ares V Light, some people affectionately call it. And that causes you a problem for ISS. So, now you'll have to look and we put together a set of launch vehicles from the commercial arena that will serve the ISS.

And then, you have another potential for new launches is a very nice future program, the heavy Atlas phase II heavy lifter. Now that one might have a lower cost but then you'll have a marginal performance. The one thing I have learned over this lengthy laborious career of mine – give

margin. See, don't set yourself on a path with almost no margin because that's the lowest cost and then you spend the rest of your career living laboring trying to unbury yourself. So, this is why I'm talking of robustness margin goes a virtue over good management, believe it or not. And sometimes, you'll learn about it too late in your career.

And the last one is, to be honest with you, as an American, I'm not sure I'm all that warm to. Don't build a big launch vehicle. Use HLV or commercial mid-sized vehicles, stimulate commercial, it creates a mission complexity for this beyond LEO, mission success because you are talking about massive amount of logistics trying to send a lot of smaller vehicles to Low Earth Orbit, so you can and some of our colleagues are warm to that idea that this is a little better way, over the difficulty to think that this is the best way for the country. So, let me just give you, we are not through, Ed will talk, then we will do the integration between our teams, but just some things preliminary observations or findings.

Insufficient funding for the Constellation to achieve ISS and Lunar IOC with a reasonable gap. Just so you know, what I consider reasonable gap, I think 2015 is too long, but I say in context of this statement it's like, we are probably below 2016, and that's my reasonable definition of (when) it starts falling apart. And in spite of its technical and budgetary problems, I probably should have had them reversed. Your budget problems in my opinion are bigger than your technical problems. Constellation, you have matured enough and I have seen you guys for the last two years that could be successful given adequate funding. And let me just mention this technical, your technical challenges. I was buried in technical problems during shuttle development. Shuttle was more complex system than the Ares I and Orion. First of all, it was new, it was different. It was much more complicated. So, if you think you are overwhelmed by your thrust oscillations and your acoustics and your drift, Relax. Those are solvable if you address yourself and have enough money to do that. NASA, and this is broader NASA; NASA needs to address its detrimental effect of this fixed cost on execution of major programs. You have this fixed cost component that is more than half of Jeff Hanley's budget. You know, when shuttle ends all the stuff falls on his plate and NASA needs to address it. That's a significant drag on your ability to do what you commit yourself to do.

And just one other comment of the last observation, is if NASA mission or other implementation of that mission is changed then maybe by the new administration resulting changes to Constellation Launch System will have a very significant impact in cost and schedule. You will have a perturbation that is going to last, in my judgment, somewhere between a year and a half and two years and there will be a lot of instability, a lot of impact on the workforce, some of this cases may affect industrial base capability of America. So, let's go walk into it with open eyes.

And in summary, we have identified this commercial and government vehicles. We got data that we wanted, probably more than we wanted, but we have it. Aerospace independent variation conducted. Gary gave us more than he was able to present here because some of this is proprietary stuff and we don't want him to get in trouble. Beyond LEO and I have said it enough times, beyond LEO, an SSP team scenario will drive selection of the launch vehicles. We have identified the criteria of filters for this selection and proposed match of what we think we ought to have in terms of launch vehicles with those scenarios identified by the two teams will be deliberated in a DC meeting, and Mr. Chairman, I know you always value margin. Well, I'm turning six minutes of margin back to you, sir.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you, Bo. Well, I do value margin a lot. I always call it reserves but margin is a just a good or better a term. Thank you. That's a very helpful presentation and as you pointed out, you've touched the tip of the iceberg compared with we've had available in preparation for this meeting so that we don't have to do this meeting a Sabbath-day affair. I think the committee also owes a special thanks to the Aerospace Corporation for a very professional job. We have asked you to do something and of a short period of time and it would have been tempting to say you just can't do that and that is virtually true, but what you have done is, I think you've been very, very helpful. I guess I can also say that you're lawyers would be proud of you with all the caveats you offered. But that's the nature of the affair. I think we probably got some questions. We have your six minutes of reserve then we'll take a little bit more. I will lead you to the program and do what you always do here. We'll cut spares and trading, and so on and take a little more time. So, we'll answer questions and I'll hold mine to last. Who would like that? Okay, Les.

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
Bo or Gary….

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair
Why don't you ..... Gary, so I don't do this.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Go ahead Les.

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
In some other discussions, there was an expression of a need for a new launch strategy, NASA launch strategy Broad Area Review or BAR for the country. I think the last time one was done was 2002-2003 timeframe. Do you think that that's a valid suggestion or recommendation for the nation in general and not just for NASA? And if so, do you think that this would be sort of a body of the analysis that would fit in to such a review?

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair
Well, okay. I think it's a worthwhile thing to look at an American capability, our nation's capability. If that doesn't detract, doesn't slow down NASA from doing its mission, it could enhance because you get a better value for the country where you look at DOD and NASA. As long as it doesn't, like I say, slow down the progress at NASA. That's my view. Anything you want to add to it?

Speaker 3
To say that's the broader area of view that was accomplished previously was enormously beneficial. It helped us understand where we were and what we need to do. So, those kinds of looks really helpful but they do take time and a lot of effort and energy, but certainly, the output of that is a useful thing for the community as it decides a path forward.

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair
Any questions from anyone?

Wanda M. Austin, Ph.D., CEO of The Aerospace Corporation
Yes, I have a question. Bo, in your charts, you indicated that using the commercial market place for human lift is a drastic change and the circumstance that we find ourselves in is that if we keep doing what we've always done, we'll continue to get what we always got. So, would it suggest that it's…

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair
You know what, I gotta get close. I'm sorry.

Wanda M. Austin, Ph.D., CEO of The Aerospace Corporation
That's okay.

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair
I hope it's better in the room in the audience that it is on my side of the room. Go ahead.

Wanda M. Austin, Ph.D., CEO of The Aerospace Corporation
Yes, the bottom line of the question is, if we need to do something different, what do we need to do to inspire the commercial marketplace so that they are in a place where we can put humans on the top of the commercial rockets.

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair
Great question, Wanda. I gave it some thought. I actually talked to some people from previous NASA programs that says how would you be able to stimulate competition in such a way that small providers have an opportunity to come and compete. And the interesting answer was, if you divide the business, you know, NASA frequently acquires in big pieces from large contractors and believe me, I loved it when I was a Rockwell guy. We had a comfort of somewhat 25 years working on a major program. We took care of our customer. They took of us and it was very comfortable. And in retrospect, now I look as a retired US citizen, I'm thinking, is that the best thing for NASA. And I think if you want to stimulate industry, bring in a new wave of commerce to the business, you would put it up in small chunks whenever it's practical. Some think they're not practical to do it. Identify small enough chunks and compete them. I think if NASA start doing this, you will find out that a lot of people will rise and compete and some of them will fail, some of them will succeed, but you will have essentially a creation of a new industry. I don't want to call it cottage industry because there is nothing cottage about going to space. But I think you would stimulate if you would compete small chunks. Gary, you want to add anything to that?

Gary Pulliam – The Aerospace Corporation – Vice President of Civil and Commercial Operations
It was not intended to have an opinion about it but rather just to remind us that as we contemplate an offer that is purely commercially developed with a capsule and our humans on it, that we need to really make sure that we understand how much drilling down we are going to do, what our level of understanding needs to be about that so that we can be comfortable with it and just that we need to recognize that.

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair
It's okay for us not to be totally in agreement, isn't it?

Gary Pulliam – The Aerospace Corporation – Vice President of Civil and Commercial Operations
Yes.

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair
Well, I asked this question yesterday. Sally, I'll get to you in a second please. I asked the question, why would someone think that the American engineer, ambitious American engineer, working for a small company does less credible job than the other American engineer working for a big company? And that's the question. So, this issue of drilling down and so you've got to comply with all of these stuff. It's wonderful, it makes it easy, it makes it compliance easy. But I think we ought to trust that people who want to stay and get into business they are just as good as the rest of us or they will be like the rest of us and we ought to give them a chance.

Go ahead, Sally. I'm sorry.

Gary Pulliam – The Aerospace Corporation – Vice President of Civil and Commercial Operations
Sally, go ahead then we'll pick up next.

Sally K. Ride, Ph.D. - former NASA Astronaut
My question is a follow up on Wanda's. I have my parochial interest I guess by the sub team that I was assigned to. So, my parochial interest today is on ISS. And I noticed just in your comments, you have next to one of the options to Dual Launch Ares V light that this may apply to others as well ISS by commercials. And I was struck by your comment based on your years of experience that the things you always want out of a system are robustness and margin. And, you know, I look to ISS now that we've learned an awful lot more about it just in the last. I mean those of us in the subcommittee feel like we know almost as much as Leroy knows about ISS. I'm concerned that we're possibly going to find ourselves in a position where we might as one of our options recommend or pose an option extending ISS and perhaps this will be part of several of our options. But we don't propose with that option the opportunity to actually make use of ISS. In other words, we put it in jeopardy. We take away the robustness and the margin from ISS by the launch system that we choose for LEO access that's intended to satisfy the station and support the station. So, I just wonder whether you could comment on that and whether that fit into your considerations at all or whether you're not to that stage yet.

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair
I got to have an opinion on almost anything. Some of them are probably great, few of them might be correct. But I think that access to LEO, it's time, in my opinion that access to LEO should be opened up to more new comers. You know, my God, NASA, great NASA has been to the moon and we are sort of thinking that there's a big challenge for us to continue going to LEO. Let's try to turn it over to new comers. Let them learn how to do this and this frees NASA. NASA has some of the most brilliant people. I wish I have some of their brilliance myself. But they have brilliant people doing ops. Ops to me is sort of a low value on the value chain work and NASA is doing ops. I think NASA should buy ops from guys who do crank, turning crank for a living and direct its brilliant minds to some of the challenges that Ed Crawley is going to be talking tomorrow. But as far as LEO, I think commercial would be given the chance. They were that smart. They're just as good as we were 20 years ago or 15 years ago and I think they'll do a good job.

Sally K. Ride, Ph.D. - former NASA astronaut

So, agreeing with that completely, I guess I'd ask the question how do we ensure a smooth transition between where we are today and where we want to be which is commercial access, certainly for cargo, in as near a term as it can be provided to ISS. Because if we don't have that smooth transition, now the program of record right now is a hard stop in the shuttle in 2010 and no government access to ISS until the next vehicle that you come up with. Right now, Ares I with Constellation in 2015 through 17, pick your favorite day. We said from the Aerospace estimate we kind of put our wisdom and said, "well it would be prudent to assume 2017 given the budget constraints that the programs are under." And so that leaves us with essentially no insurance for ISS and waiting for the commercial providers who we've got complete confidence in their ability to produce systems. But the question is given the technical delays and the potential cost over-runs and schedule over-runs that we all experience in this business. How do we make sure that we're not leaving a system up in orbit for us and our international partners that actually requires a lot of servicing, a lot of mass brought up to it, and right now, quite a bit of mass brought down. How do we ensure that we not kind of detracting the margin and robustness from that system that we've already built by not having a nice smooth transition?

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair

Sally, I like your question, how do you effect smooth transition. I don't know whether there is a smooth transition. Every transition I have been through, it was a torture.
It was unpleasant to face. They are almost impossible to go through and at the end, you find out you are okay. I mean, that was my experience. We dragged our feet. It was unpleasant to go through, and we were okay in the end. So, I don't know if I have anymore wisdom, Sally, here and I'm not making light of it but each transition is difficult. The last bullet on my chart was "A" you agitate the program of record. You are facing yourselves through out of torment in terms of feelings, people, jobs, families, you know, not to mention cost and schedule. I don't know how to design smooth transition. Somebody smarter than me will have to try to figure that one out.

Sally K. Ride, Ph.D. – Former NASA Astronaut

And the difficult transition is fine when your program is the one that's being affected by that difficult transition. But when your international partners and a different program are the ones that are being affected by that very difficult transition, that's when I think you need to step back and think just a little bit about whether there's something that you can do to kind of soften the impact of the transition.

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair

Sally, you know these are on the chart that you are looking at, the one that I showed a while ago. We do show some system that would have affect somewhat easier transition like some of the shuttle derived version, obviously, because there is some synergy who could make an argument wherein if a have picked a very large of a shuttle derived vehicle not loosely shuttle derived vehicle, you could perhaps couple it synergistically with some level of extension of shuttle and this is obviously one of the potentials here. The question is, is that the right course of action? The answer is (inaudible) a lot frankly.

Gary Pulliam – The Aerospace Corporation – Vice President of Civil and Commercial Operations
I need to regain control of the meeting here. I saw Jeff and then I saw Charles.

Jeffrey Greason – Co-Founder of XCOR Aerospace
Well, since we're allowed to deliberate now, this is exactly the topic I want to talk on. We're all in favor of commercial but when we talk about the risks that the commercial entrants we're facing which realize what we are asking them to do. We are asking if we put up maybe 20-25% of all the development money and no guarantee of any kind, but just a hope that there will be a market there for them someday. Will they please come in and solve the nation's problem for us? And they might, which is a very pleasant thing to see. But if you want insurance, buy some. There are several more providers out there. They are not all small companies that are very interested in doing some kind of crew taxi, we have heard from many of them in fact finding missions and the cost of turning on one or two more of those as parallel pads is a rounding error in the cost of some of the other programs that we are sustaining. Furthermore, the spectrum is not while we'll be glad to use them when they show up on one end and NASA would design every nut and bolt of the vehicle on the other end. There is a huge spectrum in between, one of which might include that I think we need to strongly think about, is some kind of government-furnished equipment small human rated booster because a very large risk element in these programs is the question of whether or not new entrants with new spacecraft were also developing new boosters can assure NASA that their astronauts would be safe to fly on these things early in the flight history. But that's not the only option. We have the option for a very small amount of money to think about human rating, something already in the market place today that has already got a lot of our payloads on it and already has government insight and oversight, and then offering that as a service to people who want to do crew taxis, and that's a huge risk production element and now you're out looking at the question of how do we select commercials very briefly. The commercial guys do have more problems than the government guys because we're always struggling for little tiny amounts of money, which means a lot of us, are going to fail. But the rate that you get success out of commercial efforts is you don't just bet on one horse. You bet on the field and you pick the horse that wins, and if you want that to work, you are going to have a lot of horses.

Gary Pulliam – The Aerospace Corporation – Vice President of Civil and Commercial Operations
Charlie?

Charles Kennel – Former Director of Scripps Institution of Oceanography
There we go. This whole discussion has prompted the reflection on my part that I think might be an important task for us on the integration part of the committee General Lyles, as I listen to this whole discussion whether NASA should be aggressive technically and move beyond LEO and so forth, I reached the conclusion myself that for cargo access to LEO, the most important technology is no longer engineering, it's policy. Whether or not you want to stimulate commercial market, how you're going to deal with the fact that there will be a sort of an international maritime fleet competing or cooperating with our commercial capacity, the role of government furnished equipment in the transition, the possibility that other elements of the United States government will be interested in a sort of a resupply capacity LEO suggests to me that the most important thing that the government can do beyond NASA to stimulate the commercial market is to straighten out the ground rules for COTS, the degree of government investment therein, to make specific the role that government furnished equipment will play during the transition, how we

would propose to deal with the boundary with the new international set of suppliers that includes not only the Russians with whom we do know how to work but now in addition, space faring nations such as Japan and Europe, and how we will deal with our international interests in competition, if you will, or at least in the interface with our commercial interest. So, I think the most important thing that can happen… you wouldn't think of making a new policy if you thought that IOC were just only 3-4 years away but now we're looking at 2017, looking at 7-9 years. We are looking at a whole decade's provision for a whole decade. So, I think the policy technology is the one that is the most important at the present time for that problem.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Good point.
Go ahead Chris…

Chris Chyba – National Academy of Sciences Committee
This is just a followup on some of the recent comments. Bo has laid out a set of possible options for launch vehicles. We need to always remember that we're locking the nation into 30 or 40 years of choice and however critical the near-term problems we face with this, we'll expect to closing the gap and if we choose to extend station making sure that we can extend station, that's an issue that we face in the next decade and yet the decisions we make we will have to live with for another 30 or 40 years. So, it's understandable given the time and budget pressure we're under, that we're going to be pushed towards making decisions that solve our short-term problem and everything about the way Washington works is going to align with that. And yet, we cannot make that short-term, the need to solve that short-term problem lock is into a very suboptimal solution for the long-term. So, we need to keep that discriminate in mind.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
A very important caution, let's see, I'll ask my questions if no one else has any that they want to ask right now. The first one, Gary, I think I should address this to you and both, if that's alright. It pertains to the chart you showed of the (inaudible) program budget versus time and it appeared that you would attribute the decline from the ESAS anticipated funding to budget cuts and my question is, was ESAS anticipated funding ever an official budget line or was just a want from the program office?

Gary Pulliam – The Aerospace Corporation – Vice President of Civil and Commercial Operations
We see where we are today, but honestly, attribution of the time is as reflected just in the bottom line from the original program record and what I would actually have to get back to the committee on what the earliest congressionally approved profile was and how close that was to the ESAS line, I'd be happy to provide that. I'm sure Jeff knows that. I don't have that with me but it was mostly a function of where we are today with regard to the stated IOC.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Gary, if you could to do that, It would be great, I'm trying to understand the cause here of issues. My second question is comes back to human rating and for the older guys in the room and gals in the room, I think back that we did human rate Titans and Atlases, which were designed probably

nowhere near the reliability in mind that the COTS vehicles are being designed today and I guess I'd like…, you said that it's a very tough thing to human rate, and I agree with that, but I guess in view of the experience on Atlas and Titan, could you give us anymore insight into… is the mission is even harder than it has to be?

Gary Pulliam – The Aerospace Corporation – Vice President of Civil and Commercial Operations
I'll work on looking at human rated EELVs as much as three years ago, the approach we took was to simply take the NASA standard and apply it, and then as Ares I and Orion came into development, we came into a better understanding of how NASA was applying that standard because it allows for changes and waivers and ways of accomplishing what the standard calls for. So, all I can say Mr. Chairman is with regard to our looking at these alternative vehicles, we tried to make our assessments as best we could based on how the human rating standard is being applied today in the Ares I, Orion Constellation believing that that reflects NASA's very best thought about what should be done and how hard it is. We ask ourselves that question a lot about isn't it simply a function of reliability and maturity, and availability and those kinds of things, or are we making it too hard but we deferred to how NASA was implementing it realizing that as they proceeded into the development of Ares I and Orion, they gave that subject a lot of thought so rather than us getting into a policy debate, we tried to apply that standard as best we understood it to other systems.

Unknown Floor Speaker:
(inaudible – no microphone)

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair
A lot of it has to do with, you know…., you always state how confident you were applying it on Soyuz. NASA's standard is a very nice plateau for some things that we rolled down from our experience but it's all about good engineering. You want to have a little stretch of safety effect greater than 1-5 to get yourself comfortable. Redundancy is important so you don't fail, and if you fail the launch vehicle launches satellites and I have done that, it costs you increased insurance rates. In this case, it's a tragedy for the nation so you have to be a little more prudent. You have to automate how you shut down liquid propulsion. In satellite launching, you go until you fail because there is no cause for aborting. Of course, if you apply (inaudible), there are things that you would do as a good engineer. And yes, by the way, most of them coincide with NASA standard. In effect, recently, NASA I think did something smart is relative to the full tolerances. How about looking at the system reliability by looking at the component reliability and let them drive to the full tolerance rather than simply declare two-fault tolerance like we do in a shuttle. We are a little smarter today so I think you can take the document then design to it or you can use good engineering judgment and you will be equally safe and you would be equally safe. That's my thought.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thanks for that. Yes, we will take two last words quickly but on this topic really I want to ask you because you're the one who has lived with this kind of thing particularly Russian Launch Vehicles and Human Rating. Do you have any insights you want to share with us?

Unknown Floor Speaker:

Well, I agree with Bo and I think everyone would agree that foreign launchers aren't necessarily designed to the same standards or they are just designed at different standards and I have to admit that in the very beginning of working with the Russians, I was a little skeptical but as I went over there and learned their processes and got to actually meet the people working on the vehicles, went to watch the vehicles being made and the care that was being put into it, I got to learn their systems and their engineering. I became very extremely confident in their system because the engineering that Bo was talking about is very simply pragmatic system, very really robust high-quality control work counted so I agree with Bo, it's not just a matter of designing to a document and in fact, some of the debriefs that I came back with after station talking about some of the things that we do not with launchers but with just how we operate the station, we stick to the letter of the law instead of sometimes looking back and using judgment saying okay, the letter of the law doesn't really make sense. We're wasting a lot of resources and time doing things to the letter of the law rather than to the intent.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Good reply. Let's see. Last comment on this particular part of the meeting? Ed, You get the last word.

Edward F. Crawley, Ph.D.
Good morning Bo. I was just going to comment that as we look across this array of possible launch vehicles and combinations of launch vehicles that we have in front of us and how they fit into the recommendations that we make to the White House, I think there's an important thing that we've heard over and over, and I think Gary eluded to it, Bo has eluded to it is that there has been a fair bit of churn in this business within NASA in the last decade and I think especially here at Marshall, this is felt. The space launch initiative, the orbital space plane, then on to Orion, there has been a lot of cycles of this that we've lived through recently and I think we have to keep this in mind in our current deliberation and be careful if we make recommendations that displace the current path there, they are very well founded and almost indisputably correct. That it isn't the view graph rocket versus the rocket that we know something about. We've actually invested a lot as a nation in the last decade in space flight. We've been provided that by NASA in real GDP corrected terms and we want to make sure that we either give the workforce something they can really do and deliver with pride or propose something that is indisputably better than that.

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair
Mr. Chairman, Ed. Stability is a wonderful thing and if you destabilize yourself, you better go to something that is so much better for the very simple reason that no matter where you went to is going to look very much like what you walked away from. I've lived through that over and over and over. You say, I've got too many problems. I've got this new thing that looks so much better. I will embrace it and two years later, you are hyperventilating like you did on the previous program. So, the bottom line is, if you change, you should change to something so much better that is overwhelming.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
That's terrific and I read the audience. Gary, thank you very, very much and we especially appreciate to your entire team for their effort. We still got more to do as you know but we got 3-4 days.

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair
Thank you, Gary. Thank you for flying into Huntsville but we had a little mechanical problem and I thought I was going to do this briefing so I did not want to.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
We don't have reserves.

Let the record show that the airplane had the mechanical problem not Gary.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Well, okay. Bo, thank you. That was very well done and one thing I got to note here for you that there's a group waiting outside the door from the ops that would like to talk with you.

Okay, now we come to a really important briefing. We've had several briefings on various aspects of the Constellation project as a whole. Our subgroups have had near infinite group of briefings. Today, with the group as a whole is going to get another segment of the Constellation project update and we have scheduled an hour for this and I want to be sure you get at least that hour so don't be concerned that we are little behind. We'll find a way to make up. We will take our reserve out of someone else.

Jeffrey Hanley – NASA Constellation Program – Program Manager
Well, I'm Jeff Hanley. I'm the Program Manager for Constellation. I'm happy to be back here in Huntsville. This team here in Huntsville that is managing the Ares I project and the center that supports the project and the community that supports the center has really embraced Constellation and has really gotten it moving here these past four years. And some of that we will put on display here today.

I'm gratified by the words that and the display of understanding that Bo and Gary both portrayed. I think the assessment that we saw here this morning as fair. As Program Manager, I'm paid to be a pessimistic optimist to an optimistic pessimist. I'm not sure which. I, of course, have a different view based on the tools and the landscape that I see a different assessment and we can share that with the panel. As to our executability, not quite as pessimistic as the Aerospace study but in the range particularly with schedule, the outcome of schedule… looking at schedule risks, we found to be a little bit like hurricane forecasting in trying to forecast which model to believe as to where land fall is going to occur. There's a range of models we used to assess the outcome of the program both from across the schedule perspective; those who are informing our decisions and we've shared those results with our independent assessors as we've gone through this process and we're happy to provide those assessments as well. But I think the assessment that you've seen here this morning stands on its own merits.

There's a famous prayer that I've come to really appreciate in the past four years, the serenity prayer, that probably many of you know. The serenity to accept the things I can't change, change the things I can, and the wisdom to know the difference. And that's really been the emphasis of the last four years in learning for this team, for myself, and I think what you'll see here today is the active management of the program here in the Ares portfolio. The active management to address

many of the challenges that we face in bringing Ares I and Ares V to fruition and so let me hand it then to Steve Cook, the Project Manager here at the Marshall Space Flight Center for Project Ares.

Steve Cook – NASA Marshall Space Flight Center, Project Ares – Project Manager
Thank you, Jeff. And thanks to the panel for the opportunity this morning to speak before you for the second time. And when you here the last time in Huntsville back at the end June; I enjoyed the opportunity for the dialogue and to show you the progress that we're making around the center and our hardware. And it's good to be here again. And this morning, we're going to give… Actually, we'll split over the morning and afternoon so way we set this up, Mr. Chairman, with your agreement is we've got an hour that we will go through part of the Ares programs. We have an hour then after lunch. We will finish up the Ares story and also talk some of the other parts of the Constellation program and we'll allow… I think probably the best way to do this is to have Q & A after each one of those sections. Otherwise, it gets late into the afternoon. Is that acceptable, sir?

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
That sounds perfect. Thank you.

Steve Cook – NASA Marshall Space Flight Center, Project Ares – Project Manager
Great. Okay.

Next chart please.

So we've been off and running for four years. In fact, I got… we had a task assigned to us four years ago almost exactly this week as we were completing the exploration systems architecture study. By the way, four years into this, one of the things that I know is I look for trends. One of the trends that I see is when I see five Macs and one PC and I know that the Ares project is mostly Mac, I feel good about that. So I know when I'm supposed to read in to what you're doing but I think that's one thing we can do.

It's really been both a blessing and an honor to be part of this team. We've made tremendous progress from literally paper concept study four years ago to now, we're almost a year, pencils down on our preliminary design review, and well heading to CDR.

Ares is really a family who is designed to be a family. I and V go together that was a big part of the approach that we've laid in early and it is shuttle derived as well as parts of the EELV system and, of course, the heritage from the Saturn program and that's a good part of why we ended up with the system we ended up. We're trying to have a good transition from the Shuttle program basing our lessons learned over the last 50 years and bringing them into the systems we're putting together today. With the Ares I and V, we're going to have 60% greater capacity to the moon than we had with the Saturn program and at substantially lower cost. In fact, approximately if you look at the Saturn cost per pound to orbit compared to where we are on Ares V because we have designed in or we are designing it for sustainability. We believe that we'll be on the order of 60% cheaper than we could do in the Apollo program. Again, difference in focus; the focus here is on sustainability, having that margin to do a significant number of programs out into the future.

I think we had a computer problem. So I'll just kind of keep talking and when the computer catches up, we'll get there with that.

Let me talk a little bit about as well the benefits that we've got today with the Ares approach with Ares I and Ares V. Ares I is really the stepping stone to Ares V. We will learn significantly from the booster, from the first stage in flight, gathering critical flight data that will give us greater confidence when we move to the Ares V. As the same applies to the upper stage engine, the J-2X which we use on both vehicles. That's a significant advantage as, again, I see Ares I-X, our test flight is a crawl, Ares I is a walk, and Ares V is a run. We haven't done something of like this in our industry in over three decades. I think it's important that we take it in a stepwise approach. And so we and our industry partners are learning as we put this whole program together as we are successful. If we look at Ares I itself, we look at the benefits of the Ares I and what it brings. From a top down perspective, it is important to look at some of the characteristics that we believe that we get out of this approach. Number one, top down is that commonality that I've already talked about between Ares I and V so you can crawl before you walk, before you run. From the bottom up perspective though, what we get is because we're using a first stage system, it's the most reliable propulsion system today that is flying, Soyuz is just slightly behind it. The system derived from the solid rocket booster on the Space Shuttle. We believe that will give us a much greater chance of having both a reliable and a safe system. And Dr. Joe Fragola will follow me and walk you through our safety story and our safety approach and how we have designed it from Day 1 and into the overall Ares family. We believe that that based on our analysis, we'll get at least a factor of 10 better than the Space Shuttle today and the factor of two better than other systems.

Why don't you go forward please? If it will work. Alright. Next chart please. Next chart. Thank you.

To start off, if we look at risk reduction, Ares I is again allows us to, much like the Saturn I-V flush out the issues on the Orion system both in ascent and then because we get it to orbit, our orbital environment re-entry on the smaller vehicle, on the cheaper vehicle upfront. It is that stepping stone from one point to the other and also allows us to transition our shuttle workforce from one program to the next.

When we talk about heritage and we talk about heritage systems, we tend to focus on the hardware. I think what's even more important to talk about, and Robert hit on this, this morning, it's more important to look at the workforce and the capabilities that we are driving. We are taking the engineering teams from the Space Shuttle solid rocket motor and applying them to the first stage. We're taking expertise down in Michoud where we built the external tank today and applying that to the upper stage. We're taking expertise that Pratt and Whitney Rocketdyne has gained up through work on the Space Shuttle main engine and the RS-68 engine and applying it to the J-2X. And so this is really an ability for us to transition appropriately from one system to the other. And in the end, having a government system to LEO that is a stepping stone to a system for beyond LEO gives us a dependable U.S. human access to space. Now, that's Ares I.

Let's talk a little bit about Ares V. Ares V is really a game changer in terms of its capabilities. It will give us seven times approximately the lift capacity of anything else that we fly today with significantly larger payload volume looking at on the order of 10 meters… almost 10 x 10 meters of usable space and the volume. And if you talk to the user community, they're actually more interested outside of human exploration, they're more interested in the volume than in the mass

that we're going to give. It allows us to look at a wide range of diverse missions. The National Academy's last fall published a report on the use of Constellation and we spend an awful lot of time on the Ares V and how that could be a game changer in terms of scientific missions whether they're large aperture space telescopes and you'll see an example of that this afternoon or flagship outer planetary missions in much, much lower time. It really is an enabler for looking at missions being able to, for example, image another planet. Having the capability to do that and that kind of volume and mass allows us to get there. And whether the U.S. is in unique position to build a heavy lift system of this class, we got our legacy production and operations capacity for both the Space Shuttle from the EELV programs that we bring into the system and that includes the infrastructure you'll see tomorrow down at the Kennedy's Space Center, the vehicle assembly building, the crawlers, the pads, all of that and frankly, if that national capability is lost, it's going to be very hard and we may never recover the ability to do something like this. So I think when you look at were other countries are going, they don't talk about something in this class because frankly they don't have the ability to build off of something like we have today. So I think that puts us in a very unique position and it's important to consider as we look at our launch system capability.

Next chart please.

If we plot here then the various missions that the various architectures A through E that the panel has been looking at, both lunar surface missions, go to a lot of different destination missions, go near earth objects, then eventually onto Mars, you see those plotted A through E and you see down below, where the Ares I, Saturn V, and the I + V, stack up against that. What you see is that the Ares I + V gives us a very robust capability to address all the missions that the panel is off assessing today and Dr. Crawley's team has been looking at. I'd like to think he's got a slightly different version of this chart that he'll show tomorrow in terms of the various launch vehicle architectures. The other thing that you can pull off of this is, it's very interesting and instructive, about 50 tons to trans-lunar injection is really a gateway point for enabling a wider array of missions whether that be lunar surface, NEOs, or Mars assembly missions down the road. That is a real key driving point and so what that tells you is the folks building Saturn, we have that legacy here in this town and if you go upstairs and you'll see it lying there, they had it about right in terms what it takes to have that sustainable approach for exploration because we're trying to enable several destinations.

Next chart.

So let's talk a little bit about Ares I. We'll spend most of our time today and tomorrow talking… or today and this afternoon talking Ares I and then we will also give you an overview of Ares V and where that stands.

Now let me start off by saying our acquisition model here is somewhat different and General Lyles, you asked the question yesterday of Mark about this new model and I think we had an opportunity to chat when you were here in Huntsville about this. So and the model is really the Saturn model where NASA is serving as the prime integrator for the entire launch vehicle. We… the government is the prime. We have key contractor partners obviously in this. The first stage is being developed by ATK Launch Systems, the upper stage engine by Pratt and Whitney Rocketdyne. You see the relative current contract value that is for DDT&E only. Then we have the instrument unit and the upper stage where we have another unique model. Again, very similar to parts of the Saturn where NASA is leading the design and we brought on Boeing about

six months prior to PDR in order to help us build a more producible design and then to produce that. And as we are moving now through the design cycle, Boeing will take on larger and larger chunks of that work because the sustaining engineering by the time we get to the design certification review will be the responsibility of Boeing. So we're on that hand off stage as we move from PDR to CDR, Boeing takes more and more responsibility.

Now, the reasons we chose this model early on was first of this is a multi-generational program and we haven't done something like this in a long period of time. And it's going to be here for a long period of time. I think there're some lessons learned from the Space Shuttle in terms of intellectual property and where the intellect lies for solving problems 20 and 30 years in to a project's life.

We applied…., when we started this program, there were some pretty critical reviews coming out on space acquisition in general. One of my favorites is Mr. Tom Young's report on space acquisition that came out in 2004 and a couple of key recommendations there was that the government was losing some fundamental internal system engineering capability and hand in hand with that is our capability to manage large projects. And so this was a means to start ensuring that we take the core capability that we have in a government and rebuild that capability. It's not the intent that we would pursue this model to this degree once we move in Ares V. In fact, we know that we can't because frankly we are at capacity in working on Ares I with this model. But now we got a lot of smarter buyers within the project management realm, safety mission assurance, and engineering that have gotten their hands dirty. And I think as you saw on the tour here the last time, there're a lot of folks getting their hands dirty every day. And that's going to make us better when we go build the largest launch system ever developed, the Ares V, and put that into place.

So we believe in this phase this is an appropriate transition into a longer term model with the government still has much more active role but it won't be to this extreme as we move into Ares V, but we do believe this marries is the best of industry skills and NASA skills for the Ares I.

Next chart.

Here is the team we got today. We got over 4000 folks nationwide, over 324 organizations across 38 states. It takes a nation to put together a system like this. And we got small businesses ranging from up in Oregon to Minnesota down to South Alabama that are helping to put this project together and make it successful. This is really about the people and so we've gone from basically employee one, four years ago this week to about 4000 folks on board, which you'd expect as we're heading into the critical design review phase.

Next chart.

Here's our schedule. This is just a top level summary view. You can see the blue line there in the middle. That shows the demarcation of what's been completed over the last four years. We've completed over 200 design reviews to date ranging from components through subsystem elements and full-up systems. Of course, we've completed the preliminary design review for the stack itself and all of its associated elements and where we've actually completed last November the critical design review for the upper stage engine, the J-2X, and now we're into manufacturing for the first development engine to put that system in place. We got a lot of milestones, a lot of runway behind us. We're about a third of the way through the development from an overall dollar

standpoint in terms of executing the project. And we got some pretty key milestones up ahead and you see it right there later on in about a month, on August 25, we got development motor number one for the first stage which is our first five segment motor firing that is set up for the Ares I and Ares V. So that's our next really key milestone followed by Halloween. We promise we hope to not to make that a trick or treat. On Halloween to have Ares I-X flying which is going to be a really key part of our strategy because that's something else that's different. And since Apollo, we hadn't had a development flight test. Where we could actually have engineers in a relatively short cycle from start to finish, just a little over three years, go through a full development cycle on a test rocket. One, the learning for that work force has been enormous and the lessons we've learned have been almost immediately transferred over into the main line Ares I and Ares V projects. But we have over 900 pieces of data and 900 channels of information that we will get off of this system that will allow us to validate a lot of the design work that we've already done to date. And we're doing it sufficiently ahead of critical design review. If we find some things that aren't working like we thought they were, and I know that will happen, that we can inform our design. And that's a critical part of the risk reduction path and we'll talk about Ares I-X and what it does for us later on this afternoon.

Next chart.

The other thing I think is important is that we have to earn our value everyday in what we do and so we brought in rigorous earned value metric management throughout this project. This is our latest June-July report. You can see our CPIs and SPIs up there. I won't walk through those. By the way, those always look green. Alright. That's where we are today and that's one of… we use this tool to help us manage to put focus on where we have problem areas as we go through the development of this project.

I'm proud to say that our team won the NASA EVM Award of Excellence just a little over a month ago for the implementation of EVM on in-house projects. Our contractor partners, in a large part, are very used to working EVM and developments. We had not done that on the government side and so we're well into working through that process.

Next chart.

I mention the people. We talk about hardware a lot. We're going to talk and you're going to see a lot of progress on the hardware front as I bring up some of the key leadership for the Ares team. But it really comes down to the people and so how we ensure that we're getting a quality product? Well, we've met our milestones and from that growth standpoint, we believe that we're meeting our norms and you see up there on this screen what are the norms that we live by and the number one norm we live by is that the team members have got to have fun. This is a tough job. It hasn't been done in a long period of time and frankly, if we're not enjoying what we're doing, putting this together this once in a lifetime opportunity that we're really blessed to have then we're not going to get the most out of workforce to make it happen. So the managers have to walk the walk and talk the talk. We've got to encourage openness and diversity in ideas; I think we have done that. Constant communication is important whether that being… and by the way in my mind, e-mail is not a form of communication. It's get into the room, have a conversation, work things out.

And frankly, we were given a pretty straight forward mission. Go get this rocket built and get it done as soon as we can. Some of the challenges in doing that is we're taking a culture that's

largely an operational culture, had been, and technology culture and turning and honing overseers into producers. Now that's been a challenge but it's been also a great opportunity because when we started this project, if we look at the history of what have led up to this throughout the '90s, we were in a very much a stop start mode. We probably had two- or three-year cycles and direction would change and we'd head off down another path. We got four years under our belts on this one. And I think the folks really want to fly this rocket and make it successful and knowing that, we've got to do that confidently but with humility because the hardware is going to teach us a lot as we get into the test and we put these things together.

The other key aspect to this that I think is very important is that training all of our engineers and our managers to think as a system engineer. You're not focused on just reviewing one discipline or one subsystem. What are the impacts across the board? And so how do we inculcate that into the culture has been a very critical aspect? In addition to how can we do this leaner? Alright? We had… we've brought lean thinking in and lean practices in over two years ago. We've had, I don't know, oh, well over a hundred I'm sure, lean events across the project to really focus on value-added items and where it doesn't make sense, let's push back on the requirement. Let's do that whatever we can to make this successful. It's all this plus the heritage we bring together that will allow us to have a successful program in the end.

Now, let me start turning over to some of the folks, next chart, that are going talk you through some more of the details. We'll come up after the morning session and we'll all be available for questions. I want to first introduce Dr. Joe Fragola; many of you know him. He will be walking through our safety story and the work that we have done to drive safety into the design and then again, we'll have a session at the end for questions. Joe?

Joe Fragola – Valador Inc. – Vice President

Thank you, Steve. Mr. Chairman, members of the committee, and members of the audience, I'd like to say what an honor and privilege it is to speak before you today to tell you a story. A story that I'd been sort of passionate about for the last 40 years. A story that is directed at what Bo challenged us to talk about, which is developing some thing that's a lot better than what we have today. And in this case, a lot safer than what we have today. Now this story didn't begin with ESAS and it didn't begin with Ares I. So I'd like to take you to that story.

The story was enhanced and was started with the Challenger effort…as a post Challenger effort. It was enhanced by the Columbia Accident Investigation Board asking us that in the next build of a vehicle to replace the Space Shuttle that we give overriding priority to crew safety and the Astronaut Office at about the same time, it set a very challenging goal of a 1 in a 1000 loss of crew during ascent. I think those two motivations were the motivations behind the work that eventually led to what you see today as Ares I.

Next slide please.

Going through the history a little bit after the Challenger accident, we had the Rogers Commission Report and the Slay Report. That motivated people to concentrate on revisiting safety and try to understand in the shuttle vehicle how we could enhance the safety significantly. The crew office under the Bryan O'Connor investigated ways to escape from the shuttle system. Despite all the efforts that were done, we recognized that everything that we did, it was going to increase the mass of the shuttle and decrease the payload to the shuttle so that for the ISS missions, the payload decrease was such that the number of missions that had to be flown to

bring the payload to the station would be increased to the point where the overall integrated risks will actually go up rather than down by the number of missions increased.

At about that time, there was a first integrated assessment of… of the shuttle risk done in 1995 and we began to realize that the shuttle although it's a tremendously capable vehicle and reliable as a launch vehicle had genuine problems because of the safety limitations of the vehicle. So that led to two efforts, one directed at the improvement of the launch vehicle itself and its reliability, so called shuttle upgrades were considered and added to the vehicle, and then to consider alternatives to the shuttle in it's a launch vehicles that included abort. The reason for that is very clear that we saw with the shuttle since escape was not possible without degrading the payload significantly and the upgrades only added incremental to the safety enhancement of the shuttle, the next generation of vehicle to meet the challenges of safety would have to include some sort of abort capability. That led to the consideration of the so called orbital space plane program, which just about that time the conclusion of that program, the Columbia Accident occurred. The crew office issued the memo that I showed you and the Columbia Accident Investigation Board issued their charge to the next generation of designers. The orbital space plane considered alternatives that were winged bodied, lifting bodies, and capsules. We found that in the descent and landing phase of the mission both the winged body and the lifting body had advantages from a safety perspective. But those advantages were overwhelmed by the disadvantages in the ability to sustain a loss of mission and loss of vehicle accident in ascent which led us to the capsule concept which we felt was more robust. At that time, the search was for a launch vehicle to allow us to incorporate the more robust and what we thought safer concept of capsule.

We investigated at that time the full spectrum of the available launch vehicles and proposed launch vehicles. Safest by far were those launch vehicles that included a single core and a single engine, but the problem was the payload capability of the single core single engine vehicles was incompatible with the size of the capsules we were talking about. So that left us with the dilemma. And the crew office came up with a possible solution to that dilemma and that was to consider a safe, solid first stage as opposed to a liquid first stage with the enhanced 2.5 million pounds of thrust, it might be possible to incorporate with the newly designed second stage a vehicle that would incorporate the safety features and abort system and also allow us the payload capabilities. That led us to the beginning of the so called ESAS report where we again investigated the full spectrum of launch vehicles and so quite quickly that the alternatives allowed for payload enhancements required us to go beyond a single core vehicle to a so called heavy vehicle which increased the complexity of this system and you'll see in a moment the reliability was decreased.

Next slide please.

This is my favorite slide. It's not a very elegant slide but I come from the era of the slide rule, the nomograph, and the carpet plot and this is my favorite from that standpoint. It explains very simply how one converts from launch vehicle reliability to crew safety. What it says is that the conditional probability given on an abort condition is important in establishing the overall safety of the vehicle. What that means is even if you had a shuttle with extremely high launch reliability, if it has no abort capability, there's no way to handle the conditional probability of failure given an abort requirement. It also suggests that for the full spectrum of existing launch vehicles at the time this was done, you would require an extremely high so called abort effectiveness in order to meet the goal that was sent by the Astronaut Office of 1 in a 1000. So that was our challenge.

Our challenge was to enhance the abort effectiveness and yet maintain the reliability of the launcher. Now a subtle fact that's in here that wasn't spoke of before and something I'd like to challenge a bit of what Bo said is that this chart indicates that it's not only important that the launch vehicle be reliable but what is also important is that it be robust in enabling abort capability given a failure. And I think I should repeat that. What I'm saying is it's not only the probability of requiring your abort that's significant, it's the condition that requires that abort that is also significant. And if the conditions requiring abort are benign then the effectiveness of that abort is enhanced. If the conditions requiring that abort are not benign then the abort effectiveness is degraded. And the things that led us to the alternatives we considered were not only the probability that there would be a failure in the first stage or second stage of the vehicle, but what sort of condition did that abort situation impose upon the capsule and on its vulnerabilities. And I think that something that hasn't really been said. And that leads to the challenge of what Bo just said. I believe it's true, in my own personal opinion, that launch vehicles to earth orbit have gotten to the point where commercial people can take over but it's another thing to talk about a crewed launcher because for a crewed launcher one not only has to consider the reliability of the launch vehicle but the effectiveness of the integrated launch escape system and the robustness of that escape system against the likely failures of the vehicle. That is not a trivial exercise. Having been the person who sat with the leader of the Chinese Safety Program and spoken to him by hours about their conversion of their Long March to a human rated vehicle, I can tell you that was no easy challenge for them.

Next slide please.

What this chart also told us was that it was no longer sufficient to consider only the logical models, the logical probabilistic models in the design process. We had to also integrate at every step of the design phases the physical processes that gave us the conditions that imposed environments upon the crew's escape process given an accident. So through the beginning of ESAS, we attempted to what I called sculpt the risks. Sculpt the risks by identifying, using the probabilistic process from the top-down, to identify the likely scenarios and then using physical simulation models to simulate the environment created by those likely scenarios to determine the abort effectiveness. We did this through SRR, through SDR, through PDR, and then to CDR by stepwise enhancing the accuracy and the faithfulness of both our logical models and our phenomenological models.

Next slide please.

In cartoon fashion, we began to evaluate the individual alternatives. And you can see from this chart, in a cartoon like way are the driving influences basically the number of engines in the stage, the number of stages, and the ability to abort given an accident. Those are the things that influence the establishment of the loss of mission probability and then the conversion from loss of mission probability to loss of crew probability. As I've said, the loss of crew probability involves not only the accident but the ability to abort given the accident environment.

Next please.

Every step of the process then going from the ESAS to what we call the single stick, today what we call the Ares I vehicle, use the combination of the best tools available from those on the probabilistic side that is scenario development using probabilistic risk assessment theory and the physics side that is the best computational fluid dynamic simulations available using the best

super computers available to establish the environment and it's the confluence of the logical and the phenomenological that gave us the confidence that we have today that we we're on the pathway to achieving that significant difference that Bo talked about in our crew launch vehicle.

Next please.

Now, in a qualitative way, I show in this chart how one converts from loss of mission to loss of crew. Basically with the various alternatives, you assess the actions and conditions in groupings which we call bins each of which give us an implication of a particular accident environment imposed upon the crew module. In three basic areas, one is fragmentation, one is in impulse, pressure wave progression, and then lastly in a radiant form from a thermal standpoint of the blast. And what you see here is an assessment qualitatively of the effectiveness of the abort system against those types of insults and on the bottom we show the probability of being in each one of those buckets or bins for each alternative. So it's the combination of those two things that produce what I'm going to show you on my last and final chart.

Next please.

What you see here is the relative results of an independent assessment. Independent in the sense that the loss of mission calculations were done by our team independent of anything that NASA or anybody else has done. And what we looked at was how much better would the Ares I vehicle be from a safety perspective that is from a loss of mission and loss of crew perspective as compared to other launch vehicles. So here you see Ares I as the baseline, unity. And what we're speaking about are factors of safety above the baseline of the Ares I that the others would be worse. In other words, the worst risk as Steve said. And you'll see that in every vehicle across the line at the mean, Ares I is at least a factor of 2 safer from a loss of crew perspective and in some cases closer to a factor of 3. You'll also see from a loss of mission perspective, the Shuttle C since it is significantly based on the existing shuttle is closer to the Ares I than any of the other alternatives. But the fact is that the conversion from loss of mission to loss of crew on the side mount which makes the side mount a factor of 3 worse from a loss of crew perspective.

So there you have it. It's something that we've tried to do to address the goal that Bo talked about. Getting something, not just a little bit better, but generationally better and safer from a crew standpoint.

Thank you very much.

I'd like to now introduce Alex.

Alex Priskos – NASA Marshall Space Flight Center, Project Ares – First Stage Manager
Good morning. I'm Alex Priskos. I'm the First Stage Manager. It's truly a privilege to be here today. I want to communicate three basic thoughts to you that are simple because I'm pretty simple. Actually, the three thoughts that I hope to get across to you are a little bit in terms of the tasks that we've been asked to go accomplish and undertake. The way we chose to skin this cat, for the lack of a better way to say it, because there are various ways to go about it. And then thirdly, where we stand in terms of progress.

So go ahead and hit the next chart while I talk for a second. Let me talk about skinning the cat briefly though. I'm a little bit different than some of the other folks have had the privilege of

working for NASA for a long time. I've been in the industry doing solid rocket motors and development on solid rocket motors and boosters for 25 years now and doing the development piece continuously in that period. I've spanned from the commercial to the DoD now to the human rated side of this. In the way we go about it does vary. There are some fundamentals that are the same but the way you choose to skin the cat does vary somewhat and I want to talk to that here in a minute. But in terms of the task, it really can be broken down into two simple things that we had to go do. We have to go take what is the best understood, most reliable large solid that this country has active today which is the RSRM and we have to adapt that to this architecture, this vehicle, its mission. Therefore, several design changes had allowed us to keep many of the heritage pieces but it did change… it forced several fundamental changes also at the same time. In adapting it though we had one other task, and it really hits to what Joe was talking and what Steve's talking about and that other task was to make it better. What do I mean by make it better? In this one, the biggest context to make it better is make it safer. The nice part of making it a safer on this one is we had a wealth of knowledge to work from. The fact that essentially after every mission on an RSRM that thing gets a full autopsy. We not only know the strengths, but we know the weaknesses inside and outside of that vehicle. So in terms of making the mission in adapting this, the first thing we did was we went to five-segment that had more total impulse. But we didn't just stop there. Other than opening the throat up and changing the burn rates so that we could utilize the same case, we also took lessons learned from RSRM and lessons learned from the Titan IV-B SRMU to enhance the grain geometry. We had different radii we added different features in that grain so that we could mitigate the risks of bore-choking and another things that we have learned over the years.

So there's a whole lot of knowledge that goes in to making those better and safer. I will mention a couple of other things that we specifically did as a result of our knowledge on RSRM and that is we made some significant changes that we are trying to achieve relative to the nozzle. We actually are carrying two designs on the exit cone right now; one would be tested in DM-1 another one will be tested in DM-2. The purpose of that is to test out some objectives that will eliminate the consequence that we know of ply lifting or delamination that can sometimes occur although it's not critical, it's not good.

The other thing that we had done is we've made some modifications to the TVC. This was a recognized issue on shuttle. As a matter of fact, this TVC system is shared between the booster and the orbiter. The orbiter made some improvements to the shaft seals on the fuel pump sometime ago. The booster for various reasons was still on the process of making those when it was decided to bring the program to culmination and so they didn't go ahead and adopt those changes. We have adopted those here. Notionally, what that has resulted in from a reliability sense and you get a look at this thing relatively because these are probabilities, but it's about a 20% increased improvement of reliability on this booster. It is what it's forecasted. We had a requirement of 1 in 1670 going into this program and we believe we're a little better than 1 and 2130 right now.

So those are some of the things that we did to actually customized or adapt this to the current mission. We've also added new electronics, new forward structures. As Bo mentioned earlier, I absolutely believe in some of his lessons learned in terms of robustness. And one of the places that our team took advantage of that was on the Frustum. And it is a composite Frustum and you'd say well, why the robustness there? Well, as it turns out for the same mass properties and in about the same cost, we could increase our buckling margins by 40% and with the new vehicle

where you know loads are going to change that turned out to be a critical place in one of the places where we try to anticipate where we may need robustness and we incorporated that.

Next page.

I'd like to talk a little bit about the uniqueness of this team because this team has had an opportunity to fully engage not only in the Ares I main vehicle program but also I-X. We are delivering on the first stage for the I-X test flight that's coming up here at the end of October. The rail cars you see are the deliveries of the motors going down to Kennedy here last summer. On the left, you'll see a stage separation test that we enacted for I-X that had applicability. And one of the things I'd like to talk about is the interactions between the two programs because sometimes that's underestimated. There are so many… on that separation test, we learned interactions between the parachutes and the pyro charges that were invaluable and will feed in to the Ares I program. We have learned a lot going both ways back and forth in terms of thrusts oscillations. Ares I was ahead at the power curve in terms of thrust oscillations and understanding what it meant to primary structures. Interestingly enough, Ares I-X is actually learning more lessons about the 2L modes and what it means to secondary structures. And so there's so much learning going back and forth. Thirdly, the little movie that you see right in here is, you know, of the new parachutes that we're developing. We are developing those for Ares I but that will be used for their first time on Ares I-X. They are in the stack, they're ready to go. We've had a very, very successful development program and testing program on the chutes to date.

Next chart.

A little more in terms of where we are up in the top left hand corner are Avionics boxes for first stage. We have 6 Avionics boxes. All of the engineering units, prototypes are developed and are in testing right now. So we are significantly well on our way to maturing those and having them tested. I'll tell you up on the top right is a photograph of one of the solutions that we've come up with to deal with the coupled dynamic response of thrust oscillation in this vehicle. And in 25 years, this is the first time I get a chance to really work this. We've seen the issues and solved it up at payloads on various vehicles, different ways in the past, but this was truly a unique opportunity. It's very similar to other development programs as has been mentioned several times, there's not a real significant development program that you come into that you don't run into issues. That's just a standard part of this business. This is one of three solutions that we actually engineered, developed, prototyped, and have tested. This one's an isolation system shown on the top right; the other two are more thrust dampeners.

Again, development will come with problems. This team I believe has very quickly responded and shown and that they can formulate fabricating tests or solutions expeditiously.

Lastly, right now what you see on the bottom right hand clip that is running is the assembly of DM-1. DM-1 is our first five-segment full scale motor test. You see it being put into the stand. There is it in the stand. We're less than 30 days out from that test. That motor is ready to go, it's ready to fire; we're in the final throws of putting instrumentation in it and really excited to get the results. In the lower left, are some tests that were done on the DM-1 igniter. One of the reasons we wanted to re-test igniters like the motor, we have updated some of the subsystems in these and in both of these cases, we have removed asbestos from any of the insulation systems to

make them safer and more environmentally friendly. So both the motor that we are testing and the igniter will be asbestos free in this upcoming test.

And then thirdly, on the next chart please. There is DM-1 in the test stand; we're ready to go, but furthermore, DM-2 is right behind it. As a matter of fact, I mentioned we have two different nozzle designs. That nozzle for DM-2 is already fabricated. It's ready to go. The motor is in. The cases are insulated and ready to go. I have held up casting only so that we can get the data from DM-1 to make sure we don't want to make any alterations before we go on. But that's kind of where we are. DM-1 is in the test stand and DM-2 is chomping at the bit right behind it.

I guess what I'd like to leave you with is the understanding of how far we are in the progress we've made because when you think about this kind of major tests for those who have been around it, these are some of the biggest gates that we'll end up going through. There's still a lot of work in front of us but these are some of the higher mountains that we'll have to climb.

So with that, thank you, and I'd like to turn the time over to upper stage Danny Davis.

Daniel J. Davis – NASA Marshall Space Flight Center, Project Ares – Upper Stage Manager
Thank you, Alex, about those solids. First of all, just a pleasure to present our upper stage progress and status to the panel today. Robert showed you an engineering wheel that we're moving through. We are an in-house design activity at the Marshall Space Flight Center and we're supported by many other centers. The Glenn Research Center, Langley, and KSC and also at AMES we have some work.

We are finalizing our design and manufacturing in operations base launch based on the learning we had at our PDR scrub and we're heading right toward a plotting our information so that we can take this engineering and implement it.

First slide please.

We have a very solid flow down of requirements, needs, objectives from the Constellation program and our design is responsive to those. We have a safe design first. The performance is as it should be for the mission that we've been given. And we feel like our design will be affordable. Our design team is… we're actually doing two designs at one time, the design of the flight hardware, the configuration of the hardware, and the manufacturing system that goes with it. What this allows us to do is avoid any surprises in manufacturing that could be significant cost drivers later on.

Our design is informed by a lot of heritage work that went on before us. Our structures are large aluminum-lithium aerospace structures with friction stir welding. We have good experience with these processes. Now we've had to learn some new tricks so that we can for instance use friction stir welding throughout the design as opposed to just linear applications. We have, of course, a main propulsion system that provides a loading and conditioning of propellants and then we supply those propellants, liquid oxygen, liquid hydrogen to the engine just as the engines prefers them. They are very picky about their propellants. We have pressurization system that we've optimized to do that with as little risk as possible during the staging event. We went after those risks early on and we felt like… we feel like we've mitigated that risk. Our thrust vector control system is a hydraulic system driven by a turbo pump that's energized from gases off the engine. Very straightforward, very practical system for this application. The reaction control

system has some heritage brought into it. Our roll control system has 600 pound thrusters on it and that's a little bit of a challenge. It's a large thruster. But in this case and in all of our subsystems, any place we perceived a risk early on, we implemented advanced development programs and we'll show you a little bit that we've had great success in developing and firing these thrusters for our application. Now we have a composite interstage. We've had a lot of flexibility there, as Alex mentioned, and the tailoring of the composite materials to our loads application. Our other settling motors, again, this is an in-house design of a small solid rocket motor, 4000–5000 pounds, 4-second burn time. We built these in advanced development programs and fired them and learned a lot from it. And you can see our baseball card there with our masses and all.

Let me go to the next slide please.

This is where we discuss our avionics. We did in-house development of the avionics system, the architecture, the specifications for the components, and then the coding of the software. This has been a good challenge for us and I think we've made great progress there. We're responsible for guidance, nav and control, command and data handling, pre-flight check out. We also do power, power distribution, instrumentation, all of the usual suspects in an avionic system. Our systems, our boxes and cabling, are naturally distributed throughout the stage. We understand where all of these boxes go, what their functions are, and what environments they have to be able to survive.

Next slide please.

As I mentioned, the NASA design team has been working very closely with the production team. So that we understand what the design needs to do to support production and the operation. The Boeing team has been on board with us from about six months before our PDR and we have really enjoyed the collaboration there of merging production systems into the design flow. We have had hundreds of Kaizen events to lean out the manufacturing system and that often pushes requirements back into the design world.

We're very fortunate early on. We said we need manufacturing demonstrations. We were able to implement a very robust manufacturing development center here at the Marshall Space Flight Center where we've worked on our robotic welding of friction stir welding of unusual shapes. In our case, we have elliptical domes that have to be welded together. This hasn't been done before so we needed to go work that out. We had complex geometries in our common bulkhead. We have to go work that out. To date, we have great success in this. And we've learned a lot. We anticipate that when we set up our production line at the MAF, the Michoud Assembly Facility, in New Orleans that we will have the right tooling, we'll understand that tooling. As importantly, we'll have the right fixturing, the right processes, and the right skilled labor to walk into that job and be successful. One thing that the lab here at Marshall really provides us is if we're in production, on the production line, and we have issues, we got a laboratory to go work those out and that's very much important to us. You can see our friction stir welding, our large tooling, and the human intellect that's watching these developments. They're learning the hard way on some these lessons. And it's our NASA design team and our Boeing team, shoulder to shoulder, developing these systems.

Next slide please.

So we are invading MAF. We've… the shuttle program has been able to clear a large section of the very large facility down there for us so that we can begin to put our tooling in. We're very mature with our large welding tools, some of our vertical tools, and we're ready to start installing those.

One thing I'd like to mention also is the complex aerospace structures don't come easy. We have 18-foot diameter single forged Y-rings and T-rings that we've had developed. These had been delivered to us. We've investigated the processes required to make them. The properties you get out of that. Also, our lump form orthogrid panels. These components have been delivered to us and we've had a good look at how those… the processes needed to make them. What we get out of that process and then how we assemble those. We have 18-foot diameter single piece spun formed domes that we're going to use in our common bulkhead. I'm very excited. It's a beautiful piece of hardware. I think some of you guys got to see it when you're down. I'm just excited to have that.

Next slide please.

I mentioned that our design was informed by development testing in the places where we perceived risk early on. We were lucky enough to get development components in place to go work. Ullage settling motors we've had a successful firing. We're coming up on putting a more flight weight motor in a test stand so that we can validate all of the things we've learned of the first firing. Reaction control and roll control thrusters had been tested with our partners out in Sacramento. The RCS team has also built a fluid mock-up so that we could look at water hammer effects, our propellants, and things like that. The thrust vector control team at the Glenn Research Center, we've done single-axis testing and now we have our facilities almost complete so we could start our 2-axis testing up there.

I think that's my last slide. Next slide.

With that, I would like to introduce a gentleman very important to the upper stage is the upper stage engine manager, Mike Kynard.

Mike Kynard – NASA Marshall Space Flight Center, Project Ares – Upper Stage Engine Manager

Thank you. I'm the engine guy and from the engine guy's perspective, I'd always like to say thanks to Danny for that important review of the flight support equipment for the engine. So go to the next chart please.

I want to talk a little bit today about the progress we're making on the development of the J-2X engine. My team is very proud of the progress we've made thus far and glad and pleased for the opportunity to come and share it with you today.

We were given the task to build an engine that would meet the requirements of both the Ares I and V vehicles. It has a couple of different missions. On Ares I it is the second stage engine, the upper stage engine. That will get us nearly to orbit and then the Orion will do circulization from there. Then for Ares V we actually go to burn twice. We'll help the EDS do this, perform the same mission to get to lower earth orbit and then we will do the TLI burn to do translunar injection and progress towards the moon.

We were asked to start with J-2X, excuse me, the J2 from the Apollo era and that was based on the fact that J2 have performed a very similar mission to this and so we knew that we're starting from a good point from a piece that worked. We needed to make some changes where necessary to be able to meet the Ares I and Ares V performance and vehicle requirements. And so we did that. We were asked to rely on heritage a lot and a lot of folks think that just means J-2 heritage, but really the workforce we have was fresh off of developing the RS-68. We have a lot of history from the SSME program and from other rockets that Pratt and Whitney Rocketdyne has been developing over the last 30 years since the J-2. And so we try to take heritage where it made sense from several pieces. Gentlemen at Pratt and Whitney Rocketdyne like to say from a TRL level a poker term," it takes nines to enter". And so we'd like to make sure that we have good understanding because we want to limit the amount of technology that we need to put into this so we could robustly get to an engine design that we could be ready to offer the vehicle for safe flight.

One of the things we were able to do is make some changes to the turbomachinery that was based on J-2S design. We have been able to use the J-2S pumps and I'll talk a little later about those to make some changes to help meet their performance and put some robustness into the system. Instead of using the original J-2 gas generator, we actually instead of scaling it up, we decided to scale the RS-68 one down. That was because the people in the Pratt and Whitney Rocketdyne are very familiar with that design. For an engine control, we're going very simply. We're going to go with an RS-68 based design and software architecture and make some changes for this to control this engine. We're going to use the… for the regen nozzle part, we're going to use the tube wall nozzle and as folks that are maybe familiar with SSME is concerned, they know that some tube wall nozzles can be complicated. We did choose not to use a more complicated design. We want to use more simple design based on RS-27. We took some other things from the J-2 which were the flexible inlet ducts, scissors ducts, that allows us to have a nice tight package for the upper stage. It allows a neater solution for gimbaling. With the HIP-bonded main combustion chamber which is a direct pull from the RS-68 program which makes much simpler manufacturing and much more robust manufacturing versus the structural plating done from the Space Shuttle main engine, main combustion chamber.

And then the thing that gives us a lot of the performance we need is the big large nozzle extension and that we're going to make out of Haynes 230. We're going to spin-form it, chemically mill it down to the right size and it will allow us to expand the gases and get a bit more performance. To our performance were roughly at 300,000-pound engine, 294,000 pounds of thrust at primary mode, we do have a secondary mode. We are able to throttle to a secondary position and that will be used during the translunar injection burn. ISP is very aggressive with 448 seconds but that is accomplished and we think we got a good way to get there by making injector changes that will increase the combustion efficiency and also the large nozzle extensions that allows us to gain performance through further expansion of the gases.

Go to the next chart please.

We're making a lot of progress. We are past our critical design review on almost all pieces. We have a little bit left to go on the avionics. The avionics naturally lags to make sure it lines up with the vehicle very well. As you can see, we have actually a lot of pieces that are getting put together for the first engine. We have got a good design. Those designs have gone out to the vendors. The vendors have begun to make the pieces as you can see here. You can see the turbine exhaust gas manifold forgings down the lower right hand corner. The main combustion

chamber spun liner we're getting ready to slot that in just a few weeks. The turbomachinery for the first engines, the castings are here. We are beginning to make the discs and shafts for those. And so we're making a lot of progress towards getting into our first engine firing.

Go to the next chart, please.

That design we have a lot of confidence in was informed by some early testing that we were allowed to do. I mentioned before that we were able to take some of the turbomachinery and make a powerpack and be able to put it on a test stand down at Stennis and actually ran some tests with heritage J-2 hardware at Ares I performance conditions. We could see what changes we needed to make to accomplish our mission versus the original J-2.

Down the lower right hand corner, we're also doing some subscale testing for the operation of the large altitude facility that we're building now, two test facility that building down at Stennis A-3 and that facility is going to allow us to have long duration, burn capability for altitudes greater… stimulating altitudes greater than 100,000 feet. And so we want to make sure that the facility and engine come together at the same time that we understand how to operate that facility. So we built subscale diffusers. We are running lots of tests there and we're going to make sure that we can robustly run that facility to support the test campaign.

Next chart, please.

Here's some more of things we're doing. We built an auto-version of our gas generator. We brought that out here to Marshall to the East test area. We tested it. We found some issues. We have made some design changes and now we are back into testing again. In fact, we are testing this week on the workhorse gas generator. We think we have a good solution to some combustion issues that we had and the testing this week should prove that out. Once we understand that we'll go into making our production combustion, our combustion gas generators… our gas generators for the production engines.

In the lower left hand corner, you can see good progress being made on the altitude test stand A-3. I was just there yesterday. It is an impressive size. They've got the barge docks in. The next thing to do is to start populating that big metal structure with the components for engine testing.

In the lower right hand corner, you can see that we're actively engaging our vendors and our prime contractor in the development of the control systems of the valves and the actuators.

Next chart?

That's all for me. I'll turn it back over to Steve Cook.

Steve Cook – NASA Marshall Space Flight Center, Project Ares – Project Manager
So Mr. Chairman, that wraps up the first hour of session. What I'd like to do is open it open for any Q&A that you may have on this section. This afternoon, after lunch, we will be talking about our risks and our risk mitigation posture and what we have been doing there as well as our flight test program and then we'll give you flavor for where we are on the Ares V concept. So, questions please.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
So thank you. That was a terrific set of briefings. I'm not sure really that many of us have heard all or parts of those, so I do not how many questions we have. We probably have some though. Leroy, you have one?

Leroy Chiao, Ph.D.
Yes, I would like to ask a question on the risk assessment, I think Joe? Joe Fragola?

Joe Fragola – Valador Inc. – Vice President
Yes.

Leroy Chiao, Ph.D.
Could you put up that chart you said was your favorite chart and I'm still struggling a little bit to understand it.

Joe Fragola – Valador Inc. – Vice President
Okay. It is chart 3 including the title.

Leroy Chiao, Ph.D.
So while they are finding it, first of all, I just want to ask a general question, where did you get all your numbers?

Joe Fragola – Valador Inc. – Vice President
Oh, okay. Those of… one more…. one.. two… next one. This is the chart you are referring to.

Leroy Chiao, Ph.D.
Correct.

Joe Fragola – Valador Inc. – Vice President
Okay. Each one of the abort effectiveness numbers were calculated just simply by determining what abort effectiveness you would have to have in order to convert the failure per launch frequency to a safety number and then I drew the isolines across to indicate that. The numbers for the various launch vehicles came from a combination of Isakowitz and updates of Isakowitz that we have also from the 45th space wing analysis. We have comprehensive data sets on each of these launch vehicles which I'd be pleased to share with you if you'd like.

Leroy Chiao, Ph.D.
Okay. I was just looking specifically at the Soyuz number, 0.98. That seems… I mean I think I've seen Soyuz's numbers much higher than that.

Joe Fragola – Valador Inc. – Vice President
Well, it depends upon if you are talking about the recent Soyuz experience or across the spectrum of Soyuz launches. One of the things that someone mentioned here is maturity has a lot to do with your estimate. So if you are talking about Soyuz from now into the future, it is closer to 0.99. Right? But it is about the same as the Shuttle's as a matter of fact in forecasted risks going forward.

Leroy Chiao, Ph.D.
Okay. Well, nonetheless, I guess if I come down your Soyuz line and I assume a 95% effective abort system, I get to exactly the target line, right?

Joe Fragola – Valador Inc. – Vice President
Exactly right.

Leroy Chiao, Ph.D.
One thousand.

Joe Fragola – Valador Inc. – Vice President
But 95% effectiveness is a very difficult thing to achieve and because we're talking about integrated abort effectiveness and that is how effective your abort system is across the spectrum of abort scenarios at the various stages of the launch trajectory. And one other thing, advances, I think we've done it in the Ares I development is to make use of super computer capabilities to quickly calculate at various points in the abort… in the launch trajectory, what the impact of different types of scenarios would have. So, for example, lower in the trajectory, blast propagation is important because you have atmospheric effects. Later on when you lose those atmospheric effects for the same scenario, fragmentation takes over. The combined impact of all of those, for example in the Ares I, is about an 85% to 86% integrated abort effectiveness. 95% is very, very, very difficult to get.

Leroy Chiao, Ph.D.
Okay. But I mean in other briefings, we've been told that Ares I escape system is being designed to 0.95.

Joe Fragola – Valador Inc. – Vice President
Okay. Escape is different than abort effectiveness. Escape is related to the probability if you push the button that the launch system works. But what this talks about is does it survive and remove you from the insult environment. It is not only the probability that the launch aborts… that's what I was trying to say. When you try to convert in a expendable launch vehicle to a crew-launched vehicle, it is not just whether or not the launch abort system works and yet you have to do that, you have to design it to a higher reliability, make sure it works when you press the button, but you also have to make sure when it works, will it allow you to survive the insult caused by the abort environment. One of the significant advantages and one of the reasons why we are confident in the Ares I is that for a significant portion of the most probable aborts scenarios on Ares I that is case breach or burn through to soft goods which represent historically over 80% of the solid rocket booster insults, those conditions are very benign from abort perspective and that's… it's a combination of the benign abort conditions imposed on the vehicle by the predominant failure modes with the already high reliability, demonstrated high reliability of the solid rocket booster. The combination of those two things, which makes us confident in Ares I.

Leroy Chiao, Ph.D.
Okay. So those ISO numbers are not just the abort hardware. It is that whole integrated system.

Joe Fragola – Valador Inc. – Vice President
That's correct. That's right.

Leroy Chiao, Ph.D.

In that case, where would Ares fall on this charts?

Joe Fragola – Valador Inc. – Vice President
As I recall, it is about 0.85 to 0.86.

Leroy Chiao, Ph.D.
Okay, do you have a pointer, can you kind of show us where that might be?

Joe Fragola – Valador Inc. – Vice President
It's about… this is 0.8, so 0.85 is approximately around in here. If you talk about a 1 in 200 or 1 in 400 launch vehicle, you are talking about the Ares being up in this area and that is rather significant. If you start looking at the probability that you'll get better than 1 in 1000, no vehicle comes close to Ares I. And, of course, models have uncertainties associated with it. That's why I showed these significantly large bands of uncertainty. But the fact of the matter is it's the combined confidence of high reliability demonstrated on the SRBs for the Shuttle with the understanding of the significant scenarios that create the abort environments that gives you that feeling of confidence on the Ares I.

Leroy Chiao, Ph.D.
Okay. And help me a little bit because we've been seeing numbers of Ares being 1 in 2000, but you are saying it might be even be a little less than 1 in 1000.

Joe Fragola – Valador Inc. – Vice President
Our calculations are better than 1 in a 1000, better than 1 in a thousand.

Leroy Chiao, Ph.D.
Okay then. Maybe I'm confused about what this 1 in 2000 or 2153 number…

Joe Fragola – Valador Inc. – Vice President
Well, there are different… this was an independent assessment. There were different models. There were different teams. The teams have not gotten together to resolve the uncertainties but it's important to understand that independent of what the absolute of that number is, the thing to remember is the relative safety level of Ares I is significantly better, to talk about both, significantly better than all the alternatives and significantly better than the current shuttle. Even though the shuttle has demonstrated with a very high level of reliability, it is a question of reliability and abort effectiveness that makes the combination.

Leroy Chiao, Ph.D.
Okay. Thank you.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
If I might, I have got a question on the same topic. Has anyone else has the same topic? You do? Go ahead, Jeff.

Jeffrey Greason – Co-Founder of XCOR Aerospace

There is something that I think that we have come to understand as we've heard a lot of fact finding briefings but what I want to get on the record because people who are listening to these briefings may have not been through all of that process which is, you really have to be careful about comparing the probabilistic risk assessment of an as yet unflown vehicle to the demonstrated reliability of flown vehicles. The probabilistic risk assessments look at hardware driven random failures and then you have a very sophisticated methodology in which you do your very best to look at what that effect is on the system failure but in wild terms historically, about 10% of the failures of launched vehicles are driven by those kinds of random effects. So, not only do PRAs grossly overstate the reliability of an as yet unflown system, a fact everybody is aware of, but it also means that you have to be really careful driving your program design with factors of 50% or factors of 2 on probabilistic risk assessments because at the end of the day, you don't really know what factor with a real reliability launcher is within a factor of 10. So there is nothing wrong with using PRA to guide your decisions but you got to use the numbers with great caution.

Joe Fragola – Valador Inc. – Vice President
I think that is a very important point. And it's one of the strengths of the Ares I because the demonstrated reliability of the SRB is solid in more ways than one. And all the other vehicles also a require second stage. So the second stage to a degree is not a discriminator on safety because all the vehicles require a new second stage. The first stage of all the vehicle alternatives with the exception of the Shuttle C, the demonstrated reliability and the demonstrated risk is much, much better for the Ares I. From that perspective, the Ares I is far superior from all the other alternatives. If you look at the Delta IV Heavy for example, we have only had nine Delta IV launches and only I guess two Heavy launches and in the first launch, there was a discrepancy. Okay? So from precisely the perspective you are speaking, that is one of the strengths of the Ares I.

Jeffrey Greason – Co-Founder of XCOR Aerospace
But, let me add that your history will… you're taking a big risk by assuming in that statement that future new launch vehicles, however, derived will not also experience early anomalies because that is the history of…

Joe Fragola – Valador Inc. – Vice President
Absolutely. If you look… it will take me a long time go through the whole thing, but yes, absolutely. Where you to look into the history of a launch vehicle it is very important how many test flights you have. The growth history of any launch vehicle is significant as any other developmental system and that has to be taken into account. When we looked at these numbers here, these are numbers that in my comparative chart, when number is taken at the mature level of all the launch vehicles, at the first lunar flight, we call it. So in other words, we anticipated successes on the Delta IV Heavy until 2015 and still the Ares I forecast is two times better. And it is precisely because of the failure modes interacting with the abort effectiveness. Yes, sir.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
If I may, I would like to weigh on this too. Jeff said much of what I wanted to say but my own experience has been with calculated reliability has been not very happy. The one thing I have learned is that calculated numbers are always higher than the real world numbers, almost invariably. Over the years, I have kind of drawn the conclusion that the expendables are somewhere like 96% moving to 97%. Shuttle is like 98% moving to 99%. The Apollo, excuse me… the Astronaut Office said I think, they wanted three 9s at 95% confidence and even if we

use the calculated numbers that you've got, we don't get to that level by a considerable factor and it's likely the real numbers are going to be well under the calculated numbers and having said that, Joe, I would take one small issue, semantic I suppose, the way you said that one of the things I've learned is that there is no such thing as a random failure, that there is a reason for every failure.

Joe Fragola – Valador Inc. – Vice President
I think that is one of the reasons why we wanted to do a comparative assessment rather than an absolute assessment for the very reason that you mentioned. And why we try to focus on the historical demonstrated statistics rather than on forecasted bottom up numbers.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Les, you have a question.

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
Yes, a question to Alex. But before I do that, Steve, I would like to complement you and thank you for answering my acquisition management questions. My questions were not critical ones but they are also shaped by DoD lessons learned as you noted on your chart that we have began a spectrum from LSI, lead system integrator, to the government being the total integrator if you will and have had problems on both sides and it was the latter that we heard some comments if you will from some of the contractors, but they also said that the communication now is much , much improved and they recognized that it was sort of their early lesson learned of going through the different changes in roles. So, compliments to you in the way you and your team are doing this. I am very, very impressed at the way you have tried to approach it.

Steve Cook – NASA Marshall Space Flight Center, Project Ares – Project Manager
Thank you, sir.

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
My question, Alex, deals with the thrust oscillation mitigation approaches. You've mentioned two, the one, the isolation versus thrust dampeners and I do not know if you've settled on any one of the two different schemes. More importantly, are there design impacts or performance impacts on either that would weigh into your decision?

Alex Priskos – NASA Marshall Space Flight Center, Project Ares – First Stage Manager
First of all, General, let me say the solution needs to be a system solution and it is being looked at by level 2 and they are making the decisions and I will tell what the current baseline here is in a second. But, when we identified this issue from a first stage perspective, we went and looked at the two physical ways to mitigate this and one was to isolate it and two was to absorb the energy somewhere else. And so we actually designed other than what you saw which was an isolation system, we designed and have tested two dampening systems which people simplistically called

them a mass on a spring kind of thing. One is active, it actually cancels, like your… Bose headphones that cancel out noise in an airplane and the other one is passive. Both of those were actually sitting on the shelf because as we do the system analysis and looking at different ways to do this at the system level, we were looking for the simplest way to get the effective solution. And that simplest way right now, the program has determined are two isolation systems, one between the first stage and the upper stage and one between the upper stage and Orion. Steve, do you want to add anymore?

Steve Cook – NASA Marshall Space Flight Center, Project Ares – Project Manager
And so what were are doing there, General, is we're carrying and John will talk about this a little bit this afternoon, we're carrying some risk mitigation on that. One because while the solutions that we've been carrying along is coming up the technology readiness level curve very, very fast. That's what we call the LOX Damper. And the elegance of that is it uses something that is in-situ to solve the problems. It uses the mass of the LOX captured by 30% of the mass, put it to work. It just pounds this problem flat. And gives you a very wide range where frequencies can move and things could change, so it increases our robustness. So we've been hustling it along such that later in the summer or early fall, we will take a review point and say, is our…., do we want to stay on this baseline that we are off mitigating to or is there more benefit to going to a dampening system like the LOX Damper. Things like the active mitigation, we've really kind of put on the shelf as a very, very remote backup, but we've got if we need it as the noise cancelling headphones approach that Alex talked about. That answered your question?

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
Yes, I think the LOX Damper is a unique system you showed us during our last visit here.

Steve Cook – NASA Marshall Space Flight Center, Project Ares – Project Manager
Correct. Exactly.

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
It's really impressive. Thank you.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
I think we have time for one more question. Bo, you have that.

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair
My question is to Joe, Joe Fragola. Joe, you and I we're from a system build by the Soviets or Russians later. I was at a sense that they were less relying on full tolerance and more on good design, good engineering, and then test the heck out of it. And the question specifically has to do with the number of parachutes. We have three parachutes where two out of the three are sufficiently to get you safely to ground on Orion. Soviets use single parachute with a single backup. Have you have done an analysis that shows which part of the world is right?

Joe Fragola – Valador Inc. – Vice President
You know, that is a very interesting question. We have an extensive work, not for this study, by the way, extensive work on that alternative and it's not clear. It depends a lot on the mass of the vehicle, alright, because there is a limit to the size of a single chute mass. At least in terms of it,

as I understand, at least in terms of reliable deployment of the chute. Soyuz is a lot lighter than the Ares I and so I believe and it has been some time and I have to look it up, I believe that one of the problems was that we could not get a single chute that was big enough to handle the load reliably with enough margin and therefore, we had to have at least two, two chutes which gives you the three chutes system unless you're going to launch two chute systems and then you have the problems of potential entanglement and things like that and I think that the trade came out that three-chute system was best for the mass that we had.

Bohdan Bejmuk – NASA Constellation Program Standing Review Board – Chair
So am I hearing you to say that if you could build a big enough chute, single with a single backup, would be more reliable?

Joe Fragola – Valador Inc. – Vice President
I'm saying that it is a significant trade and the trade is not clear. It depends upon how… it depends upon, first of all, for example, the common cause failure effects and the interactive effects. It is not a simple calculation. It depends upon what you assume on that. There is not a lot of information related to common cause of failures of single chutes versus multiple failures of double chute. So I think the trade has been done from the perspective of the existing systems and in that case the three-chute system came out the best. But if there were bigger chutes that were demonstrated that might change the equation.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
On behalf of my colleagues, I thank each of you for your presentation. We look forward to the rest of the discussion this afternoon. I picked up one open item which was, Jeff, you indicated that there were differences in your view with those of Aerospace in some areas of scheduling cost and could we ask that you get together with Aerospace. Not with the idea that you will come to an agreement necessarily although that would be nice but you could give us the understanding of where it is you disagree, what drives the disagreement. If you wouldn't mind doing that, we'd appreciate. Got it. Yes.

Jeffrey Greason – Co-Founder of XCOR Aerospace
Just very briefly, another action item is that there's got to be a huge amount of backup data behind these charts and in my copious spare time, I would like to read some of it, I wonder if we could get that as data dump?

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
We have received a number of comments from members of the Congress that we could ask to share among our committee and with the group here today. Needless to say, our time has been very short so we have had to somewhat limit this. I have talked to quite a number of the members in Washington and the members also are voting… I think they're either tied up in probably health care…

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program

I would like to take a few moments before lunch to share with you messages we have received from five principally local senators and representatives at their request, that we display their videos. So I will do that now. The first one is from Senator Shelby and it goes as follows:

Senator Shelby's Video Comments:

I'd like to thank you for visiting Huntsville and Decatur and for providing the opportunity for those directly involved with space as well as the general public to interact with the committee. The objectives that you are undertaking are both a challenge and an opportunity. You have a huge challenge before you and a critical responsibility of determining the options and direction of nation's human space flight program. I appreciate your willingness to devote the time necessary to conduct this review. North Alabama and specifically the Marshall Space Flight Center has been at the forefront of human space activity since the beginning of our nation's space program. Today, we meet in the shadow of the great achievements the people at NASA have accomplished. I hope that the enthusiasm that surrounds this area with its ties to human space flight has been evident to the committee. We've just celebrated the 40th anniversary of humans landing on the moon for the first time. It has been a time to reflect on what our nation is capable of when leadership, motivation and perseverance come together with a goal that's defined and supported. Now we must move on and move forward and this committee will provide options that will define the direction man's space flight will take in space for decades to come. There is a robust space economy in Alabama and across this country with companies that can do everything from building rockets that will go to the far reaches of the universe to developing nano-particles for stronger materials that will stand the rigors of space. No matter what has been deeded, American ingenuity combined with the capability and direction from NASA has brought an understanding of the universe that only a few generations ago would have been thought impossible to know. This would never have happened without NASA leading the way. NASA's manned space program, its astronauts and its accomplishments are the inspiration that leads future generations to become our innovators and engineers and scientists. The impact of human space flight reaches far beyond aerospace activities. It attracts people to scientific careers in the development of technologies that improve our lives in many ways. The inspiration provided by the Human Space Flight Program watched an entire generation that, while aspiring to be like astronauts that would go to space, would become the scientists and engineers that make our country the leader in science, technology and innovation it is today. For us to maintain such leadership, the children of today need the same opportunities, dreams and excitement to maintain our country's place as a leader in aerospace as well as in other scientific disciplines like physics, biology and chemistry. I support the manned space flight and see it as relevant today as it was over 40 years ago. The benefits to our nation go far beyond NASA, yet, without clear action and purpose, NASA will achieve less as it fights internal battles over what direction it should take. As a ranking member of the Senate Appropriations Sub-committee on Commerce, Science and related activities and as a senator from the state that is the home to the NASA center that focuses on delivery of humans to space, the funding and direction of the NASA space program is of great importance to me. History shows that when the nation is provided the necessary resources and called upon the people of Alabama to deliver humans to space, they have delivered. I wish to thank you and the rest of the members of the committee for their commitment to human space flight and to our nation." And it is signed by Senator Shelby.

We also have a letter from Senator Sessions.

Senator Jeff Sessions' Letter:

"It is my pleasure to welcome you to Huntsville, Alabama and the Marshall Space Flight Center, the original home of NASA as you continue your mission to ensure the nation pursues the best trajectory for human space flight. I know with great interest that the distinguished membership of this committee brings a wealth and broad range of experience to this analysis. I offer my congratulations to you all for your selection to participate in this important review. Given the groundbreaking work to propel our nation into orbit conducted at MSFC over the past 50 years, I could think of no better place to host your proceedings. As you know, MSFC has made tremendous contributions to our nation's space program since its establishment in 1960. When President Kennedy set forth the challenge of putting a man on the moon by 1970, it was the team at MSFC who made that challenge in to a reality by building the Saturn V rocket. The drive, innovation and spirit of achievement continues today at MSFC as the center supports NASA's portfolio of science, aeronautics and exploration including the development of the next generation of rockets that will provide transportation for future human space flight missions. As we look toward the future and seek to continue our nation's unparalleled legacy in space, it is clear that the Marshall team will continue to play a vital role in ensuring that the United States maintains the world's preeminent space program. I welcome you to Marshall, wish you all the best for a productive session, and thank you for continued service on behalf of our nation. Please do not hesitate to contact me or a member of my staff if I may be of any assistance" and that is signed by Senator Sessions.

We have also letters or inputs from three congressmen, the first two in the form of pre-recorded tapes that if we could, can we play Representative Griffith's tape first?

Representative Griffith's Audio Comments:

"Chairman Augustine and honored committee members, thank you for allowing me this opportunity to provide you with my thoughts on the future of our nation's human space flight policy. Allow me to welcome you to North Alabama, where we are proud of our strong space exploration legacy that includes the Apollo, Skylab, space shuttle and the international space station programs. We're also proud of the progress that has been made on the Ares I launch vehicle and excited about the challenge of developing the heavy lift Ares V. As you all know with the impending space shuttle retirement, there'll be a 5-year gap in human space flight capability, threatening our nation's dominance in space, technology and innovation. As the retirement of the space shuttle nears, it is imperative that we as a nation develop the next generation space flight program to return to the moon and beyond. Constellation, the current launch architecture for our return to the moon is the appropriate architecture. This architecture has received the bipartisan approval of Congress in both the appropriations and the authorization process. It's capable of achieving our human space flight goals in a safe, innovative, affordable and sustainable way. As you will surely recall, our nation suffered a great tragedy on February 1, 2003 when we lost the crew of the space shuttle Columbia. The Columbia accident investigation board's final report recognized that the tragedy was due in part to failings of a haphazard policy process. The board noted a pattern of optimistic pronouncements about a revolutionary shuttle replacement, followed by insufficient government investment and then program cancellations due to technical difficulties. If our nation's space agency and its space programs are to have future credibility in Congress, we must break this cycle. The current architecture was selected utilizing technical analyses that involved more than 20 technical experts at NASA headquarters, and hundreds of employees from across the agency. NASA and its contractors have demonstrated good progress on the Constellation architecture. They have faced their share of technical challenges but we shouldn't be surprised that the human exploration of our solar system is technically challenging. We overcame these kinds of technical challenges during Apollo, and we will overcome them again.

We should keep this current space transportation architecture on track and not throw away the substantial investment, of tax dollars that this has already been made. The constellation program is essential to our national security and to maintaining space dominance on the international stage. Our return to the moon and the benefits that our nation will see as a result of continued human space exploration depends on a series of sustained investment in the Constellation architecture. North Alabama engineered our first trip to the moon and with our current program, we will do it again. I look forward to working with NASA's newest administrator Charles Bolden in taking the next step in man's space flight and exploration. Thank you for your time and consideration as we all work together towards our ultimate goal of continued American supremacy in space."

And we have a tape from Representative Aderholt as well, could we play that?

Representative Aderholt's Audio Comments:

"I want to thank the Augustine panel for an opportunity to comment on this very important issue. NASA has achieved great things, both in terms of pure science inspiring the human spirit to great goals, and in terms of the many practical spin-off technologies and engineering achievements that would have never existed without NASA and specifically, without the exploration programs. I sincerely believe that exploration of space is not just a luxury. Other nations are pushing ahead with major programs of their own. And even apart from that, achieving access to space will continue to push us to learn more crucial matters of physics and perhaps even healthcare. The growth rate in NASA's budget has been very small in the past 20 years compared to other federal agencies. I encourage the president to send Congress a budget which requests a more realistic - in terms of the funds truly needed for exploration. We should never be dependent on other nations for access to space. I hope the President will review the findings of this panel and lay out a vision that aggressively achieves the United State's access to space, and makes plans for a base on the moon. We need a budget request which includes sufficient funding for the exploration programs and which enables NASA program's managers to put together a team of experienced government engineers and aerospace companies to get the job done. In this year which is the 40th anniversary of the Apollo moon landing, it would be great to confirm to the world what year we are returning to the moon. Of course, I'm very proud of the special role the Marshall Space Flight Center has played in so many missions with the government employees and the private company employees in North Alabama, both at Marshall and on the many defense projects managed at Redstone Arsenal, there is nothing we can't design, test and build in North Alabama. Thank you and I look forward to working with the administration and my colleagues in both the house and the senate to continue the wonderful work done by NASA."

And we have a letter from Congressman Davis that I have been asked to read.

Congressman Davis' Letter:

"As an Alabamian and as an American, I'm proud to support NASA and North Alabama's own Marshall Space Flight Center. Since the agency's inception in July of 1958, NASA has led the world to the far reaches of space and in doing so, to set new standards for scientific research and discovery. It is because of what scientists and engineers have accomplished here in North Alabama at the Marshall Space Center that America remains the undisputed world champion in space exploration and our age in space has emboldened us as John Kennedy said it would, to chart new paths in the fields of aviation, defense technologies, telecommunications, medicine and across other research disciplines that requires human genius. Here in Alabama, our support of

NASA has created a high wage, high-tech job base that was once beyond our reach. Our state that once languished has now contributed to America, the Ares I and Ares V and Orion space capsule projects that will assemble the international space station. To be designed and manufactured here in Alabama, these projects represent an essential component of America's next generation space fleet and they deserve America's commitment. We must be mindful that in Washington we have had to constantly fend off proposed cuts to these investments. A country that dreams as boldly as we do simply cannot forego the investment in a marvel like the international space station. When it comes to space, you lose ground when you fail to move forward. Scaling back our standing as the global leader in space research and space defense systems would be a huge step in the wrong direction. When President Kennedy called on us to put a man on the moon at the time when freedom' s survival was uncertain, we responded with an unprecedented investment in an unproven space program. The result was another testament to America's capability to bend even part of the universe to our will. Today as the world shrinks and circumstances change rapidly, there should be a few simple truths about our will as it relates to the final frontier. We are not willing to cede our position on the cutting edge of aerospace technology. We are not willing to hand over our role as the leader in the sciences. We are not ready to choose retreat over another push towards the outer edge or outer reaches of knowledge. I believe we are equal to the challenge that faces us at these times so I urge the Augustine commission to support full funding of NASA and the Marshall Space Center for continued progress in its current mission.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program

And so let me thank each of those individuals for their input and for their support of this program…" and we now have used up - we've got five minutes of negative slack in our program today that shows poor management and why do we not plan to meet - we will cut lunch by five minutes and regain slack and we will plan to meet back here at exactly 1 o'clock is that right?. Right, 1 o'clock here, thank you.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program

If the members will take their seats we will begin the afternoon session. I apologize for being a little bit late getting back, we had a few things to take care off. We will pick up the afternoon and continue the discussion of Constellation…, who will be first briefer this afternoon? Steve, are you the first briefer this afternoon?

Stephan Davis – Deputy Manager Ares I-X – Mission Management Office

Okay, let's bring up the first chart please. Next chart, so we've got a just a couple of wrap topics for the panel to hear, we will talk through progress we have been making on our key risks, or risk mitigation activities. Dr. John Hutt whose our chief Engineer for overall vehicle integration, will walk you through that. We will walk you through that, we will talk about the development of flight test of Ares I-X and give you an overview of Ares V, where we stand with that and its capabilities and some options and then I will wrap it up with a short summary. So with that…, Dr. Hutt.

Dr. John Hutt - Ares I Vehicle Integration - Chief Engineer

Okay, thank you very much. Good afternoon everybody. We are back from lunch and ready to go. Before I jump in, I just want everybody to know how much I appreciate this opportunity to come and talk to the committee on the technical issues. I really appreciate from the role I have in engineering to come and sort of spearhead the effort and speak for engineering on what we do to drive out these technical issues and go resolve them. So with that, the first chart, a lot of discussion today about the technical risk of this development of Ares I today, good conversation and just to continue on that theme of launch vehicle development, we all know we are building high energy systems with limited margins. We know we are going to have technical challenges. Each vehicle we build has unique technical challenges and we are set up in our organization to go off and work those. We do that through a rigorous risk management system approach were we identify these risks, set up mitigation plans and put resources on the problems. What I am going to give you today is a quick snapshot, the big technical challenge is this 15 minutes, a quick snapshot of where we are today on our issues and if you talk to me in a month on what is on the radar screen, I think it is going to change quite a bit. In fact, some of these to my mind are ready to fall off. We are going to talk through first stage thrust oscillation. You all heard quite a bit about that. I will give you a quick status of where we are on that. The liftoff clearance issue, you have probably heard something about that which is primarily driven by the availability of requirements so we will tell you where we are on that, separation system power shock, well taught-cept (ph) systems. We all know launch vehicles, the separation system is something we have to be very careful about because it is so easy to get into problems there and we will talk later of others. We will talk of the vibro-acoustics problem which has been mentioned a couple of times earlier today and where we are on that problem which is probably where my key focus area is right now from our engineering focus. And we will talk about payload mass performance, particularly this area we will talk because of the fact that fixing all these other problems tends to impact mass performance. That is from a performance standpoint how we pay for those problems. And again, we expect to be retiring these and new ones will pop up so I will show you where we are.

Okay, next chart please.

Thrust oscillation. In order to kind of reap the benefits of this vehicle configuration, we gave ourselves one challenge that had to get to work. We put the solid motor in line with the vehicle structure so now we have an acoustic resonator if you will in line with a flexible structure, classic dynamics problem. So we have go to go address that problem and the real technical challenge here from my perspective is not the structural limits of the vehicle. It is not the crew health limits we have talked about. Those are very easy to get to limits where we do not have a problem. The issue is when we, in certain parts of the burn, the modes get very close. We can get on resonance and we potentially have issues with oscillations that affects the crew situation awareness, their ability to read displays, operate and do the functions that they need and actually they are very sensitive to that and they need very low levels. A lot of ways to solve the problem. We have got a host of solutions. Our engineers love this problem actually because we keep finding different ways to solve this problem but we are trying to get to the simplest solution and what we have chosen to do, the simplest way to work the problem is to simply de-tune it, get the forcing function and the response frequencies away from each other, separate the frequencies. That is what we have chosen to do.

So next chart.

A lot of information on this chart but the point here is back in June, we met with the program, selected the baseline, relatively simple baseline of a spring in the middle of the vehicle and one below Orion. We were working the analysis of this system in parallel with the crew, doing testing to really kind of hone in on exactly where those sensitivity limits were for their situational awareness. We all came together and looked at where we were from the ability of that system and where we were from our recommended requirements. Well, the recommended requirements of 0.21 g root mean square averaging for the oscillation on a 0.7 g peak. When we looked at our system being compared to that, they wanted that to be able to meet with a 3-sigma equivalent of 99.86% probability. Our initial analysis showed we could get to a 93.8% probability with the current structure as we know it now, which is evolving by the way. One of the issues that we worked was a dynamic response of the vehicle will evolve. So also we are looking at structural change that we could do and say well, this is a good place to set our baseline design and then start looking at some of the changes Orion could do on their side to drive that probability up to 99.86% and also will be refining our models. Well, we have done model refinement since then and actually the 93.8%, is already up to 95.4%, before we had done any structural changes. So this design is progressing. It is a relatively simple design because we are essentially putting springs in at the interface. Now the interface designer said well, that is not so simple of course but its design work and it is very doable and we have concepts in place.

So, next chart if you will.

Now, in the event we do not get there, to get ourselves comfortable, we have got limits that we can come to closure with the crew officing and get the requirements so we can solidly lock down. We have a number of other solutions and you have heard about LOX damper which has been mentioned earlier, we really like this solution. It is a very robust solution. It is very simple. It does a lot for us from the standpoint of de-tuning and absorbing, using the mass of the propellant tank. It is a very elegant solution that we think we like it a lot. The issue is to do the prudent work here. It was a very low TRL when we started. It was rapidly going up the TRL curve. We would like to get there as soon as possible. Our engineering team loves the solution. It is very powerful. Also, we have had for some time an active system that basically does force cancellation and totally wipes out or essentially wipes out the forcing function which is there and we are just trying to avoid the cost and complexity of the implementation but very feasible design. So we feel that we have got a host of ways to solve this problem. We are trying to get the simplest, least impact to the program solution. So from a technical standpoint, I think we have this problem well in hand.

Okay, next chart.

Lift off clearance. When we started, our initial trajectory profile was to liftoff the vehicle essentially straight up and go into active control once we clear the stand. Well, our requirement was to do this with 34 knot winds blowing from the south into the stand. Well, in some of our probabilistic cases, that showed re-contact with the stand, not uncommon for vehicles that have to deal with this problem. The 34 knot wind is pretty unique to us. We are trying to get as much availability as we can out of the system. Well, from very simple fixes of doing command biasing and turning active controls as soon as we get out of the hole, we were able to fix these problems and meet all our re-contact requirements. So re-contact in my mind is not a significant issue. What remains to be worked now is as we fly the vehicle out, we have got to look out the plume impact on the stand so we do not do enough damage to the stand so it affects our ability to re-fly so now we are going

into the mode of looking carefully on where the limits will be on stand damage from the plume. The 34-knot wind is still a concern and I suspect we will probably wind up placarding winds from that one direction from the south so that we do not have to do so much fly-off biasing that we damage the tower. We have looked at the amount of placarding that it takes to be able to prevent plume damage and it looks like it is actually going to be a minor impact to overall launch availability so I do not see this problem as that significant of a concern. And it is mainly here on my mind because it appears to be a significant concern, in my mind it is not that really, okay?

Next chart.

Separation system power shock. We have done extensive work on our separation system for this vehicle, a great deal of analysis to ensure that we get clean separation. In fact, we have had an independent study performed by Aerospace Corp in fact and basically they agreed with our basic results. We have a robust separation system overall concept design. The issue that it did drive us to is because of packaging constraints on avionics, we had a very linear shaped charge to ensure we got a very clean separation. One thing we have to be clean if we do not hang up when we separate. So we had a very large charge, initial analysis to ensure that we separated the system and in the near field, we had avionics boxes, seeing very high g-load shocks from that, unacceptable g-load shocks from the standpoint of what we could practically qualify for avionics. Just recently, I think it was in the last two weeks, we have changed that design to a frangible joint design using, it is now I think, 30 grains per linear foot frangible joint which also has a much lower shot load. So the shock load to the avionics boxes is now more than an order of magnitude lower than it was in the previous design, well below where we see historical issues with shock loads on avionics components. So I think essentially have got the only open issue here from fully retiring this is getting that design material for frangible joints up to where it was for the linear shaped chart.

Okay, next.

Okay, vibroacoustics issue. This is one where we have got a lot of focused effort on right now. This one is going to be more of a long term effort because it is going to move around on us as we mature the vehicle. The nature of this vehicle is we fly a high dynamic pressure trajectory, which means we go and we go transonic very low in the atmosphere so we have pretty high acoustics in transonic, which leads us to higher vibroacoustic loads. Now, a lot of launch vehicles typically have a high vibroacoustic loads so ours are somewhat higher than typically seen but it is very much at manageable levels. Now, we have got to attack this problem at all levels, in our minds, to get the cleanest overall system solution. The first thing that we have got to focus on and are focusing on is our predictive methods and do we have adequate resolution of the key areas in our wind tunnel testing. Are we appropriately transferring those acoustic results to the vibroacoustic predictions that the designers have to use to design their environments to and are they adequately bracketing what we are going to see in flight but not bracketing more so, so that we are stressing our designs, are stretching where we are at the design more than we need to. The thing that we had been doing and have probably exercised as great as we possible can is what can we do from the vehicle's perspective, how can we file the trajectory differently? Can we put limits on an angle of attack that will help, those kind of things, from how we fly the vehicle and are there things we can do a protuberance standpoint, smooth out the mould line to get these noise levels down. Once we had exhausted those, and of course this is iteratative activity, once we had exhausted those we then go into what we can do at the component level.

Okay, next chart.

A lot of things we can do. You can move the components, we can isolate, we can do absorption and we can increase the effective mass. Vibroacoustics is very much mass-driven. If we can get the effective mass of the component up by either combining them, adding mass, change how you mount them, we can get the overall acoustic levels down. That is what we are working on right now. We have done all that. We worked the instrument unit, avionics with and have gotten now the levels well within where we can qualify the components. The issue now is on the reaction control system and the roll control system. Right now, the limit is based on the current - the way we are mounting those systems exceed where the heritage qualifications are for those issues. Now that is a significant concern to the designers and we are working out our design options. We have a wide design space on how we can fix that problem from anything as far as how we mount the RCS system to redesigning the RCS system in the most extreme level and we are working through those.

Next.

Okay, let me get to the mass issue, where are we relative to mass. We have been watching this problem for -- not really a problem, we have actually had the luxury of designing in a robust level of margin from the standpoint of we are using historical mass growth alignment which is allocating that to the elements. They are well within the historical growth curves for those elements plus we have margin at the project level that we have been managing quite well and we have gotten on the order of 2000 kgs margin above mass growth alignment which the elements have for the ISS mission and there are some 600 or so kilograms less than that for the lunar mission so we think we are in a robust state from the standpoint of payload capability.

Last chart.

In summary, I think I have gone through the ways where attacking all of these problems and I think we are in relatively good shape and as I wrap up here, we will be turning this over to Steve Davis, the Deputy I-X project manager and there are two key problems that we are going to get critical data for on these issues from I-X, one being thrust oscillation data. We are getting a great data point the first time we have flown an in-line vehicle. We will do predictions on that and see if we are actually matching our models and we will get more data on the vibroacoustic environment to see if our correlations are actually working well so a very important test coming up and Steve will lead us right into that.

Stephan Davis – Deputy Manager Ares I-X – Mission Management Office

Thank you John. It is a real privilege to speak to the committee. I just have two charts. I understand tomorrow you will be at Cocoa Beach and the Mission Manager, I am the deputy Mission Manager, Bob Ess will be down there and I would suggest if you have an opportunity, the hardware is over in the VAB at KSC and we have begun stacking and it is well worth your time, I suggest, if you get a chance to go see it.

Next chart.

As I said, I have two charts, one is an overview of the flight test and the second is a status. We are flying a suborbital vehicle. Its, essentially, we have a four-segment RSRM with a fifth segment spacer so that the first stage has the same characteristics as the Ares I first stage and

the upper portion of the vehicle is essentially is a metallic simulator. We are about 750 or so sensors. We are going to get 900 measurements back. That is in addition to all the operational flight instrumentation data that you would get from just flying the vehicle. There are five primary objectives. They are listed here in blue. We are going to demonstrate controllability. As you can imagine, this rocket is very tall. It is almost 330 feet tall. It is 18 feet at its max width and so it has a very high slenderness ratio and so we are interested in understanding the controllability as part of the risk mitigation for Ares I. We are also interested in separation. You have heard that come up earlier today at 130,000 feet which is about 2 minutes into flight we will perform our first separation. It is our primary separation. There is a second smaller one when the primary chutes come out a little later. Our third objective is to demonstrate the assembly and the recovery of the first stage. We are going to demonstrate that we can go and recover it as part of risk mitigation for Ares I. Number 4, we are going to look at the first stage reentry dynamics after we have separated and as we turn on the tumble motors and eventually trim out and produce the chutes and the fifth thing is to characterize the integrated vehicle roll torque. Interestingly, the roll control modules we have are essentially decommissioned peacekeeper, large portions are from decommissioned peacekeeper parts including the tankage as well as the thrusters but we have reconfigured them to work with our vehicle.

Next chart.

I could go through a lot of details on our status but I think the easiest way to look at it is this. All the main hardware is down at KSC now. We are occupying two bays in the vehicle assembly building, high bay IV and high bay III. High bay III is where the mobile launch platform is and where we have already stacked the motor segments which we call stack zero. There are five sub-stacks that then go on top of it and we made the decision just yesterday, last evening actually, to begin stacking of the upper portion of the vehicle. So the expectation is that in about two to two and a half weeks or so, the vehicle will be stacked and we will begin the process of integration, of test out and electrical integration. You have heard that we have adjusted our schedule to October 31st. Actually, internally we are working to October 17th and the reason why we have adjusted that is had some issues with shuttle conflicts but more than that is we have added additional time to do our testing of the integrated vehicle, all the electrical testing and we have made that six weeks long and double shift so that we have time to work through any issues that may come up and certainly from a first time vehicle we are expecting to see some things. So with that, I think that is an overview and I think tomorrow when you are down at Cocoa Beach I believe the Mission Manager will spend a little bit more time going through the details of it. And following me is Steve Creech who is in charge of our Ares V development.

Steve Creech – Ares V Integration Manager

Thank you Steve. So you have been through the Ares I that is in development and Steve just showed you Ares I-X about to go to flight test. I am gong to tell you about our - take you back to the concept definition stage and tell you about the work we are doing on Ares V, go ahead.

This is our point of departure vehicle that we established at last year's mission concept review for not only Ares V but the entire lunar architecture. The vehicle is a 10 meter diameter vehicle, same as the Saturn V first two stages that are in the room behind us here. The core stage is a six RS-68B engines. We fly with a 5-1/2 segment version of the solids. This is actually derived from Ares I first stage and adds a half segment. We have also traded for longer term options going to new solids and we are also actively trading, actually staying with the current design of the Ares I first stage five-segment. The Earth Departure Stage serves as the second stage for

the launch vehicle. It then loiters on orbit for up to four days, provides station and keeping for the whole stack, power, attitude, tries to keep from burning off all its propellants and then does the TLI burn to go to the moon and then you see the payload shroud that encapsulates the lunar lander, Altair Lunar Lander.

Next chart.

You have seen this today and I know it has been a recurring message but I wanted to hit again that the family nature of Ares I and Ares V. For reliability reasons that we get experience with the hardware but also really driven by cost, we cannot afford two unique vehicles and so the selection of hardware not only for Ares V but I would say a section of hardware for Ares I was driven in large part by the requirements of the heavy lift vehicle and what we needed to go back and do lunar exploration. The first one I mentioned is J-2X. You saw that today. The EDS wants an engine in this thrust class that can restart. The other options that are out there are to do a much lower thrust engine where you are talking about multiple engines on the stage and you tend to want to add another stage in between that and the core stage and so you are back to this engine again but all the vehicle concepts, a lot of the vehicle concepts we have looked at really want this class of engine. So as you saw earlier today, the J-2X which is past CDR is being designed with our requirements for the heavy lift vehicle. We will then add just kitting to maintain or to be able to handle the on-orbit environments and then verify the restart and that will be as is. The first stage, all the heavy lift kind of architectures we have looked at to get into certainly into a 1-1/2 kind of launch class vehicle, launching a heavy with an Ares I class vehicle, we believe you need a 5-segment booster even for a two launch, two heavy kind of launch class vehicle, you really want a 5-segment booster to design that vehicle. And so we take that as I said either as is from Ares I or in a configuration like adding the half segment where you still get the benefit of you using the same infrastructure. And I guess I would say that is important, those are important only from a cost standpoint upfront but maybe even more importantly to be sustainable because of the fixed cost kind of infrastructure with unique aerospace systems. We feel like there needs to be commonality there. We also use on the right there as I mentioned earlier the Air Force Delta IV vehicle core stage engine. We are using core stage, 68 is flying now, 68 was dubbed 68A, is in development and actually in test now by the Air Force and NRO and our version we called 68B includes a couple of operability kind of improvements to address helium usage and free hydrogen and handle the different burn time requirements we have. And we think that leverages obviously a commercial DOD program and an existing hardware that we can share that fixed infrastructure with and also it is a very producible engine which is going to be one of the challenges of a heavy lift architecture, is the core stage, a number of rocket engines are going to need to produce to field some of these missions.

Go ahead.

Some of the status - we are back at the concept stage and it is cheap to do, to look at different alternatives now and you saw I think when you visited the center our advanced concept organization, some of the analyses capability we got in engineering so we continue to look at the different options, option of trying to find and honestly being driven to this point mainly by cost, number one meeting the requirements of the program and what we are trying to do with the nations laid out but secondly by cost and looking if there is a more costly system that is also more reliable. We have gone at the concept stage not just a running post with mass fractions but it is actually a five or six person team that does trajectory and loads and structural design to come up with those in a couple of days. We also have an in-house design team, about 60 people that are

focused down at the elements looking at the next level design issues, understanding requirements and also understanding what it takes to build and test these systems because they are so large and that is a big part of the challenge too, is how we are going to test it and what is the development plan for doing that. I have already mentioned that our pod I showed you was from LCCR, our Lunar Capability Concept Review. It was really focused on getting more margin in the overall architecture there as well we made some of the decisions for that pod. The other thing I would point out is we have been driven not just about designing a launch vehicle but working with the overall architecture and what the mission needs are and those are manifested mainly for us in the Altair Lunar Lander. We have also spent a lot of time talking to different users, potential users of this vehicle. Our primary mission of course is NASA and exploration but we have also spent time talking astronomy and science and DoD.

Next chart.

This is what they are interested in of course, is you not only have unprecedented lift capability but volume and C3 and that allows you to use that capability to greatly increase the size of payloads, reduce the time of interplanetary missions and also removes volume constraints on space telescopes. We have done several workshops and also there was a national academy's study that I have got a quote from there.

Next chart.

Let me finish out because I know that you are looking at different architectures and different options and Bo in his charts mentioned Ares V light. This is kind of the different things we have looked at, similar vehicles and on the bottom, I will only make the point in the I and V architecture, we have looked at a range of options there, depending on the requirements and how they would phase in over time and how much capability you would have. On the top, we have looked at the first vehicle there that actually flies an Ares I upper stage, gets you about 35 metric tons to TLI. That is a lunar flyby with Apollo-8 kind of mission capability and then the other two vehicles are what Bo referred to as the Ares V light. That is sizing the vehicle, taking the same building blocks, reducing the complexity and making it a little simpler using the 5-segment boosters but sizing the vehicle to do the lunar mission in two launches. And the payload wants to be, if you do a dual launch kind of mission, the payloads want to be about 40 metric tons, the Altair does and so we think you want to size the vehicle in the 45 and up kind of range and Ares V is flexible to do that. That is my last chart, let me turn it back over to Steve to wrap up.

Stephan Davis – Deputy Manager Ares I-X – Mission Management Office
Mr. Chairman and the panel, we appreciate the time that you have given us today to review the progress that the Ares V team and Ares I team have made over the last four years. Before I get in to my formal remarks, I would like to say we did run down an action for you at lunch and the ESAS budget line that you saw was indeed the submit, NASA submit to OMB in the fall of 2005 so we were able to confirm that.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Could I pick up on that, it was a submit from NASA to OMB but not approved by OMB.

Steve Creech – Ares V Integration Manager
It was approved by OMB. That was the budget going on in the 2006.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
It was the OMB budget? It was the budget.

Stephan Davis – Deputy Manager Ares I-X – Mission Management Office
Okay, next chart. I have two charts here to wrap it up. We have talked a lot about the people we have talked about the hardware but one of the other things I wanted to close on was this is not just about NASA seeking out ideas from within itself and trying to work within the aerospace community. One of the things that we have tried very hard to do is to reach out to other communities and bring in their ideas, their technologies for example, the thrust oscillation baseline approach today. That design came from some folks that came up directly out of the automotive industry as a comparison. We have been working with the ship building industry on how we can transfer out our technology on friction stir wielding so they can take it and mature it further and then we get an even better product back. The LOX Dampening is something that came out of our engineering research community here at the center. We are working closely with industry and the university community on coming up with large, 10-meter diameter composite options for Ares V in particular, the payload shroud and we would like also to do the inner stage if we can. That may be one piece that may be in and out of our cloak (ph). It may also include lightweight fastening and joining concepts, really trying to take the state-of-the-art there in the aircraft world and see what we can bring over to the space lift world and then finally we have talked about the asbestos-free insulation that we are replacing as we move from the space shuttle over that does definitely reduce environmental impact. It is a requirement to do that but it is also turning in a material that may also end up in protective equipment for firefighters. So this technology, we are trying to spin it out into the right places and also bring in the best ideas from other industries as well to solve our problems and make this the most robust solution we can.

Next chart.

In closing, I would like to say that we believe that Ares I and V is the fastest and most prudent path to closing the human space flight gap while enabling exploration of a sustained program to the moon and beyond. It was made after a systematic evaluation of many, many concepts and we came up with what we believe is the highest reliability, safety and lowest cost solution to meet the requirements that we were given. It is built on the foundation of proven technologies and capabilities and infrastructure and we are not going after as we did in the 90s the highest tech solution, single stage to orbit and things of that nature. The team has really done an outstanding job of meetings its milestones. We have done what we said we would do and we are well on our way towards first flight test here in the next couple of months and the design of the mainline system is also well-along. Ares V of course is well underway. We actually have a draft, request for proposal that is on the street. It is on hold pending your review but it is ready to go at the conclusion depending on what the answers may come out. Ares V will clearly give us an unprecedented national asset and the United States is in a unique position to enable something of the Saturn V class again. So I would like to think about it as I am sure you have had time to walk up here and see the Saturn V, just imagine that that machine up there with two solid rocket boosters down the side and you get a rough idea of the kind of capability we are intending to enable. We are not drinking our own bathwater. There have been several external assessments of the project since we started, both from the national advisory council, the NASA advisory council and the NASA standing review board that has come in at every one of our reviews and

has lived with us through these reviews and given us good, sound insight and guidance as we move from step to step in addition to the other typical government oversight boards such as GAO and the Inspector General's Office. So, I am pleased again that we have had the opportunity to talk with you today. I think you have gotten the idea for the three product lines that we have in work today and how we are working to actively mitigate the risk to keep this gap as short as possible. With that, I will ask for any final closing questions from the panel.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Are you planning to brief the material on the human exploration to Mars or is that?

Steve Cook – Ares Project – Manager
That is following me. That is Mr. Drake and he is here and ready to go.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Why do we not do that then take questions all along, okay? Thank you.

Bret Drake - NASA Lunar and Mars Integration
All right. Thank you. What we want to do right now is just give you a feel for - you've heard a lot about the launch vehicles in the last few days, Orion, space station deliberations, where does this all go in terms of the future and what we might do, as one of the goals that the committee may consider for a future direction for human exploration.

Next chart please.

We maintain human exploration of Mars as one of those goals as a challenge for us to guide some of our deliberations in our thinking, trying to understand how the systems, how the technologies, what we need to expand our frontiers beyond low earth orbit. We have maintained a reference mission to compare and contrast different technologies and systems and reference approaches. It is a culmination of the best ideas we have to date. It should not be construed as the plan of going to Mars but it is basically where we are today in terms of our thinking. We update it as we go along. We have just recently in 2007 completed a study and we have developed documentation for that and we have released that and given that to the committee for your further analysis. I have extracted a few charts from that study just to give you kind of an overview and so you have a feel for how some of the systems that we are thinking about fit together.

Next chart please.

To give you a feel for human exploration of Mars, it is not like lunar missions where you have an opportunity to go just about any time you want. The moon revolves around the Earth. For Mars, you have to concern about the relative phasing of the Earth and Mars relative to each other and you have an opportunity to go about every 26 months. So the strategy that we employ is a two-phased approach. At the first injection opportunity, we send cargo ahead of the crew. That cargo consists of two landers, one is a decent/ascent vehicle and another is a habitat lander and that provides us several different advantages. First, it allows us to reduce the total mission mass and because we are able to send that cargo on slower, energy-efficient transfers. Plus, it also gives us some risk reduction capabilities in terms of we know that that cargo is in place either on the

surface or in orbit at Mars and we know that it is functioning the way we want it to be functioning before we ever commit the crew to leave Earth orbit. Once the crew does leave Earth, they have no return opportunities. They are committed for a long duration mission so ensuring that those assets are at destination and operating the way you anticipate them to is very critical. Pre-deploying cargo also enables some revolutionary new operational concepts. Because the cargo is there, you can think about different approaches such as using the resources that are at Mars to enable further exploration. For instance, we can extract the carbon dioxide on the atmosphere, we can crack it into oxygen for breathing for the crew, plus we can also use the oxygen for ascent off the surface and that gives us a significant mass leverage in terms of the overall architecture and how it ripples all the way through. So pre-deploying those assets gives us some robust capabilities, 26 months later when the ejection opportunity opens up for the crew, we send them on fast transits out to Mars. The fast transit is about 180 days and if you think of it, that is basically what we are doing every time we send a rotation crew to the space station, we are in essence simulating a Mars transfer, 180 days to get there, the research we are getting from the space station is providing us some valuable lessons in terms of human conditions for those periods of time, how to counteract those things like bone de-calcification and muscle atrophy. Once the crew gets to Mars, they rendezvous with the habitat lander, descend and land and they explore the surface for about 18 months. Again, we are waiting for the proper alignment of Earth and Mars for the return back home. So the missions are very long and as I mentioned earlier, once we commit the crew to leaving, they do not have a return capability. So reliability, robustness of the architecture, understanding how systems behave and the reliability of systems is very critical for these missions.

Next chart please.

Just to give you an overview of some of the in-space transfer vehicles, we are still looking at the concepts for Mars transportation. The two leading concepts are nuclear assembled rockets and it is based off a technology concept that was developed and actually tested in the late 60s and the early 70s in the Rover Nova program and it gives us a very high specific impulse which is good for these missions because it helps reduce the total mass of the vehicles in Earth orbit, plus it also gives you some overall architectural efficiency. The margins, there has been some discussions of margins throughout the day and margins for these vehicles are going to be very important and having an in-space transportation system which is very robust helps that margin posture. We are also looking very heavily at the chemical option, chemical combined with aero-capture of the payloads at Mars using the atmosphere of Mars for capture of those payloads but those are locked hydrogen systems based on rocket technology we have in place today. For instance, RL10 type derivative engines for the major maneuvers. Both of those require cryogenic propellants, so storage and maintenance of cryogenics for long periods of time is critical. So those are fairly large vehicles. We tend to try to minimize the amount of on-orbit assembly and complex operations to the greatest extent possible to help improve the overall reliability of the systems.

Next chart please?

Now how do Ares I and Orion as well as Ares V fit in? Ares I and Orion provide us two primary functions. First of all, delivery of the crew and any checkout crew at the beginning of the mission so that would be Orion and Ares I, delivery of those crew to low Earth orbit and then also at the end of the mission, as the crew returns to Earth, we use a derivative of the Orion capsule for direct Earth entry at the end of the mission. So Orion fits both of those bills, delivery of the crew

to the vehicles at the beginning of the mission as well as Earth return at the end. Because we have gone with these long stay conjunction class missions, the entry speeds back at Earth are about 12 km/sec rather than lunar which is about 11 km/sec. So we are really close in terms of the system requirements of Orion being able to meet those mission needs. From a mass perspective of getting all of these hardware into Earth orbit, the total mission mass is about 800 metric tons for the nuclear option and about 1200 metric tons for the chemical option. To put that into context, the space station at assembly complete will be about 400 metric tons. So we are talking at a minimum two orders of magnitude if not three orders of magnitude of total mission mass and that is including the incorporation of a lot of advanced technologies. We have thought ahead of what types of technologies we want to incorporate, things like closing the life support system and things like that in order to reduce the mass and those have already been to a certain extent dialed into that mission mass. So it is a significant amount of mass. For the NTR option, we need about 7-9 Ares V launches each time we go, the total mission mass, and if we want the chemical option to be on the order of 9-12. Again, that is dependent upon the final end-result of the payloads and the technologies we dialed in. Maintaining a launch center, we try to minimize the amount of assembly as I mentioned earlier and so those launches occur about 90-day centers, trying to get all those launches up into Earth orbit to provide us enough schedule slack as we recognize the schedule slack is really important because we have a fixed window when to leave. So launching those on time is very critical.

Next chart please?

Once the crew is at Mars, we need to enable a robust exploration. We are there to explore the surface. They are there for 18 months and so giving the crew all the capabilities and skills and techniques necessary is critical. That includes maximizing the scientific return. When we land, we are going to land in fairly benign, safe locations and we want to get to those areas of high geologic interest which means roving long distances, so having small pressurized rovers, having routine exploration of the surface is important and that is another area where using in-situ resources is critical because that can enable us to have much more robust exploration. Plus, we want to do sub-surface access, do some drilling, get to understand the strategic review et cetera and collaborating with scientists here at Earth. So we are there for 18 months so we can pose questions, explore and postulate new questions to enable the exploration.

Next chart please.

In the documentation that we have provided you, we have got a long list of key technologies and challenges, just a few here that I want to mention. I will not go into too much depth with these but those that kind of come up to the top are landing large payloads on the surface of Mars. Right now, we are limited with our current technology to about 2 metric tons and to enable these, we need to get up to about 40 metric tons of landed useful payload. That has been recognized as a challenge from the agency's perspective and we are actively addressing that, both from an aeronautics research, science mission directive because they want larger payloads and also from the human exploration perspective. As we mentioned with launching large mass and large volume, the systems that we talk about do not just require a lot of mass but they also require volume. We have go to fly these vehicles for entry and landing through the atmosphere, which means aerodynamic maneuvers so packaging CG control et cetera are very critical. So when we consider the launch infrastructure and the launch process, we need to also include volume as well as mass. Supporting humans in space for long periods of time is critical. The experience we are gaining from the space station is giving us a lot of good information there. As I mentioned

earlier, we do not have just in time supplies delivery. We have to pre-deploy the cargo for the crew or we have to take all the necessary equipment with them. So that lack of supplies, that lack of abort capabilities, being able to enable the crew to be able to operate for long periods of time by themselves is critical. I mentioned the cryogenic fluid storage and management, production of consumables et cetera and the bottom line of all this is system reliability, understanding the behavior of systems, understanding the failure modes and being able to predict that, understanding how to repair things in space as the crew is by themselves for long periods is critical.

And lastly, just to close, next chart please.

Part of the evolutionary strategy that we have talked about when we frame human exploration of Mars is ongoing today, and what we are doing on the Earth in our laboratories, in our field tests, doing analogue research at the Antarctic in our desert exploration are all feeding into our knowledge base that we are using today. What we are doing on space station, our zero gravity research countermeasures protocols are vital and as I mentioned, for simulating every time we go to the space station or to Mars transit and those operational concepts and the moon is also another critical link. As I mentioned, Mars missions, there is no return capability. So the moon serves as a viable test bed to be able to prove those systems. We have the punch out capability from the moon that we do not have from Mars. If things go wrong, we have the option of coming home. That is something that we do not have at Mars so the moon serves at that viable test bed. It serves as the test bed of being able to simulate the validity of all these systems. It is a system of systems perspective, do they all work in the large scale which is difficult to do in laboratories here on Earth. So the larger scale system-of-systems demonstration and validation is important, plus our operational concepts, how do we explore for long periods of time with the crew is vital. And every time we send a Mars robotic program to Mars, we are learning from that. They are gathering a lot of the vital information that we have, that we need in terms of the characteristics of the environment at Mars, plus we have opportunities coming up in the future with development of Ares V and the need for landing large payloads on Mars. We have the opportunities to scale up our Mars robotic programs, demonstrate some subscale systems for humans and tie in things like institute resource et cetera. So there are a lot of activities going on although not directly funded for Mars integral throughout all the agency activities. That is a focus that we try to maintain on the ball there. And that is all I have. I would be glad to entertain any questions.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you very much. I suspect my colleagues here have questions, anyone want to start?

Participant – Human Space Flight Review Committee
Yeah, my question is to Steve Cook if you do not mind Steve, you showed a chart, you showed a chart near the end there about transition in to your program if I can use that terminology. As you know, the NASA research council study that just came out talked about the need to align our civil space program, human space flight programs to address other national needs and I am wondering if you have examples or process here where you look at opportunities like that, the most obvious one that immediately comes to mind is your water recovery program that you have on the international space station? One can only imagine how that could fit not just our national needs but the needs of many, many nations, particularly third-world nations around the world?

Steve Cook – Ares Project – Manager

I think that is a - we would love to take that action if I could. We would love just to followup with you and give you some more examples but the way that we have done the process to date is actually we have used the - NASA has a technology transfer function that has been around for a long time and it has been heavily focused historically on spin off, okay. There is a magazine and a publication about how we spin off our technologies to other uses but in the last few years, they have developed a process by which they look at how we spin technologies in, use them and then kick them out and so bring them back around, almost like a big figure 8. We have used that process here. We have got a great tech transfer folks here at Marshall Space Flight Center who work with the Comstock up in NASA headquarters and we have used that process and what they do is they bring in, we give them a list of our key technology areas and challenges and our risks and they go out and they work through a series of other contractors that help them do this, look and see where other industries are working on those areas that we can match these out then they will bring them in. We will have sit down session for example. We were getting with our large scale integrative ground vibration test article down here in kind of a mini VAB at Marshall Space Flight Center, we needed some way to be able to move up and down the stack once we get it in there. The way the shuttle did it was it built individual platforms, very expensive, very time-consuming and actually we found a company -- I think it was, I cannot remember what the company was but we found a company that built systems like that for construction and they were able to come in and for non-aerospace prices, gave us some very robust solutions to get the job done. The same kind of things with LOX Damper. We reached out to the research community there for their ideas so I would love an opportunity to give you an example of how that process works and some other examples that we have looked at and some other opportunities.

Participant – Human Space Flight Review Committee
I would love to do that and particularly if there was a way you can as part of your process interface with other agencies as an example again, the water recovery system would be a tremendous need to the State Department, AID et cetera so I would love to followup on that if you can.

Steve Cook – Ares Project – Manager
Okay, we will do that. Any other questions?

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Excuse me Chris, do you have a question?

Chris Chyba – National Academy of Sciences Committee
Thank you. I have a question for Steve Creech and it is about the Ares V. You quite reasonably cited the National Academy study on how science missions, high mass science missions can be enabled, high mass, high volume science missions can be enabled by Ares V. The other piece of that puzzle of course besides the capability is what the actual pre-launch cost would be and whether the science community is likely to be able to afford any such launches so I wonder if you could tell us, once the Ares V is in production what you would estimate - you know, I would be happy with one significant figure, the pre-launch cost to be and what are you including in that cost estimate?

Steve Creech – Ares V Integration Manager
Our cost estimating process for both of these vehicles is as we have said before high driven by fixed cost and we share fixed cost with Ares I and then we estimate what the variable cost is per

launch and to a second customer like this, we envision that would be charged, that variable cost, which in 2006 dollars is $300 million for the variable cost.

Chris Chyba – National Academy of Sciences Committee
Yeah, a quick followup on that one, if you look at systems that have high fixed cost and a variable cost like that, there are breakpoints in that your fixed cost from your work force or size to support a certain number of launches and when somebody needs more launches per year than you are set up to do, that is no longer achieved at X variable cost so do you have capacity both under the current cost estimates to support more launches than the exploration mission is projected to demand?

Steve Creech – Ares V Integration Manager
That is a good point. The exploration mission is sized to eventually ramp up for Ares V launches up to four flights per year. We have even been asked to look at more than that. Most of the mission model is two flights per year so you would want to do these back in a two-flight per year mission or I think - I guess my answer to your question is I think it fits but you would not be able to handle if you are flying four flights a year, you would not be able to do a lot of these extra missions and the main thing that limits that in my mind is going to be the engines because our pod vehicles got six engines, you may have five engines but you are talking more than 20 engines per year and so that will be the flow, from processing and those kind of things, I do not think it is a driver at these rates.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Well, I have three questions. Why do I not speak them all and whoever wants to answer them could be thinking about the answer. The first one was to - actually you spoke a little bit of the radiation risk to the crew on these missions. The second question, I was thinking at lunch...., I think you mentioned an ISP VAC of 448 which was I think it sounds like an awful lot and I am wondering what - I realize you are working off of a modified existing engine but how confident are you of that? What tester do you have? The third question is that this goes back to some experience that is not really correctly relevant and for that I apologize but some years ago when I was in the Department of Defense, someone had the idea we would have a contractor develop a system, make a proven data package and then we would auction it off to some other company that would put it into production and that turned out to be a terrible idea because one companies measuring procedures do not match another very well and what are you doing to make sure that the work you are doing with Boeing, I guess Boeing is going to work when it comes time for them to put this thing together?

Steve Cook – Ares Project – Manager
Alright, so first question with respect to radiation, radiation protection for the crew still continues to be a challenge for beyond low Earth orbit missions. It is an integral part of our decision process as we design our missions and basically, we continue to research several areas in terms of what is the environment in which the crew is going to be exposed to and understanding and characterizing that but also mitigation techniques such as we design our vehicles to minimize the radiation effect by design in terms of the packaging of the systems, trying to maintain high hydrogen content systems around where the crew will spend most of their time to help mitigate the radiation effects as well as minimize their exposure during the mission. For instance, as the Mars mission as an example, that was a key decision point when we looked at the mission classes. There was two different designs, one where they stay a long period of time on the

surface and one where they spend a majority of their time in free space chasing Earth and Mars and there was not a discriminator from a radiation perspective. The radiation effects were essentially the same so we wanted to make the surface where the crew spends most of their time the safest place to be. But in terms of the research, the biological effects, there continues to be a major risk area that we are keeping our eyes on, no clear answers yet at this point but we will continue to address it in all of our activities.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Chris would you like to follow that up?

Chris Chyba – National Academy of Sciences Committee
I would just like to ask a followup question, not a discriminator for radiation effects with respect to spending a lot of time on the surface versus a lot of time in deep space, what puzzles me about that is that I thought that the current limits on lifetime exposure put you in a place where you are limited currently with our current understanding. I understand there is substantial uncertainties to about 200 days in space and that is the primary driver that I believe is galactic, cosmic rays which are hard to shield and the advantage of course of being on the surface is you cut that by a factor of 2 because we have Mars behind you so to speak. And since 200 days is close, it is kind of knocking at the door within a factor of 2 or so of the amount of time we actually need to do a mission and for the time they will spend in space, I would think that the factor of 2 would in fact make a big difference.

Steve Cook – Ares Project – Manager
That is correct and all of our design so far exceeds the limits, so we actively addressing it and in terms of our mission design or Mars systems, we do not have any clear answers at this point that is why it is high up on our risk areas in terms of addressing, no clear answers yet but it is high on our list. Next question?

Steve Creech – Ares V Integration Manager
Yes sir, you wanted me to address the 448 ISP for J-2X

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
I would appreciate that.

Steve Creech – Ares V Integration Manager
Yes sir, we have several different design solutions that are pointed towards getting to the full 448 as a reminder of the J-2S at a 40:1 expansion ratio was around 436 so it was looking at about 12 more seconds. We are allowed to get most of that from the large nozzle extension due to an upper stage engine. We are going from 40:1 to 92:1. It is about foot in diameter so that is a large chunk of it right there. We are also making some injector modifications that will raise the C-star up to over 99 and so we are making the main injector much more efficient so characteristic exhaust velocity is up, larger nozzle extension and to boot, we are attempting to supersonically inject the turbine exhaust gas from the gas generator back down the wall of the nozzle not only to cool the large nozzle extension but also to gain some performance. Our current power balance model shows this at nominal of over 450 and so the 448 is what we are calling the guaranteed minimum to the vehicle so we would make sure that we make a 448.

Stephan Davis – Deputy Manager Ares I-X – Mission Management Office
With regard to our transition from the NASA design team development of the configuration, the engineering for the configuration specification to Boeing, we had a plan that we basically put in place before we did the acquisition and had some transition points. For instance, we transitioned manufacturing, planning, roughly PDR timeframe. We intend to transition the design authority if you will at the DCR timeframe. By that time, the NASA design will have been matured to a point where the procurements are all very well understood. We will have a significant amount of hardware in the flow. All of our verification qualification will be done. There are two things we want out of that, one is it gives us plenty of time to work with the Boeing team to become familiar with the design so that they can take ownership of it and operate it and secondly, it gives the NASA design team an opportunity to finish the design, complete it. We will continue to hold all of the CAD models, the drawings, all of the specifications, that our NASA design team developed that belong to the government. Now, we never intended to design valves or thrusters or what we call the source control items. Those would always be in the vendor community anyway but that was our strategy, is to make sure that we have a good hand off point where we feel like we have got good ownership of the design and we have had an opportunity for the Boeing team to become familiar with it so they could operate it. I hope that answers the question.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Yeah, I understand what you are doing and it sounds like you are dong everything you can do but in my experience, these are dangerous steps so it is going to take a lot of logic in that regard.

Stephan Davis – Deputy Manager Ares I-X – Mission Management Office
It is particularly interesting now, we are at the point of detailed process specs, how you put a common bulkhead together, what are our bonding procedures and all those things. We hold a lot of that work in-house so that it is a NASA product that we are putting out there and I recognize some of the pitfalls in there. We are trying to guard those so that those are government products that will be held by the government and understanding the issues.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
I guess the concern is that once you have even a proven data package from one source, in this case the government, there are usually a lot of surprises when it comes to - I guess you just have to allow time and put the work through those…

Stephan Davis – Deputy Manager Ares I-X – Mission Management Office
We hope so…

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Actually, I saw Bo first and then I will come to you Charlie.

Bohdan Bejmuk, Chair, NASA Constellation Program Standing Review Board
I have a question that is really - it is not my question but it came to me from a gentleman that I trust immensely his engineering judgment and I could not answer it so I will see if Bret, if you are still around if you can answer it. And the discussion went like this, he says, you know, we carried

wings and tail on orbiter through ascent which by the way designed those things so we can land, so we can enter and land. We have carried the parachutes, flotation devices, heat shield to the moon so we can use it for the last, I do not know, 20 or 30 minutes of this mission. And his question was, did you ratio, as you guys call it, how much to you have to launch to LEO so you can actually get to Mars and he said is carrying all that stuff all the way to Mars, the only way to go to Mars for humans? Do you have to take parachutes and flotation devices and heat shield all the way to Mars on orbit so you can two years later use it for the last 30 minutes of the mission while you enter?

Steve Cook – Ares Project – Manager
Right, okay, so you have got a couple of options. At the end of the mission, you got the crew living in a transit habitat that has been designed to keep them alive for a minimum of 400 days and then a contingency of up to 900 days so it is a fairly sizeable element, the transit habitat. If you did not want to take all those systems for a direct Earth entry, you would have to stock those systems in Earth orbit, and at the end of a Mars trajectory, you have got a lot of energy that you have got to get rid of which means you have got to take propellant to slow yourself down so that you can rendezvous which is I think that is where you are going, so you can rendezvous with something in Earth orbit. So that means you have, one way or the other, you either take the propellant to slow yourself down at the end of the mission or our preferred approach the direct Earth entry of the crew at the end of the mission, which means you try to minimize the size of the system which leads us to things like not wanting wings and things but instead a small capsule which has limited life of 2-3 days to keep the crew alive with parachutes and Orion fits that bill. A derivative of Orion fits right in with that.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Charlie?

Charles Kennel – Former Director of Scripps Institution of Oceanography
I would like to followup a little bit on Chris' remarks about whether or not there is a fundamental limitation due to radiation exposure to human expeditions in deep space and it is probably early times to answer that question. On of the unknowns I am told is on the biomedical side whereby research could end up with two possible benefits, one is risk clarification and risk differentiation amongst subjects on the one hand and the other possibility is of course remediation and mitigation of radiation exposure. And so it would seem to me that if the country is going to spend tens of billions of dollars over the next decade building exploration systems, I might be willing to spend 10 to the minus 3 of that on a serious program to clarify these risks before we let them make a significant impact on the design reference and other engineering decisions that you might make on the physics and engineering side and it is probably the case that over the 10 years in which our, I would bet at least personally, that over the 10 years in which our engineering systems are being developed that clarification will come in and be a better way of informing the choices you have for exploration afterwards?

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Would someone care to respond to that?

Steve Cook – Ares Project – Manager

I think your point is right on in terms of the fundamental research on humans and the biological effects following those protocols and understanding how humans behave is critical and I think you are right, that we need some fundamental research in that area. From an engineering perspective, we are trying to follow all of the mission design, system design, protocols in order to minimize that but getting the biological behavior to those systems and characterizing the environment, a lot of what is driving us is the uncertainty in the environment and getting those measurements so we understand better the environment is also critical. Do you want to add anything?

Steve Creech – Ares V Integration Manager
Yeah, just to follow on. We also have a part of the exploration portfolio in the exploration systems mission directorate, it is a human research program and what we could offer to the committee is to provide you more background on what that program is doing on the human health protection and countermeasures with respect to radiation and any other aspect of the life sciences.

Charles Kennel – Former Director of Scripps Institution of Oceanography
A sub-team though consisting of Chris and myself got probably an inadequate briefing and I would appreciate learning more and Dr. Greason here - the imaginable fact…

Steve Creech – Ares V Integration Manager
And so we owe you that and then I think you are also coming at it if I am understanding your questions, from a vehicle design engineering perspective, assuming that there is this constraint on the human, how are we going to protect them.

Charles Kennel – Former Director of Scripps Institution of Oceanography
Yeah, and the question will be, how will that constraint look in 10 years when you also have to make other design decisions?

Steve Creech – Ares V Integration Manager
Absolutely, absolutely.

Charles Kennel – Former Director of Scripps Institution of Oceanography
Just to clarify that, it was a very good briefing but I think it is clear there are other information we could get.

Unknown Panel Member
We are now well-briefed on what we do not know. I have a question for Steve Cook but I want to start with an editorial comment. I have reached a new first. I just heard Orion referred to as a small capsule, that is a first. The question I have is, Bret or Steve said earlier this morning that has been chewing at my brain and I am paraphrasing it so I doubtlessly will get the sentence wrong but it was something like we are turning our NASA people from researchers and operators into producers and I hear that and I am going why is this good, because the nation has people who make manufacturing drawings and it has people who build hardware for a living but we only have one space agency that does our forward looking research and our deep in-space operations and mission controllers to bring Apollo XIII home but we are not going to outsource that. You stipulated that it was a good thing to do the job you were asked to do perhaps, why is it a good thing from a national policy perspective to do it that way?

Steve Cook – Ares Project – Manager

I am going to give you a couple of perspectives on that. First off, when I talk about - if you look at the history of NASA's culture up until we started this project, we were either largely focused on - will only talk about Marshall Space Flight Center because that is where I got most of my background, we had a large cadre of folks involved in the oversight of a largely operational program, space shuttle and space station, with the engineering and scrutiny that goes into doing that, and that that typically implies is you are there grading paper, and you are solving problems, one problem comes up but there is a lot of paper grading that goes on with that. We also had, and this is the side of the wall I came up on, the research and technology side where we are working on advanced technology solutions which may one day find themselves into something. So that is my background, that is what I came up through. What we are trying to do, what we have been doing for the last four years, is trying to find a good blend of those two cultures such that we get - the government team more in the line of putting out a product. Now the product does not necessarily mean a drawing, that is one form of product. When I talk about product, I mean like the LOX Damper you saw. Turning that from a very, very conceptual research project into something that could actually be flown, that is engineering, that is what the center was largely founded on doing and that is the kind of mentality we want to get back in the game because we have not been in a large scale development mode in a long period of time so it is more the culture of people being alone to produce a product and put it out. Now, we could make an argument on whether is doing a design drawing something that you really want the government to do? As a part of walking through and building up that culture, we decided that that was a good demarcation point for the upper stage. We are not using that on any other stages but when we get to Ares V, I do not see us going to that point either so that is part of going back up that curve so the final state of putting out a model and verifying it, no, that is not where we are really trying to get to. What we have been trying to do is get a product mentality versus either checking somebody's paper or just working on things that may never fly. Okay, so it is bringing that culture back in versus - I do not intend to see the government becoming a final end item producer from here on our, that is not really where we plan to take this. Yes Jeff?

Jeffrey Hanley – Program Manager, NASA Constellation Program
I just want to add, I think what you are also watching us do is reinvigorate large scale systems engineering in NASA, and it is something that had atrophied over the years and the DOD found a similar phenomenon going on through the 90s and getting back to doing systems engineering, and that is taking it from concept through to execution, is one of the things that this program is trying to embody. Now, as Steve says, we would not be able to do that the way we are doing it today on Ares I and Orion, we would not be able to do that for this entire portfolio of work but it is making us smart buyers in the future and I think that is important for the agency.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
I want to thank you all very much for the presentation. We will have more tomorrow about (inaudible) and better move ahead to our next presentation.

Our next presentation today will be by one of our colleagues and we are there to talk a little bit about our integration group, which has a tough job which cuts across everything that we are doing..... General Lyles.....

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
Can you hear me? Oh, now you can. Yes, thank you.

Thank you very much Mr. Chairman. I'm very, very happy to be here and good afternoon everybody. I guess I should note… Did Steve leave already? Okay. I was just wondering if Steve left already. Okay.

Steve, I just wanted to note that I have been talking about your water recovery system all afternoon. I noticed at our table we have these bottles of water with no labels on them. I hope it's from your system and not someplace else.

[Laughter]

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair

Okay. Thank you very much. Well, this is a topic. I think I am going to be able to buy back some margin for our schedule this afternoon. Mr. Chairman, at least try to get us a little bit back on schedule from all the great deliberations we've had today.

As our chairman said, this ostensibly called the Integration Sub-Committee, but in all honesty it encompasses a lot of different things. The integration function is a very, very critical part of our deliberations, but it is something that we're going to have to really take and really address as a result of all this other sub-committee activities after tomorrow. So that's still yet to come.

What I want to focus on this afternoon are two different elements of this particular sub-committee and that is the international perspective and interagency perspective. To some extent, particularly the international, we had a chance to have some deliberations yesterday. The sub-committee consists of me obviously, Dr. Sally Ride, Dr. Charlie Kennel and Dr. Leroy Chiao and I will also note like Bo, I'm the only one that does not have Dr. in front of my name, but anyway.

We had a chance as part of Sally's deliberation on ISS and STS, shuttle extension and ISS extension opportunities and options, if you will, to discuss the international piece a little bit yesterday. This is perhaps a little bit fuller discussion today hopefully to provide some illumination to you as to what our thought process has been in this particular area.

I will tell you ahead of time, probably the obvious if you will, this is a very qualitative assessment. You won't see any equations. You won't see a lot of graphs, if you will. You will see one matrix, but a lot of qualitative assessment based on inputs from international partners, lots of other potential stakeholders in this particular topic. But again I think has helped us figure out what are the kind of things that we, as a body, want to consider.

Next chart.

These are the sort of questions that we needed to address. The major questions and it deals with the role of the international partners in our overall Human Space Flight Programs. Role, if the program is expanded or not expanded. What country should be included in the expansive cooperative Human Space Flight Program? What are the roles that should be played by international partners? What issues, policies should be addressed if we are going to make that a reality? And then from a perspective of other government agencies, what are their attitudes, their opinions, their concerns, their issues in the involvement of international partners in this particular endeavor?

Next chart.

To try and get to this I mentioned this was a qualitative assessment with lots of detailed discussions, lots of interaction with lots of stakeholders. The most obvious, of course, talking to the NASA people themselves, both Bill Gerstenmaier and his people from the International Space Station perspective. The PA&E office and those involved in international activities within NASA headquarters in the NASA community. And we talked to just about every space agency around in the world. The one that is not listed on there by oversight, my fault here, that we did talk to first off is JAXA, the Japanese Space Agency. They were also part of our deliberations. But you see the kinds of individuals that we had a chance to engage with. You also see the perspective from other agencies. In particularly, the Secretary of Defense' s Office at DoD, we talked to the policy people there because of some major activities that they are currently involved in doing a Space Posture Review. I will explain that a little bit later why that is important and where it fits in both the overall national equation on an international perspective and what kind of feedback and comments we got from them.

We talked to the Department of Defense and National Security Space Office. That is a joint service and perhaps a joint agency organization within the Pentagon reporting to the Secretary of Defense and ostensibly also reporting to the head of the NRO and CIA for that matter in looking at Intel aspects of National Security Space.

And we talked to the White House in the form of the National Security Council and their staff and their deliberations also in this area and once again I will share with you their comments and their perspectives on this important topic.

Lots of dialog with lots of experts. Dr. John Logsdon who is a world recognized expert in Space, Space programs, Space policies, Space issues, and particularly international, came out to talk to us during one of our visits and we had a very extensive media search, if you will, literary search. Particularly, the most recent study for the NASA Research Council, which dealt with Civil Space, the topic of which was America’s future in space, aligning our Civil Space programs to National needs. There were obviously major inputs in that particular document dealing with international cooperation and dealing with our Human Space Flight Program. So, lots of other dialog. Those are the key stakeholders that we brought into the picture.

Let me set the stage, if you will, by sort of doing a trendsetting, if you will, of the tone, the environment that we are dealing with both for our perspectives but also our international partners.

Next chart.

If you review the overall picture about the Space economy in the world we are looking at something that is astonishing when you look at the numbers. $265 billion Space economy and that has been a steady growth since these figures have been tracked over the last several years and it doesn’t include National Security Space Assets, certainly, for the Department of Defense. There are some fifty different space agencies around the world that have a stake, if you will, in space and space activities, all of whom are watching closely or dying for the opportunity to collaborate with and work with the United States those who are already doing so.

There is a U.S. sort of asymmetry in terms of use of space assets, space capabilities, but also dependency. You will see that in some numbers I will show you here subsequently, but you can also see it as pointed out in our National Research Council Study and other studies along those lines that we are heavily dependent on our space capabilities in this country to do almost everything. Almost everything we do every day involves space and space capabilities.

Services, commercial services are growing. Commercial businesses are growing. That term photon-based services points out to the obvious about communications and data and information like that we get from space. We depend on space to communicate and transmit capabilities and knowledge and information. This is really growing and obviously will grow some more in the future. The other growth areas are small, but growing. They are obvious things that I think people can think of.

The International Space Station is obviously largely through its development phase, or building phase. It is now to the point where people want to take advantage of its capabilities to get a return on their investment. You will hear that statement made in some of the comments that we receive.

And a growing number of countries and entities are looking beyond LEO with growing implications of Cis-lunar space and their involvement in Cis-lunar space. And lots of activities involved in robotic technologies, robotic efforts, particularly as to where it may play in terms of Human Space Flight activities in the future.

Next chart.

This is sort of a three short paragraphs or a few sentences from the National Research Council's Report, America's Future in Space. It points out a couple of significant major messages coming out of that entity. One deals with directing or aligning our Civil Space programs to look at broader context or how they can help solve major national needs, not only for us, but as it turns out for partner nations and other nations around the world.

The last one I think is the one that is probably very, very relevant to this and that's working internationally to build a safer and more sustainable world was one of the other major messages, major underlying themes that was part of that particular study.

Next chart.

I touched upon the policy perspective, if you will. There is a United States National Space Policy Review directed by the President through a PSD (Presidential Study Directive), PSD3. The National Security Council is responsible for exercising and executing this particular policy review and these are some of the major principals. I will point out that international cooperation; growing interest in international activities is a major part of the National Space Policy Review activities. And again you will hear some better perspective, a little bit more perspective in the comments and feedback that we've heard.

Next chart.

And this also is further documents from other studies as part of our literary search. Again, growing interest, growing support, growing relationship to the Human Space Flight Program in several different contexts.

Next chart.

Here is the one chart that I'm going to show, matrix if you will. It, again, sort of puts a perspective on the involvement of other nations in space flight activity, again, not counting National Security Space. This is sort of an investment profile and they categorize it in terms of not only actual dollars in the budgets of the various country, their share of the overall space investment activity that we're doing jointly through the International Space Station and other things like that, the percentage of their budgets in their particular countries that these dollars represent and then the actual percentage of their gross domestic product. You see obviously NASA, the United States leads. Russia, if you look at the magnitude of their dollars, it's certainly not as significant as ours, but in terms of their GDP and percent of its budget, it comes out fairly high, actually better than us, if you will relative to the share of their national budget. And then you see the other countries listed here. The ones that are listed in red are, particularly India, China, and South Korea, are partners who we don't currently have as partnership in the International Space Station. Then you see other countries that are represented here in those who are part of our current partnership and those we do other things with. I will let you take just a quick glance at that.

Okay. Next chart.

So, with that, what does that all mean and how does that factor into our deliberations and discussions about where international, where interagency play in our Human Space Flight programs and what options do we might have in addressing that particular question.

I want to give you sort of a quick summary from our sub-committee and then I am going to breakdown the comments and feedback that we got in the four different areas. How it relates to space exploration. How it relates to the International Space Station as it exists today, the current program, the program of record. How it relates to future potential utilization of an International Space Station. Interagency comments and then I will wrap up with some issues before I get to my final chart of what our panel needs to deliberate upon over the course of our activities.

Next chart.

Here's the summary and it was very obvious as we talked to the various stakeholders in this particular area, this particular arena. It is strong, almost unanimous support for continuing and expanding international cooperation in all aspects of the U.S. Human Space Flight Programs. What exists today? What we might do further with the International Space Station as option if that is one of the things we recommend in coming out of our Study Committee Report. And what might portend to take place in the overall Human Space Flight activities, going to the Moon, going to Mars and potentially beyond. That's the overall summary.

Next chart.

Let me break that down, if you will, relative to specific comments. Let me just sort of highlight that some of the comments that we had with the space agencies in other nations were sensitive in nature and by that I mean there were personal viewpoints, there were agency viewpoints, but in

most cases or in some cases I should say they had not been formally discussed with their own governments and so I will not give you a specific nation or a specific person attributed to some of these comments. So I have sort of generalized, if you will, and summarized exactly what the key messages were without attributing it to one individual nation or one individual himself or herself.

In the area of overall space exploration, very strong message to us that there is growing political and media interest in space exploration in general and that included Human Space Flight, not just what we have today with the International Space Station. One of the comments mentioned to us was that there is a tremendous outpouring of support and interest just a couple of weeks ago when one nation, one agency announced its latest crop of astronauts to be part of the overall activities here within the International Space Station Program. The individual commented that it was unprecedented in terms of the support from the media and the support and interest from the politicians and being part of that particular event.

There are no detailed plans yet for exploration beyond the International Space Station, but that notwithstanding every one of the organizations we talked to, every one of the individuals we talked to detailed specific plans as they planned to put together, put in front of their leadership and politicians to get their formal blessing so it could be part of their overall Space Flight deliberations and plans for the future.

International Space Agencies, the ones we talked too obviously in some cases, are very, very enthusiastic about exploration, but a caution, both from them and from other independent assessments that their governments may not be yet. One of the key determinants in whether or not that yet becomes an issue is what happens with the United States and our plans for the International Space Station and our Human Space Flight Programs in the future. Sort of a caution.

International roles in the Human Space Flight should take advantage of the expertise and capabilities of our partner nations. This is something that we expected to hear and we heard it in space from everybody we talked to. A very strong concern, in spite of how much people are getting out of the International Space Program and the international cooperation today. Very strong concern that for the Space Station and certainly for Human Space Flight, the role of the international partners seems to be limited to some extent and there is very strong concern that they want to take a stronger role, a larger role, and they want to take advantage and give to us their expertise and their capabilities to help us in the ventures that we are all embarking upon.

Probably the last major thing that I will highlight here in terms of overall space exploration feedback is that political will and symbolism are key elements needed to show the United States' support for international cooperation in the Human Space Flight Program. Political will is sort of an obvious thing. They are waiting to see what we do relative to the International Space Station. What do we do with the gap if that is something that we want to address and then what do we finally do with the current plans and whether it might be modified for the Human Space Flight Program the exploration vision we currently have in the United States.

The symbolism comment was one that was not surprising but it was also foot stomped by several of the people that we talked too. The symbolism of having a nation's astronaut's name to be part of our program and particularly as two of the respondents we talked to pointed out that it would really, really send a strong signal if one of their astronauts is named to be part of the first lunar party if we decide to go to the moon.

The other symbolism is one in terms of policy and documentation. In the current exploration vision when it was expressed and defined in 2004 and 2005 the talk about international cooperation is essentially one or two sentences. Now that was still very significant coming from our President and our administration at the time and carrying over to the current administration but it is very, very symbolic to our international partners that we didn't take it seriously. And so they are going to be looking very closely as to what the future is going to hold relative to international cooperation as to whether or not we are more expansive relative to our support for that particular venture.

Next chart.

Key comments relative to the International Space Station specifically. The previous comments were about the overall area of space exploration. One that should not be that big of a surprise, it should not be a surprise to anybody, it is very, very important to the international partnerships that exist today for the ISS to continue beyond 2015. One of the obvious, again, comments mentioned to us by everybody we talked to that the politicians, the leadership in those partner nations are now looking for their return on investment. We have spent roughly $70 billion on the International Space Station, $55 billion roughly from the United States, $15 billion roughly from our partner nations, and each one of those partner nations are now looking for the opportunity to get a return on the investment from that great, great laboratory, if you will, that we now have in space. So now that we have got it built, or just about completed building and we have the opportunity to utilize it for science, for research, for development, for technology maturation, etc. that's where the return on investment point comes in for the international partners.

Notwithstanding that concern, everybody sees that ISS is the proof of the value of international cooperation. It is more than just technical, it is nation-building. I cannot foot stomp how often we've heard that statement mentioned from all the people that we engaged.

They are watching us, again, to see how much commitment we make to the International Space Station beyond 2015 and if there is an opportunity to go beyond that a commitment to full cooperation as I sort of hinted to it before on the previous chart. Not just a marginal role, but an extensive role for the partners to play a significant part in. The failure of the International Space Station partnership and by failure they mean the failure to have the opportunity to get that return on investment or to be a full partner could jeopardize further international cooperation in other areas, not just in Manned Space Flight, not just in space endeavors at all, but other activities beyond that.

And probably the last question that needs to be addressed in this area particularly given the fact that there are others around the world who are interested is that the current partners are all willing to accept other partners in this particular venture as long as they come in at a level playing field and by that I mean in terms of information sharing, willingness to be a full partner, and not holding anything back, if you will.

Next chart.

In terms of ISS utilization, this is relatively short because it is sort of an obvious extension of the previous comments. They are all looking if one of the options is there to extend the International Space Station to have the opportunity to fully utilize all of its capabilities. All the great laboratory

potential that is there today in the International Space Station is going to be very germane to the opportunity for them to get a return on their investments. And something that was foot stomped to us that was also very, very much part of the National Research Council Study that talked about other national priorities is that these other nations have an interest in other national priorities in using any opportunity to utilize the space station to help them, to help us, to help others around the world to address national priorities like energy concerns, climate change, environmental concerns, the sort of global common things, if you will, that need to be addressed.

Next chart.

Let me go switch very quickly the interagency in a perspective from particularly DoD and the NASA Security Council, and others that we talked to. It turns out that as part of the National Space Policy Review and the National Space Posture Review, there is strong interest from a national security perspective to enhance cooperation in space with international partners. It is part of the major policy deliberations from both bodies. There was even some surprise and pleasure expressed in talking to the National Security Council staff that the National Security Arena is actually taking the lead, if you will, in actually addressing and supporting international cooperation. They see, the National Security Arena, great value in having that cooperation going on in the civil world actually to mirror which is now taking place in a more expansive sense to collaboration going on internationally in the National Security realm; the sort of Mil-to-Mil discussions that are going on. There are a lot of things that are happening. Something, some of it, a lot of it in the classified realm, I can't talk to but it would be very, very pleasing and very surprising to everybody to know that cooperation is growing, and growing leaps and bounds from what it used to be.

There was some concern expressed by particularly the National Security Council and also DoD that the cost and the complexity of all of our space programs, whether you are talking NASA Security Space or Civil Space, or Human Space Flight Programs, the cost and complexities are so large that there is value in having international cooperation and international participation to help us address some of the complexities, to play a greater role in helping to solve some of the problems, but also potentially to share resources as we all try to address some common themes.

There are some common issues amongst the partner nations. They address and they impact National Security programs. They impact Civil Space programs; they potentially impact Human Space programs in the future. It's space débris, space situational and awareness, and space protection are the obvious ones and there is very, very strong interest and concern in having international participation as we address those kinds of things.

Very interested and actually I was very pleased coming from the National Security Council that the need for space exploration program and having a space exploration program that inspires a nation is very, very strong, at least coming from this current administration as expressed by the National Security Council. However, they also foot stomp, they realized that leadership commitment from the very, very top in this administration is going to be required to actually succeed in some of the things that are going on.

Next chart.

So, let me just talk very quickly about comments, concerns if you will, expressed from the various people we talked to. Whether it's international partners, whether it's in the National Security

Council, or whether it's the Department of Defense. The most obvious one I foot stomp here three times because it is so severe as everybody knows. It is ITAR, ITAR, ITAR. We in our sub-committee and in our overall committee did not address ITAR concerns directly. We did, however; in part of our literature search note that this topic has been hit very, very strongly in recent studies, major studies, the most recent one being another National Research Council Study called Fortress America in securing our… putting controls and how do we deal with controls on science and technology in a globalized world. That study was led by former National security advisor Brent Scowcroft. They had some specific recommendations on how to deal with this particular problem primarily in the area of not changing the controls, if you will, but improving the process so there's more balance, if you will, between the needs of science and technology protection and the needs for economic growth here in the United States. I understand that this administration and this Congress now are taking their recommendations out of that study seriously and all I can say from our sub-committee perspective that we foot stomp and agree with what's already been said in that particular area.

There are some industrial base issues. Our committee, overall committee for this Human Space Flight Study did not delve into great detail. We did look at industrial based issues relative to solid rocket motors and we've investigated that area and understand both what is real and perhaps what's not real in terms of concerns there. There is an expressive need and concern about the need for a national launch strategy. I raised this question earlier today. This primarily comes out of the Department of Defense in their deliberations and their very strong concern, if you will, that there may be decisions made in the launch arena as part of our Human Space Flight Program that don't necessarily agree with all the concerns that the Department of Defense and National Security Space people have. The most obvious concern there deals with Human Rating EELV. There's more data we are gathering on that particular topic from key people and talking to the leadership in the Pentagon. In the Secretary of Defense office the sort of general tone is they support the potential of Human Rating EELVs as long as it doesn't jeopardize the opportunity to have sort of a whitetail approach on a production line. Their concern is an obvious one. It's vehicle, launch vehicle availability and not having two costly production lines, if you will, one to support a Human Rated EELV and then one to support EELV for either National Security white world or Intel world launch capabilities, so dialog still needs to be done in more respects on that. One of the comments made, not directly to me but to one of our other committee members from General Bob Taylor, the head of the United States Space Command, was that we need a process to get all the stakeholders together, a formal process. There is not a formal process that brings together the stakeholders from NASA, from the NRO, representing the Intel community, and from DoD represented by the United States Air Force to deliberate on these launch vehicle sort of questions that need to be addressed overall for our nation. Hence, the interest in having a launch strategy review, I call it the Board Area Review when I raised the question earlier to our aerospace colleague. Bottom line, human rating is okay if there is a way we can work around what the mods are. So, let me go to my last chart.

What all of these means in terms of what our committee, our subcommittee and also the overall committee has to consider and particularly in addressing the international thing. There should be a question mark along one of these because these are not the final answers. They are not final conclusions. They are questions that we have to deliberate upon and we have to determine. As an example, should there be, as part of our recommendations coming out of this committee, should there be a mandate and a policy, if you will, that international cooperation is a foundation and an overlay for all scenarios we might have in our human space flight programs, not just those we have talked about so far with the international space station but the broader scenario

considerations we are going to get into tomorrow from Ed and others as part of his subcommittee's recommendations and activities. So, should there be a policy that addresses that and if so, how much should that policy extend in terms of mandating cooperation in an international realm?

If there is a recommendation to extend the International Space Station beyond what its current plans are at 2015, should that extension be a venue to extend partnership, obviously the parties have expressed their desire to us in that realm and if we are able to expand the partnership if we think that is one of the options we want to recommend, should the expansion include exploration research related to the exploration program? Should it consider contributions to other national priorities not just for us but for other nations who are also interested in the same sort of global common concerns? And then, probably more near-term, if any of these things are potential realities or options, should we recommend sanction by the leadership not just in NASA but in the country that we start the dialogue now with the international partners for consideration of these growing partner opportunities at the regular discussions which take place for the current ISS partnership deliberations.

So, that sort of encapsulates what this subcommittee looked at in terms of international and interagency considerations for our human space flight programs. Mr. Chairman, I will just close here and either take any questions from the rest of the committee members or sit down and give you some more margins.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Okay, thanks very much. I am sure we have got questions. Jeff, do you want to start?

Jeffrey Greason – Co-Founder of XCOR Aerospace
I will be derelict if I let mention of ITAR pass without one more foot stomp, I am going to just focus on one specific aspect of it. The notion that in the name of our National Security, we invite the best and the brightest technical minds from all over the world to come to this country so that we can give them a world-class technical education so that we can tell them, please do not come work for our companies because we are afraid you might learn something, so that we make them go back to their own countries and do not let them come in and join their brains to ours is the most mindlessly self-destructive policy I could conceive of if my goal was to damage the US industrial base.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
I guess, I will ask Bo to clarify what you said.

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
I agree whole heartedly with Jeff. As a matter of fact, I mentioned the NASA Research Council Study which touched upon this. This is such a major, major problem. At least, I could think of at least four other major studies coming out of independent assessments. One done by Congress or recommended by the Congress looking at National Security Space, not international space, but looking at National Security Space but we realize the limitations of having ITAR restrict so many

different things. That particularly I said we because I was part of that study group, we also foot-stomped the ITAR issue along the same lines as the Brent Scowcroft study as the one that needed to be addressed and that was the study that went to Congress. The National Research Council Study, as you know, I chaired that for the National Research Council, so again, we foot-stopped that same very, very important study. I mentioned Brent Scowcroft. There are enough messages out there, flashing lights, red lights, everything that you would hope that somebody would get the message that we need to change. I keep hearing that there are changes underway but the proof is in the pudding. We have not seen it yet.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Chris.

Chris Chyba – National Academy of Sciences Committee
Thank you. My question concerns your comment that your subcommittee looked at industrial-based issues including solid rocket motor issues and what is real and what is not. Since this is our chance to deliberate as a committee, clearly one of the questions we need to think through as we think about Ares I and Ares V is the extent to which they all are not critical for maintaining our national capability in segmented solid rocket motors. So, I wonder if you could just say a bit more about that issue to help us deliberate.

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
Well, I am hoping, Chris, I am hoping that in Ed's discussion tomorrow and in our further deliberations where we start talking about the key measures or merits, if you will, for our overall deliberations coming out of this committee that industrial-base is going to be one of those flags. I think we have all talked about that in fact-finding, but in our formal deliberations we need to determine whether or not that is going to be one of the keys because that needs to be held up against some of the options and scenarios that we are finally going to address. As you know, we have had lots of information presented to us, particularly in the solid rocket motor area in terms of segmented rockets, P-ban as a prevalent formulation versus HTPB, big rockets, little rockets impact on the industrial base for tactical rockets if something were to change in the current architecture. I think it is a major, major issue that we have to consider as part of our measures of merit overall for our final decisions.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Okay Charlie.

Charles Kennel – Former Director of Scripps Institution of Oceanography
If I could - that we had with the international partners was something - to a person that almost - one of the maintenance of an appropriate industrial base and we saw one country that seemed to have a very designed strategy to participate industrially in future generation endeavors. So, that was another aspect of the industrial-based discussion that we had was that just that we have to be delicate in understanding that they too had their industrial-based issues. On that comment, I would like to make it for the record something that I have said privately. After the vision for space exploration was announced, there was a great deal of uncertainty in the international community of partners including the ISS partners. And so, as a result of that uncertainty, they asked and

arranged for the AIAA supposing to be held in, all of places, Anchorage, and the results are therefore, not very all known, but the international group got together with some of us in America and they had two things to say.

First, they are absolutely delighted that we got presidential endorsement of a strategy for future space and that was very important and they were upset that they have not been warned earlier in advance that this might happen and in particular the European Space Agency that had a strategy called Aurora, that looks a bit like the VSC. And so the outcome of that discussion was what NASA eventually to their credit acted on, was the creation and forgive me if I do not remember the exact name, but an international council or exploration working group in which agency representatives get together on a regular basis and share on a no commitment basis their plans. And so as to, at least to eliminate the no surprises issue, but from our experience in the earth sciences, such a forum also can serve later as confidence is built, such a forum can begin to develop the horse trading and the disclosure of future plans that leads to the schematic outlining of agreements that then can be taken forward formally. And so, I would hope that as part of our discussion of the international situation, that we give a mention, in my personal view, a mention of that working group as a very constructive step that has already been taken.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Good point, thank you. Bill?

Bohdan Bejmuk, Chair, NASA Constellation Program Standing Review Board
Excuse me. When we look at international cooperation it has two effects. One has to do with economics and the other one has to do with instrument of international policy of this country. Economics is really simple, if I was going to do this, we are going to join venture to build sea launch, and we could have never come even close to building that system if we used it with Western means. We could not. We spend a little over a billion dollars to build a whole launch system, home port, two vessels and if we tried to use our own resources, it would have been probably three or four times more or worse, but you have to find a match. You have to find people that have value that is complementary to your own. And this goes a little bit in crossways with the other objective which is foreign policy. Sometimes you bring partners to the table who maybe do not have a perfect match in terms of economics, but they have a good political fit. So, it is a tricky thing, but if you work it and I think it will benefit both. It can elevate NASA profile in relevance because you become an instrument of foreign policy and it also can work to benefit in the economic sense because you can get partners who bring products that you could not build or buy for the same number of dollars in America. So, you know, I love your idea of expansion of international cooperation to be one of our thrusts in all the scenarios we work on. The planet has gotten smaller. It was a little bit bigger when I worked in sea launch. It is smaller now it is time.

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
I just want to say a few words generically about industrial-based issues to share views with the rest of the committee by way of deliberation. Industrial-based is a flag under which an awful lot of less than mobile things can gather. There is a crucial difference between preserving the fundamental capability that we as a nation have to do to do certain things, that is a very important value and saying that whenever you stop buying anything, you know, the nation has been irreparably damaged. I draw the analogy as some of you have heard me do, you know, as a result of that, some policy decision we have irreparably lost our ability to purchase 1964 Corvettes and we will never get it back, but that is, you know, but so what? You know, at some

point you move on. So, we got to be very careful when we look at these things to distinguish between those two kinds of industrial-based issues because they are not of equal importance.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
I guess it is my turn. I have got several questions for you Les (General Lyles) if I may. The first one is a fairly specific one, is it the recommendation of your subcommittee that international partnerships include activity that is on the critical path for missions?

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
Mr. Chairman, yes it is. It is. We have opened the opportunity for considering it.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Let's see, I was really truly in there. You had to be a little general, how about giving me an overview?

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
Let me be more specific. I think and I think the committee agrees that we need to change the policy. We would recommend changing the policy so it is not restricted that the possibility cannot even be talked about if you will, at least open the aperture so you can openly consider having international partners participate if there is a capability there on the critical path. Right now, the dialogue cannot even take place.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you, and the way the General phrased that, the rest of the group or is there any one of the group that may want to disagree with that or take a different position? You see, I gather that we are all with you on that. My second question is in one of your charts, it said that the international community or some part of it that will support in continuing the ISS felt that it should be expanded, its objectives should be expanded to include exploration and I wondered whether they just meant the effects of zero G on the astronaut's long term exposure or whether they really meant exploration?

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
I probably should have put that in capital letters as part of the exploration program. It is to include goals, and by the way this is similar to one of the things we deliberated upon yesterday from Dr. Ride, Sally Ride and Charlie and Leroy and that is use the ISS to also investigate technologies or research and development related to the exploration vision, exploration program as opposed to just those laboratory capabilities that exist on the ISS today and that is the same sort of message we heard from several of our partners, that that possibility becomes open if the ISS is extended.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Terrific, thank you. Let's see, I have got two more questions Les (General Lyles) if I may. One is the proposal which you have on the national launch strategy and so a mechanism to create it or maintain it, which sort of makes an awful lot common sense. You and I talked a little bit about this but I guess I would kind of like to get it out, this question here, given where we are today as a nation in terms of the Constellation Program, if we open that up to National Security strategy and so on at this point in time, maybe a good thing to do I do not know but it seems like it might add a couple of years?

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
And I do not think that is the objective of any of the people, the stakeholders that we talked to whether it is DoD or broader National Security or certainly within NASA. I think the objective was really just to allow a process by which any other agency equities or at least considered. And if that does take place, I'd be very, very naïve if I did not say that does not take place today, but it is more of an informal ad hoc basis and there is a need for a sort of broader formal basis that does not become a bureaucracy to allow that sort of dialogue to take place. A sort of related comment here is one that came out of Grace's. Any of the studies I just previously mentioned earlier, the National Security Space Study I talked about, the National Research Council Study and we have talked about it here, the need for a National Space Council within the highest area of our land, within the White House, I think, is the recommendation to allow all the stakeholders who are involved in space to get together on a formal basis to coordinate, integrate, compare, better leverage each other's equities, requirements, capabilities, resources. That does not take place anymore. We no longer have a national space council and the foot stomp, I testified to Congress on this a couple of weeks ago, the foot stomp is not to create a bureaucracy that makes it a "mother may I", that impedes everybody's progress, but to have a formal basis for a dialogue and perhaps even rebuttal for people to consider but not to slow anything up.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you for clarifying that. And my last question relates to some newspaper article I read while I was traveling during the 40th anniversary celebration outside the country. And several of the articles I saw talked about the US going back to the moon and the possibility of somebody else, other countries might get involved with it and several of the articles I saw, not all, played the why go back to the moon. We have been to the moon. We have seen the moon. That is ho-hum, who cares? And they said that a few years ago and Mars, that would really be exciting. It is something worth doing, but they said in so many words that the US, the President of the United States himself said 20 years ago that we were going to go to Mars. Another president said it eight years ago, I think it was, or whatever, that we could go to Mars. And now we are saying that we will go to the moon and if we have money, we will eventually go to Mars. Nobody knows when and so, given such an unexciting program, why would anyone want to get involve in it including us? Was what they said.

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
Oh, I am not sure who wrote those articles, to me it is somebody who is uninformed or how exciting and challenging all of these ventures are even today. Not going to the moon, it is just the fact, the great things we do at the international space station. Let me just give you my comment from the perspective of our subcommittee and that is to share, I think the general consensus we heard from the international partners. Now I asked Leroy and Charlie if they disagree or have any other thing that they want to add. I think to a nation, if you will, everybody saw that going

back to the moon was an important step. One, to mature the technologies and to get back on the step, if I can use that terminology, get back on the step of exploration beyond LEO which is something we obviously have not done in a man presence in, well, since 1973 or is that Apollo 17, '74, since Apollo 17? They saw the value of that. They also saw the value of using the moon as a way to mature those technologies, those capabilities, those operations that we would need to go to Mars. And I think I heard pretty much of consensus that going to Mars while all the nations haven't said that is something they want to do, certainly, from a formal standpoint. I think the space agencies all seem to have a support for human space flight beyond LEO and beyond lunar, but they see that that is still important. Going to the moon is a critical sort of waypoint to really get back to the capabilities to make going to Mars a reality, Leroy and Charlie?

Leroy Chiao, Ph.D.
Ah yeah, I would just like to tell you a little bit, take just a few minutes just to talk to you about my personal experience with international cooperation. I have to admit that, you know, in the early to mid 90s when we started up with the former Soviet Union, I was not a big fan of cooperating. And I thought, well, what are we going to get out of this? It really was not until I started going over there and really until I started training for my ISS mission that I really got an in-depth look of what they were doing and got a bigger picture of what we were doing as a country and I have to say I had my views turned 180 degrees around. I became a big supporter of international cooperation. It gave me a greater understanding of what the other folks were doing and how everyone fit together and the bigger picture beyond just the space program of the good of international cooperation. Since that time, I have visited the space programs of various countries including China and I have been very impressed and I am able now to, from the vantage point, all the points that are Les (General Lyles) talked about in this briefing, I can see the potential of where this can go not only in the space program but for the whole country and the world as a whole.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you, Charlie?

Charles Kennel – Former Director of Scripps Institution of Oceanography
I would like to make one comment. It seems to me that everybody, the prominence of the vision to space exploration, everybody sees that the mainline to Mars at present runs through the moon. On the other hand, in the context of a much broader international collaboration in the future, there are other exploration objectives whether it is to LaGrangian points or lunar orbits or Phobos orbit or landing, you can see other rich objectives in the exploration of the solar system that the various nations of the world may wish to engage in, let's say, in the next 50 years that could be the part of enriching the dialogue of international collaboration in the exploration arena. And I think, it is fair to say that we thought more about it than any of our partners and that is some sort of international dialogue, a deeper dialogue on the goals and objectives would be very useful and I think there have been a recent statement by the international working group to that end, but a deeper dialogue, I think, would be very useful.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Please. Chris.

Chris Chyba– National Academy of Sciences Committee
Les (general Lyles), in your comments you - about the international partners, you talked about how the international agencies are enthusiastic about exploration. I wonder if you could tell us a bit about what you heard with respect to any desire to participate in planning. Does that extend it to the point where those agencies would like to be involved in planning something like the new architecture and do you think there is a practical route to that end and/or is it too late with respect to the US program?

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
Chris, I do not know if it is too late, but I think there is a recognition that we are where we are if you will, and most of the planning, a lot of it has already taken place, and certainly, they would like to now if there is an opportunity for ISS extension or greater involvement in international partnership. They would like to be included at the table for future planning. They certainly do not want to disrupt things, if you will, as to where they currently are, but I think again, it was sort of a unanimous view that they want to be a full partner. I think that is the key word in all the activities and planning is part of that.

Chris Chyba– National Academy of Sciences Committee
So sir, would you say that the committee should or should not have a recommendation to the White House that in the coming months because that is the timescale we're talking about, even less than that really, that more consultation be done at some level with international partners?

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
I would say yes and perhaps, not perhaps, I know I was probably inarticulate in crafting my last bullet on the last chart. It talked about getting their involvement in upcoming discussions on international partnerships. It was really meant to say exactly what you talked about. There is a short-term opportunity to now engage with them and to get them involve if that is one of the things we agree as a key recommendation coming out of this.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
If there anybody on the panel would disagree with that recommendation? Alright, Les (General Lyles) you made it another recommendation that had to do with creating a more formal mechanism within our government to coordinate space vehicle (inaudible) in particular, and I assume you offer that as a kind of a formal recommendation in your group?

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
I do. I hesitated and actually we did not. We have only touched on it peripherally during our subcommittee but I hesitated in making that a formal recommendation because it is one that is slightly outside of our overall charter, but it is so germane to succeeding in various things I would have to say yes, Mr. Chairman, I would recommend that to the overall committee.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Yeah, I think that is within our charter, within reason but does anybody have no problem, so okay, that is fine. Wanda, did you have something that you wanted to say?

Wanda M. Austin, Ph.D. – Panel Member
I was just going to speak up in support of that recommendation. I think it would be valuable given the limited resources that if we as a government could get organized and speak, you know, in a unified voice on what was good for the nation, that that would be good. So, even if it was viewed as outside of our charter, I think it would be something that we should offer up.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Okay. Les (General Lyles), anything else from you?

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair

No sir. I thought I was going to get you back on schedule but I took about 15 minutes of your margin. So, I apologize for that.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
We helped you. It's really, you do not 15 minutes with a negative margin. It does not work that way.

General (ret) Lester L. Lyles – National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program – Chair
Touché.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Okay, thank you Les (General Lyles). Does anybody on the panel have anything else you'd like to offer today? Tomorrow, I am sorry.

Bohdan Bejmuk, Chair, NASA Constellation Program Standing Review Board
This ITAR - I know that there are some good reasons for it but Les (General Lyles) had it three times in his chart, ITAR, ITAR, ITAR. If you are of NASA, maybe you have some special treatment but let me tell you, here in the industry, it is so difficult. And I will give you some quick example. You bring some Russian flight hardware to Long Beach, somebody declared that since these rockets, they are not ICBM's, they are rockets, they are on US soil, we cannot have Russian or Ukrainians have access to them. We scramble, you know, pyro-light, pyrotechnics, they are pressurized and we, you know, were in this awful situation, trying to figure out how to get these guys who know their stuff come and take care of the flight hardware and that shows you how extreme, extreme case of what ITAR can do to a private business, so I do not know Mr. Chairman if - I have not really - I am just reacting to a Les (General Lyles) here but if there is some recommendation we could make when we talk about the international corporations, somebody has to look at our ITAR rules or it is going to be - otherwise it will continue to be an incredible drag.

PUBLIC COMMENT PERIOD:

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
I see. We probably should make a recommendation along those lines. You do not want to get me going on ITAR but I recently chaired a committee for the Department of Commerce on the subject and it is an amazing thing that there is one related provision having to do with what is called deemed exports. If you are a professor, in this country, Chris, maybe you could explain, better than I**,** but if you have a foreign national in your classroom and say something to that individual that is covered by ITAR, you may have committed crime and when you see the list of things that are covered with ITAR, by ITAR the last time I checked they included shotguns, handcuffs and something called the horses by sea in this long list of ITAR coverage. This was written of course during the height of the Cold War with technology of the time, without international technologies and without international students, it was not the goal of the world. It just was not relevant but it sure was an impediment, end of speech. Back to more serious things.

Maybe not more serious but more appropriate. We come out of the part of the today that we look forward to and that is to get comments from those in the audience who would care to share any particular views with us.

Phil McAlister, Executive Director, Designated Federal Official (DFO)
There are two mics in the center.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Okay. I will ask that you hold your comments to a max, max of 3 minutes just of courtesy to your other colleagues who may want to make comments. Phil, I will ask you to be the enforcer so be tough, and I ask that you not read something that you have in a written statement. Those could be submitted on the website probably more conveniently for your and for us but just an opportunity to speak out. We have got 30 minutes allotted for this and if each person takes 3 minutes, that means we can cover 12 people with a 20 percent overrun and we will limit this to 12 people. There are 2 microphones in the center isle.

Phil McAlister, Executive Director, Designated Federal Official (DFO)
We are going to alternate first and then back.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Yeah, we are but we are going to limit six people to each mic so if you are number 7, send us an email or just go on to our website. So with that, let us start out and we will start out on the back. Please identify yourself and your affiliation.

Tommy Battle – City Mayor, Huntsville
Ladies and gentlemen, I am Tommy Battle, Mayor of the city of Huntsville and you are on a path of determining the future of a lot of what we have been determining for the past 50 years. We had a number of people in the past who are citizens of this community, little guys who wore - and ladies, who wore white shirts, pocket protectors, multicolored pins and they determined the route and found out how we could get ourselves to the moon. It inspired a whole generation. It inspired a lot of us. And today, you are making a decision…or this week or this month, you are making a decision on what our future is, what our future inspiration will be. We have had this past month, we have had multi-celebrations on the lunar landing and the lunar landing to us has been described as mankind's most significant technological achievement and I guess my question to you is what will be our future achievements? Where will we go in the future? What will inspire our children? Is it going to be sports stars, is it going to be musical stars or is it going to be people who actually takeoff and do the technological things that we have the capability of doing? This community has worked for 50 years doing that and we stand prepared to do that for the next 50 years. Thank you for your dedication. Thank you for your work. And thank you and I hope that you can give us something that will inspire us for the next 50 years. Thank you.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you for sharing those thoughts with us. We will go to the lower microphone.

Shar Hendrick – Vice Chairman Tennessee Valley NASA Advocacy Committee

Chairman, I promise not to read but in the effort to try to stay on track, I will refer to my notes here if that is okay. My name is Shar Hendrick and I am serving as the vice chairman of the Tennessee Valley NASA Advocacy Committee. The Advocacy Committee was formed in the wake of our community's BRAC efforts when our BRAC committee said we needed a similar effort around informing policy for NASA in our civil space program as we go forward from a community perspective. Today, the community consists of an array of companies both large and small that are engaged in Ares I and Ares V projects as well as several other undertakings for NASA. The companies represent both government space as well as commercial space efforts in the community. The Tennessee Valley NASA Advocacy Committee strongly endorses the NASA Constellation Program and the current architecture we have. We believe it is critical to move forward with the development of US capability to move humans behind low Earth orbit and while some have said it is time to revisit the ESAS study of 2005, we believe that that would be a critical mistake given the fact that it would perhaps exacerbate the US gap in human space flight capability. Moreover as a community steeped in launch vehicle heritage, we fully understand that any alternative architecture that is put forward will itself be wrought with technical and programatic challenges as it moves from concept to actual systems development. We have seen that time and again. Currently, hardware is under development. Successful tests are being conducted and the entire system is making progress. We cannot stress enough the importance of providing continuity to both NASA and the industrial community as we move forward. The history of our efforts in launch over the past several years have been a start and stop approach and it has clearly taken a toll on US launch capability. While the community endorses the moon as an important destination for the constellation effort, we believe that by developing a robust launch in space transportation community that many new destinations become available for consideration. I would close my comments by simply saying it is also the hope of the Tennessee Valley NASA Advocacy Committee that we continue to encourage full utilization of the ISS through international partnerships, private and government investment research and as a valuable test bed for future exploration efforts and to that end we certainly appreciate the comments and reports that General Lyles has presented. Thank you very much.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you so much. We will go to the upper microphone?

Dennis Wingo – NASA, DoD, DARPA
Yes sir. Mr. Augustine, my name is Dennis Wingo. I work in advanced technology. I work with NASA, the Defense Department, DARPA. I have also authored books on the economic development of the moon and the solar system. I have written, co-authored books with the National Defense University on space power theory on that same thing. I stood before you just a few miles from here in 1990 as a fairly angry young student wondering why in the world that 20 years after Apollo XI that we still had not gone back to the moon. It is 19 years later and I am not any happier. I looked at the reports that have gone forth in the past, Sally Ride's report, Tom Stafford's synthesis group, your Augustine Commission of 1990, the Aldridge report, all of these other reports and commissions and the question that would go to you is what are you going to do that is different than what was done then and what never was accomplished because all of those reports if you look at it in the recommendations in the historical context can be considered historical failures. We want your commission to be a success and when the vision for space exploration was announced by President Bush, it was an incredible departure towards the economic development of the solar system as Dr. Marberger presented and I as a public speaker speaking around the nation and around the world, have found that that theme resonates with both

the American people and our international audiences where unfortunately it did not resonate was with the agency and in the implementation of the ESAS architecture. You would not be here today if the ESAS architecture that is currently being implemented by NASA was all roses and light. So therefore, my question - not question but my statement to you is you have and your team has a historical opportunity as well as a responsibility to not only our generation but to the generations yet unborn to come up with a set of options that our political leaders can buy off on and pay for because as we have seen here, both by Dr. Ride and others, the current architecture as it is being implemented is not fundable because we are already over-budget and behind years and years and years. We must come up with something that our Congress and our President and our nation can get behind. It is not money. We have been borrowing trillions of dollars on the economic recovery in the past few months. The American people will support something that is in the best interest of our future but it has to be in the best interest of the future, not some parochial interest. Thank you.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you for those comments. Yes?

Dr. Barbara Cohen – Planetary Scientist
Hi, I'm Dr. Barbara Cohen, I am a planetary scientist. I work for Marshall. I am speaking today as a private citizen. I have 15 years of experience working with lunar samples, with meteorites, with the Mars rover Spirit and Opportunity, who does not love those, and I love the other destinations ideas but I am here today to talk to you a little bit about lunar science itself. I keep coming back to lunar science as a planetary scientist because lunar science is planetary science. The moon functions like a planet. It has got a crust, a mantle and a core just like Mars, just like Venus, all the terrestrial planets. It has got a lava flows, fire fountains. It has got current moon quakes today. It is still acting like a planet. Lunar science is fundamental to planetary science and understanding the moon helps us understand all terrestrial planets. Another good thing about the moon, it is not just any moon, it is our moon and the Earth and the moon formed together. They have a common history and we want to learn about what happened on the Earth back in time before we erased our quest we go to the moon. It is all there for us to read, all the craters that formed on the moon that you can see when you look at it, they had counterparts here on the Earth back in time. We do not see them today. If we want to learn what the bombardment history of the Earth was like, we go to the moon to find that. So the moon is a fantastic world. It is a wonderfully diverse, geologically active body and to explore it is not going to be very easy. You can either mix robotic missions, sample return missions, there are some things that only humans in the field can do. We know that. And so I urge you not to overlook lunar science as part of your deliberations. There is a 2007 National Academy's report, the scientific context for the exploration of the moon. If you do not have that, I am happy to provide that to you. I hope that goes into your mix so that you understand the richness of the moon and the opportunity that exploration affords to us to build a new scientific community, one that is young, international, excited about the moon. Thank you.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you very much, can you pick up the microphone?

Homer Hickam – NASA Engineer (ret.)

Commissioner and the panel, my name is Homer Hickam. I am a former NASA engineer, retired NASA engineer and I ride a little bit. You might recognize me. I wrote that book called Rocket Boys. I made that movie called October Sky. You recognize me because I look a lot like Jake Gyllenhaal, sure. I was invited to come over today to say hello to you and most of all, I just want to welcome you to Huntsville, the rocket city. I hope you had a good day here. I have been paying attention and watching over the internet and I must say that I am very, very proud, the rocket girls and rocket boys out at Marshall Space Flight Center, they had given some wonderful presentations today. I learned a lot just watching it but besides the content, I hope you caught up on the passion of these folks. In Huntsville, the rocket city, we have always been passionate about the space program. We are all space junkies here. We are all ready to go. We want to go somewhere. That is the main thing. Wernher Von Braun 40 years ago, he was carried on the shoulders of Huntsville. A lot of folks were dancing in the courthouse square about Apollo XI and Dr. Von Braun told the folks at Huntsville, well, do not put your dancing shoes up quite yet. We have got some more dancing to do in space. People of Huntsville, the folks out at Marshall Space Flight Center, we are ready to put our dancing shoes back on and I think if I am hearing everybody right, most of the folks, we kind of want to put our moon boots on when we go dancing. The moon is a symbol that we can see, all of us, everyday. When I go back up to West Virginia, we have an annual October Sky festival where I talk to teachers, talk to students, talk to just plain folks. I talk about the show. I talk about the international space station. They like that. When I talk about going back to the moon, you can just see their eyes light up. So that is where I kind of think that we ought to go but mainly I think we ought to go somewhere. We need to build the rockets to make it happen. If you are going to be a great nation, you have got to do great things. Going back to the moon and on to Mars, that is a great thing in my consideration and I hope you think so too.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you for sharing those remarks, sir?

Steve McKamy – NASA Contractor
Mr. Chairman, my name is Steve McKamy and I live here in the Huntsville area. I work for a NASA contractor and I have been involved in a lot of the studies that came before this architecture and during this architecture, after this architecture and I want to disagree with Mr. Wingo. I think we would be here today no matter what we came up with because quite frankly, the commitment to what we are doing has been lacking and it would not have mattered which architecture we came out of the ESAS study with. I think we would be right here today looking at it because the commitment to follow through with it just has not been there. We have been asked to make a silk purse out of a sow's ear and I know that your charter does not include - includes trying to come up with a solution that fits within the current budget but I honestly do not believe that that solution exists. I think that it is going to require some more commitment. One thing that struck me, I have got several small children and I would like to read the landmark history books too. I just finished the stories of both Columbus and Magellan and I thought it was interesting that the Portuguese had the opportunity to sponsor both of those expeditions, turned them down, sent them to Spain. The Spanish, at least for Columbus' expedition, formed a commission to look at it and that commission's recommendation was that they not fund it. I have more faith in this commission. Thanks.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program

And thank you for those comments. Sir?

Michael Milling - Masten Space Systems

My name is Michael Milling. I am with Masten Space Systems. We are a small VTVL sub orbital launch company in Mohave, California. We are looking at building a spacecraft to allow K2-12 education and kids like that to be able to fly space missions the way NASA does right now. One of the things I would like to suggest the commission take a look at when you are looking at your figures of merit, is the non-government portion of our GDP that the space industry produces. I was involved in the Internet early back in the 1990s and I watched the National Science Foundation exit from running the Internet backbone at the time. They have lost a core competency to run the Internet and that was a good thing because within a year after that, Netscape had an IPO and it was very obvious the Internet was going to become a new industry. New industries are something that America is good at creating. NACA created the aviation industry. We created the computing the industry and we created the Internet industry. If the commission takes a look at the flexible path approach, the scenario, coupled with the focus on depots, and integrating commercial services as tightly as possible into that, you end up having the opportunity to create another industry and one that America leads in because we have the talent. We just need to be able to unleash the entrepreneurial spirit that we have in this country and build a new industry. Thank you.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program

Thank you. We are going to hear as many people comment as we can. We do have an airplane that is going to leave us so if you are at the back of the line, if anybody else comes up, we will just get everybody in line but if somebody else comes, if would tell them that we are going to have to cut the line off with the folks that are there now. Sir?

Dave Williams – University of Alabama, Huntsville – President

Thank you Mr. Chairman, members of the commission. My name is Dave Williams. I am the President of the University of Alabama in Huntsville. Like research universities around the nation, we face challenges in attracting the next generation of young men and women into the science, technology and engineering fields. Here in Huntsville, we are extraordinarily fortunate thousands of such young men and women come through space camp here in this very building. They are attracted by 30 and 40-year-old artifacts. They are inspired by them. Just think how much more inspired they would be by the next generation of moon and Mars flight artifacts. We still need thousands more inspired men and women to joint the future workforce in science and engineering if this country is to maintain its lead and compete effectively in the global economy. By bringing human space flight back beyond low Earth orbit, you can help make that happen, at the next level, attracting graduate students and post docs in the same fields. A generation ago, in the post-Apollo glow, thousands of such students came to this country, I was one of them, to work on the next generation for aerospace alloys which right now are being welded over at NASA Marshall Space Flight Center. It is cutting-edge technology that so often is a product of the most difficult challenges that we face that attracts the best minds for the future research in this country. If the best research is in the Darmstad or Bangalore, that is where the next generation of graduate students and post docs will go. If it is here in this country, many will continue to come here, ITAR not withstanding. Thank you very much.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program

And thank you for those comments. Sir?

Tim Pickens – Orion Propulsion – President

I am Tom Pickens. I own Orion propulsion. I started it about five years ago. I am from Huntsville and I have got a small business here and we are actually working on Ares' upper stage with Boeing and we are about a third DOD, a third commercial and about a third NASA. It has been an interesting three years. I actually had the opportunity to go to Mohave and work on Spaceship I and work propulsion so I understand that it is like to be part of a commercial effort that completes - in fact, I used to go watch (inaudible**)** with Jeff Greason and I am very excited about the industry and that was when I started the business and I knew that I could not have a pure commercial model unless I had a sugar daddy and I do not. So it is my and the wife, we had to secure these loans and everything was very personal running a small business. We do not have investors and what not so it has been quite a culture change to say put an AS9-100 quality system within our small R&D company to do production on things like Bigelow - we actually built a propulsion system for Bigelow's sun dancer and on the NASA side, we are doing Roll-Thruster work with NASA and Boeing so one thing I am kind of noticing is this whole uncertainty thing is very disruptive environment to my small business, people wondering what is going to happen and as a business owner, I have to ask myself these questions and look at contingencies and as I am out here working in the community, some folks know I like to get involved in education, maybe a little too much sometimes but the point is, the kids like to see things getting completed. I picked the lane of building hardware because I wanted to be competitive with the world. The old business model, the cold war models that is so expensive, we have to break that model and to be world-competitive and that is why I started this business but we need to pick a lane and we need to finish something we start because the kids that are looking to go into these fields of engineering, they really wonder can it sustain itself. Is it - are we ever going to complete things. Some of my best engineers, they have the most fun when they get to work with the hardware they design and get to see tests and look at data and stuff so I just want you to just kind of understand the perspective of a small business guy who do not have infinite resources but I do believe in vision of space exploration and I just wanted to share that. I appreciate it.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program

We appreciate you sharing your viewpoint with us. Please?

Ronda Cox – High School Math Teacher

Good afternoon. My name is Ronda Cox and I am a high school math teacher from Illinois and a summer employee here at the US Space and Rocket Center. I work with teachers in the summer doing professional development with them. I could tell you that when I talk about the Constellation program with my students, I have had high school students actually say things like that is so cool and when I talk, I have talked to fourth graders and I told them that you are the perfect age to be the first person to walk on Mars and you should see their eyes light up. It is just an amazing thing to witness. Teachers know that nothing motivates children to excel in math, science, technology and engineering like the promise of space exploration. Here we are sitting in Huntsville, the rocket city, the place were Von Braun made his childhood dreams come true and I think we all know that his dreams motivated many, many young people to work harder and to reach farther. The shadow of that rocket out there is a testament to the hard work of thousands of people and quite frankly, that shadow is also an inspiration to tens of thousands of teenagers and younger children who dream of their generation stepping on a new world. NASA inspires children to dream extraordinary dreams and gives them the reality that they can make those

dreams come true. We should continue to give our children the encouragement and hope that they can achieve anything that they put their mind to. The challenge of space also honestly motivates me as an educator to do a better job in the classroom. As an educator, the promise of landing a human explorer on Mars motivates me to do my job much, much better and to give the kids the skills that they need to achieve anything that they put their mind to. NASA gives them the dream and educators give them the tools. I think it is time that we give our young people the opportunity to live up to the challenge that Harrison Schmidt gave when he said I think the next generation ought to accept this as a challenge. Let us see them leave footprints like these. And I would like to add that I would like them to be on the red soil of Mars. Thank you.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you. As a high school math teacher, you are my heroines. Let's see, we seem to be adding people here which we cannot keep doing so I am going to start counting. We will be able to listen to five more people and I really feel badly to do that. We do have a website. We take emails. We take letters by the US mail. I would love to hear from everybody but only five more today or we are going to have to walk to the Cape tonight. Sir?

Ray Moses – Retired Space Engineer
My name is Ray Moses. I am a retired space engineer. Fifty years ago, Arthur Clarke proposed that we build elevators to space. The science fiction story I found totally unbelievable because there was no material around that would be anywhere near suitable for building such an elevator. However, progress has occurred in the last 50 years and the aerospace companies are now going from metal to composites on their vehicles. When I tried to check to see what NASA was doing in this area, I called the public information office and they said they were going to get back to me but there is no carbon, nano-tube data as far as I know or work being done by NASA at this point. I highly recommend that a program using carbon nano-tube composites be established by NASA and be expanded and I recommend that this program be done for two reasons, one, you could get vehicles that way about an order of magnitude less than the one you got today which means that the cost to space would go down dramatically and the other one is eventually you could start by building the space elevator on the moon, from an inter-LaGrangian point.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you and we will be able to hear from four more folks, please.

David Ward – Space Camp Counselor
Good afternoon. My name is David Ward and I am a space camp counselor here at the US Space and Rocket Center as well as a student at Georgia Institute of Technology. Many years ago as a young child, I had a dream of becoming a rocket scientist, using my afternoons to build model rockets and model airplanes. This led me to a trip to space camp in the year 2000 where the briefings, presentations and the simulated shuttle missions solidified my inspiration to become a flight engineer and aerospace engineer. Later in high school, I learned with hands on experience by restoring my 1987 Toyota Supra. I used all my stepdad's tools and techniques to create and refurbish each part by hand, much to his amazement, using every square inch of the garage, much to my mother's dismay. Then, I went on to become an aerospace engineering student at Georgia Institute of Technology. I also joined the aerospace design team as a

freshman and we went on to build an award-winning airplane, winning he award for the most weight lifted and second overall in an international competition of over 30 teams. Two years later, I received a message letting me know that there was a position open as a counselor here at the US Space and Rocket Center. I could not pass up the opportunity to share the inspiration that I received at space camp with the children of today. Now, seven months later, I have led teams of scout troops, general space campers and school groups through the wondrous grounds of the US Space and Rocket Center showing them the amazement that I discovered as a young child right here at the US Space and Rocket Center, all inspired by our country's greatest asset, our manned space flight program. I would like to leave you with this thought. In two short weeks, I will retire from my wondrous position as a space camp counselor and be returning to the Georgia Institute of Technology to finish my career as a student and to one day finish my dreams of becoming a rocket scientist. Thank you.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you so much for sharing that story with us, sir.

Andy Welton – University of Tennessee – Physics Major
My name is Andy Welton. I am a physics major at the University of Tennessee currently and I guess along with a lot of people that have been around today, I had been inspired by NASA to be where I am today. I spent my entire life with this dream of being an astronaut and NASA employee and it has been the sole driving force basically behind all the hard work that I have put in to get to where I am today and I just wanted to stand up here and convey that to you and I guess make sure you think inspiration in any recommendations you make, that would be one of the most important things that I would want to consider if I were in your place so Godspeed and thank you for your time.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you very much for that thought. Sir?

Yoshi Takahashi – University of Alabama in Huntsville – Professor of Physics
I am Yoshi Takahasi, a professor of physics at the University of Alabama in Huntsville. My written comment was rather short, that we are going to miss the delivery capability of the large payload on space station from 2010 to 2015 or beyond. It was suggested that Orion may make astronauts to go up and that the Soyuz can carry astronauts but the space shuttle was such a marvelous vehicle and it was monumental, historical doings of that delivering very difficult satellites securely and perfectly from the space shuttle with the help of human wisdom, of astronauts and the communication was marvelously made for the last 25-26 years and now we are going to lost it and the shadow's beauty is that it has a human, very much well-supported by the ground humans as well and heavy lifting capability and big payload available for the best use of the space into the space exploration or the universe exploration. Hubble Telescope was one of the good examples for serviceable and it was well-serviced and the Chandra Satellite and Observatory or this very large space vehicle was well-driven and well-operated and that is what we are going to lose for almost 5-10 years in space. I had a project of the European Space Agency approved and NASA funded for the space station payload of 2.5 meter telescope looking at us and that was built and designed at Huntsville and unfortunately, the Columbia accident deprived us of all these capabilities because of no manifest available and in that case, we should give up all these beautiful human space programs, shuttle-delivered in the past but the resource

there are, European ATV and Japanese HTV which is unmanned space craft carrying the large payload. However, ATV exit point is only something like less than 30 or 40 inches and 2.5 meters does not fit. The Japanese HTV fit somehow to that. Therefore, we negotiated with the Japanese space agency from Huntsville using the Japanese colleagues in Japan and it is in the serious design study completed and could be evaluated in a month or two and I believe that this is a case that could revitalize the almost dead project of international, large cooperative mission into space station with astronauts helping for mounting that one, that is just Japanese space station module external payload facility was mounted just last week or this week and will be that active for about 5-10 years. I think that the US, it is the US who started the space shuttle great program of having the best use of human resources and that large instrument and we should not lose it and I hope the committee will address some of the remedies or the alternative for us to be able to do in the next 10 years without losing that great capability historically manifested by space shuttle experiments. Thank you very much.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you for your comments. Sir, you get the last word.

Unknown Audience Member:
I would just like to impress upon the committee the importance of going to the moon and Mars and manned exploration. I have heard a number of people lately, a number of commentaries have been published in various papers as to why it is a waste of money when there are so many other things we could be doing or that we could accomplish, similar things but much cheaper than Mars missions and to which I would like to make correspondence with missions of discovery or what not but I think putting it on the forward ground, the important thing to know that the technological challenge that is presented to us in space but the sending people in space we are currently challenging ourselves that few places on earth can provide. Overcoming those problems with some of the most brilliant people in the world into a situation where we are bringing out the technologies and even creating new technologies to allow us to even survive. I think that that is one of the reasons why NASA has become synonymous in the public eye with the genesis of new and unbelievable, even miraculous technologies and it is a position that is absolutely invaluable and is even irreplaceable and to (inaudible – sound interference**)** space exploration is to say essentially that (inaudible – sound interference**)**. I just really wanted and I am willing to say that investing in manned space exploration forces us to overcome new technical challenges that are basic and fundamental to human beings, things that robots cannot duplicate. Those challenges keep us sharp in the same way that school forces children to solve problems and learn about themselves in the process and about their world and if we were to consign all that to robotic exploration or cut it entirely, I think we would be losing a very important aspect of what makes us who we are. Thank you.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
Thank you very much, and that completes the public input.

Phil McAlister, Executive Director, Designated Federal Official (DFO)
Can I make a comment just to add a little controversy here. I did not have to cut off one commenter today but in Houston, I had to cut off every commenter so I am going to leave that for the media to make whatever you want out of that.

Norman Augustine (Chairman), former CEO of Lockheed Martin, former Chairman of the Advisory Committee on the Future of the United States Space Program
And the representatives of the Houston papers, be sure to quote him, not me. Well, we have reached the end of what I think has been a very useful and helpful day for us and I certainly want to thank all the audience from wherever you come, particularly thank the NASA folks who have taken time. You have great responsibilities, a big one coming up this Friday as well as what is going on now and our committee will be meeting again tomorrow at the Cape. We will be meeting next week in Washington. As I said, our schedule is such that by August 31st we will have a printer-ready report. The report will go to the White House and also the Administrator of NASA. As you know, I think or I believe I said we have been asked to provide options for the President and for Congress upon which to base their decision and we will be doing exactly that. I think you will perhaps agree that ours is not an easy job. In fact, it is not one that any of us asked for but the one thing I would like to assure you on behalf of everybody at this table including Sally who had a long term commitment she had to take this afternoon, I just would want to assure you we are going to do our very, very best to do what is good for America and good for the American space program. So with that, thank you all very much for your courtesy in listening today and we wish you all well.