2002 Commercial Space Transportation Lecture Series Volumes 1, 2, and 3

- The Early Years, AST -- A Historical Perspective
- Reentry Operations: COMET/METEOR Lessons
- Setting Insurance Requirements: Maximum Probable Loss

Ronald K. Gress

Federal Aviation Administration
Associate Administrator for
Commercial Space Transportation
800 Independence Avenue, S.W., Rm. 331
Washington, DC 20591

2002 Commercial Space Transportation Lecture Series:

- **The Early Years, AST - A Historical Perspective**
- **Approval of Reentry Vehicles**
- **Setting Insurance Requirements: Maximum Probable Loss**

Ronald K. Gress
Office of the Associate Administrator
for Commercial Space Transportation
Washington, D.C. 20591

Federal Aviation Administration

Office of the Associate Administrator for
Commercial Space Transportation
800 Independence Avenue, S.W., Room 331
Washington, D.C. 20591

April 2003

NOTICE

Use of trade names or names of manufacturers in this document does not constitute an official endorsement of such products or manufactures, either expressed or implied, by the Federal Aviation Administration.

Available from the following:

Federal Aviation Administration
Associate Administrator for
Commercial Space Transportation
800 Independence Avenue, S.W. Room 331
Washington, D.C. 20591

or

www.ast.faa.gov

TABLE OF CONTENTS

INTRODUCTION

The 2002 Commercial Space Transportation Lecture Series emphasizes the role of the Federal Aviation Administration, office of the Associate Administrator for Commercial Space Transportation (AST), in regulating; licensing; setting insurance requirements; and conducting safety inspections, investigations, and enforcement actions in the commercial space launch industry. Changes in technology, interdependencies of corporate and national cultures, interagency missions, international businesses, and global market places are some of the factors that affect AST's efforts. Such factors influence and often determine the type of work this office performs.

These proceedings contain transcripts of lectures that explore those changes. Topics range from AST's history to issues that will require consideration in the future. While reading these proceedings, think about ways to use this information to influence the future and to promote AST's mission to ensure protection of the public, property, and the national security and foreign policy interests of the United States during a commercial launch or reentry activity and to encourage, facilitate, and promote U.S. commercial space transportation.

Mr. Ronald K. Gress, Manager of AST's Licensing and Safety Division, was the speaker for these lectures. He has over 30 years of experience in analysis and risk assessments involving weapon systems, computer systems, and federal regulatory issues and requirements. This includes 15 years of experience in commercial space transportation safety issues and the responsibilities for licensing, insurance requirements, safety inspections, investigations, and enforcement.

Mr. Gress retired from public service on October 1, 2002. These lectures represent an attempt to capture at least some of his wealth of knowledge. Designed to promote a lively exchange of ideas, many audience comments and questions interspersed throughout these lectures provide details and greatly enrich the ongoing dialogue in this technologically advanced, competitive, and dynamic field. These lectures were held in the FAA Third Floor Auditorium, Washington, D.C.

"The Early Years: AST - A Historical Perspective," the first lecture provides insight into the evolution of the commercial space transportation industry. Ways in which issues surrounding selection of the Department of Transportation and later the FAA as the Federal agencies responsible for licensing and safety of commercial launches not only inform the past but also impact current efforts are discussed. Approaches to major events, such as the first mission, license, and launch approvals, are highlighted. At first glance, the lessons learned regarding the value of using team work, examining issues from multiple perspectives, laying a strong foundation by completing rigorous analyses, and understanding the responsibilities of all of the entities involved in launch efforts seem like common sense. Yet, such lessons provide valuable opportunities to allow the past to inform our futures. This lecture was held August 16, 2002, from 9:17 a.m. to 10:38 a.m.

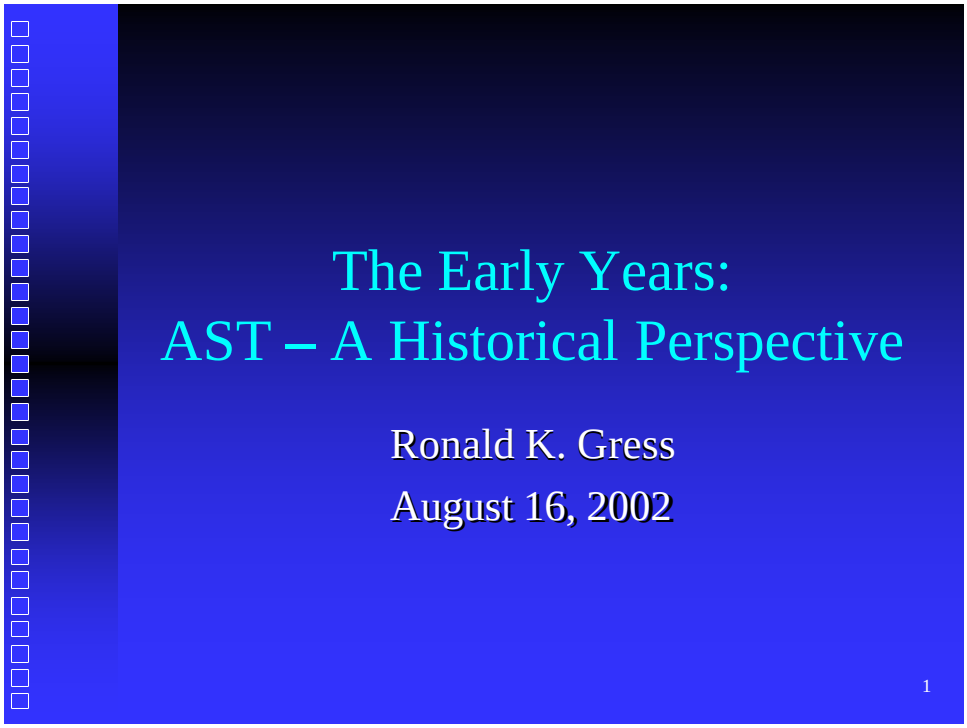
The second lecture titled, "Reentry Operations: COMET/METEOR Lessons," addresses a technological first for AST, approval of a reentry operation that occurred in the early 1990s. Mr. Gress examines factors resulting in this NASA grant program, originally called the Commercial Experiment Transporter or COMET undergoing a hiatus then being restarted as Multiple Experiment To Earth Orbit and Return or METEOR. The mission, systems, and operations of this program as well as the licensing and safety approval approach used by AST are described. In addition, he compares the approval requirements used for the COMET/METEOR program with those outlined in the Reusable Launch Vehicle Rule issued in 2000. This lecture was held August 30, 2002, from 9:00 a.m. to 10:43 a.m.

In "Setting Insurance Requirements: Maximum Probable Loss," Mr. Gress explains the rationale for establishing financial responsibility requirements. Safety issues associated with establishing insurance requirements for commercial space transportation vehicles using the maximum probable loss approach are outlined. Implications of using the maximum *probable* loss instead of a maximum *possible* loss approach to setting insurance requirements are explained. He discusses the roles, concerns, and considerations of stakeholders that are involved in and affected by the process. Current and proposed legislation and regulations, including provisions for indemnification that currently sunset at the end of 2004, are explored. This third lecture also focuses on vehicle launch and reentry operations. This lecture was held September 13, 2002, from 9:10 a.m. to 10:48 a.m.

The broad range of topics Mr. Gress selected for these lectures emphasizes the variety and complexity of issues AST must address, such as regulations, insurance requirements, licensing and launch approvals, technology, stakeholder considerations, and international competitiveness. As you explore your areas of specific interest, do not overlook the other areas. Remember, as Johann Wolfgang von Goethe stated in 1810:

> The modern age has a false sense of superiority because of the great mass of data at its disposal, but the valid criterion of distinction is rather the extent to which man knows how to form and master the material at his command.

LECTURE 1. THE EARLY YEARS: AST – A HISTORICAL PERSPECTIVE



OPENING REMARKS

MS. CAMILLA MCARTHUR: Good morning. I'm Camilla McArthur, and I'd like to welcome you to the first in a series of lectures hosted by the Federal Aviation Administration, office of the Associate Administrator for Commercial Space Transportation, or AST. The 2002 Commercial Space Transportation Lecture Series provides an opportunity for AST to share information about the role of the FAA in regulating and helping to develop a safe, competitive, technologically advanced commercial space transportation industry for this nation.

Our speaker for this series will be Mr. Ronald K. Gress. He is the manager of the Licensing and Safety Division in AST. He has over 30 years of hands-on experience in analysis and risk assessment, involving weapon systems, computer systems, and federal regulatory issues and requirements. His background also includes 15 years working with commercial launch vehicles and launch site safety issues in the areas of licensing, insurance requirements, safety inspections, investigations, and enforcement.

In today's lecture, Mr. Gress will provide a historical perspective on the evolution of commercial space transportation. He will also discuss issues relating to licensing and safety and to commercial launch operations. Mr. Gress will retire from public service in October, and he will truly be missed. In an effort to

capture at least some of his wealth of knowledge, we are videotaping this series of lectures. The lectures are designed to promote a lively exchange of ideas, and we encourage you to ask questions and to share your insights. To ensure that we get your question on tape, please raise your hand when you want to ask a question. We'll bring you a microphone. Also, if you didn't sign in, please do so, so that we can make sure we have our records up to date. And now, ladies and gentlemen, please join me in welcoming to the podium, Mr. Ronald K. Gress.

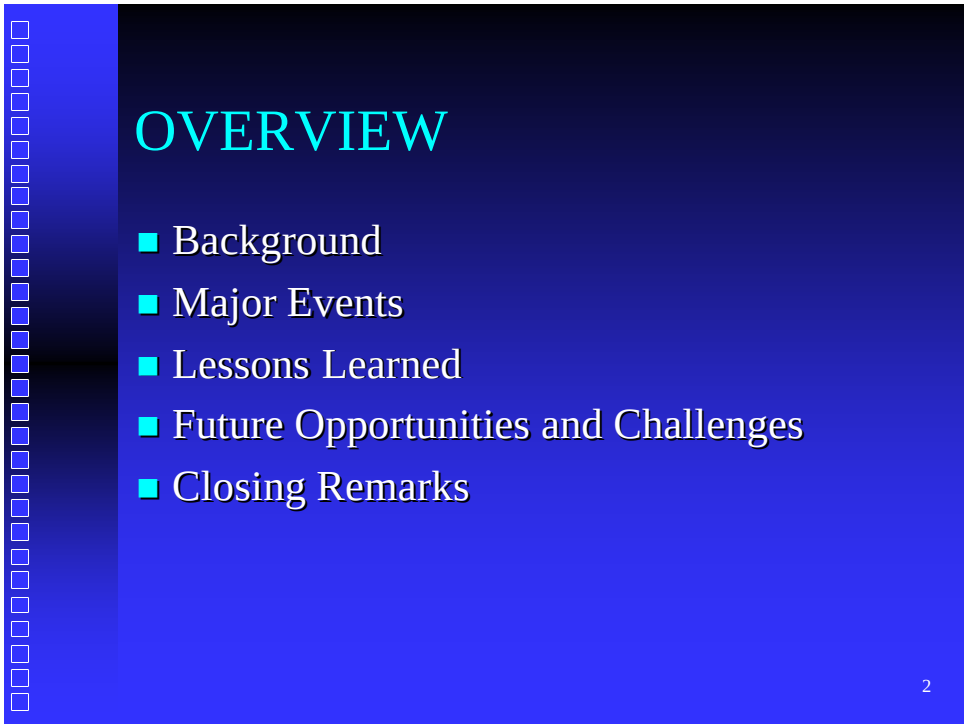
PRESENTATION

MR. RONALD K. GRESS: Thank you Camilla for that nice introduction. What I'd like to do is keep this as informal as possible. As I go through the discussion this morning, don't be shy; raise your hand. I'll try to keep my eye out, and we'll talk about whatever questions you have along the way. I want to re-emphasize that I want this to be as informal as we can make it. The idea would be for you to focus on areas that you want to learn more about.

What I'm presenting here are things that I thought were important; I thought were interesting; I thought would provide a perspective for looking into the future, so don't be shy. Interrupt me. I won't be disappointed. I'm going to start off this morning by talking a little bit about some of the background of the commercial space transportation industry. I'll emphasize some of that by focusing on several major events.

These events seem particularly significant to me, looking back. Then, I'll spend a little bit of time looking at the lessons that one might have learned or I feel were important from those events.

Next, I'll spend just a bit of time looking at the future challenges and opportunities. Having spent most of this particular lecture looking back, we'll look ahead just a bit and talk a little bit about some of the future activities.



How did we get here? Well, I think it's important to understand the past because it helps forge the future. One of the things that I mean by this is, it isn't necessarily restricted simply to "don't reinvent the wheel."

The past hasn't been easy, I don't think, for whatever entity you have an opportunity in working in. Looking back, the past is never easy. The future isn't going to be an easy process either, but looking back, there are a number of things that you can gain.

You can gain from the lessons learned. You can gain from learning the perspective, the sensitivities of the industry, for example, or our sister government agencies, and perhaps even most importantly, ourselves.

I'll talk a little bit about the creating of the commercial space transportation industry, and as I alluded to a few moments ago, we'll talk about some of the major first events that occurred.

The first approvals that were issued, what was behind them? The strategies the industry used in the early years. I'll talk a little bit about a particular study that I was involved in, the Astrotech Safety Issue. I think there's a lot to be gained from that in terms of controversial issues and how one can approach those.

I'll talk about the “Questioned License” that was issued in the early years. I'll talk a little bit about the various perspectives, how that came out, and why it came out the way it did.

Commercial space transportation, what is that? It's interesting that the term "commercial space transportation" is ingrained in our being in our office in AST. Yet, when you look at the statute and you look at what we're responsible to regulate, the word "commercial" isn't used. Oftentimes, I've found that to be a bit of a stumbling block. Because automatically with the word "commercial," one thinks of "for profit," "a business," and the like, but that's not the case.

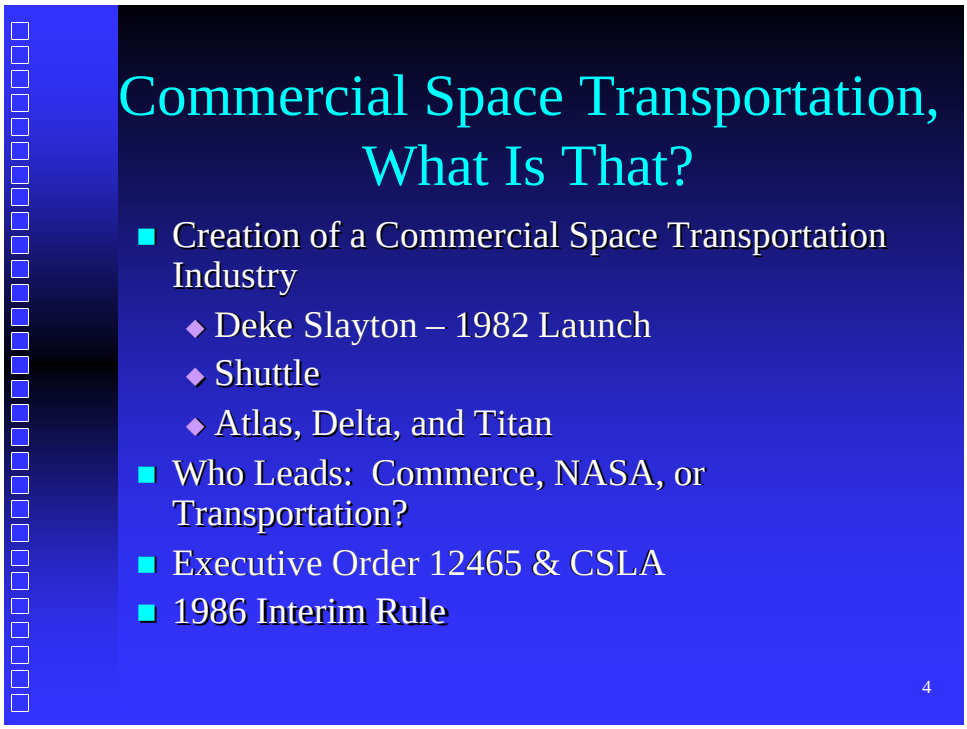
Our statute says that no citizen shall conduct or operate a launch without a license from us. There is nothing in that statement about "commercial." Keep that in mind. I think that's important. It's a lesson to be learned, and it often comes up in dealing with issues today.

Now, when was the first commercial launch? It's interesting. In 1982, Deke Slayton, former astronaut, conducted a launch from Matagorda Island in the Gulf of Mexico.

I'm sure there are some of you who know more of the details about that launch than I do, but it created a series of issues; primarily, because, what do we do? I mean, is there a law against this? What role should the government play? How is the government going to exert any oversight on this activity?

What came about was a whole series of approvals. I don't remember the numbers specifically. Again, perhaps somebody in the audience remembers that better than I, but everybody from the State Department,

Treasury Department, EPA [Environmental Protection Agency], all of those organizations had some role to play in this process.



It was quite unwieldy. That was the lesson learned. Of course, the shuttle was coming along. During this period, it's interesting to note that there were a number of commercial launches being conducted by the government.

Up until the end, I believe NASA conducted more than 200 commercial launches, and by that I mean communications satellites for this company and that company, both on expendable launch vehicles and, ultimately, on the shuttle.

As you all are probably aware, at that point in time, the shuttle was intended to become the exclusive access to space vehicle for the U.S. At the same time, President Reagan had some questions and issues.

Looking back on the experience of Deke Slayton, looking at the heritage that had come about through the Atlas, Delta, and Titan vehicles, well what are we going to do with these? I mean, there's a whole industry out there that, in essence, is going to be replaced by the shuttle. Should that occur? Is that what we want? Apparently the answer was no. There was a definite interest in opening up that commercial industry, allowing these companies to use these vehicles or, might I say, continue to use these vehicle designs to conduct private launches to support customers, such as the commercial satellite industry.

UNIDENTIFIED AUDIENCE MEMBER: I have a question.

MR. GRESS: Yes.

UNIDENTIFIED AUDIENCE MEMBER: I wanted to ask you if you could briefly describe the vehicle that was used in that first 1982 launch?

MR. GRESS: I'm not sure of the actual motor.

AUDIENCE MEMBER, HUGH COOK: Minuteman Second Stage.

MR. GRESS: Minuteman Second Stage, thanks Hugh. I think there were some questions about how successful the mission really was, as I recall, but everything did happen. It did occur, and it did occur safely. Thank you, and thank you Hugh.

Now, if you're going to create an industry, and remember, I said there were the issues of who was going to. All of the myriad government agencies that had to get involved, and it was sort of a trial and error process by Deke Slayton to ultimately get everybody to sign off on letting him fly, including the FAA.

The question was -- well, if we're going to have an industry, we need to have somebody in charge to ensure that operations are going to be done safely. What we really need is a one-stop shop. We need to avoid having to go around to 20 or more organizations or government entities and get approvals. You know, it's quite a task to get all these people to coordinate wherever it's necessary. So the question came about – well, who's going to do this? There were some obvious choices.

Commerce, after all, it's the commercial space transportation industry. They said, we're looking at a commercial industry here. Right?

NASA, remember I had said earlier that NASA had conducted over 200; well, I don't know at the time but ultimately had conducted 200 commercial launches. NASA was certainly a known entity in this field, but it seemed to be a bit out of their primary purpose or reason for being.

The Department of Transportation -- after all, aren't we talking about transportation? Is not the delivery of a piece of cargo, a satellite, to a particular orbit a transportation process? Yes, it was.

I've been told that NASA really wasn't interested in getting involved, so it dropped out quite early in the consideration. The choice came down to the Departments of Commerce or Transportation. There were some issues there that I understand played a significant role in making that decision. I think Commerce -- I can't speak for Commerce, but I've been told Commerce really sought and wanted the responsibility. DOT did too. At the time, Elizabeth Dole was the Secretary of Transportation, but there were some concerns. The concern at the time was that, in talking to the industry, the industry was very concerned about whether or not, if it went to Transportation, the process, the oversight, would be done by whom in the Department of Transportation.

A clear, possible choice was the Federal Aviation Administration. At the time, the industry was quite opposed to that. There were concerns about the rigor, the burden, and the other issues associated with the Federal Aviation Administration, which, of course, had an excellent record in the aviation industry and in aviation safety. Was the FAA really the place for this evolving new industry? Ultimately, I believe the decision was made, as I understand it, based upon the fact that, yes, transportation really looks like that's where this belongs. That's what it is, just like moving cargo by ships, moving cargo by rail, moving cargo by aircraft, moving people by these means. This is a transportation function, but let's not put it in the FAA. As I understand it, Elizabeth Dole committed to not putting it in the FAA. As a result, the office was actually formed in the Office of the Secretary, and that's where we resided for several years.

When the decision was made, it was made first through Executive Order 12465, followed almost immediately by the Commercial Space Launch Act, which in essence legislatively reflected what was in the executive order, signing over responsibility to the Secretary of Transportation. In fact, that's where it lies today. Even now, the authority lies with the Secretary of Transportation, delegated to the Administrator of the FAA, down to Patricia Grace Smith, the Associate Administrator for Commercial Space Transportation.

That was in 1984. Two years later, an interim rule was issued, and then nothing. What were we doing? Well, nothing was really happening. I'll talk a little bit about that in a moment, but the Office's focus in the mid to late 1980s was primarily policy focus.

Yes, there was work on the regulation, which was by the way a relatively short regulation. It talked about the responsibilities of licensees and what was required in an application in very general terms. The regulation very much assumed the use of federal ranges. Very brief, and as an aside, later on when, as often happens in a cyclic way, there was a review of all federal regulations. The brevity of that rule was actually applauded. This was during a period, which often happens, where the administration goes back and says, we've got to sort through, shorten, or eliminate regulations. That process was done in DOT, and our rule was part of that review process.

Some of the other issues we were working on in that era were sponsorship. Remember, the Commercial Space Launch Act actually provides and grants a commercial entity, a private entity, the ability to use excess capacity of facilities and services at ranges. That was nothing new, really, we found out. There had long been, through other statutes, the ability of private entities to use facilities at government ranges, government facilities, DOD facilities, for example. However, it required a sponsorship. Such use required another agency, for example, to step up if it wasn't the agency that owned the facility and sponsor that organization, that company, and to take responsibility for whatever that company might do in using that facility.

Well at the time, you know, you follow tradition. You do things the way you've always done them. When a company wanted to go to the range, there was the question of, well, who's going to sponsor these people?

Our position was that these companies don't need a sponsor. The Act, which recently passed, says that they can use it, so we had to educate our sister organizations and agencies in that regard. That took some time.

This was a new industry, and there were new entrants. There wasn't just General Dynamics, McDonnell Douglas, and Martin Marietta, but there were other organizations, like Conatec and American Rocket [AmRock] Company, who wanted to get into this new business. Remember I said the Act allowed these entities to take advantage of excess facilities, properties, services. These companies were looking for motors. Motors that were being stored at Redstone Arsenal, for example, and were about to be destroyed. They would like to have some of those motors, so we had to work with the Army, educate the Army to make them aware of the Act, make them aware of the ability to access and, perhaps, buy at a reasonable cost these resources.

I'll say a few words about American Rocket. American Rocket Company was a company that has a lot of interesting aspects associated with it, but it was going back and trying new technology. I say new. It really wasn't new technology. It was resurrecting old technology -- hybrid rocket motors -- in which the fuel was solid propellant with a liquid oxidizer.

There were several advantages to that approach. It had been considered early on in the development of rocket technology. It was passed by for various reasons.

Here we had a new company that was getting investors, investing money into developing this technology, and doing a demonstration. The problem was that as they were making progress. The interest in hybrid rocket technology grew.

NASA became interested in it. When a company is looking for investors, a company is actually spending its money. At this point in time, AmRock was actually conducting static firings out at Edwards Air Force Base, California, and a government agency steps in and puts out a RFP [Request for Proposal] for doing research in hybrid rocketry. It has a dampening effect. A company and investors, venture capitalists, are not willing to put money into a private entity if the government agency is willing to pay somebody else to do that research. They can't compete with it. They've got to recover all of their investment, hopefully, because they're paying, the private entity is paying for that investment.

That RFP had quite a dampening effect. One of our responsibilities, remember, is to facilitate the industry, so we spent time interfacing between American Rocket Company and attempting to make other agencies, like NASA, aware of these effects. To a greater or lesser extent, I think we succeeded in that regard.

Another area was insurance. You know the history. When NASA conducted a commercial launch, it asked for a half a billion dollars of insurance to protect them, NASA, or the maximum available at a reasonable cost. Actually, at times, I understand it went above a half a billion dollars per flight. Now, with private launches taking place, what was going to be done?

Our office had been working on risk-based insurance. I'll say more about that in a few minutes, but we actually held a symposium down at the Cape with participants from our office, the Air Force, and the insurance industry to kind of educate the insurance industry on public risk associated with launch operations. There was a lot going on in our organization at that time.

Moving on to the effect of shuttle on the market. This is pretty straight forward. Even after the shuttle started to fly, commercial payloads were being put on the shuttle. NASA was, of course, charging for those but nowhere near the actual cost to NASA and the taxpayer to conduct that operation. Now, that had a dampening effect on the U.S. industry because who's going to want to pay to launch on a Delta or an Atlas if you can get it cheaper on the shuttle?

The second effect was, I'm told, that the -- remember the shuttle was a man-rated vehicle. Perhaps I should say person-rated vehicle. That added a lot of requirements and tests on the spacecraft that would go in the shuttle bay to be released. There were some in the satellite industry, customers who weren't too pleased. It added a lot of burden. It added a lot of uncertainty.

Remember the shuttle flights, even initially, were having problems keeping their schedule. Schedule is important for the industry. Where else to go? Well, they could go to Ariane. Ariane was new at that time, and it was open for business. If you didn't fly in the shuttle, you flew on Ariane.

Our industry sort of stagnated, that is, until Challenger in 1986. At that point, there was a policy change. Shuttle wasn't to carry a payload unless it required man-tending. Most of the communication satellites, of course, don't, and away we went.

I'll talk a little bit about some of the first approvals. It's probably not widely known, but back in that era we had a multistep process. We required mission approvals, and I'll say more about that, and safety approvals.

A company could come in, even a customer could come in and seek an approval for a mission. They couldn't launch it yet, but the mission approval was to focus on national security and foreign policy interests.

And the first one through the door was a company that wanted to launch Cremains. It presented a lot of questions, a lot of issues. The executive order required us to consult with other agencies, such as the State Department, the Department of Defense, for example, and any other agency that might be appropriate.

Gee, did we really want to be launching cremated remains into orbit? You know, is that something worthy of
-- something that the United States wanted to be associated with? That was one issue.

Another issue, of course, was that the original concept had to do with taking lipstick-size pellets and spewing, I'll use that word, these pellets, lots of them, in orbit, once they reached orbit. That had some issues, orbital debris issues.

It had issues with astronomers. If you can imagine as you have more and more of these small things in orbit, it interferes with astronomical observations.

There were some lessons learned in that process. Cremains agreed to not spew these pellets out but keep them in one location. An approval was ultimately issued in that process. That was the first approval actually issued by what was the Office of Commercial Space Transportation.

One of the things that was learned in that process, by the way, was that in consulting with other government agencies, that's exactly what the executive order's focus was, it was consulting.

It didn't require us to seek concurrence from these other organizations. We had the ultimate decision. What that meant was -- not in this case, but in some of the other cases that we were involved in -- if another government agency had a concern, they should voice it. However, they had to voice it in a way that would be supportable. Because the Act and our regulation allows for the applicant to appeal. The burden of proof falls on the government to show why we denied an approval, so that was a -- Yes, Laura?

AUDIENCE MEMBER, LAURA MONTGOMERY: Am I right that the context at the time was that we did not have identified standards in our regulations, so the denial would have to have a reason behind it? More than it was a burden of proof, we had to have a reason.

MR. GRESS: Well, we had to have something that -- I would have to say that even today we don't have clear standards on national security and foreign policy. My sense is that we not only had to have a reason, but we had to have a valid reason, a very supportable reason because the appeal could conceivably go to court. This became an important tool for us in many respects because, oftentimes, what we would get back in the early years from another agency was an opinion.

AUDIENCE MEMBER, LAURA MONTGOMERY: I guess I would question whether it was really a burden of proof question so much as that there had to be a reasoned decision-making. That of course would have to be supported by evidence, but I don't know that that was sorted out as to who had the burden of proof.

MR. GRESS: Well, it had to be something that would stand up in court.

AUDIENCE MEMBER, LAURA MONTGOMERY: Yes.

MR. GRESS: Okay, let me use those words, and we can agree.

AUDIENCE MEMBER, LAURA MONTGOMERY: Thanks.

MR. GRESS: Okay. At this same timeframe, just talking about mission approvals, another issue came up in the interagency coordination, and that had to do with Delta commercial launch activity and the concerns voiced about orbital debris. Many of you may be aware that in the past Delta launches conducted by NASA

went through a period where, mysteriously, the second stage left in low Earth orbit would blow up. That really wasn't a nice thing. These events spewed a lot of debris around and posed a risk to other property on orbit, other satellites on orbit at the time. That became a concern. We addressed that, of course, at the time by looking at what had transpired.

There were new procedures in place, actually adopted by NASA, who was still using the Delta vehicle in part at the time. These procedures resulted in safing the vehicle, depleting any energy sources, including propellants, pressure vessels, and the like in that process. It's important to understand that those kinds of issues were raised.

We addressed them because McDonnell Douglas, of course, had been doing this routinely. We understood, and they committed themselves to continue to do that at the time.

Titan was one of the first ones through the mission approval process. I emphasize that because, like Cremains, Titan chose the route where the activity, the licensing activity was sequenced. They actually submitted first a mission approval request and chose to follow that up later with the safety review. Only when those two processes, those two approvals were issued would they have a license to operate.

Again, I think that isn't the norm today, but I think it reflects kind of the tentativeness of the industry at the time. It may reflect, in part, the concerns with respect to Titan and the types of propellants used on the vehicle as well. I don't believe that it really reflected the nature and type of payloads on board although it might have. Some of the early payloads were not only communication satellites but foreign, NATO-type satellites as well.

Today that's not a normal process although it's still possible to do. The idea of doing it is that between the two processes, mission approval, now we call it policy, requires much less effort and time than the safety approval. Mission approval's pretty fast. You can get it pretty quickly. The process goes fairly quickly. The idea originally was why put somebody through having to submit a whole application for a license if there is a policy issue?

You know, launching a remote-sensing satellite for Iraq might raise some policy issues. You can get that resolved and not go to the expense of doing a lot of other application development or not if the policy review, or at the time the mission review, would be denied for some reason.

Now, another thing that's not widely known is the first license that was issued was to Conatec, and it involved a suborbital launch, using a Black Brant, from White Sands Missile Range. If I recall the license, we coordinated that. We got the support, a lot of safety analyses done by our sister organization at White Sands, the Army in that process. The launch never happened, so the first license issued never resulted in a launch. At about that same time, there were some amendments to the Commercial Space Launch Act, 1988.

I mentioned a moment ago -- Yes, Hugh?

AUDIENCE MEMBER, HUGH COOK: I think that Wayne Montag was key to that first license. I mean, he was probably Conatec's senior engineer on the front.

MR. GRESS: Absolutely.

AUDIENCE MEMBER, HUGH COOK: I just wanted to point out to those working today with Wayne Montage that he has as much history with us as anybody.

MR. GRESS: Yes. Wayne was associated with Conatec at the time. Good point, Hugh. I think I alluded to the fact that we were working on that license. We issued the license, and we also had an insurance requirement associated with that license based upon risk.

The 1988 amendments had not yet passed, which provided for indemnification and other requirements, but we issued that license. We were the first to issue a license that had associated insurance requirements, which did not follow the previous NASA model: We don't care what you're launching; get as much as you can buy. Half a billion dollars is required. If you can't get that for a reasonable price, then we'll work with you to find out how much you can get at a reasonable price.

Yes, Stewart?

AUDIENCE MEMBER, STEWART JACKSON: Okay. Can you tell me why Conatec's launch did not take place after they received a license to launch?

MR. GRESS: Well, I suspect they didn't have a customer. I also suspect they counted on a particular customer, which ended up launching on somebody else's vehicle.

In fact, you'll notice that the next launch, actually the first licensed commercial launch, dare I use the word, occurred by Deke Slayton's company, SSI, from White Sands Missile Range.

The customer, as I recall, was the University of Alabama at Huntsville microgravity experiments. I think that was the payload that Conatec had hoped to get. They didn't get it, so Deke conducted the launch operations.

If I am not mistaken, Hugh Cook, now manager of the AST Systems Engineering and Training Division, was involved in that activity.

AUDIENCE MEMBER, HUGH COOK: The last in that series, there was a total of seven.

MR. GRESS: Total of seven, and Hugh was involved in the last of that series, so the first actual licensed launch occurred in 1989, in March, as a suborbital launch.

That same year the first licensed orbital launch occurred from Cape Canaveral on a Delta. A BS-BR1, if I'm not mistaken, was the payload. A TV satellite system designed to support TV transmissions to the UK, as I recall.

It was interesting. This was the first launch that took place from an Air Force range. It really presented some issues. There was a major paradigm difference, if you will, between these activities and what the range was used to supporting.

You know, obvious questions. Why is DOT down here? Who are these people, and what are they doing? Are they going to take over inspections? Who are they inspecting? Are they inspecting us or McDonnell Douglas?

There was a lot of tentativeness, a lot of uncertainty. Our answer at the time was that we're relying on the range, the range infrastructure, the range approval process, and the range inspection process to ensure that these launches take place safely. That's what McDonnell Douglas has signed up to. They're paying you the direct costs for those services. We're there to ensure that the licensee complies with the representations that they made in their application and the requirements of our regulation.

We don't see a need to overlay or have yet another inspector -- somebody performing a function, a company inspector watching that operation, an Air Force range inspector watching those two, and then a DOT inspector watching. I forgot how many that was, three or four people!

We didn't see that as being necessary, and we took some time to kind of convey to the people down there what our role really was. I think one of the things that I'll talk about later is that they learned through trust and experience. Of course, I think our relationships to a large extent have moved way on beyond that today, but you still get those kinds of questions today.

The other was hand-holding of McDonnell Douglas. You know, McDonnell Douglas was going in here. McDonnell Douglas was doing this as a private entity. The range was used to dealing with these companies as contractors to them or NASA [not] as a customer of Air Force or NASA. The ranges were used to being in the driver's seat. If they didn't like something, they'd say change it, whether it had to do with safety or not. It was either a NASA or an Air Force program. That's the way they looked at it, even if it was NASA launching a TelStar satellite or something. That perspective had to change. It was quite important for McDonnell Douglas to convey that they wanted the range's help but in the respect of public safety. They didn't need the range's help with respect to mission assurance in situations where the two could be separated.

The other was preemption. Commercial Space Launch Act had some provisions for preemption. Provisions weren't good, I think, from the perspective of the Air Force or a government entity. If you had a schedule, and your schedule was somehow affected, that meant that that private entity might, in fact, be able to be reimbursed for their costs. As a result, there's a feeling of let's not commit anything with respect to schedule. Then, we can't be found in fault on preemption.

Our role in that process was really to go down there. Monthly meetings occurred where the range and McDonnell Douglas met and talked about issues, outstanding activities, and the like, and we were kind of there just to show our presence and ensure that things went along smoothly. McDonnell Douglas, I think, very much appreciated that of us.

Another study was -- and I'll try to speed things up, we have just 30 minutes. I want to make sure that if you have questions you can ask them.

In the 1989-90 time frame, all of a sudden, around that same era, there was a bunch of NASA people who decided that they wanted to open up a payload processing facility -- a private one. There were going to be all these operations taking place. They could process these payloads, and it looked like it was a good opportunity and venture.

Then, of course, Challenger occurred. Following the Challenger incident, there were some government launches of Atlas and Delta and Titan. All three had failures, so that was extremely dampening on the U.S. launch industry, particularly the commercial industry and even a greater impetus for things to go to Ariane by the way.

Nevertheless, they constructed this facility. It sat empty for a while. After Challenger and after these launch activities started to take place, the facility started to get business. It was located in Titusville in an industrial park. Across the highway was a residential area.

All of a sudden, there were questions. Why are there people over there? You know, there's this facility. It has these big buildings and chain link fence with barbed wire around it and a gate, and every once in awhile we see somebody over there in a SCAPE suit. What's going on over there? Ask around, there were some people who worked at NASA, of course, KSC and Cape Canaveral. Oh, you know, they're processing payloads, and they use those suits because there are hazardous materials there. In fact, the materials are so hazardous that if something gets away, it could wipe out Orlando. That was the word, a lot of concern. "Hey, what have we gotten ourselves into?"

Titusville was certainly concerned. Our office was invited by the Lieutenant Governor of Florida at the time to do an independent investigation and evaluation of the Astrotech facility.

Now, we don't license that. At the time, it was viewed we never would. It's not a launch site. It isn't on a launch site, but the idea was -- at the same time, you have to realize that there are political considerations in here, in terms of who the [lieutenant] governor of Florida was at the time -- we could learn a lot by doing this. Those kinds of activities also take place on the range, and we could learn a lot by looking at this. It was quite a charged, as you can tell or imagine, issue, however.

What we decided to do was to put together an interagency team. Once we decided to do this, we invited EPA to step in and become a joint sponsor of our study. They did so. We also developed a contracting support team to support the effort with expertise both on explosives and environmental issues, toxic issues.

We looked at the issue from a number of perspectives. We actually conducted inspections of the facility. We monitored operations as they were going on. We conducted risk analyses and dispersion analyses, particularly those based on worst-case scenarios.

As I recall, the largest rocket motor explodes, the facility is ruptured, and the maximum amounts of toxic materials are released. What is the worst-case that could happen under that same circumstance relative to the health of people in the area outside the facility?

We also looked at comparative uses; for example, hydrazine, which was one of those highly toxic materials that fuels spacecraft. We looked at the use of anhydrous hydrazine in other applications, [such as] cleaning cooling tanks at power plants. Hydrazine is used as a weed killer by certain highway organizations, state highway organizations and the like. We looked at not only what would happen if it were released, but we also looked at what happens over those minutes as it's dispersing. Recognizing that there are certain chemical reactions that can take place with both nitrogen tetroxide and hydrazine as it interacts with the air and moisture.

We issued a report. I happened to bring a copy.[1] You can find that in the AST library, I believe. What was interesting is probably the greatest influence on safety wasn't the N_2O_4 or the hydrazine. It was the HCl, hydrogen chloride released by the rocket motor.

This all culminated in a meeting, a city council meeting, at Titusville. The public was invited, the press was there, and here we were. We had to explain what our answer was; what our assessment was of the safety of that operation to the mother who lived across the highway, who wheels her baby in the baby carriage down the residential street; what we found; and why we concluded that the operation was safe. We did make some recommendations that should be followed. We also clearly, at the time, identified certain quantity limits based upon our study for that operation.

Turns out that it worked very well. We had a panel, represented by DOT, myself, EPA, and the contractors representing the various areas of expertise. We made our presentation and participated in an extensive question and answer period. That worked very well, I thought.

The first commercial Atlas launch. This is the one where there was a questioning of the license itself. I'll give you some background. At the time, the National Space Policy, as it does today, encouraged that government entities begin to take advantage of commercial launch services.

NASA said, oh, okay, we're going to do that too. We're going to go out, and we're going to acquire commercial launch services. We're going to do our launches commercially. In the RFPs that they released, they billed the launch of CRESS. Don't ask me what it stood for. I don't remember exactly, but it was in a scientific experiment, scientific payload.

NASA put it on its manifest and called it a commercial launch. General Dynamics, who was the company who manufactured Atlas, wanted that launch to be licensed. They applied for a license.

I think they wanted it to be licensed, and this is just my opinion, for really two reasons. First, that most people come to mind as, well, because after the 1988 amendments, there was a provision for indemnification of government property if it exceeded the amount of insurance we set. By the way, I'm going

[1] ICF Incorporated and Research Triangle Institute, *Safety Evaluation of Astrotech Payload Processing Facility: Titusville, Florida*, U.S. DOT, Office of Commercial Space Transportation and U.S. Environmental Protection Agency, Washington, D.C., August 1990.

to talk in great detail about maximum probable loss in insurance in another follow-on lecture if you're interested. Indemnification for quasi- or so-called indemnification for activities against claims by third parties. That's the first that comes to mind, but I like to believe, and sincerely believe, that there were other reasons as well.

Remember the industry is just starting up. In a competitive market, there is an advantage, and I think General Dynamics believed this, to having a license. "Gee, DOT has looked at us. We have a license. See, we got a license for this launch." The next customer that comes along if they ask, well, what are the chances of you getting approved? They can point back and say, we were already licensed for other launches, so the chances are minimal, negligible that we won't be able to get a license.

Also, it's a very important marketing aspect as well in my opinion. The other thing I'd like to point out in this context was General Dynamics approached this a bit differently than McDonnell Douglas in the marketing aspect as well. General Dynamics committed to manufacturing a number of vehicles. Hugh you may --

AUDIENCE MEMBER, HUGH COOK: Nineteen.

MR. GRESS: Nineteen, I was going to say, I thought 20, but 19 I think, good. Nineteen vehicles without any -- or certainly without having 19 customers.

Why did they do that? Well, they did it because if you build 19 and you commit to build 19, your costs go down, are reduced for a larger lot. You can then go out and market at a smaller or lower cost. It showed commitment. Again, I think it was a business, economic, and marketing decision that served General Dynamics well in the end.

Other companies approached it by [saying] you sign up as a customer, and then we'll put the order in to start putting the vehicle through the assembly line.

The launch took place in 1990 as a licensed launch issued by DOT. NASA was really mad at us. They took us to the Department of Justice. They said, DOT had no right to issue that license; it was our launch.

Now, what I'm going to say is what I understand was done. The Department of Justice said, okay, well let's hear your arguments.

NASA submitted their arguments to say, hey, the launch was conducted by us and for us. Key, because a launch conducted by and for the government is exempt from a license.

Our view was that the National Space Policy said government agencies should be encouraged to seek commercial launch services, my words. NASA advertised this as the fact that they were now operating commercially.

I'm not sure, again, what that means. Again, the confusion of "commercial." I can't think of any launch that took place without the manufacturer, whether it be Rockwell, McDonnell Douglas, General Dynamics, Martin Marietta, Lockheed, or whomever, being involved in the launch and really providing significant technical services and the vehicle, but that's neither here nor there. Our argument was well, they said it was commercial. The policy says they should do it commercially, so that's why we licensed it, and that's why we should license anything like that in the future.

DOJ found for NASA. DOJ said they thought it was by and for the government because NASA was substantially involved in the launch. Now, I've always felt that had we argued substantial involvement instead of policy, the decision might have gone the other way. Why do I say that? Because every single analysis, every single test that was conducted, was conducted or done by General Dynamics. Was it reviewed by NASA, overseen by NASA? No.

NASA played the role, perhaps more significantly, in my opinion, but played the role of any customer: I want to be sure my vehicle or my payload is going to be safe. I want to look at it from that perspective. I want to make sure that the environments that my payload is going to be seeing are okay.

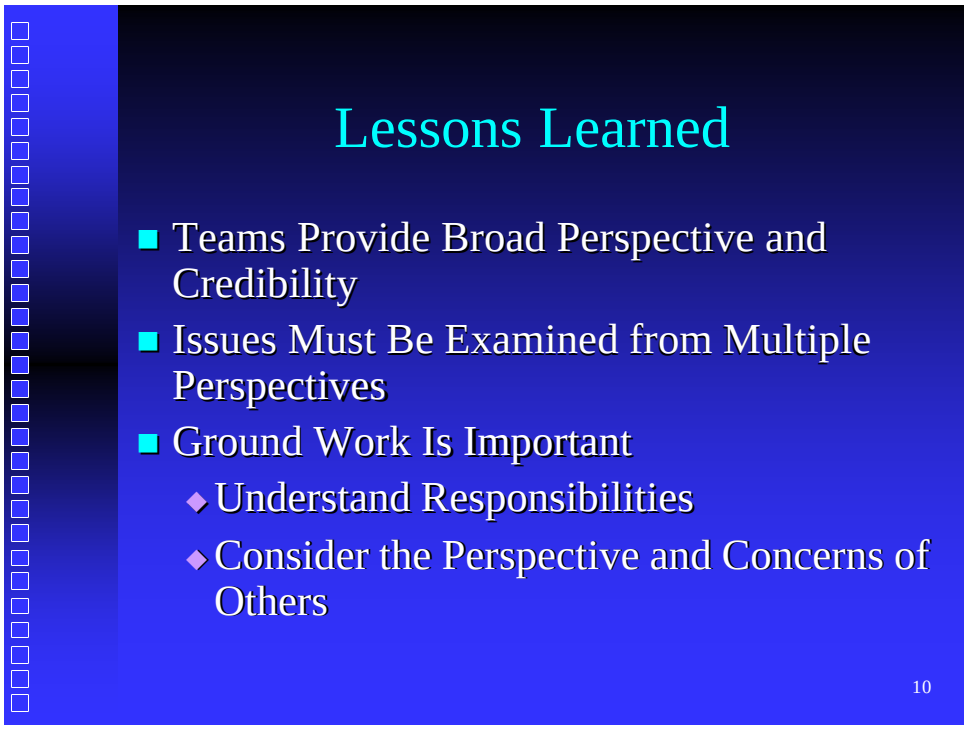
They might have tracked certain issues associated with the vehicle, but they really weren't involved in any of the safety oversight. By that, I mean public safety oversight. As a result of the decision, there was an agreement that was encouraged, I guess, by the Department of Justice that when you talk about "conducted by the government," what really are the indicators of substantial involvement?

There was a list that came up, was in fact generated between us and NASA, which were indicators. No single item was in and of itself a determinant, but these items were indicators of what substantial involvement really was. I'm not going to go through the list. I don't even think I've ever seen a copy of the

list. This list was negotiated by our legal counsel. However, they included, I'm told, things like, whether the vehicle is actually owned by or the ownership was transferred to the government.

Is it still owned by the launch service provider. The type of oversight that might be done. Following that, the agreement really, then, was anytime that NASA felt that they were substantially involved, all they had to do was tell us that they were substantially involved, and we wouldn't question it.

Lessons learned. I just put down a few. I think that how some of these issues were approached can be useful in other applications, other problems, other things that the office will face in the future.



I don't think there is anything surprising here. They're not anything that I would call Eureka-type statements. However, I can certainly point to the past and say, you know, they sure worked in the past, and I would encourage these types of approaches to be used in the future.

Teams provide a broad perspective and credibility. I mentioned that in the case of the Titusville issue in particular. It was quite important that we had not just us but others involved in that process.

You'll hear more about this when we talk about maximum probable loss, but issues must be examined from multiple perspectives. You don't necessarily need -- it's quite helpful to look at an issue from different perspectives.

You may get the answer you're looking for, confirming your views, doing it one way. On the other hand if it's controversial, you should look at looking at the problem from many different perspectives, doing different kinds of analyses, for example, different approaches, specific analysis of the system itself. Go back and look at empirical data on systems like that is an example to further support the conclusions.

Ground work is important. Understand your responsibilities. Understand the responsibilities of others. In the early years when we were working with the Air Force, the question was "well, I'm responsible. There can only be one responsible entity."

Well, that's not true. It's important to recognize the responsibility of not only yourself or our organization but also to understand the responsibility of the other entities involved -- the licensee, the range, and anybody else that may be involved.

Consider the perspective and concerns of others. Another situation involved much the same kind of issue. For example, when we started working with the ranges, the ranges were quite relieved that we were going to take on the burden of kind of finding out how much insurance would be appropriate to protect their property.

By "their" I mean the Air Force's or NASA's property. Now, that seems kind of counter-intuitive. "Hey, it's my property. I want to make sure it's insured, and I'm the one who wants to do that."

Ranges kind of understood the complexity, the issues associated with setting insurance, and based upon how we approached that problem -- again I'll talk more about this in another lecture -- as we briefed them on our approaches and how we made certain conclusions, how we reached certain answers, they were quite happy to say, "Okay, you know more about this than we do. You're the one who's going to be in trouble as well if it's not right." Another important thing to remember, they were relieved that we were actually taking on that responsibility and burden.

Every request for an approval requires close attention. We'll talk more about this, but you have to look at all of the issues. You have to cover all the issues. You have to be sure that you have a reasonably supported argument for your decisions. I think, as well, the applicants have to understand what they're doing and the risk.

I have just a few minutes and I'd like to before I go to the last slide or the last couple of slides, I'd like to tell you a little story as a way of bringing some of these together. Some of you may have heard this before, so bear with me.

There was a young wife, recently married, just starting a family. She and her husband lived in the city where her parents lived. It wasn't unusual for them to go over to her folks' house for dinner on occasions, such as Sunday. Being a newlywed and responsible for cooking meals and the like, I'm sure she had done it many times at home, but, you know, this is all new to her, and she wanted to get it just right.

One day she asked her mother, "Mom, how come we cut the end of the roast off when we put it in a pan?" You know, the mother thought for a minute and said, "Well, you know that's a good question. That's the way my mother taught me. I don't know."

Well, the grandmother didn't live in the city, so several months passed. I guess it was the holiday season when the grandmother came for a visit. The daughter remembered the question. As the three women were in

the kitchen working away, the daughter asked, "Gram, you know, I asked Mom how come we have to cut the end of the roast off when we put it in the pot."

Grandmother said, "Well, I always had to do it because [of] the size of our family. Oftentimes the roast wouldn't fit in the pot."

The lesson is obvious. Sometimes, we do things simply because that's the way they've always been done. It's important to understand why we do things. In some cases, why we do them, the reasons and rationale for why we do things a certain way, don't exist anymore. However in other situations, they probably do and you just haven't realized it. For these reasons, I think it's always important to question things and equally important to understand background.

I just wanted to cover very quickly some future opportunities and challenges that are faced by AST. Launches from non-federal ranges are likely to continue to increase. We have seen such launches. We have things like Astrotech launching from Australia. We have still other new activities that very possibly will lead to launches outside federal ranges.

Technology is changing. Some of this isn't new to many of you. The evolved expendable launch vehicle, which by the way is scheduled to launch at shortly after 6:30 on the 21st, next Wednesday, in the evening.

Reusable launch vehicles really present issues with respect to mixed technologies. Some cases, many of you are aware of this. You know, is it an airplane? Is it a reusable launch vehicle?

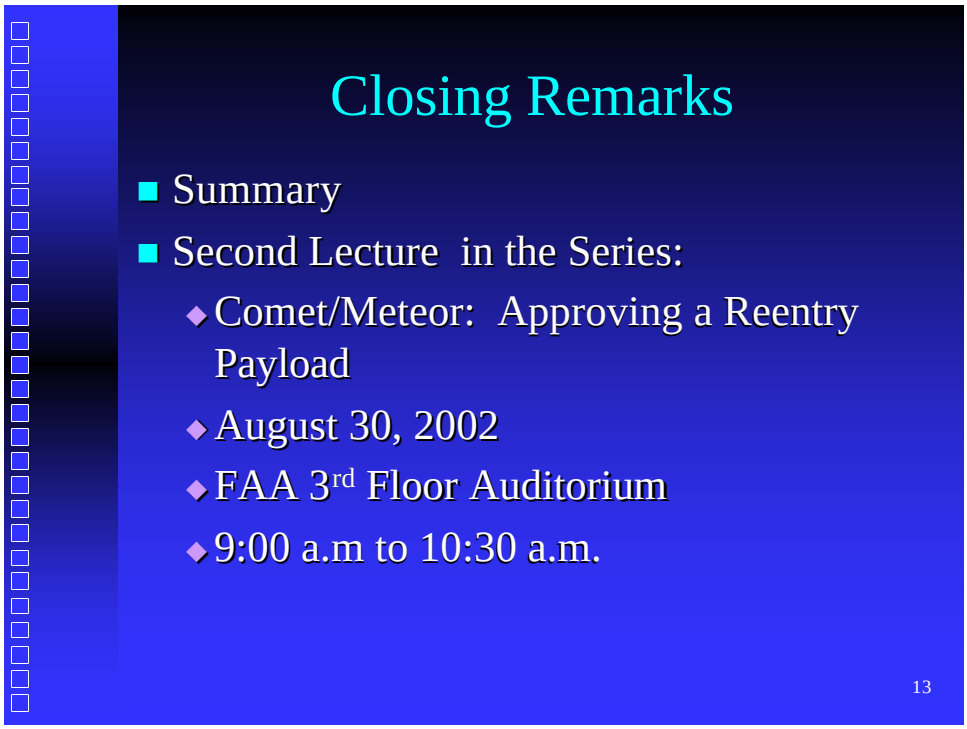
If it's a rocket and it's got wings, is it an airplane? Maybe, sometimes. On the other hand, I can give you an example of a rocket that has wings that everybody would say is a launch vehicle -- Pegasus.

For those of you who don't know what Pegasus is, when you go out the auditorium, look on the wall of pictures. Pegasus is the vehicle with wings that's launched from the belly of an L-1011 airplane. Most people would say that's a launch vehicle. Well, somewhere in between you've got to transition from one to the other. Identifying those extremes may be helpful in reaching a rational, reasonable decision as to what becomes an airplane and falls under the aviation regulation and their Parts and what falls under Part 400.

Ultimately, and one thing I didn't talk about is the differences between licenses and certificates. We license operations. The rest of the FAA's focus on vehicles is certification. They're approving the aircraft. We need

to know about the vehicle, but we're really authorizing the conduct of a launch. Now, that may change in the future, or it may stay the same. In fact, think about it.

Again, next session, I'll talk a little bit about this because this situation actually comes up in COMET/ METEOR (Commercial Experiment Transporter/Multiple Experiment To Earth Orbit and Return). You can have a manufacturer manufacture a vehicle and then have somebody else operate it.



Right now with the exception of the Black Brant, the manufacturer is the operator. Certification, of course, as I said, looks at the vehicle and at the standards associated with the vehicle and its capabilities.

A summary, I've basically already done. I've talked to you a little bit about the second lecture, which will be on COMET/METEOR, approving a reentry payload, August 30th, same place. This is an exciting area. I think we'll need all of the time, so if you're interested, try to get here on time. We'll finish by 10:30. Any last questions?

AUDIENCE MEMBER, STEWART JACKSON: I have a question. With the decision or process that you had to go through with the Justice Department and NASA, did that adversely affect the relationship that we had with NASA? Was there something that we had to not climb out of a crater to build up a permanent relationship, or was it done on a very friendly basis? I mean, what's your opinion?

MR. GRESS: Well, I think that's a good question. I think that NASA in the early years, while it had a commercialization or commercial office -- issues like AmRock that I touched on -- I think our relationship with NASA was kind of bumpy from the beginning. I wouldn't say there was a lot of animosity, just differing views.

Obviously, this issue didn't help, but I don't think it made anything all that much worse either. I think that as a general observation I can say that our relationship with other agencies, [including the] Air Force and NASA, have markedly improved over time, looking back.

I believe that change in some respects takes time. In part, it's not how hard you work it; it's what you work on. Over time, you gain a better understanding of each other's perspectives and roles. Looking back, I can see that we've made a lot of progress. You wouldn't believe the difference between the relationships we have today, for example, in working on common standards with the Air Force. That cooperative effort would have been unimaginable 15 years ago. I see the same differences or the same improvements, I think, with NASA as well.

I don't know whether I answered your question. I don't know if there's really a specific answer to that question.

AUDIENCE MEMBER, STEWART JACKSON: You did, thanks.

MR. GRESS: Anybody else? Well, I want to thank you for your time and your participation. Again, I'm kind of excited about the next one. I think it's going to be really fun.

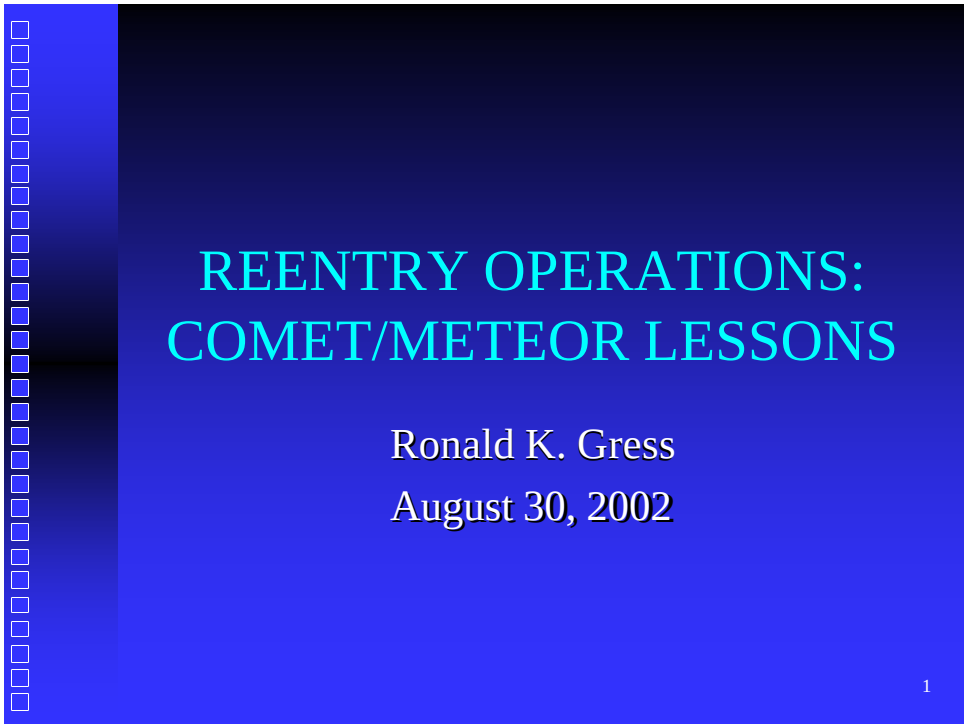
There [are] a lot of lessons learned that can be applied to RLVs, or Reusable Reentry Vehicles, as a part of that process. We can put it in context of our regulation in place today for RLVs. Very interesting.

While COMET/METEOR wasn't an RLV, the approach that was taken, the lessons we learned, and the process, I think, are very enlightening.

Thank you again, so much, for your time.

(Whereupon, the lecture 1 was concluded.)

LECTURE 2. REENTRY OPERATIONS: COMET/METEOR LESSONS



OPENING REMARKS

MS. CAROLE FLORES: I am Carol Flores, and I am the Deputy Manager of Commercial Space Transportation, Licensing and Safety Division. Welcome to the second in a series of lectures on commercial space transportation. These lectures are hosted by the Associate Administrator for Commercial Space Transportation.

As some of you are aware, we are often referred to as AST, so when I make reference to AST, you know who that will be. The 2002 Commercial Space Transportation Lecture Series provides an opportunity for us to share information about the role of AST in regulating and facilitating development of a safe, competitive, and technologically advanced commercial space transportation industry.

Our speaker this morning, Mr. Ronald K. Gress, is the manager of AST's Licensing and Safety Division. His background includes 15 years of experience in commercial launch and launch site safety issues in the areas of licensing, determining insurance requirements, performing safety inspections, investigations, and taking enforcement actions, when necessary. This expertise is also supported by his nearly 30 years of experience and analysis in risk assessments involving weapons systems, computer systems, and the Federal regulatory issues.

Mr. Gress will retire from public service in October. These lectures provide an opportunity to capture some of his knowledge of the pivotal moments in the development of the commercial space transportation industry, including technological firsts and other major events.

In today's lecture, a technological first for our office will be discussed. Mr. Gress will discuss approval of reentry operations, with special emphasis on the COMET/METEOR experience that occurred in the early 1990s.

These lectures are designed to promote a lively exchange of ideas. We encourage you to ask questions and make comments. We are taping this series of lectures so that we will have them for all time, and we want to make sure that we do get your comments. Any time you have something that you want to say, a question to ask, raise your hand. We have people stationed around with a microphone. Please wait until you have the microphone in your hand and then speak. That way, we won't miss anything. Ladies and Gentlemen, help me welcome Mr. Ronald K. Gress.

PRESENTATION

MR. RONALD K. GRESS: Thank you, Carol. Good morning. I want to reemphasize what Carol said about asking questions. Don't be shy. I may not have the answer, but it gives an opportunity to exchange some ideas, so by all means do that.

As you heard, I am going to be talking primarily about COMET/METEOR. First, let me tell you what COMET/METEOR is. COMET was the program's name when it initially started. It was a grant program from NASA to universities, and COMET stood for Commercial Experiment Transporter.

I will talk more about the vehicle characteristics in a minute. Later on the program ran into funding problems, went through a hiatus, and was eventually restarted. When it was restarted, it took on a new name although the vehicle and the design were the same, METEOR.

METEOR stood for Multiple Experiment To Earth Orbit and Return, so you can see they have come up with some very good names. To give you an overview of what I am going to talk about today, I am going to talk a little bit about the mission, systems, and operations.

I am going to talk about our approval approach, and I am going to spend quite a bit of time on that and some of the issues that came up. We will talk about some of the lessons that we learned. By the way when we

finished this project, we actually went back and did a study on lessons learned and wrote a report as I recall on that. If you have interest, you may want to look for that report.

One of the other things that we did in the process by the way was while we were working on the study on the evaluation, we brought in Mitre [Corporation, with principle locations in Bedford, Massachusetts, and Northern Virginia]. Many of you with the FAA, of course, and who have been with the FAA for a long time, recognize Mitre as the FAA's FFRDC (Federally Funded Research and Development Center). We brought them in and had them do an evaluation of our approach, and this was during the process. They included a close examination of what we were doing as well as an examination of what NASA might do if it were responsible for the project. I think one of the conclusions in that process was that we had the right approach. We were doing everything the proper and correct way, but they were quite surprised that we were doing it with so few resources compared to how others would approach the problem.

Then, finally, obviously, when you learn lessons, the next thing to do is to take advantage of them. I am going to talk a little bit about some of the comparisons between what we did and what we have started off with in our regulation for reusable launch vehicles in reentry operations.

As I said, we will start with the mission description. The purpose of COMET/METEOR was obviously to conduct microgravity experiments. The goal was to put these experiments on orbit and be able to monitor them. For at least 30 days, they would remain on orbit.

After 30 days, it would return some of the experiments to Earth. Obviously in order to recover them, the goal initially was to bring them back to land. Later when the project was changed to METEOR, the landing site was changed from Utah, which was the Utah Test and Training Range, to a location in the Atlantic just off the East Coast. The Utah Test and Training Range landing site was a 24-mile wide by 51-mile long, fully controlled area by the test range, and that was their goal for landing. When they moved it to the Atlantic, the Atlantic site was a bit narrower. It was a little over 18 nautical miles wide by 87 nautical miles long.

The vehicle would return certain experiments, but there would be some that would be left on orbit. Those experiments would remain on orbit and could be monitored for up to 130 days on orbit. While they wouldn't bring them back, they had telemetry and other things that they could monitor those experiments over the

longer time. Future projects envisioned in the program were quite broad. They included, and I just mention this, there were several other concepts or ideas. The one that I think caused the greatest amount of interest was ultimately to have two of these on orbit and to dock them remotely automatically.

COMET/METEOR wasn't a launch vehicle. It was a payload, and we had originally envisioned our oversight of this to be done as a licensed activity. We tried to think outside the box a bit and thought that the best way to approach it would be to consider this launch from orbit back to Earth. We started that approach and quite literally were well into that approach although we ended up doing the same thing.

There was some concern on the Hill about our authority to license this activity as a launch. A launch should take place on Earth, for example. Yet, there was still an interest in the FAA having appropriate oversight of this. Somebody needed to look at it and ensure that operations would, in fact, be safe, so we changed gears a bit and decided to oversee this as a payload determination. If you are familiar with our regulations and our statute, we do have authority to issue payload approvals for vehicles that aren't otherwise licensed by another Federal agency.

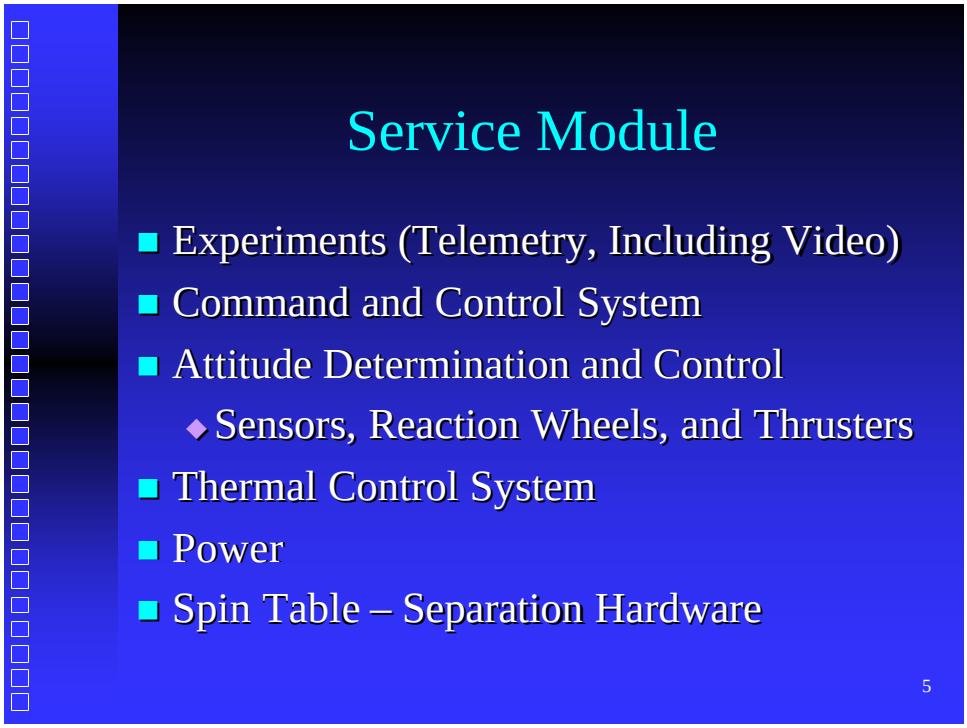
What we did was that our payload approval is really a broad authority to determine whether the launch of an otherwise unlicensed payload, such as a reentry vehicle system, should be prevented because the launch would jeopardize public health and safety, safety of property, foreign policy, and national security interests. Quite literally, what we were looking at, public safety, didn't change. Just the mechanism in which we carried out that oversight changed. This did have an affect to some extent on the operation because licensed activities, licensed launches require the operator to carry insurance to protect against liability claims, including claims made to the U.S. Government or other participants. Under the payload determination that wasn't possible.

Major vehicle systems included the service module. This was the part that stayed on orbit and the reentry module. I should say that the reentry module looked very much like the *Mercury* capsule. Actually, the same entity designed it, Max Faget [Space Industries, Inc. of Houston, Texas]. It was shaped a bit different. The proportions were a bit different, but basically just imagine a *Mercury* reentry capsule, and that is what the reentry module looked like. It was not constructed of the same material, but the shape and size were basically like a capsule. Another major system was the ground control system. There was going to be one, and I will talk a little bit more about each of these systems next.

Starting with the service module, as I mentioned before, it contained experiments as well. Obviously, it had capabilities for command and control. The ground station could and experimenters could uplink commands to their experiments as well as the operator uplinks commands to the vehicle.

One of the major systems that affected public health and safety was the attitude determination and control system. Obviously, this was critical to setting the system up for the reentry process. If attitude way that it was pointing its retro-rocket wasn't absolutely within tolerances, you could miss your landing site by literally hundreds of miles.

There was a thermal control system on board the service module as I recall and primarily to control electronic temperatures and things like that. Obviously, power was an important system, not only to power, to operate the experiments and the basic vehicle operations but also to carry out the operations necessary to set up and carry out the reentry operations. It was a critical system.



There are other systems that I won't discuss. These are the primary systems of interest to this discussion. As you will see in a moment, the reentry vehicle used a solid rocket motor and very much like is done on Delta II's with PAM-D's at a spin table. It spun up the reentry vehicle before releasing it, and the spin stabilized it before separation of the reentry vehicle from the service module. Again, I will talk a little bit more about the role these played in the analyses that we did when we get into our approach.

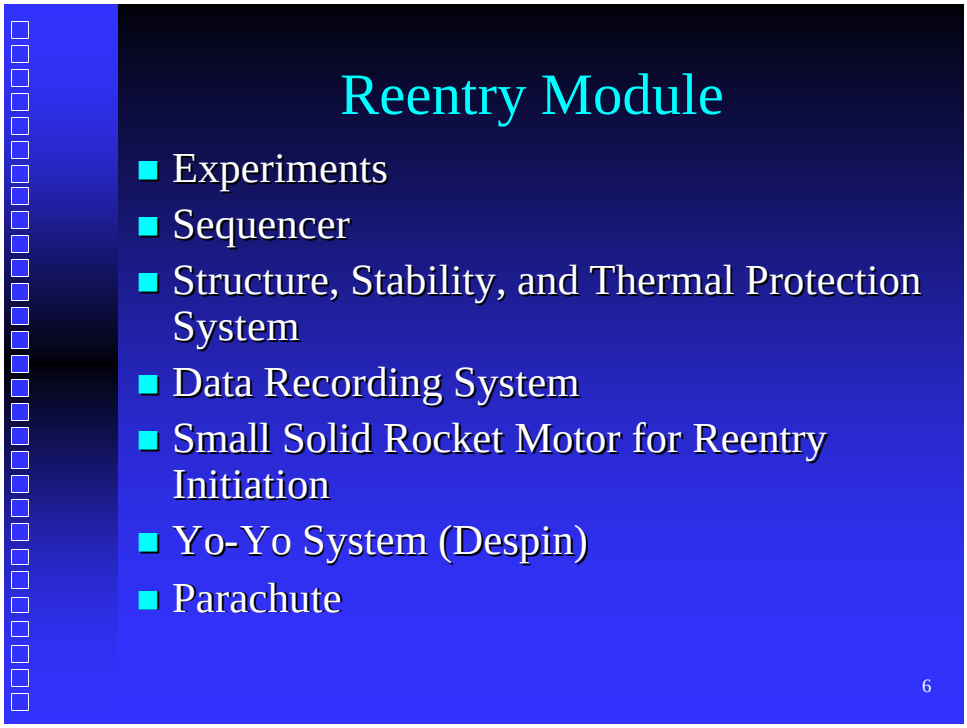
The reentry module obviously -- its purpose was to bring experiments back, so some experiments were located within the reentry module. With respect to size, that entity, the reentry vehicle wasn't very large. It weighed about 730 pounds as I recall when it landed. It was about 3 feet high. At its broadest point, where the heat shield was, the vehicle was about 52 inches across. Imagine a small-sized desk, for example, coming back to Earth.

It had a sequencer on it, which controlled the sequence of certain execution of commands. Obviously, the firing of the motor as an example was controlled by that sequencer.

Another major system is what I will characterize here, or what I have characterized here, is really the structure, the stability issues based upon the structure's shape, the structure's strength. This vehicle as I alluded to was made out of different materials. It was made out of composites with an overlaid thermal protection system on it to ensure that the system would survive reentry. Stability was an important issue in structure, of course, and a very important issue with respect to the capabilities of the vehicle, and its ability to land in the desired location.

There was a data recording system on board, and not a telemetry system per se, but the ability to record certain data useful for the next mission so that they would keep and be able to demonstrate that the gravitational (G) loads that they had attempted to stay within on reentry were achieved. I also suspect that there may have been some data recording of perhaps some of the experiments on the way down. I am not sure, but primarily it was vehicle environment information. The idea was for the data to be recovered then when they recovered the vehicle.

One of the most important systems on the reentry vehicle was the retro-rocket. It was a small Star-13A rocket motor. While people think of these motors as being very reliable, and they are; as reliable as they are, this was another major contributor to dispersion and failure mode.



Some of you may have been following what is at the Contour Mission, which disappeared or ended up in pieces. It is very possible that that had a motor problem on it, I guess. Occasionally, looking back historically, you will note that the motors have failed to ignite on occasions and have had other catastrophic events.

It also had a Yo-Yo or a D-Spin system, sort of a very simple system, but as you know, I discussed that it had a spin table and spin-stabilized it on the way prior to its release from the service module. Once the motor had burned and before it entered the atmosphere, it needed to be D-spun. This was not part of the original concept. In the analyses that had to be carried out, and again I will talk a little bit more on the process, the need for that system had been identified, both by us and I think the good news is by the operator independently, so that was added.

It had always been planned to have a parachute and an airbag kind of system to limit the G-loads when it landed. We treated this system as if it wasn't going to work. That was the simplest thing.

We did an awful lot of research on parachutes. NASA had an extensive balloon, high-altitude balloon program, in which parachutes played a very significant role in recovery and safety, but there were a lot of differences in this situation. NASA could choose when to bring the balloon down or the payload that is on the balloon down. They also could track the descent, using aircraft, and look at what the balloon was over. If it looked like the balloon was going to land in a populated area, they could cut the payload away from the parachute and cause it to land in a field. That wasn't going to be possible with this system, so we felt that it was appropriate from our perspective to treat it as not a critical system and to treat it as if it didn't work.

We are also concerned that a lot of times you will see a parachute coming down, and you are not sure of the winds. When you start running to get out of the way, you run right under the parachute.

Ground operations, this was a very important concept. There was a single ground station. For the first part of the program, it was going to be in Houston, Texas. Later on, I think it was in McLean, Virginia.

A single command and control system, and this was where commands would be sent and received from the vehicle. Also, I believe experimenters could operate there or perhaps even remotely through there, but a single system. This certainly affected the safety of operations issues, and I will talk about that in a few minutes. It served very much the opportunity not only for the operator to send up commands and, in fact, initiate the reentry process but also to do health monitoring.

The status of certain critical systems needed to be within tolerances, and those could be monitored and problems perhaps corrected, if possible. One of the other aspects of this was that this ground station needed to coordinate with the U.S. Space Command, Space Surveillance Center, because knowing where the vehicle was played an important part of the process in the reentry process.

Now, our approach to this was literally to issue a set of regulations specific to the reentry operation and the payload determination. These are termed "regulations of specific applicability." They went out for comment. We got comments only from the operator as I recall. Nothing really tremendous, but we ended up that it was very much a performance-based regulation.

We required that the vehicle have the ability to land in the designated landing site 3 times out of 1000 tries. The rationale for this was to ensure reliable, accurate, and incident-free reentry operations in order to foster public acceptance and to minimize public exposure to risk.

Now, this criterion was later appealed, and I will talk a little bit about that if I have time. There were two other criteria, both very similar to one another. One dealt with the risk to the population within a hundred miles of the launch site, and one that dealt with the risks to the population outside a hundred miles from the launch site.

This may seem familiar to you for those of you who know how we look at expendable launch vehicles and our risk criteria, but it is different, and it is different in a couple of ways. First of all, today we use expected casualty and this says that the probability per mission and on an annual basis -- the probability of casualties within a hundred miles of the launch site should be less than one in a million.

Now, the other difference is one in a million instead of 30 in a million. This is quite a bit more stringent. It says you can't have the probability of having any casualties. One, two, three, four, ten, a hundred -- no mater what, it has to be less than one in a million.

One of the things that we found in this process was that it took a great deal of education. This is jumping ahead to kind of lessons learned, but while I am thinking of it, let me point it out here. The operator of the vehicle and the vehicle designer were required to have quite a bit of education on the part of our office in order to understand how to work with a performance measure.

I mean, this isn't always the case, but in this particular case, my impression was that they would have rather have had specific design specifications. You tell us what the design limits are, and we can build to that requirement. Tell us how it has got to perform and what standards. Oh my goodness, that is a whole layer and a whole new set of expertise that they have to develop in order to make that demonstration. We spent a lot of time working with them, and we worked through it.

Our view, of course, was that it gave far greater flexibility in the process. Now, perhaps I should have gotten into this. No, I shouldn't have. Next slide.

This started off as a very interesting approach. There were different contractors that were awarded parts of this process as a grant. A grant was awarded to an entity to design and build the vehicle. A grant was awarded to an entity to operate the vehicle. I believe obviously that there was a grant awarded to an entity to launch the vehicle, and a grant, I think, was awarded to kind of be responsible for system integration.

It is kind of interesting because my feeling is that in the distant future that kind of model may not be unreasonable, and it calls to mind aircraft and commercial air operation.

That approach, even though it turned out as I recall originally the manufacturer, or designer/manufacturer of the vehicle and the operator of the vehicle, actually ended up being the same awarded entity. Later on when the project restarted, it all became under EER Systems, Inc. and Westinghouse as I recall.

This kind of focused to a large extent some of our approach in a few moments. What we ended up doing then is focusing on the design of the vehicle. All of the analyses on systems, vehicle capabilities, et cetera, and focused on that with the idea that we wanted to understand what the vehicle's capabilities really were.

What is the dispersion footprint that this vehicle was capable of achieving? What are the failure modes? How is it going to fail? In some instances, the failure modes could be mitigated through operations. We noted those and tracked those failure modes and passed them on to the operations side of the review to make sure that the operator was cognizant of those operating limits.

The initial focus and in fact in the development, even though it ended up being the same company, the development very much followed that model too. Let's first focus on the design, and then we will try to figure out how we are going to operate this. Maybe they had some ideas, certainly, but final operational criteria really came into sharp focus once the vehicle design and capabilities were identified. As a result, we divided up our approach into a vehicle safety approval, and an operations review approval, and again I will talk more about that. Obviously, we did not have any specific vehicle requirements, just safety requirements.

We talked about demonstrating the vehicle capabilities and looking at the operations to ensure that they were consistent with the vehicle's capabilities. If the designer in the analysis noted that the vehicle behaved squarely under certain conditions, what they would say was, well, we simply won't operate it under those conditions. Then, we would say, okay, we will buy that, and let's make sure that the operator has that in their criteria for controlling their operation. It worked quite well actually.

We focused on critical systems. One of the first things that we had the company do was a preliminary hazard analysis with some slight variations, and the variation being what are those systems that will affect public health and safety and not the operation of the vehicle. I have just listed here a few of the systems and situations that we ended up focusing on. Obviously, we looked at failure modes and what those failure modes would result in.

Stability was a big issue. Yes, it looked like a *Mercury* capsule, but who knows if it is going to perform like a *Mercury* capsule. After all, the initial concept was to spin this up and reenter it. That would work, I guess, because there wasn't a person on board. It was to be spun up to about 75 rpm, as I recall, but we needed to understand, and we needed to ensure that the designer understood how this vehicle was going to perform.

Stability was very important, and it affects all sorts of things. If the vehicle becomes unstable, the area that is exposed to high thermal loads could be different. That means that interfaces then with your thermal protection system. If it becomes unstable, it also affects the reentry drag and the trajectory, for example. Obviously, the attitude determination and control system was a very critical system.

That system was designed to operate within some very fine specifications. We were interested in not only the analytical demonstration that it would perform within that performance limit but also that tests showed that it would perform within that performance limit.

The motor I discussed a few moments ago, and the motor presented some problems as well, in addition to while it was very reliable, how it affects the performance measure of probability of the casualty, and the like. Also, the variance if you will in the total specific -- well, the thrust or the ultimate thrust and Delta V that is presented when the motor fires. That variance was a bit too much for the designer to tolerate. They made attempts to reduce that, and I think they did a fairly good job by getting the manufacturer to agree to some special processing of that motor. They basically, as I recall, included some additional fine calibration and weighing of the vehicle to identify exactly how much propellant was really there.

Dispersion, of course, is affected by all of these aspects. We ended up doing analyses, and they did analyses several different ways. They went through and looked at the contribution to down range and cross-range error based upon the performance of each of the systems that affected the reentry and then attempted to identify that through sum of the mean squares process.

They also did it using the Monte Carlo trajectory projections. We did the same thing in addition. Obviously, as I pointed out before, some of the system's performance actually affected other systems.

The nature and type of stability affects drag and trajectory. It also affects heat loads. Those interrelations had to be looked at by the manufacturer. In addition, we had to make sure that they were all considered and addressed.

Just a simple story on that one was that they, the manufacturers, were going to an ablative material that they could apply. Obviously, the material, the thickest part of the material, was on the heat shield, but it did extend around and up the neck, if you will, of the vehicle. The thickness, of course, was varied by how much was needed in order to keep the structural temperature within tolerances.

They had very well thought out what that was. We were very much on board with them in terms of the analyses that they have done and of the testing that had been done by the vendor who supplied the material on the materials capabilities, but the question lingered: If you are going to apply this [ablative material], how are you going to know that you have applied it to the necessary thickness or more in each location? As a result, they had to go back and devise a way to ensure that they had exceeded the thickness amounts that were the minimum amounts that they used in their thermal analysis.

Another story is the stability and the spin issue. Stability is kind of a very difficult thing to address in an analytical way. It becomes much more of an art than a science in many respects. Yes, you can go and use wind tunnels, but even at the high reentry velocities, you still have some uncertainties. They knew that they had to do this type of analysis.

We were concerned because of the fact that it is more an art than a science in many respects, so we had two independent stability analyses done on our own, using different approaches. One was very much a parametric approach. Actually, it was done, I believe, by an individual from Princeton, who had been involved in supporting NASA on the *Mercury* and *Gemini* programs. Another one we did using a CFD [computational fluid dynamics] and finite element analysis approach. We went off and did both of these, and both parties on our side didn't talk to one another.

In the meantime, we had the operator, who was the manufacturer, doing theirs. Well, we finished ours first and became aware that both our independent analyses showed that there was a procession of the vehicle as it entered the atmosphere, which would cause it to cone and go down.

We remained silent on that and waited for the company to come back with their analysis. As I recall, several weeks passed, and we still had not heard from them. More time passed, and we still had not heard from them. Pretty soon they came to us and said, well, we are not done with that yet because we have to do some redesign. We are going to have to put a Yo-Yo system on it.

Right away, click! Great, because we had seen the same issue. That raised a whole slew of problems as I alluded to earlier in terms of heat loads on the side and drag forces, and trajectory would be all off. I am also sure it wouldn't meet the microgravity experiment tolerances that they had needed to meet; therefore, we did quite a bit of independent analysis like that on our own.

One of the things that we were heavily involved in as well is as I mentioned; of course, typically you get involved in these. In the early stages, there is a lot of analysis. Companies are trying to pick components. They are also trying to confirm their original design concept and make sure that everything is going to work well.

Later on when they have actually made commitments on hardware, you get into testing, and testing is very, very important. I mean, we were at all of the major tests: the thermal vacuum test, shake-and-bake kind of test, bread board tests of the attitude determination and control system, integrated tests, et cetera.

One of the things that we found with this company that gave us concern was that the company didn't like to do test procedure plans. They were operating on a shoe shoestring, I guess. Their engineers, system engineers, would say, well, we are going to do the test, and we are going to put it on here, and they pretty much knew what the tolerances needed to be. However, there were no pre-developed test plans that showed exactly what the past-fail criteria were going to be. No test procedures were well laid out that we could review in advance.

That happened, and that [lack of written test plans and procedures] gave us quite a bit of pause and made it even more important for us to be at the test, so we could observe exactly what was tested, how it was tested, and what the result was. Then, we would go back and draw our conclusions from that material and other approaches. I would have expected to see test plans in advance and look at them.

The concern was, of course, that they could do a test, and we could go back and say, well, you didn't test everything, or your test showed X to us, and we believe that it showed Y to you. You know, that is debatable. If you have test plans up front, it can avoid problems of having to go back and retest. It won't entirely eliminate that, but it can certainly mitigate the likelihood of it. That wasn't done here.

Now, the operations review. I kind of described how they relate to one another. Really, here again our focus was the system safety process and what are the critical operations. Do we care if somebody's experiment messes up? Only if it messes up in a way that adversely affects the ability of the vehicle to perform its reentry operation.

We did look at those by the way, just to assure ourselves that there wasn't anything that was going to be on board that could affect some of the other critical systems. Here in terms of critical operations, that was an important element, and we will talk a little bit more about that. That involved everything from ensuring that when they checked the health of certain systems, such as the battery, available power, operation of the command and control system, and operation of the attitude determination and control system, that those systems were, in fact, checked. They were checked and verified to be functioning, and they were checked over time to ensure that they remained within their performance tolerance as well as the actual reentry procedures themselves.

One of the things that became important to us was, for example, the process. They only had the ability to communicate with this vehicle on a certain period when they had signal, while it was passing near their command and control center. That meant that perhaps even on some orbits they weren't able to communicate with it at all. How this was all orchestrated with respect to initiating reentry was very important to us, and we focused a lot on that. I will say a little bit more about that when I talk about the coordination with the U.S. Space Command.

Landing site size. You know, just like an aircraft, you can build an aircraft, but it can conceivably try to land any number of places. This was kind of fortunate to us by the way. Remember that I told you that they moved the landing site. Well, our initial focus was on the vehicle capabilities, so when they moved the landing site, it wasn't a great deal to us. All we needed to know was if the new landing site was within the capabilities of the vehicle.

It did affect our risk analysis. Obviously, the population around the landing site in the second instance was different from the population around the landing site in the first instance, but we characterized the landing site as part of the operations side.

Casualty probability analysis. I mentioned that we had to do quite a bit of education of the company on how to go about doing risk analysis and how to take their vehicle performance and translate it into what it means with respect to risk analysis. Also, [we educated them on] how to look at the failure modes and treat them with respect to a risk analysis. Speaking of failure modes, I am kind of jumping back a little bit. As I recall, the capabilities of the system in our estimation was that if there was about a 0.972 or a little over a 97-percent chance that the vehicle if it reentered would reenter nominally. By that, I mean it would reenter with all of the systems functioning within their normal design performance ranges. That meant that there was an almost 3-percent chance that it wouldn't.

The major contributors to that almost 3 percent were the D-spin system if one of the Yo-Yo's didn't release after it had spun down. That was considered to be fairly unlikely, less than 1 percent. Structure, and of course that included a thermal protection system. Because if there were a problem with that elimination or something of that type that could affect structure, but structure primarily about 1 percent. And the motor, now you would look at a motor like a Star-13 and say that it has 99-percent reliability, and that is pretty darn good, but that 1 percent really was a big deal in this operation. In fact to some extent, I think it certainly caused these three elements that I just summarized and certainly caused them to not be able to demonstrate that the vehicle would land 3 times out of 1000 in the designated landing site.

However, they met the other two criteria. The company did, I think, a very conservative estimate. We did our own again, naturally. The results of which were fairly close. We believe that both analyses were conservative in the following ways:

- They assumed that the vehicle was going to land outside the landing site and outside the normal dispersion. In other words, they assumed that it was going to have a malfunction of one of those systems. They ended up with a casualty expectation of about 5 times 10 to the minus -- I'm sorry, a casualty expectation of, yes, a little over 5 times 10 to the minus 7.
- We looked at it, and ended up with a casualty expectation of about 7 times to the minus 8.

Obviously, ours was lower. While we still thought ours was conservative, ours wasn't quite as conservative as theirs, but it points out an interesting element here. They made some assumptions in their analysis, which were perfectly fine. They felt that it was easier to accept some conservative assumptions because they already knew that they were going to be able to meet those criteria. Why spend a lot of time and money doing a more refined analysis, particularly when you are landing in the ocean, and you don't have a lot of downrange people, ships, and aircraft?

Up range, some of the failure might expose part of Virginia, so what they assumed was that they were going to land in Virginia a hundred percent of the time. That's how they got the number, and the number still showed that they met the criteria. Obviously, they didn't believe that that was the way that it was going to be, but they made that demonstration.

One of the major elements again of dispersion was where you are starting from; you know, where you are going to land is driven by where you start. Even if you have a perfect system, you are pointing in exactly the proper direction. Your motor fires with a total specific impulse that you believe that it had. The vehicle performs perfectly. It behaves exactly like your analysis shows it is going to perform, and everything is just like following a railway track right down to Earth.

Now, imagine if you start from a different point, you are going to end up at a different point, so the question was how accurately are you going to know where you are when that motor fires. Well, that was a good question. All along they were very much dependent on, in their minds, having the ability to get the orbital ephemeris -- you know, the vector status, state vectors, from Space Command.

The Space Command didn't know who these people were, and they were very concerned about how you give these people this material. I mean, what in the world are they going to do with it? What if we give it to them, and we make a mistake and transpose two numbers? We don't want to do this.

Well, you know, part of our role is facilitation, and we played that role with respect to Space Command. We introduced ourselves. Then, we went several times and met with senior individuals out at Space Command and talked about the importance of being able to achieve something like this. We assured them that we were looking at it, but we also needed their help over and above just getting them to agree to track this vehicle and provide the information to the operator. We asked them, well, how accurate are you? What is your [margin for] error? It is kind of important. I mentioned the railway track, and it was a little more complicated than that.

What we did early on in the process, we did a sensitivity analysis just so we made sure that we understood what were the important elements that we needed to really focus on here. You know, if you have a certain cross-track error that is going to translate into a certain cross-track error where you impact down range. If you have a certain long track error, remember that you are moving at 17,500 miles an hour, and a little bit of error in where you are, or knowing the velocity of the vehicle at that point along its -- or parallel to its orbital track -- you can move pretty far in just a short distance or a short period of time. Excuse me.

The other fact though was the biggest contributor to error was altitude. In fact, what we found was that, in general, there appeared to be about a factor of 10. If you are off one-tenth of a kilometer in where you believe the vehicle is versus where it is when you impact, you will impact up or down range 10 times that or 1 kilometer.

After talking to Space Command, we got them to agree, and by the way, we used a team approach here. I will talk a little bit more about that later. We had a contractor who was on our team who worked with us, and this contractor had a very good relationship with Space Command. In fact, it had a contract with Space Command at the time. We talked Space Command into finding an object up there in the rough orbit that this vehicle would be put in, about a 250 nautical mile orbit as I recall, and have them do a study, and bring up as many resources as we could get them to agree to bring up, and track that vehicle. Of course, the

more resources that you bring up, the longer you track it, and the more data that you have within reason, you can begin to see how your accuracy improves.

One of the other things that we got them to do or that we did as part of this analysis is the degradation of the accuracy of the information that you have after you reach epoch. That is the point in time in which you are saying, okay, I have gathered all this information, and this is the vehicle state vector, and this is the orbit its in. These are the error tolerances I have at that point in time when I did my measurements and my analyses. Now, they go away, and that uncertainty grows as a function of time. If you want to predict where that vehicle is 1 hour later, you are no longer as accurate as you were at epoch. Two hours later, you are less accurate, and 3 hours later, and on and on.

The reason that was important is, remember, this vehicle was under constant command and control. The operation as it worked out was that obviously they were always monitoring vehicle health. Two orbits before the motor fired, they would check help, and they would update the sequence and the commands that would be followed for the reentry, so a clock, an on-board clock, was started. The computer had the commands in it, and it was going to carry out certain commands, subject to being enabled. On the next orbital pass that they had, and obviously this requires two consecutive passes in which they have communication with the vehicle, we brought in Sat Track [a satellite tracking software program] here by the way so that we could simulate where the vehicle was based upon this information throughout the 30-day period just for show and tell.

On the next pass, they had the opportunity within the time that they had signal to verify again that all of the systems were performing properly. At this point, they would upload the enable command. The enable command would now say, okay, this is it, and it would go. So they had about a 3-hour period then, or more, from when the measurements of uncertainty associated with the tracking -- and by the way, the U.S. Space Command was going to support them by bringing up again as many assets as they could.

There was a lot of support on Space Command's part on this effort. By the way, when they did that study or when they did those measurements for us earlier, we actually went through and wrote a report. We agreed not to release it and gave them a copy.

I think that was -- I have to believe that while they may have other assets that they can use for tracking this was something that provided them information that they had not had before. Of course, they used many different assets. You know, regular radar, phase-to-phase radar, radar that tells you very accurately when someone crosses a gate. All of those types of resources were, in fact, used as part of this process.

The next thing, of course, or part of that process was getting them the information to upload. We had all sorts of issues with respect to the -- they didn't have a fax machine at -- well, I guess they didn't have e-mail either at the time.

They didn't have a fax machine in the rocks. Somehow or another they had to go to another room somewhere to fax the material. There were procedures to ensure that the numbers were cross-checked and verified before they were, in fact, uploaded because it was extremely important and critical in the process.

I have kind of described some of the reentry procedures. I won't go into a lot of detail, but one of the operation issues that became very important to us -- and one of the ones that happened at the end -- naturally was crew training.

This was really originally going to be a brand new command and control center that they were building in Houston. This center would be PC-based with a set of commands and software to process the commands, the software to verify in certain instances the logic of certain commands and the sequence of commands, and a number of people who all played a role in that process, including the one person who was responsible for actually uploading or sending the commands up to the service module. Clearly, the use of the equipment and the training of the people were of utmost importance to us.

We brought in Aerospace Corporation to provide us with what they felt were criteria for assessing a control center and its capabilities, including the team that ran it or operated it.

We also were fortunate enough to take advantage of the Clementine mission. That was a low-budget, shoe-string type mission back when faster, better, cheaper was at its high point, I guess, and in many respects a very successful mission. They had much the same kind of approach, and in fact I am not even sure they may have ended up using the same control -- command and control center that they used at Clementine. I don't know that for sure. Do you know, Carol? [Audience member, Carole Flores indicates, no.] Okay.

You know, we didn't have standards out there for performance. We had some guides and things that we were looking at and interested in that we had Aerospace put together for us, but we were very interested in rehearsals. This is where we could see if they were really going to do and they understood all of those procedures, particularly the ones that said that they shall not if.

I think at this point the company was EER, and they went out and started running their rehearsals. I think they had two or three planned at most, and we had a team made up of a couple of different contractors who actually went out and monitored their rehearsals. The fact that the operator very quickly realized that they were going to need, on their own need, more than two or three rehearsals was heartening to us. Because if they hadn't realized that on their own, we would have had to tell them that because we had [reached] the same conclusion. I don't know how many were ultimately done, but it was like five or seven or more. Ultimately, they really got the process down. They got Space Command, I think, into supporting the rehearsal, but it was a learning process. Just like this whole thing was a learning process to us, it was a major learning process to the operator and to the people who worked on the vehicles and designed the vehicles.

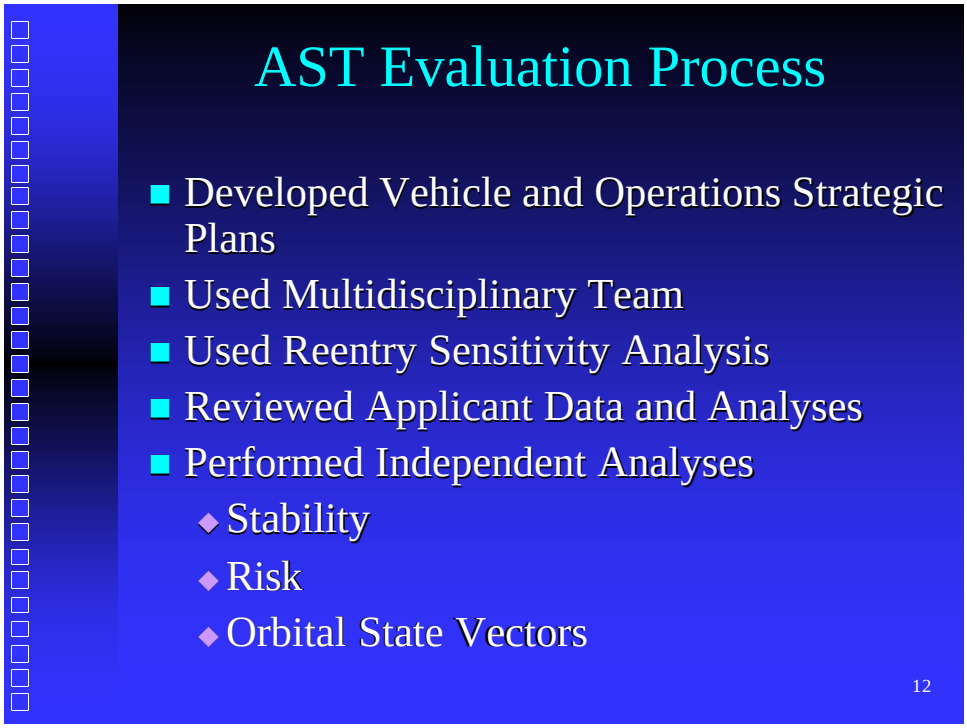
Now, the evaluation process. I have sort of hinted and talked about some of this as I have gone along. We were very careful in how we wanted to put this process together and how we wanted it to work from our end as well as the applicant's end. In that regard, we put together two plans or strategic plans, literally: one for the vehicle safety assessment and one for the operations review approval. The plans clearly reflected the fact that we expected to see an evolutionary kind of approach on getting data and information.

As I alluded to earlier, first the identification of systems was of major import to us. The fact that each of those systems was likely to undergo analysis in terms of performance, how those systems needed to be designed, what components would be used, and how they ultimately would perform, et cetera, et cetera. That was as I have alluded to earlier a natural process on the part of the manufacturer and designer in selecting components to a large extent on which ones that the applicant or the designer was going to select. In that process, they kind of, in their mind, created a dispersion budget, a variance budget if you will, where they would allocate certain performance capability arranged to certain systems. The engineer responsible for that was ostensibly to develop a design and select components that would meet that specification.

As I said, sometimes plans change. The Yo-Yo system was a good example of that, but our strategic plan sort of laid out that natural evolution of the process. It grew over time. The idea is that as we got more information on systems, we had people on our end, teams literally on our end, who had primary responsibility for the various systems.

Let me just run over with you some of the outside support that we used.

- Kaman Sciences was the entity who brought to the table a lot of orbital dynamic expertise. They were the ones who worked on, for example, the Space Command accuracy information. They did things like the attitude determination and control system and that kind of stuff as I recall.
- Futron and Aerospace Corporation of El Segundo, California, very much focused on operations.
- ICF Incorporated of Fairfax, Virginia, literally was primarily our own integrator and, in essence, to ensure that our documentation was flowing properly. We had processes in place for exchanging information, tracking data, and ensuring that something was not happening over in this area that another area needed to be informed about. They participated in that regard. Of course, we had team meetings at least weekly as I recall throughout the process to exchange information as well as meetings with the applicant weekly. This was over and above engineer to engineer exchanges that went on during a daily basis.



- Research Triangle Institute (RTI) did a lot of work in the systems area for us, for example, motors, stability, thermal electronics, and command and control kind of issues.

In summary, we had multiple people in-house who were responsible for certain areas. They worked with their respective teams, with their counterparts either on the operations side or the vehicle side throughout that process.

One of the other things that we did, of course, was each of those teams was responsible for initial reviews and for the identification of deficiencies. When deficiencies were identified, they had to be cleared through the division manager and the team lead before they were passed back. The reason for this was we were very cognizant of the fact that we did not want to place any more burdens on the applicant than were absolutely necessary. We wanted to ensure that perhaps an easy thing was that, well, perhaps you should do it this way. When that engineer on our side said you should do it this way, that might have been a suggestion in his mind but a requirement on the applicant's mind. It may have been a very perfectly good suggestion, but we wanted to make sure that the lines were drawn.

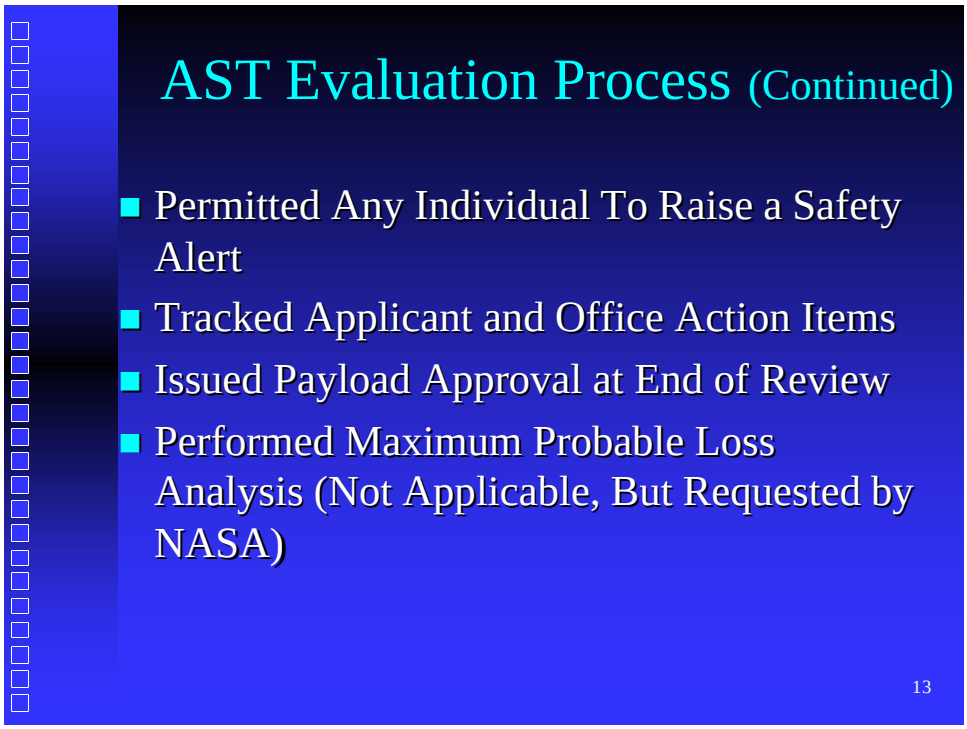
We were reviewing what they were proposing. We would tell them if it didn't meet ultimately the safety requirement. They wanted to have an attitude determination and control system that had a pointing accuracy of 1-1/2 degrees. That was their call, but ultimately that caused the dispersion to be so large that it violated one of the performance criteria. Then, they had the responsibility to tell them.

I have talked about the independent analyses that we did, and I talked about the stability one. We also did the risk analyses several times, and I have already talked about the orbital safe vector issues. That one was a bit different because we asked the applicant what the accuracy was, and they made a guess. We obviously had no basis upon which to know whether that guess was accurate or not, and we found out obviously that the Space Command wasn't able to tell us whether it was accurate or not when we went into the study.

We did the study, and as a result of the study, we went back to the applicant and said that these are the numbers that you can use. We didn't make them do an independent study on that. It was a bit different because it was a government to government kind of relationship, and we were quite concerned that we had that relationship both with us and Space Command. The Space Command had a good relationship with the operator as well, so that is how we handled that.

Let's talk a little bit about some of the unique things, or maybe not so unique, but some of the special things that we did in addition to the process I just kind of laid out for you. We had a rule. Anyone who was on

any team could raise any question or any concern that they felt they had. They could raise it, and it would come up and be evaluated by the senior management and then passed, if appropriate. Then the question would be passed on to the applicant as a concern.



We did do that several times. The idea was that just because you were kind of focusing over on this area, you could certainly raise issues there. If you heard anything, saw anything, felt that there was a problem that was not being addressed, and you weren't satisfied, you had the ability and the authority to put it down in writing and submit it up the chain. In fact, it was encouraged.

One of the biggest tasks, of course, was pulling everything together, particularly as we were nearing the final stretch; the final stretch being maybe the last year since this process actually started in 1992. The launch occurred in October of 1995. Even accounting for the hiatus, the last year I would call the final stretch. Throughout that period, we were very interested in trying to understand what the timetable was on the part of the applicant in addressing each of the systems and each of the things that they were to do. We would get them to submit us a schedule, and we would track it. During our meetings, we would say, are you still on schedule with this, and on schedule with this, and on schedule with this? No, we're not, they sometimes replied.

Now, it wasn't that we wanted to force them to remain on schedule. What we wanted to do was -- we wanted to know when things were expected to come here because this was a big operation. I forget, but we spent -- in the end, I think we calculated that we spent several million dollars of contract money on this, not counting in-house resources.

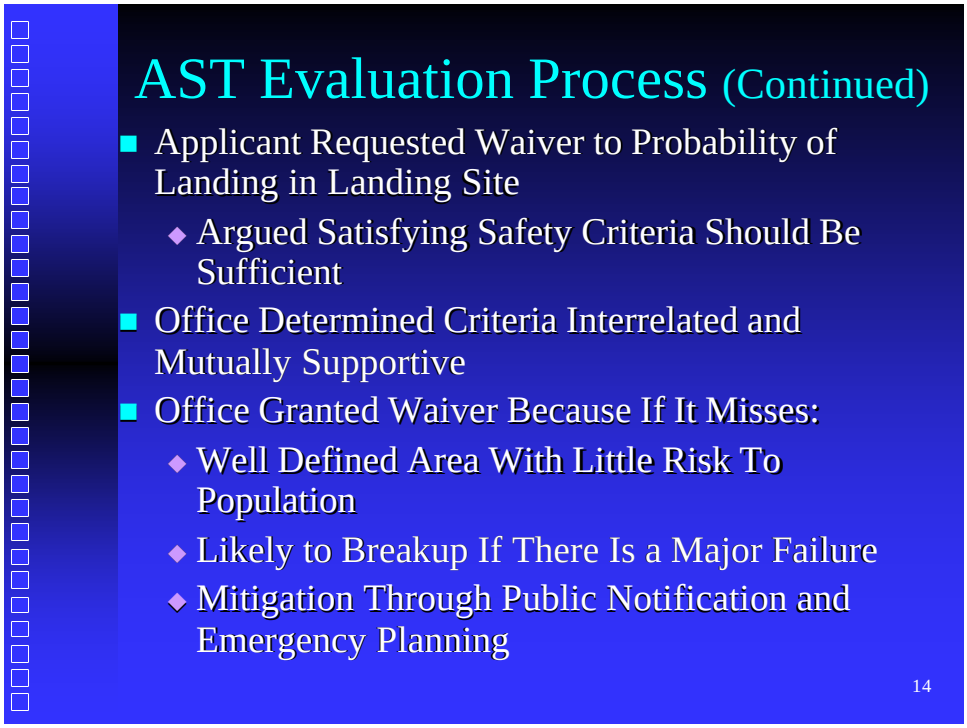
They could do that to us if they submitted something, and we thought that we could get feedback to them in 2 weeks, and that was tracked during our joint meeting. Where is your review?, they could ask. Then, we would have to answer. I think we did a very good job in meeting our responsibilities and providing a timely response back.

The balance there was that we wanted to understand what their schedule was and when we were going to or could expect to get certain information but not necessarily put them in a position where they were -- that they felt that they had to get us the information by that date. There was one hook, however, and as we got down to the final stretch, they had to understand that there was an implication. If they didn't get that information in, that implication was the completion of our review and an approval or a determination as to whether they were going to be able to fly or not. Let's say in the last 6 months or so, that certainly was on

everybody's mind, particularly the applicant's mind. We made it very clear through our tracking that if they were a week late on something, our determination would very likely move out a week.

They had to coordinate. They had a launch date set up, and they had EER and Conestoga getting ready, and all of that, so it was quite important. I think in many respects the fact that we were really the major element that they had to look to and satisfy, in that regard, it worked very well. I think that in some instances where a company is trying to do a lot of things and satisfy a lot of different people at the same time, sometimes things slip. The focus is on other things important to the company rather than getting us data. In this particular case, I think it worked very well in that regard. This process resulted in the issuance -- and I actually have a date. The determination to approve launch of this payload was issued in August of 1995, and the launch occurred in October of 1995. I'm sorry, but I'm just about out of time.

There was an appeal. They weren't able to meet the first criterion, and they requested a waiver. They argued that satisfying the safety criteria should be sufficient. Even if they were not able to land 3 times out of 1000 on the landing site, as long as they met the other two criteria that should be sufficient.



We disagreed with that specific argument. We felt that they were interrelated, particularly if you had a very small vehicle with very little risk or a very large vehicle that had a lot of risk. At the time, we felt that it was important that generally that criterion be met. However, we also recognized that the risks were extremely small, and they were well below the criteria in the other two. We felt that they were able to define a well-defined area with little risk to the population even if the vehicle modes failure modes occurred. We looked at that, but we also felt that we wanted something more if we were to issue an approval waiver on criterion 1, the 3 in 1000. They needed to inform the public and have emergency response plans, so that was the basis upon which we granted that waiver.

Lessons learned. The systems safety process worked real well, I think, and at least supported it, and followed the focus of critical safety systems in operations. It did provide for significant design flexibility. They could decide where they wanted to put emphasis on certain systems. I pointed out that we felt that some applicants sort of wanted more specific requirements, and this one at the beginning probably did. We would have liked to have had things a bit different. Notice the tendency to place little emphasis on planning for tests. I think that was something that we would need to emphasize in the future.

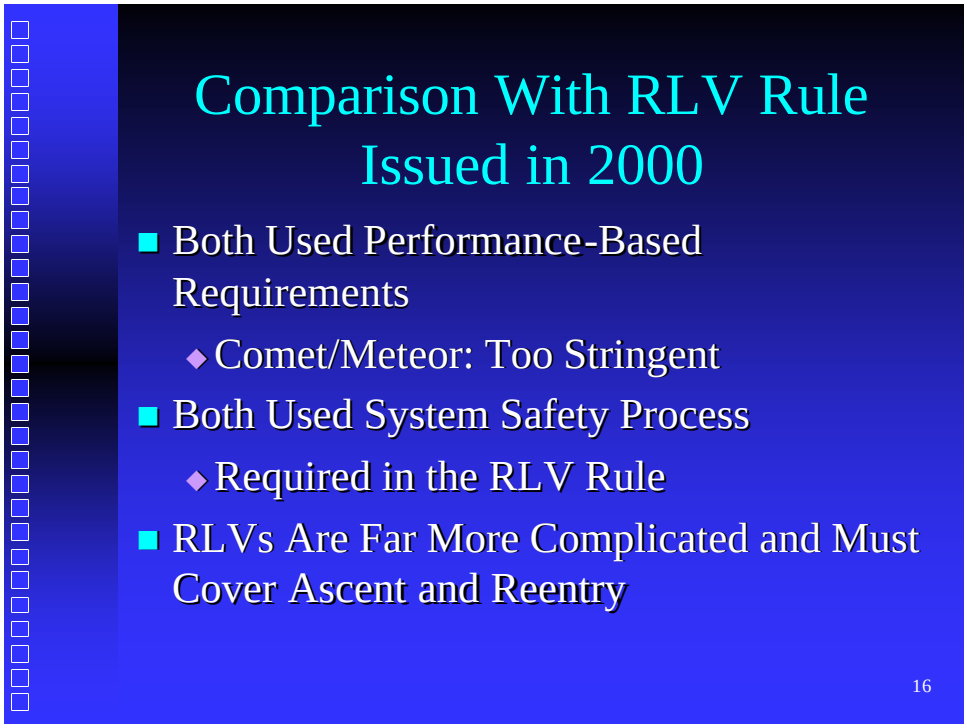
Now, I'll just do a comparison with the Reusable Launch Vehicle Rule. Both use performance-based requirements. As a result of the post-assessment that we did, we felt that maybe our requirements that we imposed on COMET/METEOR were more stringent than were absolutely necessary. Remember, any casualty with a probability of one in a million. This was during a period where it was becoming evident that the ranges were using 30 in a million in expected casualty.

At the same time, we kind of had this feeling that this is the first, and we need to show that this is going to get a lot of scrutiny. Maybe there were some things that we might miss, so to be at that level was appropriate, but in the future, we looked at that and made some changes.

Reusable launch vehicles are far more complicated than this thing was, far more complicated -- a point and shoot system, a handful of critical systems compared to another type of vehicle. Let's say like almost any of the other ones I can think of, whether it is Kissler, Pioneer Rocketplane, Solvang, or what have you.

In summary, I appreciate your time. I don't know if we have time for a few questions, if anybody has one, but I just would like to point out that the next lecture will be on insurance requirements and maximum probable loss on September 13th, the same place, the same time. Any questions? Yes, Pat. I noticed that nobody interrupted me, so I was probably talking too fast.

AUDIENCE MEMBER, PATRICK HOAR: You mentioned Yo-Yo systems to prevent procession of the reentry vehicle. Could you quickly describe that?



MR. GRESS: Well, the Yo-Yo system is really just a set of cables that wrap around the vehicle with weight on the end. When it is deployed, an explosive volt releases it. The spinning of the vehicle causes the cables to fly out, and that changes the physics and causes the vehicle to slow down. When it gets slower, the attachments are such that the cables just slip off the attachment, fall away, reenter on their own, and, of course, burn up. I think the weights were lead. It is quite a reliable system, but it wasn't the Yo-Yo that had to do with the procession. It was the D-spin, which caused the spinning of the vehicle as it was reentering, which caused a link between the vehicle's performance, and it would process, and the D-spinning had stopped that process.

Okay. Anything else? Is that it?

UNIDENTIFIED AUDIENCE MEMBER: Ron, I don't know if you mentioned this, but the time from the initiation of the application to when we issued the license, how long did that take?

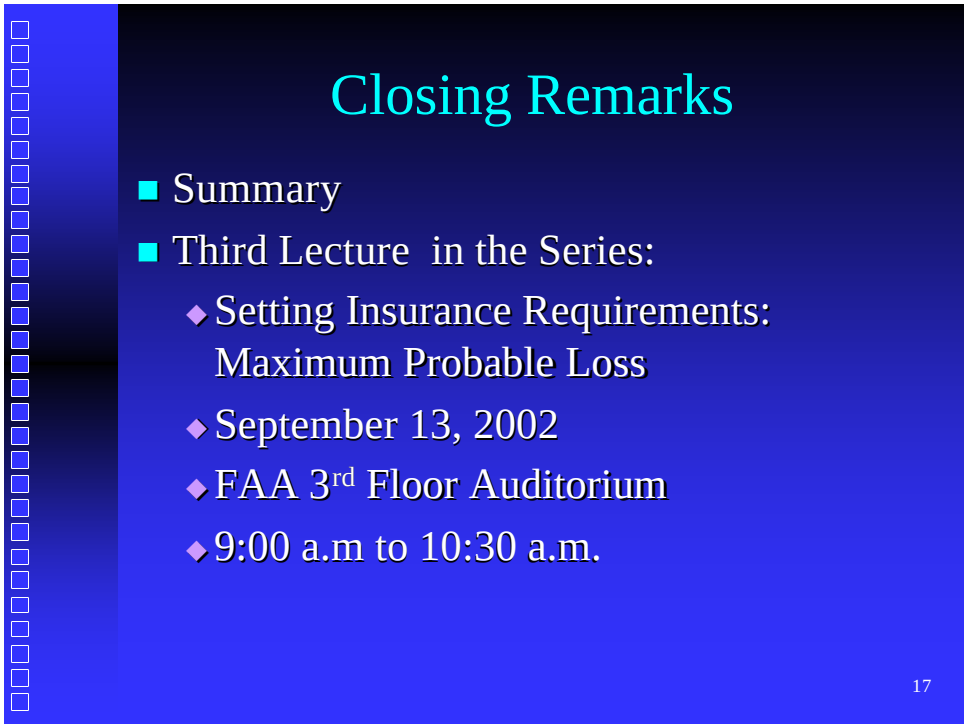
MR. GRESS: Well, from memory, it is a little difficult. As I said, it started in 1992, and the vehicle was launched in 1995. If I am not mistaken, there was probably a year hiatus roughly. There was little learning because the company that started the vehicle design didn't want any part of it anymore. Actually, the company literally sold the vehicle and the data as well as all of the information and analyses that it submitted to us to the EER, who was then going to be the operator. There was a learning curve that had to come back up. My guess is at least a couple of years through the process, and it was going on in parallel with their development and design. It wasn't like they had to do everything and they come to us. That would have been bad, bad, bad.

UNIDENTIFIED AUDIENCE MEMBER: Payload approval was issued in August of '95. Was that separate?

MR. GRESS: In '95, yes.

UNIDENTIFIED AUDIENCE MEMBER: Separate from the launch license?

MR. GRESS: Yes, it was. Well, let me rephrase that. It was a separate analysis, but the payload determination is one of the elements of the mission review -- and Esta [Rosenberg] is going to catch me if I say anything wrong -- of the part of the launch license. The launch license was issued earlier, but it, in fact, was predicated on receiving a favorable payload determination, so it was a condition of the license.



UNIDENTIFIED AUDIENCE MEMBER: What was the reason for moving the landing site from land to a water landing site?

MR. GRESS: Good question. NASA was more heavily involved. Originally, this came out of a NASA grant to a university. The University of Tennessee, but don't hold me to that, I think, was -- Lou Ullianis saying yes.

They ran out of money, and the politicians got involved and appropriated some money to NASA to make this project start up again. This time, NASA was going to be the customer directly, and NASA felt that they wanted to move it to the ocean, okay?

By the way, we did do a maximum probable loss analysis. I think that my slide may show that we did it at the request of NASA, but I am not sure that is correct. I think we did it maybe at the request of EER. It had no bearing on requirements because this wasn't part of the launch itself. The payload determination doesn't have that associated with it, but I think if I remember correctly, we had no government property insurance in the end because there was no government property exposed to the reentry process. We had like a $15 million maximum probable loss value that we came up with. I don't really recall that NASA necessarily used those numbers, in fact, but we did do that analysis. Okay.

UNIDENTIFIED AUDIENCE MEMBER: The casualty last figure that you approved on, 1 to 10 to the minus 6, is considerably less than what we go on now, 13 to 10 to the minus 6. I just wanted wondered how we drifted up into this higher number, and if you could comment on that.

MR. GRESS: Well, I think I said that at that point in time there were a number of reasons. First of all, what we originally had identified was we did not want the public exposed to any greater than background risk.

We did some research on that and felt that one in a million was as good a number as any and certainly supportable at a level of background risk. The other thing that I want to remind you of is that the criterion was the probability of any casualty should not exceed one in a million.

Expected casualty is a somewhat different number. Although when you get into very, very, very low expected casualties, they very much equate to the probability of any casualty to a large extent.

All I can say is that that is the background that we originally started from. I can also tell you that the story is that the Air Force reached its 30 in a million criterion sort of predicated on what not wanting to expose the public in the area to any greater risk than it is exposed by aircraft flying over. They decided that is 30 in a million, and so it sort of became practice, and that's how come they were different.

Again, I would point out that initially our concern was very much that this was going to be the first time that something was going to be landing in the United States, and we felt that we wanted a very conservative number. Even if we did the best job that we possibly could, there is always a chance that we might have overlooked something.

UNIDENTIFIED AUDIENCE MEMBER: Ron, I would like to -- as of one of the few sole survivors of the program, I would like to make a couple of comments. One is for the audience's appreciation. This was an aggressive attempt by a bunch of small, scrappy, little outfits to do something that in our opinion other larger and more established aerospace corporations wouldn't have dared or didn't want to dare to do.

And we are kind of proud, as many of the entrepreneurial types that we support today, they are proud to be small and scrappy. While we didn't understand everything that was happening at OCST [DOT, Office of Commercial Space Transportation] at the time, we did recognize that it was major ground-breaking work inside the regulatory arena, and that it was going to be hard. At the same time, we recognized that we were being supported by a small, scrappy team of regulators. All during the years, we sort of felt very comfortable that we were going to work this out ultimately.

It was very important to us. I mean, it was a huge contribution, and I want to express my appreciation years after the fact for the leadership that you provided, Ron, and for creating this “can do” environment that actually resulted in a successful payload determination. Thank you.

MR. GRESS: Well, thank you, and I would like to echo your characterization of the people involved on the applicant's side. I very much agree with that. I think they are a model of the kind of people that you are very likely to be involved in initially, whether it is X-Prize or something else. You know, they want to do it right.

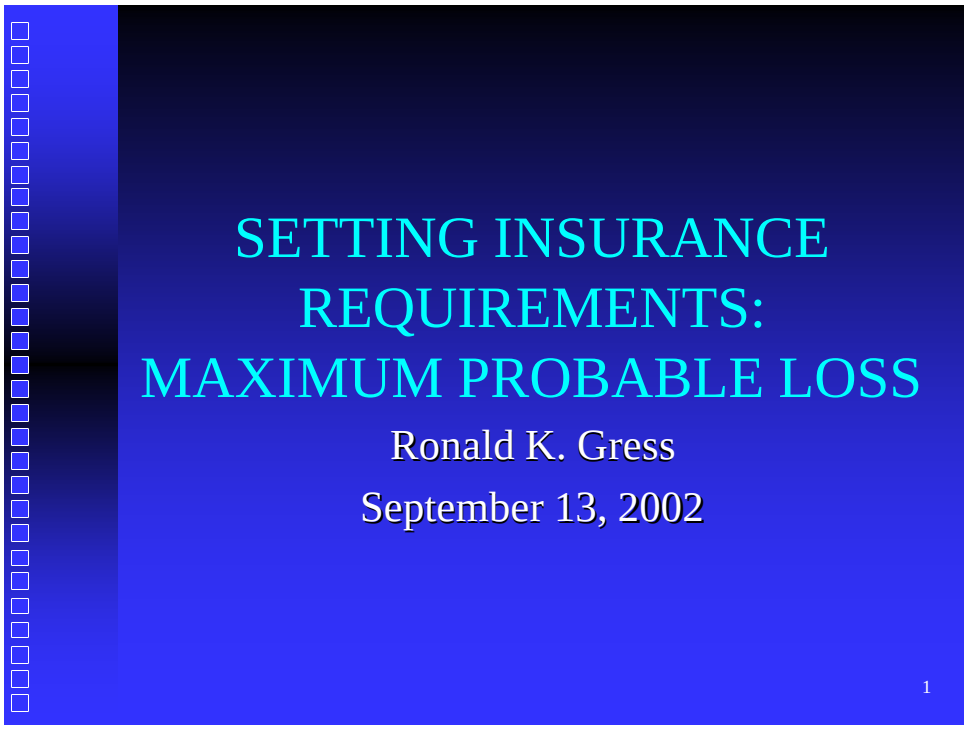
Money and time were certainly on their mind, but they had as much interest in succeeding at this and at being safe that I think as we did. I think the whole office at the time probably had 14 people in it, and that is the whole office.

We very much needed the support that we got through our contract. I think a lot of that is different now. We probably go about doing a lot more in-house with respect to that, but I think there were still things -- there were leading experts that we went to out there to really get a reading, if you will, in certain areas. I suspect that will be necessary in the future, especially if there is that much on the line, both with respect to the company and with respect to the FAA in the office.

Well, if there aren't any other questions, I thank you for your time. I am sorry for running over. I appreciate your attention, and I look forward to seeing you on September 13th. Have a good day.

(Whereupon, the lecture 2 was concluded.)

LECTURE 3. SETTING INSURANCE REQUIREMENTS: MAXIMUM PROBABLE LOSS



OPENING REMARKS

MS. CAMILLA MCARTHUR: Welcome to the 2002 Commercial Space Transportation series, hosted by the Associate Administrator for Commercial Space Transportation. We are also referred to as AST. These lectures provide us with an opportunity to share information about AST's role in regulating and helping develop a safe, technologically advanced commercial space transportation industry for the nation.

Our speaker is Mr. Ronald K. Gress, and he's the manager of AST's Licensing and Safety Division. He has over 15 years of hands-on experience with commercial launch and launch site safety issues in such areas as licensing, insurance requirements, safety inspections, investigations, and enforcement. This expertise is supported by over 30 years in analysis and risk assessments involving weapons systems, computer systems, and federal regulatory issues and requirements.

In today's lecture, Mr. Gress will discuss the safety issues associated with establishing insurance requirements for commercial space transportation vehicles, using the maximum probable loss approach. This lecture also focuses on vehicle launch and reentry operations. Mr. Gress will be retiring in October, and the lectures provide us an opportunity to capture some of his knowledge before he leaves us, in this highly dynamic field.

The lectures are designed to promote a lively exchange of ideas, and we encourage you to ask questions and share your insights or comments. We are videotaping the lectures. To ensure that your question gets on tape, please raise your hand, and there are people in the room who will bring you a microphone. Now, ladies and gentlemen, please help me welcome Mr. Ronald K. Gress.

PRESENTATION

MR. RONALD K. GRESS: Thank you Camilla. As Camilla said, we try to make this very informal. In the tradition of the last couple of lectures, we'll continue that, but I'm going to warn you. This time I may ask you questions. This morning's discussion involves maximum probable loss and our responsibilities for setting insurance requirements. I'm going to talk a little bit about why there is a financial responsibility requirement and discuss the roles, concerns, and considerations of stakeholders that are involved in and affected by the process.

We'll talk about the characteristics of this term "maximum probable loss." Then, we'll discuss a little bit about some of the other considerations that fall into this issue and perhaps even some of the changes that may be taking place in the future, both resulting from technology changes as well as from changes, perhaps, in the legislation.

Why financial responsibility? Well, perhaps one of the major reasons is that the United States is a party to a couple of United Nations treaties. Now, you'll note the dates on these treaties. By the way, the latest one was 1972.

If you think back in the era of 1972, you'll imagine what? There were two countries involved in putting payloads into space, conducting major launch operations. In spite of that, the Outer Space Treaty passed in 1967 noted that there was international responsibility for national actions, including non-government entities. One might hypothesize from that [treaty] that even at that point in time there might be somebody else, other than the governments of the United States or the former Soviet Union, conducting launches from those countries, or perhaps even other countries, in that era.

Following that, the liability convention set certain standards or criteria with respect to liability. For example, a launch conducted by a launching state would -- that state or states would be strictly liable for any damage or loss that would occur on Earth or in the air.

What that meant was it didn't matter if it was somebody else's fault, or somebody else was implicated in it, let's say another country. I mean, things that come to mind are a ship enters an exclusion area, or an area -- to be more precise -- an area in which a NOTAM (Notice to Airmen) has been issued warning of the risks or hazards. Let's say an aircraft was damaged in the air off the coast of Spain. Even though there may

have been notices and control actions implemented to attempt to keep aircraft out of the particular area, the launching state or states would be strictly liable. It does not matter that somebody else screwed up.

Why do I say, "state or states"? Because if you go back to the treaties, there can be several entities who might be involved as a launching state. Obviously the country from which the launch took place, who owned the territory [would be considered a launching state]. Another might be the country or entity which procured the launch, and there could be several other entities as well.

Let me see if I can think of another example. It could be, for example, if a launch took place from Australia that the U.S. licensed, and the launch was for, let's say, the Netherlands. Conceivably, you might have three launching states. Of course, all of this would be hashed out in court at some point when liability claims were submitted.

We all know what tends to happen when there may be several defendants, I'll use that term, that are cited by somebody or some entity that is affected. The one with the deep pockets is the one that's likely to pay the most.

There was another reason in my opinion that financial responsibility became an important part of the Commercial Space Launch Act after it was amended, and that was that we, even today, hear about assured access to space. Now, most commercial launches take place from federal launch sites, federally operated launch sites, and use federal facilities that are critical to supporting government launches. Having insurance in place to cover potential launches to these facilities precluded the need for that entity to have to go to Congress, for example, to get a supplemental appropriation to replace or repair the facility or in a situation where time is critical to reprogram existing funds, and take it away from another high-priority program that that government entity may, in fact, be pursuing. One thought here is that it provided reasonably quick replacement funds to fund replacement of the facility. It's also important to know when a commercial user is using the facility.

What happens when a government user is using the facility? Told you I'd ask some questions. Anybody?

UNIDENTIFIED AUDIENCE MEMBER: They self-insure.

MR. GRESS: Yes, they self-insure, so in essence, the kinds of things that I just talked about -- they're willing to accept potential delay, potential need to reprogram funds if something should happen. They self-

insure. The argument for that is over time self-insurance is probably cheaper on the whole, but that's where we are. We have this program, and it accomplishes those two tasks.

I touched on this a moment ago when I talked about liability. When we require financial responsibility, in most cases carried out through the obtaining of insurance, the U.S. as a participant is potentially liable and is covered in the insurance coverage that we require the launch operator or the licensee to get. In this case, the launch operator gets the insurance.

If there are liability claims, the claims may go against any or all of the participants, including the U.S. government, and the U.S. government does not have to pay the premiums for the covered insurance. You, in essence, have the U.S. government protected by the insurance procured by the licensee at least up to the point of the value of the insurance, and we'll talk a little bit more about that. How is this different from issues and the way things were done prior to the Commercial Space Launch Act and more importantly prior to the amendments of the act in 1988, which bolstered and made significant changes and additions to financial responsibility requirements?

I think I mentioned in one of the previous lectures that there had been over 200 commercial launches prior to this time, and they were all conducted primarily by NASA. When it was conducting a launch with a payload for a commercial or private entity, NASA would, in fact, require that that entity buy insurance. The requirement at the time was basically to procure $500 million of insurance. If they couldn't get $500 million worth of insurance, that's like a half a billion dollars, NASA would require the maximum available at a reasonable cost.

In this era, there was a concern on the part of the industry whether insurance capacity was going to be sufficient. There was in part, I think, a belief that insurance should be risk-based, not based upon all you could buy for what you could afford. If you think about it a little bit, the natural extension of that kind of thinking would mean that the first person to buy insurance should buy until the cost of the next dollar becomes unreasonable. The next person in line who wants to have insurance coverage at the same point and time by definition would not be able to buy a dollar of insurance at a reasonable cost.

Now, that's just my Economics 101. Things don't always work that way, but there was a concern about insurance capacity. I'm not sure that that issue really is as critical today. I'll talk a little bit more about some studies that have been done and things that have been looked at in that arena later.

I mentioned how insurance was handled by NASA. I mentioned or alluded to the fact that in 1988 the financial responsibility regime, if you will, was added to the statute 49 U.S.C. Subtitle 9, Chapter 71. (That'll become a mantra for all of you new people.)

This office had already had the responsibility to set some type of insurance requirement. This office had already determined at that point and time that it was going to be based upon risk rather than the most you could buy at a reasonable cost.

We had been working with Conatec, who was a licensee. I think I mentioned them in the first lecture I gave. We had done some risk analyses and had pretty much concluded what insurance amount would be appropriate for the operations they were conducting. As I alluded to before, that company, while it got a license, never conducted a launch. Before that launch even took place, the amendments came out.

The amendments adopted a lot of the philosophy, if you will, that our office had been considering up to that point. Obviously, the major emphasis was a risk-based approach to setting insurance. They stated in the statute that risk should be based upon maximum probable loss, and they established some ceilings. Five hundred million -- you can imagine where $500 million came from -- $500 million for third party liability and $100 million for government property. That's kind of important here. Why would they even be talking about government property?

Well, I talked to you earlier about the concerns of replacement of government property. Launch operations were taking place from federal facilities. Clearly, it was envisioned that those launches, commercial launches from federal facilities, would require a license and that there should be insurance in place. As I understand it, the $100 million was really derived by input directly from the entities, such as the Air Force and DOD, who, when asked how much would cover most everything, the answer was $100 million.

I want to point out that this office bears certain responsibilities of reporting to Congress if there are situations in which we determine that the maximum probable loss value for a particular situation exceeds those ceilings. Nevertheless, if we determine that the true maximum probable loss, let's say for third parties, is $550 million, we are obligated to set it at $500 million at this point.

The other aspect of this is indemnification, and I've listed on the chart here really the third party part. It's often referred to as "so-called indemnification." What does indemnification mean? In this case, it means that if losses exceed the maximum probable loss value, i.e., the value that the licensee has been made to get insurance up to, there's a possibility of indemnification by the government for any claims that exceed that amount.

The reason for this at the time was it was a new industry -- new in the sense of new commercial industry. Launches conducted prior [to this time] by many of the U.S. companies, with the exception of those 200 some odd launches that I referred to earlier, were really conducted by the government. The government would hold these companies harmless, in essence, for any losses that might occur in their carrying out actions for the government.

There was a concern by the industry that they were going to bet the company. If there could be significant claims, the company could literally go bankrupt.

The reason it's called, with respect to third party liability, so-called indemnification is that the act requires that any payments in excess of the insurance requirement maximum probable loss are subject to appropriations of Congress. We all know that Congress may on a case-by-case basis decide to appropriate or not appropriate. If they decide not to appropriate the funds, then the liability falls back on the company.

Probably the even more significant, in my mind, indemnification provision isn't so-called, it's indemnification. It is that the government agrees not to seek claims for any losses to government property that exceed the maximum probable loss value. Period. It'll be interesting, and I'll cover later some of the government property maximum probable loss values that we have made determinations on, but I think that's significant.

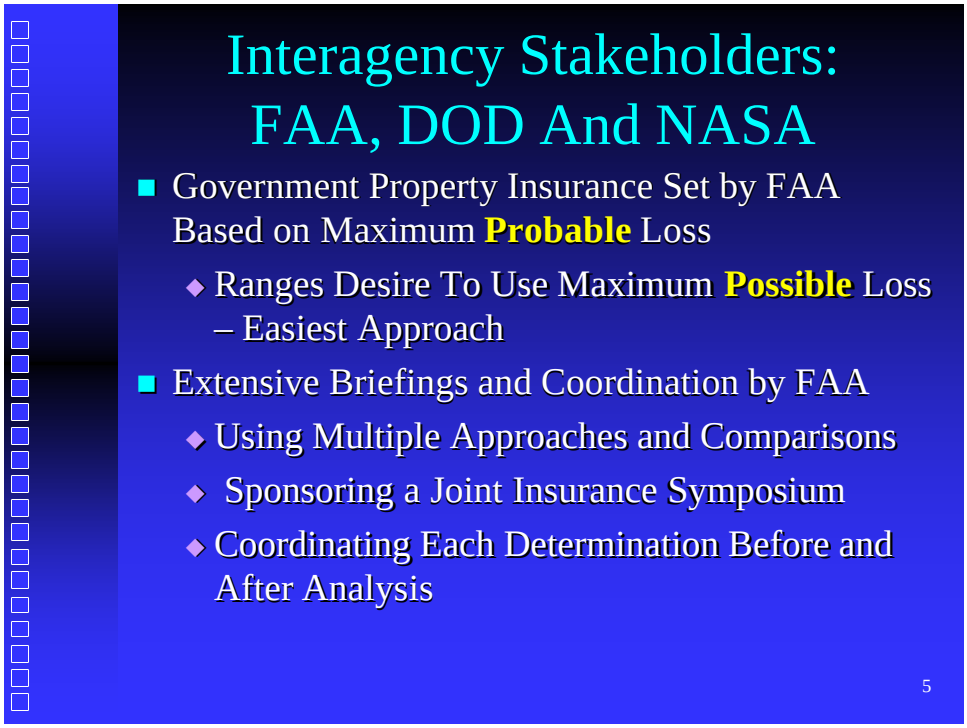
Finally, there was a cross waiver provision between the licensee, the customer, and the government. Basically, the idea here is these are three major parties. They all have contractors and subcontractors and sub-subcontractors, perhaps, and each of these parties must enter into an agreement where they, in essence, agree not to seek claims against the other party.

I'll read you what the statute actually says. I'm going to take some liberties and leave some words out for clarity, but this is basically it.

> A launch license issued shall contain a provision requiring the licensee to make reciprocal waiver of claims with its contractors, sub-contractors and its customers, and contractors and sub-contractors of the customer involved in launch services under which each party to the waiver agrees to be responsible for property and damage or loss it sustains, or for personal injury to or death of or property damage or loss sustained by its own employees resulting from an activity carried out under this [license].

The rationale here, really, is that, I believe, there was a recognition that there can be a great deal of litigation involved here. One area where you can eliminate or reduce the amount of litigation is to make it very clear: You're all in this boat. You each are responsible for your own losses, irrespective of how they may have derived. There's one case, by the way, that I am familiar with where this issue came up, and that had to do with one of the Martin Marietta launches, in which the Intelsat satellite failed to separate from the second stage.

Now, I'll talk a little bit about some of the interagency stakeholders from the perspective of the government entities. Yes?



UNIDENTIFIED AUDIENCE MEMBER: Hi. Is the $500 million cap on third party liability still in effect?

MR. GRESS: Yes.

UNIDENTIFIED AUDIENCE MEMBER: Just one comment. I'm surprised. That seems like a really low number to me because commercial airliners, prior to a year ago, routinely carried one and a half billion third party liability. Even the little Regionals carry half a billion.

MR. GRESS: Okay, that's a good point. Now, remember that airliners are carrying passengers. Remember that we have cross waiver agreements, so we're not concerned, necessarily, with the loss of the payload, which could be several hundred million dollars. We're not concerned with the loss of the launch operation, which could be well in excess of $100 million in and of itself. We're concerned with third parties, and third parties are those who aren't involved in the licensed activity.

In a moment, I'll cover what some of the maximum probable loss values have been. We can look at those in light of the ceiling and see how things are doing, but those are some differences that I think may come to mind.

Jumping ahead a little bit as well is that AST was directed by Congress to prepare a study of the liability regime associated with launch activities and to address certain questions. One of the questions that we were to address, actually it was sort of focused from the perspective of reusable launch vehicles that might carry people -- I think it might still be of interest to you, was whether the airline industry, the airline requirements, the Warsaw agreements and the like, how applicable they might be to, at some point, be used as a model in the future for changes to the regime.

That study by the way is available on our website, http://ast.faa.gov. One of the things that I've kind of emphasized here is that government property insurance as well as third party insurance is to be set and based upon maximum probable loss.

That's interesting, you know. What is probable? Many years ago we went and looked around to see if there was a definition of that term, and it so happens that the *Glossary of Insurance and Risk Management Terms* -- I don't know how old this edition is, it's probably somewhere in the `80s, because that's when we were using it -- actually has a definition for maximum probable loss. Its definition is that maximum probable loss is the largest expected loss of a risk under normal circumstances.

Well, it doesn't say a whole lot, and there were some other things that sort of drove us to how we defined it in our process and ultimately in our regulation. Now at that point, we were looking at setting insurance. You may recall that we had in mind doing something that was risk-based. We hadn't heard the term "maximum probable" yet, but we really did have an understanding that, generally, the higher the losses or potential losses, the lower the risk of those losses.

There comes a point where you need to spend some money to cover the next highest increment of potential loss, perhaps, even though that next increment might be reasonably inexpensive. Where does it end?

We determined that we were going to base it upon risk, and there needs to be an end. In looking at some of the issues, we looked at the ranges. The ranges had very little idea on how to approach this, but there were some that were proposed.

Some ideas included, well, what we really ought to do is do maximum possible loss. After all, we want to ensure that anything that can happen will be covered.

My goodness, why don't we just add up all the value of the property on the range, and make that the insurance requirement. Why wouldn't that be a good idea?

AUDIENCE MEMBER, PHILIP BRINKMAN: Because it's impossible to destroy all the property on the range at the same time.

MR. GRESS: Phil Brinkman said it's impossible to destroy all the property on the range. I assume at the same time, with the same event, the same launch, so right there; yes, it's easy to do, certainly. You need an inventory. You go to the engineering office on the range, and you get all the numbers, and you simply add them all up, and you do it. Yes, maybe you can back off on that a little bit. You don't add up everything. You add up everything within the launch danger area, for example, or you add up everything within a given distance of the launch pad. Again, you still have the problem that it's very unlikely, if not impossible actually to, in fact, destroy all the property on the range within any given distance of the launch site.

Therefore, we initiated a series of briefings, a series of coordinations with the other stakeholders. We talked a little bit about our thoughts on risk-based. We actually attempted to do a number of comparisons.

Now, let's put this in context. We went so far as to attempt to get major airline, or airplane, aircraft accidents in the United States that occurred in-flight over metropolitan areas and find out how many people on the ground would be uninvolved. They would not be participants to the operation. What were the damages or fatalities, for example, to those individuals?

Just looking at given an event, given a crash, how many fatalities were there on the ground? Usually, there were one or two. I think the average by the way, given an event, given a crash, was a little over two and about the one in a million was something over four.

We also were working at that time on hazard analysis of launch operations. This was published in 1987, I believe. I didn't bring a copy with me, but it looked at those issues among other things. It looked at the safety procedures. It also looked at aircraft and other types of transportation modes. What kind of damage could occur? What kind of energy is available for causing property loss and injury and fatalities to the public in those?

We looked at large-body, wide-body aircraft. Interesting to know, while the energy is released in a much different way, that a 747 [airplane], if I recall, has the same amount of energy and propellants as something akin to a large Atlas or a Titan. Those were the comparisons we made at the time.

We also looked at other types of accidents that actually occurred -- rail cars where propane tank cars blew up, gasoline stations or trucks exploding -- to get an idea of what the effects would be. We compared these findings to what we were looking at in a risk-based approach and sort of put them in contrast or in comparison to one another.

At the same time or in that era, we also sponsored an insurance symposium. Jointly sponsored with the Air Force and DOT, it was held down at the Cape. The major invitees were all of the underwriters and people interested in commercial launch activity. It primarily focused on insurance issues and was intended to educate the insurance industry and underwriters in terms of how and what is done in terms of the oversight and safety issues associated with launch operations.

We had Lou Ullian from the -- well at the time it was 65 55th, but at Cape Canaveral, there. We had, I believe, people from NASA, obviously our office, and others make presentations. It was at least a full day if not a day and a half as I recall. We produced a lot of products out of that symposium. We generated a lot of products for that symposium as well.

You have to think that this was kind of a touchy and sensitive issue for the ranges. After all, what was happening is the ranges owned this property. Yet some other government agency was, in essence, "taking care" or ensuring that the facilities that were put at risk by operations would, in fact, be covered by insurance. They didn't have, necessarily, the ability to do that. They weren't going to be doing it. It was the role of DOT; however, we were very careful about coordinating and bringing the ranges along in this process.

Among the things that I have already talked about, as we went through a process, we began to share our thoughts, going way back to Conatec. We also began to look at the Deltas, Atlases, Titans at that time, do similar types of analyses, and share them with all levels within DOD, from the Office of the Secretary of the Air Force for Space all the way down to the Safety Office at the ranges.

The process kind of continued on. We actually get a lot of the data to do the analyses from the range. We also require certain data from the launch operator, a lot of the input. You know, what's the value of the facility? The property? How many people might be exposed to the operations who are government employees or government contractors? You'll understand why in a little bit. That's important.

Then, we perform the analysis, and before we issue a determination on that, we share that as a draft to ensure that we haven't misrepresented any of the information that the range has given to us. We give the range an opportunity, or the Department of Defense or NASA an opportunity, to point out where there may be errors in the analysis.

Only after we get that feedback, generally, do we issue the determination. There have been a couple of exceptions to that where we have gotten agreement that we needed to issue the result and the requirement now. However if the range or the government entity hadn't completed their review as yet, and that review necessitated a change in the value, we would make the amendment at that point.

In the majority of cases, that amendment would occur before there were any operations that would begin at the time anyway. However, it's our intent and desire in the future to always have these analyses completed and everything in place at the time we issue the license. These analyses are based upon replacement cost, and that's an interesting concept. It isn't based upon, "Gee, it's a 10-year-old facility, and the facility's gotten a little bit run down; therefore, we're going to depreciate it." It is based upon the replacement cost. Now that's a two-edged sword because it's the replacement cost of the function that it's performing.

[A] good example would be the shuttle complex at Vandenberg. We actually issued a license for launches from that complex. Lockheed Martin's Athena launches took place from there.

Actually, there were a whole number of interesting issues that came out of that which I think were of interest. One was that this complex was built to support the shuttle but was never used for it. In fact, it probably still is the most expensive launch complex ever constructed in the United States. It was supported not only to launch the shuttle but also to support Air Force black programs, so there's payload processing associated with that that involved very critical security issues. The construction of the facility and support facilities in the area, of course, were designed to withstand serious incidents associated with the launch of the shuttle.

Yet, we now had some expendable launch vehicles taking place from there, very small ones. If something should happen, should that facility be built, replaced, or repaired to the standard that it was originally designed for or to the standard it was currently being used for, which certainly didn't require a lot of those additional expenses? Coordinating with DOD we determined that no, it should be for the function for which it is currently being used.

There were some other nuances associated with that. There were facilities in the area that the Air Force had for a long period of time mothballed. Their operations and maintenance budget had minimum values for maintaining those facilities and keeping them from further deteriorating, but even at some point, that funding was stopped. The facilities really became a scavenger yard. I mean, they would pull cable out of the facility. They'd pull piping out of the facility.

In those instances, the facility no longer had any value, basically, to the government, so we chose to make that consideration. In fact, sort of jokingly, we argued that some of those kinds of facilities that were exposed, actually, if something happened to them, the government should pay the launch operator for the demolition that it did.

Those discussions all went very well and give you an idea of the kind of two-edged sword. We're out there looking to ensure that we're reasonable, and we're not charging or making requirements in excess of what is necessary.

All the amounts that we have set for government property and for third party liability are available on our website. I found it kind of hard to find, just by going into the website and trying to find it. It takes a little time, so I've listed here the actual address of the list of determinations that we've made.

I'll give some examples in a little bit on some of those values. The process has not only been accepted by the ranges, I would say, but I would also note that they've been accepted by the licensees.

In a few instances, we've had a licensee come back and say, "Why is our insurance this value?" While this has been very rare, we've been happy to explain.

In one instance I can think of, the licensee chose to make a change in its operations. It was going to perform certain hazardous operations in one government facility on the range that unfortunately was a very high-value facility. The potential losses there were higher, and they could do the operation just as well at another, lower cost facility. They chose to make that change.

In another instance, I think perhaps more recently, a lot of the data comes from the licensee. During the flight portion of the launch, certain data, like break-up data, becomes very critical to setting insurance requirements. In some instances, there's an interest in that data, certainly, for flight safety issues. That data's also obviously important for insurance determination and maximum probable loss issues. There have been times where that data has been put together in a fairly conservative way to justify flight safety issues. Also, there have been times where that data may not necessarily be the best data to be used for insurance determinations. We can expect in the future, I think, where some companies may come back and do some refinement of their break-up data, for example, due to that.

I talked a little bit about the recent congressional study on the liability risk-sharing regime for U.S. commercial space transportation. That [study] is available on the website. I think one of my final slides actually gives the website address.

I'm not going to spend a lot of time talking about that study, but the study was generally focused on looking at the current regime, answering a series of questions, addressing a series of issues. For example, it looked at the aviation industry model. It also looked at the issue of spaceports and basically determined that there are other options, alternative ways of designing or creating a regime to accomplish certain things. Each of those [options] has certain strengths and weaknesses, and those are all summarized in the report. One of the things it did determine, however, was that the current regime is adequate and appropriate to accomplish most of the goals associated with this.

I think a major concern isn't necessarily betting the company as well. One of the things I omitted and didn't talk about when I talked about rationale for financial responsibility was international competitiveness and how other countries address the same sorts of issues. Most cases, they have a set of requirements and benefits that are similar to what we offer or, in fact in some instances, exceed the benefits that are offered under the current financial regime. Particularly at this time, the comparison and issues associated with competitiveness, let's say, between the U.S. industry, China, or Arianespace are all very important.

The study looked at spaceports, as I said. One of the issues there is that financial responsibility really is focused on launch and reentry operations and licensees that are conducting those operations. It is not focused on the operation of a spaceport. There are a couple of reasons for that. One is, of course, that if a spaceport, a commercial launch site, for example, is supporting a launch, it really is a party to the operation contracting with the launch licensee. Therefore, it is subject to cross waivers, subject to being a participant, and subject to the benefits against claims that the insurance is supposed to cover.

However when there isn't a launch licensee on the facility and there is that nexus between the launch operator and the launch site as a contractor, the type of operations that take place there are viewed as not being ones which would otherwise warrant some type of special coverage. I just wanted to summarize very briefly that the study goes into a lot of other areas, but those are the ones that I thought would be of most interest.

Maximum probable loss considerations for third parties. One of the things I didn't talk about earlier is as we look back, we actually attempted to find out historically, you know, the U.S. has been conducting rocket launches of vehicles since right after World War II. Actually before that, but if you get to Goddard and others, major rocket launches started to occur right after World War II, out of White Sands at first.

What kind of accidents occurred, and what were the losses? What historically have third party losses really been? Well, what have they been, and how can we find out?

One of the things we found out very quickly is there's no place you can go to find that information. We spent quite a bit of time talking to people. People who were around at that time, it's all in their head. Yes, there might have been files, reports, and other things written up, but those long ago disappeared or are buried in some filing cabinet somewhere.

We talked to people like Lou Ullian. We talked to people who not only had first-hand experience but also had concerns and issues at the time about accidents that had occurred.

One of the things you find is, of course, a third party accident is pretty rare. There really haven't been a whole lot. There have been accidents, certainly. There have been accidents that involved the participants in launches. Yes, there have been some accidents that involved third parties. At the time we looked at this, we weren't able to uncover in total -- this was in the 1988 or '89 time frame -- we weren't able to uncover more than $10 million total if you added up everything we found.

That's from 1945, let's say, to 1988, and perhaps the biggest one is the fabled -- and by the way, I don't have any data on this, really. I mean, this was basically just talking. It was the fabled cow in Cuba.

When the U.S. decided that they wanted to do a launch from the Cape, a southerly launch, there was a problem. Part of the vehicle fell in Cuba, and there was a $3 million cow -- must have been quite a cow. That was the settlement; at least, that is rumored. Finding documentation for all this was next to impossible, so we had a problem. What is probable? We had a problem on expectation. What did Congress expect this to mean? How did this compare to what NASA had been doing?

All of these issues are kind of important because yes, we had the ability. We were given the authority and the responsibility to come up with something. We needed to come up with something, and I'm sure whatever we came up with was going to be looked at from those kinds of perspectives.

We looked around the launch area and the kind of risks that people are exposed to -- and by "around the launch area" -- people like in Port Canaveral, people in Cocoa Beach, people in Lompoc, for example.

One of the things we looked at is what the standards were in terms of risk that had been in place. Of course, we all know, or many of us know that the expendable launch vehicles safety-wise, the focus hasn't been much on the motors, the vehicle itself. Most of the safety concentration involving the vehicle itself is

involved in the flight termination system. There are some pretty strict goals associated with that system that have been in place for many years.

That involves the on-board system as well as the ground support part of that system. On the airborne system, it's supposed to be designed; the intent is to achieve a 0.999 reliability at the 95-percent confidence level.

The ground part of the system is supposed to have the same level of reliability. Assuming both of those systems each have that level of reliability as a standard, the system as a whole would have 0.998 reliability. That's pretty good; maybe not as good as a 777 [airplane], certainly, but that's pretty good. Is that achieved? Well, it's kind of hard to say, but it seems to be.

Remember, I said it was a goal. Also, we've talked a little bit, I think, in the past, about how one can prove that you've got that reliability. Yes, you can do analyses. Generally, it's pretty easy to design a system with today's technology that the design level would meet that level of reliability.

Problem is, does it really? And the U.S. government and the Air Force and DOD that overlaid those requirements? A series of testing requirements associated with components and the system as a whole, but still, looking back, can we really say that that reliability has been achieved?

It's difficult to say because requirements have changed over the years. In other words, the systems that have flown in the `50s aren't designed to the same requirements and standards necessarily in terms of testing and other things because there have been lessons learned as those that are flying today as an example, but let's assume that they all are. Okay, what does the data show? Well, the data shows that at best we appear to be very close to that level of reliability, just going back and looking at it empirically.

Unfortunately, here again, it becomes an issue of, you notice I said again "appear"? It appears because there isn't a lot of data out there that necessarily people are aware of or know with respect to the functioning of these systems.

If something goes wrong, sometimes it's better not to know that, I guess. I'm not accusing anybody, but it is a sensitive system.

I can tell you that there have been several malfunctions of systems in the 15 years I've been in this office. In some instances, what that meant was that the system simply wouldn't have worked if it were needed, at least during some phase of the flight. I don't mean that a component or a redundant track failed, but the system would still work. I mean that the system simply would not have worked during a certain phase of flight had it been needed. Surprisingly, most of these involved the ground part of the system, operational errors, equipment errors, or a combination. I think this is something that we need to learn more about; we need to watch carefully.

How to "cost" potential casualty claims. That's interesting. That was another issue. You know, I've talked a lot about government property and the value of property, the replacement cost of property. That's all well and good. That's in some respects if you have a lot of data on the property, that's pretty straightforward. Yes, you may need models to give you an assessment of what the extent of the damage would be to property, but it's strictly an engineering problem. Those are relatively easy to solve and have been at least in that context.

Now, you start talking about people. What's a casualty? A casualty is an injury or a fatality. Well, what value do we place on that? Well, we place $3 million, and a lot of that was based upon looking at things like the value of life.

Looking at things that have been placed on life in other industries. There's another approach where you look at willingness to pay. If you are an employer and you have, let's say, some hazardous work that needs to be done, what kind of premium or excess do you pay for that?

Steel workers, who work on skyscrapers, is an example that comes to mind, but there are many others. Perhaps, in my opinion, the most appropriate way to look at this is court cases. Why? Because now we're talking about how much money comes across, and really, they involve liability claims. Unfortunately a lot of the things never get to court. They're settled out of court. There are restrictions on releasing what the settlement is, so that's made it hard.

The Department of Transportation has done studies on several occasions and addressed many of these issues. At the time we set $3 million, I think they were something about two.

For perhaps different reasons, the value of life you place when you're doing an economic analysis on potential regulation. One distinction here is that so far I've talked about value of life, but remember, we're talking about casualties.

Casualties being injuries and fatalities. There's been a recent study that Phil Brinkman has, and I think it was also brought to light by one of our contractors -- Futron, which, again, looked at the value of life and actually has some more data on the cost of injuries.

Injuries as I recall from the study tend to be considerably less than a fatality. I think an important point here is that they vary widely. You can imagine a certain injury that, in fact, may result over a lifetime in more pay-out than a fatality, for example. A lot depends upon the particular circumstances associated with the claim. My point here is that if one were to plot a histogram of claims, it wouldn't have a very large sigma.

This situation presents kind of an issue for us. One that we have not addressed in a regulatory manner but on a case-by-case basis in how we set insurance is that if we do an analysis, and the analysis shows one or two potential casualties at our threshold level -- we'll talk some more about that -- we tend to look at a minimum value. Why? Because you're never sure whether the claim will be at that higher end of the spectrum. Unfortunately, one could approach this in a very statistical and analytical way and address that. However, I don't think that we necessarily have the data to address those kinds of issues at that time or the fidelity of the data.

I'll talk a little bit about how to cost property claims. It has been a problem for us, for third parties, and I'll talk a little bit more about that in a minute.

I have to move on a bit more quickly here. [I] talked a little bit about considerations for government property. Government property is always exposed. If the pad is owned by the government as it has been in the past -- but not for EELV (evolved expendable launch vehicles), Atlas V, or Delta IV -- you always have exposure. After all, they're in the business to support this operation. That's what they do.

As vehicles get larger, as we add more complexes at ranges, there is an increased potential for exposure. There's also an increased potential for multiple exposures. In the past, it's been pretty straightforward. You can look at a facility, and you can look at the launch pad, and pretty much everybody agrees that the launch pad is exposed within our threshold and what the damage to the facility would be.

As vehicles get larger, you can begin to affect more than one facility at the same time. In the past, you would either affect this facility or you would affect that facility. Remember the questions and the discussions we had about adding everything up? Well, now it gets to the point where you need to know exactly if this facility gets hit, can that one also be damaged by the same event?

In some instances, the answer is "yes." Maybe the vehicle crashes in between the two facilities, so we need to look at correlations between the facilities. That's becoming an ever greater problem for us. A lot of times we just look at the probability of impact at the facility or that point and can make a judgment. However, the probability of impact isn't always the driving factor in that regard.

I've talked about replacement cost. We've had situations where we've had abandoned facilities. We've had situations where we've actually had government-owned motors stored near a facility. Some of which had failed qualification, so the government was never going to use those [motors]; therefore, we chose to value them much lower, if not zero. These happened to be, I think, Titan segments at Vandenberg.

Here's what we did. We set government property insurance such that the likelihood of exceeding the value we set was less than 1 in 100,000. Now, these tend to provide or have in the past at least provided values that were under the $100 million ceiling, which DOD said at the time was quite adequate as a ceiling.

In comparison to third parties, you'll note that this threshold of 1 in 100,000 is far higher in probability terms. Why? Because that's what these facilities are there for. They're there to support those kinds of hazardous operations. They also provided numbers that were in the range that everybody seemed to expect. One thing that is a common misconception. Although this is a -- oftentimes it comes out this way; the result appears this way.

MPL Considerations for Government Property

- Government Property Is Always Exposed
  - Launch Complex
  - Larger Vehicles, More Facilities, More Potential for Multiple Exposures
  - Amount of Damage to a Facility as a Function of Probability
  - Correlations Between Losses
- What Is the Loss Based On?
  - Replacement of What?

8

Maximum Probable Loss Government Property (Con't)

- Sets the Amount Such That Likelihood of Exceeding It Is < 1 in a 100,000
- Is Not Based on Most Costly Facility With Likelihood of Loss Within 1 in 100,000 (MPL Threshold for Government Property)
- Does Not Include Licensee or Subcontractor Property

9

It's very easy to go around and look at the facilities and find the highest valued one, which is exposed at a probability level of 1 in 100,000 or less. Well, that's the value. If you set it at that value, all the less costly systems or facilities are automatically covered, especially if you hit the high cost one means you don't hit any of the others.

The majority of the time, that works. It's really kind of a simple answer and a simple approach, but I caution everybody, and this has been my pet peeve, if you will, while I've been here. It isn't necessarily the right answer all the time. What if I had 10 facilities that were exposed with an individual probability on any given launch of being hit at one in a million? What's the probability that I'm going to hit any one of those?

I'll give you a different example. I have a die with six sides, numbered one through six. What's the probability that I'll roll a four, five, or six? Somebody?

UNIDENTIFIED AUDIENCE MEMBER: One-half.

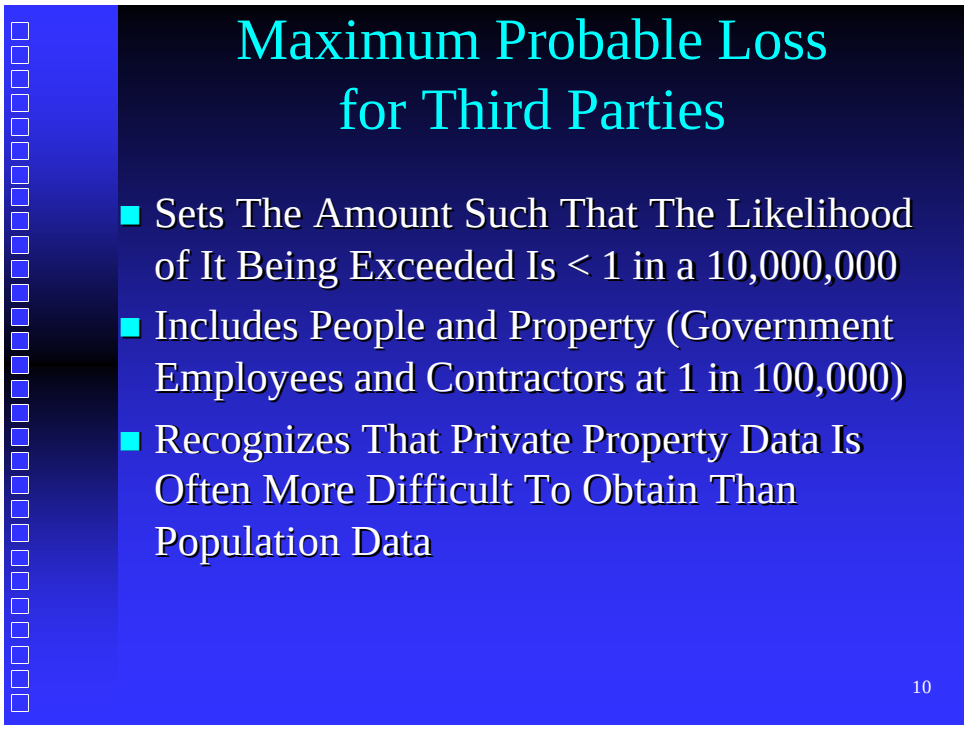
MR. GRESS: What's the probability that I'll roll a four?

UNIDENTIFIED AUDIENCE MEMBER: One-sixth.

MR. GRESS: One-sixth for five, one-sixth for six, but what's the probability if I roll it, that I'll hit either a four, five, or six? It's 50 percent. Same issue holds here. You need to look at facilities that may be beyond the threshold amount. If there are enough of them and they are higher and more costly than the 1 in 100,000, they may be the driver because of the likelihood.

Remember the definition is such that there is only a 1 in 100,000 chance that the amount I set or we set will be exceeded, so keep that in mind. Also, keep in mind that it doesn't include the licensee or the licensee's contractors, subcontractors, or property. They are the participants in the operation.

Remember I talked about launch sites? Third parties are a bit different, but it's the same idea. We set the amount such that the likelihood of it being exceeded is not 1 in 100,000 but 1 in 10 million.



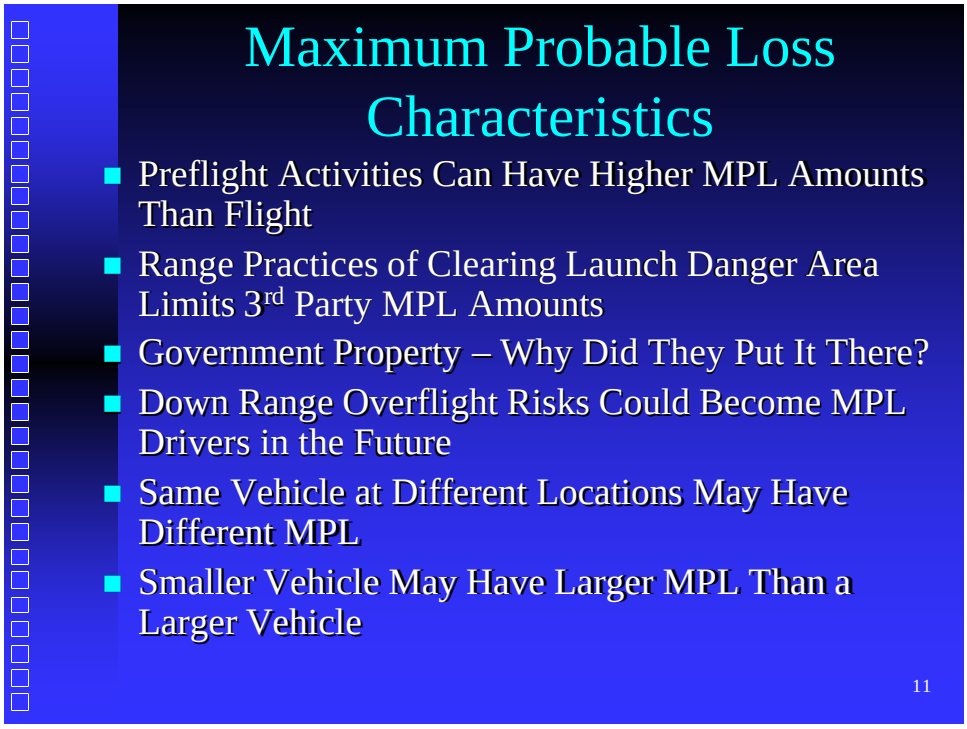
Why that value? Well, remember I talked about the FTS (Flight Termination System), and the ranges have impact limit lines. The idea is to be able to take the vehicle out, were the vehicle to be moving or going in the wrong directions, such that any significant impact of debris or explosive or pressure would be maintained within the impact limit lines.

Right there, you have a very major safety provision. If third party property is outside of those impact limit lines, the possibility of getting to it is pretty remote. You'll see in a minute what kind of values you get. Usually, at the 1 in 10 million range, you are looking at potential costs, potential damage or fatalities that are outside the range's boundaries, particularly when you're talking about around the range area.

Private property here has been really kind of a problem for us. It's a little bit difficult to get. It's not like going to the engineering office at the range and finding out about a particular facility. How much it cost to construct? How much equipment and the like are in it? My preference has always been that we need to look at that property value because we're covering not only people but also property outside the range.

There are some sources that can be used: publicly available property tax records, information on the type of structures, residential areas, commercial/residential areas, high-rise areas, etcetera, etcetera. So there are sources. What's involved though is time and effort to dig it out and [compile] an assessment of what losses might result both to the property and people in that area. It's a lot different than population. Population data's pretty easy to get. Yes, you have to deal with issues about distribution versus time of day and things of that type, but it's a lot more straightforward as I've found.

Characteristics of MPL. It's important to note that -- these are just some observations. With preflight activities, we have noted that not only do we have government property and third party as two different types of insurance requirements but also, quite frankly, we have chosen to look at preflight operations: those hazardous activities that occur on the range in preparation of the vehicle and what sort of losses might occur to the government facilities or third parties at that point. Sometimes those have a higher value than the flight. Why? Well, you have a motor or whatever you're processing in a facility. If there's a catastrophic failure of some type, that facility is certainly at risk.



You have people working around that motor who may be third parties or at least included as third parties in the MPL assessment. Either way, you as inspectors are third parties. If you use a contractor to help in inspecting, that contractor is a third party. U.S. government employees at the range, Air Force, whether they're wearing a blue suit or wearing a short-sleeved shirt and shorts, are third parties. A contractor to the Air Force, that may be exposed, is a third party. During the launch activity, the range's practice of clearing the launch danger area tends to limit third party risk.

One of the things we've noticed in many instances is we'll be doing the analysis, and we'll scratch our head and say, why in the world did the government build that facility there? A good example was, as I recall, the launch of Conestoga. Not picking on NASA, but there was a facility right near the launch pad. I think it was currently being used by the Navy and had a lot of equipment and material in it. At one point, this facility had the potential to be the largest government property insurance we would ever have issued. That's even in

comparison to the Titan at Cape Canaveral at 41 or 40. Just shows that there are these nuances and issues.

In the future, [it] hasn't been the case in the past, but in the future, drivers may in fact be down range, overflight of Europe or Africa, for example. Vehicles in the past have pretty well had relatively short dwell times over those areas prior to reaching orbit.

Should there be a failure in the vehicle at that point, those countries or that track is exposed. In the past, though, most of the vehicle's gone by then. It's dropped off in stages. It's almost in orbit. It's going very, very fast. It's almost at orbital velocity. A lot of it will break up or burn up before it reaches the ground; therefore, the exposure doesn't tend to be a driver.

There's something else that resulted in a higher premium value or a higher requirement set. Of course if something happened, certainly the amount is sufficient to cover any event like that. However in the future, vehicles getting bigger, they're operating more efficiently in many respects to keep costs down. They're moving slower. All of these may combine to raise the exposure levels down range.

AUDIENCE MEMBER, PHILIP BRINKMAN: We have one example in Sea Launch, correct?

MR. GRESS: Well, an example in that case is not a change. Sea Launch, of course, launches from out in the middle of the Pacific about 300 miles from the closest island, which is behind it, and about 3000 miles, as I recall, from South America. However, it overflies South America prior to reaching orbit, and it is that factor that becomes a driver at that point.

Just moving on quickly. The same kind of vehicle launched from a different launch site has different risks. It should be kind of obvious because population distributions are different. The facilities that are exposed are different, etcetera, etcetera.

I gave you an example. There have been some situations where smaller vehicles have had higher insurance requirements. What I did was, very quickly, I tried to summarize some of the extremes. I went to the table that I cited earlier, that's on the website, and looked at the highest amounts for orbital launches of government property.

Atlas IIAS for preflight operations has had the highest government property insurance requirements at $55 million. Atlas IIAS also holds the record for the highest flight government property insurance. Now, the lowest amount is for orbital launches. Phil mentioned Sea Launch a moment ago. There is no preflight Sea Launch license because there's no launch site. The licensed activity doesn't even start until ignition and flight. There's no government property there either; that's another good reason. During flight because there is no government property exposed, it has a zero insurance requirement.

Third parties. Same kind of comparison, the highest amounts for orbital launches. Atlas IIAS preflight, $45 million. For flight, it's different.

Delta IV, the M or M^+. For flight, $261 million. The lowest amount is for orbital launches. Look at the contrast. For flight, Delta IV had the highest. For preflight, it has the lowest, $3 million; and Sea Launch, for flight, $10 million.

UNIDENTIFIED AUDIENCE MEMBER: Question. If you go back two slides, for Sea Launch preflight or flight, there are FAA inspectors on the Sea Launch boats.

MR. GRESS: That's government property, that one.

UNIDENTIFIED AUDIENCE MEMBER: Oh, I got you. I'm sorry.

MR. GRESS: It turns out that the government inspectors on flight, yes, they are third parties, but the higher exposure is down range.

UNIDENTIFIED AUDIENCE MEMBER: Okay.

MPL Amounts for Government Property

- Highest Amounts for Orbital Launches:
  - Atlas IIAS — Preflight = $55M; Flight = $78M
- Lowest Amounts for Orbital Launches:
  - Sea Launch — Preflight = $0; Flight = $0

12

MPL Amounts for Third Parties

- Highest Amounts for Orbital Launches:
  - Atlas IIAS — Preflight = $45M
  - Delta IV M or M^+ — Flight = $261M
- Lowest Amounts for Orbital Launches:
  - Delta IV M or M^+ — Preflight = $3M
  - Sea Launch — Flight = $10M

13

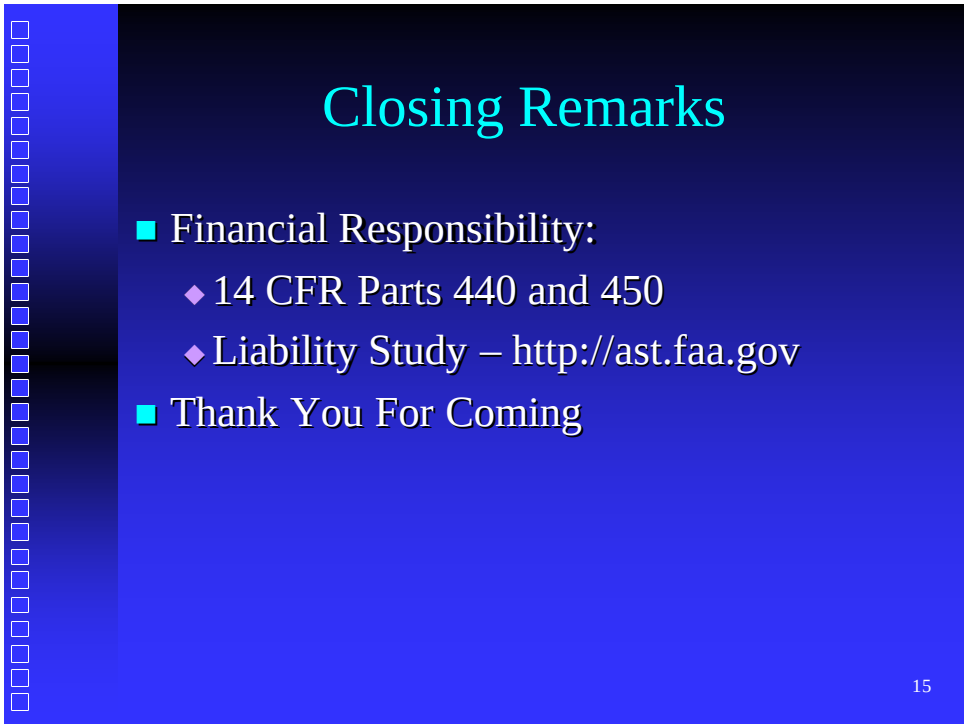
MR. GRESS: Okay? Good question though.

I've emphasized this in the past, the considerations MPL and financial responsibility apply to launch and reentry operations, not site operations. Commercial operators, site operators, and launch operators may negotiate among themselves on insurance. The provisions for the indemnification currently sunset at the end of 2004. That's, in part, why we were asked to do this study. [One goal] was to prepare Congress and the congressional staff with information on how to proceed when that sun sets.

One other thing I want to emphasize that wasn't on this slide is that in the current notice of proposed rulemaking for launch safety there is an issue raised that has to do with insurance. Both ranges operate differently. Vandenberg will let another launch company, who would, by the way, be third party to the company conducting the launch. Let's say there's another launch company out there conducting operations or preparing for a launch, and they might be exposed, let's say, during the flight of the vehicle. Vandenberg would consider letting those people, at their choice, continue to operate. Apparently, it doesn't matter whether they're working on a government launch, or they're working on another commercial launch, they'd let them operate. The Cape doesn't. When people are within the hazard area, they are moved out. We've asked industry, what do they want to do?

It's kind of a unique circumstance because it's a two-edged sword. If you move them out, that other company has to lose some time in preparing their vehicle, but they are third parties. The company doing the launch might need to cover them in the insurance requirements. Here you have a situation where Company A is going to have to pay the insurance to protect Company B, and Company B gets the benefit of not losing any time, continuing to process their vehicle. Hey, they're even a competitor. On the other hand, if you don't include them, then -- and A may be in the shoes of B the next time around -- what does the industry want to do?

I didn't emphasize this before, but if you have an interest, please read 14 CFR. Part 440 deals with financial responsibility for expendable launch vehicles. Part 450 deals with much the same issues and reads very much the same for reentry operations. Our liability study is on ast.faa.gov, and I want to thank you for coming. If there aren't any other questions, we've run over a little bit. Yes?



UNIDENTIFIED AUDIENCE MEMBER: A quick one. Everything we've talked about maximum probable loss for third parties, and that's for launches over water. What do you think will happen when we start heading inland for launches?

MR. GRESS: Well, the first answer to your question is that your assumption is wrong. Most of the things I've talked about today have dealt with that. Actually, the very first launch that actually occurred was over land, and we did deal with that.

Later on though if you have a vehicle that's going to overfly a lot of land and cities or at least areas that are inhabited or otherwise open to the public, yes, it can create a problem, and we've had to address that question.

Some feel that it's not fair that if I'm launching over land, your requirements are too strict for me, and I ought to be treated somehow differently. Our focus is on you look at the risk, you look at the situation and circumstance. Some guy in Nevada, for example, shouldn't be exposed to a greater risk or the operator have lower insurance values just because he happens to be in Nevada than somebody who happens to be on the coast. In other words, they ought to be treated, at the performance level, the same. Now, it could mean that the operator because of potentially greater risk may have to get greater insurance, but that's a business decision.

UNIDENTIFIED AUDIENCE MEMBER: But the inland launches you deal with were not orbital?

MR. GRESS: They were suborbital, certainly, yes.

UNIDENTIFIED AUDIENCE MEMBER: They stayed within the test range?

MR. GRESS: There was one failure that almost left the test range, but, yes, the normal operation was within the test range. However, there were third parties exposed within the range itself as well.

Any other questions? Good question.

AUDIENCE MEMBER, PHILIP BRINKMAN: Well, Ron, I'd like to just -- Well, I don't mean --

MR. GRESS: Yes, you do. Please.

AUDIENCE MEMBER, PHILIP BRINKMAN: Okay. It might be worthwhile to point out that in your discussions early on, you discussed how, initially, the Air Force was kind of reluctant to accept this methodology.

A number of years ago, the Navy and the Air Force came to the Office and asked us to conduct an MPL study for Spaceport Florida. As Ron has pointed out, we do not set insurance requirements for spaceports; however, the Air Force and the Navy were interested in setting insurance requirements for Spaceport Florida. By that time, they had become comfortable with the concept of maximum probable loss and asked us to conduct a maximum probable loss study for Spaceport Florida. I think that shows some acceptance of the concept by some of our other partners in the government.

MR. GRESS: Yes, they wanted to get that number so that the Navy contractually, I think, could require a certain amount of insurance of Spaceport Florida.

I think that also points out the government property we've worked with, obviously the Air Force, NASA, the Navy, and the Army. All of those services have, in fact, been affected or are affected by our process. We've had interactions with all those services.

Okay? Yes, Hugh?

AUDIENCE MEMBER, HUGH COOK: In today's presentation, we've had two quantitative numbers that relate to the concept of "really thorough." We have the range, and the execution of their public safety responsibility says that if something fails 2 times out of 1000, that's an acceptable measure of really thorough, really reliable (speaking of the flight safety system).

In our assessment of doing a thorough estimate of the maximum probable loss, we hold ourselves to a very high standard of not being wrong more than 1 in 10 million times.

MR. GRESS: That's not exactly correct. I think what we --

AUDIENCE MEMBER, HUGH COOK: But you understand. The nature of my question is, why is there a five order of magnitude difference between what is really thorough.

MR. GRESS: Well, I think I disagree.

AUDIENCE MEMBER, HUGH COOK: Conversely, why wouldn't we use a much lower probability that the accident cost might be greater, for example, 1 in 1000 possibility instead of 1 in 10 million?

MR. GRESS: Well, actually I kind of alluded to this in a couple of ways. I mentioned that there are a lot of other factors that are associated with what we decided to do in terms of picking thresholds.

One of the most important was expectations on the part of the public as well as Congress. If you picked 1 in 1000 for example in essence, you would come up with almost no insurance requirement.

We went to that extent of 1 in 10 million, in part, because it was that threshold where we started to really see "significant" numbers. You'll notice what those numbers tend to be, and at this point, none of them have exceeded the $500 million ceiling, or in the case of government property, the $100 million ceiling.

In part, we went to those more extreme numbers, really, in part because of what numbers came out. That isn't the only reason though. You look at risk acceptance. You look at other things that the public is reasonably comfortable in.

While we're not doing this for safety requirements, we're doing it for protecting the U.S. and the participants against claims. The public is used to, typically, background risk is called one in a million, so, in part, that's how we get there. To some extent, maybe you could call certain aspects of that reverse engineering, but it's how we selected the numbers, and that's how we've done it for the last -- since 1989.

AUDIENCE MEMBER, PHILIP BRINKMAN: It's consistent with what other agencies use, such as the Nuclear Regulatory Authority and some of theirs. It's not inconsistent.

MR. GRESS: It's not inconsistent although I would argue that in some instances what you're comparing is really safety standards versus insurance standards.

AUDIENCE MEMBER, PHILIP BRINKMAN: Correct.

MR. GRESS: Insurance is a different issue than the 30 in a million, for example, for public safety. Okay? Good question. All right? Well, thank you very much for your time. Obviously, if you have any questions, I'll be happy to answer them whenever they come up. Have a good day.

(Whereupon, the lecture concluded.)

ABOUT THE SPEAKER

RONALD K. GRESS

Manager of the Licensing and Safety Division

Mr. Gress has thirty years of experience in analysis and risk assessments involving weapon systems, computer systems and federal regulatory issues and requirements. This includes 15 years of experience in commercial space transportation safety issues and the responsibilities for licensing, insurance requirements, safety inspections, investigations, and enforcement. He holds a Bachelor of Arts Degree in Physics and a Masters of Business Administration.