The most complex mission America has conducted

A Delta rocket orbited two vehicles to test a new sensing and tracking capability for the SDI.

The following is an edited and abridged transcript of the Sept. 11 Pentagon briefing on the Strategic Defense Initiative experiment, by Lt.-Gen. James Abrahamson, head of SDIO, and Lt.-Col. Mike Rendine, project officer.

Abrahamson: We're a few days late in bringing, a little bit more detail on the mission that we flew last Friday [Sept. 5], which, of course, we are just very, very delighted with, because I think it had a great deal of significance, not only for SDI, but for the nation. It's a real tribute that we were able to conduct the overall program, and in particular the successful launch, by NASA and their team of contractors, and do this whole thing in about 14 months, in spite of a failure on the [Delta] 178, and to be able to correct for that and be able to have a very successful launch for the nation; because in my judgment, what that does is it really brings us back to what is the standard for this nation's launch capability. The success that we have had has been a standard, and the anomaly has been the failures that we have had. Unfortunately, it's been presented like it was all good luck in the beginning. I think that that's incorrect, just flat incorrect.

Now what I would like to do is to talk very briefly, and invite you to ask questions about what it is that we did. But in order to do that, I think you have to understand right from the beginning that this is an experiment. This is not a demonstration of some kind of a finished capability for a space-based kinetic kill vehicle. This is part of a very important sequence of experiments in our research program, very valid; hurried because we needed the data at a particular point in time. It will lead just inexorably to the kinds of capability that we're all trying to move to in this research program as quickly as possible.

Now in order to understand this experiment, we have to give you a little bit of background. . . . Then, I'd like to introduce my project officer, who worked through NASA, the Air Force, a whole series of agents in order to make this thing happen in this incredibly short period of time. He'll give you the details of the mission, and what it is that we did.

Now, the data is only slowly coming back, and the data is very, very sensitive. So we'll give you a very brief glimpse of some of the less sensitive parts of the data, but that will be reduced over a long period of time, and will become design-basic information for subsequent systems. . . .

This is part of the multilayer defense concept. We are talking about multiple sets of layers, in order to be able to stop ballistic missiles. Well, what we have demonstrated in the past have been things that have taken off in a terminal phase, and have either demonstrated the ability to intercept a warhead in space, or last June, we intercepted within the atmosphere, for the first time, a warhead down into just the last few seconds. In that acting like a short-range, or a theater type of ballistic missile threat system. However, we have always said, right from the very beginning, that we are very vitally interested in, particularly the boost phase, the ability to destroy an SS-18, a sub-launched ballistic missile, an SS-20—all of those range of systems—and to destroy them as early in the boost phase as possible. With all of those systems, they have two or more phases of rockets that get them out, and they, in fact, fire out well beyond the atmosphere. So that, for example, the SS-18 is a fairly slow missile. The second phase is firing out in space itself.

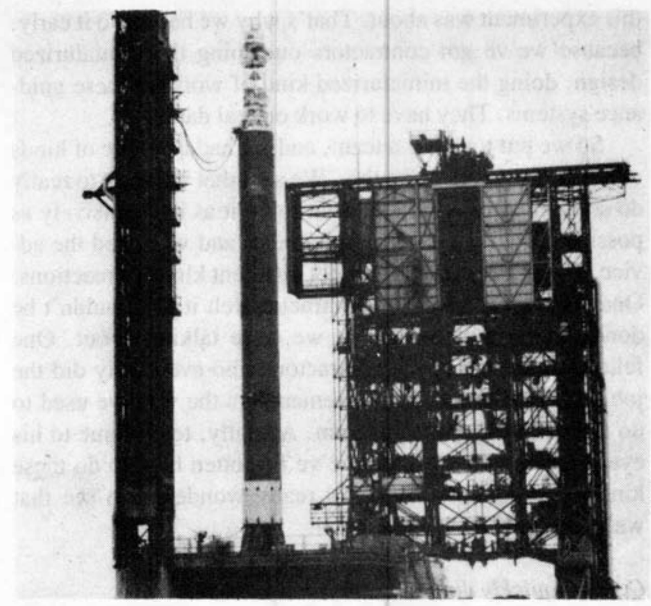
Of course, the advantage of destroying them in that second phase, or at that point in time, is that if it's an SS-18, you destroy 10 warheads, or more. You also prevent them from putting out a whole bunch of decoys and things, that will make it much more difficult later on in the system.

So, then the question is, how do you destroy boost-phase systems? Well, many people always focus on the lasers and the work that we're doing on lasers, and potentially, at some point in the future, that will be one concept. But another concept will be these small kinds of fairly conventional, fairly simple rockets. I'd like to say that eventually they might be very small, what we call a space-based kinetic kill vehicle, a rocket that can go very fast that would be put in a kind of a garage in space. . . .

One of these garages is a fairly inexpensive kind of place where you would store several of these rockets; it might be hundreds, it might be five or ten. . . . It's a fairly conventional kind of technology, but it would provide one of the early options for destroying a missile in the boost phase, and that's very important. . . .

Q: How big is the one that's actually used?
Abrahamson: It's huge. I'm just trying to give you the background of what we're doing. One of the great areas of emphasis in the research program is how do you make those things small so that they can work and work effectively? But how do you make them small and inexpensive? Because we're going to have to have lots of them, perhaps thousands of them, in order to deal with a very, very robust threat in the boost phase. But it's not enough to just have research programs to make things small. We already have that. You've also got to make sure that you have a guidance system that will work very effectively, not against just a warhead that's sitting out there in space that is a certain temperature, and of course, you can look with infrared or heat-seeking eyes against that warhead, and see against the coldness of space, but now we've got to look at a much more complex target—it's a rocket. That rocket has got gases flaming out of the back end. That is a very tough scientific problem. We've known that right from the very beginning.

Our first means of trying to get at how tough a scientific problem this is, we've built really effective simulations. We took the best aerodynamicists and rocket engineers, and people who know how to deal with supersonic plumes and data like that. We built these kinds of computer simulations of a rocket plume in space. Now remember, it's not going to act like what you see when you see a rocket take off from the Cape. When a rocket takes off from the Cape, you've got air pressure acting, and therefore it's one of these typical shapes and there's some fire and smoke at the bottom of it. But it's a very well predictable kind of shape. That is not what happens in space. What happens in space is that it spreads out because there is no air to hold the plume in. It spreads out into something that is absolutely huge. In simulation, every square is 30 meters, 90 feet essentially across. By temperature, the reddest ones are the hottest ones in one frequency band. Then you get down to the ones that are less hot. What you see is a very confused kind of picture for an automatic guidance system, the eyes for one of these things.


Department of Defense

The Delta 180/SDI Launch Vehicle, whose successful tests on Sept. 5 have put the Strategic Defense Initiative on a new plane.

Now, if you're a long, long ways away from that, in shooting that rocket, that's good that it's big. That helps you accurately get in the area. But when you're within two or three hundred feet traveling at 5 kilometers per second, now you're in a situation where what you see is a huge, confused mass of burning gas, of different kinds of temperature. In fact, to show you how confused it is, and one of the surprises that we got out of our early computer simulations, is that there's a little, tiny black dot that symbolizes the upper stage of an SS-18. One of the surprises we had is that, even though that SS-18 is thrusting and moving, the actual plume goes in front of it. So that means, now, we have really got a confused picture, that these eyes have to operate against.

So it wasn't enough just to be able to do theoretical calculations. We had to get real data on these things, real data, up close, so we understood it.

So, the next best way to do that was to get information on actual rockets. So we took some airplanes that were infrared observatories, and we took shots against various U.S. missiles as we fired out of Vandenberg Air Force Base.

Where there was still some atmospheric pressure, it looks like a normal kind of plume. You can imagine that off the front of it is the real rocket. Then, as you begin to get out where the air pressure gets lower and lower and lower, it begins to spread out all kinds of ways. Finally, it gets out into space, and it becomes just a blot.

And again, our problem is, how can that sensor see that, and know it very accurately, when it's in very, very close. There is no way on the surface of the Earth to really know that. We had to get out into space. We had to be able to measure, up close, and in several frequencies. That's what this experiment was about. That's why we had to do it early, because we've got contractors out doing the miniaturized design, doing the miniaturized kind of work on these guidance systems. They have to work on real data.

So we put together a team, and we had a couple of kinds of reactions. I really like this. We said that we want to really do something rapidly. We want to do it as inexpensively as possible. We defined the experiment, and we asked the advice of a lot of industry. We got different kinds of reactions. One group of responsible contractors felt it just couldn't be done, in the time scale that we were talking about. One fellow, from one of the contractors who eventually did the job, is an old timer, and he remembers the way we used to do things in the space program. Actually, tears came to his eyes and he said, "I think we've forgotten how to do these kinds of programs." And it's really wonderful to see that we're going to try it again.

Q: How quickly did you want it?

Abrahamson: I gave people a target of a year. Obviously, we didn't quite make that because of the Delta 178 failure. But we came very close. We did it in 14 months. . . .

Okay, with that background as to why we did this test, I want you to also understand that right from the very beginning we had to ensure that this experiment was done clearly within the [ABM] treaty. That wasn't a problem, because we really didn't run into major treaty constraints, because we're not trying to pull a stunt here and blow up something in space and all that sort of thing. What we're really after is a valid technical experiment to get this kind of information. We got it. With that, I'd like to introduce Lt.-Col. Mike Rendine, the guy who led and inspired this team to do that, who will explain how we did it. Mike?

The most complex mission ever

Rendine: Thank you, sir. What I'm going to do here in a short period of time is to, as much as possible, explain a very complex and, in my view, elegant mission, and show you some actual real data that we did recover and we can release to you. There is a story here that I'm not going to tell you, and it's the best story, and that's the story of the thousands of men and women who just did miracles in a year, to put this program together.

As General Abrahamson mentioned, our major objective was to get plume data; what do plumes look like in space. So our very first task was to build a set of eyes to look with. . . . At the top of the Delta, we put a hollow ring, and on that ring we mounted the very best eyes we could find in a year's time. One of those eyes was, at least to our knowledge, the world's first space-based laser radar. It's a radar system, but it uses a laser. It's not a weapon. It won't burn a piece of paper at a foot distance. What it does is it gives you very accurate distances with very, very low power requirements. So we used that brand new laser radar to steer some of these other sensors, these other eyes, because they have very narrow fields of view, down to one degree. To put that into perspective, a one degree field of view means that if you put your head down on the grass at one end of a football field, you could only see a five and a half foot radius circle down at the other goal line. So it's very important that we had very accurate pointing, and we held our tolerances very close. So the laser steered some of the other sensors.

One of the other sensors was actually a cluster of ten sensors; four pointing frontwards and four pointing back toward the second stage's own plume. It's quite a ways, if we look back at our own plume. Four pointed forward, and then we had two cameras that also looked forward in two different spectrums.

We also had—and I'm very pleased with the results of this—we carried a maverick infrared TV sensor that comes off an anti-tank weapon—not what you'd expect in space, very inexpensive device. It's the Free World's only infrared TV tracker. So we put a cluster of four, very good sets of eyes and batteries and transmitters, on the second stage.

Then we needed something to look at and we needed something with a nice plume. So we built an entire new third stage in less than a year. It's a liquid stage, it's a miniaturized version of another Delta stage. That gave us a nice liquid motor to look at. Of course, our second stage is liquid for the Delta.

In order to make sure that this vehicle stayed inside the field of view of these sensors, we needed a nice, accurate guidance system so they came directly together. So we looked around, and for a guidance system, we selected a Phoenix air-to-air missile. It's a Navy air-to-air missile carried on the F-14. It's a radar missile. That gave us a fifth sensor. We could look with this radar on the Delta second stage plume and see how that plume influenced the radar signature that came out of that body. In order to help the Phoenix, we also put a corner reflector inside the hollow ring I mentioned that the third stage motor is on. That helped the Phoenix find the second stage at the very long distances.

Once we put together this part of the experiment, we got spin-offs, once we had the basics. It's been reported these two vehicles did a ballet in orbit. Before we lit the motors on the third stage, we maneuvered it at various distances without a motor on it, and we viewed what this looked like without a plume. That gives us data on what vehicles look like after the motors have shut off. So we did that in sunlight, we did that in space background, Earth background, because that all changes what a sensor sees.

We had a total of six aircraft involved in this mission, probably the most complicated mission that—at least, from the communications and coordinations aspect—the U.S. has ever attempted. Besides the six airplanes, we used 38 radars and 31 satellite links, just to pass information around our network. I did mention, and we wrote, probably in excess of a million lines of new computer codes. Those were all tested for the first time during the real experiment, and they all worked perfectly.

The Delta took us to a 120-mile orbit, which is as low as we could go and get the data, which helped us transmit information down, and also kept the orbits very clean, because all of the residuals came down very quickly.

As we crossed over the Indian Ocean, we separated both vehicles. We had two ARIA aircraft, from Roy-Patterson Air Force Base, over the Indian Ocean, because we did not have a ground station there. We sent a lot of information down to those two. ARIA is Advanced Range Instrumentation Aircraft. They acted like mobile receivers.

So as we came around to the Indian Ocean, we separated the aircraft. The Delta second stage then turns away from the third stage, and fires its motor. That data is sent down. Our separation after this burn is 120 miles, but these two vehicles then normally criss-cross back and forth.

As we came over Hawaii, we sent more information down, and corrected the pointing, very minutely, of the Delta second stage, about 1/10th of a degree. Over White Sands we launched the ARIAs, within 1/10th of a second of when we needed it to come up.

It was a very clear day at White Sands. After the burnout, the whole Delta second-stage vehicle turned and looked back toward the third stage.

Then, again, we continued over the Pacific and over the Indian Ocean again, where we downlinked a second time to the second ARIA aircraft. At that point the vehicles separated again, just by their natural orbits, and after the maximum 120-mile distance, we lit both motors on both vehicles and allowed our set of eyes from the second stage to watch the third stage maneuver in as close as we could get. As a matter of fact, we were successful in our new guidance equations, and the third stage did hit the second stage directly. . . .

Ending what we call the endgame, the two vehicles were traveling towards each other at roughly 6,500 miles an hour. They were both accelerating at five times the force of gravity, or five Gs. So it's a very interesting guidance problem that we were faced with.

Q: They were both trying to hit each other?
Rendine: Only the third stage was steering. The second stage was told to fly in what amounts to a straight line, which is difficult to do in space. The third stage was guided by the Phoenix sensor.

From all the optical data and radar data, our scientists are debating whether the center-to-center error here was 6 inches or 12 inches. . . .

Q: Using the maverick sensor, did it prove that you could look over a wide area and pick these up or did you have it pointed intentionally toward a specific area?
Rendine: We pointed the Delta second stage strictly on projection of where everthing would be. We did have the maverik sensor caged—it was not allowed to move. So an interesting part of the experiment was where did the plume come up in the picture?

Q: It was strictly a tracking test and doesn't have any relationship to whatever kill mechanism you would eventually use, is that right?
Rendine: We arranged what we called the endgame so that we could get the sensor data. This particular experiment, if there was anything relative to purpose, it was the guidance equations and not the hardware, not at all the hardware.

Q: General Abrahamson was talking about the space-based rockets. That's another technology?
Rendine: Yes, that's a different subject matter. This is available hardware. . . . It's a research vehicle. It was meant to get sensor data so we knew what kind of eyes to put on.

Q: What information did it provide to help you in determining the plume characteristics needed?
Rendine: We sent down 12 channels of data—three of them were width and length. We used up 85% of the entire instrumentation bandwidth to do that. It's an unprecedented amount of data. We've got that data both on liquid plumes, solid plumes, and post-boost with the motors off, before we ever lit the motors. The specific knowledge we got, of course, is going to go into the research program and that's sensitive.

We've already learned some pretty interesting things about the shape [of the plume] and things like that. But a lot of the data is going to come out now as we do very detailed examinations and compare the temperature of the plumes at different positions, and compare that to the different materials and the kind of reflectives that are on the side of the stage vehicles. You know, it was more important that we are simulating an upper stage of a missile, because that's what these things are looking at, than we are trying to simulate one of these little spacecraft that's going to be a kill vehicle.

'An easier job than we thought'

Q: Has that been proved? Can you say in terms of boost phases that this proves it's possible?
Rendine: This was a textbook mission. I feel it was a storybook mission. Most of the folks who worked on it feel the same way. The sensors worked beyond the point we even dared hope they would.

What I will say about that is that since these sensors worked so much better, I, at least personally, believe from the data I've seen that our job's going to be a lot easier than we thought. I think you're looking for a quotable handle there, and that's what I think we learned. The specifics, of course, are very sensitive information.

Q: Did it prove boost phase intercept feasible?
Rendine: Well, I think that we knew that it was feasible, but we had some unknowns in terms of what the target looks like. Now we know that so much better that, in the next stage of the research, when we actually begin to design experimental versions of these things to be tested at some point in the future, we will have the specific kinds of data in a series of

portions of the spectrum, several different parts of the spectrum. So we can pick the best part of the spectrum. We can ensure that we can pick a part of the spectrum that they can't counter-measure easily and work against us. We can develop, then, a very, very reliable system that won't come zipping in and do a good job and get close, and then miss, but will actually hit. Remember, we're not trying to put warheads on these. That means that that endgame, that last few seconds of guidance, is absolutely critical. That's why it was so important to get this kind of information, so you can design that.

A long time ago, I worked on the Maverick missile. That was one of the first of the optical kinds of guidance missiles. The first problem we had is, it was great, it came in a long, long way, and really did great. Then, at the last second, it would always decide, I think I'll make one more little correction. It'd go—whoosh—right over the top. You can't have something like that happen. In order to do that, you have to have the target signature.

Q: How closely did the second phase resemble a Soviet warhead?
Rendine: . . .There are different Soviet upper stages. Some are liquid fuel, some are solid fuel. The important thing is that it is an upper stage. Not for a ballistic missile, but it is one that at least has basic size, shape, characteristics, and basic engine characteristics, close enough, that it gives us the kind of fundamental design data that we need.

Q: People have often talked about lasers being used as the technology of choice for that boost-phase kill. This experiment seems to suggest that kinetic kill vehicles also have great application, or may be nearer term. Are you shifting your thinking?
Abrahamson: I think that, you all haven't been listening very well, is the real issue. We've been saying right from the very beginning, that we are always going to be exploring two or three different kinds of ways of conducting every function. The weapons function is one of those functions, the destruction function. We have talked about these kinds of kinetic kill vehicles for a long time. They are not that complex, if you have the basic design information. We're making progress in the lasers, too, obviously, and I'm very proud of that as well. It does not represent a shift in thinking. It represents progress on a broad front.

Q: General, how long will it be before a technology like this is ready to be deployed?
Abrahamson: Well, I would say that the biggest unknown is how much money we have in order to do the program. That seems to be a very big unknown.

Q: If you were given a five-year plan, would you be able to deploy this system within the five years?
Abrahamson: Well, there's always some unknown factor in how fast you can go. I've defined a new law, by the way, now. I think it has all the validity of Newton's Third Law. It goes something like this, that technically, if you can get a few talented people, and at least some resources to do the job, you can do the technical job in about half the time that anyone projects. Unfortunately, if there's a political dimension, it takes about twice as long.

Q: You haven't really answered my question.
Abrahamson: I know I haven't. That's in this research program, and I'm not telling you that. I have said very consistently that if we get sufficient money so that we can conduct this whole broad range of scientific research, we could, by the early 1990s, be in a position to make a very broad kind of national decision to go ahead. Then we could quite quickly go through a development and begin a deployment phase. Obviously we're making progress daily. It's exciting.

Q: Explain to me the significance of tracking the rocket out of White Sands.
Abrahamson: We've used satellites from very, very high altitudes just to see those plumes. We've never tried to understand what it looks like up close. That's really the simple message of this whole mission, is to see with different eyes, in heat-seeking eyes and in other parts of the spectrum, what these things look like just as close as you can get.

Q: Did the challenge of setting up a relatively brief experiment like this tell you something about the logistics involved in deploying a real system?
Abrahamson: Right. I think what it did is that, it can't be considered a simulation of a real command and control set for an SDI system. But it did give us, I think, a very worthwhile initial experience in what a command and control set will be. I've always said: I think that is the long pole in the tent, not that of the development of the weapons. I think Mike said it in a qualified way, because the guys did it. They just stood up to it and did it.

It was the most complex command and control mission that the United States has ever conducted. We tied together all of the ranges, the Eastern test range, the Western test range, the Army Range out at Kwajalein. We've the NASA assets, the Air Force assets. All of those—we put a whole bunch of communication links, 31 separate satellite telecommunication links together, kept them together, and some of those were commercial, and some of those were military. We utilized ground communication links where that was necessary in order to handle the high volume of data. I think that's one of the major achievements. It gave us a good set of experience in the command and control problem.

Q: What is the message you say this sends to critics of Star Wars, of SDI?
Abrahamson: That we're doing everything that we said we'd do, on schedule, or faster. That's what it is.