UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
RESTON

OFFICE OF THE DIRECTOR July 15, 1991

To: NMD

From: Congressional Liaison Office

Subject: Review of Congressional Transcript of Testimony

Please review the attached transcript of the and questions June 26 testimony before the House Science Committee and the House Permanent Select Committee on Intelligence.

Note, please, that all edits should be made in pencil and limited to the correction of errors in transcribing.

Please return the transcript to the Congressional Liaison Office by COB Wed, July 17.

Attachment

Note: Please answer questions designated for your division.

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

SUITE 2320 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
(202) 225-6371

July 11, 1991

Dr. Dallas L. Peck, Director
United States Geological Survey
Mail Stop 101
Reston, Virginia 22092

Dear Dr. Peck:

On behalf of the Committee on Science, Space, and Technology and the House Permanent Select Committee on Intelligence, we would like to thank you for your testimony at the Landsat hearing held on June 26, 1991. We valued hearing your perspective on the current and future applications of data from the Landsat program. Those comments will help serve as the basis for any policy decisions developed by our two Committees on this subject.

Enclosed please find a copy of the hearing transcript for your review. As noted in the original letter of invitation, the proceedings of this hearing will be printed strictly in verbatim form; only typographical and transcriptional errors will be edited in the transcript. We will proof the transcript for any such errors, but request that you return a corrected transcript as well.

Also enclosed are some additional questions we would like you to answer for the record. Please send answers to these questions and the corrected transcript by July 19 to Pete Didisheim, Room 2320 RHOB, Washington, D.C. 20515. If you have any questions, feel free to contact Mr. Didisheim at (202) 225-6375.

Sincerely,

GEORGE E. BROWN, JR.
Chairman
Committee on Science, Space,
and Technology

DAVE McCURDY
Chairman
Permanent Select Committee
on Intelligence

Enclosures

Questions for Dallas Peck

104 1) One of the major findings of the draft CEES report concerning the value of Landsat for global change research was that early Landsat data is degrading and may soon be lost unless converted to a stable medium. In your view, how serious is this problem?

NMD 2) Did the Department of Interior's FY 1992 funding request at any time in the budget preparation process contain a request for funds to preserve early Landsat data? If so, how much was that request for and what happened to that request?

NMD 3) What specifically is the Department of Interior doing to preserve early Landsat data from being permanently lost?

NMD 4) How much money is needed to complete the conversion of early Landsat data to a stable medium and how long would this process take?

104 5) How serious would the impact be on global change research if the Landsat program were essentially terminated after Landsat 6?

104 6) As the Chairman of the Committee on Earth and Environmental Sciences, can you tell us what role CEES will play in implementing the President's policy to ensure the continuity of Landsat-type data?

104 7) The President's Budget for Fiscal Year 1992 contains the following statement in the section which discusses the Landsat program: "Acquisition of data from land remote sensing satellites is an important element in understanding global change." Given this statement, how do federal agencies involved in the Global Change Research Program plan to acquire new Landsat data for global change research, both before the expected demise of Landsat 6 in 1997 and after?

104 8) Please give us a status on the draft CEES report concerning the value of Landsat to global change research. When can we expect this report to be released from the Administration?

NMD 9) If the U.S. government were to reassume control of the Landsat program, would role might the Department of Interior, or the USGS in particular, envision playing in such a situation?

NMD 10) How concerned are you that the U.S. has not yet initiated plans for a follow-on to Landsat 6?

Original transcript

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JOINT HEARING ON SCIENTIFIC, MILITARY,

AND COMMERCIAL APPLICATIONS OF THE

LANDSAT PROGRAM

WEDNESDAY, JUNE 26, 1991

U.S. House of Representatives

Committee on Science, Space, and Technology

Permanent Select Committee on Intelligence

Washington, D.C.

The committees met, pursuant to notice, at 10:07 a.m. in room 2318, Rayburn House Office Building, Hon. George E. Brown, Jr. [chairman of the Committee on Science, Space, and Technology] presiding.

The CHAIRMAN. The committees will come to order, please.

We appreciate the substantial amount of interest evidenced by the size of the audience here this morning and the press interest, and we believe that it's well justified because of the importance of the subject.

This joint hearing of the Science, Space, and Technology Committee and the House Permanent Select Committee on Intelligence will come to order.

To my knowledge, this is the first joint hearing ever held between the Science Committee and the Intelligence Committee, and for that matter, it's one of the very few times that members of the Intelligence Committee have convened in the open for an unclassified hearing, and we're particularly grateful that they would use this occasion to do that.

The topic of today's hearing is a natural one for joint consideration by our two committees. LANDSAT is the civilian satellite program which has provided our Nation and the world with valuable scientific, economic, environmental, and military intelligence since the launch of the first LANDSAT satellite in 1972. I used the word ''intelligence'' here deliberately, since I genuinely believe that LANDSAT provides information that is as important and powerful as the information gathered from many, if not most, of the classified intelligence systems.

[illegible] to keep secure the

funds needed to keep the program running, more than two years have since passed, and the program remains burdened by policy, management, and funding questions. The

Mr. SHUSTER. Thank you very much, Mr. Chairman, and I certainly want to compliment you and Chairman McCurdy for arranging this joint session. The interrelationship between our two committees with regard to space is obvious. We have common cause, and I think it makes an awful lot of sense for us to get together.

I recognize how important it is for us to become familiar with the present and potential uses of LANDSAT before we tackle decisions about whether the program should continue, whether it should be operated, and who should pay for it.

I'm wondering, for instance, to what extent the French Spot System could address these needs. If LANDSAT is upgraded to meet defense requirements, it remains unclear to me whether this will equally benefit other users, or even penalize them. A more sophisticated LANDSAT and ground system might be far more costly than the $400 million figure I've seen quoted for LANDSAT 7, so I'm wondering if support for the program, already tenuous, could be sustained as budgets decline.

My impression thus far is that LANDSAT is tapped by a wide variety of users, sometimes because it's the only, often non-optimal way to compensate for some big information gaps. It's unfortunate that these users seem so scattered and disparate that we have been unable to assure momentum and

support for the program. The challenge will be to find sufficient common interest and concurrence on satellite design and operation to justify indefinite continuation of the program, or even a major upgrade.

So I look forward to working with you, and I know our committee looks forward to working with the Space Committee on this important issue.

Thank you.

[The prepared statement of Mr. Shuster follows:]

********** INSERT **********

The CHAIRMAN. Thank you, Mr. Shuster.

I'll entertain brief opening statements from other members.

Mr. Packard?

Mr. PACKARD. I won't speak for Mr. Walker, who I'm sure is on his way here--the Secretary of State was meeting with the Republican conference earlier, and he may still be there -- but let me just simply say that there is concern by many of us of the rapid loss of leadership on the U.S. part in our civilian role in remote sensing. Certainly, the French have quickly filled the void left by the U.S., and they have committed themselves to developing a remote sensing system that could really dominate the globe in this area.

Funding for LANDSAT has been, for the most part, unstable. It's caused potential customers to look elsewhere for their data, and, frankly, I think that there is a longing for a long-term commitment by this country to LANDSAT. It is essential that we make a commitment that the LANDSAT Program will work to bring about a launching of the LANDSAT 7 and thus ensure a continuous flow of information and data.

Mr. Chairman, I'm very pleased to see you take the leadership in this and to craft a piece of legislation. You have my total support and co-sponsorship of it, and hopefully we will be able to find the funds to continue our

efforts in remote sensing.

Thank you very much.

The CHAIRMAN. Thank you, Mr. Packard.

Does anyone else care to make a brief opening statement?

[No response.]

The CHAIRMAN. Thank you for your restraint.

Mr. PACKARD. Mr. Chairman, I would ask unanimous consent that others may wish to introduce their statement--

The CHAIRMAN. Certainly. Any member may put a statement in the record if they wish.

We're expecting Congressman McCurdy here briefly, and when he comes in and at a suitable occasion, I'll certainly expect him to have an opening statement, and in the meantime, we'll proceed with our first panel.

This includes two witnesses from the Department of Defense. We will first hear from Major General William K. James, Director of the Defense Mapping Agency, which is responsible for mapping the world for the various needs of the Defense Department. We will then hear from Mr. Brian Gordon of the Defense Intelligence Agency. Mr. Gordon serves as Chairman of the Tactical and Military Multispectral Requirements Working Group, which is the Defense Department's panel for assessing the use of LANDSAT and Spot data for military missions. At the end of Mr. Gordon's testimony, we will view a short video of a

simulated flight over Kuwait City that was generated using LANDSAT and Spot imagery. Mark Bromley from the Planning Research Corporation will provide an introduction and background on that video.

So we now--well, how opportune. Let me yield to Chairman McCurdy, who, may I say, is one of the--probably the key member of Congress involved in the policy aspects of this issue in the sense that he chairs the Intelligence Committee, he's a senior member of the Science Committee and a senior member of the Armed Services Committee, and I don't know how he got himself into such a key position, but since he did, welcome.

Mr. MCCURDY. Thank you, Mr. Chairman.

First of all, let me commend you for chairing this joint committee meeting to discuss LANDSAT and its many and varied applications. It's a pleasure to be with you today and to have the opportunity to co-chair this hearing with you.

I have long, as you stated, been a supporter of LANDSAT Satellite Program, and I welcome the opportunity to have the Intelligence Committee participate in this joint hearing. Today's hearing is most unusual for the Intelligence Committee, since this is one of the few intelligence hearings that will be open to the public.

Mr. Brown and I are both concerned about the future of LANDSAT and have taken action on our respective committees

to provide funds in fiscal year 1992 to begin acquisition of the next LANDSAT satellite. Many difficult decisions still need to be made--in particular, who will step up to pay the bill and how the system will be managed in order to support both civilian and military users.

Our purpose today is to gain a better understanding of the current and projected uses of LANDSAT data. We plan to have a follow-up hearing to address the management and budget issues associated with the program.

The recent conflict in the Persian Gulf pointed out the need to continue the LANDSAT Program. We will first hear testimony from the military panel and their thoughts on the importance of LANDSAT imagery. We will also hear from panels presenting applications pertaining to scientific research and global change, plus civilian and commercial applications. I look forward to hearing these presentations.

Mr. Chairman, again, I appreciate your interest and continued support and for calling the hearing today, and I yield back my time.

[The prepared statement of Mr. McCurdy follows:]

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The CHAIRMAN. Thank you very much, Mr. McCurdy.

As I indicated, we'll proceed, then, with the first panel.

General James, would you start out? Welcome.

STATEMENT OF MAJOR GENERAL WILLIAM K. JAMES, U.S. AIR FORCE, DIRECTOR, DEFENSE MAPPING AGENCY, FAIRFAX, VIRGINIA

General JAMES. Certainly, Mr. Chairman.

To both Chairmen and to distinguished members of both panels, I appreciate this opportunity to discuss the Defense Mapping Agency's use of the current LANDSAT systems, and I'd like to talk about modifications that would be required to make a system like this suitable for mapping, charting, and geodetic support of military forces and military needs.

I do, sir, have a written statement I would like to submit for the record.

The CHAIRMAN. Without objection, the full text will be included in the record.

General JAMES. Thank you, Mr. Chairman.

The Defense Mapping Agency uses the current LANDSAT for interim, special purpose, and crisis support products. Examples have been our support of the counter-narcotics effort in Latin America to provide an interim product where there are no maps available at this time while we build the imagery base to build the maps from. We also used LANDSAT in Desert Shield and Desert Storm to build interim products for our forces, and we do some interim work in producing navigation hazards for the people afloat.

I would like for your staff at this time to hand out some

image maps and some regular maps that we have produced of the Kuwait City area to make a comparison for you of LANDSAT as it was versus a map that we would make for a military force. I will tell you while these maps are being handed out, this particular map of the Kuwait City area was done by the United Kingdom Military Survey, done to the same specs that we use based on a Memorandum of Agreement between our two countries, which has been longstanding and very useful for us, particularly during crises such as this.

If you will compare the detail provided by the map to the lack of detail that you get from LANDSAT, you can see from a military map maker's standpoint why we have some difficulty with LANDSAT resolution as it now stands. Image maps are useful--they're better than no maps at all--but certainly if you are a military person with a high-technology weapons system that you're trying to employ, you need the other product we produce, and that is the detail presented on that military map. In fact, LANDSAT is limited by its low resolution at 30 meters, its lack of stereoscopic coverage, and its lack of precise positioning data.

I have given you a handout, and if you would look at the DMA requirement chart in that handout, it makes a kind of nice comparison of what we require to the current LANDSAT.

When you talk the characteristics of resolution, for instance, what we need to make a military map for military

customers is three to five meters, at least that good, and as a matter of fact, we need some resolutions for some products as good as .5 meters, but the current LANDSAT only gives us 30 meters. We need stereoscopic coverage, and LANDSAT gives us none of that. You might ask why would you need stereo pairs, and the answer is it helps us measure heights, and products like Tomahawk missiles cannot fly without our terrain data that we feed to it. We call it a TERCOM product. To produce a product like that, you have to have stereo pairs so that you can get the detail that you need to make the product. And LANDSAT does not give us any precise positioning data. Certainly, in order to tie the map to the face of the earth worldwide, we need those star sensors to help us do our job.

Now, military requirements for features is what drives the resolution and positioning needs of my map-making products, and examples of features that we need high- resolution imagery on are provided in your handout, and you can see such things as we need information on drydocks, buildings, bridges, point features such as towers and flare pipes, and ferry crossings and bridges and the like. You saw some of those targets in living color struck during the war, and it takes our sort of precision in order to be able to do much of that work.

So the bottom line is that we cannot make maps from 30-

meter resolution; we need five-meter and better. If you will look at that same handout, there is an excellent comparison of the resolution required. The 30-meter resolution represents what you see from LANDSAT, and when you blow it up, on the bottom of the comparison, you'll see how everything fades out. Ten-meter resolution, by the way, is what you get with Spot imagery, and 10-meter resolution is better than 30, but not good enough for military map-making, and then five-meter resolution is--then it starts to become very useful in order to attribute the features that you see and tie them to the earth's surface.

So that's a pretty graphic representation of what LANDSAT today gives us versus what we need. Many people think that maps produced by Rand-McNally are much the same as maps produced by military map makers, but you can see that we could not do the precise work that has to be done for the military customer in order to strike those targets.

I'd just quickly summarize, then, for you that to meet military requirements and our other customers or DOD, we need some better resolution, some stereo pairs, which we can't get with the current LANDSAT system, and we need to be able to position all of that in space so we know where it is on the face of the earth to make the map. However, having said that, I will tell you that an improved collector of this type with those specifications--better resolution,

stereo pairs, and positioning data--would help us do our job. There is no question that we have more requirements than we have imagery to fulfill those requirements, and an improved collector with broad area coverage would help us overcome that shortfall.

I will tell you, too, sir, that to do this--and certainly Congressman McCurdy is well aware of this--in order to use an improved collector of a multispectral sort in our new digital production system, we would have to modify the production system slightly to take the imagery we currently use and mix it with this in order to produce a product.

Having said that, we estimate--but we don't know for sure, because we haven't done any deep study on it--that it would cost $20 million to $30 million to make software changes to the digital production system in order to use an improved collector called LANDSAT or something like that in our production process. There again, I still think the country would get its money's worth, because it will help do the job that we've been asked to do and will overcome the shortfall. So I think the up-front money that it would cost to modify my software would be small change in the long haul.

With that, sir, I'd be happy to entertain the following questions.

[The prepared statement of MG James follows:]

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The CHAIRMAN. Thank you very much, General. We'll hear from Mr. Gordon first, and then we'll question both of you.

Mr. Gordon?

STATEMENT OF D. BRIAN GORDON, CHAIRMAN, TACTICAL AND MILITARY MULTISPECTRAL REQUIREMENTS WORKING GROUP, DEFENSE INTELLIGENCE AGENCY

Mr. GORDON. Let me thank Chairman Brown, Chairman McCurdy, and the rest of the members for the opportunity to speak to you today.

I am going to show you what happened in Desert Storm and Desert Shield before that--the use of not only LANDSAT data, but because it's relevant, the use of Spot data and even AVHRR. The use of the data was certainly successful. There were significant contributions by LANDSAT, by Spot and AVHRR, contributing to the success of Operation Desert Storm.

I'd like to point out that certainly DOD would be using LANDSAT and Spot. We recognize that it's very important to get a wide area of coverage over our areas of interest, and we'll use everything we can get our hands on--any and all imagery data--because of the very, very strong technical tradeoffs between resolution and a broad area of coverage. Its technology doesn't come cheap, and the cost of the data in terms of technology or money is quite high, so we certainly used this.

We also used it because it's unclassified. We had a coalition of forces. We had to have unclassified data in

order to share certain types of operational and targeting material with other countries' forces during that particular operation. Also, we noticed that the use of the data itself played a heavier role than we had thought in the first place. We were surprised when we found out that from $5 million to $6 million of this data was actually purchased by DOD for this particular operation.

I'll be showing you many examples of how this data was used during the operation, and you'll see a lot of color pictures, I think a lot of impressive products, but to help keep things in perspective, I would simply request that you keep in mind that even though there were highly significant uses of civil data during Desert Storm, that imagery actually represented a small percentage of the total amount of imagery that was used during that operation.

Next slide, please.

In the Defense Intelligence Agency, we set up and maintained a logistics flow of LANDSAT and AVHRR right to the command. That's Central Command, the J2 or intelligence operation over there. We made sure that the imagery was sent on flights on the same day or at 48 hours at the most to arrive in Riyadh in the most expeditious manner. I'll show you some examples of all of these bullets.

We produced briefing graphics. Some of the graphics that you saw on T.V. presented by Admiral McConnell here

state-side and General Neil in fact came from those, and I'll show you examples of those. We supported the special operation folks with graphics, because, of course, they're extremely interested in getting the best possible picture of how the scene actually looks, and we supported the Central Command in general with area limitation products from LANDSAT and Spot. I'll go into that in some detail.

Next slide, please.

In this particular case, just to show you what low resolution can do for you, this scene is from the AVHRR--that's a NOAA satellite; think of it as a weather satellite--and here in this extremely low resolution--we're talking in terms of kilometers--you can see the oil fires near Kuwait City and, perhaps even more importantly for some, where the smoke trail is going over those two countries.

Next slide, please.

This shows you an example of trafficability and why we consider it so important. Even though LANDSAT has 30-meter spatial resolution, we can also integrate that with the Spot 10-meter data. I'm very proud to say that DOD units, right down to small units, have become so sophisticated in the use of data that they all know how to integrate the 10-meter Spot data with the 30-meter LANDSAT data, and the different colors you see represent different types of sands and soils, so the commander is becoming used to identifying these

various different types of sands and soils and associates it with the ease or difficulty of maneuvering throughout this terrain. In fact, some of the areas are a so-called ''no-go'' area, where, in other words, you cannot get certain vehicles through. This is for all types of vehicles. Really you're talking about jeeps, hummers, or tanks.

Next slide.

DIA received LANDSAT data within 24 hours of what we call time over target--that means the time that the actual imagery was taken--and within 24 hours, we actually had an estimate. I recall that quite vividly. In fact, I recall the news that was released from the Defense Department talking about some number of oil fires in Kuwait--I don't recall exactly what it was, a couple hundred--and when I went home that night, after looking at this imagery and counting the oil fires, I discovered that, in fact, rather than a couple hundred, we had some 560 that we could see on LANDSAT data. So that number was released soon thereafter, so it was a good story of how fast we can get it. Please recognize, however, that LANDSAT data collects once every 16 days. Actually, there were two birds up during the operation, so it was once every eight days. So that was fortuitous that we had coverage and then we could use the data immediately the next day.

Next slide, please.

I'll go down by service. First of all, the Army's Intelligence Threat Analysis Center, which is located here in Washington, produced many, many different types of products. In fact, I've only generalized up here, including image maps, mosaics, change pairs--that is, what has changed between some previous imagery coverage and the present--and lithographic maps--and I'm using the word ''maps'' instead of ''charts,'' because using LANDSAT data, you do not necessarily get the type of metric quality you do from imagery that was specifically designed for charts--prospective views-- you'll be seeing examples of these throughout the day, if you go to the demonstrations in particular--and digital slope elevation products--that is, being able to understand how steep a slope is in certain areas.

I'll also show you some products by the 30th Engineering Battalion that was actually deployed to the theater in a van -- a van, by the way, which was configured within 45 days, from day one to the time it was over there, 45 days, and that was quite an accomplishment. And lastly, I'll show you some examples of what the Corps of Engineers did in analyzing oil slicks.

Next slide, please.

This is quite a simple product. It's a Spot photograph of

an airfield to show various features--large buildings, hangars, runways, taxiways--and overlayed with a geographic reference system of your choice. That is, if you're in the Army and like UTM, you can do it that way. If you're in the Air Force and like the geo coords, you can do it that way.

Next slide, please.

In this particular case, this was one of the first identifications of the oil fires at al-Wafrah, which is in the extreme south of Kuwait.

Next slide, please.

I used this example because this was produced on a garden variety printer, which is one of the advantages of multispectral that people don't often get into. The fact that you have color means you can differentiate much better among different features than black and white, and so we ran this off on the garden variety, probably a $300 or $400 printer. The interesting thing about this is you notice the facility in the center is labeled as a fertilizer plant, and yet you'll notice the antiaircraft sites around it very curious, protecting this thing so strongly for producing fertilizer.

Next slide, please.

I'll show you what was done in deploying that van into theater. I mentioned the 30th Engineering Battalion.

Next slide, please.

They support the 8th and the 18th Corps and special operation forces.

Next slide, please.

And 45 days, they stuffed in the appropriate equipment to include the digitization of products, the digital manipulation of those products, leading to a product called a lanatronic printer, which went into a regular lithographic process, and so they could react quite quickly in producing massive charts. A lot of LANDSAT and a lot of Spot went through this particular process.

Next slide, please.

This is a photograph of oil slicks. The vivid color you see on either side are land forms, and the lacy pattern you see toward the center of the slide is the oil slicks themselves. The Army Corps of Engineers actually set up a capability right at LANDSAT's office in Lanham, Maryland, and stayed on-site and got this information to Washington users and, more importantly, to command users in Riyadh, and a lot of this data was also used in combination with Department of Commerce, NOAA, the U.S. Coast Guard, and contributed to a task team to try to assess as quickly as possible the difficulties of that oil, including desalinization plants.

Next slide, please.

Switching to the Air Force, very importantly, the Air

Force integrated Spot data, 10-meter data, into their mission support system. This is an Air Force-wide program affecting almost all Air Force organizations dealing with flying planes, which I guess there are a few that aren't. The 480th Tactical Intelligence Group at Langley produced many types of target graphics very widely deployed, and they supplemented standard cartographic and Intel products. Quite importantly, SAC used this system and processed LANDSAT and Spot graphics, to include navigation charts. In other words, if the navigation chart did not have a recent update, they would use this data and then extract the data from the LANDSAT and Spot-- particularly Spot--information and then annotate and update those particular nav charts.

I didn't realize this until I pulled this together for this particular hearing, but Spot data was actually used to rehearse that attack on that manifold complex. That was where the Iraqis had let prodigious amounts of oil flow out into the water, and we attacked the manifold to stop that flow, and we did it successfully. They actually used Spot, and they rehearsed that.

Next slide.

Again talking about the Air Force, through Air Force 10-Cap, which is an organization which seeks to improve and to enhance present capabilities further in support of the operational commander, the tactical commander, they

sponsored a workstation called ''Wings.'' This is where a pilot can look at a screen, sit there with a joy stick--they were using a mouse when I saw it, and I told them that will never do, it's got to be a joy stick--and the pilot can interactively make turns and see the prospective view in front of him change as he makes those turns. These types of products are quite in demand wherever you find air crews. You can interactively fly through and visualize your mission and your target.

Next slide, please.

These capabilities were deployed to Dhahran with the Air Force First Special Operation Wing and Bahrain with the Marine Aircraft Group 11.

Next one.

Switching to the Navy, the Navy integrated Spot data into their TAMPS--the tactical air mission planning system. This is a system that's parallel to the Air Force mission support system I talked about, and the TAMPS was in fact used by all six carrier groups and all of the Marine Corps Air Wings. This capability came on-line late, literally in the final days of the campaign, so it wasn't used as much for operational, but the users did say that for those few days, it was a highly valuable capability, and that if it was available from day one, they definitely would have used it.

I want to qualify the last bullet very carefully. LANDSAT

was not in fact used for targeting the cruise missile. It was not on-line. But LANDSAT will be used for deriving the types of information you need to put in the guidance system in cruise missiles. For choosing the areas where, for instance, it would have to make its turn point, you would have to program that into the guidance system.

Next slide, please.

That's it. Thank you very much.

The CHAIRMAN. Before we start the questions, we have a brief video, which is going to be given to us by Mark Bromley from PRC, and we think that this is another very effective device.

Mark, would you go ahead with that?

Mr. BROMLEY. The video you're about to see was actually prepared under Air Force Project 2851. It's administered by the Air Force, but it's really a tri-service program, and the purpose is to standardize the digital data base of products that will be used in training simulators in the future.

This is the first true step we had to demonstrate photo texture, and it's photo texture independent to the rest of the data base at this point. So the video you're about to see basically is a preview using the photo texture. It was prepared by Image Data Corp. It consists of 7,600 still frames that were then spliced together. Ideally, the actual

weapons system trainer is the simulators themselves. We do this in real-time. We did not use DTED in this case; it is going to be used in a later version of it.

This is a natural color image. It's made from both LANDSAT and Spot. The dates of the LANDSAT data given to us by EOSAT was August 15, 30, and 31 of 1990, and the Spot data was given to us for September 16, 1990. The data base was actually prepared in the December-January time frame of this year and was distributed shortly thereafter. This is a natural color image. It is not a true color image. It is not made up of red-green-blue light wavelengths; it's actually made up of red and two infrared bands. It was determined that this was the best combination to portray natural colors in a desert environment. The image processing was done by Trifid Corporation. You can see even some of the sensor artifacts, some of the striping in the water actually kind of looks like waves. You can see some of the current patterns in the water texture itself. Very realistic looking.

The video will fly around Faylakah Island and then head out over Kuwait City. There are approximately three LANDSAT scenes in this data base and two Spot scenes that were used. The next version of this tape will basically raise some of the building structures, apply photo texture to the building structures to give it more of a three-dimensionality. You

can get a feel for some of the resolution in this. It's going to fly over an oil tanker, and you can actually see the impression created by the wake of the oil tanker. The data was delivered to us approximately in the October time frame, so it was fairly timely in its delivery. The resolution is good enough you can see the actual traffic island on the highway here by the Key. You can see there's also a fire in the downtown Kuwait government area. Again, later on we'll raise some of the buildings.

We also purchased Sojuzkarta stereo pairs to use in the analysis, and it turns out a couple of days after this image was acquired, the boats that you're seeing just coming onto the screen were actually gone at that point. Vegetation is green, and that was supported. As you approach the Kuwait International Airport, you'll see there are objects laying on the road. We never did determine what they are right there. Again, you can see the kind of resolution you can get from commercial sources. This data base was built primarily with all commercial sources. And the oil fields that are currently on fire.

We found that the Spot data itself was very good for simulating night vision systems. The LANDSAT was very good for simulating daytime operations due to the color hues that you're seeing. The Sojuzkarta data that we did not use in this video was actually purported to be about three- to

five- meter resolution. There's the capability to add haze factors and an artificial horizon. The program is currently finishing up its prototyping stage and is moving into an interoperation stage, where we'll crank out sample data bases for distribution to both government agencies and the private community.

If there are any questions, I'd be more than happy to answer them.

The CHAIRMAN. Thank you very much, Mr. Bromley.

Let me recognize Mr. McCurdy first for any questions that he might have of this panel.

Mr. MCCURDY. Thank you, Mr. Chairman.

First of all, I want to thank General James and Mr. Gordon for their testimony. General James has appeared before our committee on a number of occasions, and we did so in our committee, but I think it's important that we do so here as well. If there was a success story that perhaps was not heralded enough in the Gulf War, it's the performance of the Defense Mapping Agency. They worked overtime and spent countless hours gearing up to produce the maps that were needed for Operation Desert Shield and Desert Storm, and the tons of maps and paper that was delivered on time and in a very relevant fashion was truly a success story, and we commend DMA for that.

General, a Department of Defense review completed last

year concluded that LANDSAT is ''mission essential'' for the Defense Mapping Agency to support broad area coverage and map preparation. Would you describe the tradeoffs between using LANDSAT imagery and other imagery sources, such as the French Spot System, for these DMA applications?

General JAMES. Well, yes, sir. Thank you, Mr. Chairman, for your remarks on the success of the agency in support of Desert Shield/Desert Storm and our military forces and the Department Defense.

Reference your question, you heard some testimony about how Spot was merged with LANDSAT, and that does enhance LANDSAT because, of course, it has better resolution, and as I said earlier, for the military map making purposes, 10 meters is not good enough. No doubt, it's better than 30 meters. Of course, it's monochromatic, so you don't get the multispectral view.

Mr. MCCURDY. But I think we probably should operate on somewhat of an assumption here, and that is the basis of our hearings is to determine whether there would be support as we go to the next generation of LANDSAT, and you might, without going into areas that might be classified, indicate the benefits and some of the criteria that you would like to see available from the broad area search but by incorporating that upgraded technology into a LANDSAT 7.

General JAMES. Congressman McCurdy, it's a true statement

that we have a backlog of work in the Defense Mapping Agency using the current systems. I have told the committee that it takes better resolution, stereo pairs, and we have to be able to fix that system into space. Therefore, it would be highly beneficial to the Defense Mapping Agency if we had a source, a collector, that had that kind of capability. It would help us work our backlog, and since we are charged with mapping the world and you have to use satellite imagery to get to those places that you would be not at access otherwise, that would be useful to us.

It would have to be a significant improvement in that you would have to have a three- to five-meter resolution, for example. It would also--if we take a system like LANDSAT and improve it for the Defense Mapping Agency, it would improve it for the rest of the Department of Defense users without question and solve some of the broad area search, multispectral needs that we have. It would also get us out of the foreign market for buying Spot.

It should cause all of us some concern, I think, when we hear that we used a lot of French Spot in order to do work in a war. That kind of capability may be limited next time, may be shut down next time, and we in turn may not have any capability of our own.

Mr. MCCURDY. Thank you, General.

Mr. Chairman, in the interest of time, I'll yield back my

time.

The CHAIRMAN. Mr. Shuster?

Mr. SHUSTER. Thank you, Mr. Chairman.

The May issue of the Armed Forces Journal contained an article on the use of Spot images during the Persian Gulf War. The article reported that 108 Spot scenes were purchased during the conflict and that these images contributed to bombing missions against downtown Baghdad and other high- priority targets, including the surgical strike that cut off the flow of oil into the Gulf. Can you comment on the accuracy of this information?

General JAMES. Congressman Shuster, no, sir, I can't comment on the accuracy of it. I would say that as the DOD purchaser of such imagery for whoever the customer may be in the Department of Defense, we did buy a lot of Spot scenes, and as you have heard testified to, the Air Force uses Spot imagery to help make their mission planning system work. I would say that certainly the United States Air Force uses Spot imagery for pre-planning study. It won't give them the precision they require on the target, but to plan a mission or to see what the terrain looks like when you combine, for example, LANDSAT and Spot and you drive it through a computer system, like you just saw in that presentation, it is useful for planning the mission. For the precision you require, you require something even better than Spot.

Mr. SHUSTER. When you talk about ''mission essential,'' can you tell us whether the different organizations involved in the review that came to this determination were asked to rank the importance of LANDSAT against other DOD programs? Just exactly what do you mean by ''mission essential''?

General JAMES. Congressman, I'm not sure I understand or that I can answer that question. Can I ask for some help?

Mr. GORDON. The survey that you're talking about, first of all, is about 18 months old now, so if we were to resurvey, I'm sure we would get some different results. But certainly the organizations that identified LANDSAT as ''mission critical,'' it should be understood that that's for a specific function. In other words, it's not that it's mission critical to the entire organization; it's mission critical for some specific mission within that organization.

I believe DIA, SAC, DMA, SPACECOM, Special Operations Command, Forces Command all had some tasks that they considered critical. Certainly, this was not a net assessment. In other words, this is what we would call an unconstrained requirements call. The important thing to understand is that an unconstrained requirements call does not demand any sacrifice to be made by the person responding, and so they will just flat tell you that, ''Yes, we need something to make something better.''

Mr. SHUSTER. I understand, and, therefore, it perhaps

suggests that that kind of a call isn't as significant as one might otherwise think. Stated another way, if indeed DOD were to say it's mission essential, then we could perhaps say then DOD should put up more money to see to it that LANDSAT 7 gets built, and if DOD isn't willing to put up more money, then maybe it isn't that important.

Mr. GORDON. I would suggest that if this was a constrained data call--that is, people were asked to rack and stack those requirements against the chance of losing some other capability--that the results could be expected to differ.

Mr. SHUSTER. Well, maybe we're going to need that kind of an evaluation.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Mr. Shuster.

Mr. Wolpe?

Mr. WOLPE. Thank you, Mr. Chairman. I do have just one question.

Obviously, the LANDSAT system is as valuable for purposes of environmental monitoring as it is in terms of meeting our national security requirements and defense needs. If you had a high-resolution system of five meters in the future, what would be the DOD's response to the question of civilian access? Would there be an effort to try to deny civilian access to that data for fear that our potential adversaries could use the information in some way?

General JAMES. Let me try to, if I may, sir, give you the DOD view about LANDSAT that's been given to me, and that view is that the LANDSAT Program should continue within the civil and commercial sector and that DOD would then remain a customer. However, realizing that the program is funded only through LANDSAT 6, DOD is currently reviewing the options with respect to future multispectral data acquisition to include an assessment of requirements as well as possible technical and operational alternatives. That review is expected to be completed in sufficient time to influence the fiscal year 1993 budget if necessary and considered feasible, but DOD does have requirements for multispectral data in several areas and accounts for a large part of what Government LANDSAT data purchases amount to.

As far as if you made it so good that the commercial sector couldn't get to it, I don't know the answer to that, sir. I don't know at what point it becomes so good that you suddenly end up in the classified arena.

Mr. WOLPE. How is the present situation handled when it comes to third party purchases of this kind of data? Like during the war, our Government, I gather, issued instructions to the LANDSAT contractor not to sell any of the data to the Iraqis, and the French did the same with respect to theirs. What about third party purchases? How is that addressed under current law?

Mr. GORDON. It's my understanding, talking with folks in the LANDSAT and Spot organizations, that they would only sell to people that they knew were either government or had some sort of government association--for instance, contractors working for DOD--and that it was their decision -- that is, the Spot folks and the LANDSAT folks--not in fact--to do everything they could to prevent that imagery from falling into Iraqi or ''third party'' hands.

Mr. WOLPE. But in other words, you're saying this is discretionary with the contractor? This is not a matter of our own Government direction and contractual understanding with the contractor?

Mr. GORDON. Well, in those cases, of course, the Government entity would decide that they did need a contractor to work with the data, and perhaps that contractor might buy the data directly from Spot or LANDSAT, but it would be a witting situation--that is, Spot and LANDSAT would understand that the data would be under our control.

General JAMES. As far as purchasing LANDSAT and Spot data today, the Defense Mapping Agency is the middleman for those purchases for DOD users, but certainly no Third World people are asking me to purchase. If DOD managed a system like LANDSAT, then that would solve that problem that you're asking for.

Mr. WOLPE. That's right, but under the current system, that's not the situation.

General JAMES. That's not the situation at all for either Spot or LANDSAT.

Mr. WOLPE. I mean, is the answer--if a LANDSAT contractor were to sell this data to a third party or another country's source that presumably was a secure source compatible with our interests, are there any specifications in current laws as to trying to condition those sales upon such understandings about subsequent sale to third parties?

Mr. GORDON. I'm not aware of any laws that are specific to the reselling of LANDSAT data. I think that's an ad hoc situation.

Mr. WOLPE. Okay. Thank you.

The CHAIRMAN. Mr. Packard?

Mr. PACKARD. Is there a significant difference between the usefulness and the quality of work done by Spot versus LANDSAT?

General JAMES. Congressman Packard, from the map-making viewpoint, it provides better resolution; therefore, the quality of the imagery is better. But as I told you, to genuinely make a product that's unique for military purposes with the precision required, from a map-making viewpoint, neither is preferred. There are preferred alternatives as they're currently configured.

Mr. PACKARD. Assuming that LANDSAT 7 will go forward and funding will be made, are those that will be using LANDSAT 7 in agreement on the design and the configuration of the satellite, or are there--are you working with those that would also be using it?

General JAMES. Certainly, in the Defense Mapping Agency we're working with them, sir. It's under study right now in the Department of Defense by the Department of Defense users, and from our viewpoint, we have given them the kind of requirements that we would need on LANDSAT 7 to make it a useful map-making tool for the Department of Defense, and I've specified those requirements. But all the major players are involved in a study at this time on this subject.

Mr. PACKARD. Thank you.

Thank you, Mr. Chairman.

The CHAIRMAN. Mr. Kopetski?

Mr. KOPETSKI. Thank you, Mr. Chair.

I was just curious about whether there is a race going on at all in terms of the Soviet Union, and are they moving in these technologies at all?

Mr. GORDON. In the commercial arena, it's really an interesting subject. The Sojuzkarta, which is a Soviet so-called civil system, is being marketed throughout the world. In fact, they're looking for U.S. private interests as a

sales cutout to sell Soviet Karta data in the U.S. The thing to keep in mind here is that Sojuzkarta is a film return system. That is, it's not downlinked. So one would have to put film in the system, launch the satellite, and retrieve the bird to process the data, unlike LANDSAT and Spot, that are downlinked, so that one has the data soon after you actually take the picture.

So many of us think that Sojuzkarta really doesn't play too strongly, but that would be a distortion, because there are potential users who really don't care if the data is all that old, and the spatial resolution of Sojuzkarta, I believe, is around five- or six-meter spatial resolution, so we have a rather ironic situation here, where our friends, the Soviets, are releasing five-meter data; however, they're not too anxious to release data over their own country.

Mr. KOPETSKI. And one can understand why. Who do you think--is it an open market, or are they limiting--have they targeted potential users?

Mr. GORDON. I don't think that we have enough experience really to set down any patterns at this time. From the Department of Defense standpoint, we've looked at some of the data, and the products we've gotten from them have been quality-wise not as good as we think they could be doing. Photo processing and such is not what we would consider to be top quality. We're not that interested in it.

Mr. KOPETSKI. And what about--I mean, we're not interested in it, because you're saying that, I mean, our technology and the potential enhancement of our technology is much better. Is that correct?

Mr. GORDON. I would say using a combination of the French Spot 10-meter panchromatic data that is black-and-white data digitally integrated with LANDSAT 30-meter multispectral is in general a much, much better product than Sojuzkarta. I find that most of the users in DOD at one time or another will integrate those two datas. Also, when you compare LANDSAT and Spot, it's kind of like comparing apples with orangutans. It's a really different situation. LANDSAT, even though it's 30-meter spatial resolution, is much more spectrally interesting than the Spot data, many more spectral bands to work with, and the DOD user community has gotten quite sophisticated in using that spectral data.

Mr. KOPETSKI. Do you know if the Soviets are trying to -- if their potential clientele includes terrorist organizations?

Mr. GORDON. That would be a very difficult question to answer, depending on from whose viewpoint, I guess. Once you sell civil data, you have to assume--as brought up earlier, third party organizations can certainly buy data for anybody, so the basic assumption is, when you get in the civil game, that once that data is sold freely that anybody

can wind up with the data.

Mr. KOPETSKI. Do you know if the White House, the Administration, is having any discussions with the Soviets in terms of limiting the kinds of clientele one might sell this kind of information?

Mr. GORDON. I know of no discussions.

Mr. KOPETSKI. Okay. Thank you.

Thank you, Mr. Chair.

The CHAIRMAN. Mr. Geren?

Mr. GEREN. Thank you, Mr. Chairman. I have a question for Mr. Gordon.

Mr. Gordon, I was particularly intrigued by the Kuwait fly-over video. Would you just go into greater detail about how that is generated, and also, how much time does it take to do something like that? Could the DOD do that virtually anywhere in the world? Just give us a little more background on how that work product came about.

Mr. GORDON. Certainly much credit is to be given to the free enterprise system. We view computer technology today as kind of a candy store. We've got so many goodies out there, it's sometimes hard to make a choice, and the processing power in recent years has become so good so fast that you can look out in the marketplace and configure a workstation to put that, and the hard part is, of course, the software. So the companies you see in the

demonstrations, for instance, have put considerable talent into that software.

I've seen the capability of doing that change drastically in the last couple of years. You'll see ''L.A.,'' the movie. It took literally days of computing to make that movie a couple of years ago. With a specifically designed workstation to do that, instead of days, you're talking about hours, and I think pretty soon it's minutes, and we're getting to the standpoint where it's going to be interactive real-time. In other words, you'll be able to sit there with a joy stick and actually at video rates--it will be a few more years yet-- video rates actually do it in real-time.

So we have plenty of opportunity to make use of that data, and at the command level and at the unit level, those folks are in fact obtaining that equipment.

Mr. GEREN. How expensive would it be to produce the images that we saw?

Mr. GORDON. I'm sorry. Again, please?

Mr. GEREN. How much would it cost to do the Kuwait fly-over?

Mr. GORDON. Well, the cost in producing the fly-over is not just the equipment itself, but the manpower going into it, but I would say that you could buy a system today to do the computing for in terms of under $100,000. Now, it's always with hesitancy that I price something like that,

because the peripherals, for instance, can often outcost the basic unit. If you start talking about how you convert to hard copy and how you put that stuff together, it can run up into hundreds of thousands of dollars. But if you had lots of time, you could certainly put one together and use it if you had a lot of time to integrate the data for under $100,000, maybe even under $50,000.

Mr. GEREN. How much does DIA typically spend per year on LANDSAT data?

Mr. GORDON. It would vary. I would say that we would probably purchase somewhere around, at present rates--now, I'm not going to talk about Desert Storm, because hopefully that's not going to happen that often--but we would probably purchase between $1 million and $1.5 million at present rates per year. Keep in mind, of course, that DMA is the organization that actually purchases the data for us.

Mr. GEREN. Thank you, Mr. Chairman. I have no other questions.

The CHAIRMAN. Mr. Slaughter?

Mr. SLAUGHTER. No questions.

The CHAIRMAN. Mr. Sabo?

Mr. SABO. How wide an area does LANDSAT cover, and how quickly can you target an area? Excuse me. The question was, how large an area do you cover in a fly-over of LANDSAT, and how quickly can you target an area? Also, part

of the question--to what degree can you image through clouds or smoke, as in the case of Kuwait?

Mr. GORDON. You don't see through clouds. I'm afraid there's no magic here. We all wish we could.

Mr. SABO. Pardon me?

Mr. GORDON. We don't see through clouds with any of this type of data. You can pick special bands so perhaps it would see better through light haze better than black and white imagery, for example. LANDSAT frame is 100 nautical miles by 100 nautical miles. Those fly-throughs you see are considerably less than that. They would pick a slot through LANDSAT frame and only use that data for the fly-through, and so you're probably seeing like from horizon to horizon maybe 30 nautical miles at the most.

Mr. SABO. And how long does it take you to--if I said tomorrow I want this area targeted for a fly-over, can you do it, and how long is it?

Mr. GORDON. The LANDSAT satellite--if you did not have the data in storage somewhere and you had to have it collected, then you might have to wait for--we have two birds up now--you might have to wait for eight days for the next opportunity to collect. If it's in storage and if it's an emergency situation, LANDSAT or Spot would react for an emergency situation, so that we'd probably have the data in our hands in hours. We could have it in our hands in six to eight

hours.

Mr. SABO. I guess I'm not following. From the time of fly-over until you get it, it's six to eight hours?

Mr. GORDON. You mean from the time the satellite imagery is taken?

Mr. SABO. Yes.

Mr. GORDON. Yes, it could be--if you have to have new data taken and you're not using historical data, you may have to wait as long as eight days for the satellite to be over the area of interest and to take the picture.

Mr. SABO. Okay. Now, how long would it take for you to get it back a second time in roughly the same area?

Mr. GORDON. Best case was that oil fire situation, and we in fact got the data, processed it, and released information within 24 hours. So you can--under ideal circumstances, from the time it's taken and if it's taken that day, you can have analyzed the data within 24 hours.

Mr. SABO. Okay. But if you wanted a second image of the same area?

Mr. GORDON. Then you'd have to wait for the next access, which would be eight days later with two birds flying. So it's not what we would call a quick reaction system. You can't count on having access to the target every day, for instance, or every couple of days.

Mr. SABO. I'm just curious. What happened with the oil

spill into the Saudi water supply?

Mr. GORDON. You mean in terms of how did we use the data for--

Mr. SABO. No, I'm just curious what happened. You know, I recall the reports were we thought it was going to destroy their water supply, and I--

Mr. GORDON. Oh, that was interesting.

Mr. SABO. I don't know what happened.

Mr. GORDON. The Army Corps of Engineers has got a real great story there and also the Department of Commerce, NOAA. The winds shifted fortuitously during that time period, and to our utter amazement, through the NOAA AVHRR data and through LANDSAT, we saw it inch toward the shore, then back off, then go north, then go south, against all weather predictions which said that, you know, the wind should shove it down along the shore, so we certainly lucked out in that situation to an extent. So it didn't become the threat to the--

Mr. SABO. The wind sent it elsewhere.

Mr. GORDON. Yes, it played with it. We were amazed. We said, ''Here it is today, there it is today,'' and it was just meandering about.

The CHAIRMAN. Mr. Gilchrest?

Mr. GILCHREST. Thank you, Mr. Chairman.

Mr. Gordon, during the video, the simulation, you said or

one of you said that it was from commercial sources. Does that mean it wasn't from military satellites?

Mr. GORDON. Oh, I meant the image processing equipment that did the work for that. All the processing, all the digital machinery and software, was from commercial sources. No, the data itself was from commercial satellites.

Mr. GILCHREST. Oh, the data was from commercial satellites?

Mr. GORDON. Right.

Mr. GILCHREST. Then the DOD put it together for this simulation?

Mr. GORDON. That particular viewing was put together for a military project by a commercial entity. We can do that ourselves within DOD.

Mr. GILCHREST. I see.

Mr. GORDON. In certain organizations.

Mr. GILCHREST. When LANDSAT 6 goes up, it will be a much-improved version of the things we've seen and heard today? I mean, as far as the spectral images and things of this nature are concerned. Or is this going to be similar to what we have?

Mr. GORDON. No, it will be different. The LANDSAT 6 satellite will have a 15-meter sharpening band, we would call it. It's a black and white or panchromatic band. The rest of the LANDSAT 6 will be quite similar with LANDSAT

today, but that 15-meter panchromatic band will be used with the 30- meter, and the spatial resolution of the entire product will be more like 50 meters rather than 30 meters, so that's--

Mr. GILCHREST. A little improvement.

Mr. GORDON. Numerically, twice as good.

Mr. GILCHREST. So then we're hoping with LANDSAT 7 it will be down to five?

Mr. GORDON. The requirements that we submitted to the Department of Commerce--and this is now a little old, this is a couple of years ago--I chaired a panel which put together requirements for DOD, and we stated in that particular unclassified document that we would prefer to see a system that had five-meter spatial resolution.

Mr. GILCHREST. So it's very possible to have five-meter spatial resolution, and it's nothing that's out of reach?

Mr. GORDON. Well, there's sort of a tradition in the civil community, any entities that work with new systems, and that's that when you produce your requirements, it's relatively technology independent. That is, we in the user community do not want to tell the engineers how to do their job. We just give them the requirements, and then they determine how they would do that. So I guess there would just be an assumption that five-meter spatial resolution is doable today, but it's always the same: for what amount of

money can you do five-meter spatial resolution?

Mr. GILCHREST. Well, looking at the LANDSAT--let's say LANDSAT 6 or LANDSAT 7--is there any way to coordinate, understanding that it takes--let's say if you need a particular area photographed and it might not be in that area, you might have to wait eight days to get that picture. Is there any coordination or way that that same satellite can be useful for environmental purposes and useful for military purposes?

Mr. GORDON. I have observed that the use of LANDSAT data within DOD is so varied, we have so many different tasks and missions, whether it's at the national level here in Washington or particularly if it's in the commands, there are so many different objectives that they pretty much cover the waterfront, and the civil community would probably conclude that, by and large, the Department of Defense requirement for multispectral data is quite close to their own requirements.

I would think the only time that you would part company in this concept is if we went into what's called hyperspectral data, where instead of seven bands, for instance, we're talking about hundreds of bands. I don't really personally see that this is financially doable in the near future. When we get to that, then indeed specific narrow bands are at issue, and maybe a geologist would have some requirements

that we have no use for in DOD and vice versa.

Mr. GILCHREST. When the LANDSAT satellite goes up, I suppose it's in a permanent fixed orbit. I mean, you can't move it to different areas for different purposes once it's in orbit.

Mr. GORDON. Yes, I would guess that would be true in any LANDSAT follow-on. Also, in our DOD submission to the Department of Commerce, we did say that we needed more frequent revisit times. That would mean that a satellite would have to be designed so it can look out. The LANDSAT is called a nadir system. It looks straight down and that's it.

Incidentally, that's a tradeoff. In other words, there are advantages to that. Every time you come back to that area, it's exactly the same as it was last time, and you can integrate the data better. When you start clicking off to the sides and so on, you give up some of that. So it's a tradeoff.

Mr. GILCHREST. This is the last question, Mr. Chairman.

Is there ever a use--and I think there are certain satellites up there that just fly over the same spot. In other words, they rotate at the same rate that the earth rotates, and the same area is photographed constantly. Would there be any use for that in LANDSAT programs?

Mr. GORDON. Yes, if we had an intense interest in India,

but it stays on the equator. In other words, it's an equatorial launch in synchronous orbit. So if you have targets that are near the equator, that would work, but it doesn't work for more northerly or southerly targets. So that's why LANDSAT and Spot speak of polar orbit, so that they can go around the earth from pole to pole, and then the earth obligingly turns underneath it, so you have access to the entire world.

Mr. GILCHREST. Thank you, gentlemen.

Thank you, Mr. Chairman.

The CHAIRMAN. Ms. Horn?

Ms. HORN. Thank you, Mr. Chairman. I have no questions.

The CHAIRMAN. Mr. Glickman?

Mr. GLICKMAN. Thank you, Mr. Chairman.

I'm not sure this question was asked or not, but I want to go back to LANDSAT 7 and concerned about the impact if we don't build it and whether foreign satellite systems would be the only sources for multispectral, broad area coverage imagery. I wonder if you could comment on that, either one of you.

Mr. GORDON. If we don't produce a system, then in DOD we would certainly use any source of data we could--and maybe even including Sojuzkarta if they improve theirs--that we can get our hands on. We're quite pragmatic about the situation. When it comes to national defense, we're going

to use everything, every possible source we can get.

Mr. GLICKMAN. What is there to use is what I'm saying. Give me what's out there.

Mr. GORDON. The French Spot would assumably be around. The French Spot folks would tell you that they have already budgeted and planned for many years out, out to Spot 4 and 5, when they plan on making a change or improving the system out there, and they certainly will tell you that they have no problems in those areas. They've got the money, they've got the money in the books, and they've got one on the shelf, and they'll have one on the shelf. So if you can believe them, then we'll have a spot to look out of.

Mr. GLICKMAN. And is that of the quality that would provide you what capabilities you would need?

Mr. GORDON. Spot does not have the spectral characteristics of LANDSAT, so we would take a hit there, but we might be able to also use Japanese data. The Japanese are working on a system. They've got a system up right now, but it's no real advantage to us. In other words, it doesn't advance--it doesn't give us any better data than we've got access to right now, but they do plan on launching an improved system, I believe, toward the mid-1990s, which would have an improved spatial resolution and spectral resolution.

The Canadians plan to launch something called RADARSAT,

which will give us radar data around--I forget the exact spatial resolution, but I think it's somewhere in the 15- to 20-meter spatial resolution. And then depending on how you believe, there are several other countries who claim that they're going to get into the business as well, but I tend not necessarily to put a lot of faith in--

Mr. GLICKMAN. But you do believe that the French and perhaps the Japanese--

Mr. GORDON. Definitely the Japanese.

Mr. GLICKMAN.--will be heavily involved in this and that at a minimum, we could use their technology, and at a more serious rate, they could leapfrog us in terms of their satellite capability.

Mr. GORDON. If they keep on putting money in it, yes. It's interesting to note, however, that when the Japanese made the decision to create their own sensors and detector, which is a very arduous task, getting into detector technology, they had an argument within their country as to ''Why don't we just go to the U.S. because they do it best?,'' right down to the company that was making them, and they made the decision not to go to the U.S. because they wanted to build up the national capability in that area.

Mr. GLICKMAN. Okay.

General James, do you have any comments on my question?

General JAMES. Only from a map maker's standpoint, sir.

Multispectral capabilities provide us limited new data over what we already do. We do use it for determination of soil composition, moisture content, we identify water/land boundaries and some hazards, but to have the multispectral capability wherever, it enhances what we do, but it's not a live or die for the Defense Mapping Agency work.

Mr. GLICKMAN. What about for--and I'm not sure either one of you can answer this--but for the kind of environmental problems that this earth may have over the next 20 or 30 years, trying to anticipate what they might be, from volcano eruptions to fires to I'm not sure what else we're talking about, but is a LANDSAT 7 significantly important in understanding what environmental degradation there might be to the earth over and above what we have now?

Mr. GORDON. I can only--well, not only. I think the best is to probably refer to NASA's statements earlier, years ago, when they stated that work that they were going to do on, for instance, the EOS observation system depended in some measure on a continuing LANDSAT Program. That is, that the environment is obviously quite large and that all these little -- this is my personal opinion--all these little tiny instruments that are going to look at a spot--which I'm not terribly interested in, so I'm prejudiced--they're great.

They do immense measurement of all different types for a small area, but you need context, and so in any

environmental situation, just like in mapping and just like in intelligence, one needs the big picture, and one needs basic spectral information over large areas, and so that's I guess a rather long answer to your question, saying yes, of course, these types of satellites are going to be very important to civil environmental problems.

Mr. GLICKMAN. Thank you very much for your testimony.

The CHAIRMAN. Mr. Volkmer?

Mr. VOLKMER. No questions.

The CHAIRMAN. Gentlemen, let me just ask you one question. Both of you have testified directly or indirectly that LANDSAT provides certain unique value-added characteristics because of its multispectral capability, and both of you have indicated that it could be improved upon by certain technical modifications, and that other nations are moving in the direction of developing sensors that provide both higher resolution and multispectral capability. We're debating whether to continue with the existing system.

Let me just ask you this. Have I correctly interpreted your testimony that this is a unique system, that it needs to be upgraded, other nations are upgrading theirs, and we're debating whether to continue ours? Is that about the situation?

General JAMES. Mr. Chairman, answering for the Defense Mapping Agency, again, I can tell you the Department of

Defense is studying this problem. It is some concern, because multispectral imagery is required by many DOD users, and, of course, I have personal concerns that this Nation should have some capability of its own rather than buying or leasing or renting it from someone else. So yes, sir, I think you've interpreted my remarks. My specifics about what it would take to make a military map is strictly military map-making business.

The CHAIRMAN. I don't think the lack of LANDSAT would put you out of business.

General JAMES. No, sir.

The CHAIRMAN. But you have testified that it does give you certain unique capabilities.

Mr. Gordon?

Mr. GORDON. It's probably a good point to mention that a lot has been made of DOD being the major customer for LANDSAT data. I've seen the use of the data grow over the past several years, and it's to my chagrin that I think that the reason for this is not that we're necessarily buying all that much data, but that the civil market itself has not gone as far as it could go, mainly because--and I think this is extremely important--it's hard to sell your boss on new equipment and to analyze this data when you can't guarantee him that you're going to have a source of data in the future.

So let me submit that one of the reasons why we look like the largest customer is because in the civil community, the investments have not been made to in fact take advantage of this data, and I think they would have been made if in fact there was a continuing LANDSAT Program, and I think right now the civil uses of LANDSAT data are vastly underestimated in potential. I still firmly believe that the biggest use of LANDSAT data is inherently in the civil community, but what we have here is an aberration where we have increased our use of that data at the same period of time when the civil community has either decreased its use or in fact has chosen not to get into those areas.

The CHAIRMAN. Thank you very much. The civil community is probably not developing its market potential for perhaps the same reason that some of the Government agencies aren't, that the system--there's no guarantee of it, it doesn't meet all of their qualifications, the market would be better if it were five-meter resolution and faster turnaround and all that.

Mr. VOLKMER. Mr. Chairman?

The CHAIRMAN. Mr. Volkmer?

Mr. VOLKMER. I'm sorry I was late and didn't get all the questions that have been addressed.

The CHAIRMAN. We accept your apologies.

Mr. VOLKMER. This may have been addressed before, and if

it was, just say so, and I'll just find out from staff. But the question is, does the military have any plans in the future for a LANDSAT type of satellite?

General JAMES. That question was answered, Congressman.

Mr. VOLKMER. Okay.

The CHAIRMAN. Thank you very much, gentlemen. We will want to perhaps call one or both of you back when we have subsequent hearings with regard to some of the policy issues. I'd love to take them up with you now, but that wasn't our purpose, and we very much appreciate your testimony. Thank you.

The next panel will be invited to come forward at this time, and it includes Dr. Peck from the USGS, Dr. Corell from National Science Foundation, and Dr. Rock from the University of New Hampshire.

We're going to take about a 10-minute break to go answer the roll call, gentlemen, and if you'll just relax and have a cup of coffee, we'll be back with you as quickly as possible.

[Recess.]

The CHAIRMAN. Would the audience resume their seats and the panel come forward? The members are a little slow returning from the roll call, but I think we need to get started anyway.

This next panel is going to talk about the scientific and

global change applications of LANDSAT. It's rather interesting that the first panel discussed the use of LANDSAT data by the military, which turns out to be meeting a real-- although still I think a niche--need as far as the military is concerned. It's widely rumored that they have a system of their own which is considerably better than LANDSAT for most purposes but doesn't have the multispectral coverage that LANDSAT does, so LANDSAT meets that need.

The witnesses before us now will speak with regard to the scientific aspects of LANDSAT, and I'm going to insert in the record after their testimony a letter that the committee has received from Dr. Goward, the Director of the Laboratory for Global Remote Sensing Studies at the University of Maryland, because it has a couple of sentences that kind of define how LANDSAT started, and I thought I'd read them.

It says here, ''LANDSAT, from its origin, was developed to monitor land vegetation growth and related environmental conditions. The specifications for the spectral bands, radiometric resolution, and spatial resolution were all developed with the intent of monitoring activities such as agriculture, forestry, resource exploration, and urban/suburban development. Interestingly, the spatial resolution was constrained more by national defense considerations than technological limitations.''

Without objection, I'll put the full text of this in the

record. But just as the system has shown itself to be sufficiently versatile to be useful to the military, it has also developed both scientific and other commercial uses which were not anticipated when it first began.

[A copy of the letter from Dr. Goward follows:]

********** INSERT **********

The CHAIRMAN. With those observations, let me welcome Dr. Peck as the first witness, and we'll have each of you present your testimony and then have questions.

STATEMENT OF DALLAS PECK, DIRECTOR, U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR, WASHINGTON, D.C., AND CHAIRMAN, COMMITTEE ON EARTH AND ENVIRONMENTAL SCIENCES; ACCOMPANIED BY: GENE A. THORLEY, ASSISTANT DIVISION CHIEF, NATIONAL MAPPING DIVISION, U.S. GEOLOGICAL SURVEY

Mr. PECK. Thank you, Mr. Chairman.

If I may, I'll place the full statement in the record and give you an oral summary.

The CHAIRMAN. Without objection.

Mr. PECK. I'm speaking today from the viewpoint of Director of the U.S. Geological Survey, and Dr. Corell will be talking more from the viewpoint of the Committee on Earth and Environmental Sciences and the Working Group on Global Change. I'm accompanied by Dr. Gene Thorley from our National Mapping Division, and as we go into questions, I may need to rely on him to help me answer.

I'd like to--under the leadership of former director William T. Pecora, the Survey has played a major role in defining the LANDSAT and technical specifications, and as a result, we've developed an active program of remote sensing research in the Department of Interior, and we've had responsibility for processing, archiving, and distributing LANDSAT data using our EROS Data Center in Sioux Falls, South Dakota.

The Survey is a major user of LANDSAT data. In the early years of the program, most of our cooperative research and applications development work was conducted with civilian agencies in the U.S. and other countries. In recent years, we've also worked very closely with the defense and intelligence communities on data products prepared to meet many of their information requirements, such as terrain analysis, image mapping, and change detection.

The Department of Interior used the 19-year LANDSAT data archive for many operational and research needs. In this case, I'd like to refer for the next minute or two to some of the illustrations that accompany my testimony.

The first one, for example, we've demonstrated that the extent of deforestation in the tropics can be assessed using LANDSAT and advanced very high-resolution radiometer--AVHRR -- data. The Figure 1 shows deforestations in Rondonia, Brazil.

We've also monitored urban area growth and the expansion of irrigated agricultural land, and the second illustration is of Saudi Arabia and shows the development of center pivot irrigation in north central Saudi Arabia near Riyadh, the capital.

We've also assessed the impact of volcanic eruptions, such as the Mount St. Helens eruption in 1980, and we've monitored the recovery of natural ecosystems of such areas

with LANDSAT data. So the next illustration is three panels, and it shows an image of St. Helens on September 15, 1973, before the eruption; an awesomely different one taken May 22, 1983, three years after the May 1980 eruption; and the third one taken at the end of August 1988, showing, particularly in the upper left-hand corner, a real change in the vegetation cover. I was in that area last week, and that vegetation has continued to grow and expand.

We've also assessed environmental changes such as changes in lake levels caused by a long-term drought or withdrawal of water for irrigation, and the last figure shows the significant drop of water level in the Aral Sea of the Soviet Union due to diversion for irrigation purposes.

I want to emphasize that comparisons like this couldn't be made without historical LANDSAT archive. The current policy is to acquire data only when a paying customer requests it. There's no Government plan with funding to place orders for repetitive data of the earth, so our future archive of data will not be as complete or as frequent as it used to be. This will continue to be a problem in the LANDSAT 602.

There are a variety of other applications of the data, as you're well aware. These include satellite image maps of the U.S. and foreign areas, including production of LANDSAT image maps to support operational counter-narcotics efforts in the U.S. and in poorly mapped areas of South America;

support for the Persian Gulf War and post-war environmental conditions; land cover mapping in Alaska, which we've completed for more than 250 million acres; wildfire monitoring--the assessing of impacts and recovery monitoring in Yellowstone National Park; monitoring changes in glaciers and sea ice. A particularly good example is the breaking away of enormous blocks of sea ice from the Antarctic ice shell.

We use LANDSAT data for mineral assessment of the United States to identify and analyze potentially mineralized areas and rock alteration zones. Mineralized areas near Reno are identified by Thematic Mapping data, as shown in the exhibit room next- door. LANDSAT data for mapping and identifying geologic structures for hazard assessment, particularly as it relates to earthquakes, volcanic eruptions, and landslides. Finally, the use of LANDSAT and Spot data for map revision and satellite image mapping. Research in this area has demonstrated the value of higher spatial resolution in the stereo imaging capability of Spot.

We continue to maintain the U.S. Government archive of LANDSAT data through direct appropriations to our annual budget. We recognize how important it is to preserve the LANDSAT archive for global change research and as a base line for environmental assessment. To do this, we're taking steps to convert the U.S. archive to a stable storage and

reproduction media. This is essential, because the data are currently stored in different formats, and they are becoming unreadable due to the degradation of the tapes and obsolescence of the processing system.

We're now distributing all LANDSAT MSS data more than two years old, because EOSAT released these data from their exclusive marketing rights. Access to these data at the cost of reproduction and distribution is increasing their use for global change research and other change detection applications.

As you can tell, we have a high degree of interest in the future of the LANDSAT Program. We continue to represent the Department of Interior in working groups and studies on the LANDSAT 6 follow-on system. We are an active member of the CEES Task Group studying the value of LANDSAT to the U.S. Global Change Research Program under Bob Corell's direction. And our role as Chairman of the Civil Applications Committee, we provide an important interface so that civil Federal agencies can become aware and make appropriate use of the Department of Defense capabilities. The CAC could serve as a mechanism for ensuring that civil requirements for LANDSAT- type data are adequately represented in the Department of Defense planning.

We also support NASA's EOS Program. Our EROS Data Center will process archive and distribute land-related data from

EOS sensors. Our longstanding participation in the LANDSAT Program provides the basis for a continued USGS role in several management options for the LANDSAT 6 follow-on program. Regardless of the option selected, the Survey will continue to maintain the Government's permanent long-term LANDSAT archive of existing data and will also address the issue of how data from commercially operated systems, such as LANDSAT 6 under EOSAT management and Spot, can be acquired and preserved for long-term use by Government and civilian users. The Survey will continue to provide a LANDSAT information and inquiry capability, and as part of the U.S. Global Change Research Program, we are developing a global land information system, which is a computer-based inquiry system. That system will provide users with information about land-related global change data, including LANDSAT.

We're always looking for more opportunities to provide international linkages to our data bases. The EROS Data Center, for example, now houses the North American facility supporting the UNEP-GRID network, which exchanges information about environmental data on a worldwide basis.

Thank you for the opportunity to express the views of the Survey on this important subject. LANDSAT is important for many domestic, national defense, and international programs, and the public benefits from the use of LANDSAT in these

programs. We're prepared to participate in the conceptual design of future LANDSAT systems and in decisions about the most effective way to manage and operate the systems.

Thank you.

[The prepared statement of Mr. Peck follows:]

********** INSERT **********

The CHAIRMAN. Thank you very much, Dr. Peck.

Dr. Corell?

STATEMENT OF ROBERT W. CORELL, ASSISTANT DIRECTOR FOR GEOSCIENCES, NATIONAL SCIENCE FOUNDATION, WASHINGTON, D.C., AND CHAIRMAN, CEES WORKING GROUP ON GLOBAL CHANGE

Mr. CORELL. Thank you, Mr. Chairman.

It's a pleasure to be here this morning to testify on the use of LANDSAT in the U.S. Global Change Research Program. As you may know, I serve as the Chairman of the Working Group on that topic. What I'd like to do is outline a number of the aspects of the LANDSAT data issue and their relationship to the USGCRP.

First, let me outline the major objectives of the Global Change Program and the importance of LANDSAT data to meeting those objectives. Secondly, I thought I'd talk a bit about some of the complimentary satellite systems that are intended to support global change research and then say a word or two about the availability of LANDSAT data for global change.

First, the Global Change Research Program itself. It was established to provide a scientific basis for national and international policy-making related to natural and human-induced changes in the overall earth system, and to meet that broad objective, the CEES has established three specific objectives, one of which is very much tied to the LANDSAT issue, and that is the establishment of an

integrated, comprehensive, long-term program of documenting the earth system. In addition, the Global Change Program will conduct a series of focused or process-related studies to substantially improve our understanding of how the earth system works, both on global and on regional scales. Finally, all of this is intended to be integrated to extend dramatically our conceptual understanding and our predictive ability to understand how the earth works.

In doing that, the USGCRP set up seven scientific areas that would reflect the interdisciplinary nature of this complex research program, and it would give us a framework within which to set priorities so we could establish funding profiles that were realistic in terms of available dollars and yet clearly addressed the key scientific questions. One of the key issues that fell out of that analysis is that the research effort must be supported by a consistent, long-term set of repetitive measurements and observations into the mechanisms and processes that are associated with global change, and earth-orbiting satellites are an essential source of these data.

I'll say a word or two now about the needs more directly with respect to LANDSAT. Data from the LANDSAT series of satellites are particularly suited not only to monitor seasonal variation in ground cover, but also provide long-term understanding of the variation and changes in

standing vegetation biomass, biological productivity, land cover, snow and ice cover, the rate of deforestation, desertification, and an understanding of changes in fragile ecosystems.

LANDSAT data, which is consistent in format and characteristics, have now been collected without interruption for the past 19 years, and the existing LANDSAT data provides a unique base line of land conditions in the 1970s, 1980s, and 1990s that are not available from any other source. The President's policy to continue LANDSAT-type data supports our ability to monitor these changes in global environment that are occurring in response to climate and other environmental stress.

LANDSAT data is used to support a wide variety of efforts within the Global Change Program, and I thought I'd just touch on some of those more or less in a list. LANDSAT data is used to help us study the role of clouds; the role of land, atmosphere, ocean water and energy fluxes; the role of the cryosphere in global change; a whole host of topics in the bio and terrestrial area--terrestrial biosphere nutrient and carbon cycling, terrestrial inputs to marine ecosystems, and so forth. One of the areas in which it is a substantial contributor of data is in the broad area of ecosystems and dynamics, and there's a whole host of things which are outlined in the written testimony.

Similarly, as we understand the anthropogenic inputs to global change, or, as we call them, human interactions, LANDSAT data is important in the broad GIS data bases and are essential to many of our modeling efforts in terms of population growth, energy demand, land use, and industrial production. It's also central to much of what we do, as Dr. Peck has indicated, in solid earth processes. More specifically, LANDSAT Thematic Mappers have been used and will continue to be used to support global change in determining continental biomass dynamics, the role of snow cover in establishing adequate soil waters for seasonal vegetation growth in semi-arid areas, it's been used in helping us understand the role of alpine snow and the changes in surface radiation budget and so forth.

In short, LANDSAT data provide one of the very few long-term data sets available now for almost 20 years that is useful for geophysical and ecological research and includes our ability to determine forest cover, land surface vegetation, geological parameters, seasonal distribution and movement of sea ice, land surface albedo, changes in polar ice sheets and the movement of large glaciers, and a whole host of others that are outlined in the document.

However, no one data set will prevent the USGCRP from making significant scientific and research progress. Budget realities force us often to make tough decisions, and we are

continuing to examine the relative importance of all data sets in supporting the USGCRP and its ability to support the policy process in this country and with our partners abroad. We have not completed that evaluation, but it's an ongoing one and is a part of each of our submissions to the Congress in our budget request each year.

I indicated that there are some data sets that are complimentary, and I'll just mention the two that are most important to our discussion this morning. First is the Earth Observing System of NASA, and the second is Spot.

The primary EOS land-observing sensors are the pointable high-resolution imaging spectrometer, or HIRIS, and the intermediate and thermal infrared radiometer, called ITIR, and finally the moderate resolution imaging spectrometers, MODIS-N and MODIS-T. These EOS sensors, while very important to the conduct of the U.S. Global Change Program, do not yield data similar in character to that provided by LANDSAT in that it provides high-resolution spatial characteristics, broad spectral band data, and provides us with a broad area of coverage and provides us that context which was discussed earlier in the first panel. The EOS Program was designed with the expectation that existing LANDSAT data and the continuation of LANDSAT-like data throughout the lifetime of EOS missions would be available.

Second, the Spot System, as we discussed during the first

panel, provides land-observing capability that is complimentary to and important to LANDSAT data sets. However, the LANDSAT Thematic Mapper has significant spectral capabilities that are not available on Spot. LANDSAT is also providing us with a longer record, since 1972, rather than that provided by Spot, which is only since 1986. Because of our need to have global perspective or treat large regions of the world, the nine Spot images that are required to cover one LANDSAT image produces an additional cost to the research community necessary to do the job. So you can see LANDSAT and Spot are complimentary in that Spot, in our judgment, is not a substitute for the need for LANDSAT data.

Data availability. Existing commercialization policy has resulted in higher data prices that seriously inhibit the use of LANDSAT data for important global environmental monitoring and earth science studies that require large data sets. Researchers at universities and other scientific organizations simply cannot afford to buy the large quantities of LANDSAT data at the current commercial prices. However, a recently signed agreement between EOSAT and NOAA resulted in EOSAT relinquishing its exclusive rights to market the first 16 years of LANDSAT MSS data. This agreement will cut user costs for LANDSAT MSS data for that data which is more than two years old, and, hence, it will

improve access for the scientific community.

The agreement, however, does not reduce the cost of LANDSAT data less than two years or does not reduce the cost at all of the Thematic Mapper data. In order to enable more effective use of large quantities of LANDSAT data, it is desirable, we believe, that all options be investigated for providing LANDSAT-like data to the scientific community and to do so at cost recoveries that involve cost of reproduction and dissemination, and, of course, we seek not to do that in a way that would sacrifice trade secrets or other important restrictions, many of which we discussed in the first panel. Recognizing the constraints of standing legislation and current contractual agreements, we believe that reaching that goal may require a modification of the commercialization aspects of the Land Remote Sensing Commercial Act of 1984.

In conclusion, the CEES is committed to implementing an integrated research program that balances the needs of research against budget reality. LANDSAT-type data can make an important contribution to the goals and objectives of the USGCRP. However, we have not yet completed our full review of the scope of LANDSAT data required for USGCRP, nor have we been able as yet to prioritize those against all other USGCRP requirements.

However, the President's policy to continue LANDSAT-like

data is the context within which that review takes place. Policy issues surrounding the LANDSAT Program involve competing needs within the research community, the needs to support national security, and, of course, the commercial community itself. Hence, these issues are continuing to be reviewed by the Administration in its commitment to fulfill the President's policy concerning the continuity of LANDSAT-type data.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Corell follows:]

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The CHAIRMAN. Thank you very much, Dr. Corell.

Dr. Rock, we're going to recess so I can go vote, and I'll be right back.

[Recess.]

The CHAIRMAN. Dr. Rock, before you begin, I thought I'd ask Congressman Swett if he'd like to say a few good words about New Hampshire.

[Laughter.]

Mr. SWETT. Thank you very much, Mr. Chairman. I appreciate that opportunity. I had prepared some remarks.

I wanted to welcome Dr. Barry Rock from the University of New Hampshire. He and his associates have taken the time and the interest to give me a full tour and several demonstrations of the LSAT equipment that they have at the University of New Hampshire. They are very involved in the EOSAT Program, and I was very impressed with the high level of activity that they are currently engaged in at the University of New Hampshire. Although they don't reside in my district, I consider them a very integral and important part of the State's educational and scientific community, and certainly that has broader implications than just the State of New Hampshire. It applies to the entire country.

It is with great pride and pleasure that I welcome Dr. Rock, and I look forward to his testimony, and I thank you,

Mr. Chairman, for the opportunity.

The CHAIRMAN. It's a pleasure, and you may proceed, Dr. Rock.

STATEMENT OF BARRETT N. ROCK, ASSOCIATE PROFESSOR OF NATURAL RESOURCES AND THE INSTITUTE FOR THE STUDY OF EARTH, OCEANS, AND SPACE, THE UNIVERSITY OF NEW HAMPSHIRE, DURHAM, NEW HAMPSHIRE

Mr. ROCK. Thank you, Mr. Chairman, and thank you, Congressman Swett. It is my great pleasure to be here.

I have a written testimony, which I would like submitted to the record; however, in light of the time restraints, I'm going to shorten it by speaking to some slides.

The CHAIRMAN. Dr. Rock, the full statement will appear in the record, of course, and you may abbreviate it in any way that you wish.

Mr. ROCK. All right. Thank you.

What I would like to do today is to talk about a particular application in terms of global change studies. This particular application, which is looking at forest damage -- forest damage caused by what some would refer to as acid rain--this particular application could not be done without the LANDSAT Thematic Mapper. It turns out that the extended spectral coverage of the LANDSAT Thematic Mapper is absolutely critical for seeing the kinds of initial stages, the early stages, of forest damage which have led in Poland and Czechoslovakia and Eastern Germany to just tremendous ecological disaster in the upper elevation forests.

This work that I will speak to is part of an ongoing United Nations Environment Program pilot study. It is being conducted by personnel from the University of New Hampshire as well as Czech and Polish scientists. We meet on a fairly regular basis, and what I would like to do is to talk about some global change applications in studying an area along the border between Eastern Germany, the former German Democratic Republic, and the Czechoslovak Federal Republic.

This is an area known as the Ore Mountains, or in German, the Erzgebirge; in Czech, the Krusne Hory. These mountains have some of the heaviest damage in forests that exists on this planet, and there is without debate a direct connection between the pollution, the unbridled pollution, in this area of Poland and Czechoslovakia and Easter Germany and the death of the forests. I would call your attention to the fact that the current issue of National Geographic has as its cover story ''East Europe's Dark Dawn,'' and it addresses this particular area, and in fact one of the images you'll see today from the University of New Hampshire appears in this issue.

I would like to begin with slides of the ground conditions just so we get a sense of the level of damage that we're dealing with.

This is a photograph taken from the ground in 1989. This is in the middle of July. This used to be a coniferous

forest, an evergreen forest. This is in the Erzgebirge region in Eastern Germany, and the type of damage that you see is typical of these forests. By published report, these forests were living and healthy as recently as 1978, and by 1989, we see this kind of damage.

This is a similar image, a ground photograph taken in Poland in the Sudeten Mountains, an extension of the Erzgebirge, and here we see, again, just tremendous damage. These forests were living and healthy as recently as 1981. One of the tremendous benefits of using satellite data to assess ground conditions and, in particular, forest damage conditions is that one is allowed to see the big picture.

In fact, I refer to the remote sensing capability as used by earth-bound scientists as the use of the macroscope. I think we're all familiar with the idea of a microscope needing many lenses; the macroscope also needs many lenses, but it gives us this big picture that we once were not privy to, we were not able to see. As a result of having this big picture, we see that damage in these upper elevation sites in Eastern Europe as well as in the United States occurs generally above 1,000 meters.

This is the area of the atmosphere known as the Free Troposphere, and it is here that these forests come in contact with elevated levels of anthropogenic ozone as well as very, very acidic cloud chemistry. This photograph, the

clouds in the background--that may look rather pristine and idyllic, but in fact those clouds are terribly, terribly damaging, and it wasn't until we used LANDSAT capabilities to look for forest damage that we recognized this relationship between elevation, the areas where the trees grew, and their contact with atmospheric chemistry that has changed dramatically in the last 20 or 30 years.

The CHAIRMAN. Dr. Rock, I actually thought that was smoke and that that was a forest fire.

Mr. ROCK. No, those are clouds. Those are very acidic clouds. The pH of these clouds has been measured to be 1.8. That's extremely acidic. Battery acid has a pH of 1. The ground water at this site has a pH of 2.6. Lemon juice and vinegar has a pH of 3. These kinds of pHs are just incredibly disastrous for the vegetation.

I should point out it's not just the vegetation that is suffering. It is the people as well. This article in the National Geographic gives chapter and verse on the incredible problems of emphysema, lung cancer, the problems people especially in these upper elevation sites have. I'll come back to that concept in just a moment.

You might notice that in this particular photograph there is a little bit of green that looks like grass growing between the dead trees, but in fact it's sedge. It's a particular kind of vegetation modified for growing in acidic

bogs, and it can tolerate the pH of 2.6, where nothing else can.

This is now a LANDSAT Thematic Mapper image. It was acquired in September of 1985, and this particular image shows the Erzgebirge Mountains, the Ore Mountains, highlighted in orange, and they run diagonally from the lower left to the upper right-hand corner of this scene. This is approximately a quarter LANDSAT Thematic Mapper scene, so the dimensions across the bottom is approximately 50 miles. The Erzgebirge are orange in this case, because that's where the dead trees are, and that photograph that I showed you of the dead trees, that's not just an isolated standing dead forest. That's the entire mountain range of the Erzgebirge. It covers an area of approximately 700 square kilometers based on this particular image, so 400 square miles of dead forests, and they were dead in 1985.

You might be able to see if you look closely some faint smoke plumes that are coming from sort of the center right-hand portion of this image. Those are near the city of Chomutov in Czechoslovakia. These are coal-fired power plants. The linear patterns between the two adjacent smoke plumes are the strip mines where the lignite, the soft coal, is taken out of the ground. The lignite itself has a sulfur content of 12 percent, and when that is burned, it generates sulfur dioxide gas that is toxic by itself, and when it

combines with cloud moisture forms sulfuric acid that generates the pHs that I've described.

This area, again, apparently, according to written documentation, was alive and healthy in as recently as 1978, but in 1985, certainly that entire area above 1,000 meters is simply dead. The black zones are actually healthy conifer vegetation, and this particular image was produced using LANDSAT band 5--some particular spectral coverage that Spot does not provide, AVHRR does not provide, the Soviet products do not provide. This band is unique to LANDSAT Thematic Mapper and is absolutely essential for seeing the initial stages of damage. Here we're seeing the final product of that damage. We'll talk a bit more about the initial stages in the next slide.

The next slide will focus in the lower left-hand corner, where you see the orange giving rise to some greenish healthy areas, and it's an area characterized by largely healthy conifer forests. This is a close-up of the area. It covers a total of about 300 square kilometers. There is a little village, the village of Bozi Dar. Bozi Dar in Czech means ''God's gift.'' You can see the little village on the left- hand side about center. It's surrounded by conifer forests. Some of the conifer forests are dark red, but other conifer forests are reddish, and in the approximate center of this image, you see almost a

fluorescent orange coloration. The fluorescent orange would be the most damaged forest conditions, the red would be an intermediate damage condition, and the dark areas in the conifer forest would be nearly healthy vegetation.

This is an enlargement of that 1985 image. What I'm going to show you is the same area in 1990. You might keep your eye on the luminescent orange in the center. The areas that are now white have been clearcut. Either they have been clearcut or they have died totally. There is a tremendous and dramatic increase in the damage in the central area, but also in the surrounding areas.

This is a change detection image of the same area, again, generated using Thematic Mapper bands, and the areas that are shown in red that correspond to essentially that central area are areas where the forests have either totally died or have been removed through clearcutting. More disturbing are the areas shown in yellow, and those are the areas that between 1985 and 1990 became significantly damaged to show up in a particular Thematic Mapper band ratio that we find to be extremely sensitive to forest damage. And in fact, based on this image of the conifers that were healthy in 1985, 44 percent of those have become moderately damaged or have died by 1990.

And this retrospective capability of being able to go back and look at 1985 data and 1990 data in comparison, doing

this difference imaging approach, is an essential component of global change work, and this could not be done using Spot data, because Spot data are acquired only on demand, and who would have known in 1985--well, that was before Spot was up -- but by 1986 or 1987, who would have known you wanted to look at Bozi Dar in Czechoslovakia? One can't predict a Chernobyl. One can't predict a drop in the Iron Curtain and access by western scientists to these areas.

I should point out that in Bozi Dar, the average life expectancy of its citizens is 34 years, so this final slide expresses the sentiment of Central Europe. If your German is a bit rusty, what it says is, ''First die the forests, then die the people.'' And I think if you're wondering, ''So who cares about these upper elevation sites in Poland and Czechoslovakia?,'' I think we all need to care, because it's not just the trees that are dying, it's the people.

These Montane Boreal forests represent very sensitive indicators of global change, sensitive to air pollution factors, and much of the northern hemisphere is covered by boreal forests, and the conditions of the Montane Boreal forests may be an indication of what we can look forward to in terms of the future and the state of the boreal forests.

In conclusion, I would simply like to say that this work could not have been done using Spot, it could not have been done using MSS or AVHRR or Sojuzkarta data. It required the

extended spectral coverage of the Thematic Mapper, and it required the routine acquisition of data, every 16 days or every eight days--absolutely essential.

Just as a final statement, 30-meter resolution from the standpoint of studying forests is actually an advantage to me, and if I use Spot data, the panchromatic 10-meter data, I find that I cannot use my standard algorithms that look for non- forest or forest damage, because the shadowing within the canopy of the forest shows up as non-forest or damage, and it makes it virtually impossible to use the 10-meter data. The 30-meter data, on the other hand, is just exactly right for doing this kind of work.

The next step in this research is to look at the LANDSAT multispectral scanner data, the MSS data, looking back to 1972, and thanks to the new pricing policy of EOSAT, the USGS, NOAA, we will in the university community be able to do that.

So I'm looking forward to future global change studies. It is important to the people of this planet. As I've said before in addressing some members of this committee, I don't view continued operation of the LANDSAT system as a matter of national pride. It's a matter of a moral obligation that we have to the people of this planet to be able to conduct these kinds of research activities, and the LANDSAT Thematic Mapper is absolutely critical to being able to do this work.

Thank you.

[The prepared statement of Mr. Rock follows:]

********** INSERT **********

The CHAIRMAN. Thank you very much, Dr. Rock.

Mr. Swett, would you like to begin the questioning?

Mr. SWETT. Thank you, Mr. Chairman.

My first question is who said that the State of New Hampshire is a State of tacit understatement? I think that your eloquent and very forceful comments have given all of us here a very clear understanding of not only the dire situation in Eastern Europe, but the ability that LANDSAT has in helping us discern where that is occurring, why it's occurring, and hopefully tracing the sources of the occurrence to enable us to stop it in the future.

My questions are not many and revolve around the economic side of this. You, in your demonstrations to me when I was at your facility, also demonstrated a very capable ability of recording wetland information and spoke of how certain parts of the country had been recorded by images through various universities and programs, but that there was not a cohesive picture, a macro picture, of the United States that might help the Federal Government in establishing a more regionally oriented wetlands policy.

This imagery that you showed us about the Eastern European problems, again, is not a full picture of the acid rain conditions throughout this global environment, and it is my understanding that one of the impediments to acquiring such

a body of work is the funding that is available and the cost of implementing such programs. Where in the future are these funds going to come from, and exactly how much greater than what is currently being spent can we expect to spend in order to amass such a library of information?

Mr. ROCK. Well, I would just mention that I'm from Vermont rather than New Hampshire. That may explain why I haven't been as reticent in my comments as you might have expected, but I am very pleased to be in New Hampshire at this point.

In terms of the cost, that's a very serious question, and what I have shown you is simply one quarter scene of the LANDSAT Thematic Mapper image. In order to do all of the Erzgebirge and the Sudeten Mountains, this area in Eastern Europe that has the very severe damage, one would need to purchase a total of 18 scenes, and if you multiply that times the approximately $4,000 cost per scene, you can see that just for one data set that becomes expensive. If you wish to do the change detection, that implies a need for two data sets per point on the ground, and so the costs begin to add up rather rapidly.

And to answer your question as to who's going to pay for this, I cannot answer that. My research grants, my budget, will not allow me to pay for it.

Mr. SWETT. Is the improvement in technology an issue that would lower these costs, or is this a fixed cost that will

remain fairly constant throughout the use of the program and rather the cost be mitigated by increasing the number of entities relying on this information for their use?

Mr. ROCK. I guess we would need to ask EOSAT that question. I don't know what the actual improvements in terms of technology will do for the cost of the satellite imagery. I'm assuming someone will need to pay for that. From my standpoint, I don't view that there is much advantage to the improvement in the technology. I don't have much use for five-meter data; however, one person's trash is another person's treasure. So I can appreciate that someone else is going to want that five-meter resolution over Kuwait City. I will not need it. As to what the improvement in the technology will do to the cost of the data, I cannot answer that.

Mr. SWETT. If and when LANDSAT 7 is implemented, will that have technical improvements, or is that going to be just the continuation of the program? My understanding is that these satellites are not stable. They last for so many years, and then they fall back to earth, and we're just replacing a previous model that could no longer maintain its orbit.

Mr. ROCK. My hope is that LANDSAT 7 will be a continuation of the current capabilities from my standpoint. Again, that technological improvement may not be necessary for forest damage assessment.

The CHAIRMAN. Do you want to comment on that, Dr. Peck?

Mr. PECK. There was some discussion earlier. One of the Defense Department representatives were here, and they brought out--and we're all aware--that the LANDSAT 7 is currently undergoing a lot of discussion of just what the capabilities will be. The LANDSAT 6 will have some additional capabilities over the current LANDSAT 4 and 5, somewhat greater resolution.

Mr. SWETT. Are these capabilities primarily focusing on greater resolution instead of 30-meter--

Mr. PECK. As far as looking at LANDSAT 7 and considering alternatives, one is greater resolution. Another would be stereo coverage, the ability to point the imaging system, so you could get stereo coverage like stereo air photos.

Mr. SWETT. I see. So you'll be able to get depth perception as well as--

Mr. PECK. That's right. You could make a simple graphic map.

Mr. SWETT. I see.

Mr. PECK. As far as the cost of imagery, for some uses, one help is that older imagery will be priced at a different level. For example, MSS data greater than two years old, as the result of an agreement between EOSAT and NOAA, is made available by the U.S. Geological Survey, our EROS Data Center, at a cost of $200 a frame rather than $1,000, and

the Thematic Mapper imagery, once it's more than 10 years old, will be available at a price of about $400 a frame rather than $4,000.

Mr. SWETT. My last question pertains to Federal policy as it relates to the environment, and in particular, wetlands. How much of the country--and I address this to anyone on the panel who might know the answer--how much of the country currently has been imaged--in particular, we can talk about it as it pertains to the wetlands issue, but it could be to any one of environmental problems that this country currently faces--how much of the country has been imaged with the LANDSAT Program, and is there a program that is currently being orchestrated to complete that imaging, or what needs to be done to implement such a program?

Mr. PECK. All of the country has been imaged several times, a number of times, by Thematic Mapper, by LANDSAT imagery. Also, of course, there's repeated aerial photography, which is useful in delineating wetlands, and the Fish and Wildlife Service has an ongoing program centered in St. Petersburg, Florida, to map the wetlands. Depending on your classification of what is a wetland and what isn't, some of the wetlands require not only the imagery, but also visiting the wetland and sampling the soil. One aspect of the definition is a hydric soil or the amount of water coverage during a year. So you need all

those avenues of approach.

Mr. SWETT. Okay. Thank you very much.

I appreciate the opportunity to question, and I appreciate your bringing this panel before the committee, Mr. Chairman.

The CHAIRMAN. Thank you, Mr. Swett.

Mr. Wolpe?

Mr. WOLPE. Thank you very much, Mr. Chairman.

This morning, of course, we heard of the value of LANDSAT to national security, and now it is clearly obvious that LANDSAT has equal or greater value as the tool for measuring and monitoring the extent of changes in the global environment. My concern relates to whether or not the Administration has been attuned to how important LANDSAT actually is in monitoring the global environment, and my questions center on that concern.

Dr. Peck, my understanding is that over a year ago you asked Dr. Corell to conduct a study on the importance of LANDSAT to the U.S. Global Exchange Program. Is that correct?

Mr. PECK. Yes.

Mr. WOLPE. What led you to initiate that study?

Mr. PECK. Several things, as I expressed in my letter to Dr. Corell. One was the concern of this and the other committees in Congress. Also, issues that had arisen as a result of some studies by the National Academy of Sciences

looking at global change and the National Academy responding to some questions raised by the Administration.

Mr. WOLPE. When did Dr. Corell submit his study to you?

Mr. PECK. I think it was in November of 1990.

Mr. WOLPE. In 1990 or 1991? It must be 1990, of course.

I have a copy here of that study, and I'd like unanimous consent, Mr. Chairman, to enter this study in the record at this point.

The CHAIRMAN. It's not classified, is it?

Mr. WOLPE. No, it's not.

The CHAIRMAN. Without objection.

[A copy of the study follows:]

********** INSERT **********

Mr. WOLPE. The report states that CEES believes that a continuing LANDSAT Program is essential to the U.S. Global Change Research Program, that CEES urges that the policy, management, and technical aspects of follow-up on satellite systems after LANDSAT 6 be resolved as soon as possible to avoid lengthy data gaps, and that CEES supports the efforts to preserve and improve utilization of existing LANDSAT data. Is that a fair summary of the conclusions of this report, Dr. Peck?

Mr. PECK. Yes, the report prepared by the working group and transmitted by the committee to the President's Science Advisor.

Mr. WOLPE. Contained within the report is a table in which--containing a ranking of LANDSAT importance to a number of science elements and priorities. Did anyone within the CEES group object to the ranking of LANDSAT importance that is contained within this table?

Mr. PECK. Well, not to my knowledge, but let me turn to Dr. Corell, who is the proud author of this document.

Mr. CORELL. Thank you. The document to which you are referring has been reviewed by the science parts of all of the CEES agencies and concur from the perspective of the use of this data to support global change research activities to what's in Table 8. What has not been completed by ourselves

is how this importance of LANDSAT data and the need for that fits into the total budgetary framework of CEES. I think our colleagues in DOD referred to this, in a sort of restricted use of the word, as essential or important.

We are in the middle of that. In fact, we do that every year as we put together the total USGCRP recommendations to the agencies and to OMB, and out of that kind of analysis, we can then see the budgetary implications of what is in this report, essentially stating the substance requirements for doing science.

Mr. WOLPE. But again, this particular ranking of LANDSAT importance contained on this table, described as Table 1, there was no dissent, was there, among the CEES reviewers?

Mr. CORELL. The participating agencies have all reviewed this. That is correct. The operational agencies.

Mr. WOLPE. That's right. NOAA, NASA, DOD, CEQ, and Agriculture endorsed the report. Is that correct?

Mr. CORELL. I'm not sure about CEQ in that particular case, but the other agencies, yes.

Mr. WOLPE. And my understanding is that the Interior Department supported it with minor reservations and that the Department of Energy supported it, at least verbally. Is that correct?

Mr. CORELL. That's correct.

Mr. WOLPE. If all these agencies have supported the study,

Dr. Peck, why has it not been made public yet?

Mr. PECK. Well, it's not within my authority to make it public. In the capacity as Chairman of the Committee on Earth and Environmental Sciences, I report to Dr. Bromley, the President's Science Advisor. So earlier this month, I transmitted it to Dr. Bromley, in part because it had not only science aspects to the report, but it raised policy issues relevant to pricing and other matters. So I felt and we all felt that it needed to be reviewed from that policy aspect, and that was appropriate either for Dr. Bromley and his Office of Science and Technology Policy or for the National Space Council.

Mr. WOLPE. Are you saying that Dr. Bromley is holding up the release of this report?

Mr. PECK. I'm not sure where the report sits now, whether he has it or whether it's been transmitted to the National Space Council.

Mr. CORELL. I guess I would say that ''hold up the report'' is not quite the phraseology that I would use. We have been in many discussions with OMB and OSTP and others in the Administration concerning the report, and what is at issue are the policy aspects, some of which we raised explicitly in our report that need to be resolved, and they have budgetary implications and they have implications that connect to our discussion in the first panel. I see it as

an ongoing part of the process. We have submitted this as an internal report to Dr. Bromley, and during our efforts this summer to build an fiscal year 1993 budget, we will integrate that into these discussions.

Mr. WOLPE. Yes, but my understanding is that you were not asked by Dr. Peck to put LANDSAT in the context of other priorities, you were simply asked to assess the importance of LANDSAT data.

Mr. CORELL. That's correct.

Mr. WOLPE. No other global change programs seem to be prioritized in this way. So you're telling us today that OMB is among those objecting to this report?

Mr. CORELL. OMB is considering this report. I wouldn't say objecting. I have no reason to believe that OMB is objecting to this report. What is happening is a very careful review within OMB and other parts of the Executive Offices about the future of this whole activity.

Mr. WOLPE. Well, that's right. I mean, I have no quarrel with that policy review taking place. What I'm trying to understand is why a report that was very narrowly circumscribed to address the technical reactions to the importance of LANDSAT data has not yet been released. Why cannot the policy review continue to take place in the context of the release of this report?

Mr. PECK. Well, as we said, it's because of the policy and

budgetary issues raised, and actually that question would be best addressed to Dr. Bromley.

Mr. WOLPE. It's true, is it not, Dr. Peck, that for three years the National Space Council has had the task of recommending policy options for the LANDSAT Program beyond LANDSAT 6 and that this review is scheduled to be completed before this fall?

Mr. PECK. That's my impression, yes.

Mr. WOLPE. Have Dr. Corell's conclusions been transmitted to the National Space Council?

Mr. PECK. I'm not sure.

Mr. CORELL. I'm not sure.

Mr. WOLPE. Okay. I see the Chairman has his gavel in his hands, so with that, I shall cease and desist.

The CHAIRMAN. The time of the gentleman has expired.

Mr. WOLPE. Thank you.

The CHAIRMAN. Gentleman, we recognize that some of these questions are above your pay grade, and--

[Laughter.]

The CHAIRMAN.--Mr. Wolpe is just alerting you to the fact that when we have our next hearing, we may want to have somebody with the appropriate pay grade answer these questions.

Mrs. Morella?

Mrs. MORELLA. Thank you very much, Mr. Chairman.

Mr. Chairman, I'd like to ask that an extensive statement that I have prepared be included in the record.

The CHAIRMAN. Without objection, so ordered.

[The prepared statement of Mrs. Morella follows:]

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Mrs. MORELLA. Thank you, and I again congratulate you on this first joint hearing of Science, Space, and Technology and Intelligence.

One of my concerns is the lack of a clear direction in funding, and some of this has been alluded to. Currently, we have satellite coverage by the aging LANDSAT 4 and 5 satellites, and while their service life is waning, we've made some provisions for LANDSAT 6, and that's going to take us to 1996, and yet we cannot say with any certainty today, despite the fact that all of the demonstrations have been shown, that there will be a LANDSAT 7 unless it's funded in the next fiscal year and that we will then have continuous satellite coverage beyond 1996.

My concern is one that has to do with how are you going to find a market for it among the commercial and public clients if we don't have this kind of assurance? I wonder if you might give us your comments about it. Is there something that--should we be firmer on it? Is this true that we do not have that kind of direction that we need?

Mr. PECK. Well, Congresswoman, I think that really is a problem. That was pointed out by one of the earlier speakers. Some of the user community has not taken full advantage of the imagery because of the investment required, either because of uncertainties on LANDSAT 7 and the life of

the program or because of the cost of the imagery. From a scientific perspective, as one of the users of the data, I really do hope that we will resolve this problem of the continuation of the LANDSAT Program and get on with a LANDSAT 7.

Mrs. MORELLA. Do we have trouble with the French, for instance, competitively?

Mr. PECK. Well, again, as was pointed out, Spot has some real advantages. One is the resolution, one is the pointability, the ability to get stereo coverage. It does lack the Thematic Mapper, so there are spectral bands that would be enormously useful not only for study of vegetation, but for mineral appraisal, mineral exploration, and many other applications that Spot does not have that capability.

Mrs. MORELLA. So it's the kind of thing that we could then pick up on.

I was very interested in the slides. It's really incredible what we've been able to discern and what it's done for our understanding of global change. Does it provide to us the understanding that we cannot get any other place? In other words, ''mission essential,'' if that's the phrase that they use. How essential is it?

Mr. ROCK. I would say it's absolutely essential. There are things that we are able to ''see'' because of Thematic Mapper eyes that our own eyes do not tell us, and from the

standpoint of other sensors capabilities, the Thematic Mapper provides a very unique and diagnostic manner of environmental assessment, and in particular--and I'd like to emphasize this--we are seeing with Thematic Mapper some of the initial stages of damage rather than the vast devastation that I showed you in the one slide of the entire Ore Mountain region, and I think from the standpoint of understanding how the environment--how the ecosystem is responding to pollution, for instance, we need that early warning assessment capability. I would rather be a physician rather than an undertaker in terms of dealing with forests. I can do nothing with the dead forests in the Krusne Hory.

Mrs. MORELLA. That's a very good metaphor. What does happen, incidentally, after you do the diagnosis? Do you have an opportunity to follow through to make sure that we are doing more than just being cognizant of this happening?

Mr. ROCK. Well, the fact that we are able to work directly with both Czech, Polish, and Eastern German scientists gives us an opportunity to provide them with insight that they would not have, based on their own ground assessment capabilities, and there are some reforestation activities, especially in Czechoslovakia, that are looking quite promising.

It turns out that the Colorado Blue Spruce, of all tree

species, seems to be the least sensitive to pollution, and so there are some very active reforestation activities using Colorado Blue Spruce to replace the native species that has died there, and we will be able to use the LANDSAT capability in the future to monitor that recovery.

Mrs. MORELLA. There was set up maybe a year or so ago in Budapest, in Hungary, kind of a regional environmental project for all of Eastern Central Europe. Do you work with them or know what's happening there, too? Is there a flow? I guess I want to make sure there is this continuity beyond what LANDSAT discerns to recovery.

Mr. ROCK. We are not directly working with people from that particular program; however, some of the Czech scientists are a member of that program, so one would hope that there would be the trickle-down effect. I should also tell you that this pilot study that I showed this morning is essentially three months old, so this is brand new results. The images that I showed of the change between 1985 and 1990 are a few days old.

Mrs. MORELLA. So even after the launch of the first EOS system satellite, there will still be information that will come from LANDSAT?

Mr. ROCK. Yes. As one of the other panelists mentioned, many of the sensors on board the EOS platform will look in rather small areas--small Spot sizes, so to speak-- whereas

the Thematic Mapper provides the routine acquisition of data that will be very important in the future.

Mrs. MORELLA. Thank you.

Did you want to say anything, Dr. Corell?

Mr. CORELL. No.

Mrs. MORELLA. Thank you, Mr. Chairman.

The CHAIRMAN. Let me acknowledge the presence of our distinguished ranking member and ask him if he'd care to have a statement in the record or to ask questions at this point.

Mr. WALKER. I have a couple of questions, if I could, Mr. Chairman.

The CHAIRMAN. Go ahead.

Mr. WALKER. Thank you, sir.

Can any of you tell me what the status is or what the record is of attempting to market LANDSAT as a media asset? Has there been a conscious attempt to market LANDSAT to American media sources as something that might be useful to them?

Mr. PECK. If I could address that question to Dr. Thorley--

Mr. WALKER. Sure.

Mr. THORLEY. My understanding is yes, there has been an attempt to do that, but the time of acquisition, which, as mentioned earlier, is a 16-day repeat cycle, it's almost fortuitous that they would get an image within the time of

the newsmaking. There is an expert in the room, Dick Loginski from EOSAT, and I'm sure he was part of that marketing effort, but that, plus they want exclusive rights which are difficult in certain cases to provide from the LANDSAT but may be provided from other satellites, like the Spot, where they have more control over how they sell the data.

Mr. WALKER. So it is more the time of acquisition and the rights which is a question, rather than the resolution?

Mr. THORLEY. It obviously depends upon the application that they're interested in. For something like an image of Kuwait City or of Baghdad, any image would have been appropriate, even of low resolution, just because of its newsworthiness, and of Chernobyl and things like that. For certain other applications, you would not be able to use LANDSAT.

Mr. WALKER. If we were, for instance, able to develop a downlink capacity that would shorten the time frame in the next generation, media might be willing to buy data from the LANDSAT at that point?

Mr. THORLEY. I believe that they will buy anything that they consider to be newsworthy, and it will obviously help them to use it that way, but again, normally the news events are such that they require almost 24-hour turnaround of the image of the day, and the 16-day repeat time is probably the

most difficult thing for the use of LANDSAT.

Mr. WALKER. Thank you, Mr. Chairman.

The CHAIRMAN. Mr. Walker is expressing our concern about the commercialization aspects, which, of course, have been an underlying, ongoing concern for many years. Hopefully, we could put the whole cost of financing LANDSAT 7 onto the media and save the taxpayers.

[Laughter.]

The CHAIRMAN. Ms. Horn?

Ms. HORN. Thank you, Mr. Chairman.

I guess I'm going to be much more basic here, and if there's something here that I have missed because I've been in and out, I would be happy to get that from the record or from staff.

Just as sort of real general comments, what the total costs are, what the share is between DOD and the civil applications. As the civil applications are requested and acquired, is the cost to the user an incremental cost, or is there a recovery cost involved in there? Are we being particularly friendly to users in terms of encouraging them? This is a multipart question. And then I'm also wondering about additional equipment costs at their end that might be alleviated by some sharing of equipment. So the total costs and the 4 and 5 that are up there now, perhaps you could also give me some sense of how much that increased for 6

that is about to be launched, and then the share and what percentage users are commercial or other even Federal departments non- military are using.

Again, if that information is available on a piece of paper somewhere, I'll be happy to get it off the piece of paper.

Mr. PECK. It's not a matter of our pay status, it's maybe the agency that we come from, but I don't think we've got the right crowd up here to answer your question. It's maybe an EOSAT-type question or a NOAA-type question or a NASA-type question.

Ms. HORN. Well, total costs and share between the military and the civilian--

Mr. CORELL. I think that's the sort of question, if you'd like, we'll supply for the record.

Ms. HORN. I would appreciate that.

Mr. CORELL. I think it requires some analysis, and we'll maybe talk with you and get exactly what you'd like, because we'd like to meet your--

Ms. HORN. Well, I'm just trying to put a lot of these other things in perspective in addition to our distinguished Chairman's legislation in terms of making sure that 7 gets launched--I shouldn't use that word--gets off the drawing pad and to an eventual launch. Thank you. I'll look forward to that information.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Ms. Horn.

Let me ask you just a few questions. Despite my long experience with the program, there are times when I don't fully understand everything that I should.

I understand that USGS is the broker for all civilian purchases of both LANDSAT and Spot data.

Mr. PECK. Yes, that's true.

The CHAIRMAN. Could you give me a rough idea of how much you're brokering these days?

Mr. PECK. The volume?

The CHAIRMAN. Yes.

Mr. PECK. Dr. Thorley?

Mr. THORLEY. We've had a voluntary brokerage in existence since 1986, and approximately $10 million has been brokered, you might say, under that agreement.

The CHAIRMAN. Total?

Mr. THORLEY. Total.

The CHAIRMAN. So it couldn't be much more than a million or two a year.

Mr. THORLEY. A couple of million a year, on the average.

The CHAIRMAN. Okay. The testimony from the military panel earlier pointed to the fact that they had some problems with the lack of TPS data in connection with LANDSAT, precise positioning, and in my visit over to your facility the other

day, I got the impression that the system provided adequate data for you to make accurate geographic information basis from it. For your purpose, at least, it was adequate. Now, tell me what the weakness is, and is that to be corrected with LANDSAT 6 or 7?

Mr. PECK. Let me give part of an answer and then turn to somebody who's more knowledgeable than I. That precise location of the satellite I do not think is included in the LANDSAT 6 plans. The LANDSAT 7, we're still discussing whether a LANDSAT 7 and what might be included. My impression is that for our purposes of making image maps, considering the resolution of LANDSAT 6, the 30-meter resolution, that the current situation is adequate. We could make those image maps. For a very, very precise map, the mathematics requires a precise location of the satellite, and that's where the Defense Department spokesmen were coming from.

But let me turn to Dr. Thorley in case I misspoke.

Okay. Oh, I did okay.

The CHAIRMAN. Dr. Corell, you listed some of the instruments proposed for EOS, including a pointable high-resolution imaging spectrometer, HIRIS. When you use the term ''high resolution,'' how does that compare with the existing resolution, the 30 meters? Is this better or worse?

Mr. CORELL. It's a spectral resolution that HIRIS has. I think the overall comment I would make is that the EOS data systems are really designed for looking at, as he indicated, smaller areas with high precision, there's no question about that, and get detailed information, but LANDSAT gives us the larger context within which to put all that understanding that we're getting on a fine scale. It's like having a microscope to do some things and then the macroscope to put it all together, and LANDSAT provides that capability--swath widths of 100 miles and so forth--and we can put this all in context.

The CHAIRMAN. Yes. All right. That helps me understand it a little, I think.

In view of the time, gentlemen, I am going to ask if we can supply any additional questions in writing, and we'll get on to the next panel, which has already been kept waiting much longer than I wanted. Thank you very much for your help.

The CHAIRMAN. We will call the next panel: Mr. David Thibault from Earth Satellite Corporation; Mr. Steve Sperry from ERDAS; and Mr. Lawrence Ayers from Intergraph Corporation.

Gentlemen, we appreciate the fact that you've been kept waiting unduly. We apologize for that. We appreciate very much your being here. In a sense, you represent the cutting

edge of where we really want to go on this LANDSAT Program, namely successful commercialization, and we probably should have put you first instead of last.

Mr. Thibault, do you want to begin?

STATEMENT OF DAVID A. THIBAULT, VICE PRESIDENT, EARTH SATELLITE CORPORATION

Mr. THIBAULT. Thank you, Mr. Chairman.

I think I would not characterize the wait as undue. It was informative.

I ask that my remarks be included in the record. They were presented earlier. I will abbreviate them here so as not to cover ground already covered and to save time generally.

The CHAIRMAN. Without objection, the full statement will appear in the record, and you may proceed as you wish.

Mr. THIBAULT. The Gulf War demonstrated to the military intelligence communities what the civilian commercial users of LANDSAT data have known for more than a decade. LANDSAT and Spot can provide accurate and current information on land cover, natural and cultural resources for large areas, for inaccessible regions, and can do so quickly and inexpensively.

My remarks will focus on three activities which we believe will be at the center of commercial applications of earth resource satellite activities in the next decade: mapping, resource exploration, and global environmental monitoring. Before examining these applications, I would like to briefly recount EarthSat's Desert Shield and Desert Storm

experiences, because our contributions to these efforts were made possible by vigorous technological development spurred by private sector business. In 1990, less than 8 percent of EarthSat's business was for the Federal Government.

On July 15, 1990, EarthSat completed a major petroleum exploration project for the Northern Arabian Platform, which includes all of Kuwait and Iraq and parts of Iran, Saudi Arabia, Turkey, and Jordan. Our clients for this study were international oil companies. On August 3, 1990, following the Iraqi invasion, we offered to provide the U.S. Government with current satellite-derived maps of the Gulf Area within 48 hours using Spot and Thematic Mapper data. Our proposal fell on deaf ears. It apparently failed for two reasons. The Government was satisfied that it had adequate maps or that it could produce them, and the Government experts were convinced that what we proposed could not be accomplished in time to be useful, let alone in 48 hours.

In early September, early on a Monday morning, we received a telephone call from one of those Government officials asking whether we were available to produce image maps and whether we could do so quickly. Apparently, existing maps were not entirely adequate. What followed were several projects in which we produced 46 image maps at a scale of 1:50,000 from pre- and post-invasion Spot 10-meter data.

One of EarthSat's staff went to France to pick up the Spot data, which had been embargoed. The maps, along with the stereo image reproduced from off-nadir Spot data, were produced in 48 hours. Subsequent to that, we produced 33 multispectral image maps at a scale of 1:100,000 from LANDSAT Thematic Mapper data. These maps were produced in 36 hours. Following that, there was a need for multiple copies of these maps which had been produced, and we produced, of those 33 multispectral image maps, 100,000 lithographed copies in four days.

This illustrates, I think, the value of having vigorous commercial activity. The capacity to respond quickly to the Government's requirements was developed in response to civilian commercial market demand for rapid service, complex products, and the highest possible quality. Let me add that our efforts received the strongest support from the Government, and without their participation, we could not have met our objectives. Examples of these products are on display down the hall.

For Desert Storm, we produced rapid turnaround image processing, six to 12 hours from receipt of data, and used a variety of proprietary techniques developed for mineral exploration, land and environmental studies to produce imagery for use by the Department of Defense.

Now let me address the three subjects of my discussion.

The first is mapping, and we heard some considerable discussion in the first panel about what's required to a make military map. Let me say that there are many, many maps, and military maps are not the only maps in the world which are useful for addressing a variety of social problems. Map requirements vary widely. It would be an error to conclude that developed countries are well-mapped and that developing countries are not. It depends on the user's requirements and not some theoretical definition of scales and accuracies, themes and presentations.

Many map user requirements can be met by earth satellite data, as we've heard today, or a combination of satellite data and existing maps. Standard 1:24,000 scale U.S. Geological Survey topographic maps of the southeastern United States updated in the last 10 years may be useless to a public utility which needs current information on land use, urban and rural development, and the location of new roads. EarthSat is producing such updated maps from the 10-meter Spot data at a cost to our customers of $500 per map. This update is produced in two weeks and relies on existing USGS maps for control.

An update by the Government would require three to five years and relies upon aerial photography. It would cost on the order of $10,000. In many respects, the Government product would be far better than the one that we've

produced, perhaps, in some instances, better beyond the needs of the user. In one respect, it would, however, be a poorer product than the one that we produce. That is, it would be three years out of date by the time it was published.

A nation may be mapped in days with satellite data, as was done during Desert Shield, or in weeks, as we are currently doing for the government of Afghanistan. For the FAO, EarthSat is producing a national map series from LANDSAT TM data. Eighty-three image maps at a scale of 1:100,000 covering the entire country will be produced in five weeks. These maps will be lithographed at a scale of 1:250,000. The cost of these maps is $2,000 per map approximately. Lithographed copies will cost less than $3 a map.

The second area of commercial promise in the decade ahead is resource exploration, and it's one that's received much attention in the past. Of all the commercial applications of LANDSAT data, resource exploration is probably the best known, most widely discussed, and least understood. The perception that satellite data alone can locate minerals, hydrocarbons, ground water, or arable soils is, at best, an oversimplification.

Satellite data are powerful and valuable tools serving a growing community of users in what has recently become a rapidly expanding world. Political developments in the

Eastern Bloc have highlighted one of the great values of satellite data: the ability to provide extensive information on large areas quickly and inexpensively. Resource exploration in the Soviet Union and China has relied heavily on LANDSAT data for geologic mapping.

We've been involved in a number of projects, and those are illustrated in the exhibits down the hall.

While satellite data represent a very small percentage of the information the explorationists must consider before purchasing mineral rights or drilling a hole, they may represent the most cost effective exploration expenditures. Satellite data, because of their wide coverage, help to eliminate from consideration 90 to 95 percent of the area of interest to the explorationists.

What follows are a discussion of several projects, hydrocarbon exploration projects, which were conducted for international oil companies. I'll discuss one quickly, and that is a project which we finished just a couple of weeks ago for Mongolia, an area which has only recently become available to western investment and exploration.

The geologic study covered an area of more than 245,000 square miles, and it was completed in six months. I think the significant thing about this study is it provided critical geologic information to international companies at a very low cost. The cost of the study to the participants

was $45,000. If they had purchased the LANDSAT data and processed it, it would have cost $57,600. Multiple subscribers make it possible to provide this information at a substantially lowered cost.

I think the value to the United States is clear. LANDSAT has provided us a means of looking at the entire world, of understanding the world's resources and their potential, and I think has provided a competitive advantage in the development of technologies, which the next two members of this panel will discuss.

We've also been involved in water exploration in southern California, a subject which is dear to the hearts and concerns of many in the United States. This is a commercial activity, commercial investment, looking for water for sale to municipalities. This technology has great potential for Africa and other arid regions and is as yet not well utilized.

The final area that I wish to discuss in this presentation of markets for the future is global environmental monitoring. I think it would be difficult to improve upon the presentation that Dr. Rock made earlier in terms of the magnitude of the problems that we face and the true value of LANDSAT in addressing those problems. I, in my discussion, have likened the very costly EOS Program to a venture which will take the temperature of the patient. Clearly, the need

is to deal with those activities which are affecting the health of the planet, and to do that we must have higher resolution data of a variety of kinds. Certainly, the systems that are existing today and planned will provide those data.

I also have in my extended remarks extensive discussion of the needs and benefits to the developing world of these technologies, and as population increases and stress on resources from environmental problems and consumption increase, these data are essential.

Finally, I will quickly go over some issues which I perhaps should hold until August, but they are important to those in the commercial sector, and they deal with some of the policy questions with which you must come to grips.

I perhaps should leave the first, which is the question of whether the taxpayers should be asked to continue to contribute more than $100 million annually to support the LANDSAT Program, and my question is, do the benefits justify the expenditure? The second issue is what those concerns are of commercial users of the LANDSAT system should the system or the Land Remote Sensing Commercialization Act be changed in the months ahead. Finally, the question which has received much press coverage in recent months, which Federal agency would best be suited to assume operational responsibility for the program, if there was a change?

I think you probably know the answer to the first question, which is whether taxpayer support should be continued. I think we've seen clear benefits, compelling benefits, from this technology to both society in general, to the economy, to the world environment, and those benefits will grow.

Commercial exploitation of the technology is still immature. The current sales of LANDSAT are probably on the order of 20 to 25 percent of the total sales. The Government is still the principal user. We as a company purchase about half as much data as the Defense Intelligence Agency, which makes us a very large consumer, but still that's less than $1 million. It's a long way from $100 million, which is the bogey that we have to attack.

On the issue of those concerns to commercial users about the changes which may be imminent in the program, I guess I'd like to go back to the Commercialization Act of 1984, I think a good act. I think it embodies some of the principles that we think are essential to this program, and here I think I speak for the vast majority of the users of LANDSAT data. I think these principles have to be contained in any policy that relates to LANDSAT in the future. Open skies, as provided in the act. Non-discriminatory access to data, and I think here ''non-discriminatory'' has a broad definition. It must be both in terms of price and system

access. We can't have a system where only some users are allowed access to it.

Continuity. I'd like to read my discussion here, because it doesn't really follow the testimony of some of the other witnesses this morning. We favor general continuity, but we're not necessarily in favor of a one-for-one copy of the existing system. Spectral bands may be changed so long as the general spectral regions covered by LANDSAT 6 are included. Slight changes and even the elimination of some bands are acceptable if the users have an opportunity to comment and the decisions made represent a consensus of the users. It is convenient to have similar coverage patterns from one satellite to the next, but not essential. Today's computers allow us to combine disparate data sets with ease. When continuity and technological advancement conflict, we favor progress; however, if funding realities mandate that LANDSAT 7 be a clone of LANDSAT 6, we will be terribly disappointed, but we view program continuation without interruption as essential to the commercial market.

Third, service, regardless of the client's needs, must be quick, efficient, and consistent. Without service, there would be no growth. Much of the non-growth or small growth in recent years I think is attributable to the fact of the uncertainty of the program. And technological progress, finally. In many respects, earth sensing from space is an

infant technology with seemingly infinite potential. Airborne studies have shown that increased spectral resolution--and this morning we've talked a great deal about spatial resolution--increased spectral resolution will contribute significantly to environmental monitoring, geological exploration, and military intelligence. Increased spatial resolution will obviously contribute to mapping, as will stereo coverage.

Finally, on the question of Federal responsibility, the answer to which Federal agency is best suited to operate the LANDSAT Program is simple. That agency or organization which steps forward with the necessary funds for the program is clearly best suited. If ever there was a program without an ardent suitor, it is the LANDSAT Program. Unwanted, seemingly unloved--except perhaps for the Congress--by NASA, USGS, NOAA, and most of all OMB, this program, for more than a decade, has needed a strong advocate in the Executive Branch. To EarthSat, the largest value-added commercial user of LANDSAT data in the world, the only thing which matters when it comes to Federal responsibility is strict adherence to the principles which we have discussed above: open skies, non- discriminatory access to data, service, and technological progress.

Thank you.

[The prepared statement of Mr. Thibault follows:]

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The CHAIRMAN. Thank you, Mr. Thibault.

Mr. Sperry?

STATEMENT OF STEVE SPERRY, MANAGER OF MARKETING, ERDAS, INC.

Mr. SPERRY. Thank you, Mr. Chairman.

I would like to submit my entire statement for the record, and I will abbreviate my testimony in the following slide presentation.

In my testimony, I would like to concentrate on our company's history, deal with the current applications and use of LANDSAT within the GIS and image-processing realm and to deal with trends that we see in applications, and finally, then, our recommendations.

This is the sixth time that a representative from our company has made a presentation in front of your committee. ERDAS was incorporated in 1978, and we actually produced the very first commercial micro-based image-processing system. Today we're on a variety, from PCs to high-speed workstations, and we have really grown to the level where we are now the leading image-processing software company in the world.

Last year in February, I made a presentation to your subcommittee out in Riverside, California. That was in February of 1990. At that time, we had 1,200 systems. In the last 15 months, we have now over 2,000 systems. This really parallels very closely with the overall growth of the GIS industry. According to a research company called

Daritech, the overall GIS industry is expected to be over $2 billion by 1993. The growth in this is at a rate of about 20 to 30 percent. The points of all this are that there is a market out here for image-processing software. We have new users who are coming on at an explosive rate, much faster than it ever has in the past.

From a market direction, we think that image-processing has been and always will be tied to the GIS industry, and that really needs to be looking at the focus from a commercial application standpoint. An interesting aspect out of it is that our research and other hardware vendors out here really feel that the overall potential market out here, that 75 percent of the users in the 1990s do not even know what image- processing or GIS is today. So we're dealing with something that is really just now starting to grow, and we expect to see significant benefits in the 1990s.

The original market really was scientific users. Today you see users having some training in image-processing and having strong analytical interests. The new market really will be they'll have no training in image-processing. What they're really trying to do is visualize the data, and I think I can give an example of the people who were out there visiting the different booths today. What catches their eyes are the images, and they can start to infer information

by seeing that. What historically has been thought of as image- processing has been the manipulation of the data, and today we're developing software capabilities to make it much easier for people to be able to use this technology in a very fast and efficient format.

Some project examples that we at ERDAS have been working on in the past couple of years I think really can point out what has been the need and the use of LANDSAT data. The Suwannee River Water Management District Project is in northern Florida. That was 7,600 square miles of area and dealt with a land cover/land use classification for 35 different land types. It was tied in with the Florida land use code system. It used LANDSAT, but it also used aerial photography as a joint product. It was integrated in here, being able to get that final product that they needed.

The NASA project is working with San Diego area governments. They originally were just part of the research group, and now they have completely bought into the concept. So for the entire County of San Diego, which is 4,200 square miles, they are using LANDSAT imagery with Spot data as a merge product for 10-year multispectral data, using it to update vector GISs for land use and land cover information.

The Georgia Department of Natural Resources is a project that we're completing right now. It is mapping the entire State of Georgia. It is being driven by mapping of fresh

and salt water wetlands. The interesting aspect here is two-fold. First of all, it is trying to be able to update the national wetlands inventory. That program, while as good and efficient as it has been, has only resulted in less than 40 percent of the entire State being mapped, and that was starting in the early 1980s. In less than a year, we will have mapped the entire State, and we will have produced 1:24,000 coverages in a raster and vector format. Another aspect of this project is that approximately 20 to 30 percent of the data that we had to purchase from EOSAT on that is throw-away data. We could not use this in the State of Georgia, yet we had to pay for it. It's an additional cost at that scale that makes it somewhat prohibitive for a greater opportunity of large area mapping in a commercial world.

The last study I want to point out is the Lake Michigan ozone study, which is work that we're doing right now. That is for the Lake Michigan Basin. We're doing a land cover classification of which the statistical information will be fit into an air quality predictive model, and it is being mandated by Congress--I mean, not by Congress, by the Supreme Court--to be able to produce this study, and it's being worked in conjunction with EPA. So we're starting to see the information being used more also in a legal sense for large area mapping.

All of these things have one thing in common. Really what we're doing is monitoring. We're doing change detection, we're doing a lot with raster-vector integration, we're finding that the use of the data with our software is responding to what we call ''heads-up'' digitizing or on-screen mapping of vector data, and we're doing land cover classification for resource monitoring, all these leading to what we think will be an important aspect of the 1990s--predictive modeling--and we're dealing with it with a ''red flag'' approach. Look at your troubled areas, and then spend more of the money on the more detailed areas for a more refined research. But that first approach of looking at a broad region is very important.

All of this is really leading to, I think, in the software development--and you can see those examples in the other room today--is what I call ''visualization.'' People want to have multiple views of the same data. They want to use multiple data sets together, and by this, they want to be able to look and compare this information.

This just being one example here. This is the San Diego study in which we have up in the upper left-hand corner LANDSAT data, which has done what we call a ''Tassle Cap'' transformation and is something that cannot be done with the Spot data and which very easily shows us major drainage patterns in those areas. The lower left-hand corner is the

merging of two Spot scenes from 1986 and 1988 to immediately show change detection. The red areas are the areas that are undergoing change, and the blue areas are where actually change has been completed. Then we have a detailed aerial photograph of one of those areas, and then we have a USGS quadrangle sheet from 1977, which is the most recent paper map that's available for this area on that.

Other areas that we're looking at here--we're looking at a sales compartment map for a forest company, and we're looking at 1990 data, in green or what we call ''true color,'' and in the lower area, 1982 data, in false color on that, being able to compare and update those and change the actual boundaries of the vector maps on that.

This last side on this application here is actually showing aerial photography on the right-hand side with tree stands and the sales compartment, and then on the left-hand side are, again, a Tassle Cap transformation of TM data and a TM data showing bands for 4, 3, and 1, and we've got overlayed on top the vector maps themselves. When we have been showing this with these companies, what they are able to see is they have the detailed resolution of the aerial photography, but the imagery itself can give them a lot more information actually about the ground situation, and in conjunction with them, when they look together at all these scenes, they can infer more than either with one set or with

the other set, and they need to have both sets of data at the higher resolution, at the aerial photograph stage, and at the multispectral stage, which LANDSAT offers.

The common band combinations that we found with our users out here for land cover mapping, 4, 5, 3 and 4, 3, 1 are the most standard band combinations. Within the forest industry, they'll usually use bands 4, 5 and the principal components, which is taking the major statistics of bands 1, 2, and 3 or the visible bands. Bands 4, 5, 3 is another one, and I think in the previous testimony it was shown that is a very good combination for forest mapping. Geology, the most common ones are bands 7, 4, and 2. For wetlands mapping, what we're seeing--and again, a repetitive one--4, 5, 3 is a very good one there for species separation, as is 4, 3, 1, with the band 1 being very good for shallow aquatic vegetation. But a Tassle Cap of all of the bands has proven to be a very effective product for actually delineating wetlands maps.

The least used--and it's tended to become a throw-away item for many users--is the thermal band. The major reason is the poor resolution. The 60-meter resolution is just really not adequate for the type of information that needs to be inferred from thermal bands. But also that particular sensor has always brought out very poor quality data, not consistent with the other bands.

From our perspective and the directions that we're seeing, high-resolution data at the five-meter level is needed. Pointer capability is also needed for this one. And a thermal band at that resolution could be very effective, especially for looking at toxic waste and also getting a sense of the overall soil moisture there. Multispectral imagery is needed at this resolution, and stereo coverage would be required.

We can really be able to use detailed terrain data at this level, and there is digital data that is now available in the U.S. at the 1:250,000 scale from USGS. There is a program going on for updating it for 1:24,000, but it's coming out at a very slow pace. We and other companies have developed digital ortho modules that can use imagery such as Spot's panchromatic to be able to generate 10-meter digital terrain data. The reality of that, it's about a 1:50,000 scale mapping. At the five-meter, we really find we could be able to use this more at a 1:24,000 scale, which really is the level that we need for detailed planning purposes within the GIS industry on here.

The final thing that we've really been seeing here is the idea of that fused or merged product. In this case, systems such as ours can be able to merge, like in the upper right-hand corner, Spot panchromatic data at 10-meter resolution with, in this case, the bands 4, 5, and 3 of the LANDSAT and

30-meter resolution and produce 10-meter multispectral.

Out in San Diego County, where they have been using this combination, they're tying it in with the 1990 census. They are updating 1:24,000 scale land use vector maps, and while the Spot data in panchromatic helps them delineate the spatial boundary, the spectral resolution of the TM data makes it easier for them to interpret the different land use types. In bright orange, what we're seeing up here, we're seeing golf courses and agricultural land. In the green is just the basic chaparral vegetation out in southern California. And purple is really pulling out the urban landscape.

This color backdrop makes it easier for the user to be able to do their updates and interpreting, and they've found that it has improved their performance by maybe a factor of two to three times the speed it would if they were having to use just black and white mapping.

The overall trend that we see is that satellite imagery is being used extensively with aerial photography. The two go hand in hand. The higher resolution of aerial photography makes it easier to interpret some of the attributes of a vector GIS capability. But digitizing today is definitely changing. What has been the technology of the GIS industry, tablet digitizing, is really past technology. Scanning is now being used for the initial data capture. But what we're

seeing out here is what we call ''heads-up'' or on-screen digitizing being used to update these vector data bases, and a merged high-resolution multispectral product will be very important for the industry to do this updating of the data base.

Imagery is also being matched to the application need, the fusing of the Spot TM data, taking what sources you need and getting the products that you need out from it. Terrain-corrected imagery is becoming very popular out there, and it is being offered by a variety of service bureaus.

Finally, what users really want to do is they only want to pay for the imagery that they're needing, confined to their study areas. It is a very major rub for a lot of users out here to have to buy excess data. They really have a model out there, and it's the photogrammetric industry. They buy the 9x9 photographs that they need for their area; they don't buy for some other county. And they feel the same way about that with digital satellite imagery.

So in conclusion, what we feel is that LANDSAT today is a very useful product. The spectral capability and the spatial resolution is adequate for a lot of applications. The spectral capability merged with Spot data is offering us high- resolution spectral capability. The consistency with the existing data is important. LANDSAT 6 will have the same spectral band, but it's now added a co-registered

15-meter product. LANDSAT 7 needs to have the same spectral bands. It needs to maybe have more, but it needs to be in that same general range to work with it.

Finally, I think really better marketing is needed out there. One of the other rubs out there is the acquisition time it takes to get the data. While Desert Storm can get quick turnaround, a commercial user such as ourselves may have to wait anywhere from three to four months to get the data that we have ordered. There is a tremendous backlog in getting that information out, and that has to be streamlined if we are going to have a real commercial product out there.

Finally, we need more repetitive coverage. It was alluded by the other questions earlier from the other speakers about the time cycle. We're looking at eight-day and 16-day cycles. Well, in reality, a lot of times, with cloud penetration problems, you may get three or four coverages in a year for large study areas. We need to be able to have either more satellites up there or looking at the pointer capability, such as in Spot. That higher resolution at five-meter with pointer capability, I think, would be important.

And to deal with the bottleneck of getting the data, we ought to look at some other models out here, so like local ground receiving capabilities similar to what is out there on the AVHRR programs. People can have their own satellite,

they pay a fee out there to be able to access that data, and they get it down when they need it. That will be able to help for large landholders, such as petroleum exploration firms, forest products companies. All could be able to have and acquire the data when they need it and be able to tie back into their particular GIS system.

Finally, I would look at the photogrammetric infrastructure. All of these different small companies right now are really turning to developing data bases in the GIS industry, and they are a natural for being able to supply that information to the GIS services out here. And working off of that structure in a delivery capability, whether it be massaging the product for a user or actually just producing the product out there in their format they need for their study area, I think are ways that we can be able to improve the overall commercial viability of the satellite and LANDSAT products themselves.

Thank you.

[The prepared statement of Mr. Sperry follows:]

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The CHAIRMAN. Thank you, Mr. Sperry.

Mr. Ayers?

Mr. Sperry, you were complaining about the large number of times you've had to testify before the--

Mr. SPERRY. No, no. I appreciate it. Actually, the reason I was bringing that up is that we have been following and we have been part of the industry's growth and pointing out that we've given testimony before, and we appreciate the opportunity of doing it. No complaints whatsoever.

The CHAIRMAN. I thought that the number of appearances correlated well with the increase in the growth in your company.

[Laughter.]

Mr. SPERRY. I agree. I agree very much.

The CHAIRMAN. Go ahead, Mr. Ayers.

STATEMENT OF LAWRENCE F. AYERS, VICE PRESIDENT OF INTERNATIONAL MARKETING, INTERGRAPH CORPORATION

Mr. AYERS. Mr. Chairman, it's a pleasure to be here before the committee, and I have a brief statement that I'd like to make.

I'd like to preface the statement by saying that it was really an opportunity to sit here today and watch my career go by, because I spent 32 years in the Department of Defense, ending up as a senior civilian for the Defense Mapping Agency and running some of their plants over the years, and now I sit on the other side, having spent four years in industry, so my perspective of sitting and watching this testimony has been extremely interesting to me.

I think I would like to start out by saying that the public satellite data, as you know, has been in being for 20 years; aerial photography goes back to World War I, when it really became in vogue; and, of course, mapping--the history goes back to the early navigators, and when the information from these disciplines of remote sensing and mapping are combined in a computer data base, you get a synoptic relationship developing which allows users to address geographic questions.

This combination of disciplines are now using Geographic Information System to solve problems. The reliability of

the decisions are based on the geographic data required to be precise, accurate, and timely. I think, Mr. Chairman, we've heard a lot of discussion about timely data.

Satellite-based remote sensing obtains a repetitive, synoptic view of the earth from space over large areas, and I think I heard you say, Mr. Chairman, the big picture, and that's exactly what it is--the big picture.

In addressing the markets for remote-sensed imagery, there is a logical division of the data. The first is a need for spatial data, and the second, for spectral, and I think that's been quite clear in some of the testimony that we've heard today.

The spatial data users are primarily the people trying to obtain the location, identification, description, or trail of man-made and natural features. This requires a broad stereo coverage of resolutions--and our experiences showing five- meters, when you're talking about a broad area, seems to be very reasonable--and a positioning accuracy--and I noted in some of the testimony, and ours agrees, three to five meters is important. The multispectral coverage is also used for feature identification and classification.

In the second area, the users seek to measure change over time of natural and man-made features, such as water or air pollution, for clean-up, for monitoring effects on the forestry, agriculture, and urban expansion. This set of

users explores remote-sensed data collected at many bands across the electromagnetic spectrum, as I think Mr. Sperry has described.

Now, when I was contacted by your staff to appear before the committee, they suggested I might address some pretty specific questions which were of interest to the committee, and so I have directed my testimony to those questions.

Number one, what is the market for remote-sensed data? I chose to quote a Dataquest report. I know there was another one referenced, but I think both of these are independent research companies which are recognized in the industry. For 1990, the worldwide sales in mapping and GIS hardware and software was $1.4 billion and equated to 42,000 seats or places where people could work. Intergraph was the largest supplier, with 29 percent, and we sold $400 million this past year. IBM was second, and the list contained 92 other companies. Many of them are here today.

In Intergraph's case, 25 percent or $100 million of hardware and software were used specifically for exploiting remote-sensed data, and some of the others were used as a byproduct or a workstation that also did other work. Twenty- five percent were used specifically for remote-sensed data. There has been a steady increase in this market over the past three years, and our markets have ranged over a broad set of industries, which I have enclosed

in my testimony, but it ranged from Federal, State, local, defense, forestry, petroleum, and transportation industries, just to name a few.

I believe the use of the systems sold to exploit and process remote-sensed data is growing. If Intergraph's share of the overall market is indicative of the share of the image exploitation, then one would conclude that about $400 million worth of hardware and software entered the market in 1990 to exploit imagery.

Materials being used? I think they've been discussed pretty well here today: commercial LANDSAT, Spot, conventional film, and conventional digital imagery.

How is the market changing? Service bureaus and Government agencies are producing value-added products from source to meet the needs of the users, and this market is growing. The general public, industry, and government users are demanding value-added data in rapidly increasing numbers. The cost of the desktop workstation or PC is significantly decreasing, and the software data base technology is expanding.

Now, while the leadership in commercial remote sensing appears to me to be moving toward Europe and Japan, the leadership in technology to exploit the imagery is increasing in the United States, and I found of interest that in Dataquest's report, it stated that 87 percent of the

hardware and software that was sold around the world came from United States companies. This is an area that the U.S. leads in export.

Is LANDSAT essential? The direction of LANDSAT has been away from broad area, high-resolution stereo collection and toward more channels of the electromagnetic band at increasing cost to the sensor. Spot image has maintained some balance between these two areas but has technical limitations. I would answer yes, commercial satellite remote sensing is essential, but at a lower cost and with a balance of high- resolution stereo collection and the most-used, most-needed bands of the electromagnetic spectrum. To this end, there are some attractive design proposals being offered in the industry.

How cost effective is satellite data collection over conventional? For ready access with broad area coverage delivering timely data, satellite collection is by far the most economical. However, the cost of the imagery is pricing the first-time users out of the market and making the use of satellite imagery as a monitoring device cost-prohibitive, and I think Dr. Rock made that point very well earlier today.

I'd just like to note for you, Mr. Chairman, just to give you a feel for it, I think most of us in industry would tell you that if you wanted to buy a workstation and the software

to exploit it, you could probably have a reasonable capability for something on the order of $15,000 to $20,000, yet if you want to go purchase the imagery, you're going to pay $25,000 to $104,000 for an image. That seems to be a bit out of kilter.

For very high resolution over local areas in response to local needs, aerial photography collection is best and does quite well.

Is image-processing technology available to use the data? The answer is obviously yes. The market demand is growing, the exploitation technology is here, it is becoming commonplace, and it is inexpensive, but more important, it is now appearing in many industries for planning, design, operation, environmental assessment, and so forth, as revealed in the Dataquest statistics and our own experience in sales.

In closing, I would like to offer the following comments and observations. First, the potential benefits of satellite imagery for both spatial and spectral is high. Second, use of satellite data and its level of acceptance with the user community is expanding, and I think we have just--there is a reality really coming there. Third, the recent costs of developing and maintaining a satellite system and a data distribution infrastructure are high--those costs are too high--and we ought to look at alternatives or

ways of reducing that. If the data costs remain high, the demand will not grow, and the true potential of the data will not be realized.

We need a national joint investment from both Government and industry to make available low-cost remote-sensed data. This will allow more effective management of our resources, our environment, our infrastructure, and affect our quality of life. The alternative is to become dependent on foreign satellite systems to supply all our needs for our Government, our industry, and our public consumption.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Ayers follows:]

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The CHAIRMAN. Thank you very much, Mr. Ayers.

May I ask if Mr. Valentine has any questions at this point?

Mr. VALENTINE. Mr. Chairman, I do have one short question. I know we've got to go vote. Perhaps this has been answered previously, but I was unable to be here.

Would you gentlemen who are concerned with the commercial interests look with some suspicion if the control of LANDSAT were in the Department of Defense, or would you prefer that it remain in some civilian agency? Or to put it differently, with the DOD, do you think your access to data would be affected?

Mr. AYERS. I'll make a crack at that. One might say I'm biased, because I've spent a lot of time in there, but I believe the Department of Defense will carry out any mission that it's assigned, and I would refer back to GPS, because I think that's a very interesting example where the Department of Defense did in fact produce that, made it available, and I think there were some suspicions and concerns about its availability. I think that's waning.

I think it's appearing around the world in all our commercial markets, and I think with proper leadership and direction, I would have no problem with the Department of Defense if it was elected that that would be the agency that

could carry it out. I would add, however, that I think it's quite clear and important that a directing body that determines how to task in the priorities of the tasking should be a civil responsibility and provide that kind of guidance to the operators of the system. But that's my view on it.

Mr. VALENTINE. Do you gentlemen who perhaps have different backgrounds have a different feeling about that?

Mr. SPERRY. I think it can be fine. I really actually don't see a problem with DOD actually being kind of the keeper of LANDSAT. I think the examples given by Mr. Ayers about the GPS are true. The local-based capability of receiving if we were to go to something like the AVHRR, that's, I think, an issue that would have to be addressed, and it might slow up the ability of civilian access to the data. But if it really follows the guidelines of the open skies policy and they work on the same levels that we're doing with GPS right now, I think it could maybe a very good boom overall for the commercialization.

Mr. VALENTINE. Thank you, Mr. Chairman.

The CHAIRMAN. Mr. Thibault has already answered the question. He said the agency should operate it that has the money.

[Laughter.]

The CHAIRMAN. Thank you, Mr. Valentine.

Gentlemen, just to reassure you, we're going to adjourn in about five minutes because of the vote, and I don't want to keep you waiting here unduly, and I do want to express my appreciation for the testimony which you've given.

I want to try and get in mind certain fundamental things here. Everyone has testified, including you, to the importance of maintaining the continuity of the data, and with some variations, I think you've indicated that this includes something close to the present 30-meter multispectral data, but that the system also needs to have a capability for five meters, for stereoscopic, for quicker turnaround, maybe even some radar or something like that. In other words, we can think of a lot of ways to improve the system.

Can we do both? Can we keep the present series going and add the other things on in a new instrument? I should know the answer to that, but I don't.

Mr. THIBAULT. I think those system improvements are very costly, and as we've seen in the LANDSAT 7 studies, as one increases the spectral and spatial resolution of the instruments, the costs do not go up slowly, and if we're struggling today to fund a $300 million to $400 million satellite, I think it's going to be very difficult to find the funds to fund perhaps a series of satellites to provide five- meter stereoscopic coverage. So the issue is not a

technological one. Certainly, it's an economic one of sizable proportion.

The CHAIRMAN. Go ahead, Mr. Ayers.

Mr. AYERS. From the information that we have and what I've seen, some of the studies that have been done, there is a tradeoff for resolution and the cost, but there seems to be a very sharp break in that, and technology has significantly increased, and that break, from every indication I've seen, seems to be around five meters, and the technology--I think it would be very interesting to see some competition come forward for some design and the cost of the design to come forward with a five-meter resolution system. I believe you will find that that is not as cost-prohibitive as one might think.

I do share the concern that there seems to be--as you move up from that, the data rates and volumes seem to go off the chart in cost, but I would suggest that I think our technology and our space industry now can come forth with some rather economical solutions to that.

Mr. SPERRY. I think just one aspect on there, at least with LANDSAT 6, they have a 15-meter panchro now that they do co-registration. I think co-registration is an important aspect on it. We could probably even look at five-meter panchro with that 30 meters and be able to get a lot of information out there in the multispectral world, and if

that was the only alternative that we had, I would say that should be the--we should at least do that option.

It's also my feeling that if LANDSAT 6 had done originally as planned to have had that five-meter resolution that the overall commercialization aspect would be growing significantly. The demand is out there right now, and we still don't have a product--we don't have a capability of supplying that demand.

The CHAIRMAN. All of you have described the market in the equipment and in the value-added services in addition to the cost of buying the data itself. The equipment market and for value-added services seemed to overwhelm the cost of the data, and I've been thinking in terms of this little, dinky $15 million, $20 million, $30 million for buying the data, but you're talking about billions of dollars in processing equipment and in value-added services.

What happens to that market? Does the United States stand a chance of losing that market or losing points in that market if we're no longer in the LANDSAT business? If we're no longer producing the imagery, are we going to continue to be able to have even the declining share of the market that we now have? We have obviously a pretty large share of the market now.

Mr. Ayers?

Mr. AYERS. I think from our standpoint--and I think I'll

let the others speak for themselves--47 percent of what we sell goes into the overseas market. So I think that if this country elects not to put the sensors up, I don't think that the sensor is going to go away. I think that this country will become dependent on providers of sensors such as the Japanese and the French. I think we do enjoy a large equipment, hardware and software. It is an area that is becoming very competitive, the margins are tight, and you have to make a research and development investment, as we all do, to keep ahead. But I would suggest that that's bringing a hell of a return back into the balance of payment to this country, and I think that it would behoove this country to retain its posture in the space collection system as well as the processor.

The CHAIRMAN. All right. I've got less than a minute to go vote, so I'm going to have to terminate this, and I hate to do it, because I'd like to ask a lot more questions, but if you will cooperate, we'll send you some more questions in writing, and upon termination of this hearing, which will be in 30 seconds, Kevin Hussey of JPL is going to do some more demonstrations on the screen here of some of the LANDSAT data used, and I urge any of you who are interested to remain for that.

Thank you again, and the committee will be adjourned.

[Whereupon, at 2:14 p.m., the committees adjourned, to

reconvene at the call of their respective Chairs.]

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