Committee on the Peaceful Uses of Outer Space

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Fifty-fifth session

645th Meeting
Wednesday, 6 June 2012, 3 p.m.
Vienna

Chairman: Mr. Yasushi Horikawa *(Japan)*

The meeting was called to order at 15.06 p.m.

The CHAIRMAN Good afternoon distinguished delegates, I now open this 645th meeting of the Committee on the Peaceful Uses of Outer Space.

The CHAIRMAN Distinguished delegates, I will shortly adjourn this meeting, so that the special panel on "The 40th Anniversary of the Landsat Programme and the Worldwide Evolution of Remote Sensing from Space" can be held in this room. After the panel, at 6.15 p.m., there will be a reception hosted by Japan in the Cafeteria 3 of the VIC restaurant. This morning I said it's Mozart room but now the place is changed to Cafeteria 3, it's just next to Mozart room. You are very welcome.

Before adjourning this morning, ah this meeting, I would like to inform delegates of our schedule of work for tomorrow morning. We will meet promptly at 10.00 a.m. At that time, we will continue our consideration of agenda item 5, General exchange of views. We will also begin our consideration of agenda item 6, Ways and Means of Maintaining Outer Space for Peaceful Purposes, and agenda item 8, Report of the Scientific and Technical Subcommittee on its Forty-ninth Session.

There will be one technical presentation tomorrow morning by a representative of Japan entitled "Japanese International Cooperation".

Also, Expert Groups under the Scientific and Technical Subcommittee Working Group on the Long-term Sustainability of Outer Space Activities will meet tomorrow morning on the margins of the session. Expert group A on Sustainable Space Utilization Supporting Sustainable Development on Earth will meet from 9.00 a.m. to 1.00 p.m. in meeting room MOE27. Expert group B on Space Debris, Space Operations and Tools to Support Collaborative Space Situational Awareness will meet from 9.30 to 12.30 in meeting room MOE100. Expert group C on Space Weather will meet from 10.00 a.m. to 1.00 p.m. in meeting room MOE19.

During lunch time tomorrow, at 1.00 p.m., there will be a reception hosted by the United States of America and Secure World Foundation, on the occasion of the fortieth anniversary of the Landsat programme. The reception will be held in Special Function Room D, right outside the Mozart Room of the VIC restaurant.

Are there any questions or comments on this proposed schedule?

I see none.

I would now like to invite the speakers to join me in the special panel on the "40th Anniversary of the Landsat Programme and the Worldwide Evolution of Remote Sensing from Space".

This meeting is adjourned until 10 a.m. tomorrow morning.

The CHAIRMAN Distinguished delegates, You will recall that the Committee at its fifty-fourth session in 2011 agreed on the importance of commemorating the fortieth anniversary of Landsat — the first Earth observation satellite mission, providing many countries with remote sensing data since 1972 — and decided to hold a special panel discussion during its present session dedicated to this anniversary and to the worldwide evolution of remote sensing.

I am therefore very pleased to act as the chair for this special panel on the "40th Anniversary of the Landsat Programme and the Worldwide Evolution of Remote Sensing from Space".

The first satellite in the Landsat series was launched on 26 July 1972 as the Earth Resources Technology Satellite or ERTS, as it was originally called. The launch marked the beginning of the longest running civilian Earth Observation programme. The latest satellite in the series, Landsat 7, has been launched in April 1999. It will be followed by the Landsat Data Continuity Mission (LDCM). The construction and final testing of this newest satellite in

the Landsat series is presently being completed and the launch is scheduled for January 2013.

I was told that the term "remote sensing" first appeared in the International Symposium on Remote Sensing of the Environment", hosted by the University of Michigan in 1962. After the launch of the first Landsat in 1972, high spatial resolution ability and data accessibility became a top agenda for various Earth observation satellites among countries concerned. This led to the UN resolution on Principles relating to remote sensing of the Earth from space in 1986.

Landsat data is being used operationally for a wide range of applications such as in agriculture, cartography, geology, forestry, resources monitoring, water availability, surveillance, education and national security. We will hear more about the satellite and their innovative application from the speakers in this panel.

The special panel today will consist of two parts. In the first part we will hear the presentations of seven speakers who have been closely involved with the Landsat Programme and with the development of space-based Earth Observation Systems. In the second part we will invite Mr. Sergio Camacho of Mexico to moderate a round table discussion on the theme "Landsat and the Evolution of Earth Observations over the past 40 year". Several speakers will join him to discuss the contribution of the Landsat Programme and of Earth Observations programme in general to policy- and decision-making in support of sustainable development at the global, regional and national level.

The CHAIRMAN Distinguished delegates, we will now begin with the first part of the special panel. I first invite Mr. Ken Hodgkins Director for the Office of Space and Advanced Technology in Bureau of Oceans, Environment and Science of the United States Department of State to make some opening remarks. Mr. Hodgkins please.

Mr. K. HODGKINS (*United States of America, presentation*) Thank you Dr. Horikawa, thank you for well I would first like to thank the Office for Outer Space Affairs for putting on and organizing this panel as well as the excellent exhibition in the Rotunda, if you have not seen the exhibition yet I really would urge you to do that.

A year ago I had talked with my colleagues about the idea of celebrating the 40th anniversary of the Landsat programme. Not necessarily because it was a US programme but because of the huge impact that it's had on the World, if you will. Not only from a scientific standpoint but from a social and economic standpoint. I began my career in 1980, working at the National Oceanic and Atmospheric Administration Satellite Service on the Landsat programme. Programme was in the process of being transferred from NASA to NOAA to be operated on an operational basis, and my job was to renegotiate the Landsat ground station agreements. In that capacity I also was the NOAA representative on delegations to the UN Outer Space Committee, so I am now entering my 32nd year of COPUOS meetings and so I thought that perhaps I could give you a bit of a perspective from that I have gained from all of those years concerning the importance of Landsat and then Earth observations in general.

When Landsat was conceived and launched, the idea that an average person, not necessarily a researcher but anybody could have photos of the Earth that up to that point had been pretty much limited to Governments for reconnaissance purposes. So the idea that you could, people could use this for any type of purpose was rather revolutionary and the Landsat programme was conceived with the notion that we would make this data available on a public non-discriminatory basis for global and regional, as well as national research and that was another, rather again I would say revolutionary idea.

For many countries, this was the first opportunity to participate in the space age. At that point you know, much of the space activities were limited to a handful of countries, But now through the Landsat programme you could build a ground station and get data directly from the satellite to use for your own purposes and make it available to the general public. Or you could buy data from NASA or from NOAA and eventually from USGS. If you didn't want to have your own station, or you could buy the data from the various ground stations. So all of a sudden now you had a source of information from space that was not otherwise available and you could, you as a country or an individual, could be participating in the space age, and when I was thinking about this, it occurred to me that many of you out there, of course I'm not a scientist I only pretend to be, but it occurred to me that many of you in the space community got your start or your Governments got their start in the Landsat programme and understood suddenly the value of space-based information, and that led to many of your countries taking the decision to move beyond remote sensing but to space sciences, eventually building your own satellites. So today we have some 60 countries that might have their own space programmes.

The other interesting part of the evolution of Landsat was the impact I believe it's had in the work of this Committee. The Space Applications Programme became, if I could say, more robust and Dr. Abiodun can talk to this more because now we had a source of space data that the UN through the Space Applications Programme could make available to other countries, particularly developing countries, and assist them in capacity-building and the use of this data. So for COPUOS and for the Office of Outer Space Affairs and for the Space Applications Programme, Landsat had a tremendous impact I believe. The other part about the Landsat programme that I think is important to bear in mind is that at the time we launched the system and operated it, there was a huge concern among countries that all of a sudden the programme was gathering data about their territory and about their natural resources and the many countries were concerned that this data could be exploited to their detriment and so a part of the Landsat programme and it's policy was that we would make the data available on a public non-discriminatory basis and that concept is enshrined in the 1986 UN Principles on Remote Sensing from Space where it provides that data of a sensed State should be made available on a public non-discriminatory basis as soon as possible. The principles also enshrine the idea of cooperation in the use of the data and to share the benefits of that cooperation.

Today, most if not all, either commercial or Government-run remote-sensing programmes operate on that basis where data is made publicly available, and in some cases it's made publicly available free of charge in the case of Landsat. But the whole notion that the greatest benefit from this particular technology is to share as much data as possible has its roots in the Landsat programme. So I had agreed to make a few opening remarks and I think I'll probably stop here because we have a number of very interesting presentations that I think will add greater perspective to what we're trying to achieve here. I guess the final note was that when we did think of this idea of commemorating the Landsat programme, we wanted to make it as inclusive as possible and that's why it's important that we bear in mind that from Landsat we have an evolution of systems operated by various countries that are providing huge amounts of data today and into the future for better understanding of our environment and what happens on Earth. So with that I'll conclude my remarks. Thank you Mr. Chairman.

The CHAIRMAN Thank you Mr. Hodgkins for your presentation.

The second presentation is by Ms. Jean Parcher, Senior International Relations Specialist of United States Geological Survey (USGS), entitled "Origin and Legacy of the Landsat Programme". Ms. Parcher you have the floor.

Ms. J. PARCHER (*USGS, presentation*) Thank you very much Chairman.

What I'm going to through in a really short time is the history and legacy of Landsat. Many of you may know this better than I do, but I've found some very interesting observations when I was doing my research. First slide shows the first Landsat satellite which was the ERTS satellite (Earth Resources Technology Satellite) which was built by NASA and the early vision of Landsat was inspired in part by NASA's early moon surface observation satellites. But in reality, Dr. William Pecora, who was a Director of the USGS, began proposing before he was the Director in the late 1950s, the idea of building a civilian led remote sensing platform to collect information about our natural resources, and then in the early 60s when we had a little bit of a wheat pricing crisis in the US due to well it was actually due to issues around the world where we miscalculated the amount of wheat that would be available to the world, our President at that time said we need some way to observe the world and see what's happening in agriculture to help us with our commodities pricing.

So what happened in 1966 there was a press conference with our Department of Interior Secretary William Udall — Stewart Udall I'm sorry — and at that press conference he announced that we would go ahead and initiate Project EROS (Earth Resources Observation Satellites) to collect valuable resource information about our environment and to improve the quality of that, and at that press conference he named William Pecora to be the new Director and oversee the Landsat satellite and work for the EROS data centre.

And NASA then was recruited to build the satellite, and I want to take you back to that time period, the 1970s the early 1970s, that's when, was kind of the time of environmental awareness, we you know, that was a time when we had the oil spill in Santa Barbara, we had mercury poisoning in Japan, we had floods in other parts of the world and we knew that it was really important to start monitoring our environment and having some way to know what was going on and our communication process was improving so we could do that through communication but we wanted to do it through pictures.

So the US realized that the was a great need to build a civilian remote sensing satellite to monitor mankind's footprint on the Earth.

So, NASA was designated to build the first Landsat 1 satellite, and they built it on top of a Nimbus weather satellite and launched it. One of the really important issues here was that Dr. Virginia Norwood of Hughes Aircraft Company proposed the design of a new process that was kind of like a scanner mirror that would go back and forth and it would actually pick up the different bands and pixels instead of just using the satellite as like an aerial camera which was our reverse video, reverse-beam videocom. So both of those instruments were placed on the Landsat 1 and the scanner which was later named the Multi Spectral Scanner, the MSS, was so successful that that was actually replace the RBV instrument, and this was the first time that we had a civilian instrument that could travel the Earth and at a fast orbital rate and in real time downlink the pixels needed for us to view the images.

Since it was so successful, Landsat 1, Congress gave us money to build 2 and 3, which were built by NASA, we also had a large user community using the data and Landsat 2 was launched in '75 and Landsat 3 in 1978.

So this is an example of one of the first MSS images downlinked from Landsat 1972, July 23rd Monterey Bay, California. What was really interesting in these first images, in this one you can see how clearly the MSS image was, you can see the agricultural lands and the healthy growth around the Monterey Bay but what you can't, what was also noticed in this is geologists from the USGS who used to trampse through that area of California, they knew there were fault lines from the San Andreas fault, but they couldn't see them on the ground, they could see them in these images. So they discovered where the fault lines were.

Other kind of successes from these first images was in Fairbanks, Alaska, there was a forest fire that was growing, that was really expanding north of the city but no one could see it until they saw the image and then they realized that the city was in danger. A third anecdote to this was, there was a ship out in the Arctic Ocean that was trapped by ice and they couldn't figure out their way through it and so they received copies of the Landsat images and then found the way that they could travel through the ice, the breaks in the ice to get out of the Arctic.

So just to give a real quick overview of the Landsat satellite missions, I mentioned 1 and 3, Landsat 4 was launched in 1982, it flew for 11 years, it used both MSS and the Thematic Mapper and it was the first satellite that had GPS, civilian satellite that had GPS on board. At this time, Congress gave the instructions to, since it was becoming operational and NASA only really works on further observation on research, NOAA was given, or National Oceanic and Atmospheric Administration was given the charge to run the Landsat satellites as operational but also given the challenge by Congress to turn it into commercialization. So at that time with Landsat 4 it was taken over or commercialized by a private company EOSAT and they had to sell the data at cost which resulted in very very high prices and the user community basically dropped out because a lot of the user community was other federal agencies or people or other agencies around the world.

So Landsat 6 was also built by EOSAT but unfortunately it failed at launch and Landsat 7 was going to be commercialized but the Congress realized that we really needed a stop gap measure since 5, they didn't know how long 5 would be flying so they proposed to NASA and Department of Defence to build Landsat 7, and finally in 2001 it was turned over to the USGS and just to mention the Landsat 8 or data continuity mission is on schedule and will be launched this January 2013.

This slide actually shows the shifting Landsat responsibilities. You can see on it that, under the mission acquisition that NASA, NOAA we basically in charge over the years. Mission operations: it was NASA, NOAA and then around 2000 the USGS took over mission operations and we will take over mission operations for Landsat 8. But during the whole science data operations, it's been mainly the USGS Department of Interior that has been managing getting the data out to the users and a big success story of that is when we opened up the archives in 2008 freely available to all and Barbara Ryan will talk more about that in her presentation.

I know we're talking about history but we have to acknowledge that Landsat 5 that was launched in '84 is still operating today so more than 25, actually 28 years and it does have some problems, it's no longer transmitting the Thematic Mapper data but it is still transmitting the Multi Spectral Scanner, the MSS data. Unfortunately many international cooperators around the work do not have access to proper software and equipment to downlink to MSS but we are downlinking it for the US.

It is also the longest operating Earth observing satellite, has rotated the Earth over 150,000 times and transmitted over 5 million images.

Landsat 7 is still flying, it's capturing 350 images a day and the data is all free and open and we hope it can continue until 2017.

So the early collections of Landsat, this shows with the Landsat 1 and 2 the MSS collections, and this is
US-based that we were collecting just from the US ground station and until we had Landsat 7 we did not have an on board recorder that could capture the images and downlink them later. So we really had to rely on our international cooperators around the world to downlink the data and also our international cooperators realized that they could downlink when the satellite passed over downlink what they needed rather than rely on what was important to the US, and as you can see at this time what was really important was many of the agricultural areas around the world that we were monitoring.

The other important anecdote here is that before it took 21 days to reprogram the satellite so if we wanted to change and decide to start capturing over certain areas of the world, we could not, we had to anticipate 21 days in advance. With Landsat 7 we can determine if there is cloud cover in the way and immediately decide to collect or not collect.

This slide shows, this is our international ground stations, the number we had around the world and how they changed in terms of what they were actually wanting to downlink.

First we only had five at the beginning, now it's grown to almost 25 and in this graph you can see that you know, first the MSS data was really, was the only thing available but when the Thematic Mapper came through on Landsat 4 and 5 then they were more interested in downlinking the Thematic Mapper. When the enhanced Thematic Mapper came, was available with Landsat 7 they switched over to downlinking the ETM+ data but in 199[...], that was started in 1998 but then you can see in 2003 when we had the problem with Landsat 7 when the Scan Line Corrector then everybody switched back to downlinking the Thematic Mapper from the Landsat 5. So very interesting graph.

This shows who were our historical International Cooperators from our earlier days and this shows who's active today. So quite a growth in our international cooperators and we really really appreciate working with you all and also getting a lot of the historical data archives for Landsat Global Archive Consolidation projects that we can have historical data freely available to all around the world.

In just the last slide I want to mention, this is kind of looking at the goals of the visionaries, how we accomplished what we want to accomplish. Well we did get a satellite-based remote sensing system. We went from local to global with our cooperators. Our biggest accomplishment I think is in 2008 when we went freely open with our data policy and Barbara Ryan will talk more about that and we are working towards an operational Landsat system and later we'll see a video from our Department of Interior. This is in Secretary of Water and Science, Anne Castle that will talk about that. So thank you very much.

The CHAIRMAN Thank you Ms. Parcher for your presentation. We had a very glorious history of Landsat series.

The third presentation of the special panel is by Ms. Barbara Ryan, Director of the World Meteorological Organization's Space Programme, entitled "Space-based Earth Observations". Ms. Barbara please.

Ms. B. RYAN (*WMO, presentation*) Thank you very much Chairman Horikawa, colleagues, old and new friends in the audience, it's great to be back here. Let's see, I think just in terms of full disclosure, I am currently with WMO right now. I am the Director of the Space programme at WMO for one more month and then I will be moving in to be the Director of the Secretariat for the Group on Earth Observations and so what you will see in this presentation is not only the references to the importance of the open data policies that Landsat has to the Organization to which I am in and going to be moving into, but maybe also some of the challenges that we faced in this transition to the open data policies.

So, Space-based Earth Observations and the Importance of Open Data. The coordination mechanisms for which I think this open data policy for Landsat have been both supported by and have had one of the greatest effects on are the two above; the Committee on Earth Observation Satellites for which I was the Chair in 2007 and then the Group on Earth Observations, the Organization that I am going to be going into. But I do want to mention two other Organizations because I've had associations with both of them. The International Charter for Space and Major Disasters, I Chaired that back in 2005 or 2006 and also my current Organization, the World Meteorological Organization or WMO and I can tell you that these

open data policies for Landsat have had positive impacts and also been supported by each of these Organizations.

So let's look a little bit, Jean mentioned a graph that looked like this which was the international partnership that actually existed for Landsat so you will likely see your countries here either covered by the footprint of one of these ground stations or maybe one of the ground stations is in your country and I would have to argue that therein lies the core reason that this has been a successful partnership although it was a US asset and still is a US asset, there are many stories that are told, I think we all have our stories about Landsat and my guess is that there are as many stories back in your home Governments with how this has been used as there are in the United States. So, it's truly an international partnership, first out of necessity because like Jean said the early satellites did not have on board recorders so the United States needed those international ground stations to download the data, then send the data back to the United States, but then I have to say, after Landsat 7 when there was the capacity on board to then collect all the data that you wanted, I think this international partnership part has been by design because that is, I think, one of the core contributions that Landsat has made to the World.

Now, what did that international ground station network give us? It got this global coverage, so you'll see although maybe some of the tracks are a little bit hard to see and maybe the colours are hard, at first glimpse you will see many of the Earth's land masses are covered, in fact quite honestly, while you think this is a predominately terrestrial observing system, you will see there is quite a bit of the Ocean that's covered with this, and Jean told you a couple anecdotes there where Landsat scenes collected over the Ocean have in fact been instrumental in public policy as well. The other thing it shows is clearly the bias of the collects over the United States because like I said it was a US asset but also those areas of the world particularly Russia for wheat production, or South America for soy bean production, it's those areas where much of the world's agriculture took place and has an impact on food pricing. So global coverage.

I think Professor Horikawa talked about Landsat applications, look at the list of applications that are shown on this slide, ranging anywhere from agriculture as we're moving into climate change and our carbon inventories and credits, this will be even more important. Global change, land use planning and mapping and I've got a couple of slides that will maybe show some examples of these, and particularly the examples that are shown are going to be why this asset is important to the Group on Earth Observations and the Committee on Earth Observation Satellites. So let's look at land use change, This happens to be a US example, Las Vegas, Nevada. What it looked like in 1973 when the population was only 358,000 people, what it looked like in 2000 when the population was 1,560,000 people. I don't know if this is going to work but if we could click on that weblink you may see kind of a comical animation for Las Vegas, which brings us up to the current timeframe. This is an animation put together by NASA with a little bit of music. So 1980, I guess what I would say, look at how first the infrastructure is moving west and then the housing and actual vegetation moves west over this 30 or 40-year period. So, Las Vegas, Nevada. I think NASA came up with a funny headline on this YouTube video, you know usually people say "what happens in Las Vegas stays in Las Vegas" and I think what they said something about, Jean can you remember the term? It's, I don't know, What grows, stays in Las Vegas or something like that. Anyway, you can get that link on the website. You know what? So fine. Las Vegas has grown to the west, but what does that mean on natural resources?

Let's look at a different part of the world. This happens to be Saudi Arabia Landsat in 1986 from UNEP, United Nations Environment Programme Atlas of our Changing Environment *One Planet, Many People.* 1986, what it looked like, 2004 with the tremendous growth of centre pivot irrigations, so while you don't see centre pivot irrigation growing in Las Vegas, you clearly see an equal demand on the water resources with that change in population for Las Vegas.

Let's pick a different part, this happens to be Africa on what Lake Chad looked like in 1963, now this wasn't Landsat imagery at the time, it was airborne photography because the first Landsat satellite didn't go up until 1972 but then lets come to Landsat 1972, 1987, 2001, sorry and that last one was, I guess that was the last one but I think if we were to look at it now it may be gone.

Let's so, I think those are pretty good views of just taking a temperature, a picture of how the Earth's landscape is changing, but you can also look at land management practices. Now while you think this might be two different Landsat scenes, it is not. It is one Landsat scene that shows different land management practices. So, on the left hand side of the scene you will see Targhee National Forest, so managed by the national forest and their mandate is to in fact, at the time, produce timber and so you can see the extraction of timber from this particular area. The image, the

boundary, very stark between these two different scenes is the national park, Yellowstone National Park on the right and you can see that their mandate was to preserve the natural resources. So while it looks like two different scenes, it's one Landsat scene showing the different land use practices of two different federal agencies and then what you happen to see in the middle is a burn scar from a most recent forest fire in Yellowstone National Park.

Let's look at the users because this was actually one of the driving factors on opening up the Landsat archive. What you will see here, and I don't know if you can read the fine print but by and large the blue part, the largest part of the graph were used for educational purposes, the public at large, the federal Government, business, state and local Government and then tribal Governments. So this was Landsat users in 2011.

When Ken talked about the policy decision to have it be public and non-discriminatory, that is that everyone should be able to get access to the Landsat data at the same time. That's great from a public policy perspective, but the pricing strategy actually precluded that from happening. Most certainly back in the early 1980s when it was operated by the private sector because the 4 or 5,000 dollars as seen to in fact help recover the costs of building and launching a satellite where exorbitant, no one could afford, except the very richest could afford the Landsat data and even when it came back to the US Geological Survey at 4 or 500 dollars a scene, most of those educational users that you see in 2011 could not purchase the scenes that they needed for their research.

So, while the US has a policy that you cannot collect data on who is actually buying Landsat data because of it's a personal right, they can collect data on the domain name. So, ".com", ".edu", ".gov", you can look at broad categories of who's buying Landsat data and if people choose to give you their name you can find out their individual affiliation but they must choose to do that, and so what we found from interviews is that by and large this was largely public good. Most of the applications were for the public, so the Government, the ".gov", were most of the people buying the 4 and 500 dollar scene data. The next category was ".edu", education, where were they getting their money? From the national science foundation, which was federal money and the next largest category was ".com", COM, where were they getting their money if you ask them individually? They were getting their money from defence department for special projects around the world.

So, it was largely federal money that was paying the 4 or 500 dollars a scene and the US Geological Survey was just incurring the administrative cost to track the money from taking it out of one pocket and putting it into another pocket. So we went forward with that argument to the Office of Management and Budget in Congress at the time and said Stop! We are spending dollars chasing nickels, let's just give the data away and even the private sector who are building downstream products can now start making their products on something that cost them zero to get rather than something that cost them 500 dollars to get, so we were able to even get the private sector to come in and help support that decision because it was going to produce jobs in the United States.

So, Landsat applications, these slides can be made available to you, the prints hard, but you will see some of the uses that were on the biggest slide, the biggest piece and again when we talked about agricultural applications you will see that is still one of the largest pieces of the pie. It is still largely used for looking at food production around the world.

This is a graph again you may not see the fine print but we want to show you just the explosion that has occurred with the decision to open up the data. So while the Geological Survey was selling the data for 500 dollars a scene, and at its peak, it sold 18,000 scenes in one year, by and large most of the delivery was about 11,000 scenes, you can see that right now this graph up until 2011, had 6 million scenes downloaded globally. Today it is more than 8 million scenes. Far exceeding the entire 40 year anniversary of the programme.

So, if we come back now to those international coordination mechanisms from a Group on Earth Observations perspective, which has a broad, open data policy mandate, clearly the goals and principles of this Landsat decision were aligned with the Group on Earth Observations. I can tell you that being at the Geological Survey at the time when this decision was made to open up the archive, we had a minister in the Department of the Interior at the time, Dirk Kempthorne, that wanted to make this announcement but just not nationally, wanted to make it internationally and so he chose to go to the Group on Earth Observations Ministerial in South Africa to make this Landsat data change announcement and I can tell you I think that group has given this decision a lot of visibility, and it certainly has helped lay the groundwork for global forest observation and some agricultural work that the Committee on Earth Observations Earth observing satellites is about to undertake — that GEO's about to undertake.

From a Committee on Earth Observations perspective there was a lot of international support for this decision in that committee and I would like to draw the attention to two countries in particular: ironically France at the time. They had a very vocal person in the Committee, and Brazil, who said, for as frustrated and as discouraged as I got as a senior career person, those two countries said "keep pushing, keep putting pressure on your Government because this is the right public policy decision to make" and I have to thank those two countries for that, and then also the Committee on Earth Observations science satellites is going through some acquisition planning now because other countries are coming forward while Brazil and China with their CBERS Satellite may have led the pack, the fact that the USGS and Landsat followed suit, clearly we've had that history in the weather satellites for a long time, there are still many countries out there that need to continue to push for broad, open data-sharing policies and I can guarantee you your economies will grow as a result of this. I heard a couple months ago that one small company in the United States happens to be a Canadian-owned by a Canadian company but it is a US subsidiary has now added 125 jobs in their small company just to process Landsat data that can be drawn down over the Web. So we were in fact correct when we made an argument back to the administration that you can grow jobs in this economy with broad open data-sharing policies.

So, lastly, can you imagine a world where Earth observation data and information was as readily available as weather information is today? Not only what the weather was 100 years ago, and you know every time you get a heat wave someone says "well we haven't had this high a temperature since 50 years". So we've got weather precipitation and weather temperature data from 100 years ago, from 1,000 years ago in some locations, do we have that for Earth observation data? Not always. So, 100 years ago, we've got weather data, today we've got weather data. We are even making forecasts on what the weather will be tomorrow and one week from now and two weeks from now. Why can't we be making those same kind of forecasts on our terrestrial observations, and I would argue that the open data policy for Landsat is helping to create that world where someday we will have this data as readily available and in the hands of every single citizen like we have for weather data today. Thank you very much.

The CHAIRMAN Thank you Barbara for your presentation.

The fourth presentation is by Mr. Lothar Beckel of the European Academy of Sciences and Arts, entitled "Evolution of Landsat Data Utilization".

Mr. L. BECKEL (*IGM-EASA, presentation*) Thank you Mr. Chairman. Distinguished delegates, ladies and gentlemen, I am very pleased to talk here a little bit about Landsat also from the Austrian point of view and well, let me start with the first slide.

I think it's only in very few parts of the world it is known that the father of Landsat was an Austrian, it was Dr. Will Nordberg from Styria in Graz and may welcome his brother, he is with us here in one of his collaborators, Hans Moik, he worked for many years with him at [...] and welcome and so we are a little bit proud about him and of course about the whole system since it found it originates in Austria with an Austrian physicist who moved to America, he was invited by the American Army, he moved to America, came to NASA after half a year of stays there as a researcher and well there he became the boss of the Landsat programme. And he organized whole data distribution at that time and he had great visions about the future, about which you just heard in the last or previous presentations, and we are really very happy to be with this group.

In the early days I met him, I had the pleasure to meet him in the very days. First days when they brought down the Landsat image in 1972, we met and we immediately developed ideas what to do with these thing and we also published the first book on Austria. It's downstairs in the Rotunda and unfortunately he died very young with the age of 46 but on his he was here three months before he died and on his way back in the plane he wrote the foreword for this first Landsat book. You have an autograph exhibited downstairs and you have it here on the wall what great ideas he had and he fore looked for everything what you will, what you have heard and what you will hear. He had the full visions about the application of satellite data and he saw what will happen. One thing was you will see he said just before he died it will last 20 years before Landsat becomes an operational tool and to be used by everybody. Now it's meanwhile another 40-50 years, no 40 years and still we have a lack in applicants and users because students don't learn it in school how to use satellite data. We do our best to push this thing in this way and NASA does, and ESA does, SPOT Image does, everybody we are pushing but we have to convince the teachers that they talk about Landsat as a only instrument with which you can look to the Earth at any time and all the corners in any hours almost, and this is just a pre-note so I still remember the times in 1957 when I went to university and the morning there was a newspaper in Austria on the road that said

Soviets had launched the first satellite. We still had horrors of the last World War in our legs and in our brain and we thought "what will this give in the future?" This was Sputnik-1 1957 and from this how the whole things develop, the first next thing were the tourist flights from the Americans with the Gemini programme. They brought down a lot of beautiful pictures like this for instance, hand-held cameras, and these pictures already showed what we can gain by using satellite imagery and I think this was the base for the future development besides the report of the Club of Rome about limited growth on Earth. This was what Will Nordberg was impacting and there he decided when he read his report said our resources are limited and we have to do something to collect them, to map them, to register them and to use them in a sustainable way.

Then we had the whole weather satellite series, which gave great astonishment to us. You see it in every, now you get it all fifteen minutes you can download it from the Internet, the atmospheric turbulences, you see the vegetations, the precipitation and how it moves and we learn how fast any type of air pollution moves around the world with this global cycling system and how the different seasons impact the vegetation, the agriculture, and of course, man.

What did we do in this time, in this early time? Everybody was very excited who was involved in this of course we took the first pictures and went out walking around like monks and preaching about Landsat this was the first presentation of the Landsat and how it is evaluated and said it needs also a ground root data and the Americans developed this special aircrafts to under fly the satellites SPOT Image and NASA at this time did as well, I will show you a picture, then we got the first maps of this time with the flight passage of Landsat. Landsat was able to cover the Earth every 16 days, so it was repeating its paths every 16 days, I think you get it now from the different satellite systems, all in all it passes if you like to give higher resolutions and this was something from the orbits it means the satellite was passing over each place on Earth along his flight path at the same time of the gate, what I see 10.40 or something like this, then the Europeans woke up, we got the first maps after which, or according to which we could order Landsat data, first it was Telespazio in Italy, then it was shifted to the European Space Agency and you have the flight passes of one entered, it was I think Landsat 4 with all the dots where the images were taken and after which they have been organized.

It was a difficult time for us, we were anxious to get as many data as possible, the first thing is you could not trust Rosonov from your electricity board as you will do it now. First you had to look where you are, geographic positions, when does the next Landsat pass, or when were the previous passes. This was where just print outs, and then we had to look to the quicklooks at Ezrene in Italy, they produce from the satellite data quicklooks like a postcard from every flight or from each image they had the notes on this little black microchip where you could look at we had then finally we got the first images on microfilms from there we selected and ordered 60 mm chips with all 4 bands and if you look to the right image on the bottom, right bottom, this is acquisition of one scene over Austria, the city of Salzburg, which you have in the quicklook on the left side and you see this is a full year of acquisitions over the same place. So, there is hardly one image cloud free.

To make a mosaic of Austria, it took us 3 or 4 years to have all images collected which were cloud free to fit them together, the problem was some of them were taken in winter time, some in spring time, some in summer time, so we had to balance this. We did this photographically, we purchased big photographic machines to combine the data to adapt the grey values to each other and then of course we had also to study the reflectants, the characteristics of the ground surfaces, each ground surface, you will know has a special characteristics, so water reflects different then snow or forest or roads or whatever it is. So we went out with measurement instruments, hiked to each corner of the country measuring the reflectants according to the bands of Landsat, the four bands, taking some home and doing all this research but then we did the first multi spectral camera flight, these four bands adapted to Landsat in infrared and blue-green-red and you see if you look to the right corner what surprises a cloud shows up in infrared or not, the water shows does not show up, it is black in infrared and then we discovered also their value of the thermal images so we did the first night flights. This is on the left side, it is the same area as you see on this four bands, it's a night image by temperatures of the Austrian Iron and Steel company where you can see the processes through the machines top process recalled where the put a cooling water into the Danube river, all exciting things for us at that time. Then we were lucky to get the first pictures from Skylab, you know these three-manned missions from NASA, the longest lasted about 84 days and they took a lot of hand-held camera shots and also photogrammetric cameras, which handled 10 mm size. This was on the left side my home place when I came to Houston they just brought down this film roll, I stood there working through it and looked for my house and I said "hey, here I am living", "yes" he said this is why we took this picture. Now it's

reality, they take the picture where you live on request and so you see also we had a lot of fun during this time and France IGM had equipped for this Flying Fortress from the last World War it was instrumented and did research flights. I had the pleasure to be with them a little bit in [...] when we did some measurements about the Arctic's and NASA came up with this four-engine or four-jet Galileo-2, Galileo-1 was a previous one, which unfortunately crashed but this was in [...] during the midnight sun and we took a lot of flights to measure. The aircraft was full of instruments to do all these measurements which we could use and maybe also passive microwaves and it was studied at that time already the movement of the eddy's, the melting ice going downward, we had fun when other people installed the buoys which did the ground measurement. Here is one of this results from this passive microwave images from the North Pole, and it was very hectic you see in this image, everybody was working very heavily and the will of excitement and as I said we had lot of fun during this time.

Then the first image processing system comes, we did it first with photographic processing combining the three bands with different filters to make colour profile camera images — no colour images — and then we got the first image processing systems, one of them, the costs were about 500,000 dollar. Now you get it I think for 10,000 with all the software, the software itself for several thousand dollars and the first works we did was tantalizing and then we started to process these images to understand it with the measurements we had done on the ground, this as an almost natural coloured image of, Landsat image, of the Central Alps, we could convert it of course into infrared or false colour images, we have been able. Sorry, wrong direction, to classify them with density slicing, what I just mentioned to colour the different values of the grey films into the same matter, finally we learned how to combine them with digital terrain models to make the shaded relief programmes and now you get this all from satellite, you get this shuttle DTM, you get it from say ERS data and we were able to produce 3-D fuels from vertical images from Landsat.

Since SPOT Image came into the pictures and I had some measures of his [...] to be one of his first I think customers so this is another thing, the space community they are all driven from the same motivation, and you get friends all over the world over decades and another one is Ken Hodgkins over there from NOAA at that time and it's really happy, happiness to see them all again in this conferences.

We got the first Landsat images of Vienna, it looked like this, the actual ones you will see I think know a better one, combination of land is SPOT Image where we combine the 30 metre of Landsat with the 10 metre of SPOT Image images to get the higher resolution and the colours from SPOT and what else we discovered as geographers and this was for us a great value, we understood or learned how to understand the impact of nature to the living space of man, to culture and vice-versa or what man do does on the Earth, how it is impacting our nature. The landscapes, [...] the water, whatever, and this was one of my great, I would say what would I say, discoveries, when I look to this Landsat image of the Alborz mountains it clearly shows you this interrelation or correlation which I just discussed about it, you have the Caspian Sea in the North, you have this white cloud formation on the centre ridge of the Caspian Sea, of the Caspian mountains — of the Alborz mountains — and you look down to the south sun slopes partly red, partly white or yellow. What happens is, this is explained to you, you see it on the right image, why the northern slopes of the mountains are full with vegetation, red is vegetation in this case, then you have this snow coverage on the central ridge and you have the desert-type on the dry side in the south and you see where the water runs off you see them the valleys, with their red lines and you see were the well horizons are at the bottom of this mountains where the water comes out and where they irrigate the country. So this interrelations, correlations can clearly so be easily understood except you can use only or if you work in landscaping or in agriculture, economic development you have to do it with satellite data and you have not only to look to cloud-free data, which unfortunately many people do and I just learned now from you that you look ahead of the path of the satellite and switch off when there are some clouds. The most valuable data I personally received from cloud coverages when I saw all this movement, the turbulences and whatever you can distinguish or define of it, without clouds this interpretation would not be possible.

And another thing which is so exciting for everybody who likes a little bit of art and likes or loves our Earth, this is Earth as a piece of art. You find hundreds or thousands of images if you look to it very closely. This is the mount Kilimanjaro, in the early 70s, the red is the tropical forest you see the bioclimatical altitude lines of the vegetation from the desert to the steppes to the tropical rain tropical forest up to the mountain forest, the snow coverage or the ice coverage at set time with the glacier mainly disappeared, ah I am told I am talking to long, sorry. With this types of things this is unavoidable. In black and white is a piece of art, in green as a colour images, it's fascinating how no artist could do it better. Or with this the turbulences in the air which impact our air here is the [...] island of

4,000 metre high volcano in the Atlantic Ocean look the turbulences which he causes and sees this thing this reservoir in central Europe.

So, we've produced a lot of plates some of them we have exhibited downstairs, three or four of them, at set time to this [...] to inform the users about this satellite images we've produced the first CD images and I hope you will look at this people here to one of these pictures. We have the final decision or the visions what will happen all this geographic information systems in combination. The access to the data automatically whatever you like and finally we end up with the geographic information system, what is a geographic information system? it sounds so fascinating and scientifically. It is nothing but a collection of maps and information like here which you put you queue-code it put one slide over the other, project them and see where the correlations are and what you can learn out of it in the sense of what are the impacts of man to nature and nature to man, and this is the last note, the three last images clouds around the tropical belt and this is Will Nordberg, my old friend, which is unfortunately 1976 one of the greatest persons I ever have met I must say this and three months before he died, he was from Styria, he wanted to climb up the Mount Dachstein, 3,000 metres high in Styria once more before he, ja, he has to give auf and he called me and asked me whether I would climb with him, he came along with his friend Bill Campbell, polar researcher who organized this polar flight and the weather was bad, it was horrible, you see the clouds in the background and we were very sorry because we were running out of time but then we thought, why not look to a satellite above the clouds so we climbed up, went to the top, 3,000 metres high, three months before he died and this was one of the greatest experiences also at this time. I thank you really very much for your attention, I hope I didn't talk too much personal. Thank you very much.

The CHAIRMAN Thank you Mr. Beckel for your presentation.

Now I would like to proceed the next presentation is by Mr. Gerard Brachet, the former CEO of Spot Image from 1982 to 1994, entitled "International Cooperation".

Mr. G. BRACHET (*Presentation*) Thank you Chairman I'd like to start off by thanking the organizers of this panel who asked to me to talk about the International Cooperation aspect. You will see that this is something that will prove to be very important indeed throughout the Landsat programme.

The Landsat programme inaugurated long and very successful history of International Cooperation in sat-based Earth observation and it also established the basis, the basic rules, still valid today for the acquisition and distribution of sat-based imagery.

As concerns the principles for sat-based imagery acquisition distribution, Landsat set down the following basis: unlimited data acquisition everywhere on Earth, this is important after all it should be recalled. Secondly the introduction of direct data transmission to non-US receiving stations. You may be familiar with the beginning of the Landsat programme, you will recall that in NASA's RTS programme there were just three stations working and they were US stations. No other stations had been provided for elsewhere and Larry Morley who was the Canadian director of remote sensing at the time and during a UNISPACE Conference here in Vienna that this idea of transmitting Landsat data, which was called RTS at the time, not Landsat to non-American stations was accepted and became a NASA policy.

Third principle, non-discriminatory nature of data distribution, this is always valid and very important and initially set up by Landsat, and the fourth point which is the open and updated worldwide catalogue of available data, which enable users to know what image may be of interest to it in which area and easy to access to order. Now, these principles which were set up by the Landsat programme were subsequently adopted everywhere for a government Earth observation programme (France, India, ESA and it ERS programme, Japanese programmes etc.)

And it is important to recall that these principles were incorporated by COPUOS in the draft resolution on remote sensing principles which were discussed so extensively in 1985 and 1986 here and which finally were adopted by the UNGA Assembly in December 1986, this is the famous resolution 41/55 of 1986. Now yet another aspect of international cooperation which was introduced by Landsat was the "Principal Investigator" programme, which enabled the international research community to act as the initial ERTS and Landsat programmes to run projects so we've just heard that from Lothar and secondly the establishment of the Landsat ground station operators working crew. Ken Hodgkins was very much into this at the beginning of his career. This was a very important group of all of the agency's owning and operating a Landsat direct receiving station.

This is a group that started of fairly small and developed quickly. This idea of International Cooperation went beyond the Landsat operators in

1980 upon Canada's initiative of Multilateral Meeting on Remote Sensing was organized in Ottawa to try to see whether it was possible to set up an international coordination mechanism to coordinate the various programmes ensuring Earth observation by satellites. We had a decision in 1978 to develop the SPOT system and AD was shortly after that, so this first multilateral meeting in Ottawa set up two international coordination committees on Earth observation, the CLOS and the CORSS, the CLOS (Coordination of Land Observation Satellites(committee included at the time NASA, CNES and NASDA and met for the first time in November 1980, and the CORSS, the Coordination of Ocean Remote Sensing Satellites committee included the Canadian Remote Sensing Committee (CCRS), ESA, ISRO, NASA and NOAA and NASDA and they met for the first time in May 1982.

These two committees worked in parallel until 1984 a couple of years and in 1984 a Panel of Experts on Remote Sensing from Space, which had been set up by the G7 working group on Growth, Technology and Employment recommended that the two be merged, these two committees and this seemed to be a good idea at the time. The new committee emerging from this merger is called the CEOS, that Barbara mentioned a while ago, the Committee on Earth Observation Satellites, they exist since 1984 and they held their first meeting in September in 1984 in Washington, D.C.

CEOS is a space agency level coordination committee, sort of like ESA, it's an agency committee, it works on an non-exchange of funds on the best effort basis. It doesn't have a need for staff, it doesn't even have a legal personality but a sort of secretariat pool is ensured by NASA and NOAA on the American side, ESA from the European side and JAXA from the Japanese side.

The CEOS Chair rotates every year and the current Chair hosting the annual CEOS plenary. CEOS is very much alive today, it's grown considerably, it's almost as large as it could be still manageable. They have 30 full members and 22 associate members, so 52 participants when they meet in plenary and they have specialized working groups which are very effective in their work. This is the list of the 30 full members of CEOS as it stands at present, with all the countries that have Earth observation programmes, I think this is a fine example of international cooperation, which has a certain flexibility in these operations, it's not too into procedural details and they very often do give thought to whether they should continue or not but they've always decided that they are indispensable so far.

And in the GEO context that Barbara referred to, CEOS continues to be the a group that manages the space agencies' input to GEO and I believe in conclusion we can say that the success of CEOS owes ever so much to the international cooperation principles which were first established by the Landsat programme at its origin with the openness to the world at large that characterized the Landsat programme. Landsat programme had a considerable influence on the international landscape of Earth observation, at least in the civilian sector. I'm probably one of the best placed people to thank my American colleagues for their work in founding this programme. Thank you very much for you attention.

The CHAIRMAN Thank you Mr. Brachet for your presentation.

The next presentation is by Mr. U. R. Rao of Indian Space Research Organization (ISRO), entitled "Role of Landsat in Revolutionising the Management of Natural Resources". Mr. Rao please.

Mr. U. R. RAO (*ISRO, presentation*) Let me thank UNCOPUOS for inviting me to take part in this wonderful programme.

The successful launching of Landsat 1 in July 1972, forty years ago, was truly revolutionized the science of remote sensing from space and its extensive application to monitor and optimally manage all resources.

Right at the beginning of the space age of course we used to have some measurements. In fact, lot of ground measurements were carried out to essentially look at the physical response of vegetation or whatever you want. Two different equivalents: helicopter-borne instruments were used and you see here this after the titles we unified in 1970 the helicopter-based instruments were used to essentially look at the coconut trees in India. Unfortunately this isn't in the infrared, I don't have this slide. One could feel the coconut trees having Wilt disease and in fact the ones which are down are the ones where the leaf is drooping and it is affected by Wilt disease and if you look at in the infrared you will find a very light pink, whereas the tough ones are very heavily red and they show beautifully the difference between the ones which have Wilt, the affected with Wilt disease and not affected by Wilt disease.

From the helicopter we went into the obviously the Landsat came into picture and the first Landsat went in 1972 and it carried primarily photomultiplier detectors, type of detectors and [...] detectors from

80 metre resolution it went to 30 and so on. This was followed by Landsat 2, 3 and of course as you know already Landsat 7, which is now operational. Subsequent Landsat's of course in addition to the thing also used thermal measurements including the far infrared and it started the later immediately the Landsat was so popular, particularly when it was in fact many countries built up their own ground stations to receive the data at a price and they could use it. Landsat was so popular that many other competitors are supporters of remote sensing came into picture. The first one was SPOT, the French one, and followed by India remote sensing satellites (IRS), followed by CBERS, which is the Japanese one — the Chinese one and the Japanese one. Most of them used the so-called pushbroom cameras and the resolution was essentiality increased enormously.

You see in the decade of 1970s, you had only about 12 satellites, the decade of 1980s you had 50 satellites going up, the decade of 1990s you had 90, and 2002-2011; 135 satellites, which went up from various countries, including of course the Landsat. Essentially providing imageries and also information on meteorology.

Due to the highly available sensitive sensors what has changed, you see here: from 80 metres resolution, we went to 30-10 metres in the next decade, 10-5 metres in the decade following that and just about 0.4 metres now. This is tremendous change in the resolution and you look at the spectral coverage, it has gone from just a near infrared to thermal then microwaves and so on. Spectral resolutions: multi spectral, multi spectral, hyper spectral now. Radiometric resolution from 6 bits we have gone to 16 bits. Look at the change that's just taken place. Data rate and all started with Landsat; 15 Mbps per second, it went 85, 170 Mbps now it is 800 Mbps per second. That is the data rate which is emitting. And data storage, on board storage from megabytes, it went into gigabytes, terabytes, now it is petabytes. Look at what has happened, it is absolute revolution which has taken place.

The data has been used, we'll quickly pass through, in many many applications and, I just quickly pass through because you already seen many of these pictures, has been used for land use maps, it's taken from, the first one is from Kathmandu in Nepal. How the Kathmandu has grown at a cost of course the cultivated land and the open fields are gone, water body is disappearing, the city has grown.

You have the wastelands' map and where some of the wasteland thanks to the [...] has now been brought into picture and it's producing certain amount use for agriculture. You look at the agriculture, this is from the Nile irrigation, where again almost 50,000 km^2 of natural vegetation converted to agriculture. The natural vegetation going away forestry and this is what is happening, this is the Landsat imagery and we have 5 change categories, this is in China, taken from the Chinese satellite and forests are totally disappearing and you have deforestation, degradation and [...] of that and what the forest is [...] so high.

The groundwater exploration here you can see underground water where there is availability is high, where the availability is low. This has been fully used for mapping the underground water and we use for drinking water mission in India, and you have this is the China Shanghai region, you look at the 3 cities. They have grown in size, the Changzhou one, the Wuxi and Suzhou — this is near the Shanghai region — and you see the thing now in 2005 is grown quite substantially and people have been talking of green revolution notwithstanding the fact that the green revolution also has produced its wrong ethics. Now we are talking for the first time of the evergreen revolution; to provide basic requirements of the food security for the growing population. How do we do this? Obviously it has to be done through the optimal management of the land, and this was attempted under the Sustainable Development Strategy including planning of the Government, utilization of the groundwater, increasing the capacity of the groundwater and putting dams where required and so on and it was done for almost 20 Watersheds and over a period of 40 years you see the irrigated area has increased by almost 500,000 hectares. In terms of per cent it is about 15 per cent. The forest area has increased, surface water has increase, irrigated area has increased.

You see the second one, this is of course in the United States in North Dakota, I want the United States people to know this, this is very rarely produced, it is not available in any paper. It's from a farm in North Dakota; the left side is the IKONOS NDVI, the Digital Vision Index and if you see there the index weather that is low, in fact there is the red marked area, the amount of fertilizer used is kept the same as before, and where it is green the vegetation index is quite high after looking at the soil at the North Dakota University, they reduced the chemical fertilizer to 180 and in the very green area 130 kg and result from 4 tons per hectare, the food grain production went to 4.3 tons and the farmer got money because he reduced the fertilizer, he got money again because he increased the price and increased the product and both ways. This is going

down to a local resident farm, And if you want to do vegetation farming you need vegetation index, you need soil and you have to control the inputs which is provided and optimally use them and not simply go on putting the fertilizers and spoil the land.

And in disaster management, because the thing has been phenomenal, there is about 14 million people who are affected here and this is using the Indian remote sensing satellite, this was in Pakistan when the flood was there. Then you have the thing in Chediski Forest area in Arizona, it is a Landsat picture where 468,000 acres destroyed in a forest fire and this immediately map and it has been used to save people, to essentially ensure that the damage is minimal and take every type of precaution.

And what has happened the data sharing, people already talk about it. In 2001, the total number of Landsat scenes, somebody spoke on the Landsat, I just want, yes it was Barbara Ryan, was 2001, it used to be about 25,000 Landsat series sold, in October 2008 and after the availability of global data archives, it's 2 million images sold. Add to that CBERS is providing 1.2 million per year, Indian remote sensing satellite is providing something like almost 80,000 million images per year and totalling today what used to be something like 25,000, now it has come to something like two and a half million imageries being used in the world. This shows how it has penetrated even the least developed countries in the world. Otherwise it could never have happened because this maximal usage is going to be in the least developed countries.

You look at the ground stations. Landsat started with very few ground stations, today it has about 19 ground station across the world receiving the data directly, add to that SPOT has about 20 ground stations and I don't know whether, he was talking in French, whereas I hear in English, and therefore I don't know whether our friend said about this, there are 20 ground stations of SPOT and there are 14 ground stations of the Indian remote sensing satellite. I don't have the JERS and the CBERS number, and that essentially shows that across the whole world the pictures are taken immediately so that immediate application can be done, and I want to bring where UNCOPUOS played and IAF played a very very significant role in essentially advancing the user remote sensing. This was in 1987, in Brighton, when the UNCOPUOS had a meeting, the first effort I was asked elected as a CLIODN Chairman, the first meeting of the CLIODN took place essentially to get a number of developing countries involved and without the benefit of human — of remote sensing to humankind.

Slowly, every year and UNCOPUOS joined within a couple of years and the money all shared between IAF and this had to invite. We have essentially made for the last every year you can see a special session with the [...] IAF has been going on. Where many developing country experts were called and informed, developed, briefed on what is happening.

Not only that, just somewhere in the middle, we started asking the developing country representatives and come back and say what have you done? And what changes you have brought in and now in fact, most of the lectures are given by each of the developing countries who are participating about what they have done, what needs to be done and their problems and ask, look how do you solve this technical problem, not money problems, technical problems. Money problems all of them have, but technical problems they will ask, and that is what has changed, and you see here look at the thing, you can see the forest management, agricultural management, space for developing countries, environment, rural development, health care environment and in addition UNCOPUOS of course also has been instrumental in promoting, establishing training centres, one in India, other one in Africa and one South America and one in Europe and so on. This has been working for training people in these areas, and all this happened completely because of the fact Landsat started the movement. You know just now, we just started a movement which has revolutionized the entire field of remote sensing.

I don't think there is any other satellite system which started so beautifully and spread across the world like a wildfire, but it is a wood fire anyway, and, it's truly fitting that we are celebrating its 40th year of the Landsat and I hope that Landsat will become for all the future for every other satellite systems a shining example of what one can do to improve the world as a whole. Thank you very much.

The CHAIRMAN Thank you Mr. Rao for your presentation.

The final presentation in the first part of this special panel is by Ms. Anne Castle, Assistant Secretary for Water and Science in the United States Department of the Interior. Her presentation entitled "Future of the Landsat Programme" will be delivered as a recorded video message. I now ask the Conference Room Technicians to play the video message please.

Ms. A. CASTLE (*Water and Science, presentation*) Hello everyone, Guten Tag. I'm Anne Castle, the Assistant Secretary for Water and Science at the US Department of the Interior and I wish I could be with you in person today in Vienna to celebrate Landsat's 40th anniversary. I had the opportunity when I was in college to spend half a year in Vienna so I know what a beautiful and gracious city it is and in fact, I was there exactly 40 years ago in the Spring of 1972 when the events that we're celebrating today were unfolding so thank you for the opportunity to let me be with you at least vicariously.

I want to join the chorus of appreciation for the important work of the UN Committee on the Peaceful Uses of Outer Space and that work has been done over the past half century of effort.

The US Landsat programme is a perfect example of a cooperative use of outer space. Landsat has given every part of the world a thoroughly objective look at itself for 40 years, since 1972.

Today, the citizens of 186 countries benefit from a record of the Earth's surface that has been collected continuously by Landsat satellites across those 4 decades. Although 40 years isn't long for other types of Earth-based monitoring, Landsat is the only satellite system that can claim that endurance record. With continued US commitment, with expanded international partnerships and with some hard work we're going to continue that record through the next 40 years.

The natural resources challenges that we have at the outset of the Landsat programme haven't diminished since then, they've only accelerated. When Landsat was born in 1972, the world population was around 3.9 billion people, but now there are more than 7 billion people on the planet and we're expecting to reach 8 billion as soon as 2025. We have no more land or water today than we had in 1972 and we'll have no more of either in 2025. So in order to support those increased populations, decision makers need tools that provide fundamental, impartial information about the status of the land and water and about changes in the environment and in human society. That kind of information benefits all of society. It helps us figure out what we need to do to provide a sustainable existence for populations around the globe. That's why the Department of the Interior made a decision in 2008 to make its entire archive of Landsat data available for free over the Internet, to anyone who wants it and that decision caused an explosion of Landsat data use.

You can see on this chart that we've gone from a relatively small amount of usage before 2008, it looks like zero but it was actually around 15 to 20,000 scenes per year, to now over 2 million scenes per year and growing. In April of this year we surpassed 8 million scenes downloaded by users worldwide. This policy of free distribution of Earth observation data as exemplified by Landsat, has benefits to communities around the world. In fact, it's been said that Landsat is akin to the Earth's free press. It allows citizens around the globe to see actually what's going on in their countries. Even in cases where that information is not made available by the Governments in charge. I want to thank the Landsat international cooperator network for supporting the ground stations around the world and allowing even more widespread dissemination of this data. It's not only the downloading of the imagery that has accelerated, the applications that the pictures are used for has also exploded. Climate change is an obvious application of 4 decades of Earth imagery. This is Mount Kilimanjaro and it's summit, and as Africa's highest peak its always been an iconic image but you can also see with its shrinking snow cap how it's becoming iconic as a demonstration of a changing climate.

This slide shows and application of Landsat data that I'm particularly interested in, the use of the thermal imager to estimate consumptive use of water, a huge step forward for water managers. The Landsat 8 mission will include a second thermal band that will improve temperature measurements.

In looking to the future of Landsat part of its promise involves improved ways to use the data and one of the ways we're doing that is by partnering with South Dakota State University and NASA, to develop an application that will allow users to work with individual cloud-free pixels and aggregate those pixels into a complete picture so that you don't have to wait for an entire cloud free scene.

Now we're focused on putting the next Landsat in orbit. NASA and the US Geological Survey have been developing the Landsat 8 flight and ground systems for the last several years, working toward a January 2013 launch date, just 7 months away. Here you see the two primary instruments of Landsat 8 on the left as the near completion. The operational land imager and the thermal infrared sensor.

What happens beyond Landsat 8 is our next challenge and our next opportunity. President Obama's National Space Policy calls for an operational, land remote sensing programme and operational means that it's a long-term programme where we're ready to

launch successive satellites as they're needed. Right now the Department of the Interior and USGS are working with NASA and other key agencies to try to figure out how we're going to implement Landsat 9 and beyond, even in these times of very constrained public budgets. We're looking at a broad range of space and observational technologies to do that.

Landsat is one of the latest evolutions of an innate urge that we all have to see the world from a bird's eye view. Even ancient philosophers like Socrates believed in the value of a distant perspective. "For man must rise above this Earth to the top of the atmosphere and beyond for only thus will he fully understand the world in which he lives." I love that quote, especially knowing that it's from around 400 BC, in this era of growing populations and increasing competition for natural resources, we need to ensure that we have the impartial perspective that land remote sensing from space provides. Even during these times of declining public budgets, it's essential that we don't allow short-term challenges and short-sighted opinions to undermine or ability to fully see and understand the world in which we live. Thank you, and happy birthday Landsat.

The CHAIRMAN I thank Ms. Castle for providing us with this video message.

Distinguished Delegates, with this we have concluded the first part of the special panel. I thank all the speakers for sharing with us their insights and experiences on how the Landsat programme has contributed to international space cooperation and to pioneering civilian Earth Observation activities all around the World.

Distinguished delegates, I now invite Mr. Sergio Camacho of Mexico to the podium to moderate the round table discussion on the theme "Landsat and the Evolution of Earth Observations over the past 40 years". I also invite all the participants of the round table discussion to be seated at the podium.

Mr. S. CAMACHO (*Mexico*) Good afternoon. It is an honour from me now to be moderator for this round table. For us to continue sharing experience, we'll hear of experiences in many countries with Landsat showing what has meant for the development in those countries through the application of science and technology through remote sensing. I'd like to ask colleagues please to use approximately 8 minutes if you want to have a round of questions, or you can use the full 10 minutes allotted if you feel pressed for time, and if we have time at the end we'll take some questions or comments, we might be running a little late but if you wish we can stay for questions and comments without interpretation.

So, without taking up any time from our speakers I would like to ask an old friend of mine Mr. Abiodun to share experience with us.

Mr. A. A. ABIODUN (*Nigeria*) I thank you very much Mr. Chairman. Distinguished delegates, it is a big honour for me to be invited to be part of this panel so I'd like to thank the United States, Austria and OOSA for including me as part of the panel. I have come here not to give you any scientific presentation. As a student of Landsat, I have come here to celebrate the 40 years, that is all I really want to do in the next few minutes allotted to me.

Now, some of my presentation elements have been included in previous presentations, but you cannot talk about Landsat without looking at the vision of Landsat that came from Pecora or the courage of the Secretary of Agriculture Udall, to make it a reality when it happened. You also have to look at Landsat as a trailblazer because by the time Landsat 1 went into space in 1972, United States were not the only country that had a capability to launch satellites, nevertheless Landsat was there to weather the storm globally, and that storm came out of the fact that when COPUOS was established in 1959 it was established out of fear and therefore the suspicion was still there. When the United States went for Landsat 1 and all of you who have been party to the use of that particular technology, you know what I am talking about. Again, this is my own personal interpretation. I look at ESA and I said OK, if the world was panicking and the US was going to go into space with a civilian satellite, what will Europe do in response? And the question is, would the launch of Landsat 1 have dictated the establishment of ESA in 1974.

Now I look at the challenges that face Landsat as it went in, both in the United States and globally, the military people were afraid that a satellite in space were going to reveal things that it didn't want the common man to know about. Secondly, many Member States were afraid that their territorial areas in space were going to be violated and of course you have traditionalists the lines of the Earth, the graduates of ITC particular, who will not accept satellite data as information for making maps. I was personally involved in separating a fight in 1986, where the surveyors called the remote sensing specialist as [...] in Nigeria.

Also this happened in Asia, and a little bit in Latin America, and I had to go to ITC to beg them to

call back all their educated directors and educate them about remote sensing. Now, when you go further one of the unique aspects of Landsat is its international reach and that started with the images you have seen. That is the current situation of the number of ground stations globally. What of the number of stations before that? You have several stations all over the world but the issue is how did this station come into being? I wanted to look in particular at the Asia side of that page.

I was in Bangkok in 2004 as a keynote speaker for one of the Asia remote sensing conferences and I learned from Shenzou that as of 2000, there were close to 22 stations for Landsat in Asia, now if you find out why I have an answer, in 1996 I went to Philippines and the Philippino's did not have an Earth station, but they were dying to have one and I asked the, conveniently my counterpart, why do you want to have a station? He said the Thai people have a station and they know everything about us, so we need to know something about them too.

Ok, now back in Africa, what we did, we didn't have stations but we signed an agreement with the United States to have Landsat data. I was teaching then at the University of Ife, now called Obafemi Awolowo University and we signed this agreement and we got all the data for both Landsats 1 and 2 and I believe Kenya did the same. Whatever has become, whatever became the use of those data is up to the way the individual countries interpret them. But in my own education of Landsat, that was at the Canada Centre for Remote Sensing, actually if you go to the table behind you there you will find a contribution given by Canada for the celebration of Landsat 40th year and on page 2 you will see a replica of IMAGE 100. That was the first machine used in analysing data. If you go to the rotunda you will see all the images. Everybody has presented you with the images but what led to those images? They are the machine that started it off was General Electric IMAGE 100. I used that to learn how to analyse remote sensing data and when GE made that machine there were only 3 they could make. I think they cost 100,000 dollars or 1,000,000 dollars I don't remember the cost. But there were only 3 of them, Canada bought the first one in 1974. Philippines bought the other one and another one I think stayed with NASA, which they transferred [...] city centre.

Now, when you go further and you look at the global reach of Landsat, then you realize that it has led to the employment of hundreds of award winning scientists and engineers in many parts of the world, not within the United States. In my own case I got that opportunity through Canada research council.

Now, when you go to Europe, there you find that ITC has been organized right from the beginning a variety of national and regional remote sensing meetings for decision makers, globally and regionally.

Now, here the United Nations when I came in 1977, it was only meetings about once or twice a year for decision makers as well but now we went into seminars, workshops, training courses and we concluded with the establishment of the regional centres, in Jordan now, in Morocco, Nigeria, in India as well as Brazil and Mexico for the GLOBEC community. Also FAO contributed a lot to this and WMO equally contributed a lot to this.

In Sweden we had the opportunity whereby the Swedish Government for 10 years in a row offered us 6 week training course for university educators just to be teachers of remote sensing. Now, again there are a lot of Landsat ground receiving stations as I've said but originally they used to cost close to a million dollars if you want to have a station. Many countries could not afford them. Then and they could recover the costs buy just selling the data, again in 1991 if you are still conversant with the situation then, there was the Persian Gulf War. I was in Thailand during that Gulf War and all the stations in the world were shut down except those that could be used by the ally forces to monitor what was going on in the Persian Gulf and so I had raised the question at the end. Could this have hastened the commercial development of microsatellites as a remote sensing alternative.

Now back in Africa, the options were not too many because the Africans, we the Africans were expecting support for two or three stations to be externally funded but that didn't materialize until South Africa built its own station and I think Martin has told my date is wrong, I think it was between 1978 and 1979, that's when they built their own station.

Now, Mr. Chairman, in conclusion, we should be about 3 or 4 slides. What have been the lasting impact Landsat system? And I say that the Landsat system was born as the asset of space and digital age and it soon became one of the main drivers of the information age. The lasting impact of the Landsat system continues to be in major component of today's information age. For example in the United States, the US claims to have generated about 20 billion dollars annually in the impact of Earth observation in this economy. In Australia it is about US$ 3 billion in 2008-09, in the United Kingdom about 2 billion pounds. So it is having a lot of impact in the economic development of countries. It has given birth to new companies, it has changed the way maps have been

made for good and the way they are teaching geography also in high schools and secondary schools, even at the university level. It has become an indispensable navigation — component — of the navigation system that we use globally today and it has led to a variety of organizations locally, nationally and regionally and I gave you here three regional organizations, the one in Asia, Asian Association of Remote Sensing, the one in Latin America called SELPER and the one in Africa called AARSE.

Now, in conclusion I said that the Landsat system has given employment to millions around the world at research, development and application institutions in different aspects. It is an indispensable tool in the management of our life support systems and in sustainable development as we know it today and also as a major component of tools needed for climate change. Above all, and I don't know how many of you are familiar with this, in 1974 Landsat was tested in the US Court when they took themselves to Court as a result of the pollution of Lake Michigan, I think it was a EPA that took one of the companies to Court, and Landsat data satellite, Landsat satellite data was what was used as clear evidence of what actually happened during that time. So I am here to wish Landsat another 40 successful years and I want to thank Professor Perek who is in this room who gave me the opportunity not only to travel the world and use Landsat to expose as many people as possible to the concept of the technology but to really enjoy it while I did it, so I thank you, and United States Ken Hodgkins if you are in the room, congratulations for the Landsat success. Thank you.

Mr. S. CAMACHO (*Mexico*) Thank you very much for your memories of Landsat and applications at international level. I'd like to invite Mr. Marek Baranowski of Poland now to share experience.

Mr. M. BARANOWSKI (*Poland*) Good afternoon everybody, Mr. Chairman, ladies and gentlemen, I thank you very much for inviting me to this session and giving me opportunity to share with you some reflections of the 40 years of the past remote sensing development in our country and at our Institute of Geodesy and Cartography which is the research institute dealing with remote sensing, also and one of the biggest department nowadays is remote sensing and department of our institute.

So let me say these words about the beginnings, so we should say that Landsat launching was one of the factor of developing our remote sensing studies and applications at our Institute however we started interpretation of Earth photographs 10 years earlier and some of the researchers were prepared to absolve this new technology but definitely the Landsat first images accelerated the process of developing this part of our investigations.

So, in 1975 our Government established on the special decree on the basis of the special decree remote sensing centre called in Polish OPOLiS and for many years this name was circulating in the field of remote sensing in Poland and I think also in the world. So, those days we had the first such advance system like US made computer system for image processing and despite COCOM restrictions, we got such a system with some limitations. One of them was the slowing down of the capacity of the processing of data, which has been especially developed by our Canadian colleagues just to enable us to use this high technology in those days. And what I should also mention that over 300 projects for mapping environmental studies, agriculture, forestry, emergency monitoring, water management and many many other applications has been developed at our Institute during this period and most of them were using Landsat images.

Let me just show you some slides and on the background of the slides I will say some words just to lack of time, I am not able to present it more widely. So this is the first image we used, as you can see this is the image of 2nd November 1973, so it is one year after launching of Landsat MSS and this image has been used for study of evolution in southern Poland and you can see in the part, I'm not sure I will be able to show you, this part is the so-called Moravian Gate and this is the unique direction of the fumes coming from those days Czechoslovakia to Poland territory. All other fumes they present on the same slide quite different direction and it was one of the evidence that most of the pollutions came from the south to north, not from our industrial region of Silesia. This is also the map which has been published in one of the Atlases developed here in Vienna by the Institute of Eastern and South-eastern Countries of the Academy of Science of Austria and this map shows also the direction, directions of the fumes in the territory of the southern Poland.

Let me say some words about the land use land cover mapping, which was one of the most important part of applications of Landsat images. This is one of the first map which has been published and it was distributed on the market and for many years it was the only reference map showing the land use pattern of Poland. It was elaborated in the end of the 1970s and based on Landsat MSS images. Here you have the First map elaborate within the European programme CORINE Land Cover and Poland with five other

countries of the central and eastern Europe participated first time at the beginning of 1990s in this programme and nowadays we are at the beginning of the fourth project preparing the database of land cover of Europe in other countries also participating in this project and Institute is the main contributor.

And here there is some slides showing by products like map of land use in Krakow region and this is another map or image at the National Atlas of Poland showing the Landsat composed images in one piece as you can see it looks like homogeneous almost. Here there is another application which is dealing with the flood inventory and here this is the big flood of 1997 and you can see on the bases of current land cover database the extent of the flood and we were also able to calculate losses which has been calculated on the basis of the land cover forms.

Here another application the development of brown coal mine extent in Central Poland and you can see quite easily how it was developed over the time and we have here the 1987 image and 6 year later the extent of this open pit mine was quite larger, and also some example from so-called "Black Triangle", the region of the ecological disaster which occurred at the end of 1980s and 1990s, and in 1930 you can see how damaged this part of the southern Poland, northern Czech Republic and part of the Former Democratic Republic of Germany area has been affected.

And on this slide you can see how big changes we can observe in the period of 14 years, so why yellow colour shows the extent of deteriorated forest, so this forest is in 1990 simply stopped existing.

And this is also another Landsat image, which is also used for showing this disaster. What is also interesting, we elaborated actually our colleague Professor Andrzej Ciolkosz elaborated Atlas of Satellite Images of Poland mainly based on Landsat images and also with some oblique air photographs and maps and this is quite good educational example how to use and how to interpret the Landsat images.

And one of the last applications we have today about the water management and here is a watershed modelling using also as a one of the layer Landsat images and the interpreted land use — land cover — of this region.

And in conclusion, I must say that majority of scientific works and applied studies at our remote sensing centre has been performed with the use of the Landsat missions images and this is really hard to exaggerate the impact of this Landsat images and let me say some short story which Professor Ciolkosz, which had one student and the student after participating in lectures collected also information about the timetable of the Landsat MSS those days, passing over Polish territory, and this student start to work in one of the electric power plant and he was so clever and so influential he was actually environmental officer in this plant and he knowing the day and the hours where the satellite is passing over Warsaw, stopped or used some special filters just to avoid showing the fumes on the satellite images of those days so you can hardly find fumes in Warsaw plant in those days in the end 1980s.

Well so, the director of the Scientific Institute, I should mention one of the very big impact of Landsat, many scientific years, as I have mentioned on this slide have been developing in the shadow of Landsat, it means that Landsat was one of the key source material for developing methodologies and developing some scientific works and as a last sentence I would like to say that Landsat was also very influential in our Polish-Czech cooperation and I don't remember but my colleagues remember those days when Landsat images were available already in Poland and in Czech Republic they were still classified as a restricted materials, and then our colleagues from the sister Institute of Prague, Professor [...], visited us frequently and we had opportunity to make acquainted much closer than without Landsat images. Thank you very much.

Mr. S. CAMACHO (*Mexico*) I thank Mr. Baranowski of Poland and now I'd like to invite the next presentation, Mr. Igarashi and I'd like to ask our speakers please to stay within the 10 minutes allotted as planned since we've been left with the impossible task of finishing by 6 o'clock which we won't manage to do. I would like to try finish as early as we can within a reasonable period of time. You have the floor.

Mr. T. IGARASHI (*Japan*) Thank you very much for invited me to this opportunity, I would like to talk about the early results from Landsat and prospects for the future of Landsat.

This chart is showing the Japanese Earth Observation Center established on October 1st 1978, I was first member of operating Landsat data reception and processing at this moment and this is the beginning of remote sensing in Japan. 1978, October, this EOC was established and next year, 1979, we have received Landsat 2, the first Earth observation satellite and we processed and archived and distributed these data for comprehensive users. And after that we continued our

activities, and first there was a one receiving antenna on the one building but now we have expanded these building in EOC (Earth Observation Center).

And up to now, we have been continuing operating satellites since 1978 such as Landsat series, SPOT and also we started our Japanese satellite development of MOS-1/1b and also we developed these many satellites in our countries, and also Landsat archive data is now typical accessible EO data set from the GEOSS. So it is kind of a world standard data I think.

And also in the future, now Earth Observation System provided by JAXA, Japan, will be these satellite; I think ALOS-2 and ALOS-3 will be the similar satellite like Landsat to measure the surface phenomena's.

This shows the wonderful the example of our applications. This is the first observation of disaster monitoring in Japan. This show the volcanic ash from Mount Ontake's eruption on 28 October 1979. We used Landsat 3 and Landsat 2 before and after this eruption and we estimated these volcanic ash distributions such as these constative analysis.

We have collaboration with many scientists and user groups and we have done some calibration and validation using two sensors and also grand deducing at this moment. So this is the beginning of our activities for the remote sensing.

And the next one is times 3 data analysis of ground surface change. This shows Tokyo area change in this 30 years form the Landsat 1 launch and we had big problems of civic development and using these data analysis we have many good information to think about the future planning of the urban area renewals. And one is transportation network system to rink satellite cities and also heat islands and other atmospheric and water sanitations and also we have utilization of garbage for reclaimed ground in this ocean area.

In the third one, this is a recent analysis, we have a ALOS satellite data PALSAR data here and Landsat we have also. I think inter-satellite validation of some product is very important and this is an example of forest mapping and we evaluated accuracy of classification using ALOS/PALSAR compared with Landsat-based estimation and we got 70 per cent accuracy compared with this at this moment but now we are improving these algorithms. So I think Landsat is one standard for the inter-calibration or validation of satellites.

Then finally I would like to talk about my expectations for Landsat data continuity missions. One is archived and up-to-date data sets re-analysis will improve climate change models, reducing uncertainties in natural and anthropogenic forcing factors.

Second one is time series geospatial data analysis will distinguish global change impacts on long-term trend and disturbance from static change, in regional biophysical environment and national forest inventory.

Third one is coastal zone monitoring using narrower visible near-infrared bands with practical atmospheric correction will provide information on water quality, phytoplankton, water-borne diseases.

Fourth one is megacities urban environment measured by visible near-infrared and thermal infrared bands will provide information on air pollution, heat waves relating to public health and sanitation.

And higher data products of water, agriculture, fishery, disaster and sanitation will provide information of directly affecting risks to life on Earth.

Finally, global habitability promotion will be realized by international collaboration on the data interoperability. So thank you very much for your attention.

MR. S. CAMACHO (*Mexico*) I thank Dr. Igarashi for his presentation and now I'd like to call upon Mr. Ahmad Al Mansoori of the United Arab Emirates please

Mr. A. AL MANSOORI (*United Arab Emirates*) Good afternoon ladies and gentlemen, my colleagues, thank you Mr. Chairman for the opportunity and from this platform I would to congratulate the United States delegation for the 40th anniversary of the Landsat and its success, which was the project that demonstrates a pioneering vision that had 40 years ago and it's continuous success for 40 years and its impact. Perhaps then I will talk about the softer side of the great importance of Landsat and it's programme in development, for example on our establishing a space organization and it's positive effects also on the development of different sectors of countries. So I will take that example and I will try, Mr. Chairman, to be very brief in that area and then we are going to talk about future initiatives and we'll go from there.

Landsat had great impact, positive impact on the development of the space sector in the region and

the Middle East and also on the Earth observation programmes that has been established in the United Arab Emirate.

If we are talk about applications, many decision makers right now in different sectors have benefitted from the application of the Earth Observation Programme. You know, I am going to cite these few examples and then I am going to go to other major issues.

As an example, right now the applications and the products of the Earth Observation Programme has been used in environmental level. For instance in detecting the pollution or monitoring the pollution water in the Arabian Gulf for example and talking about detecting the fault and also about the planning of the cities and also of the roads and different areas. Decision makers have been using also Earth observation programmes in many areas in education. We have learned from Landsat and also from Earth observation programme that how to share information with universities, with schools for free and to enhance the concept of multiple benefits across many sectors at the same time. Bridging the gap between academia and also the Government as well as the private sector across in different places.

As an example, Landsat has been an excellent demonstration of how innovative programme and contribution of advanced science technology and space programme can contribute to different sectors and to the enhancement of human life and of the globe.

In terms of policies, the policy of having a civilian, starting a civilian programme 40 years ago and this benefit to all sectors, indeed it was a pioneering policy that helped in many nations in getting to that sector. Besides that, Governments, many sectors political, economic, financial, security, have benefitted from Earth observation programmes, however through initiative's such as Landsat has helped with open-source information also distributing information in this currently can help education and empowering nations and encouraging development.

If I take one example of a newly established organization which is Emirates Institute for Advanced Science Technology (EIAST), which I have presented right now, through the space programme, we have our team. They have as graduates freshmen, have been given the opportunity to learn, to be given to the sophisticated sector, enhance their leadership skills and also their technical and scientific skills, to respect international law, to understand the benefit of cooperation and also to play responsible role in the community. For instance, they have been working on different aspects that help in cooperation with different countries at different levels, without waiting for any commendation or policies or direction from Government. They themselves, god forbid there is a national disaster anywhere in the world, with one satellite, they can analyse images and then provide support for different nations. This initiative that has proven that how the space sector can bring the world together in more peaceful way. How they can help people to think of cooperating in different sectors in a way that forgets theirs differences.

From here I would like to just continue as there was 40 years ago an initiative, a positive initiative, a pioneering initiative to have Landsat as a civilian programme. Here we have to think of, how can we take that further, how can we have established systematic tools to encourage the exchange of information, the exchange of knowledge among regions and nations, how can we bridge the gap between different worlds, developed world and developing world, as an example I mentioned, only from one satellite in a small team, they are willing to contribute internationally to become a better responsible actor internationally and contributing and helping other countries. I think if we can have platform for exchange of knowledge that would be very helpful.

Secondly, I think as we have our satellites cross borders without — cross borders and take images — without any limitation, I think also the cooperation will be left with that way. Also I would like to mention that, if we have the focus of, if you can have countries to focus on development and development sectors that will actually enhance the lifestyles of human being, the focus on environment, the focus on having people share information to support different nations and this thing it would be very important and we can learn from the example of the Landsat and how can we have global values, hopefully one day we are going to have each nation, they will have their own space programmes that will be supporting other sectors and hopefully that will take the initiative of Landsat and put in practice and to share information and at the same time advance international [...] thank you very much.

Mr. S. CAMACHO (*Mexico*) I now give the floor to Mr. Chaiyan Maolanont of Thailand.

Mr. C. MAOLANONT (*Thailand*) Thank you Mr. Chairman and good afternoon for everybody. I will talk about how to use Landsat data in Thailand.

Thailand has been involved in satellite remote sensing since the launch of NASA ERTS 1 in 1971 and

we have set up my ground station in 1982 to start to acquire data from Landsat 2 and Landsat 3.

[...]in southeast Asia and suddenly we have many data in my archive showing in my slide. And for the next slide show the Landsat data applications for the next year in Thailand many for, most of our use for geoinformatic system, forestry, disaster and land use, agriculture.

For the last slide about application of Landsat, for today in Thailand and I think many countries, Landsat has become a well able resource for decision makers in various fields. Landsat has also played an increasing role in diverse applications. For example, disaster monitoring, economic crop monitoring, land use and mapping for monitor in far east, I think for the previous section he talk about more this. Thank you very much.

Mr. S. CAMACHO (*Mexico*) I thank Mr, Chaiyan Maolanont of Thailand for his presentation and now I'd like to invite Mr. Felix Menicocci of Argentina who will be speaking instead of Mr. Conrado Varotto who couldn't make it here today.

Mr. F. C. MENICOCCI (*Argentina*) Thank you very much Mr. Chairman, I thank you for inviting us to speak here at this panel and I will briefly be referring to the use of Landsat in Argentina.

This history of space activity and Earth observation in Argentina is closely related to the Landsat programme, which was a fundamental programme in our development. The earliest activities in my country go back to 1961 when the National Commission for Space Research was established for the first time with the Argentine air force after that an incipient community of scientists and technicians, experts on remote sensing was established in Argentina. So we can say the use of Landsat data in my country date back to the early Landsat days.

Set local community of experts began to use Landsat data at the time they were delivered either printed or on tape and they already began to show benefits in applications in a period of 4 years between September 1980 and August 1984, the CNIE had the capacity to receive Landsat 4-Landsat 5 data in the Mar Chiquita land station in the province of Buenos Aires. So the community of experts was extended but then because of problems the users had to get Landsat data through commercial providers who were local or international. Generally this was costly and took some time.

Thus in 1991, the Government of Argentina created the National Commission for Space Activity (CONAE) as a civil entity with its mission being under the ministry of foreign relations in Argentina.

In order to fulfil its mission, CONAE had to plan, execute and evaluate a national plan for the peaceful use of space science and technology. Accordingly, it is important to note that our national space plan has key objective of developing space information cycles, in other words, precise, timely obtaining of information of space origin combining with field information thus helping best develop areas in social economic affairs. Thus the implementation and realization of the national plan has called for association with various sectors at a national and international level.

An example of these agreements of international cooperation was established between CONAE and Space Imaging which was EOSAT in the past, for reception processing marketing of Landsat 5. The agreement was then renewed with USGS when the operation of responsibility for Landsat 5 went back to the US. There was an agreement with the USGS to receive, process and distribute data from Landsat 7 as well.

Through these various agreements, the CONAE station in the province of Córdoba received Landsat 5 data from the 1st of March 1997 and Landsat 7 from the 5th August 1999. Receiving Landsat 5 was interrupted in November last year and reception from Landsat 7 is continuing now although in spite of the problems that everybody has known in May 2003 for the satellite, the information being given is still very useful for us.

As to the footprint, the footprint of our installations, this does not only cover the whole territory of the Republic of Argentina, in other words, continental, maritime, Malvinas Islands and neighbouring Islands but also other countries of the region such as Bolivia, Chile, Paraguay, Uruguay and a great portion of Peru and Brazil.

Here I would like to say that the data policy of CONAE applied to public institutions at regional, national, provincial, municipal and academic level means delivering Landsat data on a free basis to users through specific agreements.

The obligation for users through these agreements was to efficiently use the data, sending a report with results obtained and thus through international cooperation agreements, public users also

countries covered by the court of a centre footprint have received free data from Landsat in regions of interest. This broad availability and ease of access to Landsat data has been a turning point for remote sensing. Working groups have grown, multiplied throughout the country and our region and many applications included in the space information cycles of our space programme were developed extensively through the use of remote sensing techniques and Landsat data that were used for this purpose.

The opportunity to have accurate, timely information from Landsat has been a decisive factor in applications related to agriculture, forestry and mining and Landsat has allowed us to be pioneers in panoramic epidemiology, extracting from Landsat data the environmental variables related to health issues.

For our hydrology, geology and environment, the use of Landsat has allowed us to work with various institutions to obtain good management of resources and appropriate territorial planning. By way of example, I'd like to mention the National Institute of Agriculture and Animal Husbandry that uses Landsat data to monitor production in the Pampa region for naval hydrography there was the cartography done for the Río de la Plata and the Río Paraná and also the Ministry of Agriculture, Animal Husbandry and Fisheries that had produced maps with Landsat data.

There are also natural and anthropogenic emergencies which is another important application, floods, fires, volcano eruptions. Thus applications associated through remote sensing have benefitted from Landsat data and it is also important to mention that CONAE as a member of the International Charter on Space and Major Disaster, together with activations of the Charter has submitted images to the region that have proven very useful. Among these we have by way of example all the early warning systems done by INA, the National Water Institute as well as Bolivian and Argentina's activations following floods with also assessment of crop loss and damage.

As mentioned earlier, many applications have proven that Landsat data had been used throughout the country, this has been done 1997 to date with more than 52,000 Landsat 5 and Landsat 7 images produced in and delivered to users nationally and internationally. Out of this total, 55 per cent correspond to the Landsat 5 and 45 per cent to Landsat 7.

Landsat, because of its technical characteristics, selection of spectrum bands, the time for revisits in space characteristic is considered a valuable, useful tool for scientists as well as operational users.

The 40 years of historic data make up a unique database worldwide together with the proven usefulness these have established standards whereby designers of satellite institutes from other agencies and undertakings have used spectrum characteristics, influenced by Landsat.

Furthermore, in June 1999, NASA and CONAE created the first International Constellation for Earth Observation (the AM Constitution) with the NASA Landsat 7, EO-1 and Terra and the Argentine satellite SAC-C. This constellation entered into force in the beginning of 2001 and following the successful launching of SAC-C and EO-1 in November 2000, the four satellites passed over the same region within an interval of 1 half hour. The exchange of data from the various instruments of the constellation contributed to improving scientific objectives of the individual missions and education has also benefitted from contributions from Landsat which served as a basis to understand the principles of remote sensing and in particular the optic region of the electromagnetic spectrum.

And this whole, not only in the case of professionals who have experience in remote sensing, this is also useful data to teach our young people, our children in schools and universities.

The Landsat data are used effectively in classrooms in Argentina helping learning many subjects such as geography, science, environment thus bringing the new generations closer to the world of space technology, remote sensing and land sciences with a view to fostering interests and at the same time to promote an attitude more in favour of a rational use of our planet.

Taking into account all these achievements, there is absolutely no doubt that Landsat data have been and continue to be very useful for many applications in our country, our region and all around the world. This great success is of course the outcome of thorough and the analysis of the needs of users and potential applications of remote sensing done by the designers of the Landsat mission. For that reason, Argentina, which has benefitted tremendously from Landsat data would like to thank and congratulate all those who made Landsat missions possible with the invaluable results obtained over the last 40 years and we would like to wish you full success with the next Landsat 8, thank you.

Mr. S. CAMACHO (*Mexico*) I thank Mr. Felix Menicocci for that presentation and with that we have arrived at the end of this very short round table.

What's very clear to me here is that the use of Landsat images has promoted applications looking at mining, agriculture, management of natural resources and all sorts of areas and it was thanks to the 2008 decision to make this available, free to the scientific community for various applications and it is thanks to that that we see all these Landsat applications sprouting. So what I would like to do now is congratulate the United States for the tremendous success of the Landsat programme and we hope to see this continued as was said, for another 40 years and I feel I should conclude here because the Chair of the Committee would like to address the group and I feel that the Chair should have the interpreters' assistance. I would like to thank everybody for your contributions, your presentations, thank you all so much for sharing and I hope that you have appreciated it, all this new information for me there was a great deal of new information and I thank you all. Thank you for everything and I now hand over to the Chair.

The CHAIRMAN Distinguished delegates, since we passed 6 o'clock already so we will have no interpretation from now, just we will continue another 3 or 5 minutes to conclude today's panel.

I thank again all the speakers and round table participants for their presentations and contributions to this special panel. We have learned a great deal about how far space-based Earth observation programmes have advanced over the last forty years.

As you know, a large number of Earth observation missions are presently in the planning and development stage and several satellites will be launched in the coming years.

Today space-based remote sensing systems have become a vital part of a critical public infrastructure that is providing essential data and information on our environment to policy- and decision makers around the World.

I am convinced that the coming decades will see even more dramatic advances than those that we have seen taking place over the last forty years.

In this context we should note the upcoming United Nations Conference on Sustainable Development — Rio+20, which will be held in two weeks' time. Last year, in 2011, the Committee on the Peaceful Uses of Outer Space submitted its contribution to Rio+20 entitled "Harnessing space-derived geospatial data for sustainable development", identifying the use of space-derived geospatial data as the overarching theme for its contribution to the objectives of the Conference.

The use of space-derived geospatial data for sustainable development will remain critical tool for meeting the objectives of that Conference and in the implementation of its outcome. The Committee on the Peaceful Uses of Outer Space has an important role to play in increasing the awareness of decision makers worldwide on the importance of space tools for global development beyond Rio+20.

In this respect, today's discussion and proposals will enhance further utilization of remote sensing data for the benefit of humankind.

Distinguished delegates, as I already mentioned, tomorrow, Thursday, the United States Delegation and the Secure World Foundation cordially invite all delegates to a lunch-time reception, celebrating Landsat's forty-year history of providing high quality remotely sensed data to the world and its contribution to international space cooperation.

Finally, before I conclude the special panel, I would now like to cordially invite the delegates to join us for a reception hosted by Japan in the Cafeteria 3 Room of the VIC Restaurant, starting 6.15 p.m., almost it is time.

Thank you for your attention.

We will continue our meeting tomorrow at 10:00 a.m. Thank you.