Joanne: Good afternoon everyone. My name is Joanne McGuire. I am the Executive Vice President of Lockheed Martin Space Systems Company and I am just very pleased to welcome all of you to this second in a series of distinguished lecture series, co-sponsored by NASA and Lockheed Martin Corporation, in honor of NASA's 50th Anniversary. These lectures are designed to highlight the extraordinary ways in which our nation's space program has brought both tangible and inspirational benefits, not just to the American public, but to the world at large. I'd like to ask all of you to please join me for a moment in congratulating NASA for nearly 50 years of really truly remarkable achievements.

All of us at Lockheed Martin are proud to have been a strong and trusted partner of NASA since its inception and this lecture series is the latest manifestation of our half century relationship. As NASA's partner on the Orion crew exploration vehicle, we anticipate our stars will continue to shine together for many decades to come. There is no question that the greatest discoveries are yet to come, as NASA and our nation pursue a bold new era of exploration.

Joining us today is Shanna Dale, Deputy Administrator for NASA. Shanna, we're delighted to be partnered with NASA for this special lecture series and to have partnered with NASA for these many years on our nation's vital space achievements.

Today, our latest achievement is securing the services of Dr. Eric Schmidt, Chairman and CEO of Google with us today as our distinguished speaker. We're honored to have you with us today, Dr. Schmidt, and we look forward to hearing your comments.

To introduce our speaker, it's my great pleasure to have Congressman Bart Gordon, Chairman of the US House Committee on Science and Technology and Dean of the Tennessee Congressional Delegation. Congressman Gordon's commitment to responsible, bipartisan efforts to advance science, technology and education, have been really the hallmark of his Congressional service. He is highly regarded for his work on issues important to NASA and has fought for additional funding to ensure that the agency maintains a robust and balanced set of programs in science, aeronautics and human space flight. Congressman Gordon, please.

Bart: Thank you so much Ms. McGuire and more importantly, I want to thank Lockheed and the News Museum for your hospitality here tonight, or today. Maybe – oh, there's the Capitol there too. That was good timing. Thank you for that. And NASA, thank you for putting together this 50th anniversary lecture series. In that regard, it's interesting to note that the House Science Technology Committee is also celebrating a 50th anniversary this year. Both NASA and our committee are children of Sputnik. And as the inspiration for so many of the folks that were early involved in the NASA program.

And it's my great pleasure to be able to introduce Dr. Eric Schmidt today. I can really think of no one that is more appropriate in speaking to us today about inspiring innovation and exploration as it is Dr. Schmidt. I have a long history of his, or a long sheet of his resume, but I think it's – rather than take his time, you can all Google him. I'm sure he's heard that before. But you know, he really is in a rarified air of those CEOs that have been able to take a company and take it from a noun to a verb. My generation, I still say can I Xerox this or may I have a Band-Aid or a Kleenex. And so now you have joined that very small realm of verbs or nouns to verbs.

And I think also that Google exemplifies the critical importance of innovation and R&D to – that is necessary if we're going to continue the quality of life that we have in this country. I was talking to Ms. McGuire, she has a 7-year-old daughter, I have a 6-year-old daughter and I'm very concerned that when you look around the world now, there are almost 7 billion people in the world, half of which make less than $2 a day. And if our daughters were going to be able to inherit a nation with a standard of living that's going to be even better than ours, then we have to do it through innovation and research. We have to be making 50 or 100 widgets for every one widget they're making elsewhere. And that's why I was reading today about cloning. I don't know whether Dr. Schmidt we can clone you or not, but we're going to have to have increased really emphasis in this country on research and development so that our kids won't become the first generation of Americans to inherit a national standard of living less than their parents. It's a real challenge. You're going to be a part of being able to solve that challenge and I'm glad you're here and I'm sure people are glad that I'm not going to take any more time from your speech.

I will say that hopefully we might get you cloned some day, but we can't – and we can clone animals now, but we can't clone Congressman and I'm in the middle of a vote and so I've already missed the first two and so I'm – please accept my apologizes, I'll look forward to hearing your remarks that I'm sure are going to be re-telecast later. So thank you all.

Eric: Well, thank you very much Congressman, in your busy schedule, to come. This is a Congressman who has led a lot of the most important fights for NASA, for science and for space exploration. His service is phenomenal. I want to congratulate NASA for its 50th year anniversary. NASA has been a part of all of our lives for so much of the fantasy and the excitement in being an American and being a citizen of our great country.

I want to talk today about architectures and how systems will work over the next 50 years. I want to think that architectures of how we go about science and exploration and technology will be different. It will have to think about it in a different way. I think that the Internet will show a new approach for us, how we

can actually build these systems. Those of you in the audience are people who actually are in charge of how the system will evolve over the next 50 years, now is the time to think about how to design it so that we have a tremendous next 50 years. The next set of missions, that the President and others have articulated, Mars and so forth and so on, will span many generations, just as the Internet has. And I want to take you through some of my observations on that.

I also want to take a minute and congratulate the museum. Shelby and the team here are in the process of getting organized launching this formally later this spring. This is a phenomenal accomplishment by all the people involved in this and it's a strong testament to America, to the principles the country has been founded and all the things that we care about. And I'm very, very proud to have been invited to actually participate in this, I think one of the major public events here.

So let's talk a little bit about NASA and what I'm going to do is have Robin get started, Robin Ziegler, get started and we're going to do a few demos here to give you a sense of what is possible now with some of the things that NASA has been doing. As a pilot, I'm very actually grateful for everything that NASA has done. And I think one of the things that people always forget is how much impact NASA has had on things other than space – digital fly-by wire systems, wind sheer and icing. Perfect, good opportunity today to take advantage of these new systems built by NASA. Jet engine combustors, engine nozzle chevrons, all of these interesting parts of the technology that you all simply consume – as consumers you don't even notice it.

But when I think about NASA and I think about Google, I think about both as being in the business of making things that were amazing commonplace. If you look at the history of aviation, which I know something about, people were terrified with this sort of weather before NASA came along. It was actually a series life-threatening problem and now we can deal with it. That's an amazing achievement. It happens every day. And it's going to continue, given the leadership of NASA and the mission of NASA and the things that NASA is trying to do.

When I think about Google, we try to do the same thing. We try to do things that are amazing, things which were amazingly impossible 10 years ago are now routine. I was trying to think of an ahomym(?), I thought well, what is the most interesting query that I can give? And I thought how long will I live? Seems like the most important question you could ask Google. And since we use Google for everything, I asked Google and the answer is, there's an age calculator I typed in all the parameters and it came up 67. Bad answer. Bad answer, bad answer, reject that answer. So I reprogrammed the age calculator a little bit and I came up to 86. Much better answer. I stopped, I moved to other searches. That's an ahomym(?)

and I know how long I'm going to live. And the answer is it's 84, not 67 because Google told me.

Now Robin, let's start. This is the crookedest street in the world in San Francisco and you're looking at it with a product called Google Street View. We started off with a view of the earth and as you saw as we zoomed down. And you notice you see the folks and the cars, you have street signs and so forth. Is that Alcatraz in the distance there? Maybe you could sort of go – I'm not sure, it's a tourist destination now, don't worry. And here we are. And here you are and you're just on Google wandering around. What's interesting about this is look at the human scale of this experience, this exploration. Seems kind of routine, right? This is, by the way, phenomenal technology to do this, before we get too ahead of it. Let's keep going.

When we go to the same thing in Google Earth, the first thing was called Street View, in Google Earth we can see everything there is around. The first image that you saw was the same street in Google Earth and now we're visiting, looks like, Washington, DC. And of course, here's the Capitol, which we're right sort of next door. Now we can wander around and so forth. Now the pictures here include these 3D models of all the buildings. And the shapes that you're seeing, and the contours, were, in fact, calculated in 11 days in missions in the Shuttle in 2000. For completely unrelated reasons, they decided to do a topography of the earth. And they happened to, by virtue of their public mission, make it available to everyone. So we just sort of took it and use it and now when you use Google Earth, you're really following the data that the Shuttle mission calculated. Keep going.

Now when you think about Washington, there's a lot of discussions, for example, about – let's see what we're going to do next here. Yes, it turns out that there's a lot of debate about global warming. And this is a – what is the – how many years – 5 meters, 15 feet. And so the good news is the Capitol is going to be preserved. I'm a little worried about the Smithsonian and I want you all to look at the NASA headquarters. It's a little bit of a problem. I think it has an underground parking garage. You're in big trouble. Not to make a point about global warming or any of those things that are sea level change, but there is an article yesterday that says that there is a possibility of this scenario occurring by the year 2100.

Now why is it important we show this to you now? Because this is an example of the kind of visualization that you can do by taking this platform that represents Google Earth, and then showing what could happen. Obviously, we don't want that to happen. Keep going.

What's interesting about all of this, and what are we going to do next here? Yeah, let's take a look. This is another example of NASA. NASA, I think this was Langley, gave us some climate models and the climate models happen to show the

path of Katrina. And so we've now overlaid the images that we got from you all, essentially, and you can see as you see the cloud moving, it has information about velocity and position and so forth and so on. These models were used real-time in order to understand what was going on and of course you could see the velocity and that kind of thing. Many, many, many more people participated in understanding the phenomena and obviously also the aftermath. We won't show you now, but there's a large amount of imagery that was done to help rescue missions and so forth, again, overlaid on top of this work. Again, in conjunction with NASA. Let's move to our next one.

Now when I think about the Earth, I also like to think about what are the things that I'd like to do and I've always wanted to climb Mt. Everest. Now if you're looking at me, this is clearly not going to happen. So what we've decided to do is, I was just sitting in my office one day and I thought, well, let me just climb Mt. Everest on Google Earth. So here we are and we sort of wander up and you can see the South Call and so forth and so on and this is the vision, and I've achieved my objective. Well, have I? Yeah, actually I have. I have a sense of it. I have a sense of what it's like to be at the highest peak of Earth. Again, I could participate in this new and interesting way. And by the way, it's really cold.

If I then look at – let's see where we're going next. When I think about – what I also like to do, I was talking about aviation, we have a person who is a blogger who covers Google Earth who decided to build a model, a flight simulator, and he took a publicly available Swiss fighter pilot video of a Swiss Air Force pilot wandering around the Alps. And you see on one side, you see the actual film and on the other side, you see the recreation in Google Earth. Now again, this is available to all of us through the work that NASA and others have done to make it possible to see topography and pictures. This information is satellite and aviation data and you'll see that – and of course it comes with a great soundtrack and so forth and so on. And again, someone else, just like me flying Mt. Everest, this is perhaps a person who is unlikely to be flying his own F18 in the middle of the Swiss Alps, can really recreate this. And it's just a phenomenal experience.

We have many, many technologies coming that are like this over the next little while. Why don't – in fact, here's a picture of the fake pilot, there's a picture of the real pilot. So this author even inserted a picture of himself in it. Let's move to our next one.

When I think about this whole phenomenon, how we use information, I then think about scale and I was trying to think about what's the best example that I can use about scale? And I was trying to think about, well, there's the moon sort of nearby. So what we've done now is we've simply taken imagery of the moon, thank you NASA – it's by the way, moon.google.com, in case you want to go visit the moon, if you're not currently planning on a moon mission anytime soon

– and here we are and let's go visit where Neil Armstrong went. And you'll see that we can, in fact, get to the point where you can see a picture of his footprints.

Now the kind of stuff that I'm talking about which we did under a Space Act Agreement with NASA, and we're showing not just NASA planetary content, as we've discussed, but also we're working on disaster response. Here is a picture of Neil Armstrong's footprints. Again, these pictures are collaborated, given to us by NASA and others. This mechanism is generically available on all of Google Earth. So again, showing off what we can do. Let's keep going.

Now if you're on the moon, perhaps what you're really interested in is space. So let's go to a – I don't know, this is a particular interesting star field. This star field is – looks like a normal star field. It was actually done in the Deep Space Initiative, with the Hubble. And this is a picture of the – and to give you an example, the width of that picture is somewhere around 10 to the 25 centimeters, which is a number that is – here's an analogy for you. If the interaction between carbon atoms is maybe 1 over 10 to the minus 12th, because of the way they interact, and 10 to the 12th is on the order of 100,000 years. So what you're seeing is you're seeing something that has the scale or width, something you've never seen before. There's nothing in the world of this scale. This is the deepest image. It's also the most – the oldest image we have in history because it was done approximately 13 billion years ago, roughly 10% of what we believe the life of the universe is. And it was not done with one picture, by the way. The Hubble went around and took picture after picture after picture because there was so little light. Pretty neat, okay? So you say normal picture.

Let's see where that picture is in context, so you get a sense of how far it really is. Oh, it looks like a pretty normal star field. And by the way, there are billions and billions of stars and galaxies even in this field. As we move out, we begin to see that perhaps this is a tiny, tiny, little piece of a tiny, tiny little constellation that doesn't even show up on our constellation map, as we go deeper and deeper and deeper in both time and history. Some of our constellations begin to show up and now we begin to see what is familiar to us. There is no tool and there is no feature I know of on Earth that can show you a resolution that goes from 1 to 10 to the 25th in that amount of time. That's what NASA can do. That's what information technology can do and that's, frankly, why we all work at Google.

Let's thank Robin for the demo and let me keep talking. So if you think about it, what you really do is you set up audacious goals and you make this all happen. Because you cannot possibly anticipate the challenges that you have to surmount. It's clear that the assumptions will change and you cannot predict the innovations that engineers will make. The internet architecture was invented in 1973. The world wide web was invented in 1991, 1992. Protocols that we deal with every day now that are so commonplace, were not even thought about until 20 years

after the original design. That is a remarkable achievement of technology in computer science.

There's no way to understand how people will take advantage of this technical innovation. A man in Italy used Google Earth to discover the remains and antiques of an ancient Roman villa, literally in his backyard. Archeologists in France used Google Earth to discover 100 candidate sites for ancient Celtic settlements. In the search for these various meteor craters, impact craters, they're using the satellite imaging from NASA and the other work in order to actually do real science on how the Earth was formed and shaped. We didn't anticipate all of this, we just put the data out there and people did it.

It's also clear to me that the people who start the mission are not the ones that are going to complete it. An interesting fact that I did in researching this is that the average age in the front room for Apollo 11 was about 32. The average age at Google is about 31. The memory of the IBM 360s – I used as a young programmer an IBM 360-91, which will both date me and also give – you'll have a sense of sympathy for me – 2.5 megabits in core memory, real cores. The memory of the iPod that our average employee carries now is 80 gigabytes, which is 256,000 times 2.5 megabits. So the rate of change here has been so phenomenal, it's of the scale that I just showed you in that star field.

So the Internet is the fastest growing communications medium in history, again, so fitting that we're here at this wonderful museum. More than 1.3 billion Internet users worldwide, on the order of a couple hundred million new users every year, 8 hours of video get uploaded to YouTube every day, that should be every minute, and there's 70 million blogs and 120,000 created every day. So a lot of blogs and a lot of writers, not so many readers I suspect. When you – this democratization of information, which is fundamental to what is occurring here, has a lot of implications for both NASA and for Google and for the world here in Washington. Since anyone can create, edit, publish and share information, it's a new jump ball, it's a new scenario. And normally what happens is that the rate of progress in fields occurs at a relatively predictable rate. Examples would be that scientific research, the number of papers doubles every 15 years. So sort of predictable rate. In astronomy, the – since we're sort of talking about astronomy right now – the distance of the farthest galaxy we could see has doubled roughly every 10 years. So again, reasonable rates. The world that I live in, doubling times are much, much shorter. Moore's Law, of course, everybody knows about this, processing power doubles every 18 months. That means, by the way, 10 mines every 5 years, 100 times in 10. There's a law called Kryder's Law which is that memory, disk memory in particular, doubles every 12 months. So this immense, immense amounts of data stores being created over and over again.

So an obvious example is that in 2019 an iPod type device would be able to contain 85 years of video. In other words, you could never watch it. You'd be

dead. You're going to be carrying it and you'll say, well, I couldn't watch it. I'm sorry, I died. It's actually a serious problem. like because it's going to cause a lot of stress. If I'd only lived another year longer I could have watched that other episode.

So the other interesting thing about this inspursion(?) of information is that there's a lot of new voices and new ideas. With all that content out there, search is obviously what Google does, becomes more important than ever. Over 20% of the searches that we do every day are for items we haven't seen in at least the last 90 days. So people are naturally curious and I want us to take advantage of that curiosity.

So here's some ideas for success as we think about this. The buzzwords that we use in computer science are open, scalable and flexible architectures. A lot of the NASA work was done before that became the – that's the most politically correct way I could say this – before those became the principles of design. These hardware designs that are not extensible, ultimately do not serve the mission very well.

In my case, to show you how foolish I was when I was a graduate student at Berkley, I built a network – one of the first networks built of its type – for my Masters thesis. And by the way, I got my Masters thesis and I designed a protocol where there could only be 26 machines, because there were only 4 at the time and I couldn't imagine that the university would ever have more than 26. So the machines were called A, B, C, D…etcetera. They still gave me my degree and then sort of there later they tore out my network and put in a proper network. So everybody can make this mistake. The Internet started off with 4 nodes, now it has somewhere between 250,000 and a million broad networks, by any definition. It's just phenomenal. The number of servers, there are roughly – January 1983, we have an accurate number because of DARPA, 400 servers. In July 2007, our best estimate is 489 million servers. And this is growing and continuing to grow. It's growing faster than you think, because it's growing all the time.

So when you build an innovation model, you want to build it in a way that's collaborative. And this is often at odds with how people think about government programs, procurements, the traditional structures of business and private groups and so forth and so on. You want to figure out a way to do it in a much more open way. And everybody loves what NASA is doing. It should be possible to pull this off big time. The web, for example, today is built out of products known as Linux, Apache, MySQL. These are open software technologies. The creators of MySQL, by the way, just so – in case there's any concern that these might be hobby businesses – were just purchased for about a billion dollars by Sun Microsystems. These are real businesses with different characteristics, but it shows you that you can really deliver tremendous value.

So if you solve the big problem, solve it by opening it up to the public. Assume that you don't have all the answers, because I can assure you that we don't. And I suspect nobody does. Everything is too connected. You're not getting the benefit of everyone unless you figure out a way to do it in an open way. There's a couple of really good ones. NASA did something called the Centennial Challenge Program. One of the people here was one of the authors of this program, so thank you for that. A particular engineer from Maine won $200,000 in May 2007, for designing a new astronaut glove. The inner bladder of the glove used one of his kitchen cleaning gloves, because it was the right solution. It just worked. And there's example after example of that where you bring in the creativity of people who maybe he didn't have a lot else going on in his life. Maybe he needed something to work on. You just made his day and you just saved yourself a million dollars. But more importantly, you served the mission very, very well.

The Lunar X Prize that Google has announced. We announced a few months ago a prize which is graduated, think of it as between $20 and $30 million. Basically, get something launched, get it to the moon, make sure when it lands it could still drive around. Very straightforward. That's the non-technical explanation. Look at our website, you can see all the details if you want to bid. Why would we do this? Because it's fun. It's just so much fun. Now the people who are going to attempt the Lunar X Prize, and we think there's a whole bunch of folks, are probably going to spend more than the value of the prize. But what's nice about the prize is it brings everybody together, it gets everybody's competitive juices and you get the multiplicative effect, not just of the money that we're putting in, the money that NASA's putting in, but the money that all the other people, all the other universities and other programs, that really want to be part of this historic opportunity to change science in a good way.

Another aspect of the problem that I think we all face, has to do with this notion of how do you learn? And in this interconnected world, you have to learn more quickly. Part of the success of the internet -- and it's true of all of the company's, Google is simply one of the examples – is that we're built on a ship and iterate philosophy. What happens is basically we try something, we try something, we try something. And we're proud of this, by the way. We celebrate the fact that we tried this, we canceled this, this didn't work, we shifted and so forth. A wiggle in an interesting way. And not only does the technology allows that, but it's part of our culture. We have programs where we encourage our engineers to spend 20% of their time on things of their own interest, not what their manager is telling them that they have to do. Again, unheard of in traditional engineering, but drives much of the creative process inside our company. There are many, many such examples.

So I don't know – who here was a big Apple Lisa user? The old, it was the predecessor to the Mac. But they learned about from the Apple Lisa. It make the Mac a great success way back when. It happens in telecommunications. The AT&T long distance network crashed for nine hours due to a bug consisting of a

single line of C code in 1990. We've all forgotten that, but the fact of the matter is, they do it too.

So the obvious message for me is to say, well, NASA, you should just ship(?) and iterate. Well, there's this minor problem, that you can't apply exactly the same approach we do because Mars and the Earth are only this close on this day. Or Saturn is only in this position in this particular place. Or you have a particular launch window due to orbital mechanics, which you really do have to launch within this window.

And there are some humorous now, but embarrassing at the time, examples. Gemini 5 splashdown off course 100 miles because of a programming error involving the way they did the calculation with a decimal point. An even more famous example, and unfortunately a negative one in 1962, Mariner 1, went off course and NASA at the time had to blow it up because of an error in the FORTRAN. And hyphen had been dropped from the guidance program loaded aboard the computer. It's been quoted as the single most expensive hyphen in history.

So I don't think it's fair for me to say, well, hey you guys should just adopt this ship and iterate phenomena. I think what you have to do is you have to recognize that the ship and iterate model is the best model for learning and then adapt it to the constraints that are very much in your present.

So one way to think about it and as a manager I talk to people a lot about this, is that one of the best ways to be lucky is to create more luck. And the way you create more luck is you have more at bats. You get more shots, more launches, more learning, so forth and so on. So the more you put everything around one single event, the less likely it's going to be a perfect success. The more you figure out a way to iterate – and there are many, many ways in which you can iterate – you can iterate with openness. You can iterate with extensibility. Remember the story that I used about the internet. That the underlying protocols were designed around a simple model of end-to-end connectivity. No one anticipated all of the stuff that would be built on top of it. So given that you have these real constraints about launches and windows and so forth, make the platform such that it's the simplest possible platform that people can then build on top of. Build open systems, not closed systems. Don't try to solve the whole problem right now. The problem as correctly defined in my view, is to build the platform, the thing that is extensible to the next example.

Another example, we were looking this. Most spacecraft can't talk to each other in any significant way. Now you say, well, I'm not sure I want spacecraft talking to each other. Well, actually, it's kind of useful for spacecraft to talk to each other, especially when they can relay information and telemetry and other

information, and furthermore, we as a country can use that for many, many different reasons.

Well, isn't it obvious that the spacecraft should have an Internet on them too? I mean it doesn't have to be an open internet, you could have your own private copy with a gateway so people aren't randomly steering the spacecraft wherever they want to go. But the fact of the matter is, it does make sense. And in fact, there are people now working – this is a great story – people working to build an interplanetary Internet. That all the same principles that I'm talking about apply, not just on Earth, but to the objects that we're busy launching. And by the way, not just the US, but everybody, but also the moon and Mars and so forth and so on. And this Internet is interesting because there's this minor problem that as you spin, you lose connectivity, you have to wait for the packet. So the whole notion of latency is very different. It's like a long time before that packet shows up. But then it comes very quickly and then there's a long time again. We haven't quite figured a way to solve planetary rotation yet. So the fact of the matter is, you have to design these protocols with small number of modifications. It's possible for NASA and the world to have not just an Internet that is part of earth, but also an Internet that goes all the way out there. I don't know if it will get all the way out to the deep space fields, because it will take 13 billion years to get there, but it will get pretty far.

So by standardizing the protocols, by standardizing the ways in which things talk to each other, by making sure that when you have multiple vendors, multiple contractors, they're using a common substrate of communication and extensibility, you have a much, much greater chance of creating an opportunity like the ones I'm describing in the Internet where this platform, this very interesting thing that was designed for one thing, is in fact, even more valuable, even more powerful, rather than mission limited in one way or the other. So the technology-based case continues and I think it's pretty interesting.

What does it look like in 10 years? Processes and phones and computers are 100 times more powerful, storage thousand times cheaper, a ubiquitous wireless broadband, a cell phone for everyone who wants it in the world. This will occur in our lifetimes, especially since I'm living remember to 84. How can NASA take advantage of this? I'll give you another example, so something fun.

NORAD has a program where Santa – they know where Santa lives and they track Santa as he goes around the world. And these guys are pretty clever. So they shot videos of Santa visiting various city and towns around the world. And they had a route GPS as you could track him. And I thought, wow, pretty interesting. How many people look at this? 10 million people had nothing else to do, but to follow Santa as he wandered the world visiting and spreading joy around the world. Had a bit impact on families and kids. How can we, how can NASA take advantage of that? To me that's the interesting question.

There's a story about Alan Beam, one of the most famous astronauts, that there's a benefit to being an astronaut, obvious, get lost in space. No. The benefit is that you can get the attention of any kid for 5 minutes, in rapt attention. If we can't use that observation to further the mission of NASA and the things that we care about, we're not doing our jobs right.

In many ways Google and NASA are similar in that they're based on optimism. Pete Worden is my good friend, one of the directors at NASA, says that, "Remember that space is hard. It's really hard. It's hard science. It takes an optimist to want to pull all of this off." And I like that a lot. You have to be optimistic to want to send a man to the moon, to Mars, to explore every planet, to build a space station. You also have to be optimistic to believe that you can cover all the world's information started with borrowed servers in your Stanford dorm room. It's the same principle. And indeed, we're busy doing it as best we can.

Ed Liu(?) who is a Google employee and I think the US astronaut that's been in space the longest, I asked him sort of what's it like? What did you do all day? He said, "I looked at the earth. I literally just loved to look at the earth as it was underneath me." So what I was thinking about was, how can we get that – how can we get that feeling? Because if you think about it, every person that I know of, basically looks at the world on their cell phone now. How can we get that same passion that Ed had, that same feeling about the world, the world around them, the sense of wonderment? They spend – people spend literally so much time looking at this screen or the other choices as well, how can we get that information? And I think that is our joint mission. How do we get this amazing amount of information that is being generated about the world and science and the things that can – how can we get that so that it is the same level of rapt attention as Ed had sitting, spinning around? Looking at the wonderment that is the world around them? That's why I'm such a strong supporter of NASA. That's why Google is such a strong partner for NASA and that's why we're so very, very happy to wish NASA a great 50th anniversary. So thank you very much and I'm interested in your questions and comments. We have our first question in the middle.

Q: _____

Eric: Let's see if we can get the – I think the lady has a mic for you, that would be great if you could – that way they could hear you on the video tape.

Q: David Logsdan, US Chamber of Commerce, Space Enterprise Council. A few years ago, the futurist, Alvin Toffler, was at a conference, a space-related conference where he mentioned that the information age was the third wave, that space was the fourth wave. In your mind, what do you consider the fifth wave? Is it a combination of space-related activities and applications, coupled with

information? What is your vision for the fifth wave and with that vision, how can that be a stimulus to the economy?

Eric: Most people that I talk to in this area, actually believe that the huge phenomena that's going to hit us will be in biology, in biotechnology, the issues and opportunities that the genome, recombinant DNA, those sorts of things do. I think all of us are to some degree enablers of that next wave. And the argument is pretty simple. In order to do the kinds of things that we want to be able to do for health, society as a whole, improving a lot of the world, we're going to need the kind of information and computing power and networks and learning that's going on today in the other waves that you described. It's probable that the combination of the creation of this enormous information network that I talked about earlier, the commercialization of space which the NASA, the NASA leadership has done a tremendous job moving forward – if you think about 10 years ago versus now – again, which also creates a large number of jobs, a large number of opportunities and this openness, making it possible for people to enter the system at the appropriate things. Both of those create very large numbers of jobs and probably a significant wealth opportunity for investors. A lot of people believe that as more and more of the stuff is done in the private sector, people will figure out a way to make money, because there's economic value. In Google's case, for example, these satellite images that we showed you, we buy them from commercial satellite providers. They're making money and doing a great job for us, by the way. There are many, many new things of that type that can be done. So one of the reasons that I'm here is to say to you all that there are tremendous private opportunities for investment in space technology, high technology, information technology. Google is an example of it, there will be many others. Eventually I think all of us will be subsumed to some degree under this biology, biotech because the promise is so strong. They're not quite there yet because the computers aren't quite fast enough, we don't really quite understand the networks quite well, but everybody is working on it. Yes sir. Let's see if we can get a microphone.

Q: Matt O'Connell, GOI, one of those commercial satellite operators. We get criticized for taking…

Eric: And a partner, thank you. Thank you for all those nice pictures.

Q: Thank you. We get criticized for taking pictures of areas that some people think are sensitive and I know that at Google there's been a debate about whether or not you should show those pictures. I think the arguments in favor of openness are winning, but I'd love to hear your comments, because I get it all around the world.

Eric: From a Google perspective, this question about public information, what's public, what's private is turning into be one of the sort of central questions for the Internet. And you all should know that there's a law that restricts -- you certainly know this – commercial satellite imagery to a certain level resolution, which

we're governed by and we need that, obviously. So there, in fact, is some legislation and some regulation in this area. We've taken a position that subject to meeting the law, and there are certain countries which have special terms which are even more restrictive with respect to commercial imagery, we want to get as close to that as we can because we think that society benefits from such pictures. The fact of the matter is that I think we're in a transition period where people are learning that things which are – which they thought were not generally known, are becoming more generally known.

My favorite examples are these situations where something from space – people assume that you'd never see it from space, but in fact, it's embarrassing or the wrong thing or so forth, where people are making appropriate changes. So I think this is a transitional period.

The benefits of being able to see that third dimension, what pilots see when they fly, turns out to be phenomenal. I talked to Queen Noor about her husband who died, who was a pilot, and she told me that part of the reason he was a pilot was that when he flew around the Middle East, he never saw any boundaries. He never saw the little lines that we see on the map, which is what we assume those lines are like etched in the desert. We all know where they are. It's right there on the map. But it really isn't.

I went to a photography show from one of the astronauts who is particularly good a mid-format camera photography, showing what the Earth really looked like. And I think that it's both a message of peace, but also a message of the importance of the Earth that I think we want to get out.

There are some things that we do to be responsive to this. We are very, very careful not to show real-time, because we think real-time could be misused and you could imagine 20 ways in which real-time images could be used. And we also have various mechanisms for things which are sensitive or inappropriate to try to consider whether we should remove those as well. So we want to be sensitive to that. But the overwhelming conclusion is that society benefits from more of that kind of imagery being available, and thank you for helping make that happen. More questions. Way in the back.

Q: Eric, Chris Kempout(?) at Ames Research Center. Increasingly collaborate technologies are free and systems are increasingly being developed in open source. And it's hard to procure what's free. What advice do you have for federal agencies that are trying to use tools which are free?

Eric: _____ again, the government which has like a trillion dollar deficit can't buy something which is free, it has to buy something which costs money. Is that – everyone says yes. Welcome to Washington, I guess. Even the technologies that I was describing that are free, are typically come with a support burden. So what

companies do when they work with the companies that I mentioned, is they actually do a procurement in the Washington sense or in the government sense, but they do it for a service. The software itself is free, but the support, its integration and so forth – and that works pretty well. So we use the term free, but we all understand that people are paying for this, they're paying for engineering, they're paying for support and so forth and so on. And that's where the revenue is being created. To put it another way, sometimes you pay for the software, sometimes you pay for the service. At the end of the day, you're going to pay for something. But it has to do with what you're procuring. There's no question that the generation of computer people that I work with now are all building on top of this Linux platform, which is open source, but they're building tremendous companies. Google, of course, is largely Linux based, to give you an example, and obviously very successful. More questions.

Well, thank you for inviting me, thank you all for a wonderful afternoon and I hope you all get home in the middle of the storm. So thank you very much.

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