



George Bush Sr.

## Crisis in the United States (1991-92)



Richard Truly



1

00:00:00,099 --> 00:00:19,520

>> Good morning. Let's go ahead and get started.  
the panel this morning is going to be on exploring

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00:00:19,520 --> 00:00:26,039

the outer solar system. We have three talks  
and will try to do 20 minutes per talk with

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00:00:26,039 --> 00:00:31,980

five minutes for questions and that will give  
us plenty of time to have a panel discussion.

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00:00:31,980 --> 00:00:39,219

This should be an interesting panel. We have  
heard about how difficult this is that we

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00:00:39,219 --> 00:00:46,960

all try to make it easy and getting to the  
outer planets is interesting challenge. Not

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00:00:46,960 --> 00:00:53,569

something we have done with very many spacecraft  
but we will find out from the panelist about

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00:00:53,569 --> 00:01:12,820

some of the issues involved. the first speaker  
is (indiscernible). Torrance Johnson. He was

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00:01:12,820 --> 00:01:18,330

a project scientist for the Galileo mission  
and directed the Galileo science team through

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00:01:18,330 --> 00:01:27,910

the mission. He is currently involved in ongoing  
research with giant planet satellites. He

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00:01:27,910 --> 00:01:34,880

is also the chief scientist for solar system  
exploration director at JPL where he is involved

11  
00:01:34,880 --> 00:01:49,540  
in planning for the next era.  
>> Thank you. My title is outer solar system

12  
00:01:49,540 --> 00:01:59,329  
explanation -- exploration because the organizers  
told me this was an academic and serious audience

13  
00:01:59,329 --> 00:02:06,429  
and that I should prepare something suitably  
lofty. What that really means I will talk

14  
00:02:06,429 --> 00:02:13,860  
about how we decide what sorts of objectives  
we undertaken outer solar system exploration

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00:02:13,860 --> 00:02:19,860  
and how those are unaffected by the very long  
periods of time it takes to get to the outer

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00:02:19,860 --> 00:02:25,220  
solar system. This makes things more difficult  
for some of the terrestrial planets where

17  
00:02:25,220 --> 00:02:39,440  
we have much higher launch rates. Let me go  
back to a couple of the talks yesterday, discussing

18  
00:02:39,440 --> 00:02:47,860  
things like the effect of how science was  
perceived by the public and media. This can

19  
00:02:47,860 --> 00:03:03,020  
be summed up in many cases as, we send a bunch  
of spacecraft out and look what we find. Scientists

20  
00:03:03,020 --> 00:03:11,590  
are amazed, astounded, textbooks rewritten.  
I can't tell you how many times I've had those

21  
00:03:11,590 --> 00:03:19,900  
types of questions from the media. Are you  
amazed by what you just found? Our friends

22  
00:03:19,900 --> 00:03:27,680  
working on the (indiscernible) are in this  
situation now. Tell me again Sir, you spent

23  
00:03:27,680 --> 00:03:33,900  
billions of euros to find a particle you are  
almost certain was there in the first place

24  
00:03:33,900 --> 00:03:43,930  
and what will you do with it now? In fact,  
the reality is more complex. Saying scientists

25  
00:03:43,930 --> 00:03:48,790  
confirm their model while finding new puzzles  
does not make as likely lively copy for the

26  
00:03:48,790 --> 00:03:57,130  
morning paper. the reality is in between.  
We do follow the scientific method while trying

27  
00:03:57,130 --> 00:04:05,680  
to develop the objectives and experiments  
for our missions. That was illustrated nicely

28  
00:04:05,680 --> 00:04:11,410  
yesterday in talks related to the advice of  
the national academies and other advisory

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00:04:11,410 --> 00:04:17,790  
bodies give to the programs here in the U.  
S. and similar types of roadmaps and so forth

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00:04:17,790 --> 00:04:26,480  
done in the other space programs. It does  
operate in a deliberate fashion. This is particularly

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00:04:26,480 --> 00:04:33,680  
evident when you look at the way the outer  
solar system exploration has proceeded because

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00:04:33,680 --> 00:04:40,680  
the vast distances are very long flight times  
involved. It means you have to select experiments

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00:04:40,680 --> 00:04:47,350  
sometimes years before it launches. Based  
on best available evidence but not data from

34  
00:04:47,350 --> 00:04:52,890  
the previous mentioned which might still be  
on its way. Things have to be designed to

35  
00:04:52,890 --> 00:04:59,320  
be reprogrammable, mission operation procedures  
have to be flexible so they can take advantage

36  
00:04:59,320 --> 00:05:04,211  
of things discovered between the time you  
make your plans and when you actually are

37  
00:05:04,211 --> 00:05:12,960  
sitting there getting data back from the mission.  
I will illustrate that process not by telling

38  
00:05:12,960 --> 00:05:18,820  
you everything we have done and our -- outer  
solar system exploration but if you are very

39  
00:05:18,820 --> 00:05:27,870  
interested in this topic you will begin to  
glaze over after the 60th slide. What I will

40  
00:05:27,870 --> 00:05:35,210  
do is take two specific areas that are somewhat  
linked and talk about how our objectives for

41  
00:05:35,210 --> 00:05:43,270  
those have change to the process of a series  
of outer planet explorations. One is the atmospheric

42  
00:05:43,270 --> 00:05:48,770  
compositions and the other is nature and history  
of giant planet satellites. These questions

43  
00:05:48,770 --> 00:05:57,680  
are linked through the scientific goals because  
they relate directly to our understanding

44  
00:05:57,680 --> 00:06:03,889  
of the solar nebula of which the planets formed  
and our understanding that has progressed

45  
00:06:03,889 --> 00:06:12,580  
over the years as to what the processes are  
that are forming the planets. I will warn

46  
00:06:12,580 --> 00:06:20,840  
you upfront, that I will mostly ignore the  
third major theme that would also be worthy

47  
00:06:20,840 --> 00:06:27,810  
of an entire paper which is, in the exploration  
of the magnetic and plasma environments of

48  
00:06:27,810 --> 00:06:34,710  
these it planets. I will touch on that as  
it relates to the issue of the interactions

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00:06:34,710 --> 00:06:44,060  
of those environments with their satellites.  
You can ask Ralph about how you go about investigating

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00:06:44,060 --> 00:06:49,840  
the (indiscernible) of planets. I remind you,  
in the beginning of the space program we knew

51  
00:06:49,840 --> 00:06:57,980  
of only one (indiscernible) of the earth was  
to as Jupiter. It was defined and identified

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00:06:57,980 --> 00:07:03,889  
initially through radio astronomy. That was  
a major theme in outer planet exploration

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00:07:03,889 --> 00:07:11,980  
running parallel with some of the ones I will  
talk about. Let me take you back to the beginning

54  
00:07:11,980 --> 00:07:20,370  
of outer planet exploration which is not back  
50 years but almost. Take you back to solar

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00:07:20,370 --> 00:07:27,310  
system version 1.0 which is what we started  
planning the outer planet or grams with. Only

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00:07:27,310 --> 00:07:33,580  
10 years after the mariner 10 launch -- mariner  
to launch we started thinking about solar

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00:07:33,580 --> 00:07:41,730  
exploration because as was pointed out by  
several speakers yesterday, we had this wonderful

58  
00:07:41,730 --> 00:07:48,490  
grand alignment of the outer planets that  
allowed short trip times for a specific launch

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00:07:48,490 --> 00:07:59,970  
date. One of my first NASA briefings was listening  
to John tell us about the grand to her in

60  
00:07:59,970 --> 00:08:12,430  
Washington. Getting to Neptune and 1989? I  
will be in an old folks home by then. We were

61  
00:08:12,430 --> 00:08:18,650  
all very distressed when that idea got de-  
scoped but it was resurrected rapidly as was

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00:08:18,650 --> 00:08:24,150  
his best by several speakers yesterday. I  
will point out one of the things that did

63  
00:08:24,150 --> 00:08:31,340  
not get discussion yesterday was the first  
part of that resurrection, even before Voyager,

64  
00:08:31,340 --> 00:08:45,759  
was (indiscernible) pushing very hard on getting  
a fast simple spacecraft out to Jupiter. Pioneers

65  
00:08:45,759 --> 00:08:51,102  
10 and 11 were part of this restructured idea.  
They were designed to get to Jupiter and find

66  
00:08:51,102 --> 00:08:58,069  
out what was there. Voyager followed along  
with the objectives of the grand two were

67  
00:08:58,069 --> 00:09:01,949  
but only go to Jupiter and Saturn. That was  
all that was promise. They would be launched

68  
00:09:01,949 --> 00:09:14,790  
that would enable trajectories enable. Let  
me take you back to our knowledge of the solar

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00:09:14,790 --> 00:09:24,240  
nebula and the giant planets at that time.  
We were beginning to get the first quantitative

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00:09:24,240 --> 00:09:31,110  
understanding of what the planets were formed  
out of and how they were formed. By modern

71  
00:09:31,110 --> 00:09:39,420  
standards -- standards it was simplistic.  
(indiscernible) put together want to take

72  
00:09:39,420 --> 00:09:46,009  
the pressure temperature and density models  
of the solar nebula and he changed it several

73  
00:09:46,009 --> 00:09:53,110  
times per year. So people were always catching  
up coming along afterwards and trying to figure

74  
00:09:53,110 --> 00:10:00,009  
out how their models matched his several months  
after he published a. That was coupled with

75  
00:10:00,009 --> 00:10:08,610  
giant planet formation models which were quantitative  
Bob by modern standards quite simplistic.

76  
00:10:08,610 --> 00:10:15,639  
If you had something as big as Jupiter or  
Saturn it would hold a hydrogen helium atmosphere

77  
00:10:15,639 --> 00:10:25,749  
and would not cause major fractionation. by  
escaping from the top of the atmosphere. We

78  
00:10:25,749 --> 00:10:31,459  
expected at that time and this was embedded  
in the advice is from the national Academy

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00:10:31,459 --> 00:10:37,810  
that when we got to an outer planet atmosphere,  
we would see an unchanged sample from the

80  
00:10:37,810 --> 00:10:47,189  
solar nebula collected by massive gravity  
and preserved for our use for 4 billion years.

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00:10:47,189 --> 00:10:54,569  
Hydrogen to helium ratio became the mantra  
of the people interested in the gas giants

82  
00:10:54,569 --> 00:11:01,010  
at that time. The holy Grail. If we measure  
the hydrogen helium ratio in these atmospheres

83  
00:11:01,010 --> 00:11:09,300  
we will be measuring the original hydrogen  
helium gas from which the sun was originally

84  
00:11:09,300 --> 00:11:15,009  
formed. It was believed at that point that  
would be a better indicator of the original

85  
00:11:15,009 --> 00:11:20,200  
hydrogen helium ratio than what we measure  
in today's Sun because of things going things

86  
00:11:20,200 --> 00:11:28,610  
going on with solar interior burning and (indiscernible)  
had been changing the hydrogen helium ratio

87  
00:11:28,610 --> 00:11:42,179  
in the Sun. the composition of that solar  
nebula played a role in setting knowledge

88  
00:11:42,179 --> 00:11:48,899  
of the giant planet satellites at that time.  
We did not know much about them. It is amazing

89  
00:11:48,899 --> 00:11:53,660  
to think about how little we knew at that  
time. We did not know radius is, how bright

90  
00:11:53,660 --> 00:12:03,149  
or reflective they were. Compositions, general  
view among most colleagues in astronomy and

91  
00:12:03,149 --> 00:12:14,100  
geology was that we would seek greater mud balls or iced balls. We did know a few things.

92  
00:12:14,100 --> 00:12:22,179  
I collected all the information we had some from my own data about the brightness or reflective

93  
00:12:22,179 --> 00:12:29,239  
qualities of the satellites and their density and all the big boxes and error bars are because

94  
00:12:29,239 --> 00:12:40,059  
we did not know what they're masses or radii were. You could run anywhere from a few boxes

95  
00:12:40,059 --> 00:12:50,230  
like (indiscernible) could run from a density of one up to three and we had some things

96  
00:12:50,230 --> 00:13:12,949  
that had fairly high density and lots of things in between. [Captioner's Transitioning]

97  
00:13:12,949 --> 00:13:20,879  
>> We got rocky satellite and icy satellites. That's what the early planning for Voyager

98  
00:13:20,879 --> 00:13:35,389  
was based on. The data and theory for the planet and satellites and the systems in general

99  
00:13:35,389 --> 00:13:42,790  
was exploding at this period of time. That same nebula model that was applied to understanding

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00:13:42,790 --> 00:13:50,389  
and with the atmosphere of the planets might be like was taken and used by John Lewis to

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00:13:50,389 --> 00:13:54,679

try to make theoretical predictions of what the compositions of the satellite should be

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00:13:54,679 --> 00:14:01,759

like. He noted if you take the solar nebula composition and take the gas down to the temperature

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00:14:01,759 --> 00:14:09,279

and pressure that is there, you were going to get satellites that are rather interesting,

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00:14:09,279 --> 00:14:16,589

about half and half rock and ice and if they are big enough, radioactive heating is enough

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00:14:16,589 --> 00:14:29,220

to melt that eyes. We said they could be interesting evolving planets in their own right.

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00:14:29,220 --> 00:14:43,660

>> Several other things were created at the same time. There was -- we already measured

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00:14:43,660 --> 00:14:53,130

the radius a year or so earlier. That determined the radius accurately. Pioneer Irving recon

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00:14:53,130 --> 00:15:01,490

of the system at Jupiter allowed the mass to be measured fairly accurately. That was

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00:15:01,490 --> 00:15:09,989

the only one that got fairly close to and that density matched the model almost exactly.

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00:15:09,989 --> 00:15:18,279

It accounted for pressure affect that gave you a rock to ice ratio of about 50/50. In

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00:15:18,279 --> 00:15:34,540

addition, there was sodium emission lines.

The reflection spectra of Ganymede and Callisto

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00:15:34,540 --> 00:15:45,639

were gathered and showed there was water on the surface so we had an inkling of the models

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00:15:45,639 --> 00:15:49,999

Lewis was put together that were cut and this was about the time the instruments were being

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00:15:49,999 --> 00:16:02,779

chosen for Voyagers. That is with the Lewis model looked like and the basic point is at

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00:16:02,779 --> 00:16:09,570

the distance of Jupiter, this is low-pressure and low temperature and the planetary symbols

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00:16:09,570 --> 00:16:16,019

show this in the solar system, that is the water line around Jupiter. You start condensing

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00:16:16,019 --> 00:16:28,889

water and keeping it as ice. This was illustrating the -- of the Ganymede. That was me on the

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00:16:28,889 --> 00:16:44,559

left with Bob Carlson. We were measuring one quarter of that occultation. We got the radius

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00:16:44,559 --> 00:16:57,399

measured very accurately. That is the spectra -- who worked at NASA for many years and worked

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00:16:57,399 --> 00:17:08,440

with the Institute out in Ames. They showed the objects were covered with water and ice.

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00:17:08,440 --> 00:17:18,649

>> Not long after that, we have the flybys of Jupiter by pioneers 10 and 11 a year or

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00:17:18,649 --> 00:17:28,600

two before this. This was a briefing I gave to the committee in 1975 pushing for a new

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00:17:28,600 --> 00:17:36,840

Jupiter mission even though we had launched Voyager yet. It was based on the theoretical

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00:17:36,840 --> 00:17:46,389

understanding that object might be interesting world in their own right. We knew we were

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00:17:46,389 --> 00:17:53,940

going to get Voyager data it needed to go back and get a detailed study of these objects

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00:17:53,940 --> 00:18:01,460

and we could do that from the Jupiter orbiter.  
>> This is the state of knowledge of satellites

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00:18:01,460 --> 00:18:09,220

after the pioneers 10 and 11 flybys and this is showing density and radius rather than

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00:18:09,220 --> 00:18:20,299

albedo. I see things fall on the line of the radius at the bottom of this chart and Rocky

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00:18:20,299 --> 00:18:28,190

things at the top. It is interesting to note this is pretty much the knowledge we have

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00:18:28,190 --> 00:18:40,519

for the best study of planet.  
>> When we were briefing the public and reporters

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00:18:40,519 --> 00:18:48,080

at the Cape just before the Voyager II launch,  
this is a model of what the satellites would

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00:18:48,080 --> 00:18:59,880

be like. In many ways it was quite sophisticated.  
Callisto contained water and we suspected

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00:18:59,880 --> 00:19:06,809

they had enough heat to produce oceans so  
oceans were already coming into the picture

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00:19:06,809 --> 00:19:12,990

at this time. We didn't know much about E  
uropa. The reason there are no oceans on Europa

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00:19:12,990 --> 00:19:22,200

is we didn't know the density well enough.  
The ice has to be on a certain date this for

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00:19:22,200 --> 00:19:32,159

to melt to produce an ocean under it. That  
was a? At the time.

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00:19:32,159 --> 00:19:38,970

>> We modified the Voyager plans a bit based  
on this understanding and theoretical discussion.

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00:19:38,970 --> 00:19:44,130

We couldn't reselect the instruments at this  
point but we did at a couple more satellite

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00:19:44,130 --> 00:19:50,669

scientist and we increased the flybys due  
to some fine trajectory work by Jeff ricks

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00:19:50,669 --> 00:19:56,690

the work at NASA headquarters for a long time  
who found out because of the resident orbits,

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00:19:56,690 --> 00:20:05,380

he had several satellite flybys with each Voyager passed. Voyager planning in science

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00:20:05,380 --> 00:20:14,019

was modified to do that. You know the results of that. This is the nine scientifically correct.

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00:20:14,019 --> 00:20:23,250

montage -- this is a nonscientific montage. The areas look geologically active. Europa

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00:20:23,250 --> 00:20:33,799

was

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00:20:33,799 --> 00:20:43,220

very puzzling. Very few craters indicating some form of resurfacing. The ocean models,

146

00:20:43,220 --> 00:20:53,340

having been ice across mud models with a two types of models that came out of Voyager at

147

00:20:53,340 --> 00:21:05,080

that point.

>> Active volcanoes shooting up 100 kilometers

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00:21:05,080 --> 00:21:19,360

or more in shooting sulfur dioxide and gas out 100 kilometers or more.

149

00:21:19,360 --> 00:21:28,740

>> At that point we were planning the Galileo mission. In 1979, the Galileo mission had

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00:21:28,740 --> 00:21:36,740

gotten its start in 1978. We took the Voyager data in s aid, what can we do based on the

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00:21:36,740 --> 00:21:49,519

Voyager data to change our Galileo plans?  
In 1976, over a year before Voyager launched,

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00:21:49,519 --> 00:22:01,360

our science assessment group made recommendations  
to headquarters and that is contained in the

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00:22:01,360 --> 00:22:10,429

materials and follow the direction and priorities  
and complex reports of that era. Key elements

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00:22:10,429 --> 00:22:18,590

was hydrogen and helium was okay. We needed  
to get that information, although they were

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00:22:18,590 --> 00:22:24,059

beginning to model things about the helium  
might condense out and fall toward the poor

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00:22:24,059 --> 00:22:33,090

and may not be as simple as we thought. In  
addition to that, there was an increased emphasis

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00:22:33,090 --> 00:22:46,919

on satellites. They went up to the top of  
the priority. This was in 1976 that went into

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00:22:46,919 --> 00:22:59,220

the Ao for the Galileo mission. Preparing  
for that and try to respond to Voyager as

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00:22:59,220 --> 00:23:08,309

I said, Voyager one and two flybys produced  
a number of surprises. The active volcanism

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00:23:08,309 --> 00:23:21,450

wasn't really a surprise. There was the paper  
that year that said -- should start to -- was

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00:23:21,450 --> 00:23:28,169  
much more subtle. Everybody should have known  
that tidal heating was happening.

162  
00:23:28,169 --> 00:23:44,370  
>> The -- if the average eccentricity

163  
00:23:44,370 --> 00:23:49,940  
was zero but with all this interaction between  
the gravity and the satellites, the eccentricity

164  
00:23:49,940 --> 00:24:02,809  
was not zero. Tidal heating can strongly.  
We modified the mission plan to increase the

165  
00:24:02,809 --> 00:24:09,879  
number of satellite encounters from Galileo  
from three to 12. NASA only one victory because

166  
00:24:09,879 --> 00:24:17,659  
we wanted to keep the cost down and we also  
stuck Europa into the equation. Several things

167  
00:24:17,659 --> 00:24:24,659  
were happening simultaneously. We were planning  
Galileo and Voyager was flying by Saturn.

168  
00:24:24,659 --> 00:24:36,559  
For the purposes of this story, the major  
important thing is what it didn't see. It

169  
00:24:36,559 --> 00:24:41,360  
didn't see the surface of Titan but it did  
establish it had a huge thick hydrocarbon

170  
00:24:41,360 --> 00:24:56,840  
rich atmosphere and it didn't see a lot  
of craters. It looks like it has been resurfaced.

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00:24:56,840 --> 00:25:13,899

That type of thinking went into Cassini. Originally it was planned as a super Galileo with probes

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00:25:13,899 --> 00:25:22,460

of Saturn and Titan. It was too expensive and de-scoped and at that point Titan got

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00:25:22,460 --> 00:25:40,350

the nomination. They were very interesting in Titan. Enceladus then went to the top of

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00:25:40,350 --> 00:25:48,620

the list. It was no surprise we saw stuff going on. The reason we saw stuff going on

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00:25:48,620 --> 00:25:55,851

was because it was on the top of the target list for very good reasons. That is where

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00:25:55,851 --> 00:26:08,669

we were the testament study for Cassini. Galileo launched in the Jupiter arrival. Discoveries

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00:26:08,669 --> 00:26:17,629

would take two or three more days of the seminar. The program was a big surprise. The atmosphere

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00:26:17,629 --> 00:26:24,379

was not -- and I won't go into the details but basically it is enriched Inc. density

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00:26:24,379 --> 00:26:30,510

elements and in the dopa passes indicating the makeup of the atmosphere is more complicated

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00:26:30,510 --> 00:26:40,049

than just capturing a piece of the solar nebula. The delivery of the gases was particularly

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00:26:40,049 --> 00:26:48,580

problematic because it implies the gases must have been delivered by way of the -- and colder

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00:26:48,580 --> 00:26:59,690

than one would expect. There is complexity going on there. Those results are factored

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00:26:59,690 --> 00:27:13,580

into the types of objectives we now have and also led to the survey recommending we do

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00:27:13,580 --> 00:27:22,269

a Saturn probe to complement this information. >> This is going to be a fast slideshow because

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00:27:22,269 --> 00:27:34,470

my moderator is giving me the two-minute mark. The magnetic field and things we found.

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00:27:34,470 --> 00:27:40,299

High temperature volcanism and stuff going on all the time. The magnetic generation -- the

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00:27:40,299 --> 00:27:49,009

magma generation is a thousand times out of the earth. Europa which you will hear more

188

00:27:49,009 --> 00:27:59,620

from from a subsequent speaker, we found ice flow surfaces and things moved around on the

189

00:27:59,620 --> 00:28:12,980

surface looking very much like [Indiscernible]. I used to have one here -- magnetic signatures

190

00:28:12,980 --> 00:28:19,830

of oceans, if I told them earlier we were going to take a magnetometer to Jupiter and

191

00:28:19,830 --> 00:28:24,139

discover oceans, they would have probably  
thrown me out of the room so it's fortunate

192

00:28:24,139 --> 00:28:29,339

we took the magnetometer anyway for other  
reasons. Basically,.

193

00:28:29,339 --> 00:28:42,840

>> Addict field is selected around these satellites  
as if they were acting like global

194

00:28:42,840 --> 00:28:54,220

electrically conduct the spheres.

>> We now have a more sophisticated view of

195

00:28:54,220 --> 00:28:59,970

warm water might be in the solar system and  
we would hear more about that. I'm going to

196

00:28:59,970 --> 00:29:11,590

end this coming to Cassini and you will hear  
more about from my colleague. We did put up

197

00:29:11,590 --> 00:29:25,580

open the Titan service and -- [Indiscernible].

It also looks like it has been fluid worn

198

00:29:25,580 --> 00:29:33,549

and in this case the fluid is probably hydrocarbons  
and we got a few of those from an airplane

199

00:29:33,549 --> 00:29:42,169

window point of view on the way down with  
the probe showing the valley networks and

200

00:29:42,169 --> 00:29:49,169

it landed in something like this but a little  
moist. This is a methane lake in the northern

201

00:29:49,169 --> 00:29:58,740

areas which was discovered by the radar. This is the radar reflectivity. We will see more

202

00:29:58,740 --> 00:30:18,470

of that also I suspect. We also have specular reflection. Enceladus wasn't surprising because

203

00:30:18,470 --> 00:30:23,320

we knew it was an interesting place but I must admit, these pictures of the fluid on

204

00:30:23,320 --> 00:30:37,220

Enceladus, heat flow from the southern polar region -- planetary heat flow -- the heat

205

00:30:37,220 --> 00:30:45,899

flow in those cracks producing the plumes may be 10 times what you see in geyser fields

206

00:30:45,899 --> 00:31:08,289

in Yellowstone. [Applause].

>> We have about five minutes for questions.

207

00:31:08,289 --> 00:31:26,499

>> Have a question of

208

00:31:26,499 --> 00:31:39,500

how

you went from two scientists on the Voyager

209

00:31:39,500 --> 00:31:53,330

team to several hundred scientists [Indiscernible]?

>> I was really speaking of scientists, we

210

00:31:53,330 --> 00:32:04,210

started out with having the science team for the imaging team that had about 10 or 12 scientists

211

00:32:04,210 --> 00:32:11,289

that they were mostly people interested in

the atmosphere on Jupiter because the satellites

212

00:32:11,289 --> 00:32:20,039

were not believed to be two interesting at that time. NASA then looked at the team and

213

00:32:20,039 --> 00:32:26,330

the objectives as the mission progressed and added more scientists to the team. Most of

214

00:32:26,330 --> 00:32:32,990

the scientists on the team had their own graduate students and then there were other teams that

215

00:32:32,990 --> 00:32:40,169

were dealing with the -- and so forth. Then you add in the international cooperation a

216

00:32:40,169 --> 00:32:55,039

spect. We had many French spectroscopy -- and was a massive collaboration so we have perhaps

217

00:32:55,039 --> 00:33:05,819

400 scientists actively engaged with about a 50/50 split with the rest -- US and Europe.

218

00:33:05,819 --> 00:33:12,890

>> [Indiscernible]

>> Usually they have an instrument manager.

219

00:33:12,890 --> 00:33:22,419

Each of these missions have approximately 11 instruments and I was speaking mostly about

220

00:33:22,419 --> 00:33:27,519

the imaging team and talking about the number of scientists we had but even there that was

221

00:33:27,519 --> 00:33:35,809

an expansion.

>> I'm amazed I haven't thought ask you this

222

00:33:35,809 --> 00:33:45,749

question before. Now were going to put you on the spot. You portray this rigorous approach

223

00:33:45,749 --> 00:33:51,570

to following the scientific method which really is a nice example of that paradigm. Of all

224

00:33:51,570 --> 00:33:59,950

the surprises you guys did find, what surprised you the most? What was the most amazing thing

225

00:33:59,950 --> 00:34:17,190

you did not expect to see?

>> I did not expect to see a terrain on Titan

226

00:34:17,190 --> 00:34:32,700

that looked so earthlike. It was eerie. Even at near liquid nitrogen temperatures produces

227

00:34:32,700 --> 00:34:42,330

the same physics and the same sorts of things. In Jupiter, I would say most of the things

228

00:34:42,330 --> 00:34:55,800

we found were things we were not looking for. The report said were going to be looking --

229

00:34:55,800 --> 00:35:01,850

getting the induction signatures of the ocean site was the biggest major factor. That wasn't

230

00:35:01,850 --> 00:35:10,480

something we could count on and it was a surprise -- a strong signature.

231

00:35:10,480 --> 00:35:25,450

>> We talked a little bit earlier that the

state of knowledge for planets in our own solar

232

00:35:25,450 --> 00:35:32,310

system back in the 70s is sort of the state of knowledge we have now. We will touch on

233

00:35:32,310 --> 00:35:44,290

this later this afternoon. [Background Noise-Coughing].

>> Where do you see the line between the planetary

234

00:35:44,290 --> 00:35:58,670

program and the astrophysical XO planet program and what you see is ways to make sure we are

235

00:35:58,670 --> 00:36:04,150

not a stove pipe between those two programs with a common set of goals. [Background Noise-Coughing].

236

00:36:04,150 --> 00:36:14,300

>> It is very obvious from our perspective, you are not just counting these things, actually

237

00:36:14,300 --> 00:36:22,310

putting them on a mass radius diagram. The community is beating a path in that direction

238

00:36:22,310 --> 00:36:28,420

as we speak. How NASA is going to be able to respond within this system to that with

239

00:36:28,420 --> 00:36:47,190

their different disciplines.

>> I was going to ask the question that was

240

00:36:47,190 --> 00:37:45,250

just asked, but [Indiscernible].

>> This is what we are doing now and that

241

00:37:45,250 --> 00:37:52,560

is the new horizon on the way out. This is

the timeline, the green bars are the time

242

00:37:52,560 --> 00:37:59,750

it took to plan the mission. The red bars are how long it took to fly it and the symbols

243

00:37:59,750 --> 00:38:05,680

inside the red bars are planetary encounters. We've had continuous data coming back for

244

00:38:05,680 --> 00:38:18,770

40 years. We had Juneau on the way out. We notice everything -- and then there is nothing.

245

00:38:18,770 --> 00:38:31,220

There will be an inevitable gap of a decade or more before we get a satellite back. 2015

246

00:38:31,220 --> 00:38:39,270

is going to be great. [Background Noise-Coughing]. There's not much in the pipeline and even

247

00:38:39,270 --> 00:38:45,950

if we reverse that tomorrow, there would be an inevitable gap. We are back to one of these

248

00:38:45,950 --> 00:38:58,369

things that occurred in the 80s.  
>> [Applause]

249

00:38:58,369 --> 00:39:05,790

>> The next talk will be given by -- on Europe's rendezvous with Titan, the contribution to

250

00:39:05,790 --> 00:39:14,770

the Cassini mission. By way of introduction, let me mention Arturo is a former professor

251

00:39:14,770 --> 00:39:20,970

of history of physics at the University of

-- Italy and his research is in the history

252

00:39:20,970 --> 00:39:34,070

of 20th century the sixth. He has published  
on quantum physics

253

00:39:34,070 --> 00:39:45,620

in Italy and the US. [Indiscernible]. As Torrance  
was mentioning, Cassini was an international

254

00:39:45,620 --> 00:39:56,660

mission. If I

255

00:39:56,660 --> 00:40:05,630

remember correctly, -- but I believe the seeds  
of what turned into Cassini were originally

256

00:40:05,630 --> 00:40:19,880

planted in Europe. If it hadn't been for the  
fact it was an international mission, we probably

257

00:40:19,880 --> 00:40:33,980

wouldn't have known it. Let's welcome our  
next speaker.

258

00:40:33,980 --> 00:40:40,950

>> Thank you. I am very happy to be here but  
let me apologize for my English. If you don't

259

00:40:40,950 --> 00:40:53,600

like it, I can change to my good Italian.

>> The Cassini mission to Saturn and the satellite

260

00:40:53,600 --> 00:41:02,931

system is the most ambitious in planet exploration.  
It was launched in October 1997 and the mission

261

00:41:02,931 --> 00:41:09,910

was realized is a joint endeavor of NASA,  
the European space agency and the Italian

262

00:41:09,910 --> 00:41:30,870

space agency. It consists of performing multiple orbit tours around Saturn. [Indiscernible].

263

00:41:30,870 --> 00:41:37,830

NASA provided the orbiter and ESA provided the probe and ISA provided other hardware

264

00:41:37,830 --> 00:41:49,650

systems for the orbiter. The scientific instruments were realized by scientific teams in the US.

265

00:41:49,650 --> 00:42:00,370

As you know, -- their scientific missions.

The -- completed its mission on the very day

266

00:42:00,370 --> 00:42:22,170

[Unclear/Accent]. Four years after the -- around Saturn. NASA approved two extensions to the

267

00:42:22,170 --> 00:42:30,500

mission that is now due to go through September 2017. I will briefly discuss three aspects

268

00:42:30,500 --> 00:42:39,350

of the Cassini [Indiscernible]. The first is the framework which set the stage for the

269

00:42:39,350 --> 00:42:45,290

establishment of an important European effort in planetary exploration. In more than two

270

00:42:45,290 --> 00:42:52,170

decades the Europeans base science community separate technical and financial reasons,

271

00:42:52,170 --> 00:43:02,020

Europe could not compete with -- in this field. It was only the mid- 1980s and ambitious European

272

00:43:02,020 --> 00:43:10,720

planetary mission was considered following  
the successful [Indiscernible]. -- was the

273

00:43:10,720 --> 00:43:17,850

first European mission devoted to planetary  
exploration. The second was the decision-making

274

00:43:17,850 --> 00:43:28,740

process which led to the selection of the  
-- mission. -- this the outcome of a highly

275

00:43:28,740 --> 00:43:40,670

competitive process involving the various  
national sectors of the space science community,

276

00:43:40,670 --> 00:43:50,619

[Unclear/Accent] and other potential international  
partners, and so one.

277

00:43:50,619 --> 00:44:06,690

>> Finally, the -- relationship [Unclear/Accent].  
It was not so easy to cope with the different

278

00:44:06,690 --> 00:44:13,280

political and institutional frameworks in  
which the agencies were operating. The difference

279

00:44:13,280 --> 00:44:19,650

in the budget procedures is particularly important  
in this context. Decision-making can be very

280

00:44:19,650 --> 00:44:30,390

long for ESA but once a project it is selected  
-- [Unclear/Accent]. The project becomes legally

281

00:44:30,390 --> 00:45:01,750

binding and there is no threat of cancellation.  
[Unclear/Accent].

282

00:45:01,750 --> 00:45:12,830

>> The  
programmatic framework for the selection of

283

00:45:12,830 --> 00:45:23,190

the mission is the horizon 2000 long-term  
plan for space science approved in 1985. The

284

00:45:23,190 --> 00:45:31,560

basic philosophy of horizon 2000 was the establishment  
of two classes of projects. The first included

285

00:45:31,560 --> 00:45:42,110

four cornerstones that were challenging missions  
to be realized over a 20-year period of time.

286

00:45:42,110 --> 00:45:46,880

The second-class included a number of standard  
missions to be selected into a competitive

287

00:45:46,880 --> 00:45:53,660

selection procedure. Within the framework  
of horizon 2000, planetary science received

288

00:45:53,660 --> 00:46:00,540

a proper role in the European space effort.  
One of the cornerstones was an ambitious project

289

00:46:00,540 --> 00:46:13,450

[Indiscernible]. This became the Rosetta mission  
launched in 2004. Planetary mission could

290

00:46:13,450 --> 00:46:23,530

be submitted for -- in the standard mission  
program and the ESA director at that time

291

00:46:23,530 --> 00:46:36,580

wanted to foster planetary missions in the  
selection process for the new standard mission.

292

00:46:36,580 --> 00:46:47,560

[Unclear/Accent].

>> One of the most important discoveries of

293

00:46:47,560 --> 00:46:55,140

Voyager one was an intriguing composition of the atmosphere of Saturn's largest moon.

294

00:46:55,140 --> 00:47:02,130

Not only was it confirmed that molecular nitrogen was the main constituent of the atmosphere of

295

00:47:02,130 --> 00:47:13,170

Titan with methane but Voyager showed mainly organic molecules so were also present. The

296

00:47:13,170 --> 00:47:20,180

surface of Titan was obscured from the Voyager camera by a thick orange-brown smoke mixture

297

00:47:20,180 --> 00:47:39,450

of various hydrocarbon and nitrogen compounds. The designs of the Voyager -- [Unclear/Accent].

298

00:47:39,450 --> 00:47:50,910

Before -- started to -- and produce oxygen. The fundamental difference between -- is the

299

00:47:50,910 --> 00:47:58,700

low temperature which made it impossible for the presence of liquid water and the emergence

300

00:47:58,700 --> 00:48:12,360

of life. On the contrary, the -- did have a chance to evolve. Subsequent erosion and

301

00:48:12,360 --> 00:48:29,260

the evolution of life itself have obliterated all records of those original conditions [Background

302

00:48:29,260 --> 00:48:43,110

Noise-Coughing].

>> It has been told in July 1982, a group

303

00:48:43,110 --> 00:48:51,330

of 29 European scientists submitted to ESA

for certain type of mission to be realized

304

00:48:51,330 --> 00:49:01,250

[Indiscernible]. The project Cassini called

for an orbiter carrying approved to be parachuted

305

00:49:01,250 --> 00:49:09,270

into the atmosphere of Titan. The interest

was in the atmosphere of Titan. The project

306

00:49:09,270 --> 00:49:21,280

was to be -- collaboration with Europe providing

the orbiter and NASA the Titan probe. Several

307

00:49:21,280 --> 00:49:41,160

-- were represented in the group -- say make.

-- was to study the hole of the system including

308

00:49:41,160 --> 00:49:52,850

specific objectives for each of its elements.

its elements. [Unclear/Accent]. The concept

309

00:49:52,850 --> 00:50:02,280

was an important element in fostering large

support behind the Cassini project and promoting

310

00:50:02,280 --> 00:50:13,060

the mission through the ESA competitive Rosses.

>> The European initiative -- a project for

311

00:50:13,060 --> 00:50:17,930

the Saturn orbiter and Titan population was

among those -- in 1983 but the solar system

312

00:50:17,930 --> 00:50:24,750

exploration committee. This initiative -- by the space science committee of the European

313

00:50:24,750 --> 00:50:28,060

science foundation. [Indiscernible]. The joint working group eventually combined that three

314

00:50:28,060 --> 00:50:33,450

missions should be carried out in cooperative projects. This did in to launch sequences,

315

00:50:33,450 --> 00:50:37,020

this was -- [Unclear/Accent]

>> You have already seen that. The Cassini

316

00:50:37,020 --> 00:50:42,800

project was conducted in Europe by a team of 15 scientists, nine from the US and four

317

00:50:42,800 --> 00:50:46,880

from your. The Titan probe was identified -- one NASA was provided [Indiscernible].

318

00:50:46,880 --> 00:50:48,570

A dramatic definition of [Unclear/Accent].

On this basis ESA decided to support -- to

319

00:50:48,570 --> 00:50:56,340

be built in Europe. [Indiscernible]. The study was published in September 1988. One

320

00:50:56,340 --> 00:51:01,270

month later, the ESA decision-making bodies were called to select the first mission a

321

00:51:01,270 --> 00:51:04,770

[Indiscernible]. [Background Noise-Coughing].

>> The science community at large -- to discuss

322

00:51:04,770 --> 00:51:11,070

mission proposals submitted for the selection of the next scientific mission. The European

323

00:51:11,070 --> 00:51:16,090

-- was one of them. [Unclear/Accent]. As usual in the selection procedure, after the discussion

324

00:51:16,090 --> 00:51:25,020

within the scientific community, the scientific bodies -- about which of the missions should

325

00:51:25,020 --> 00:51:29,520

be selected -- [Indiscernible]. This was a two-step procedure. First the astronomy working

326

00:51:29,520 --> 00:51:33,150

group and the solar system working group would issue a recommendation in their respective

327

00:51:33,150 --> 00:51:36,070

fields of interest. Second, the advisory committee would make the final recommendation to the

328

00:51:36,070 --> 00:51:40,440

director of science. For the solar system working group, the choice was between Cassini

329

00:51:40,440 --> 00:51:43,540

and Vesta. Both missions were dedicated to planetary exploration and considered highly

330

00:51:43,540 --> 00:51:46,930

interesting. The decision was a matter of politics as -- a close-up study of a number

331

00:51:46,930 --> 00:51:50,000

of asteroids and comets was interesting and exciting. The Vesta -- [Unclear/Accent].

332

00:51:50,000 --> 00:51:59,470

Cassini with the dirt to the frontiers the solar system exploration and the European

333

00:51:59,470 --> 00:52:02,891

industry would acquire unique know-how in the domain of atmospheric probes. The two

334

00:52:02,891 --> 00:52:03,891

missions were very different. [Unclear/Accent]. Cassini was considered at the beginning as

335

00:52:03,891 --> 00:52:05,330

a collaborative project -- [Unclear/Accent]. [Background Noise-Coughing]. The American

336

00:52:05,330 --> 00:52:11,700

colleagues were awaiting the decision by ESA because they wanted to use the selection in

337

00:52:11,700 --> 00:52:14,730

support. Vesta would provide the community with the opportunity to establish a venture

338

00:52:14,730 --> 00:52:17,380

with the Soviet Union. [Unclear/Accent]. The discussion was very lively and passionate.

339

00:52:17,380 --> 00:52:18,890

Finally a vote was called by which the sober system working group recommended Cassini.

340

00:52:18,890 --> 00:52:23,330

It was set to -- to make the final choice. [Unclear/Accent]. On the one hand the support

341

00:52:23,330 --> 00:52:28,800

of the mission kind the well-established European tradition of scientific -- stresses the importance

342  
00:52:28,800 --> 00:52:31,030  
of opening in new territory to European -- [Indiscernible].  
[Unclear/Accent].

343  
00:52:31,030 --> 00:52:34,869  
>> ESA endorsed the accommodation and decided  
the probe should have its own name. [Indiscernible].

344  
00:52:34,869 --> 00:52:41,350  
>> It took 1 year but eventually Congress  
approved in October 1989 the program which

345  
00:52:41,350 --> 00:52:45,690  
included Cassini and the [Indiscernible].  
>> Follow peer review, this space agencies

346  
00:52:45,690 --> 00:52:50,290  
approved [Indiscernible]. Finally, a memorandum  
of understanding was signed so the mission

347  
00:52:50,290 --> 00:52:56,980  
was well on its way toward the scheduled launch  
of November 1995. [Unclear/Accent]. In October

348  
00:52:56,980 --> 00:53:02,610  
1991, U.S. Congress -- [Unclear/Accent]. As  
a consequence, NASA decided to delay the mission

349  
00:53:02,610 --> 00:53:05,520  
until October 1997. [Audio Cutting In/Out].  
[Background Noise-Coughing].

350  
00:53:05,520 --> 00:53:11,330  
>> Here is an excerpt of the comments. [Unclear/Accent].  
Congress approved the -- program within a

351  
00:53:11,330 --> 00:53:16,620  
budget limit of \$1.6 billion and the cost  
of Cassini was estimated at about \$1.7 billion.

352

00:53:16,620 --> 00:53:25,510

One mission had to be canceled and NASA decided to cancel the -- mission [Indiscernible].

353

00:53:25,510 --> 00:53:27,060

In this equation, [Background Noise]. The prospects were not encouraging because the

354

00:53:27,060 --> 00:53:30,580

admission did not [Indiscernible]. [Unclear/Accent]. Reactions were very strong in Europe. There

355

00:53:30,580 --> 00:53:37,560

was an initiative taken by the ESA director who wrote to the US vice president -- and

356

00:53:37,560 --> 00:53:42,710

you can read the quotation here. [Unclear/Accent]. [Background Noise-Coughing]. [Unclear/Accent].

357

00:53:42,710 --> 00:53:46,540

The review was accepted. [Background Noise-Coughing]. The mission was launched on October 15, 1997.

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00:53:46,540 --> 00:53:51,860

[Unclear/Accent]. Six months later, -- was released and started its -- toward Titan.

359

00:53:51,860 --> 00:53:57,680

[Unclear/Accent]. For the first time since the beginning of the space age, a -- would

360

00:53:57,680 --> 00:54:01,180

be landed [Indiscernible]. The news arrived that the -- from the probe had been picked

361

00:54:01,180 --> 00:54:02,180

up. [Unclear/Accent].  
>> [Applause].

362

00:54:02,180 --> 00:54:08,620

>> Let's take time for a couple of questions.

>> Thanks very much, Arturo. It's too bad

363

00:54:08,620 --> 00:54:15,370

we couldn't get another top just like yours  
from the US side because I a sure you the

364

00:54:15,370 --> 00:54:25,710

drama associated with getting a new start  
for Cassini and also preventing its cancellation

365

00:54:25,710 --> 00:54:36,600

is also filled with a great deal of drama  
on the US side a particularly inside the halls

366

00:54:36,600 --> 00:54:47,010

of NASA itself. That is just a comment. I  
was a preproject study scientist for Cassini

367

00:54:47,010 --> 00:54:52,710

and the associate administrator at NASA who  
had to deal with potential cancellation of

368

00:54:52,710 --> 00:54:59,780

Cassini. Every morning I went into my office  
and I printed my resignation letter and dated

369

00:54:59,780 --> 00:55:07,140

it and stuck it in my pocket and went upstairs  
to talk to Mr. Goldman. There were a couple

370

00:55:07,140 --> 00:55:12,600

necessary steps to go through to convince  
Mr. Goldman not to cancel Cassini and so Congress

371

00:55:12,600 --> 00:55:18,960

came to our rescue and the administration  
came to our rescue and the scientists and

372

00:55:18,960 --> 00:55:21,580

Europe came to our rescue. [Applause].

>> [Indiscernible]

373

00:55:21,580 --> 00:55:30,000

>> I am struck by the parallels of the international cooperation aspect [Background Noise-Coughing]

374

00:55:30,000 --> 00:55:37,290

in the 1980s and the political battles in the European protest. When ESA was planning

375

00:55:37,290 --> 00:55:45,810

and deciding on Cassini in the 80s, were there concerns from the scientific committee

376

00:55:45,810 --> 00:55:51,850

and ESA planners foreshadowing that something like -- will happen again and did they make

377

00:55:51,850 --> 00:55:55,920

that explicit?

>> Maybe you have read the quotation of the

378

00:55:55,920 --> 00:55:59,490

[Unclear/Accent]. In this case, there was a different situation because first of all

379

00:55:59,490 --> 00:56:02,790

there was a -- behind Cassini United States, probably much stronger than [Indiscernible].

380

00:56:02,790 --> 00:56:05,320

There was a new balance of powers.

>> Thank you.

381

00:56:05,320 --> 00:56:07,870

>> I have a question about the previous relationships -- from the European side. You mentioned it

382

00:56:07,870 --> 00:56:16,130

was going up against a mission involving the French and the Russians but had a long history

383

00:56:16,130 --> 00:56:22,940

of cooperation through the 1970s. I'm wondering to what extent -- you mentioned the moment

384

00:56:22,940 --> 00:56:28,460

when they were making the decision to have Cassini or one of four of the missions and

385

00:56:28,460 --> 00:56:34,520

one of them you said was a Russian and French collaboration. The Russians and the French

386

00:56:34,520 --> 00:56:42,740

had already been collaborating through many years. That was an existing cooperative arrangement

387

00:56:42,740 --> 00:56:52,340

but I'm wondering if there was institutional precedents for the relationship between Europe

388

00:56:52,340 --> 00:57:02,940

and America or if this was a new collaboration that had been formed through individual relationships

389

00:57:02,940 --> 00:57:10,320

on Voyager? If this was Europe attempting to make some bridges with the United States

390

00:57:10,320 --> 00:57:15,270

in a way they had before and what would lead them to make the political decision to work

391

00:57:15,270 --> 00:57:21,240

with the United States as opposed to supporting and other Russian and French collaboration?

392

00:57:21,240 --> 00:57:24,710

I want to know a little bit more about that moment?

393

00:57:24,710 --> 00:57:30,120

>> It's a long story but anyway, the French have a long tradition of collaboration with

394

00:57:30,120 --> 00:57:34,560

the Soviet Union and ESA had a long tradition of cooperation with NASA. As far as I knew

395

00:57:34,560 --> 00:57:39,830

there was no collaboration between Europe and the Soviet Union but there were personal

396

00:57:39,830 --> 00:57:45,690

contacts and individual cooperation. In the case of Vesta, the mission was conceived in

397

00:57:45,690 --> 00:57:50,630

early development. ESA joint at a later stage and there was not that much interest in getting

398

00:57:50,630 --> 00:57:53,070

involved in this mission. -- something like a junior partner.

399

00:57:53,070 --> 00:57:54,430

>> Thank you.

>> Thanks again, Arturo.

400

00:57:54,430 --> 00:57:58,680

>> Our final talk this morning will be by Robert Pappalardo on reviewing Europa is ocean.

401

00:57:58,680 --> 00:58:05,950

Bob is a senior research scientist at the planetary science section a division at the

402

00:58:05,950 --> 00:58:10,920

Jet Propulsion Laboratory in Pasadena, California.

He is research focuses on processes that shake

403

00:58:10,920 --> 00:58:16,720

the house he -- especially Europa. He is the

Europa study scientist -- [Background Noise-Coughing].

404

00:58:16,720 --> 00:58:24,770

>> Good morning. As other speakers at mentioned,

the evidence for a subsurface ocean at Europa

405

00:58:24,770 --> 00:58:33,880

is potentially profound. Europa has a surface

like no other in the solar system and its

406

00:58:33,880 --> 00:58:43,460

subsurface arguably offers the greatest likelihood

for life beyond the earth in our solar system.

407

00:58:43,460 --> 00:58:52,130

Let's take you back 400 years when Galileo

is observations helped change our sense of

408

00:58:52,130 --> 00:59:01,970

place in the cosmos. There was another center

of motion out there which argued for [Background

409

00:59:01,970 --> 00:59:09,450

Noise-Coughing]. -- we can reconstruct which

ones he saw on that first night and Io and

410

00:59:09,450 --> 00:59:16,230

Europa were grouped together into apparently

one little star.

411

00:59:16,230 --> 00:59:21,060

>> The first spacecraft image of Europa was

brought to us by the imaging photo -- the

412

00:59:21,060 --> 00:59:28,870

only image of Europa. As Torrance reviewed,  
we knew a little bit about Europa and the

413

00:59:28,870 --> 00:59:34,740

other satellites from telescopic observations.  
We knew surface composition included water

414

00:59:34,740 --> 00:59:41,480

and ice based on spectra. We had some idea  
that the density of that information was improved

415

00:59:41,480 --> 00:59:45,450

showing Europa had a density of about [Background  
Noise-Coughing] but a little different than

416

00:59:45,450 --> 00:59:53,730

Io. You can take the new -- and right along  
with the Pioneer spacecraft and at the right

417

00:59:53,730 --> 01:00:00,600

time on the right date look toward Europa  
and zoom in and see the view we had at 200

418

01:00:00,600 --> 01:00:07,350

kilometers per pixel at the time of the surface.  
It seems analogous to Galileo who famously

419

01:00:07,350 --> 01:00:12,330

recorded Neptune without knowing in in J anuary  
1613. [Background Noise-Coughing].

420

01:00:12,330 --> 01:00:19,020

>> Through the 70s, there was the thought  
there might be oceans in some of the large

421

01:00:19,020 --> 01:00:25,130

satellites of the solar system. It was proposed  
from models of composition and radioactive

422

01:00:25,130 --> 01:00:33,280

decay there might be oceans within these satellites  
and in the late 70s and early 80s, tidal heating

423

01:00:33,280 --> 01:00:41,350

was discussed potentially to maintain oceans  
although -- wrote that connection might kick

424

01:00:41,350 --> 01:00:56,710

in and freeze and ocean. If an ice shell is  
thick enough, the ice might connect in the

425

01:00:56,710 --> 01:01:01,890

solid-state and back they thought would freeze  
the notion. The ocean team went through this

426

01:01:01,890 --> 01:01:08,170

period. They said there might be enough tidal  
heat if we push the parameters a bit [Indiscernible].

427

01:01:08,170 --> 01:01:13,870

That was followed up by -- who used the more  
sophisticated model in 1989 they said there

428

01:01:13,870 --> 01:01:18,530

could be sufficient heat to maintain and ocean.  
-- maintain and ocean.

429

01:01:18,530 --> 01:01:24,280

>> That set the stage for Voyager which saw  
-- which suggested a very young surface or

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01:01:24,280 --> 01:01:32,710

perhaps the larger craters were relaxing away  
as Mike pointed out in the early 80s along

431

01:01:32,710 --> 01:01:40,850

the right-hand edge, [Indiscernible] is the  
surface very old? The bright mediated playing

432

01:01:40,850 --> 01:01:46,420

suggested mobility. It was -- in 1980 that looked at the for your images in said there

433

01:01:46,420 --> 01:01:53,570

are dark bands that could fit together with pieces moving back into place like puzzle

434

01:01:53,570 --> 01:01:59,270

pieces but it was nearly a decade before the controversial idea of -- mobility that was

435

01:01:59,270 --> 01:02:01,470

published.

>> Voyager I had poor resolution and Voyager

436

01:02:01,470 --> 01:02:08,220

It had better vision than that but it would remain for Galileo to greatly increase our

437

01:02:08,220 --> 01:02:12,110

knowledge of Europa through imaging.

>> There were [Indiscernible] by Galileo and

438

01:02:12,110 --> 01:02:15,910

three were Europa flybys. Then there was the Galileo-Europa mission because Europa was

439

01:02:15,910 --> 01:02:18,980

an exciting an extended mission. [Indiscernible].

Two ended in radiation induced upset of the

440

01:02:18,980 --> 01:02:21,690

spacecraft. [Indiscernible] we were able to learn amazing things about Europa.

441

01:02:21,690 --> 01:02:28,080

>> I had the pleasure to work with this group as an affiliate of Galileo [Background Noise-Coughing].

442

01:02:28,080 --> 01:02:34,680

-- organizing the crew a little bit. The first images were only slightly better. -- much

443

01:02:34,680 --> 01:02:40,380

higher-quality images into the surface is shown in color. [Indiscernible]. We looked

444

01:02:40,380 --> 01:02:48,910

at the science distributions and said they are all kind of the same size. The attorney

445

01:02:48,910 --> 01:02:55,000

meant to be a little is than 10 kilometers across which suggest that maybe they're not

446

01:02:55,000 --> 01:02:59,330

impact craters that maybe -- craters due to internal at unity. They seem to be [Background

447

01:02:59,330 --> 01:03:03,800

Noise-Coughing]. We found the surface was brightening with age and older features were

448

01:03:03,800 --> 01:03:08,880

brighter. Non- synchronous rotation had come up from Voyager days and based on this color

449

01:03:08,880 --> 01:03:13,850

composite, -- when we looked at the age there seemed to be a rotation through time as well

450

01:03:13,850 --> 01:03:19,200

consistent with the icy shell moving independent from the interior. There were a series of

451

01:03:19,200 --> 01:03:28,730

papers published [Background Noise-Coughing]. This picture was on the cover of the New York

452

01:03:28,730 --> 01:03:37,710

Times arguing for -- mobility.

>> This is

453

01:03:37,710 --> 01:03:42,040

the Europa surface as it looks stretched out into a global map. Very few impact craters.

454

01:03:42,040 --> 01:03:47,720

There are about a dozen or so one can recognize and from observation we know one should hit

455

01:03:47,720 --> 01:03:53,670

every three or 4 million years. Europa has been repaved since dinosaurs roamed the earth.

456

01:03:53,670 --> 01:04:01,020

We don't know whether that is -- or if it is a continuous process and is ongoing today

457

01:04:01,020 --> 01:04:08,930

but why would Europa die out? It is probably an ongoing process where Europa may go through

458

01:04:08,930 --> 01:04:13,750

cyclical at unity. Predictions of tidal heating -- eccentricity and decreasing it again on

459

01:04:13,750 --> 01:04:17,020

the time scale.

>> Here are what the ridged plains look like

460

01:04:17,020 --> 01:04:21,470

close up. The -- our double ridges crisscrossing the surface and it looks like generations

461

01:04:21,470 --> 01:04:25,660

of recessive ridges. Then there is the model terrain. Some show chaotic terrain that looks

462

01:04:25,660 --> 01:04:30,490

a little bit like hamburger where the ridged plains have crumbled in place.

463

01:04:30,490 --> 01:04:38,760

>> We were working to understand whether the surface geology told us about an ocean but

464

01:04:38,760 --> 01:04:43,800

it was the magnetometer team, if anyone discovered an ocean, it was them through measurement

465

01:04:43,800 --> 01:04:51,450

of an induced magnetic field at Europa found strong evidence Europa is acting as a conduct

466

01:04:51,450 --> 01:04:58,410

your, that Jupiters external field is reducing the magnetic field in Europa and that remains

467

01:04:58,410 --> 01:05:02,550

the strongest evidence for subsurface oceans in Europa today and of course the gravity

468

01:05:02,550 --> 01:05:06,610

data through measurement of inertia told us Europa is differentiated -- [Indiscernible].

469

01:05:06,610 --> 01:05:12,290

There is an illustration and an illustration of the induced magnetic field. Europa is bathed

470

01:05:12,290 --> 01:05:18,020

in high-energy plasma and charged particles with -- energies that are slamming into Europa

471

01:05:18,020 --> 01:05:22,540

at all times and while that is a nasty environment and would kill a person, it is potentially

472

01:05:22,540 --> 01:05:25,840

life nurturing. When high-energy parties slam into H<sub>2</sub>O, some of those things we combined

473

01:05:25,840 --> 01:05:34,460

with other contaminants on the surface and they make things like peroxide and formaldehyde

474

01:05:34,460 --> 01:05:39,760

and O<sub>2</sub>. [Indiscernible]. If all of Europa's -- then that ocean would be more oxygenated

475

01:05:39,760 --> 01:05:49,600

than the Earth's ocean. We need to understand the processes of whether that material from

476

01:05:49,600 --> 01:06:13,530

the surface gets into the ocean. Here is what the surface looks like a bit poster up. [Indiscernible].

477

01:06:13,530 --> 01:06:20,900

Some of them are quite bizarre.  
>> The story of the ridges is interesting

478

01:06:20,900 --> 01:06:26,100

because there are many rich models -- they are the most [Background Noise-Coughing].

479

01:06:26,100 --> 01:06:34,040

The ice shell being cut completely through -- a model that has been supported -- and

480

01:06:34,040 --> 01:06:39,810

it's almost incidental the ocean is below enabling large-scale tidal cleansing. -- the

481

01:06:39,810 --> 01:06:47,691

back-and-forth motion created is what is heating up playing in the subsurface and warming the

482

01:06:47,691 --> 01:06:52,780

ice and pushing the surface to form a bridge.  
It's interesting in the sense of the story

483

01:06:52,780 --> 01:06:59,470

of Galileo and Europa and exploration, it  
is modeled -- is it then that. [Indiscernible].

484

01:06:59,470 --> 01:07:09,450

>> I pointed out this model could work because  
the ice shell had to be less than 7 kilometers

485

01:07:09,450 --> 01:07:20,920

thick to cut all the way through. Models  
were suggesting it for ice shell and he suggested

486

01:07:20,920 --> 01:07:27,250

-- and so he ran with that rather than questioning  
the model itself whereas in a thicker shell

487

01:07:27,250 --> 01:07:41,040

model, the ice shell can be pierced down to  
a layer and -- warm flowing glacial ice. We

488

01:07:41,040 --> 01:07:51,460

were able to zoom in on some of these wedge  
shape bands -- had originally investigated

489

01:07:51,460 --> 01:08:00,810

and again the puzzle pieces fit together perfectly  
and the center is striated and analogous to

490

01:08:00,810 --> 01:08:08,610

what we see in the mid- ocean ridges. [Indiscernible].  
Impact craters -- argued for an ice shell

491

01:08:08,610 --> 01:08:13,910

that is relatively thick, like eight kilometers.  
-- like 8 kilometers. -- invoked a

492

01:08:13,910 --> 01:08:24,900

model that had been developed that said if we penetrate through the ice shell through

493

01:08:24,900 --> 01:08:32,650

a fluid later, the creator feels in very rapidly pulling the ice inward to form concentric

494

01:08:32,650 --> 01:08:37,950

rings and based on the scale about 40 kilometers across the -- creator, they penetrated to

495

01:08:37,950 --> 01:08:41,500

about 20 kilometers in depth.

>> In terms of surface composition, there's

496

01:08:41,500 --> 01:08:49,700

the question of what this dark redies step is and based on infrared -- or sulfuric acid

497

01:08:49,700 --> 01:08:56,220

hydrate and in reality it's probably a combination of those. It is like Epsom salt for battery

498

01:08:56,220 --> 01:09:03,311

acid, the answer is more likely like Epsom salt but a battery acid is created at the

499

01:09:03,311 --> 01:09:09,600

surface by the radiation at the surface.

>> Here are some of the f reckles. When we

500

01:09:09,600 --> 01:09:20,270

saw them they rang a bell with me as what I heard about the -- model way back w hen,

501

01:09:20,270 --> 01:09:23,950

that convection may have -- and perhaps what we are seeing the top of -- that they risen

502

01:09:23,950 --> 01:09:28,660

up through Europa's ice shell implying it would be more than 20 or so kilometers thick.

503

01:09:28,660 --> 01:09:36,370

The bottom is showing a model of the warm flowing ice, the red being only about 30 degrees

504

01:09:36,370 --> 01:09:42,900

Celsius below zero in terms of this temperature. Of the lava lamp like model [Indiscernible].

505

01:09:42,900 --> 01:09:46,940

>> Some of the most fascinating terrain is this chaotic terrain. The issue was has Europa's

506

01:09:46,940 --> 01:09:51,839

ice shell melted out completely or have lots of warm ice risen and moved to the box above?

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01:09:51,839 --> 01:09:59,370

Recently, it was -- that chaos may form above a melt zone in a thick ice shell [Background

508

01:09:59,370 --> 01:10:07,380

Noise-Coughing]. Looking at areas that used to have Lake Spinney them, -- have Lake's

509

01:10:07,380 --> 01:10:14,350

behind them. The discussion continues as to whether we are looking at floating icebergs.

510

01:10:14,350 --> 01:10:18,560

The Titanic is about 270 meters. [Background Noise-Coughing]. Europa may have the ingredients

511

01:10:18,560 --> 01:10:24,060

for life in terms of water, more than two times -- from its formation in from impact

512

01:10:24,060 --> 01:10:28,340

bringing carbon and other elements. It may have chemical energy from above oxidants created

513

01:10:28,340 --> 01:10:37,920

at the surface by radiation and potential energy from below if the mantle is warm. There

514

01:10:37,920 --> 01:10:51,220

could be black smoke like at unity -- into the base of the ocean. It is probably a relatively

515

01:10:51,220 --> 01:10:55,540

stable environment.

>> That leads to basic questions about the

516

01:10:55,540 --> 01:11:04,560

ocean and its existence and salinity, about the ice shell and the nature of water in a

517

01:11:04,560 --> 01:11:10,890

penny and the ice ocean exchange. The contribution and distribution and chemistry of key compounds

518

01:11:10,890 --> 01:11:14,800

and the links to ocean composition. At the geology. -- these release the over arching

519

01:11:14,800 --> 01:11:18,720

theme of Europa's habitability. The history of trying to develop [Background Noise-Coughing].

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01:11:18,720 --> 01:11:26,610

I was simply say the latest iteration is a feasible one that could cost about \$2 billion.

521

01:11:26,610 --> 01:11:31,350

-- would address the ocean ice shell composition objectives and have a reconnaissance camera

522

01:11:31,350 --> 01:11:38,260

to set the stage. It would do several dozen close flybys of Europa to understand [Background

523

01:11:38,260 --> 01:11:45,070

Noise-Coughing]. There are important fundamental questions remaining to answer in our solar

524

01:11:45,070 --> 01:11:53,580

system, especially with regard to the potential for life beyond Earth. 400 years ago, Galileo

525

01:11:53,580 --> 01:12:00,210

is observation of the satellite changed the human perspective in our place in the universe

526

01:12:00,210 --> 01:12:05,810

it is fascinating to think one of those worlds could change it again. Thank you very much.

527

01:12:05,810 --> 01:12:09,580

[Applause].

>> Why don't we go ahead and assembled a panel

528

01:12:09,580 --> 01:12:15,790

so we will let you take a seat. If you have a question for Bob, [Indiscernible].

529

01:12:15,790 --> 01:12:18,590

>> [Captioners Transitioning]

>> Of these deviations, are they mostly just

530

01:12:18,590 --> 01:12:28,720

produced by the [ Indiscernible - heavy accent ], or some kind of additional mechanism existing?

531

01:12:28,720 --> 01:12:42,340

And how deep these are? Whether there is an influence on the depth of the ocean, or on

532

01:12:42,340 --> 01:12:49,580

the temperature?

>> Yes, yes. So, the idea that has been developed

533

01:12:49,580 --> 01:13:01,150

is that by [ Indiscernible ] heating up, it

could heat up to the extent that it dissipates

534

01:13:01,150 --> 01:13:14,850

the ability, and to conserve the angular momentum

that will actually end up changing slightly.

535

01:13:14,850 --> 01:13:23,140

And, it will drag Europa along as it does

so. Recent models have suggested print pics

536

01:13:23,140 --> 01:13:31,790

icy shell thickness -- Europa's -shell thickness

could go from something from 10 or 15 km up

537

01:13:31,790 --> 01:13:40,980

to 30 km. It is possible that Europa may have

experienced a thin shell like history, and

538

01:13:40,980 --> 01:13:53,910

a thick shell like history, and then they

vary on something like a 10 or six year cycle.

539

01:13:53,910 --> 01:14:04,090

>> [ Indiscernible - low volume ]

>> About 10 to the sixth years. But the models

540

01:14:04,090 --> 01:14:10,940

could be tuned to the parameters. My guess?

>> This is a question on -- we could have

541

01:14:10,940 --> 01:14:15,780

a spacecraft get to the planets and -- how

that information is actually considering [ Indiscernible

542

01:14:15,780 --> 01:14:22,429

- low volume ]. And the involvement in the planet missions.

543

01:14:22,429 --> 01:14:32,540

>> Sure, communications is obviously a critical element in all of these things. And, it often

544

01:14:32,540 --> 01:14:41,210

operates to meet everybody's visibility level. It is just something that happens. And the

545

01:14:41,210 --> 01:14:46,710

scientists regard that as part of the magic. I can't figure out how to get all of those

546

01:14:46,710 --> 01:14:52,620

bits back from up there. And I know, John, I talked with you the other day walking over

547

01:14:52,620 --> 01:14:58,230

it. And then I realized, reading your bio, you were one of the people who worked for

548

01:14:58,230 --> 01:15:03,170

the facility in Australia to help fill this out when our communication system became a

549

01:15:03,170 --> 01:15:07,590

little bit flaky on Galileo. And it is a marvel and a store in itself, how these communication

550

01:15:07,590 --> 01:15:11,250

system, coats, cooperation among the various radio tracking facilities around the world

551

01:15:11,250 --> 01:15:15,250

go. You quite bring that up.  
>> This is the info -- [ Indiscernible name

552

01:15:15,250 --> 01:15:22,770

J. We will hear from Chad tomorrow about how most of the XO planets and planets show that

553

01:15:22,770 --> 01:15:29,910

most of many candidates are nearness and Neptune sized bodies. And yet, the only mission that

554

01:15:29,910 --> 01:15:37,900

has only ever gone to an ice giant was launched before I even graduated from high school.

555

01:15:37,900 --> 01:15:46,360

And now I've got gray hair. You have already pointed out that we are looking at a radio

556

01:15:46,360 --> 01:15:52,750

dark outer solar system now. What are your thoughts, from a historical perspective, of

557

01:15:52,750 --> 01:16:04,670

how that got lost? From the Jupiter orbit, and the Saturn orbit? Why did that get lost?

558

01:16:04,670 --> 01:16:13,900

That we do not have an outer planet orbiter? What happened and what is the lessons learned

559

01:16:13,900 --> 01:16:18,450

so that you can fix it?  
>> I think the discussions yesterday illustrated

560

01:16:18,450 --> 01:16:23,100

how cyclical the entire enterprise is, not just the outer planet exploration. It is not

561

01:16:23,100 --> 01:16:28,200

something taken for granted. It is something that we have continually made the arguments

562

01:16:28,200 --> 01:16:34,300

for. I would just remark from a historical point of view, we were well served by jumping

563

01:16:34,300 --> 01:16:40,950

on top of the net for the outer planet exploration. Because that actually got some data in remarkable

564

01:16:40,950 --> 01:16:45,240

a short times. It is not going to happen again for a while unless we get [ Indiscernible

565

01:16:45,240 --> 01:16:48,510

- low volume ].

>> I think we have not lost the drive to do

566

01:16:48,510 --> 01:16:54,200

these things, but we are still struggling with the generational nature of how long it

567

01:16:54,200 --> 01:16:59,500

takes to do them. I agree with you there.

>> Thanks. Jennifer [ Indiscernible last name

568

01:16:59,500 --> 01:17:04,140

], Princeton University. That was a great question. Of course, it is interesting to

569

01:17:04,140 --> 01:17:13,000

note that the generational moment corresponds to what a lot of attention has been placed

570

01:17:13,000 --> 01:17:28,130

on Mars, as opposed to how long it takes for the satellite to get to the outer solar system.

571

01:17:28,130 --> 01:17:37,580

I was struck by the presentations which look what we are talking a planets, moons and institutions,

572

01:17:37,580 --> 01:17:44,150

but we are also talking about important relationships that made those systems work. I am struck

573

01:17:44,150 --> 01:17:54,740

by the number of times we have seen the point participate or Paul Schenk's coming up over

574

01:17:54,740 --> 01:18:09,170

and over again, or the strong relationships between NASA and [ Indiscernible ] that enable

575

01:18:09,170 --> 01:18:15,130

something like [ Indiscernible name ] to be the success that it is. I would just stress

576

01:18:15,130 --> 01:18:20,560

that the cancellations of some of the larger scale international collaborations between

577

01:18:20,560 --> 01:18:26,640

NASA and [ Indiscernible ] specifically, whether it is exo-Mars or the potential of a joint

578

01:18:26,640 --> 01:18:33,250

mission to Jupiter's moons. I am wondering if you could speak from your experience, as

579

01:18:33,250 --> 01:18:39,150

to what are the parameters for success for building the kind of strong relationships,

580

01:18:39,150 --> 01:18:45,000

whether it is across institutions, or across missions, or across continents that enable

581

01:18:45,000 --> 01:18:49,700

these kinds of missions to go forward?  
>> Let me just make a preliminary comment

582

01:18:49,700 --> 01:18:55,340

on that, and then ask my colleague. I have frequently tried to make the point in speaking

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01:18:55,340 --> 01:19:05,840

to media. We got the wrong name on the program by allowing it to be unmanned robotic. It

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01:19:05,840 --> 01:19:12,280

is profoundly human, and the crew of these spacecraft are right here on earth, and in

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01:19:12,280 --> 01:19:21,590

the command center. And now, with social media and other things, we can bring the rest of

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01:19:21,590 --> 01:19:30,990

the population together that has been involved in that picture. That is true in the science

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01:19:30,990 --> 01:19:34,500

community. But, there is a proper context to it.

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01:19:34,500 --> 01:19:39,650

>> In planning these next missions, and looking toward future missions, there was a meeting

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01:19:39,650 --> 01:19:49,670

several years ago, working with many of the same members of definition teams, and working

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01:19:49,670 --> 01:20:04,940

for many years, when we came to the realization it was about the journey. But we have to be

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01:20:04,940 --> 01:20:17,960

enjoying ourselves along the way, and working with good people who have that very long-term

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01:20:17,960 --> 01:20:26,830

vision. And I think those who are dedicated to that future exploration work so well together,

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01:20:26,830 --> 01:20:41,700

because they have that long-term common goal. >> I have not much to add to what I said.

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01:20:41,700 --> 01:20:51,850

But I think first of all, you have to consider that space inside is not a scientific [ Indiscernible

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01:20:51,850 --> 01:20:59,120

]. It is a complex, a set of very different scientific disciplines, and so there is always

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01:20:59,120 --> 01:21:05,690

competition and cooperation aspects which play a role in this field. Secondly, even

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01:21:05,690 --> 01:21:12,570

given the scientific disciplines that we call the space science, space science is not only

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01:21:12,570 --> 01:21:17,160

science, they need technological means. Rockets, spacecraft, communication networks, political

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01:21:17,160 --> 01:21:20,860

decisions, huge amounts of money. >> So, it is not only science, and science

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01:21:20,860 --> 01:21:24,870

is not even the most important driving force behind space science. So, the most challenging

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01:21:24,870 --> 01:21:28,270

and important scientific mission in space has to be done in cooperation. Big collaborations,

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01:21:28,270 --> 01:21:33,870

small collaborations. Just having a launcher is a collaboration. Having a deep space network

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01:21:33,870 --> 01:21:42,500

is essential, if you want to go into the outer system, outer solar system. You need an STG

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01:21:42,500 --> 01:21:47,720

generation. So, that in many cases requires some collaboration. All of this requires scientific

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01:21:47,720 --> 01:21:48,720

personal relationships, complex and political associations.

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01:21:48,720 --> 01:21:51,380

>> The situation is always, always very fluid. There is a difference in the project system

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01:21:51,380 --> 01:21:57,489

in Europe, and in NASA has been a major stumbling block in several cases. And, was a source

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01:21:57,489 --> 01:22:01,140

of not less important controversies, in some cases.

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01:22:01,140 --> 01:22:07,080

>> I would note further that Professor. rooster -- Professor. Russo pointed out the relationships

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01:22:07,080 --> 01:22:12,600

between NASA, particularly. What leaves me is that the relationships survived. I was

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01:22:12,600 --> 01:22:16,110

not certain, when we started talking, whether my European colleagues would even talk to

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01:22:16,110 --> 01:22:20,880

us after what the United States had done,  
with respect to the Ulysses program.

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01:22:20,880 --> 01:22:25,320

>> And it was personal relationships that  
allow people to say, hey, there is a bigger

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01:22:25,320 --> 01:22:30,710

picture here. We have to work together on  
this. We are not going to be able to accomplish

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01:22:30,710 --> 01:22:32,900

these things.

>> Let's take one, final question.

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01:22:32,900 --> 01:22:39,170

>> Let me pick up on that theme, actually.  
Because that is my question. The striking

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01:22:39,170 --> 01:22:45,310

difference between what Professor. Russo described,  
in what Bob has recently experienced in the

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01:22:45,310 --> 01:22:50,770

construction of an international program for  
outer planet exploration. It seems now, we

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01:22:50,770 --> 01:22:57,390

are at a phase where the US and Europe are  
growing apart in planning their programs independently,

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01:22:57,390 --> 01:23:05,390

not just the outer planets, but on Mars, too.  
It seems. As we heard earlier. What is the

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01:23:05,390 --> 01:23:17,590

impact

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01:23:17,590 --> 01:23:52,980

of the current situation on this, with respect to the future outer planet exploration?

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01:23:52,980 --> 01:24:05,280

>> Well, I will start with the Europa discussion, and maybe you guys can pick up. With that,

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01:24:05,280 --> 01:24:16,080

we were working together as one, wonderful group, when the US said, okay, we are not

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01:24:16,080 --> 01:24:38,159

doing Europa, and Europe said, well we are doing this mission, which has become [ Indiscernible

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01:24:38,159 --> 01:24:46,739

]. And again, the personal relationships continued. We certainly want to work together with our

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01:24:46,739 --> 01:24:54,530

colleagues in Europe to explore the Jupiter system. There will be US participation in

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01:24:54,530 --> 01:25:08,500

the mission, and we are doing all we can on our side to try to keep alive that vision,

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01:25:08,500 --> 01:25:22,560

and resurrect a Europa mission for the exploration of Europa

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01:25:22,560 --> 01:25:30,120

and the Jupiter system, including Ganymede, as a whole. But without the US participation,

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01:25:30,120 --> 01:26:01,890

we will continue to have tantalizing hints of

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01:26:01,890 --> 01:26:16,920

what Europa is like, but we won't have answers.

>> My fear is that 50 years from now, when

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01:26:16,920 --> 01:26:42,060

we do export Europa if we get a lander to

the surface every sample that stuff, my fear

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01:26:42,060 --> 01:26:51,570

is people say, why didn't we do this 50 years

ago? Because it could be that important.

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01:26:51,570 --> 01:26:57,280

>> All right, let's thank our panel wants

more.

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01:26:57,280 --> 01:27:01,040

>> [ Clapping ]

>> And thanked the moderator for cutting out

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01:27:01,040 --> 01:27:03,969

seven minutes of your lunch.

>> [ Laughing ]

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01:27:03,969 --> 01:27:18,440

>> No, no. Quite the contrary. Thank you to

the panel for quite a tantalizing discussion.

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01:27:18,440 --> 01:27:32,210

A couple of quick announcements before we

prepared if you have not already done so,

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01:27:32,210 --> 01:27:54,750

please take the opportunity to avail yourself

of the history group. When they go out, it

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01:27:54,750 --> 01:29:19,890

will be to your left. We have got a lot of

experience and talent in this room, and let's

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01:29:19,890 --> 01:30:02,270

share that as much as we can with the public,  
and with the next generation. We will be reconvening

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01:30:02,270 --> 01:30:33,250

at 1 PM, so that seven minutes will not hurt  
us but we do need to be back at 1 PM. Lastly,

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01:30:33,250 --> 01:31:35,739

please remember the mission to take a buddy  
to lunch. Again, the advantage of having us

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01:31:35,739 --> 01:33:02,010

here physically in  
one place in the interpersonal interaction,

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01:33:02,010 --> 01:36:54,700

and lunchtime is a great time for that. So,  
without further ado, we

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01:36:54,700 --> 01:39:29,030

will see you