Outer Solar System & Small Bodies

	Jupiter	Io	Europa	Ganymede	Saturn	Enceladus	Titan	Uranus	Neptune	Triton	Plutoid Pluto	Asteroids	Comets
Flyby 1	Pioneer 10 Pioneer 11 Voyager 1 Voyager 2 Cassini New Horizons	Galileo	Galileo JUICE (ESA)	Galileo	Pioneer 11 Voyager 1 Voyager 2 Cassini	Voyager 2	Voyager 1 Cassini	Voyager 2	Voyager 2	Voyager 2	New Horizons*	NEAR Shoemaker Rosetta Galileo (Cassini) Deep Space 1 Rosetta New Horizons (KBO)	ICE (1985-8) Vega 1, 2 Sakigake, Suisei Giotto Deep Space 1 Stardust & Stardust-NExT Deep Impact & EPOXI (Galileo, Ulysses)
Orbit 2	Galileo Juno	Io Orbiter (JMO)	Orbiter (EJSM)	Orbiter (EJSM)	Cassini	Orbiter (EJSM)		Orbiter (EJSM)				NEAR Shoemaker Hayabusa Dawn	Rosetta
Lander 3	Galileo Probe				Probe (JMO)		*Surgery					NEAR Shoemaker	Deep Impact Philae (2014)*
Rover 4													
Return Samples 5												Hayabusa Hayabusa 2* OSIRIS-REx*	Stardust Surface Sift (NF)

1
00:00:03,169 --> 00:00:01,429
name is kristin erickson and i'm a

2
00:00:06,079 --> 00:00:03,179
member of one of the organizing

3
00:00:08,810 --> 00:00:06,089
committees of this symposium it is my

4
00:00:12,230 --> 00:00:08,820
extreme privilege to introduce today's

5
00:00:14,990 --> 00:00:12,240
keynote luncheon speaker now the

6
00:00:18,140 --> 00:00:15,000
scientific community knows dr. James

7
00:00:21,580 --> 00:00:18,150
green in several ways as a renowned

8
00:00:25,160 --> 00:00:21,590
solar physicist with over 150

9
00:00:29,689 --> 00:00:25,170
peer-reviewed papers as the director of

10
00:00:33,229 --> 00:00:29,699
NASA's planetary science and as such the

11
00:00:36,170 --> 00:00:33,239
chief Washington spear catcher we also

12
00:00:38,479 --> 00:00:36,180
know him as the visionary leader that

13
00:00:41,660 --> 00:00:38,489

successfully launched over 4 billion

14
00:00:44,750 --> 00:00:41,670
dollars of scientific missions last year

15
00:00:48,110 --> 00:00:44,760
alone one resulting in the successful

16
00:00:51,889 --> 00:00:48,120
Mars curiosity landing in August and

17
00:00:54,260 --> 00:00:51,899
another Jew know that thanks to Jim's

18
00:00:58,849 --> 00:00:54,270
foresight will be in orbit around

19
00:01:03,920 --> 00:00:58,859
Jupiter when Cassini is in a comparative

20
00:01:07,030 --> 00:01:03,930
orbit at Saturn what may not be known is

21
00:01:11,929 --> 00:01:07,040
that Jim is also quite the history buff

22
00:01:14,390 --> 00:01:11,939
he is a recognized expert in civil war

23
00:01:16,520 --> 00:01:14,400
balloons and with this one hundred and

24
00:01:19,190 --> 00:01:16,530
fiftieth anniversary year of the Civil

25
00:01:22,789 --> 00:01:19,200
War he is in quite demand as a speaker

26
00:01:25,100 --> 00:01:22,799
in that arena so with this intersection

27
00:01:29,330 --> 00:01:25,110
of is the interest in science and

28
00:01:33,260 --> 00:01:29,340
history we are in for a real treat now

29
00:01:40,419 --> 00:01:33,270
to hear his unique perspectives is dr.

30
00:01:45,139 --> 00:01:42,830
well it's just wonderful to be here on

31
00:01:52,179 --> 00:01:45,149
the 50th anniversary of planetary

32
00:01:57,980 --> 00:01:55,639
Steven for help and pulling together

33
00:02:00,819 --> 00:01:57,990
some of the statistics and mission

34
00:02:03,800 --> 00:02:00,829
information that i'll be showing today i

35
00:02:07,160 --> 00:02:03,810
think it's well known but it's well

36
00:02:10,400 --> 00:02:07,170
worth stating that nasa literally

37
00:02:14,930 --> 00:02:10,410
invented planetary science starting in

38
00:02:17,870 --> 00:02:14,940

1962 everything we knew about planetary

39
00:02:21,140 --> 00:02:17,880
science up until then we got the from

40
00:02:24,470 --> 00:02:21,150
the back of a telescope and even

41
00:02:28,100 --> 00:02:24,480
Percival Lowell got it wrong our ability

42
00:02:30,759 --> 00:02:28,110
to launch missions has provided us the

43
00:02:34,640 --> 00:02:30,769
opportunity to get up close and personal

44
00:02:37,880 --> 00:02:34,650
with many bodies in the solar system and

45
00:02:40,670 --> 00:02:37,890
of course there are many more that we're

46
00:02:45,009 --> 00:02:40,680
discovering and there are many that we'd

47
00:02:48,080 --> 00:02:45,019
like to interrogate much more thoroughly

48
00:02:50,090 --> 00:02:48,090
because of the importance those bodies

49
00:02:55,670 --> 00:02:50,100
are in our understanding of the origin

50
00:02:57,020 --> 00:02:55,680
and evolution of the solar system what

51
00:03:01,160 --> 00:02:57,030
we've heard about today a little bit

52
00:03:04,099 --> 00:03:01,170
about the decay Dalls and here are three

53
00:03:06,170 --> 00:03:04,109
important NRC documents that i would

54
00:03:09,050 --> 00:03:06,180
consider are the planetary de Cadel's

55
00:03:12,319 --> 00:03:09,060
the last three planetary teakettles the

56
00:03:18,229 --> 00:03:12,329
only planetary de Cadel's and in fact

57
00:03:20,870 --> 00:03:18,239
the the very first one was done by joe

58
00:03:23,390 --> 00:03:20,880
burns and a collection of scientists

59
00:03:26,059 --> 00:03:23,400
talking about the important questions of

60
00:03:28,879 --> 00:03:26,069
our field and some of the approaches

61
00:03:32,180 --> 00:03:28,889
that might be taken but it doesn't talk

62
00:03:34,819 --> 00:03:32,190
about the missions that are needed you

63
00:03:36,890 --> 00:03:34,829

know in that integrated strategy there

64
00:03:41,120 --> 00:03:36,900
there are the top things that we need to

65
00:03:43,190 --> 00:03:41,130
know but there's no costing of missions

66
00:03:44,990 --> 00:03:43,200
there's not this is the next one and has

67
00:03:47,300 --> 00:03:45,000
to go to Mars and it needs to land on

68
00:03:51,439 --> 00:03:47,310
the surface etc and from that

69
00:03:52,250 --> 00:03:51,449
perspective that particular document did

70
00:03:54,199 --> 00:03:52,260
not an a

71
00:03:56,360 --> 00:03:54,209
well I believe the planetary community

72
00:04:01,190 --> 00:03:56,370
to move significantly forward within the

73
00:04:05,720 --> 00:04:01,200
political environment as we entered the

74
00:04:09,020 --> 00:04:05,730
early 2000s the next akaydoll chaired by

75
00:04:11,449 --> 00:04:09,030
mike pelton new frontiers and solar

76
00:04:15,520 --> 00:04:11,459
system exploration really began to

77
00:04:19,340 --> 00:04:15,530
provide the framework that was necessary

78
00:04:22,520 --> 00:04:19,350
to move planetary science forward on

79
00:04:25,129 --> 00:04:22,530
many fronts not only scientifically

80
00:04:27,680 --> 00:04:25,139
because all the scientific top questions

81
00:04:32,020 --> 00:04:27,690
were in it just as the previous study

82
00:04:34,670 --> 00:04:32,030
report but also what we would call

83
00:04:38,529 --> 00:04:34,680
conceptual missions how they were going

84
00:04:43,210 --> 00:04:38,539
to be done now that particular report

85
00:04:47,900 --> 00:04:43,220
which went from two thousand three to

86
00:04:51,890 --> 00:04:47,910
twenty twelve was very valuable and

87
00:04:53,840 --> 00:04:51,900
enabled planetary science to be put on

88
00:04:56,029 --> 00:04:53,850

the map in many different ways and move

89
00:04:58,400 --> 00:04:56,039
significantly forward you could walk

90
00:05:01,640 --> 00:04:58,410
into congressional staffers office and

91
00:05:03,500 --> 00:05:01,650
see it on the shelf and they would pull

92
00:05:07,460 --> 00:05:03,510
it out and they would say what mission

93
00:05:11,390 --> 00:05:07,470
are you talking about so that framework

94
00:05:16,129 --> 00:05:11,400
the ability that the NRC has to be able

95
00:05:18,830 --> 00:05:16,139
to create a strategy and the overarching

96
00:05:21,230 --> 00:05:18,840
plan for planetary science that

97
00:05:23,510 --> 00:05:21,240
delineates missions of importance that

98
00:05:26,150 --> 00:05:23,520
does answer the important scientific

99
00:05:32,120 --> 00:05:26,160
questions was a real winner for the

100
00:05:35,600 --> 00:05:32,130
community now the last report the one

101
00:05:39,110 --> 00:05:35,610
that's been recently issued visions and

102
00:05:42,350 --> 00:05:39,120
voyages that was chaired by Steve

103
00:05:44,210 --> 00:05:42,360
Squyres and it had enormous number of

104
00:05:47,210 --> 00:05:44,220
people in the community participate in

105
00:05:48,830 --> 00:05:47,220
it we concentrated significantly in

106
00:05:52,460 --> 00:05:48,840
those missions and the mission

107
00:05:54,680 --> 00:05:52,470
architectures we costed those out at a

108
00:05:58,250 --> 00:05:54,690
much higher fidelity than we'd ever done

109
00:06:00,469 --> 00:05:58,260
before to try to understand from a cost

110
00:06:04,070 --> 00:06:00,479
perspective how to be able to create a

111
00:06:05,690 --> 00:06:04,080
program that is responsive to the

112
00:06:08,570 --> 00:06:05,700
science questions

113
00:06:12,470 --> 00:06:08,580

and and yet affordable in the times that

114
00:06:15,890 --> 00:06:12,480
we felt the funding projections from the

115
00:06:19,940 --> 00:06:15,900
president were given to us in 2010 when

116
00:06:22,070 --> 00:06:19,950
when the report was really completed and

117
00:06:26,300 --> 00:06:22,080
in the analysis of missions moving

118
00:06:28,340 --> 00:06:26,310
forward the report also has a number of

119
00:06:31,250 --> 00:06:28,350
important aspects to it in the sense

120
00:06:34,460 --> 00:06:31,260
that it has what do you do when the

121
00:06:37,730 --> 00:06:34,470
budget isn't is rosy so are there are

122
00:06:40,550 --> 00:06:37,740
decision making rules so there's going

123
00:06:42,740 --> 00:06:40,560
to be a lot of discussion as the all the

124
00:06:44,480 --> 00:06:42,750
decadal reports are discussed and how

125
00:06:47,030 --> 00:06:44,490
we're going to move forward in the next

126
00:06:49,070 --> 00:06:47,040
major sets of decay Dalls and whether

127
00:06:51,530 --> 00:06:49,080
these approaches will work for us and

128
00:06:55,430 --> 00:06:51,540
whether decision making rules need to be

129
00:06:58,030 --> 00:06:55,440
much more clearly delineated for us to

130
00:07:01,310 --> 00:06:58,040
be able to use within the next ten years

131
00:07:04,220 --> 00:07:01,320
but it's extremely important to note a

132
00:07:06,530 --> 00:07:04,230
couple things about this one the

133
00:07:09,170 --> 00:07:06,540
planetary community is behind visions

134
00:07:10,580 --> 00:07:09,180
and voyages as they were behind new

135
00:07:14,720 --> 00:07:10,590
frontiers in the solar system

136
00:07:16,910 --> 00:07:14,730
exploration report that allows them out

137
00:07:20,420 --> 00:07:16,920
of those four elements you know the

138
00:07:23,170 --> 00:07:20,430

science of the the administration you

139
00:07:26,690 --> 00:07:23,180
know the administrator of NASA and

140
00:07:30,230 --> 00:07:26,700
Congress it allows one of those legs of

141
00:07:32,080 --> 00:07:30,240
that of that stool to be solid we know

142
00:07:35,150 --> 00:07:32,090
what the plan is to move forward and

143
00:07:38,180 --> 00:07:35,160
that's the science community and that is

144
00:07:39,830 --> 00:07:38,190
really a quite critical and is the

145
00:07:45,050 --> 00:07:39,840
foundation of everything that moves

146
00:07:46,940 --> 00:07:45,060
forward now what's happened is this

147
00:07:51,560 --> 00:07:46,950
particular de que tal vision on voyages

148
00:07:54,710 --> 00:07:51,570
actually starts in October all right

149
00:07:57,590 --> 00:07:54,720
it's got 10 years and even though our

150
00:08:00,380 --> 00:07:57,600
budget projection wasn't s plan when the

151
00:08:03,560 --> 00:08:00,390
report was near its finishing date we

152
00:08:05,420 --> 00:08:03,570
have 10 years to live this report and we

153
00:08:06,980 --> 00:08:05,430
have 10 years for the community to get

154
00:08:09,500 --> 00:08:06,990
behind it because the science is

155
00:08:12,380 --> 00:08:09,510
incredibly exciting incredibly

156
00:08:16,010 --> 00:08:12,390
compelling and and our community is

157
00:08:19,550 --> 00:08:16,020
united as we move forward so that's an

158
00:08:22,370 --> 00:08:19,560
important important aspect I think

159
00:08:24,260 --> 00:08:22,380
to really delineate now what's happened

160
00:08:27,620 --> 00:08:24,270
in those 50 years is an incredible

161
00:08:30,200 --> 00:08:27,630
revolution absolutely unbelievable as

162
00:08:32,870 --> 00:08:30,210
I've mentioned we've had the opportunity

163
00:08:36,800 --> 00:08:32,880

to go places and to see things and to do

164
00:08:39,620 --> 00:08:36,810
the analysis and in fact which you may

165
00:08:41,000 --> 00:08:39,630
not recognize may sound like a jumbled

166
00:08:42,529 --> 00:08:41,010
set of missions while are you going to

167
00:08:44,329 --> 00:08:42,539
land here are you flying by and or

168
00:08:46,460 --> 00:08:44,339
you're open what are you doing but in

169
00:08:50,329 --> 00:08:46,470
reality there's been a methodical

170
00:08:54,620 --> 00:08:50,339
approach and that methodical approach is

171
00:08:58,400 --> 00:08:54,630
fly by orbit land Rove and sample return

172
00:09:00,079 --> 00:08:58,410
and that particular approach even though

173
00:09:02,750 --> 00:09:00,089
we don't talk about it much in the

174
00:09:05,570 --> 00:09:02,760
science community is really quite

175
00:09:08,000 --> 00:09:05,580
obvious when you stack up the missions

176
00:09:11,240 --> 00:09:08,010
and you see what we've done and we know

177
00:09:15,740 --> 00:09:11,250
what the next major steps are each of

178
00:09:21,470 --> 00:09:15,750
these fly by to orbit orbit to land land

179
00:09:25,940 --> 00:09:21,480
to Rove are huge steps they are major

180
00:09:30,800 --> 00:09:25,950
steps in science also in our ability to

181
00:09:33,500 --> 00:09:30,810
do the next element the next answer the

182
00:09:36,950 --> 00:09:33,510
next most important questions from the

183
00:09:38,630 --> 00:09:36,960
preceding set of missions and I hope to

184
00:09:41,690 --> 00:09:38,640
be able to illustrate that in many

185
00:09:44,690 --> 00:09:41,700
different ways now planetary science our

186
00:09:47,360 --> 00:09:44,700
goal the stated here is advance our

187
00:09:49,880 --> 00:09:47,370
scientific knowledge of the origins and

188
00:09:52,120 --> 00:09:49,890

history of the solar system the

189
00:09:55,430 --> 00:09:52,130
potential for life elsewhere and the

190
00:09:59,600 --> 00:09:55,440
hazards and resources presence present

191
00:10:02,710 --> 00:09:59,610
as humans explore space and that's a

192
00:10:05,780 --> 00:10:02,720
theme that you'll see throughout this

193
00:10:11,600 --> 00:10:05,790
visions and voyages de kadel as we move

194
00:10:13,640 --> 00:10:11,610
forward now over the last a couple years

195
00:10:16,100 --> 00:10:13,650
and in fact we call this the year of the

196
00:10:19,670 --> 00:10:16,110
solar system it's a Mars year so it's

197
00:10:22,400 --> 00:10:19,680
about 670 days we've really that's right

198
00:10:25,430 --> 00:10:22,410
it's a planetary planetary approach to

199
00:10:28,220 --> 00:10:25,440
things we've really accomplished an

200
00:10:31,880 --> 00:10:28,230
enormous number of missions and mission

201
00:10:33,079 --> 00:10:31,890
objectives and from these missions the

202
00:10:35,329 --> 00:10:33,089
datas are the data

203
00:10:37,429 --> 00:10:35,339
starting to come into the archive and

204
00:10:39,799 --> 00:10:37,439
the scientists are beginning to reap

205
00:10:41,569 --> 00:10:39,809
those benefits now just as an

206
00:10:43,340 --> 00:10:41,579
illustration let me point out a couple

207
00:10:46,009 --> 00:10:43,350
of these things we've flown by two

208
00:10:49,970 --> 00:10:46,019
comets and we've learned an enormous

209
00:10:54,470 --> 00:10:49,980
amount surprises in each we've launched

210
00:11:01,040 --> 00:10:54,480
three missions juneau to Jupiter Grail

211
00:11:05,090 --> 00:11:01,050
to the moon and MSL to Mars we've also

212
00:11:09,400 --> 00:11:05,100
inserted in orbit Grail to the moon both

213
00:11:13,160 --> 00:11:09,410

Grail a and B named by kids ebb and flow

214
00:11:18,110 --> 00:11:13,170
we've inserted messenger into orbit

215
00:11:21,889 --> 00:11:18,120
around mercury and we've inserted dawn

216
00:11:26,389 --> 00:11:21,899
around festa the second largest asteroid

217
00:11:28,549 --> 00:11:26,399
in addition to that we've pulled Vesta

218
00:11:31,509 --> 00:11:28,559
we've pulled dawn out of orbit from

219
00:11:34,939 --> 00:11:31,519
Vesta and moved on to the next and

220
00:11:38,660 --> 00:11:34,949
largest object in in the asteroid belt

221
00:11:40,730 --> 00:11:38,670
series another really exciting body that

222
00:11:43,189 --> 00:11:40,740
will tell us a lot about the origin

223
00:11:46,999 --> 00:11:43,199
evolution of the solar system and we've

224
00:11:49,790 --> 00:11:47,009
landed MSL Curiosity rover safely on

225
00:11:52,309 --> 00:11:49,800
Mars this is just an enormous set of

226
00:11:56,509 --> 00:11:52,319
achievements absolutely enormous so we

227
00:12:01,939 --> 00:11:56,519
have quite a bit of success I think it's

228
00:12:04,340 --> 00:12:01,949
some a testimony to the the hard work

229
00:12:06,619 --> 00:12:04,350
that's gone on in all the center's that

230
00:12:08,869 --> 00:12:06,629
participate in these and throughout the

231
00:12:12,379 --> 00:12:08,879
scientific community to make these

232
00:12:14,480 --> 00:12:12,389
missions and activities so vital and so

233
00:12:17,059 --> 00:12:14,490
successful and as I mentioned the

234
00:12:19,730 --> 00:12:17,069
science data will be flowing in into the

235
00:12:21,769 --> 00:12:19,740
archive on a continual basis and new and

236
00:12:27,319 --> 00:12:21,779
greater discoveries or going to continue

237
00:12:30,410 --> 00:12:27,329
from those now I'm going to show a

238
00:12:34,549 --> 00:12:30,420

number of charts like this on the

239
00:12:36,889 --> 00:12:34,559
horizontal axis we have the object you

240
00:12:42,429 --> 00:12:36,899
know in the inner solar system mercury

241
00:12:46,269 --> 00:12:42,439
venus our moon Mars Phobos and Deimos

242
00:12:50,199 --> 00:12:46,279
and on the vertical axis is the

243
00:12:53,350 --> 00:12:50,209
approach flyby orbit land Rove and

244
00:12:56,350 --> 00:12:53,360
sample return and what's listed here

245
00:12:58,720 --> 00:12:56,360
this is not meant to be an eye chart but

246
00:13:01,090 --> 00:12:58,730
it shows you I think the the missions

247
00:13:04,710 --> 00:13:01,100
from an international and a NASA

248
00:13:08,259 --> 00:13:04,720
perspective that have been launched to

249
00:13:11,559 --> 00:13:08,269
effectively to interrogate our solar

250
00:13:15,790 --> 00:13:11,569
system in this way now what's also shown

251
00:13:18,460 --> 00:13:15,800
in blue and highlighted are those

252
00:13:22,299 --> 00:13:18,470
elements are those missions from the

253
00:13:25,869 --> 00:13:22,309
visions and voyages de cadle which are

254
00:13:30,489 --> 00:13:25,879
the big steps for Venus it's a Venus and

255
00:13:33,299 --> 00:13:30,499
see to explore for our Moon it's getting

256
00:13:35,860 --> 00:13:33,309
back down to the surface through a

257
00:13:40,449 --> 00:13:35,870
sample return in the South Pole lake and

258
00:13:43,660 --> 00:13:40,459
basin or or a geophysical network up for

259
00:13:48,189 --> 00:13:43,670
Mars as you can see it's sample return

260
00:13:51,759 --> 00:13:48,199
we are there now we know now know enough

261
00:13:53,170 --> 00:13:51,769
about Mars to know where to go the kinds

262
00:13:57,759 --> 00:13:53,180
of things that we need to take with us

263
00:14:00,009 --> 00:13:57,769

to analyze what we find and make

264
00:14:02,049 --> 00:14:00,019
decisions are what samples we need to be

265
00:14:05,650 --> 00:14:02,059
better bring back for further analysis

266
00:14:07,929 --> 00:14:05,660
and we've recently selected insight

267
00:14:10,299 --> 00:14:07,939
which is a one-note geophysical network

268
00:14:14,319 --> 00:14:10,309
also well described in the planetary de

269
00:14:17,379 --> 00:14:14,329
kado as a discovery mission now for the

270
00:14:19,900 --> 00:14:17,389
moon as I mentioned both the the

271
00:14:22,990 --> 00:14:19,910
geophysical network and South Pole lake

272
00:14:25,210 --> 00:14:23,000
and basin are prominent in the planetary

273
00:14:27,999 --> 00:14:25,220
de kadel and of course for good reason

274
00:14:30,040 --> 00:14:28,009
these are big steps these are indeed the

275
00:14:35,280 --> 00:14:30,050
next things we need to know about the

276
00:14:38,949 --> 00:14:35,290
moon and of course the moon has on it

277
00:14:41,199 --> 00:14:38,959
really the history of ours our inner

278
00:14:45,090 --> 00:14:41,209
bombardment of our solar system let's

279
00:14:48,249 --> 00:14:45,100
hit the moon its size and and it's a

280
00:14:50,769 --> 00:14:48,259
shape of course is probably also hit the

281
00:14:52,720 --> 00:14:50,779
earth from the lunar rocks that we

282
00:14:55,929 --> 00:14:52,730
brought back from the samples that have

283
00:14:58,059 --> 00:14:55,939
been brought back from the Apollo's more

284
00:14:58,910 --> 00:14:58,069
than 800 pounds of rocks we are

285
00:15:01,519 --> 00:14:58,920
continuing

286
00:15:03,800 --> 00:15:01,529
to do that analysis and we are finding

287
00:15:05,750 --> 00:15:03,810
now much more information about the

288
00:15:09,500 --> 00:15:05,760

origin and evolution of the moon and

289
00:15:12,050 --> 00:15:09,510
we're also realizing that in addition to

290
00:15:14,600 --> 00:15:12,060
the initial creation of the Earth Moon

291
00:15:16,879 --> 00:15:14,610
which we believe occurred from a

292
00:15:19,460 --> 00:15:16,889
collision of a mars-sized body with the

293
00:15:21,230 --> 00:15:19,470
earth and and the Rhea chrétien then of

294
00:15:23,750 --> 00:15:21,240
two bodies we call the earth and the

295
00:15:28,370 --> 00:15:23,760
moon at about four and a half billion

296
00:15:31,490 --> 00:15:28,380
years ago we also recognize that about

297
00:15:33,470 --> 00:15:31,500
half a billion years later a major

298
00:15:36,170 --> 00:15:33,480
bombardment occurred in the inner part

299
00:15:40,519 --> 00:15:36,180
of the solar system with asteroids

300
00:15:42,680 --> 00:15:40,529
comets and and perhaps even Kuiper belt

301
00:15:45,319 --> 00:15:42,690
objects bringing a significant amount of

302
00:15:48,439 --> 00:15:45,329
water with it at a time when the earth

303
00:15:51,319 --> 00:15:48,449
had cooled and was ready based on its

304
00:15:53,889 --> 00:15:51,329
gravitational structure to be able to

305
00:15:56,240 --> 00:15:53,899
maintain and hold this water and

306
00:15:59,030 --> 00:15:56,250
creating the water planet that we know

307
00:16:00,889 --> 00:15:59,040
so perhaps anywhere from forty to sixty

308
00:16:03,620 --> 00:16:00,899
percent of the water that's in our

309
00:16:06,170 --> 00:16:03,630
oceans has come to us through this type

310
00:16:07,880 --> 00:16:06,180
of bombardment and these are the things

311
00:16:10,569 --> 00:16:07,890
that we are learning and these are the

312
00:16:13,400 --> 00:16:10,579
the understanding that we are obtaining

313
00:16:15,350 --> 00:16:13,410

through the analysis of samples and

314
00:16:17,900 --> 00:16:15,360
through the analysis of other elements

315
00:16:23,509 --> 00:16:17,910
and other missions that are giving us

316
00:16:25,340 --> 00:16:23,519
this important perspective we're through

317
00:16:28,400 --> 00:16:25,350
the Lunar Reconnaissance Orbiter making

318
00:16:30,530 --> 00:16:28,410
detailed observations of the moon they

319
00:16:33,769 --> 00:16:30,540
could easily see these two tables from

320
00:16:36,920 --> 00:16:33,779
orbit and these detailed observations

321
00:16:40,370 --> 00:16:36,930
are incredibly important when we combine

322
00:16:46,329 --> 00:16:40,380
them in other ways this is an altitude

323
00:16:48,949 --> 00:16:46,339
map of the Moon that allow us to again

324
00:16:51,380 --> 00:16:48,959
effectively do the next two new

325
00:16:54,079 --> 00:16:51,390
frontiers missions and that would be

326
00:16:57,860 --> 00:16:54,089
South Pole aiken basin sample return and

327
00:16:59,840 --> 00:16:57,870
a geophysical network Lander in fact

328
00:17:03,139 --> 00:16:59,850
what you see on the near side of the

329
00:17:05,689 --> 00:17:03,149
moon as compared to the far side is a

330
00:17:09,130 --> 00:17:05,699
very different structure the moiré on

331
00:17:12,079 --> 00:17:09,140
the near side of the Moon are a basaltic

332
00:17:12,860 --> 00:17:12,089
volcanic if you will on the far side of

333
00:17:14,840 --> 00:17:12,870
the Moon

334
00:17:16,819 --> 00:17:14,850
much different structure in fact the

335
00:17:18,860 --> 00:17:16,829
blue area which indicates the lower

336
00:17:22,400 --> 00:17:18,870
latitude on the backside of the moon is

337
00:17:26,840 --> 00:17:22,410
called the South Pole Aiken basin it's a

338
00:17:29,330 --> 00:17:26,850

huge impact region and between the depth

339
00:17:31,610 --> 00:17:29,340
of that basin and the white area which

340
00:17:34,549 --> 00:17:31,620
is the highest altitude also on the

341
00:17:36,860 --> 00:17:34,559
backside of the moon is more than 19

342
00:17:40,070 --> 00:17:36,870
kilometers and that's a distance that's

343
00:17:42,890 --> 00:17:40,080
larger than the top of Mount Everest and

344
00:17:45,799 --> 00:17:42,900
the bottom of the Marianas Trench so

345
00:17:48,710 --> 00:17:45,809
it's a huge distance and in fact in the

346
00:17:51,620 --> 00:17:48,720
South Pole Aiken basin we believe is the

347
00:17:54,169 --> 00:17:51,630
lower crust perhaps material from the

348
00:17:56,390 --> 00:17:54,179
lower mantle and I'll tell us a lot

349
00:17:59,110 --> 00:17:56,400
about how this body was put together and

350
00:18:02,360 --> 00:17:59,120
that's an important element of that of

351
00:18:06,169 --> 00:18:02,370
planetary structure we can't even get to

352
00:18:08,690 --> 00:18:06,179
the mantle of our earth and yet elements

353
00:18:10,310 --> 00:18:08,700
of understanding how that how that body

354
00:18:14,690 --> 00:18:10,320
was put together is laying on the

355
00:18:16,880 --> 00:18:14,700
backside of the moon we also allow with

356
00:18:19,070 --> 00:18:16,890
the Grail mission have taken a good look

357
00:18:21,410 --> 00:18:19,080
at the gravity of the moon our two

358
00:18:24,290 --> 00:18:21,420
spacecraft as they pass over and are

359
00:18:27,290 --> 00:18:24,300
affected by gravity and changed the

360
00:18:29,900 --> 00:18:27,300
distance between them an able the

361
00:18:32,030 --> 00:18:29,910
scientists to back out the gravitational

362
00:18:34,970 --> 00:18:32,040
structure of the moon not only in its

363
00:18:36,830 --> 00:18:34,980

crust as shown here in fact the best

364
00:18:39,140 --> 00:18:36,840
estimate we had of the lunar gravity

365
00:18:42,500 --> 00:18:39,150
came from lunar prospector it's shown on

366
00:18:44,830 --> 00:18:42,510
the top panel Grail after one month's

367
00:18:48,340 --> 00:18:44,840
worth of data in right now it's um it's

368
00:18:51,860 --> 00:18:48,350
on its sixth and seventh month of

369
00:18:54,500 --> 00:18:51,870
observations gives us the kind of detail

370
00:18:57,950 --> 00:18:54,510
and resolution that we need that when we

371
00:19:00,680 --> 00:18:57,960
combine the LRO data allows us to do

372
00:19:03,820 --> 00:19:00,690
precision landing allows us to put

373
00:19:07,310 --> 00:19:03,830
something down on the ground on the moon

374
00:19:09,890 --> 00:19:07,320
within the distance of this room so

375
00:19:11,480 --> 00:19:09,900
really tremendous results now from our

376
00:19:16,970 --> 00:19:11,490
missions are coming into the archive

377
00:19:19,760 --> 00:19:16,980
that indeed enable us to build more

378
00:19:23,270 --> 00:19:19,770
exciting missions into the future that

379
00:19:26,749 --> 00:19:23,280
are of decayed all importance as we look

380
00:19:28,999 --> 00:19:26,759
back and at Mars missions we see we've

381
00:19:31,999 --> 00:19:29,009
flown by weave or but we've landed and

382
00:19:36,319 --> 00:19:32,009
we've had Rovers and indeed the next big

383
00:19:38,389 --> 00:19:36,329
step is sample return our knowledge of

384
00:19:41,839 --> 00:19:38,399
Mars is increased significantly we have

385
00:19:45,199 --> 00:19:41,849
a whole session about Mars and of course

386
00:19:47,569 --> 00:19:45,209
our perception of Mars has changed from

387
00:19:50,629 --> 00:19:47,579
telescopes Percival Lowell thought that

388
00:19:53,419 --> 00:19:50,639

there perhaps was a a civilization in

389
00:19:57,289 --> 00:19:53,429
crisis based on the fact that he

390
00:20:00,229 --> 00:19:57,299
interpreted features that look to him

391
00:20:02,899 --> 00:20:00,239
like canal canals transport of water

392
00:20:05,169 --> 00:20:02,909
throughout throughout various regions on

393
00:20:08,359 --> 00:20:05,179
Mars that turns out not to be the case

394
00:20:10,759 --> 00:20:08,369
we were perhaps even more disappointed

395
00:20:13,219 --> 00:20:10,769
in the earlier flybys which made the

396
00:20:16,039 --> 00:20:13,229
moon look much more a lot made Mars look

397
00:20:19,129 --> 00:20:16,049
much more like the moon than what we

398
00:20:21,199 --> 00:20:19,139
know about it today well we've put

399
00:20:25,519 --> 00:20:21,209
together a program that follows the

400
00:20:29,389 --> 00:20:25,529
water looking for signs of water on Mars

401
00:20:32,599 --> 00:20:29,399
and we recognize that those structures

402
00:20:36,019 --> 00:20:32,609
are everywhere on Mars if we only had

403
00:20:37,939 --> 00:20:36,029
the resolution which we do now to see so

404
00:20:40,089 --> 00:20:37,949
there are many observations now that

405
00:20:43,430 --> 00:20:40,099
we've been making over the last 10 years

406
00:20:47,329 --> 00:20:43,440
well rooted at our last planetary decato

407
00:20:50,569 --> 00:20:47,339
that's providing us now the information

408
00:20:54,109 --> 00:20:50,579
we need to be able to go back to Mars go

409
00:20:58,129 --> 00:20:54,119
to the right places and bring back

410
00:21:03,499 --> 00:20:58,139
samples and in fact what's even more

411
00:21:07,099 --> 00:21:03,509
exciting even though a liquid water as

412
00:21:09,680 --> 00:21:07,109
we know it should not be able to exist

413
00:21:12,139 --> 00:21:09,690

on the surface of Mars because the

414
00:21:14,899 --> 00:21:12,149
pressure is not such that it that it can

415
00:21:18,019 --> 00:21:14,909
stay a liquid evaporates quite quickly

416
00:21:21,499 --> 00:21:18,029
and in this particular example as you

417
00:21:23,869 --> 00:21:21,509
see a number of observations seasonal

418
00:21:25,669 --> 00:21:23,879
observations over about a year of a

419
00:21:29,599 --> 00:21:25,679
particular region on Mars and there are

420
00:21:32,599 --> 00:21:29,609
many like this now any us in a sloping

421
00:21:34,819 --> 00:21:32,609
area but crater on Mars we see these

422
00:21:37,489 --> 00:21:34,829
Lynn asians we call them that but in

423
00:21:41,060 --> 00:21:37,499
reality we now believe that these are in

424
00:21:43,509 --> 00:21:41,070
the summer of where water

425
00:21:47,210 --> 00:21:43,519
tiny water can exist at this pressure

426
00:21:50,629 --> 00:21:47,220
flowing down indeed the size of these

427
00:21:54,680 --> 00:21:50,639
craters so where has the water gone on

428
00:21:57,259 --> 00:21:54,690
Mars it's gone underground and as we now

429
00:21:59,899 --> 00:21:57,269
know more about how the the water cycle

430
00:22:03,710 --> 00:21:59,909
and hydrological cycle on Mars could

431
00:22:05,930 --> 00:22:03,720
have existed it also has evaporated and

432
00:22:08,720 --> 00:22:05,940
then stripped by the solar wind because

433
00:22:12,710 --> 00:22:08,730
Mars is magnetic field had left the

434
00:22:14,810 --> 00:22:12,720
planet many billions of years ago so in

435
00:22:17,210 --> 00:22:14,820
understanding a number of these physical

436
00:22:19,220 --> 00:22:17,220
processes at these planets we also now

437
00:22:21,680 --> 00:22:19,230
understand a lot more about our earth

438
00:22:25,580 --> 00:22:21,690

and the importance of our own magnetic

439
00:22:31,220 --> 00:22:25,590
field and the importance of how climate

440
00:22:33,110 --> 00:22:31,230
changes on our earth also over the last

441
00:22:35,740 --> 00:22:33,120
10 years even our ground-based

442
00:22:39,440 --> 00:22:35,750
telescopes have made productive

443
00:22:43,369 --> 00:22:39,450
observations what you see on the left

444
00:22:45,980 --> 00:22:43,379
panel is Mars but it's it is color coded

445
00:22:49,159 --> 00:22:45,990
red being the highest intensity blue

446
00:22:52,850 --> 00:22:49,169
being the lowest intensity of a trace

447
00:22:54,740 --> 00:22:52,860
gas called methane and these methane

448
00:22:56,930 --> 00:22:54,750
observations have been observed they are

449
00:22:58,460 --> 00:22:56,940
very controversial because they are from

450
00:23:01,730 --> 00:22:58,470
Earth and we have to look through

451
00:23:04,730 --> 00:23:01,740
methane to see methane on Mars so it's

452
00:23:06,799 --> 00:23:04,740
very difficult to separate but they've

453
00:23:08,960 --> 00:23:06,809
been done very methodically and I

454
00:23:11,960 --> 00:23:08,970
believe very carefully over the last 10

455
00:23:14,710 --> 00:23:11,970
years and they show that Mars goes

456
00:23:19,450 --> 00:23:14,720
through methane emission cycles and that

457
00:23:23,149 --> 00:23:19,460
cycle is periodic with the most intense

458
00:23:27,460 --> 00:23:23,159
methane emissions occurring during the

459
00:23:30,230 --> 00:23:27,470
summer so those variations are seasonal

460
00:23:34,389 --> 00:23:30,240
the explanation of methane of course

461
00:23:38,090 --> 00:23:34,399
there are a couple one it could be

462
00:23:40,669 --> 00:23:38,100
biological is are these microbes that

463
00:23:43,970 --> 00:23:40,679

are indeed generating methane or it

464
00:23:46,100 --> 00:23:43,980
could be a biotic it could be regions of

465
00:23:48,320 --> 00:23:46,110
minerals and magma with water

466
00:23:50,720 --> 00:23:48,330
underground water and we certainly see

467
00:23:53,710 --> 00:23:50,730
from from these leaking of the aquifers

468
00:23:57,810 --> 00:23:53,720
of the major amount of water

469
00:23:59,650 --> 00:23:57,820
in Mars's crust perhaps that's

470
00:24:01,920 --> 00:23:59,660
generating the methane and that

471
00:24:04,380 --> 00:24:01,930
certainly could be the case too I

472
00:24:06,400 --> 00:24:04,390
believe we're on the edge of

473
00:24:08,950 --> 00:24:06,410
understanding the methane emission

474
00:24:12,070 --> 00:24:08,960
because Curiosity rover which is also

475
00:24:14,350 --> 00:24:12,080
now on the surface of Mars has the

476
00:24:17,620 --> 00:24:14,360
ability to make these trace gas

477
00:24:19,860 --> 00:24:17,630
measurements and more importantly also

478
00:24:22,270 --> 00:24:19,870
observe their isotopes and there's a

479
00:24:24,930 --> 00:24:22,280
biological sorting that goes on in these

480
00:24:28,930 --> 00:24:24,940
isotopes and that gives us an indication

481
00:24:31,350 --> 00:24:28,940
more so than ever before of the reality

482
00:24:36,220 --> 00:24:31,360
of where the methane is being generated

483
00:24:39,160 --> 00:24:36,230
and how that might be related to either

484
00:24:41,050 --> 00:24:39,170
geological activity or biological

485
00:24:43,960 --> 00:24:41,060
activity so we'll see I think major

486
00:24:46,720 --> 00:24:43,970
steps in that direction as curiosity

487
00:24:49,450 --> 00:24:46,730
continues throughout the spring and

488
00:24:53,340 --> 00:24:49,460

summer and winter season of observations

489
00:24:56,500 --> 00:24:53,350
so truly truly exciting and once again

490
00:25:01,600 --> 00:24:56,510
tugging on our interest of is there life

491
00:25:05,680 --> 00:25:01,610
beyond Earth curiosity's landing of

492
00:25:09,250 --> 00:25:05,690
course was absolutely a spectacular the

493
00:25:12,730 --> 00:25:09,260
response from this nation and many many

494
00:25:16,210 --> 00:25:12,740
other nations was really quite

495
00:25:20,050 --> 00:25:16,220
gratifying there are countries in this

496
00:25:25,570 --> 00:25:20,060
world that dream about the stuff that

497
00:25:27,460 --> 00:25:25,580
NASA does NASA has such a branding if

498
00:25:30,670 --> 00:25:27,470
you will when you go to other nations

499
00:25:33,370 --> 00:25:30,680
and talk to people in the street in and

500
00:25:37,420 --> 00:25:33,380
the public the admiration is

501
00:25:40,950 --> 00:25:37,430
unbelievable it's there's no politics in

502
00:25:44,320 --> 00:25:40,960
it it's all purely science fascination

503
00:25:47,380 --> 00:25:44,330
inspiration and interest and it's

504
00:25:51,010 --> 00:25:47,390
because we do some of these things that

505
00:25:52,600 --> 00:25:51,020
are absolutely astounding because we

506
00:25:55,540 --> 00:25:52,610
need to make progress in the science

507
00:26:00,010 --> 00:25:55,550
questions that we want to answer so

508
00:26:03,130 --> 00:26:00,020
engineering feats enable our science in

509
00:26:05,950 --> 00:26:03,140
many many ways and curiosity is a

510
00:26:07,539 --> 00:26:05,960
perfect example of that the engineering

511
00:26:10,330 --> 00:26:07,549
feat provides us an

512
00:26:12,970 --> 00:26:10,340
entree into the public to discuss the

513
00:26:16,029 --> 00:26:12,980

science that we are doing and the and

514
00:26:18,399 --> 00:26:16,039
share in the excitement with what we are

515
00:26:20,470 --> 00:26:18,409
finding out about each and every one of

516
00:26:25,479 --> 00:26:20,480
these bodies and how they relate of

517
00:26:29,409 --> 00:26:25,489
course to our life on this planet as we

518
00:26:31,629 --> 00:26:29,419
look into the outer solar system we see

519
00:26:33,999 --> 00:26:31,639
Jupiter Saturn a number of their

520
00:26:36,210 --> 00:26:34,009
important moons and small bodies and

521
00:26:39,700 --> 00:26:36,220
comets and asteroids and once again

522
00:26:43,749 --> 00:26:39,710
we've we've discovered many many things

523
00:26:46,149 --> 00:26:43,759
primarily from flybys but in the decayed

524
00:26:48,249 --> 00:26:46,159
ille the vision and voyages there are a

525
00:26:52,029 --> 00:26:48,259
number of important missions in terms of

526
00:26:55,590 --> 00:26:52,039
now the next step orbiters we want to be

527
00:26:58,690 --> 00:26:55,600
able to orbit some of these objects like

528
00:27:02,889 --> 00:26:58,700
Europa we want to be able to orbit

529
00:27:06,999 --> 00:27:02,899
Enceladus we want to be able to set down

530
00:27:09,609 --> 00:27:07,009
of various things on tightening and also

531
00:27:13,299 --> 00:27:09,619
interrogate its atmosphere and in fact

532
00:27:16,109 --> 00:27:13,309
if we take tighten as an example we had

533
00:27:19,200 --> 00:27:16,119
an opportunity to break the paradigm of

534
00:27:23,349 --> 00:27:19,210
flyby orbit land Rove in a methodical

535
00:27:26,379 --> 00:27:23,359
fashion with Cassini and Huygens with

536
00:27:29,200 --> 00:27:26,389
Cassini as we flew by Titan we dropped

537
00:27:31,749 --> 00:27:29,210
off the Huygens probe which actually got

538
00:27:35,109 --> 00:27:31,759

down to the ground and landed and made

539
00:27:37,060 --> 00:27:35,119
measurements on the surface not knowing

540
00:27:39,129 --> 00:27:37,070
exactly where it would end up not

541
00:27:41,619 --> 00:27:39,139
knowing if it would end up on a hill or

542
00:27:43,919 --> 00:27:41,629
a methane Lake I believe there was lakes

543
00:27:47,169 --> 00:27:43,929
of methane there and of course there are

544
00:27:50,080 --> 00:27:47,179
but not at that location and we did not

545
00:27:52,090 --> 00:27:50,090
know if Huygens was going to survive it

546
00:27:53,739 --> 00:27:52,100
had Atmos primarily atmospheric

547
00:27:56,049 --> 00:27:53,749
measurements to make so that we could

548
00:27:59,619 --> 00:27:56,059
actually get a good idea from a remote

549
00:28:02,379 --> 00:27:59,629
sensing aspect but indeed it landed and

550
00:28:04,479 --> 00:28:02,389
survived for period of time that was

551
00:28:06,970 --> 00:28:04,489
really quite exciting and very important

552
00:28:10,659 --> 00:28:06,980
and enabled us now to think of new

553
00:28:13,090 --> 00:28:10,669
things that we could do at Titan in that

554
00:28:15,999 --> 00:28:13,100
we want to do and we see that in some of

555
00:28:21,130 --> 00:28:16,009
our proposed proposals that come in and

556
00:28:22,720 --> 00:28:21,140
our discovery calls and once again those

557
00:28:25,330 --> 00:28:22,730
elements that are in blue or those

558
00:28:29,610 --> 00:28:25,340
things that are that are in the visions

559
00:28:32,560 --> 00:28:29,620
and voyages document our next big steps

560
00:28:34,810 --> 00:28:32,570
and the juice mission that's an ISA

561
00:28:38,170 --> 00:28:34,820
mission is also shown there it's going

562
00:28:40,660 --> 00:28:38,180
to end up orbiting gani made nganimate

563
00:28:44,500 --> 00:28:40,670

is our largest moon in our solar system

564
00:28:49,120 --> 00:28:44,510
generates its own magnetic field it's a

565
00:28:52,390 --> 00:28:49,130
ice world it's a much more like we'd say

566
00:28:55,530 --> 00:28:52,400
Callisto and Europa then then I oh for

567
00:28:59,080 --> 00:28:55,540
sure and so it is a fascinating object

568
00:29:02,560 --> 00:28:59,090
flybys by juice of Europa are also

569
00:29:05,380 --> 00:29:02,570
planned and should be quite exciting and

570
00:29:07,750 --> 00:29:05,390
I'm delighted to say NASA is a part of

571
00:29:13,090 --> 00:29:07,760
that of the juice mission which is the

572
00:29:17,670 --> 00:29:13,100
jupiter icy moon Explorer mission in the

573
00:29:20,770 --> 00:29:17,680
area of comets the decadal delineates a

574
00:29:23,320 --> 00:29:20,780
sample return as important elements and

575
00:29:25,330 --> 00:29:23,330
we have Don sample return already with

576
00:29:27,310 --> 00:29:25,340
the Stardust mission one of those things

577
00:29:30,400 --> 00:29:27,320
that we were able to leap frog in this

578
00:29:34,570 --> 00:29:30,410
paradigm and be able to do by flying

579
00:29:37,090 --> 00:29:34,580
through the coma and bringing back

580
00:29:40,330 --> 00:29:37,100
material that have been analyzed and and

581
00:29:45,790 --> 00:29:40,340
now we see another fabulous opportunity

582
00:29:50,470 --> 00:29:45,800
a huge comet called ice on its

583
00:29:54,880 --> 00:29:50,480
perihelion is next year in and around

584
00:29:57,370 --> 00:29:54,890
thanksgiving and the prediction based on

585
00:30:01,960 --> 00:29:57,380
the fact of how bright it is right now

586
00:30:03,670 --> 00:30:01,970
at six astronomical units away it's even

587
00:30:06,790 --> 00:30:03,680
further than the planet jupiter it's

588
00:30:10,230 --> 00:30:06,800

already at 18th magnitude and how close

589
00:30:13,990 --> 00:30:10,240
it gets to the sun which is only 14

590
00:30:17,500 --> 00:30:14,000
million kilometers very close to the sun

591
00:30:20,830 --> 00:30:17,510
that this comet will have a huge tail

592
00:30:23,950 --> 00:30:20,840
many tens of degrees and may actually be

593
00:30:27,010 --> 00:30:23,960
observable during the day that will

594
00:30:30,250 --> 00:30:27,020
capture the that will capture attention

595
00:30:33,190 --> 00:30:30,260
across the world and we're marshaling

596
00:30:34,960 --> 00:30:33,200
resources to take a look now existing

597
00:30:37,240 --> 00:30:34,970
assets that we might be able to

598
00:30:40,450 --> 00:30:37,250
make great measurements and that

599
00:30:45,039 --> 00:30:40,460
includes investigating some potential

600
00:30:48,310 --> 00:30:45,049
balloon observations also near and dear

601
00:30:50,440 --> 00:30:48,320
to my heart is Kristen mention where

602
00:30:52,779 --> 00:30:50,450
we'll go up and hopefully have

603
00:30:56,200 --> 00:30:52,789
instruments available to take a look at

604
00:30:58,240 --> 00:30:56,210
these at ison along with other objects

605
00:31:01,570 --> 00:30:58,250
in the solar system in new and unique

606
00:31:04,120 --> 00:31:01,580
ways in a Quick Reaction capability much

607
00:31:07,720 --> 00:31:04,130
quicker cadence than building a mission

608
00:31:09,520 --> 00:31:07,730
that takes many many years to do here's

609
00:31:12,549 --> 00:31:09,530
our collection of comets that the

610
00:31:16,090 --> 00:31:12,559
international community NASA and ISA and

611
00:31:19,659 --> 00:31:16,100
and the in Russia have and also jaksa

612
00:31:21,430 --> 00:31:19,669
have observed and you can see their

613
00:31:25,450 --> 00:31:21,440

structures quite different these are

614
00:31:28,630 --> 00:31:25,460
typically small bodies 10 or so

615
00:31:32,200 --> 00:31:28,640
kilometers or less in their in their

616
00:31:35,740 --> 00:31:32,210
largest dimension and we flown by most

617
00:31:38,140 --> 00:31:35,750
recently going back to Temple one after

618
00:31:40,299 --> 00:31:38,150
we had an impactor to see the results of

619
00:31:43,029 --> 00:31:40,309
that impact we've done that and that

620
00:31:46,510 --> 00:31:43,039
data is being analyzed the new comet

621
00:31:50,260 --> 00:31:46,520
that we observed over this last year was

622
00:31:54,070 --> 00:31:50,270
Hartley 2 and Hartley 2 was tremendously

623
00:31:57,610 --> 00:31:54,080
exciting we've also from Stardust now

624
00:32:00,399 --> 00:31:57,620
examined material in detail because we

625
00:32:03,220 --> 00:32:00,409
have those samples in our lab and now

626
00:32:05,279 --> 00:32:03,230
it's clear that amino acids and

627
00:32:09,760 --> 00:32:05,289
particularly glycine has been discovered

628
00:32:13,419 --> 00:32:09,770
from those materials returned from will

629
00:32:15,580 --> 00:32:13,429
too from the Stardust mission so these

630
00:32:18,570 --> 00:32:15,590
are incredibly exciting missions and

631
00:32:21,730 --> 00:32:18,580
they're really telling us a lot about

632
00:32:26,169 --> 00:32:21,740
how potential water came to this planet

633
00:32:30,279 --> 00:32:26,179
and the potential building blocks of

634
00:32:32,590 --> 00:32:30,289
life more complex biomolecules coming

635
00:32:35,260 --> 00:32:32,600
from comets and other elements of the

636
00:32:37,510 --> 00:32:35,270
solar system asteroids and as they have

637
00:32:41,039 --> 00:32:37,520
bombarded the earth over time and that

638
00:32:43,600 --> 00:32:41,049

has occurred throughout our solar system

639
00:32:46,680 --> 00:32:43,610
so it gives us the impression that the

640
00:32:48,880 --> 00:32:46,690
conditions of life may be ubiquitous

641
00:32:51,100 --> 00:32:48,890
given the opportunity

642
00:32:53,800 --> 00:32:51,110
an environment an envelope of an

643
00:32:56,350 --> 00:32:53,810
environment to survive and over the last

644
00:32:58,840 --> 00:32:56,360
15 years or so we've invested in the

645
00:33:02,170 --> 00:32:58,850
astrobiology elements bringing people

646
00:33:04,420 --> 00:33:02,180
from planetary science and in biology

647
00:33:07,390 --> 00:33:04,430
together to really tackle some of these

648
00:33:09,880 --> 00:33:07,400
these tough ideas of how life could have

649
00:33:11,830 --> 00:33:09,890
been created and look for life here on

650
00:33:15,130 --> 00:33:11,840
earth in the extremes and we're making

651
00:33:17,950 --> 00:33:15,140
major progress in that area I want to go

652
00:33:21,460 --> 00:33:17,960
back to Hartley 2 this is our most

653
00:33:23,680 --> 00:33:21,470
recent common observations when the

654
00:33:27,660 --> 00:33:23,690
comet scientists saw this particular

655
00:33:31,650 --> 00:33:27,670
image they were absolutely dumbfounded

656
00:33:35,200 --> 00:33:31,660
comets which have a lot of all tools

657
00:33:38,740 --> 00:33:35,210
water in particular and in ammonia and

658
00:33:41,560 --> 00:33:38,750
other elements that once the heat can

659
00:33:45,580 --> 00:33:41,570
sublimate quickly in other words go from

660
00:33:49,240 --> 00:33:45,590
solid into vapor do so on the sunlit

661
00:33:51,940 --> 00:33:49,250
side of the comet and when we look at

662
00:33:55,740 --> 00:33:51,950
this particular comet we see jets of gas

663
00:34:00,190 --> 00:33:55,750

coming from the dark side of this comet

664
00:34:05,130 --> 00:34:00,200
coming from regions that are not in the

665
00:34:08,350 --> 00:34:05,140
sunlight but must somehow be warmed

666
00:34:11,260 --> 00:34:08,360
within that comet that then breaks out

667
00:34:13,480 --> 00:34:11,270
and pushes material outward and in fact

668
00:34:16,600 --> 00:34:13,490
here's a here's a high resolution blow

669
00:34:19,690 --> 00:34:16,610
up there are several frames here that

670
00:34:21,580 --> 00:34:19,700
show you what's happening coming at a

671
00:34:24,639 --> 00:34:21,590
little distance away from the particular

672
00:34:28,210 --> 00:34:24,649
comment and when we analyze this this is

673
00:34:30,970 --> 00:34:28,220
not a star field background the speckles

674
00:34:34,240 --> 00:34:30,980
that are in this image are cometary

675
00:34:37,870 --> 00:34:34,250
material things the size of golf balls

676
00:34:40,770 --> 00:34:37,880
to perhaps as big as volleyballs we're

677
00:34:44,110 --> 00:34:40,780
watching the end state of a comet

678
00:34:48,040 --> 00:34:44,120
completely dissipate within the solar

679
00:34:50,050 --> 00:34:48,050
system it is flying apart this comet has

680
00:34:51,610 --> 00:34:50,060
a period of about six years and many of

681
00:34:54,250 --> 00:34:51,620
the comet scientists say it will

682
00:34:57,160 --> 00:34:54,260
probably not last more than a hundred

683
00:34:59,290 --> 00:34:57,170
but all its material will be scattered

684
00:35:01,840 --> 00:34:59,300
through the solar system and in some

685
00:35:02,410 --> 00:35:01,850
cases we actually orbit through older

686
00:35:05,140 --> 00:35:02,420
paths

687
00:35:07,089 --> 00:35:05,150
of comets and material also comes to the

688
00:35:09,309 --> 00:35:07,099

earth and we still see the excitement of

689
00:35:11,559 --> 00:35:09,319
being able to go out in the field and

690
00:35:12,789 --> 00:35:11,569
bring back some pristine material even

691
00:35:15,520 --> 00:35:12,799
though it's passed through our

692
00:35:18,190 --> 00:35:15,530
atmosphere in the near-earth objects

693
00:35:20,260 --> 00:35:18,200
we're learning a lot more about how

694
00:35:24,370 --> 00:35:20,270
these are fundamental pieces of our

695
00:35:27,579 --> 00:35:24,380
solar system here is observations of an

696
00:35:29,740 --> 00:35:27,589
asteroid called it ikawa and when you

697
00:35:32,589 --> 00:35:29,750
look at that this is not a cratered

698
00:35:36,490 --> 00:35:32,599
filled body this is a body that has

699
00:35:38,500 --> 00:35:36,500
accreted material and in and it's

700
00:35:41,280 --> 00:35:38,510
produced enormous amount of excitement

701
00:35:45,190 --> 00:35:41,290
about these loosely packed

702
00:35:47,650 --> 00:35:45,200
gravitationally centres of material that

703
00:35:50,980 --> 00:35:47,660
come together that form these objects as

704
00:35:53,410 --> 00:35:50,990
part of a building block to even larger

705
00:35:56,020 --> 00:35:53,420
ones and of course well we're quite

706
00:35:59,020 --> 00:35:56,030
interested now in building that next new

707
00:36:00,730 --> 00:35:59,030
frontiers mission osiris-rex that's on

708
00:36:03,370 --> 00:36:00,740
the books and it's moving it's moving

709
00:36:06,670 --> 00:36:03,380
quite nicely forward to bring back

710
00:36:09,660 --> 00:36:06,680
samples from also an important common a

711
00:36:12,730 --> 00:36:09,670
c-type sorry asteroid a c-type asteroid

712
00:36:16,839 --> 00:36:12,740
here are the asteroids that our

713
00:36:20,620 --> 00:36:16,849

spacefaring Nations NASA ISA jaksa and

714
00:36:22,450 --> 00:36:20,630
Russia have observed and visited some on

715
00:36:25,480 --> 00:36:22,460
the way to the outer planets some

716
00:36:28,170 --> 00:36:25,490
intentionally targeted and what's

717
00:36:31,390 --> 00:36:28,180
circled off to the side is the comet

718
00:36:35,500 --> 00:36:31,400
Hartley 2 so you can see the size of

719
00:36:39,130 --> 00:36:35,510
these are very different but as we see

720
00:36:41,289 --> 00:36:39,140
comments now we may see larger ones from

721
00:36:43,480 --> 00:36:41,299
out in the Kuiper belt eventually come

722
00:36:46,630 --> 00:36:43,490
towards us we're quite excited to

723
00:36:48,880 --> 00:36:46,640
understand how large comet Ison is and

724
00:36:51,750 --> 00:36:48,890
it may be one of the largest comments

725
00:36:54,870 --> 00:36:51,760
that we've ever seen and consequently

726
00:36:59,170 --> 00:36:54,880
one of the more exciting objects and

727
00:37:01,089 --> 00:36:59,180
something of a lifetime to observe now I

728
00:37:06,700 --> 00:37:01,099
did want to point out one thing the

729
00:37:10,510 --> 00:37:06,710
largest body on this in this set is the

730
00:37:14,349 --> 00:37:10,520
asteroid lutetia was observed by Rosetta

731
00:37:15,940 --> 00:37:14,359
and in this particular of comparison

732
00:37:18,730 --> 00:37:15,950
Leticia is the one on

733
00:37:22,060 --> 00:37:18,740
far-left it's very small compared to

734
00:37:24,790 --> 00:37:22,070
Vesta and Ceres which are also asteroids

735
00:37:27,700 --> 00:37:24,800
and then of course in size Pluto and the

736
00:37:30,040 --> 00:37:27,710
moon so it gives you a feel for for the

737
00:37:31,720 --> 00:37:30,050
size range of objects that are important

738
00:37:34,690 --> 00:37:31,730

in the solar system and they come in all

739
00:37:38,830 --> 00:37:34,700
sizes but best is incredibly important

740
00:37:42,520 --> 00:37:38,840
Don just left this object this second

741
00:37:45,970 --> 00:37:42,530
largest asteroid on its way now to Ceres

742
00:37:48,190 --> 00:37:45,980
the largest object in the in the

743
00:37:52,180 --> 00:37:48,200
asteroid belt which is about twice the

744
00:37:55,090 --> 00:37:52,190
diameter of a beste from the mineralogy

745
00:37:57,550 --> 00:37:55,100
and as they look at the surface they can

746
00:38:01,510 --> 00:37:57,560
tell some of them bombardments have also

747
00:38:05,320 --> 00:38:01,520
brought perhaps hydrated materials onto

748
00:38:08,140 --> 00:38:05,330
the surface we now know from orbiting

749
00:38:10,660 --> 00:38:08,150
Vesta for nearly a year much more about

750
00:38:14,110 --> 00:38:10,670
its internal structure we believe it has

751
00:38:18,190 --> 00:38:14,120
an iron core that iron core may be more

752
00:38:21,970 --> 00:38:18,200
than two-thirds the size or perhaps a

753
00:38:24,160 --> 00:38:21,980
half to a little larger in size inside

754
00:38:27,580 --> 00:38:24,170
the body so that means this particular

755
00:38:30,130 --> 00:38:27,590
body is differentiated the higher mass

756
00:38:33,310 --> 00:38:30,140
materials moved into the center of the

757
00:38:36,310 --> 00:38:33,320
of the body and we will now look at this

758
00:38:39,010 --> 00:38:36,320
object a little differently as more as a

759
00:38:41,650 --> 00:38:39,020
building block of a planet as a

760
00:38:44,590 --> 00:38:41,660
planetesimals one of the first things

761
00:38:47,980 --> 00:38:44,600
needed before a planet can be accreted

762
00:38:50,110 --> 00:38:47,990
and it's incomplete and in fact as we

763
00:38:52,330 --> 00:38:50,120

look at the asteroid belt the asteroid

764
00:38:54,990 --> 00:38:52,340
belt is not necessarily made up of

765
00:38:57,970 --> 00:38:55,000
material that just is blasted apart

766
00:38:59,680 --> 00:38:57,980
moons there are objects that are planets

767
00:39:02,680 --> 00:38:59,690
that were there in the past but in

768
00:39:05,410 --> 00:39:02,690
reality it's a set of material that is

769
00:39:08,230 --> 00:39:05,420
trying to become a planet but Jupiter is

770
00:39:11,140 --> 00:39:08,240
not letting it happen Jupiter's gravity

771
00:39:13,210 --> 00:39:11,150
is keeping it apart but so when we go to

772
00:39:15,220 --> 00:39:13,220
when we go to the asteroid belt we're

773
00:39:17,980 --> 00:39:15,230
actually going back in time and seeing

774
00:39:19,660 --> 00:39:17,990
some of the early processes the earth

775
00:39:25,480 --> 00:39:19,670
must have started out in this particular

776
00:39:28,420 --> 00:39:25,490
way and evolved so let me end in the

777
00:39:29,799 --> 00:39:28,430
time I have and and now show the total

778
00:39:32,920 --> 00:39:29,809
the total view

779
00:39:36,219 --> 00:39:32,930
future planetary missions what we've

780
00:39:38,259 --> 00:39:36,229
done flyby orbit land rova cross our

781
00:39:41,829 --> 00:39:38,269
solar system we'd love to do that to

782
00:39:45,069 --> 00:39:41,839
every object we cannot we have to be

783
00:39:47,799 --> 00:39:45,079
quite selective but but what has come

784
00:39:52,089 --> 00:39:47,809
before informs us as to what we will do

785
00:39:54,489 --> 00:39:52,099
next as we go from a flyby to sample

786
00:39:56,769 --> 00:39:54,499
return the cost of these missions go up

787
00:39:59,109 --> 00:39:56,779
and in many regions of the solar system

788
00:40:01,779 --> 00:39:59,119

where we have to depend on sample return

789
00:40:04,870 --> 00:40:01,789
those are the highest costs but they are

790
00:40:08,589 --> 00:40:04,880
the highest science return so in summary

791
00:40:12,099 --> 00:40:08,599
this field is matured greatly in 50

792
00:40:14,739 --> 00:40:12,109
years it has actually been created by

793
00:40:16,239 --> 00:40:14,749
NASA because we can bring this data back

794
00:40:18,249 --> 00:40:16,249
to the earth and we can bring these

795
00:40:22,479 --> 00:40:18,259
samples back and really see what's

796
00:40:24,729 --> 00:40:22,489
happening and in fact what we believe

797
00:40:26,769 --> 00:40:24,739
will happen over the next year is those

798
00:40:30,729 --> 00:40:26,779
important missions will be in the green

799
00:40:32,319 --> 00:40:30,739
areas that's will be the next big steps

800
00:40:34,140 --> 00:40:32,329
that the scientists will want to do

801
00:40:36,539 --> 00:40:34,150
we're also seeing a lot of

802
00:40:38,349 --> 00:40:36,549
interdisciplinary activity

803
00:40:40,719 --> 00:40:38,359
astrophysicists want to know from

804
00:40:43,120 --> 00:40:40,729
planetary scientists now as they find

805
00:40:45,509 --> 00:40:43,130
exoplanets what should they be looking

806
00:40:48,759 --> 00:40:45,519
for what are the atmospheres like and

807
00:40:51,880 --> 00:40:48,769
why are you join 'it's like jupiter in

808
00:40:53,979 --> 00:40:51,890
orbits that are interior to what mercury

809
00:40:57,459 --> 00:40:53,989
is there's no Jupiter like that there

810
00:41:01,150 --> 00:40:57,469
but this tells us how planets evolved in

811
00:41:05,469 --> 00:41:01,160
a solar system how planets migrate and

812
00:41:07,479 --> 00:41:05,479
move they are not static and that must

813
00:41:09,969 --> 00:41:07,489

have happened in ours and that's also

814
00:41:11,890 --> 00:41:09,979
providing a new perspective on how our

815
00:41:15,759 --> 00:41:11,900
origin and evolution of the solar system

816
00:41:18,459 --> 00:41:15,769
came about and finally also we're

817
00:41:20,499 --> 00:41:18,469
working with our science as we look at

818
00:41:23,319 --> 00:41:20,509
Venus and as we look at Mars it also

819
00:41:25,209 --> 00:41:23,329
informs us about climate change and

820
00:41:28,890 --> 00:41:25,219
other phenomena that are similar in

821
00:41:34,199 --> 00:41:28,900
those planets those terrestrial planets

822
00:41:44,120 --> 00:41:34,209
and so let me conclude with that and

823
00:41:52,410 --> 00:41:49,770
Annie Jim that was great talk I'm

824
00:41:53,880 --> 00:41:52,420
wondering you know in light of the

825
00:41:58,620 --> 00:41:53,890
comments that were made in the last

826
00:42:01,500 --> 00:41:58,630
panel where people were saying that we

827
00:42:03,570 --> 00:42:01,510
should expect more crises in the future

828
00:42:07,380 --> 00:42:03,580
that will make it very hard to plan

829
00:42:10,380 --> 00:42:07,390
strategically all of that sure from your

830
00:42:12,770 --> 00:42:10,390
perspective is somebody who's really on

831
00:42:16,650 --> 00:42:12,780
the front lines of the current crisis

832
00:42:19,770 --> 00:42:16,660
and fighting the good fight and trying

833
00:42:23,010 --> 00:42:19,780
to implement the decayed ille against

834
00:42:26,340 --> 00:42:23,020
these budgetary obstacles do you think

835
00:42:27,680 --> 00:42:26,350
we're at a point where the planetary

836
00:42:31,790 --> 00:42:27,690
program is in need of another

837
00:42:35,130 --> 00:42:31,800
reinvention or do we just need to be

838
00:42:38,430 --> 00:42:35,140

telling the story to the public more

839
00:42:40,680 --> 00:42:38,440
compellingly or both or what ok that's a

840
00:42:42,990 --> 00:42:40,690
good question up I'll tell you my

841
00:42:45,060 --> 00:42:43,000
opinion you know and it may not be the

842
00:42:46,980 --> 00:42:45,070
right right way to go but I believe we

843
00:42:49,170 --> 00:42:46,990
have a fundamental foundation to move

844
00:42:52,260 --> 00:42:49,180
forward worth with and that's the vision

845
00:42:55,800 --> 00:42:52,270
in Boise staccato it just started this

846
00:42:59,099 --> 00:42:55,810
month we've got 10 years to step up to

847
00:43:01,800 --> 00:42:59,109
the plate and live that we have also 10

848
00:43:04,380 --> 00:43:01,810
years of budget cycles now even though

849
00:43:07,109 --> 00:43:04,390
we cannot start missions that don't have

850
00:43:09,450 --> 00:43:07,119
a projected budget whether the president

851
00:43:11,310 --> 00:43:09,460
provides it to Congress or congress

852
00:43:13,050 --> 00:43:11,320
insists on it but the president still

853
00:43:15,540 --> 00:43:13,060
has to provide it in his projection

854
00:43:18,390 --> 00:43:15,550
we've got time to work things out you

855
00:43:21,480 --> 00:43:18,400
know I always said success breeds

856
00:43:25,740 --> 00:43:21,490
success but but that actually is rather

857
00:43:29,910 --> 00:43:25,750
naive it really is very naive and it

858
00:43:33,930 --> 00:43:29,920
requires a the community to get more

859
00:43:36,060 --> 00:43:33,940
involved and telling the people that pay

860
00:43:38,520 --> 00:43:36,070
the taxes that allow us to do these

861
00:43:41,160 --> 00:43:38,530
fabulous things the return on their

862
00:43:44,430 --> 00:43:41,170
investment in planetary science its

863
00:43:47,490 --> 00:43:44,440

enormous in many different ways all the

864
00:43:51,450 --> 00:43:47,500
way from inspirational to perhaps a

865
00:43:53,560 --> 00:43:51,460
necessity and runs the gamut and it

866
00:43:56,410 --> 00:43:53,570
inspires kids

867
00:43:58,720 --> 00:43:56,420
it allows them to consider more

868
00:44:00,790 --> 00:43:58,730
technical careers as we've heard that's

869
00:44:02,140 --> 00:44:00,800
you know you can talk to anybody in the

870
00:44:04,300 --> 00:44:02,150
field how they got where they are

871
00:44:06,820 --> 00:44:04,310
there's some inspirational factor that

872
00:44:10,450 --> 00:44:06,830
does that we all have our stories in

873
00:44:12,340 --> 00:44:10,460
that l and in that way and and we need

874
00:44:15,610 --> 00:44:12,350
to keep that going we really need to

875
00:44:19,060 --> 00:44:15,620
keep that going but the start is in our

876
00:44:21,040 --> 00:44:19,070
chart the green one where each and every

877
00:44:24,010 --> 00:44:21,050
one of those elements the fabulous stuff

878
00:44:26,830 --> 00:44:24,020
we do all successful we have a great

879
00:44:29,620 --> 00:44:26,840
track record now several those missions

880
00:44:33,730 --> 00:44:29,630
that we've built like juno came on time

881
00:44:39,130 --> 00:44:33,740
and under cost Grail on time and under

882
00:44:41,710 --> 00:44:39,140
cost' MSL Curiosity rover we missed we

883
00:44:43,810 --> 00:44:41,720
missed a launch window you know a

884
00:44:46,090 --> 00:44:43,820
planetary window was a blessing and a

885
00:44:48,160 --> 00:44:46,100
curse so blessing because we got to get

886
00:44:50,680 --> 00:44:48,170
it done and get it off this planet it's

887
00:44:54,460 --> 00:44:50,690
a curse if we miss it it's going to cost

888
00:44:56,320 --> 00:44:54,470

more and so yeah it over ran and we had

889
00:44:58,750 --> 00:44:56,330
people even if we solved all the

890
00:45:01,090 --> 00:44:58,760
technical problems one month after the

891
00:45:03,280 --> 00:45:01,100
launch window expired we'd still have to

892
00:45:06,040 --> 00:45:03,290
be paying for because they are needed to

893
00:45:10,920 --> 00:45:06,050
get the thing down to the surface so it

894
00:45:13,710 --> 00:45:10,930
is a tough field to do you know I often

895
00:45:16,690 --> 00:45:13,720
even when I talk to congressional

896
00:45:20,250 --> 00:45:16,700
staffers try to give them a little feel

897
00:45:22,540 --> 00:45:20,260
on how tough it is and one day I said

898
00:45:24,730 --> 00:45:22,550
you know what I don't understand is how

899
00:45:26,320 --> 00:45:24,740
come you can have somebody come in and

900
00:45:28,660 --> 00:45:26,330
build your kitchen and not stay on

901
00:45:31,630 --> 00:45:28,670
budget how many kitchens have we built

902
00:45:32,860 --> 00:45:31,640
in this country and and and of course

903
00:45:34,240 --> 00:45:32,870
one of the staffers said how did you

904
00:45:38,320 --> 00:45:34,250
know I was building a kitchen and it's

905
00:45:40,630 --> 00:45:38,330
over so this is a really tough business

906
00:45:43,420 --> 00:45:40,640
but I believe now we have management

907
00:45:46,900 --> 00:45:43,430
techniques and employed and a whole

908
00:45:50,800 --> 00:45:46,910
variety of tools and and the oversight

909
00:45:52,960 --> 00:45:50,810
that we need to give us now confidence

910
00:45:55,570 --> 00:45:52,970
that we can we can tell the American

911
00:45:59,620 --> 00:45:55,580
public that these missions are going to

912
00:46:05,280 --> 00:45:59,630
stay in cost and on schedule and be more

913
00:46:09,400 --> 00:46:05,290

truthful than we ever have before Wes

914
00:46:11,380 --> 00:46:09,410
okay Andy was the hard ball pitcher I'm

915
00:46:14,020 --> 00:46:11,390
gonna beat a softball pitcher for you ok

916
00:46:16,030 --> 00:46:14,030
ok you know planetary exploration has

917
00:46:19,180 --> 00:46:16,040
been steep since its beginning in this

918
00:46:23,200 --> 00:46:19,190
in this progression Ulm antra you know

919
00:46:25,570 --> 00:46:23,210
fly by then orbit right and land and in

920
00:46:28,780 --> 00:46:25,580
the last couple of decades we've added

921
00:46:30,660 --> 00:46:28,790
you know Rove and sample return but

922
00:46:34,240 --> 00:46:30,670
given what we've learned about Mars

923
00:46:36,400 --> 00:46:34,250
places like Europa and instance and sell

924
00:46:41,650 --> 00:46:36,410
this what do you think about adding

925
00:46:43,690 --> 00:46:41,660
another one drill that's easy to get the

926
00:46:46,090 --> 00:46:43,700
samples we want we got to get under the

927
00:46:48,880 --> 00:46:46,100
surface you know that we we know the

928
00:46:50,860 --> 00:46:48,890
aquifers are there on Mars where there's

929
00:46:52,510 --> 00:46:50,870
water on this earth you can't go

930
00:46:54,640 --> 00:46:52,520
anywhere and find a thimble full of

931
00:46:56,500 --> 00:46:54,650
water and not find life in it that's

932
00:46:58,630 --> 00:46:56,510
where you got to go we got to get under

933
00:47:02,710 --> 00:46:58,640
the surface and we know that now and

934
00:47:05,770 --> 00:47:02,720
it's true at Europa too so so drill is

935
00:47:08,740 --> 00:47:05,780
an element of one of the tools that we

936
00:47:10,660 --> 00:47:08,750
need to bring with us you bet yes sir

937
00:47:12,460 --> 00:47:10,670
okay let me go over to Harry and it will

938
00:47:15,730 --> 00:47:12,470

get back Harry lambright Maxwell school

939
00:47:17,860 --> 00:47:15,740
Syracuse University back in the 1980s

940
00:47:20,950 --> 00:47:17,870
during this drought of planetary

941
00:47:24,010 --> 00:47:20,960
programs and a time when there were

942
00:47:29,110 --> 00:47:24,020
questions in the White House of phasing

943
00:47:31,120 --> 00:47:29,120
out JPL one of the ways JPL survived was

944
00:47:34,630 --> 00:47:31,130
through a fairly significant work for

945
00:47:38,070 --> 00:47:34,640
others program in other words a large

946
00:47:40,900 --> 00:47:38,080
part of the workforce which could not

947
00:47:42,760 --> 00:47:40,910
anymore or be supported by NASA was

948
00:47:47,200 --> 00:47:42,770
supported by the Defense Department and

949
00:47:49,240 --> 00:47:47,210
other agencies in looking ahead as you

950
00:47:52,480 --> 00:47:49,250
look to preserving your assets

951
00:47:54,450 --> 00:47:52,490
particularly JPL against and keeping

952
00:47:58,660 --> 00:47:54,460
some of these geniuses that work there

953
00:48:02,170 --> 00:47:58,670
how do you are you considering the work

954
00:48:04,180 --> 00:48:02,180
for others program again I think the

955
00:48:07,090 --> 00:48:04,190
heart of you're the aunt to my answer to

956
00:48:10,930 --> 00:48:07,100
your question is balance every Center

957
00:48:13,600 --> 00:48:10,940
including our contractor facilities need

958
00:48:17,140 --> 00:48:13,610
to be looking at how they can diversify

959
00:48:19,150 --> 00:48:17,150
and that they can balance the workload

960
00:48:22,180 --> 00:48:19,160
and and that's very diff

961
00:48:25,720 --> 00:48:22,190
hope to do in tough times and so

962
00:48:28,420 --> 00:48:25,730
consequently you know organizations that

963
00:48:30,820 --> 00:48:28,430

survivor those that in that that have

964
00:48:34,420 --> 00:48:30,830
work in different areas that are related

965
00:48:36,880 --> 00:48:34,430
where skills can be utilized across the

966
00:48:39,250 --> 00:48:36,890
board in many different ways and and

967
00:48:40,840 --> 00:48:39,260
sometimes it increases and sometimes it

968
00:48:44,050 --> 00:48:40,850
decreases because of the political

969
00:48:46,030 --> 00:48:44,060
environment we are in and i believe JPL

970
00:48:49,710 --> 00:48:46,040
is working hard to be continue that

971
00:48:52,840 --> 00:48:49,720
process of diversification and right now

972
00:48:55,570 --> 00:48:52,850
i'm also working hard to provide funding

973
00:48:58,270 --> 00:48:55,580
that will neighbor our whole science

974
00:49:01,360 --> 00:48:58,280
community to be able to get back to the

975
00:49:06,010 --> 00:49:01,370
business of planetary science as as

976
00:49:07,810 --> 00:49:06,020
delineated in the decade oh thanks yeah

977
00:49:10,000 --> 00:49:07,820
one more question yeah you show the

978
00:49:12,640 --> 00:49:10,010
beautiful picture of it ikawa the

979
00:49:15,010 --> 00:49:12,650
Hayabusa mission what samples back to

980
00:49:17,430 --> 00:49:15,020
earth is dead in Australia was there

981
00:49:19,720 --> 00:49:17,440
anything significant found from that

982
00:49:21,460 --> 00:49:19,730
mission and have one of the question

983
00:49:24,490 --> 00:49:21,470
quickly will it ever be a conflict

984
00:49:27,730 --> 00:49:24,500
between NASA and Planetary an asteroidal

985
00:49:29,980 --> 00:49:27,740
exploration and the mining group that

986
00:49:34,180 --> 00:49:29,990
want to go out and mine asteroids okay

987
00:49:39,790 --> 00:49:34,190
so let me take the sample brought back

988
00:49:41,860 --> 00:49:39,800

from Hayabusa with a bit ikawa we had an

989
00:49:43,480 --> 00:49:41,870
arrangement with the japanese to be able

990
00:49:45,280 --> 00:49:43,490
to share about ten percent of those

991
00:49:47,260 --> 00:49:45,290
samples and those samples have come back

992
00:49:49,210 --> 00:49:47,270
and there are many of those now are in

993
00:49:51,850 --> 00:49:49,220
our own archiving and we've gone through

994
00:49:54,070 --> 00:49:51,860
the process of having them sent out to

995
00:49:56,350 --> 00:49:54,080
many people in the community right now

996
00:49:58,390 --> 00:49:56,360
one of the top things that have coming

997
00:50:01,630 --> 00:49:58,400
out of that is an understanding of what

998
00:50:04,330 --> 00:50:01,640
we would call space weathering all right

999
00:50:07,800 --> 00:50:04,340
these bodies exist in the solar system

1000
00:50:11,560 --> 00:50:07,810
are bathed in the solar wind for

1001
00:50:15,280 --> 00:50:11,570
billions of years and so the solar wind

1002
00:50:18,130 --> 00:50:15,290
it impacts gets embedded in the material

1003
00:50:20,920 --> 00:50:18,140
and so when we take a spectrum of it the

1004
00:50:23,080 --> 00:50:20,930
spectrum doesn't give us what really the

1005
00:50:25,210 --> 00:50:23,090
material is all about because of the

1006
00:50:27,310 --> 00:50:25,220
space weather and we get different we

1007
00:50:30,340 --> 00:50:27,320
get different spectral features then

1008
00:50:32,440 --> 00:50:30,350
then then we know how to interpret so

1009
00:50:35,440 --> 00:50:32,450
with the samples now in hand we now

1010
00:50:37,780 --> 00:50:35,450
can separate space weather effects from

1011
00:50:39,760 --> 00:50:37,790
actual mineralogy which is what we want

1012
00:50:41,710 --> 00:50:39,770
to get out now we've seen that most

1013
00:50:44,050 --> 00:50:41,720

recently with another rubble pile that

1014
00:50:46,720 --> 00:50:44,060
actually passed by the earth and it

1015
00:50:48,880 --> 00:50:46,730
passed close enough that the gravitation

1016
00:50:52,510 --> 00:50:48,890
of the earth rearranged it and the

1017
00:50:55,089 --> 00:50:52,520
spectrum before it encountered closest

1018
00:50:57,400 --> 00:50:55,099
approach and the spectrum after were

1019
00:51:00,339 --> 00:50:57,410
night and day and it's because the

1020
00:51:02,620 --> 00:51:00,349
pristine material got sifted to the top

1021
00:51:04,510 --> 00:51:02,630
and we were able to look at it that's

1022
00:51:06,609 --> 00:51:04,520
also another excellent example of how

1023
00:51:08,109 --> 00:51:06,619
we're now looking at the environment in

1024
00:51:10,810 --> 00:51:08,119
the space weathering and what it does to

1025
00:51:14,670 --> 00:51:10,820
those bodies thank you remember my other

1026
00:51:19,150 --> 00:51:14,680
question between Planetary astronomers

1027
00:51:22,030 --> 00:51:19,160
and the possible mining yeah oh yeah the

1028
00:51:26,890 --> 00:51:22,040
mining group yeah yeah now that we know

1029
00:51:30,400 --> 00:51:26,900
much more about material in space that's

1030
00:51:34,210 --> 00:51:30,410
a resource whether whether there are

1031
00:51:37,290 --> 00:51:34,220
commercial companies or their material

1032
00:51:39,550 --> 00:51:37,300
is needed to support human exploration

1033
00:51:42,339 --> 00:51:39,560
both those groups will need to know

1034
00:51:45,069 --> 00:51:42,349
what's out there we're at an infancy

1035
00:51:47,530 --> 00:51:45,079
really in understanding we got a lot to

1036
00:51:49,930 --> 00:51:47,540
do before we can say this is a place you

1037
00:51:52,270 --> 00:51:49,940
need to go to mine this tungsten or

1038
00:51:54,370 --> 00:51:52,280

whatever it happens to be that they

1039
00:51:56,230 --> 00:51:54,380
might be looking for I see no conflict

1040
00:52:00,160 --> 00:51:56,240
certainly ought not over the next ten

1041
00:52:01,930 --> 00:52:00,170
years thank you you're very welcome all

1042
00:52:07,809 --> 00:52:01,940
right I think that's the the end of the

1043
00:52:09,910 --> 00:52:07,819
question period however however what's

1044
00:52:14,349 --> 00:52:09,920
really critical that from my perspective

1045
00:52:16,210 --> 00:52:14,359
is that I've told you from a science

1046
00:52:18,400 --> 00:52:16,220
perspective what's going on and in many

1047
00:52:20,319 --> 00:52:18,410
ways we're really down in the weeds

1048
00:52:22,240 --> 00:52:20,329
we're really looking at what what we're

1049
00:52:24,300 --> 00:52:22,250
doing and how we're doing it and we're

1050
00:52:27,550 --> 00:52:24,310
her it's hard for us to tell the story

1051
00:52:32,380 --> 00:52:27,560
it's really the historians it's really

1052
00:52:34,510 --> 00:52:32,390
you that have a job to do also to write

1053
00:52:36,160 --> 00:52:34,520
about how these programs are connected

1054
00:52:39,099 --> 00:52:36,170
the things that we're finding out and

1055
00:52:43,059 --> 00:52:39,109
help relay that to the general

1056
00:52:44,680 --> 00:52:43,069
population and and and the public and

1057
00:52:46,210 --> 00:52:44,690
and and that's one of the reasons why

1058
00:52:49,060 --> 00:52:46,220
I'm really excited about

1059
00:52:50,620 --> 00:52:49,070
this particular anniversary bringing us

1060
00:52:56,500 --> 00:52:50,630
together to be able to talk about these

1061
00:52:59,950 --> 00:52:56,510
things now with that let me ask Steven

1062
00:53:02,140 --> 00:52:59,960
Williams to provide me the set of

1063
00:53:05,410 --> 00:53:02,150

information that I desperately want to

1064
00:53:08,740 --> 00:53:05,420
do next all right a planetary science

1065
00:53:11,470 --> 00:53:08,750
division at NASA headquarters from time

1066
00:53:13,660 --> 00:53:11,480
to time takes the opportunity to really

1067
00:53:15,640 --> 00:53:13,670
recognize major achievements that have

1068
00:53:18,070 --> 00:53:15,650
occurred in in the field of planetary

1069
00:53:20,620 --> 00:53:18,080
science and I'm delighted to be able to

1070
00:53:22,180 --> 00:53:20,630
do that today with many people that are

1071
00:53:25,089 --> 00:53:22,190
sitting in this audience that have

1072
00:53:28,870 --> 00:53:25,099
really made a difference and in fact of

1073
00:53:30,640 --> 00:53:28,880
the the inscription says in recognition

1074
00:53:33,010 --> 00:53:30,650
and appreciation of your leadership

1075
00:53:37,240 --> 00:53:33,020
towards solar system exploration and

1076
00:53:45,070 --> 00:53:37,250
discovery you have made a difference and

1077
00:53:55,190 --> 00:53:45,080
the first awardee is Joe Alexander I saw

1078
00:53:59,700 --> 00:53:57,630
well as a scientist you've been working

1079
00:54:02,460 --> 00:53:59,710
hard over the years a lot of things

1080
00:54:04,860 --> 00:54:02,470
happen heading the group of Goddard and

1081
00:54:06,930 --> 00:54:04,870
doing so well that it's very much

1082
00:54:08,460 --> 00:54:06,940
appreciated and indeed have made a

1083
00:54:16,650 --> 00:54:08,470
difference Thank You Thanksgiving you've

1084
00:54:19,760 --> 00:54:16,660
done the next individual I'd like to

1085
00:54:22,380 --> 00:54:19,770
honor and it's also my great pleasure

1086
00:54:28,970 --> 00:54:22,390
knowing this individual actually for

1087
00:54:40,010 --> 00:54:36,420
Jim oh you was here all right all right

1088
00:54:42,330 --> 00:54:40,020

well you'll learn much more about Jim is

1089
00:54:45,540 --> 00:54:42,340
he's one of the panelists I believe

1090
00:54:48,030 --> 00:54:45,550
tomorrow afternoon but indeed Jim Jim

1091
00:54:50,510 --> 00:54:48,040
not only has been involved in in

1092
00:54:53,040 --> 00:54:50,520
planetary missions early on his

1093
00:54:57,920 --> 00:54:53,050
dedication to educating the next

1094
00:55:00,750 --> 00:54:57,930
generation is absolutely unbelievable

1095
00:55:03,750 --> 00:55:00,760
and and needs to be recognized for all

1096
00:55:07,950 --> 00:55:03,760
he's done for that so Jim I know your

1097
00:55:15,960 --> 00:55:07,960
ears are burning the next individual is

1098
00:55:26,349 --> 00:55:22,930
and as I mentioned early earlier the

1099
00:55:29,769 --> 00:55:26,359
history of the solar system and how it's

1100
00:55:35,229 --> 00:55:29,779
and how we learn and understand what

1101
00:55:37,539 --> 00:55:35,239
we're doing very important you've made

1102
00:55:39,759 --> 00:55:37,549
it made a major difference with many of

1103
00:55:47,349 --> 00:55:39,769
the writings that you getting like you

1104
00:55:49,029 --> 00:55:47,359
very much okay my pleasure you know some

1105
00:55:51,549 --> 00:55:49,039
of the fantastic things that we do in

1106
00:55:54,430 --> 00:55:51,559
planetary science is start out with a

1107
00:55:56,440 --> 00:55:54,440
particular mission and figure out under

1108
00:55:59,410 --> 00:55:56,450
on their tough budget constraints what

1109
00:56:01,390 --> 00:55:59,420
else we can do with it and the master of

1110
00:56:06,700 --> 00:56:01,400
being able to do that is the next

1111
00:56:14,979 --> 00:56:06,710
awardee and that's Bob Farquhar Bob's

1112
00:56:18,880 --> 00:56:14,989
areas my first interaction with bob was

1113
00:56:23,739 --> 00:56:18,890

when he was involved in moving the ic3

1114
00:56:27,609 --> 00:56:23,749
mission from a up front in the solar

1115
00:56:30,309 --> 00:56:27,619
wind to fly by comet jacobi knees okay

1116
00:56:32,079 --> 00:56:30,319
we'll do it this way bob bob has to do

1117
00:56:36,969 --> 00:56:32,089
it his own way you know I said and that

1118
00:56:39,279 --> 00:56:36,979
hasn't changed and Bobby's I like to be

1119
00:56:41,160 --> 00:56:39,289
known as NASA's number one troublemaker

1120
00:56:49,680 --> 00:56:41,170
yes

1121
00:56:59,220 --> 00:56:53,260
I'll check for the stick the next one

1122
00:57:03,730 --> 00:56:59,230
I'd like to recognize is scott hubbard

1123
00:57:07,210 --> 00:57:03,740
shocked him yes right Scott Scott is an

1124
00:57:11,620 --> 00:57:07,220
individual many talents and one of those

1125
00:57:14,080 --> 00:57:11,630
talents that he's going to talk about is

1126
00:57:16,600 --> 00:57:14,090
indeed the ability to help put back a

1127
00:57:19,630 --> 00:57:16,610
program sell that program make it happen

1128
00:57:21,760 --> 00:57:19,640
and it's just reaped enormous benefits

1129
00:57:30,690 --> 00:57:21,770
for us and the community and this nation

1130
00:57:47,500 --> 00:57:37,480
pleasure Jim high jumper great damn I

1131
00:57:49,720 --> 00:57:47,510
just gave me an award here we go watch

1132
00:57:53,230 --> 00:57:49,730
out for the wonderful movie where the

1133
00:57:58,510 --> 00:57:53,240
guy was in the crapper when they were

1134
00:58:02,770 --> 00:57:58,520
trying all right okay Jim thanks so much

1135
00:58:05,460 --> 00:58:02,780
all your working in NASA and also

1136
00:58:19,930 --> 00:58:05,470
educating that next generation yeah

1137
00:58:27,830 --> 00:58:23,780
the next individual is also someone I've

1138
00:58:30,170 --> 00:58:27,840

known for many many years who's near and

1139
00:58:33,130 --> 00:58:30,180
dear to my heart has made a major

1140
00:58:52,990 --> 00:58:33,140
contribution of the field in many ways

1141
00:59:01,170 --> 00:58:56,740
it just got a few more here one

1142
00:59:04,870 --> 00:59:01,180
scientist that I believe as has really

1143
00:59:06,610 --> 00:59:04,880
epitomized the best in many different

1144
00:59:08,920 --> 00:59:06,620
ways in terms of being a solid

1145
00:59:11,470 --> 00:59:08,930
scientists working hard to relate that

1146
00:59:14,020 --> 00:59:11,480
science and talking about it in a way

1147
00:59:16,450 --> 00:59:14,030
that many can understand it not not in

1148
00:59:38,210 --> 00:59:16,460
not directly in their field and that's

1149
00:59:46,760 --> 00:59:40,849
up the next individual is really quite

1150
00:59:48,620 --> 00:59:46,770
unique his of his ability to his driving

1151
00:59:52,910 --> 00:59:48,630
ability to be part of a science

1152
00:59:56,150 --> 00:59:52,920
community and and exemplify the best in

1153
01:00:00,710 --> 00:59:56,160
as a scientist as a program manager and

1154
01:00:18,349 --> 01:00:00,720
as an educator and do it in Russia and

1155
01:00:23,850 --> 01:00:18,359
that's Mikhail more off Mikhail thank

1156
01:00:30,280 --> 01:00:28,240
one of the things that is difficult to

1157
01:00:34,180 --> 01:00:30,290
explain to people apparently is how

1158
01:00:35,890 --> 01:00:34,190
expensive our space systems are and in

1159
01:00:38,770 --> 01:00:35,900
this particular way you know we have to

1160
01:00:40,690 --> 01:00:38,780
take our power with us we have to go to

1161
01:00:43,060 --> 01:00:40,700
the far reaches of the solar system and

1162
01:00:45,040 --> 01:00:43,070
take plutonium and that's not cheap and

1163
01:00:47,590 --> 01:00:45,050

the systems that we have to develop that

1164
01:00:52,150 --> 01:00:47,600
manage that that that type of resource

1165
01:00:55,030 --> 01:00:52,160
is also very expensive and it's a it's a

1166
01:00:59,110 --> 01:00:55,040
delight to give Ralph mcnutt the next

1167
01:01:02,680 --> 01:00:59,120
award for how he has worked hard to tell

1168
01:01:04,150 --> 01:01:02,690
the story of radioisotopes our systems

1169
01:01:31,240 --> 01:01:04,160
in addition to being an outstanding

1170
01:01:38,720 --> 01:01:34,610
the last recipient really needs no

1171
01:01:40,790 --> 01:01:38,730
introduction this individual has been

1172
01:01:44,810 --> 01:01:40,800
what I would call founding father of

1173
01:01:47,960 --> 01:01:44,820
planetary science and has managed a

1174
01:01:51,790 --> 01:01:47,970
major center JPL has managed to major

1175
01:01:55,130 --> 01:01:51,800
spacecraft and many others in a way that

1176
01:01:58,130 --> 01:01:55,140
has really a stirred interest and

1177
01:02:00,260 --> 01:01:58,140
excitement and my first foray into

1178
01:02:02,990 --> 01:02:00,270
planetary science was writing papers

1179
01:02:05,840 --> 01:02:03,000
about Jupiter's dekha metric and killa

1180
01:02:26,580 --> 01:02:05,850
metric radiation from the voyagers this

1181
01:02:33,300 --> 01:02:29,770
ok we have a request for a real quick

1182
01:02:37,030 --> 01:02:33,310
group picture and we have time for that

1183
01:02:38,380 --> 01:02:37,040
we're over alright okay if we could

1184
01:02:40,120 --> 01:02:38,390
bring everybody up for a real quick

1185
01:02:45,550 --> 01:02:40,130
group picture that would be super and

1186
01:02:49,660 --> 01:02:45,560
then we'll get off the stage yeah