1
00:00:04,280 --> 00:00:02,360
and I will direct a few questions and

2
00:00:08,059 --> 00:00:04,290
then we'll open it up completely

3
00:00:09,980 --> 00:00:08,069
I'll be introducing each speaker as we

4
00:00:13,100 --> 00:00:09,990
proceed I'm going to start with dr. Edie

5
00:00:14,299 --> 00:00:13,110
Crawley Edie is a professor in the

6
00:00:16,640 --> 00:00:14,309
Department of aeronautics and

7
00:00:19,040 --> 00:00:16,650
Astronautics at MIT he has been the

8
00:00:21,740 --> 00:00:19,050
chairman of that department

9
00:00:24,109 --> 00:00:21,750
he holds a number of chairs at MIT he's

10
00:00:25,970 --> 00:00:24,119
Ford professor of engineering as well as

11
00:00:27,980 --> 00:00:25,980
professor of Aero and Astro and of

12
00:00:30,919 --> 00:00:27,990
engineering systems he was a member of

13
00:00:33,260 --> 00:00:30,929

the 1993 presidential advisory panel on

14
00:00:35,930 --> 00:00:33,270
the space station redesign he recently

15
00:00:37,610 --> 00:00:35,940
co-chaired the committee of the National

16
00:00:39,530 --> 00:00:37,620
Research Council's review of the NASA

17
00:00:42,709 --> 00:00:39,540
exploration technology development

18
00:00:44,660 --> 00:00:42,719
program and most recently he served as a

19
00:00:47,029 --> 00:00:44,670
member of the review of human space

20
00:00:49,279 --> 00:00:47,039
flight plans committee the Augustine

21
00:00:51,470 --> 00:00:49,289
committee about which one heard briefly

22
00:00:53,840 --> 00:00:51,480
from norm Augustine earlier this

23
00:00:56,959 --> 00:00:53,850
afternoon so ed I wonder if you'd start

24
00:01:00,080 --> 00:00:56,969
us off with some discussion of the

25
00:01:01,160 --> 00:01:00,090
flexible path and how it relates to our

26
00:01:02,990 --> 00:01:01,170
plans going forward

27
00:01:05,690 --> 00:01:03,000
thank you John I'm gonna step up and

28
00:01:09,830 --> 00:01:05,700
walk over here with the mic so that I

29
00:01:14,030 --> 00:01:09,840
can look at the charts along with you if

30
00:01:16,969 --> 00:01:14,040
we can go actually back one I entitled

31
00:01:18,980 --> 00:01:16,979
this talk which is based pretty directly

32
00:01:20,840 --> 00:01:18,990
on the findings of the Augustine panel

33
00:01:22,880 --> 00:01:20,850
although there's a few additional

34
00:01:25,640 --> 00:01:22,890
editorial comments a new exploration

35
00:01:29,210 --> 00:01:25,650
strategy because I think at the highest

36
00:01:31,100 --> 00:01:29,220
level that's what the discussion that

37
00:01:33,590 --> 00:01:31,110
the president presented today is about

38
00:01:37,550 --> 00:01:33,600

that this is not only a new place to go

39
00:01:43,190 --> 00:01:37,560
or a new way to get there this is really

40
00:01:46,520 --> 00:01:43,200
a new strategy for exploring space in

41
00:01:49,670 --> 00:01:46,530
the Augustine panel we actually began in

42
00:01:51,859 --> 00:01:49,680
a remarkably coherent system engineering

43
00:01:55,999 --> 00:01:51,869
way about thinking about what the goals

44
00:01:58,039 --> 00:01:56,009
were for human exploration that human

45
00:02:00,859 --> 00:01:58,049
exploration is a credible partner of

46
00:02:02,959 --> 00:02:00,869
science that it develops technology both

47
00:02:06,709 --> 00:02:02,969
for space for NASA for other users of

48
00:02:08,809 --> 00:02:06,719
space and for use on the earth that it

49
00:02:10,660 --> 00:02:08,819
produces in dec economic development and

50
00:02:12,860 --> 00:02:10,670
industrial capability and that of course

51
00:02:15,340 --> 00:02:12,870
exploration prepares for further

52
00:02:18,020 --> 00:02:15,350
exploration

53
00:02:20,030 --> 00:02:18,030
that these are the tangible benefits and

54
00:02:21,650 --> 00:02:20,040
then of course particularly in the

55
00:02:24,110 --> 00:02:21,660
policy environment there are less

56
00:02:25,910 --> 00:02:24,120
tangible benefits u.s. leadership of

57
00:02:27,770 --> 00:02:25,920
international ventures the soft power

58
00:02:30,020 --> 00:02:27,780
that comes from leading international

59
00:02:31,460 --> 00:02:30,030
endeavors engagement of the public and

60
00:02:34,490 --> 00:02:31,470
and particularly inspiration of the

61
00:02:37,210 --> 00:02:34,500
youth now at this point you're saying

62
00:02:39,530 --> 00:02:37,220
why is he reading off these platitudes

63
00:02:41,870 --> 00:02:39,540

because this is more or less the list

64
00:02:43,760 --> 00:02:41,880
that we all acknowledge and in fact most

65
00:02:47,330 --> 00:02:43,770
of this is expressed in the Space Act of

66
00:02:49,130 --> 00:02:47,340
58 well the reason we read that I'm

67
00:02:51,170 --> 00:02:49,140
spending time on this list of platitudes

68
00:02:53,450 --> 00:02:51,180
is that to have a sustainable space

69
00:02:58,700 --> 00:02:53,460
program you actually should do these

70
00:03:02,450 --> 00:02:58,710
things how's that for a revolutionary

71
00:03:05,960 --> 00:03:02,460
idea right and in particular I will

72
00:03:07,640 --> 00:03:05,970
quote the words from the letters of the

73
00:03:10,550 --> 00:03:07,650
three Apollo commanders that was

74
00:03:12,080 --> 00:03:10,560
distributed earlier this week American

75
00:03:15,830 --> 00:03:12,090
heroes for whom I have the highest

76
00:03:19,520 --> 00:03:15,840
admiration they said Apollo inspired a

77
00:03:21,680 --> 00:03:19,530
generation of Americans and it did and

78
00:03:24,640 --> 00:03:21,690
I'm here along with the president as a

79
00:03:27,400 --> 00:03:24,650
result of that inspiration but

80
00:03:30,320 --> 00:03:27,410
exploration is a but not about

81
00:03:33,520 --> 00:03:30,330
venerating the past exploration is about

82
00:03:37,160 --> 00:03:33,530
inspiring the leaders of the future and

83
00:03:38,810 --> 00:03:37,170
the most important one of these that we

84
00:03:41,449 --> 00:03:38,820
found the most disconnect in the

85
00:03:44,330 --> 00:03:41,459
Augustine panel this summer with is the

86
00:03:46,820 --> 00:03:44,340
inspiration of youth we found very few

87
00:03:50,390 --> 00:03:46,830
young people who were inspired about

88
00:03:52,820 --> 00:03:50,400

going back to the moon 50 years after we

89
00:03:54,830 --> 00:03:52,830
had been there it was a tremendous

90
00:03:59,420 --> 00:03:54,840
accomplishment and they've read about it

91
00:04:02,000 --> 00:03:59,430
in the history books we actually applied

92
00:04:05,780 --> 00:04:02,010
these platitudes towards helping select

93
00:04:07,310 --> 00:04:05,790
a strategy and we called them goals you

94
00:04:10,070 --> 00:04:07,320
know and I'll ask you the record

95
00:04:14,120 --> 00:04:10,080
question did the previous program

96
00:04:17,930 --> 00:04:14,130
inspire America's youth did the previous

97
00:04:21,199 --> 00:04:17,940
program engage the public did the

98
00:04:24,159 --> 00:04:21,209
previous program demonstrate effective

99
00:04:27,320 --> 00:04:24,169
leadership of international endeavors

100
00:04:28,100 --> 00:04:27,330
did the previous program stimulate

101
00:04:31,999 --> 00:04:28,110
economic to

102
00:04:34,939 --> 00:04:32,009
element did the previous program develop

103
00:04:38,140 --> 00:04:34,949
new technologies for use by NASA other

104
00:04:40,790 --> 00:04:38,150
users of space and the general public I

105
00:04:43,640 --> 00:04:40,800
asked these rhetorically but these are

106
00:04:46,159 --> 00:04:43,650
important considerations it did go

107
00:04:48,469 --> 00:04:46,169
directly to its sustainability that we

108
00:04:52,670 --> 00:04:48,479
actually tried to craft a strategy that

109
00:04:57,589 --> 00:04:52,680
would do these things next slide please

110
00:05:00,379 --> 00:04:57,599
and and I think a remarkable moment one

111
00:05:03,619 --> 00:05:00,389
one evening this summer this very

112
00:05:06,110 --> 00:05:03,629
diverse group of panelists from industry

113
00:05:09,320 --> 00:05:06,120

from government from academia from

114
00:05:12,369 --> 00:05:09,330
science from technology all very quickly

115
00:05:15,529 --> 00:05:12,379
and unanimously endorsed this statement

116
00:05:17,899 --> 00:05:15,539
that Mars really is the ultimate

117
00:05:21,860 --> 00:05:17,909
destination for human exploration of the

118
00:05:24,200 --> 00:05:21,870
inner solar system that staying on Mars

119
00:05:26,959 --> 00:05:24,210
and extending human civilization within

120
00:05:28,670 --> 00:05:26,969
the solar system should be our goal that

121
00:05:31,519 --> 00:05:28,680
this is difficult

122
00:05:33,950 --> 00:05:31,529
it will require a lengthy commitment we

123
00:05:37,159 --> 00:05:33,960
actually heard the president say that he

124
00:05:40,279 --> 00:05:37,169
hopes to see some of this happen in his

125
00:05:45,260 --> 00:05:40,289
lifetime but it's a time to begin along

126
00:05:48,110 --> 00:05:45,270
this pathway and that these goals the

127
00:05:50,180 --> 00:05:48,120
goals expressed in the important policy

128
00:05:51,529 --> 00:05:50,190
documents that have been promulgated by

129
00:05:54,409 --> 00:05:51,539
both Republican and Democratic

130
00:05:57,459 --> 00:05:54,419
administrations that are central to the

131
00:06:01,999 --> 00:05:57,469
Space Act should guide our our

132
00:06:05,119 --> 00:06:02,009
exploration next chart please now this

133
00:06:07,189 --> 00:06:05,129
one chart sort of summarizes as best I

134
00:06:10,040 --> 00:06:07,199
can the thinking of the the Augustine

135
00:06:12,649 --> 00:06:10,050
panel this summer that we started off

136
00:06:16,070 --> 00:06:12,659
and said well we got all these questions

137
00:06:17,990 --> 00:06:16,080
should we do something with the ISS or

138
00:06:19,550 --> 00:06:18,000

retire it should we go to the moon or

139
00:06:23,749 --> 00:06:19,560
something like the flexible path or Mars

140
00:06:27,369 --> 00:06:23,759
and very quickly we actually arrived at

141
00:06:31,059 --> 00:06:27,379
the conclusion that we should not

142
00:06:35,300 --> 00:06:31,069
disregard the ISS but embrace the ISS

143
00:06:37,969 --> 00:06:35,310
the ISS really is a laboratory that we

144
00:06:41,790 --> 00:06:37,979
can use and I should say that this was

145
00:06:44,309 --> 00:06:41,800
not a panel of ISS huggers

146
00:06:46,050 --> 00:06:44,319
this is a panel many of whom many of

147
00:06:48,600 --> 00:06:46,060
whom were on record at one point or

148
00:06:50,490 --> 00:06:48,610
another as having said the ISS was

149
00:06:54,600 --> 00:06:50,500
perhaps not the greatest investment of

150
00:06:56,399 --> 00:06:54,610
NASA's 20 years of effort to build it so

151
00:06:59,010 --> 00:06:56,409
this is sort of an only Nixon could go

152
00:07:00,960 --> 00:06:59,020
to China moment you know that these

153
00:07:03,689 --> 00:07:00,970
previous critics of the ISS that said

154
00:07:05,700 --> 00:07:03,699
now we can envision a strategy that

155
00:07:06,559 --> 00:07:05,710
engages the ISS News and I'll come back

156
00:07:08,610 --> 00:07:06,569
to that for about it

157
00:07:09,749 --> 00:07:08,620
okay so then that leaves the moon

158
00:07:13,159 --> 00:07:09,759
flexible anthem artists well the next

159
00:07:16,260 --> 00:07:13,169
conclusion is you can't go to Mars now

160
00:07:18,600 --> 00:07:16,270
that we don't have the technology and we

161
00:07:19,890 --> 00:07:18,610
don't have the National Treasury to do

162
00:07:23,450 --> 00:07:19,900
it and do it safely

163
00:07:25,680 --> 00:07:23,460

so we then moved Mars off into the

164
00:07:28,409 --> 00:07:25,690
long-term goal that we should move

165
00:07:31,140 --> 00:07:28,419
towards Mars but we should not plan to

166
00:07:33,540 --> 00:07:31,150
go and land on the surface of Mars in

167
00:07:35,730 --> 00:07:33,550
the immediate future and that left us

168
00:07:38,399 --> 00:07:35,740
with after the ISS these two

169
00:07:40,649 --> 00:07:38,409
intermediate pathways going to the moon

170
00:07:44,430 --> 00:07:40,659
or going along the deep space part of

171
00:07:46,439 --> 00:07:44,440
the flexible path exploring the Lagrange

172
00:07:48,689 --> 00:07:46,449
points though the asteroids and so forth

173
00:07:51,480 --> 00:07:48,699
as the president discussed earlier now

174
00:07:56,089 --> 00:07:51,490
I'll ask you if you were the president

175
00:08:03,180 --> 00:07:56,099
in 2035 and the administrator of NASA

176
00:08:05,100 --> 00:08:03,190
came to you and said mr. president we

177
00:08:07,140 --> 00:08:05,110
have spent the last 10 years going to

178
00:08:09,269 --> 00:08:07,150
the moon we have developed the

179
00:08:12,420 --> 00:08:09,279
capability to land on planetary bodies

180
00:08:15,390 --> 00:08:12,430
and to Rove around and explore but no

181
00:08:16,890 --> 00:08:15,400
American or no international partner has

182
00:08:20,580 --> 00:08:16,900
ever been more than three and a half

183
00:08:25,670 --> 00:08:20,590
days away from the earth we're ready to

184
00:08:33,089 --> 00:08:30,659
that's not a credible explanation on the

185
00:08:36,560 --> 00:08:33,099
other hand if you'd been on the flexible

186
00:08:38,670 --> 00:08:36,570
path and you'd spent a decade or so

187
00:08:40,279 --> 00:08:38,680
exploring deep space going to lie

188
00:08:44,040 --> 00:08:40,289

bration points and so forth and

189
00:08:46,410 --> 00:08:44,050
asteroids and in orbiting Mars but had

190
00:08:48,449 --> 00:08:46,420
never had not since Buzz and Neil and

191
00:08:51,030 --> 00:08:48,459
the others were there landed on a

192
00:08:52,829 --> 00:08:51,040
planetary surface would you would you

193
00:08:55,260 --> 00:08:52,839
say that we're ready to land on Mars

194
00:08:59,310 --> 00:08:55,270
also probably not

195
00:08:59,820 --> 00:08:59,320
so in all likelihood before we land on

196
00:09:02,430 --> 00:08:59,830
Mars

197
00:09:04,590 --> 00:09:02,440
we'll have done some combination of both

198
00:09:07,170 --> 00:09:04,600
the deep space part of the flexible path

199
00:09:09,630 --> 00:09:07,180
and done some test flights to the moon

200
00:09:13,680 --> 00:09:09,640
and the only real question is one of

201
00:09:16,230 --> 00:09:13,690
order or sequence but these give us two

202
00:09:18,210 --> 00:09:16,240
types of capabilities they teach us and

203
00:09:19,710 --> 00:09:18,220
they allow us to develop the operational

204
00:09:22,710 --> 00:09:19,720
competence to work on a planetary body

205
00:09:25,680 --> 00:09:22,720
and to work in deep space in a way from

206
00:09:28,019 --> 00:09:25,690
the in the full radiation dose of deep

207
00:09:30,480 --> 00:09:28,029
space so that leads us to this lower

208
00:09:33,630 --> 00:09:30,490
corner diagram and when you do this you

209
00:09:36,329 --> 00:09:33,640
realize the ISS actually can now play

210
00:09:38,670 --> 00:09:36,339
some new roles the ISS can play the role

211
00:09:40,730 --> 00:09:38,680
not only of human physiological studies

212
00:09:43,199 --> 00:09:40,740
and so forth but if things like

213
00:09:45,510 --> 00:09:43,209

experimentation and fuel transfer it

214
00:09:49,710 --> 00:09:45,520
could actually even be an operational

215
00:09:51,150 --> 00:09:49,720
base for early early missions so this is

216
00:09:55,170 --> 00:09:51,160
the the diagram that I'll leave you with

217
00:09:57,180 --> 00:09:55,180
for a second next chart so what is the

218
00:09:59,880 --> 00:09:57,190
flexible path as we discussed it in the

219
00:10:02,970 --> 00:09:59,890
in the Augustine report it's it's it's a

220
00:10:05,340 --> 00:10:02,980
new strategy it's to travel many places

221
00:10:10,050 --> 00:10:05,350
in the inner solar system but initially

222
00:10:13,050 --> 00:10:10,060
not walk on the surface there are over a

223
00:10:15,510 --> 00:10:13,060
hundred thousand bodies in the solar

224
00:10:18,750 --> 00:10:15,520
system inside of the radius of Jupiter

225
00:10:22,170 --> 00:10:18,760
and by my count you can only land on

226
00:10:25,380 --> 00:10:22,180
four or five or six of them the moon

227
00:10:27,780 --> 00:10:25,390
Mars two of the Galilean moons of

228
00:10:31,230 --> 00:10:27,790
Jupiter and maybe a few of the largest

229
00:10:33,960 --> 00:10:31,240
asteroids all the rest of them you would

230
00:10:36,510 --> 00:10:33,970
visit by going near them and bumping

231
00:10:39,030 --> 00:10:36,520
into them or making samples of them or

232
00:10:42,600 --> 00:10:39,040
operating around them much like you

233
00:10:44,850 --> 00:10:42,610
operate in the vicinity of the ISS they

234
00:10:47,780 --> 00:10:44,860
either don't have the gravity to sustain

235
00:10:50,819 --> 00:10:47,790
a landing you just bounce off of them or

236
00:10:52,860 --> 00:10:50,829
they're inhospitable enough like Venus

237
00:10:56,400 --> 00:10:52,870
that you would never venture down to the

238
00:10:58,319 --> 00:10:56,410

surface with humans so the idea that

239
00:11:01,019 --> 00:10:58,329
we're going to explore the solar system

240
00:11:04,590 --> 00:11:01,029
by landing on things is actually more a

241
00:11:06,540 --> 00:11:04,600
rarity than the general rule most of the

242
00:11:09,210 --> 00:11:06,550
places we might want to go you actually

243
00:11:11,699 --> 00:11:09,220
want to encounter not land

244
00:11:14,910 --> 00:11:11,709
and when you encounter it creates a new

245
00:11:17,670 --> 00:11:14,920
opportunity for a synthesis of robotic

246
00:11:20,040 --> 00:11:17,680
and human exploration you get near the

247
00:11:23,220 --> 00:11:20,050
you get near the body you send out

248
00:11:25,889 --> 00:11:23,230
probes you robotically capture samples

249
00:11:28,309 --> 00:11:25,899
you bring them back for analysis you

250
00:11:31,379 --> 00:11:28,319
operate teller robots on the surface I

251
00:11:33,720 --> 00:11:31,389
hesitate to say this but you basically

252
00:11:39,210 --> 00:11:33,730
enter a standard orbit scan the surface

253
00:11:43,230 --> 00:11:39,220
and send down a class a probe some of

254
00:11:44,790 --> 00:11:43,240
you remember that that reference so this

255
00:11:47,160 --> 00:11:44,800
is a strategy that is as the name

256
00:11:49,530 --> 00:11:47,170
implies flexible it's enabled by

257
00:11:54,540 --> 00:11:49,540
capability and it's guided by discovery

258
00:11:56,550 --> 00:11:54,550
next chart now if you sort of plot out

259
00:11:58,980 --> 00:11:56,560
where you might go in the inner solar

260
00:12:01,619 --> 00:11:58,990
system it's interesting that the world

261
00:12:03,840 --> 00:12:01,629
sort of falls into about three bands and

262
00:12:05,429 --> 00:12:03,850
the most important parameter here as as

263
00:12:08,429 --> 00:12:05,439

all the rocket scientists in the road

264
00:12:10,230 --> 00:12:08,439
room know is that the the energy

265
00:12:12,119 --> 00:12:10,240
increment represented in Delta V from

266
00:12:14,100 --> 00:12:12,129
low-earth orbit and you notice there's a

267
00:12:15,600 --> 00:12:14,110
whole set of things the earth-moon

268
00:12:17,100 --> 00:12:15,610
Lagrange points lunar orbit or a Sun

269
00:12:20,449 --> 00:12:17,110
Lagrange points near-earth objects and a

270
00:12:22,860 --> 00:12:20,459
Mars flyby that are a relatively modest

271
00:12:25,439 --> 00:12:22,870
Delta V increment from Earth orbit and

272
00:12:26,790 --> 00:12:25,449
then there's the lunar surface and then

273
00:12:28,889 --> 00:12:26,800
there's getting to the surface of Mars

274
00:12:30,389 --> 00:12:28,899
and remember the rocket equation is not

275
00:12:33,540 --> 00:12:30,399
linear as I would say in one of my

276
00:12:36,090 --> 00:12:33,550
classes at MIT it's highly nonlinear so

277
00:12:36,689 --> 00:12:36,100
it's significantly harder to get 10

278
00:12:38,400 --> 00:12:36,699
Delta

279
00:12:41,040 --> 00:12:38,410
10 meters 10 kilometers a second of

280
00:12:43,230 --> 00:12:41,050
Delta V out of a system than five so

281
00:12:44,579 --> 00:12:43,240
it's actually the difficulty in moving

282
00:12:46,889 --> 00:12:44,589
to the more distant locations is

283
00:12:48,509 --> 00:12:46,899
underrepresented by this plot so there's

284
00:12:51,540 --> 00:12:48,519
this set of things that if you could

285
00:12:53,970 --> 00:12:51,550
move around with about five or six

286
00:12:55,740 --> 00:12:53,980
kilometers a second of Delta V you could

287
00:12:59,129 --> 00:12:55,750
travel lots of places and let's look at

288
00:13:01,110 --> 00:12:59,139

what they are next chart this sort of

289
00:13:05,420 --> 00:13:01,120
represents a schematic first you would

290
00:13:07,679 --> 00:13:05,430
probably go to lunar orbit or

291
00:13:09,030 --> 00:13:07,689
interestingly we didn't put it in the

292
00:13:11,549 --> 00:13:09,040
report but another alternative is

293
00:13:13,790 --> 00:13:11,559
geosynchronous orbit it would have

294
00:13:16,439 --> 00:13:13,800
interesting service implications and

295
00:13:18,240 --> 00:13:16,449
frankly security implications if

296
00:13:21,030 --> 00:13:18,250
Americans could routinely travel to

297
00:13:22,920 --> 00:13:21,040
geosynchronous orbit I would consider

298
00:13:25,079 --> 00:13:22,930
the orbital flight

299
00:13:28,019 --> 00:13:25,089
this is Apollo 8 to go to the moon and

300
00:13:29,820 --> 00:13:28,029
orbit it that's test flight that

301
00:13:32,940 --> 00:13:29,830
basically says to the world we could

302
00:13:34,650 --> 00:13:32,950
return to the moon anytime we chose I'm

303
00:13:36,990 --> 00:13:34,660
not convinced that we need to win the

304
00:13:41,280 --> 00:13:37,000
race to the moon to be the first nation

305
00:13:45,210 --> 00:13:41,290
there the second time we've been there

306
00:13:47,250 --> 00:13:45,220
well some of us have been there but then

307
00:13:49,050 --> 00:13:47,260
we go to the earth moon the places the

308
00:13:51,090 --> 00:13:49,060
the Lagrangian and I'll talk about those

309
00:13:55,710 --> 00:13:51,100
in a second then the near-earth objects

310
00:13:57,150 --> 00:13:55,720
and then in 2025 or 2028 the NASA

311
00:13:59,400 --> 00:13:57,160
Administrator and the president can

312
00:14:01,410 --> 00:13:59,410
decide what the right depending on what

313
00:14:02,790 --> 00:14:01,420

we've learned and what capabilities we

314
00:14:04,530 --> 00:14:02,800
could we have developed we could go to

315
00:14:08,820 --> 00:14:04,540
the lunar surface we could go to Mars

316
00:14:12,510 --> 00:14:08,830
flybys there's some very nice missions

317
00:14:14,220 --> 00:14:12,520
that go to Mars and and sort of get a

318
00:14:16,500 --> 00:14:14,230
deceleration in the vicinity of Mars

319
00:14:18,810 --> 00:14:16,510
spend some time there get another

320
00:14:20,460 --> 00:14:18,820
acceleration off Mars come back so that

321
00:14:22,110 --> 00:14:20,470
you could actually operate in a flyby in

322
00:14:25,110 --> 00:14:22,120
the vicinity of Mars for a reasonable at

323
00:14:27,300 --> 00:14:25,120
a time or and they all eventually end up

324
00:14:27,900 --> 00:14:27,310
with some sort of landing on the surface

325
00:14:32,100 --> 00:14:27,910
of the Moon

326
00:14:33,540 --> 00:14:32,110
next chart please so here are a sampling

327
00:14:35,519 --> 00:14:33,550
of the places you could go on the

328
00:14:37,350 --> 00:14:35,529
flexible path this chart is in the

329
00:14:40,490 --> 00:14:37,360
report but I want to spend a little bit

330
00:14:43,440 --> 00:14:40,500
of time on it but not too much time

331
00:14:45,990 --> 00:14:43,450
Thank You mr. chairman I'm almost done

332
00:14:48,690 --> 00:14:46,000
so there are the destinations on the

333
00:14:50,690 --> 00:14:48,700
left-hand side there are types of things

334
00:14:53,340 --> 00:14:50,700
that you could use to engage the public

335
00:14:56,340 --> 00:14:53,350
that you can see listed here there are

336
00:14:58,170 --> 00:14:56,350
opportunities to do science in most of

337
00:15:00,480 --> 00:14:58,180
these places and my other colleagues

338
00:15:02,449 --> 00:15:00,490

will speak about that but the chart the

339
00:15:04,800 --> 00:15:02,459
column on this chart that actually

340
00:15:08,220 --> 00:15:04,810
causes it to make sense is the one

341
00:15:11,069 --> 00:15:08,230
called human research the big unknown

342
00:15:12,840 --> 00:15:11,079
about going to Mars or going anywhere

343
00:15:16,019 --> 00:15:12,850
other than the surface of the Moon

344
00:15:18,750 --> 00:15:16,029
frankly is the human adaptation to

345
00:15:21,300 --> 00:15:18,760
prolong weightlessness radiation and

346
00:15:23,940 --> 00:15:21,310
psychological stress and if you were to

347
00:15:26,430 --> 00:15:23,950
design a research program you would

348
00:15:29,069 --> 00:15:26,440
design it in such a way that you did a

349
00:15:31,650 --> 00:15:29,079
couple of weeks of this a couple of

350
00:15:34,170 --> 00:15:31,660
months of this a half a year of this a

351
00:15:36,870 --> 00:15:34,180
year of this a couple of years of this

352
00:15:39,210 --> 00:15:36,880
and steadily like in a Gemini like

353
00:15:41,490 --> 00:15:39,220
build up the confidence to do it and if

354
00:15:45,660 --> 00:15:41,500
you read down the human research column

355
00:15:48,870 --> 00:15:45,670
you see that somewhat by coincidence but

356
00:15:53,060 --> 00:15:48,880
luck favors the informed the choice of

357
00:15:56,490 --> 00:15:53,070
these destinations causes a sequence of

358
00:15:58,710 --> 00:15:56,500
human exposure and human duration that

359
00:16:00,210 --> 00:15:58,720
allows us to develop the confidence for

360
00:16:05,760 --> 00:16:00,220
the length of missions necessary to go

361
00:16:09,480 --> 00:16:05,770
to Mars last chart or next chart I'm

362
00:16:11,700 --> 00:16:09,490
sorry this is just it sort of laid out

363
00:16:14,370 --> 00:16:11,710

as a timeline which I'll skip over next

364
00:16:16,200 --> 00:16:14,380
chart this is actually a more

365
00:16:17,550 --> 00:16:16,210
interesting view now I have to warn you

366
00:16:20,730 --> 00:16:17,560
that these are figures from the

367
00:16:22,290 --> 00:16:20,740
Augustine report which assumed a higher

368
00:16:25,140 --> 00:16:22,300
budgetary level than is in the

369
00:16:29,700 --> 00:16:25,150
president's current plan but it gives

370
00:16:31,190 --> 00:16:29,710
you some sense at the top is what would

371
00:16:34,080 --> 00:16:31,200
have happened if we had run out

372
00:16:36,570 --> 00:16:34,090
constellation invested in technology and

373
00:16:38,310 --> 00:16:36,580
extended the ISS and you can see that it

374
00:16:42,120 --> 00:16:38,320
causes a lunar landing to occur in the

375
00:16:47,010 --> 00:16:42,130
late 2020s with an additional as norm

376
00:16:49,170 --> 00:16:47,020
said 60 billion dollars of investment

377
00:16:51,990 --> 00:16:49,180
over node above the president's FY oh

378
00:16:56,160 --> 00:16:52,000
nine budget if we do the flexible path

379
00:17:00,300 --> 00:16:56,170
we get out of low Earth orbit by the

380
00:17:03,600 --> 00:17:00,310
early to mid 2020s shortly after the ISS

381
00:17:07,400 --> 00:17:03,610
might wrap up and there's a sequence a

382
00:17:10,319 --> 00:17:07,410
steady cadence of trips to new places

383
00:17:13,260 --> 00:17:10,329
beyond the earth-moon system on an

384
00:17:16,650 --> 00:17:13,270
annual basis next chart please

385
00:17:21,059 --> 00:17:16,660
and the reason why this sequence makes

386
00:17:22,650 --> 00:17:21,069
sense is really very simple especially

387
00:17:25,679 --> 00:17:22,660
if you've ever been a project manager

388
00:17:27,929 --> 00:17:25,689

there are essentially four big pieces

389
00:17:30,150 --> 00:17:27,939
that you have to develop in order to

390
00:17:33,120 --> 00:17:30,160
land on a planetary surface a heavy lift

391
00:17:35,610 --> 00:17:33,130
vehicle a capsule a lander and a surface

392
00:17:38,670 --> 00:17:35,620
infrastructure if the first destination

393
00:17:41,160 --> 00:17:38,680
is the surface of anything you have to

394
00:17:46,440 --> 00:17:41,170
build all four of those systems before

395
00:17:48,960 --> 00:17:46,450
you can go if use this deep-space route

396
00:17:50,580 --> 00:17:48,970
to the flexible path you can build the

397
00:17:55,649 --> 00:17:50,590
booster and the capsule and start

398
00:17:57,720 --> 00:17:55,659
going while so that roughly speaking in

399
00:17:59,640 --> 00:17:57,730
the 20s you topper ate the deep space

400
00:18:01,890 --> 00:17:59,650
systems and build the planetary surface

401
00:18:03,299 --> 00:18:01,900
systems so then the 30s you could

402
00:18:07,440 --> 00:18:03,309
operate the planetary surface systems

403
00:18:09,960 --> 00:18:07,450
next turn so just to summarize these are

404
00:18:12,180 --> 00:18:09,970
the things that are the benefits of the

405
00:18:13,950 --> 00:18:12,190
flexible path it's a faster start you

406
00:18:16,620 --> 00:18:13,960
get out of low Earth orbit soon

407
00:18:18,600 --> 00:18:16,630
you go to Podesta nations humans have

408
00:18:21,419 --> 00:18:18,610
never been inspiring America's youth

409
00:18:23,970 --> 00:18:21,429
there's a regular cadence of exploration

410
00:18:25,590 --> 00:18:23,980
of new things you are developing the

411
00:18:28,260 --> 00:18:25,600
deep-space capability you need to go to

412
00:18:30,600 --> 00:18:28,270
Mars there's an authentic synthesis of

413
00:18:32,250 --> 00:18:30,610

humans and robots opportunities for

414
00:18:35,010 --> 00:18:32,260
interests interesting science you get

415
00:18:36,240 --> 00:18:35,020
this beneficial development profile you

416
00:18:38,610 --> 00:18:36,250
have an opportunity to engage

417
00:18:41,419 --> 00:18:38,620
international partners in a new way and

418
00:18:43,649 --> 00:18:41,429
it represents generational change I

419
00:18:46,649 --> 00:18:43,659
think this is in some sense the most

420
00:18:48,960 --> 00:18:46,659
profound thing this is a way that young

421
00:18:51,990 --> 00:18:48,970
people today would think about exploring

422
00:18:54,779 --> 00:18:52,000
and it will engage them and make

423
00:19:02,850 --> 00:18:54,789
progress towards our ultimate goal thank

424
00:19:06,090 --> 00:19:02,860
you very much ed I'm now going to turn

425
00:19:08,100 --> 00:19:06,100
to dr. G Scott Hubbard he was the

426
00:19:09,899 --> 00:19:08,110
program manager of the lunar prospector

427
00:19:11,570 --> 00:19:09,909
mission and was the first Mars program

428
00:19:14,279 --> 00:19:11,580
director at NASA headquarters

429
00:19:16,350 --> 00:19:14,289
successfully restructuring NASA's

430
00:19:19,710 --> 00:19:16,360
approach to Mars exploration after a

431
00:19:21,870 --> 00:19:19,720
number of failures he is a past director

432
00:19:24,539 --> 00:19:21,880
of NASA's Ames Research Center and the

433
00:19:25,980 --> 00:19:24,549
NASA Astrobiology Institute served as a

434
00:19:28,440 --> 00:19:25,990
member of the Columbia accident

435
00:19:30,779 --> 00:19:28,450
investigation board he's currently a

436
00:19:32,850 --> 00:19:30,789
professor at Stanford University where

437
00:19:35,610 --> 00:19:32,860
he works on the study of both human and

438
00:19:38,010 --> 00:19:35,620

robotic exploration of space as well as

439
00:19:43,289 --> 00:19:38,020
continued research in astrobiology dr.

440
00:19:49,960 --> 00:19:46,480
use this microphone and so I can see the

441
00:19:52,390 --> 00:19:49,970
charts let me build on the excellent

442
00:19:55,360 --> 00:19:52,400
introduction by Ed Crawley go to the

443
00:19:58,419 --> 00:19:55,370
next chart I want to talk primarily

444
00:20:01,150 --> 00:19:58,429
about robotic exploration in the

445
00:20:03,400 --> 00:20:01,160
beginnings of the true convergence of

446
00:20:06,640 --> 00:20:03,410
robotic and human exploration for both

447
00:20:09,060 --> 00:20:06,650
science national interest inspiration

448
00:20:11,850 --> 00:20:09,070
return on investment and the other

449
00:20:15,220 --> 00:20:11,860
platitudes that are the never less real

450
00:20:18,970 --> 00:20:15,230
objectives of the space program and I

451
00:20:20,470 --> 00:20:18,980
want to say something that I haven't

452
00:20:23,980 --> 00:20:20,480
been allowed to say for a while but

453
00:20:29,250 --> 00:20:23,990
under this new program I can say space

454
00:20:35,919 --> 00:20:33,159
sometimes thank you there were times

455
00:20:37,900 --> 00:20:35,929
when between never met but now we're

456
00:20:40,990 --> 00:20:37,910
allowed to say what we're really doing

457
00:20:43,960 --> 00:20:41,000
all humans are sometimes physically

458
00:20:46,299 --> 00:20:43,970
present as buzz was but many times we

459
00:20:48,789 --> 00:20:46,309
send our robotic emissaries now robots

460
00:20:50,590 --> 00:20:48,799
are terrific at the 3ds the dull the

461
00:20:53,669 --> 00:20:50,600
dirty the dangerous work and they

462
00:20:56,280 --> 00:20:53,679
generally do what you tell them to do

463
00:21:00,430 --> 00:20:56,290

humans however we've got two million

464
00:21:04,630 --> 00:21:00,440
years of evolution in our current form

465
00:21:08,260 --> 00:21:04,640
and our AI brain body combination gives

466
00:21:10,299 --> 00:21:08,270
us unmatched adaptability and an

467
00:21:12,310 --> 00:21:10,309
unstructured environment and that's the

468
00:21:14,560 --> 00:21:12,320
key because if you're going to a world

469
00:21:16,570 --> 00:21:14,570
you've never been to before you need to

470
00:21:19,900 --> 00:21:16,580
be able to prepare to react to the

471
00:21:22,180 --> 00:21:19,910
unexpected so consider all the science

472
00:21:25,840 --> 00:21:22,190
goals the National Academy has been

473
00:21:28,419 --> 00:21:25,850
looking at many of them can be very

474
00:21:31,080 --> 00:21:28,429
effectively and efficiently done without

475
00:21:35,620 --> 00:21:31,090
human intervention on the surface

476
00:21:37,600 --> 00:21:35,630
however there are a series of science

477
00:21:40,210 --> 00:21:37,610
goals where humans would be particularly

478
00:21:43,270 --> 00:21:40,220
even exceptionally value but valuable

479
00:21:46,030 --> 00:21:43,280
particularly picking out samples and

480
00:21:49,630 --> 00:21:46,040
making judgments about what science to

481
00:21:51,549 --> 00:21:49,640
do how to react to being around another

482
00:21:53,910 --> 00:21:51,559
world or on the surface of another world

483
00:21:57,360 --> 00:21:53,920
I think this budget advances

484
00:21:59,340 --> 00:21:57,370
of those goals so next chart I wanna

485
00:22:02,840 --> 00:21:59,350
talk just a minute about what I think is

486
00:22:06,060 --> 00:22:02,850
the scientific heart of exploration

487
00:22:08,730 --> 00:22:06,070
astrobiology was a term invented for

488
00:22:10,860 --> 00:22:08,740

these purposes about 14 years ago now

489
00:22:13,590 --> 00:22:10,870
for almost 15 it only has three

490
00:22:17,670 --> 00:22:13,600
questions where did we come from are we

491
00:22:20,130 --> 00:22:17,680
alone where are we going easy questions

492
00:22:22,250 --> 00:22:20,140
very tough to get the answers but this

493
00:22:25,650 --> 00:22:22,260
synthesis this multidisciplinary

494
00:22:27,600 --> 00:22:25,660
convergence of Sciences seeks to find

495
00:22:30,120 --> 00:22:27,610
the answers to these questions by

496
00:22:32,520 --> 00:22:30,130
looking at things like is an environment

497
00:22:34,740 --> 00:22:32,530
habitable by a living system and what

498
00:22:39,240 --> 00:22:34,750
are the fingerprints of life out there

499
00:22:40,950 --> 00:22:39,250
in the solar system next chart so let me

500
00:22:43,440 --> 00:22:40,960
turn to Mars since Mars has been

501
00:22:47,220 --> 00:22:43,450
designated by all these studies groups

502
00:22:50,100 --> 00:22:47,230
as the ultimate goal why Mars well it's

503
00:22:52,920 --> 00:22:50,110
the most earth-like of the planets most

504
00:22:55,410 --> 00:22:52,930
likely to have had or even possibly have

505
00:22:57,030 --> 00:22:55,420
today life on it and it's reachable

506
00:23:00,090 --> 00:22:57,040
every 26 months

507
00:23:01,950 --> 00:23:00,100
unlike the outer planets and the theme

508
00:23:04,080 --> 00:23:01,960
that we adopted in the restructuring

509
00:23:07,280 --> 00:23:04,090
over ten years ago was follow the water

510
00:23:10,380 --> 00:23:07,290
and why water because water is necessary

511
00:23:13,560 --> 00:23:10,390
for any life form as we know it liquid

512
00:23:16,410 --> 00:23:13,570
water and it is a common thread among

513
00:23:19,200 --> 00:23:16,420

science goals of living systems the

514
00:23:21,750 --> 00:23:19,210
evolution of climate the solid planet

515
00:23:23,790 --> 00:23:21,760
geology and human exploration so

516
00:23:27,120 --> 00:23:23,800
following the water provides us with the

517
00:23:29,610 --> 00:23:27,130
resources for putting humans on the

518
00:23:32,820 --> 00:23:29,620
surfaces of Mars in particular next

519
00:23:35,940 --> 00:23:32,830
chart so today's Mars exploration

520
00:23:38,820 --> 00:23:35,950
program as dr. Holdren said was

521
00:23:40,440 --> 00:23:38,830
redefined about ten years ago I got the

522
00:23:43,050 --> 00:23:40,450
chance to take a nearly clean sheet of

523
00:23:45,630 --> 00:23:43,060
paper and put a new mission cue together

524
00:23:48,180 --> 00:23:45,640
grounded in science but also based on

525
00:23:49,950 --> 00:23:48,190
the availability of technology and

526
00:23:52,410 --> 00:23:49,960
programmatic constraints and that

527
00:23:52,890 --> 00:23:52,420
mission cue ended up with bars Global

528
00:23:56,370 --> 00:23:52,900
Surveyor

529
00:23:57,600 --> 00:23:56,380
Mars Odyssey the twin rovers the Mars

530
00:24:00,510 --> 00:23:57,610
Reconnaissance Orbiter

531
00:24:03,080 --> 00:24:00,520
the Phoenix scout and coming next year

532
00:24:07,289 --> 00:24:03,090
the Mars Science Laboratory and these

533
00:24:10,100 --> 00:24:07,299
missions sought and seek to

534
00:24:12,779 --> 00:24:10,110
understand Mars as a system next chart

535
00:24:15,840 --> 00:24:12,789
so following the water how have we done

536
00:24:18,060 --> 00:24:15,850
on that water is a key to life

537
00:24:20,340 --> 00:24:18,070
climate geology and future human

538
00:24:23,549 --> 00:24:20,350

exploration and here's how you explore a

539
00:24:25,019 --> 00:24:23,559
world first you look from orbit as we

540
00:24:27,539 --> 00:24:25,029
said in the flexible path there will be

541
00:24:30,680 --> 00:24:27,549
orbital missions Mars Odyssey launched

542
00:24:34,950 --> 00:24:30,690
in 2001 found evidence for enormous

543
00:24:38,940 --> 00:24:34,960
enormous amounts of water trapped an ice

544
00:24:42,509 --> 00:24:38,950
in the top three feet of the Red Planet

545
00:24:45,060 --> 00:24:42,519
up to 50% or even more at the poles but

546
00:24:47,070 --> 00:24:45,070
this is information from orbit isn't

547
00:24:49,049 --> 00:24:47,080
really true you need to get the ground

548
00:24:51,539 --> 00:24:49,059
measurement to convince yourself that

549
00:24:54,060 --> 00:24:51,549
really you're seeing what you think

550
00:24:56,849 --> 00:24:54,070
you're observing so next slide the

551
00:24:59,700 --> 00:24:56,859
Phoenix mission a few years later went

552
00:25:01,710 --> 00:24:59,710
to the North Pole of Mars found the ice

553
00:25:05,669 --> 00:25:01,720
confirmed that by onboard chemical

554
00:25:09,539 --> 00:25:05,679
measurements so now we know that if moon

555
00:25:11,519 --> 00:25:09,549
is moist Mars is soaking wet with

556
00:25:14,430 --> 00:25:11,529
hundreds and hundreds and hundreds of

557
00:25:16,499 --> 00:25:14,440
millions of tons of water ice at the

558
00:25:18,779 --> 00:25:16,509
surface and probably we hope liquid

559
00:25:21,629 --> 00:25:18,789
water further beneath the surface where

560
00:25:23,940 --> 00:25:21,639
it's warmer next slide let's take one

561
00:25:27,299 --> 00:25:23,950
other picture Mars Global Surveyor

562
00:25:32,039 --> 00:25:27,309
launched in 1996 showed on the right of

563
00:25:35,099 --> 00:25:32,049

Connecticut sized part of Mars that had

564
00:25:39,060 --> 00:25:35,109
minerals as seen from orbit that are

565
00:25:42,180 --> 00:25:39,070
always associated at least on earth with

566
00:25:44,310 --> 00:25:42,190
liquid water but do we really know what

567
00:25:46,379 --> 00:25:44,320
we're looking at the way we explore a

568
00:25:48,359 --> 00:25:46,389
world is first to make observations from

569
00:25:50,310 --> 00:25:48,369
orbit and then go to the surface and

570
00:25:50,960 --> 00:25:50,320
confirm that with ground truth next

571
00:25:53,489 --> 00:25:50,970
slide

572
00:25:55,080 --> 00:25:53,499
so the Mars rovers these incredible

573
00:25:57,149 --> 00:25:55,090
machines they're in their fifth year of

574
00:25:59,849 --> 00:25:57,159
operations the warranty was only good

575
00:26:04,169 --> 00:25:59,859
for 90 days and they're still working

576
00:26:06,359 --> 00:26:04,179
and if you click the slide once more you

577
00:26:09,029 --> 00:26:06,369
will see that what you were observing

578
00:26:12,440 --> 00:26:09,039
from orbit was a Connecticut sized field

579
00:26:13,649 --> 00:26:12,450
of these little blue berry type

580
00:26:16,710 --> 00:26:13,659
spheroids

581
00:26:19,799 --> 00:26:16,720
of a mineral that only exists from long

582
00:26:20,940 --> 00:26:19,809
contact with water plus we also saw the

583
00:26:24,950 --> 00:26:20,950
ripples character

584
00:26:27,779 --> 00:26:24,960
stick of moving water so this is how we

585
00:26:29,759 --> 00:26:27,789
understand what's at Mars how we're

586
00:26:32,519 --> 00:26:29,769
beginning to understand the evolution of

587
00:26:35,009 --> 00:26:32,529
Mars and why Mars is such an appealing

588
00:26:38,820 --> 00:26:35,019

target for future exploration next slide

589
00:26:42,090 --> 00:26:38,830
so what's coming up next this is the

590
00:26:44,580 --> 00:26:42,100
sequence of the family tree of Rovers we

591
00:26:46,919 --> 00:26:44,590
began all the far right with a little

592
00:26:50,700 --> 00:26:46,929
toaster oven sized Sojourner from

593
00:26:53,129 --> 00:26:50,710
Pathfinder and then quite deliberately

594
00:26:56,180 --> 00:26:53,139
and the restructuring of program went to

595
00:27:00,389 --> 00:26:56,190
a sort of small golf sort cart sized

596
00:27:02,250 --> 00:27:00,399
Rover maybe 300 pounds or so which is

597
00:27:04,560 --> 00:27:02,260
sent back an incredible array of

598
00:27:06,570 --> 00:27:04,570
postcards from Mars which just happens

599
00:27:08,690 --> 00:27:06,580
to be the title of a book by the

600
00:27:12,480 --> 00:27:08,700
gentleman in the front row Jim Bell here

601
00:27:14,129 --> 00:27:12,490
and coming next is a metric ton on the

602
00:27:16,769 --> 00:27:14,139
surface of Mars the Mars Science

603
00:27:19,139 --> 00:27:16,779
Laboratory that this budget fully funds

604
00:27:22,080 --> 00:27:19,149
that will take the most extraordinary

605
00:27:24,090 --> 00:27:22,090
analytical laboratory ever built for the

606
00:27:26,460 --> 00:27:24,100
surface of another world to Mars

607
00:27:29,279 --> 00:27:26,470
it's an astrobiology instrument and this

608
00:27:32,009 --> 00:27:29,289
Rover will be capable of going tens of

609
00:27:35,029 --> 00:27:32,019
kilometers it has radioisotope power and

610
00:27:38,220 --> 00:27:35,039
it will land very precisely all

611
00:27:39,419 --> 00:27:38,230
technologies that are necessary to build

612
00:27:43,289 --> 00:27:39,429
toward the ultimate

613
00:27:45,419 --> 00:27:43,299

human exploration of Mars next slide so

614
00:27:47,549 --> 00:27:45,429
with all of these really capable Rovers

615
00:27:50,730 --> 00:27:47,559
with this investment in autonomous

616
00:27:54,629 --> 00:27:50,740
systems and systems that we drive from

617
00:27:55,529 --> 00:27:54,639
the earth why do we need humans there

618
00:27:58,529 --> 00:27:55,539
what can they do

619
00:27:59,759 --> 00:27:58,539
the robots can't do and rather than

620
00:28:01,259 --> 00:27:59,769
reading is to you I'll just tell you the

621
00:28:03,149 --> 00:28:01,269
story it's the story of Steve Squyres

622
00:28:05,700 --> 00:28:03,159
who is here not in this room but at this

623
00:28:08,669 --> 00:28:05,710
event tells they were out doing a field

624
00:28:11,220 --> 00:28:08,679
test Jim were you there for this famous

625
00:28:13,529 --> 00:28:11,230
experiment okay so out of field test

626
00:28:17,639 --> 00:28:13,539
there was a technical problem so Steve

627
00:28:20,220 --> 00:28:17,649
says to the assembled population of Mars

628
00:28:22,350 --> 00:28:20,230
experts let's do a little examination

629
00:28:24,330 --> 00:28:22,360
here I've got a stopwatch standing out

630
00:28:26,370 --> 00:28:24,340
in the field or out in the desert I want

631
00:28:28,500 --> 00:28:26,380
to start the stopwatch I want you to

632
00:28:30,960 --> 00:28:28,510
find something that's interesting go

633
00:28:34,470 --> 00:28:30,970
pick it up tell me what it is

634
00:28:36,330 --> 00:28:34,480
so go so here's Ron

635
00:28:38,250 --> 00:28:36,340
really famous expert of mayuri's he

636
00:28:40,230 --> 00:28:38,260
looks around he goes over picks up a

637
00:28:41,730 --> 00:28:40,240
rock breaks it over with his rock hammer

638
00:28:46,289 --> 00:28:41,740

looks at it with his hand lens and says

639
00:28:49,200 --> 00:28:46,299
Jairus I click total elapsed time 45

640
00:28:51,480 --> 00:28:49,210
seconds to do that same piece of

641
00:28:56,610 --> 00:28:51,490
analysis current robotic technology

642
00:28:58,200 --> 00:28:56,620
takes hours days so again having a human

643
00:29:00,600 --> 00:28:58,210
being there with all the expense it

644
00:29:04,380 --> 00:29:00,610
requires would bring us back an enormous

645
00:29:06,630 --> 00:29:04,390
amount of scientific data next slide but

646
00:29:08,580 --> 00:29:06,640
to get there the challenges is that

647
00:29:11,159 --> 00:29:08,590
Crowley said are significant they

648
00:29:13,440 --> 00:29:11,169
there's affordability in both budgetary

649
00:29:15,720 --> 00:29:13,450
and human terms there are the biomedical

650
00:29:20,039 --> 00:29:15,730
problems and we have to have the

651
00:29:23,850 --> 00:29:20,049
technologies in place next slide so some

652
00:29:25,440 --> 00:29:23,860
of those from my past role at NASA Ames

653
00:29:27,450 --> 00:29:25,450
Research Center we did a great deal of

654
00:29:30,020 --> 00:29:27,460
work on intelligent systems and

655
00:29:32,310 --> 00:29:30,030
autonomous systems I can say that the

656
00:29:34,080 --> 00:29:32,320
information technology challenges are

657
00:29:37,650 --> 00:29:34,090
things like management of large data

658
00:29:39,780 --> 00:29:37,660
sets autonomy and mobility and then the

659
00:29:42,030 --> 00:29:39,790
human machine interaction and the

660
00:29:44,010 --> 00:29:42,040
telepresence interface that was being

661
00:29:47,760 --> 00:29:44,020
spoken of a little while ago the ability

662
00:29:50,010 --> 00:29:47,770
to orbit a body and operate with very

663
00:29:53,850 --> 00:29:50,020

quick light travel time a rover on

664
00:29:55,680 --> 00:29:53,860
another world next slide so this is the

665
00:29:59,250 --> 00:29:55,690
picture this is a different way of

666
00:30:02,669 --> 00:29:59,260
looking at the flexible path shows

667
00:30:06,650 --> 00:30:02,679
things we learn from the space station

668
00:30:09,110 --> 00:30:06,660
the heavy lift possibilities the

669
00:30:13,049 --> 00:30:09,120
expeditions to the near-earth objects

670
00:30:15,299 --> 00:30:13,059
the missions ultimately to Mars and then

671
00:30:19,110 --> 00:30:15,309
down at the bottom the robotic missions

672
00:30:21,870 --> 00:30:19,120
that may precede the human exploration

673
00:30:24,270 --> 00:30:21,880
so-called precursor missions I want to

674
00:30:28,530 --> 00:30:24,280
propose the possibility of one next

675
00:30:31,520 --> 00:30:28,540
slide a Mars sample return campaign this

676
00:30:33,990 --> 00:30:31,530
would be the convergence of science

677
00:30:36,390 --> 00:30:34,000
extraordinary science the astrobiology

678
00:30:39,030 --> 00:30:36,400
community and indeed I believe the whole

679
00:30:41,789 --> 00:30:39,040
science community dealing with planetary

680
00:30:44,820 --> 00:30:41,799
exploration would agree that bringing

681
00:30:48,150 --> 00:30:44,830
back samples of Mars will tell us a huge

682
00:30:50,490 --> 00:30:48,160
amount about the evolution of that plan

683
00:30:54,540 --> 00:30:50,500
and about the potential the biological

684
00:30:56,310 --> 00:30:54,550
potential for that planet it is going to

685
00:30:59,160 --> 00:30:56,320
be an international mission I would say

686
00:31:02,250 --> 00:30:59,170
because of the complexities of sending a

687
00:31:04,590 --> 00:31:02,260
lander to the surface sending a sample

688
00:31:07,950 --> 00:31:04,600

up to orbit rendezvous with the sample

689
00:31:10,470 --> 00:31:07,960
returning to Earth and it will also be a

690
00:31:13,440 --> 00:31:10,480
precursor to human exploration because

691
00:31:15,020 --> 00:31:13,450
it will give us measures of the soil the

692
00:31:17,730 --> 00:31:15,030
toxicity it will be an end-to-end

693
00:31:19,350 --> 00:31:17,740
demonstration of traveling all the way

694
00:31:22,710 --> 00:31:19,360
to the surface of another world like

695
00:31:27,270 --> 00:31:22,720
Mars and coming back so what's the

696
00:31:30,590 --> 00:31:27,280
future for exploration it's not as it

697
00:31:36,630 --> 00:31:30,600
has been for maybe 50 years robots

698
00:31:39,030 --> 00:31:36,640
versus humans it is last slide humans

699
00:31:40,920 --> 00:31:39,040
and robots working together and I think

700
00:31:43,290 --> 00:31:40,930
this is what the new program can bring

701
00:31:50,700 --> 00:31:43,300
to us and this is what the new program

702
00:31:55,560 --> 00:31:53,590
thank you Scott our final panelist is

703
00:31:57,790 --> 00:31:55,570
dr. John Grunsfeld

704
00:31:59,770 --> 00:31:57,800
PhD in physics from the University of

705
00:32:01,990 --> 00:31:59,780
Chicago started his career as an

706
00:32:05,650 --> 00:32:02,000
astronaut when he reported for training

707
00:32:08,050 --> 00:32:05,660
in 1992 a veteran of five space flights

708
00:32:10,630 --> 00:32:08,060
including three missions to service the

709
00:32:13,600 --> 00:32:10,640
Hubble Space Telescope he is popularly

710
00:32:16,300 --> 00:32:13,610
known as the Hubble repairman he served

711
00:32:19,090 --> 00:32:16,310
as NASA's chief scientist from 2003 to

712
00:32:21,640 --> 00:32:19,100
2004 is now the deputy director of the

713
00:32:24,280 --> 00:32:21,650

Space Telescope Science Institute in

714
00:32:24,700 --> 00:32:24,290
Baltimore Maryland John thank you very

715
00:32:26,860 --> 00:32:24,710
much

716
00:32:28,390 --> 00:32:26,870
it is a pleasure to be here back at the

717
00:32:30,040 --> 00:32:28,400
Kennedy Space Center where I've left the

718
00:32:32,200 --> 00:32:30,050
planet five times and I've many of my

719
00:32:34,080 --> 00:32:32,210
astronaut colleagues during the audience

720
00:32:37,240 --> 00:32:34,090
as well

721
00:32:39,640 --> 00:32:37,250
exploring the cosmos Scott has done a

722
00:32:41,680 --> 00:32:39,650
great of motivating the case for Mars

723
00:32:45,280 --> 00:32:41,690
but it's a very big universe next slide

724
00:32:48,970 --> 00:32:45,290
and I'd like to make the case that I

725
00:32:49,950 --> 00:32:48,980
think we all science is exploration next

726
00:32:51,880 --> 00:32:49,960
slide please

727
00:32:53,970 --> 00:32:51,890
science attempts to answer very

728
00:32:56,320 --> 00:32:53,980
fundamental questions you know at large

729
00:32:57,760 --> 00:32:56,330
how did the universe begin you know

730
00:33:00,220 --> 00:32:57,770
what's been its evolution how did the

731
00:33:02,110 --> 00:33:00,230
first stars form how did galaxies form

732
00:33:04,090 --> 00:33:02,120
how did the chemical elements that were

733
00:33:06,550 --> 00:33:04,100
made of form and where did they form how

734
00:33:08,020 --> 00:33:06,560
did planets form and solar systems that

735
00:33:11,130 --> 00:33:08,030
allow us to be here to have this

736
00:33:12,610 --> 00:33:11,140
discussion about how we leave the planet

737
00:33:16,060 --> 00:33:12,620
next slide please

738
00:33:17,950 --> 00:33:16,070

I truly believe we were born as

739
00:33:19,930 --> 00:33:17,960
explorers were born as scientist even

740
00:33:22,540 --> 00:33:19,940
before we can talk we're trying to

741
00:33:24,160 --> 00:33:22,550
understand how the world works we're

742
00:33:25,540 --> 00:33:24,170
also trying to find food and what's good

743
00:33:27,250 --> 00:33:25,550
to eat and what's not but that's a whole

744
00:33:29,110 --> 00:33:27,260
nother story but we're constantly

745
00:33:31,660 --> 00:33:29,120
reaching as children were constantly

746
00:33:33,460 --> 00:33:31,670
absorbing new information and trying to

747
00:33:36,450 --> 00:33:33,470
synthesize models to try and figure out

748
00:33:41,800 --> 00:33:36,460
how things work next slide

749
00:33:44,530 --> 00:33:41,810
so in this 2011 budget that's been

750
00:33:46,000 --> 00:33:44,540
proposed is an extremely strong

751
00:33:47,950 --> 00:33:46,010
statement about the importance of

752
00:33:51,070 --> 00:33:47,960
science in our country and in the world

753
00:33:53,230 --> 00:33:51,080
and specifically the building blocks the

754
00:33:55,860 --> 00:33:53,240
innovation to allow us to make new

755
00:33:59,310 --> 00:33:55,870
investments to look towards the future

756
00:34:03,790 --> 00:34:02,320
science at NASA is incredibly vibrant

757
00:34:06,520 --> 00:34:03,800
and vital

758
00:34:09,159 --> 00:34:06,530
from Voyager the first spacecraft that's

759
00:34:10,810 --> 00:34:09,169
leaving our solar system to the Solar

760
00:34:11,830 --> 00:34:10,820
Dynamics Observatory that we've just

761
00:34:13,960 --> 00:34:11,840
launched that's going to allow

762
00:34:16,150 --> 00:34:13,970
unprecedented studies of the details of

763
00:34:18,490 --> 00:34:16,160

our own Sun you know we live around a

764
00:34:21,850 --> 00:34:18,500
star and we still don't understand how

765
00:34:24,310 --> 00:34:21,860
it works to the Hubble Space Telescope a

766
00:34:26,169 --> 00:34:24,320
favorite of mine is as you've heard the

767
00:34:28,180 --> 00:34:26,179
Chandra Observatory the Spitzer

768
00:34:30,159 --> 00:34:28,190
telescope all exploring the depths of

769
00:34:32,950 --> 00:34:30,169
the universe we have the Cassini

770
00:34:35,370 --> 00:34:32,960
spacecraft doing space exploration as

771
00:34:38,710 --> 00:34:35,380
you heard it's it's you know our

772
00:34:40,990 --> 00:34:38,720
surrogate Explorer out at Saturn we have

773
00:34:43,450 --> 00:34:41,000
the wonderful Mars rovers and we have

774
00:34:45,970 --> 00:34:43,460
the Kepler spacecraft that's discovering

775
00:34:47,380 --> 00:34:45,980
new planets orbiting nearby stars when

776
00:34:49,840 --> 00:34:47,390
only 20 years ago we didn't know about

777
00:34:51,790 --> 00:34:49,850
any of them and this is just this very

778
00:34:53,919 --> 00:34:51,800
small fraction of all the science that

779
00:34:57,550 --> 00:34:53,929
NASA is currently doing next slide

780
00:35:00,220 --> 00:34:57,560
of course the most important planet in

781
00:35:02,470 --> 00:35:00,230
our solar system is planet Earth and we

782
00:35:03,640 --> 00:35:02,480
know that there's climate change we know

783
00:35:06,280 --> 00:35:03,650
that we have an impact on our

784
00:35:08,320 --> 00:35:06,290
environment and one of the things that I

785
00:35:10,090 --> 00:35:08,330
think is tops in this budget is that

786
00:35:12,790 --> 00:35:10,100
there's a significant commitment to

787
00:35:14,950 --> 00:35:12,800
earth science and trying to understand

788
00:35:16,780 --> 00:35:14,960

the earth as a system until we can do

789
00:35:18,190 --> 00:35:16,790
that and it's a very difficult problem

790
00:35:20,020 --> 00:35:18,200
you know we're not going to make

791
00:35:22,000 --> 00:35:20,030
progress in being able to make good

792
00:35:24,670 --> 00:35:22,010
policy decisions and one of the keys to

793
00:35:26,500 --> 00:35:24,680
that is to make good measurements and so

794
00:35:29,290 --> 00:35:26,510
there's an enhancement in the budget to

795
00:35:32,590 --> 00:35:29,300
try and develop new missions and new

796
00:35:36,060 --> 00:35:32,600
sensors to understand the behavior of

797
00:35:40,120 --> 00:35:36,070
the climate of planet earth next slide

798
00:35:43,510 --> 00:35:40,130
so at large where should we go and if

799
00:35:45,100 --> 00:35:43,520
you can key the mouse as you've heard

800
00:35:46,840 --> 00:35:45,110
from Jack Crowley's talk and also from

801
00:35:48,910 --> 00:35:46,850
Scott from ed Crawley's talk and from

802
00:35:50,950 --> 00:35:48,920
Scott there's lots of places we can go

803
00:35:52,270 --> 00:35:50,960
low Earth orbit lunar surface deep space

804
00:35:55,660 --> 00:35:52,280
near-earth objects

805
00:35:57,640 --> 00:35:55,670
Mars going beyond Mars all of these are

806
00:35:59,940 --> 00:35:57,650
potentially acceptable so what metrics

807
00:36:02,170 --> 00:35:59,950
can we use if you could click again we

808
00:36:03,430 --> 00:36:02,180
should go to compelling places

809
00:36:05,710 --> 00:36:03,440
compelling places that offer unique

810
00:36:08,410 --> 00:36:05,720
opportunities to extend our human

811
00:36:11,320 --> 00:36:08,420
knowledge and at the same time to use as

812
00:36:16,120 --> 00:36:11,330
building blocks to go the next stage in

813
00:36:17,109 --> 00:36:16,130

exploration next slide so Mars the

814
00:36:19,569 --> 00:36:17,119
challenge how do we get

815
00:36:21,220 --> 00:36:19,579
there and it's amazing what you can do

816
00:36:24,789 --> 00:36:21,230
with Photoshop these days this that was

817
00:36:27,910 --> 00:36:24,799
a picture of the moon so what does

818
00:36:30,160 --> 00:36:27,920
policy in this the plants that the

819
00:36:31,660 --> 00:36:30,170
president line today offers and as ed

820
00:36:34,839 --> 00:36:31,670
Crowley said from the Augustine

821
00:36:36,609 --> 00:36:34,849
committee is stepping stones to get

822
00:36:38,589 --> 00:36:36,619
there extend yourself further and

823
00:36:41,079 --> 00:36:38,599
further and we start with robotic

824
00:36:42,670 --> 00:36:41,089
precursors and so something I think is

825
00:36:44,319 --> 00:36:42,680
extremely interesting would be the

826
00:36:46,029 --> 00:36:44,329
opportunity to rendezvous with a

827
00:36:48,130 --> 00:36:46,039
near-earth object some of these

828
00:36:49,599 --> 00:36:48,140
near-earth objects are future potential

829
00:36:51,160 --> 00:36:49,609
threats to earth but they're also

830
00:36:52,390 --> 00:36:51,170
scientifically extremely interesting

831
00:36:54,220 --> 00:36:52,400
because many of these are building

832
00:36:57,609 --> 00:36:54,230
blocks of our solar system and we don't

833
00:36:58,900 --> 00:36:57,619
understand them very well one part of

834
00:37:01,690 --> 00:36:58,910
this is I think it's very important that

835
00:37:03,150 --> 00:37:01,700
as we build these robotic precursors we

836
00:37:05,559 --> 00:37:03,160
put them together as building blocks

837
00:37:07,329 --> 00:37:05,569
that can play together in other

838
00:37:10,859 --> 00:37:07,339

destinations and that we build a real

839
00:37:14,049 --> 00:37:10,869
modular infrastructure next slide of

840
00:37:16,329 --> 00:37:14,059
course as sylvia earle said when asked

841
00:37:18,849 --> 00:37:16,339
about ocean exploration of famous ocean

842
00:37:21,489 --> 00:37:18,859
explorer you know why do you go why not

843
00:37:23,739 --> 00:37:21,499
just send robots and you know as the

844
00:37:25,569 --> 00:37:23,749
human in her she says because I want to

845
00:37:27,279 --> 00:37:25,579
go I want to see with my own eyes and

846
00:37:30,009 --> 00:37:27,289
there is that human perspective that

847
00:37:32,680 --> 00:37:30,019
human intuition in place that allows for

848
00:37:34,779 --> 00:37:32,690
you know markedly faster progress and

849
00:37:36,759 --> 00:37:34,789
here's a picture at the bottom from the

850
00:37:38,739 --> 00:37:36,769
Mars Exploration Rover opportunity and

851
00:37:41,589 --> 00:37:38,749
at the top is a photograph taken by

852
00:37:43,089 --> 00:37:41,599
Apollo 17 astronauts and I just want to

853
00:37:45,039 --> 00:37:43,099
point out if you could click the mouse

854
00:37:47,140 --> 00:37:45,049
there's a person in the upper picture

855
00:37:49,630 --> 00:37:47,150
and I really do believe that that makes

856
00:37:50,979 --> 00:37:49,640
a big difference just go ahead and click

857
00:37:54,849 --> 00:37:50,989
the mouse that's Gene Cernan and they're

858
00:37:56,170 --> 00:37:54,859
walking on the moon next slide I do

859
00:37:59,460 --> 00:37:56,180
think it would be compelling to go to a

860
00:38:03,609 --> 00:37:59,470
near-earth object and explore here's

861
00:38:05,710 --> 00:38:03,619
asteroid Itokawa and it's it's pretty

862
00:38:07,359 --> 00:38:05,720
big as you heard you don't really land

863
00:38:08,920 --> 00:38:07,369

on it Charlie Bolden talked about that

864
00:38:10,420 --> 00:38:08,930
you don't land on it you rendezvous next

865
00:38:12,039 --> 00:38:10,430
to it and kind of float near it you can

866
00:38:14,799 --> 00:38:12,049
see the International Space Station and

867
00:38:16,299 --> 00:38:14,809
a prototypical capsule to scale it would

868
00:38:17,890 --> 00:38:16,309
be quite a phenomenal mission and it

869
00:38:19,870 --> 00:38:17,900
would extend our experience into deep

870
00:38:23,559 --> 00:38:19,880
space into a radiation environment we

871
00:38:26,380 --> 00:38:23,569
haven't seen before and also by going to

872
00:38:28,749 --> 00:38:26,390
an earth object an asteroid and perhaps

873
00:38:31,000 --> 00:38:28,759
even modifying its trajectory slightly

874
00:38:33,310 --> 00:38:31,010
we would demonstrate a home

875
00:38:34,720 --> 00:38:33,320
in human history the first time that we

876
00:38:37,600 --> 00:38:34,730
show that we can make better decisions

877
00:38:44,440 --> 00:38:37,610
than the dinosaurs made 65 million years

878
00:38:46,270 --> 00:38:44,450
ago next slide as Scott said it's all

879
00:38:48,520 --> 00:38:46,280
about a human robotic partnership robots

880
00:38:50,650 --> 00:38:48,530
have never discovered anything people

881
00:38:53,080 --> 00:38:50,660
discover things people discover things

882
00:38:54,550 --> 00:38:53,090
using robots and in Scotts cartoon he

883
00:38:56,680 --> 00:38:54,560
showed a picture of a robot helping a

884
00:38:58,720 --> 00:38:56,690
human out of a crater and this is

885
00:39:01,900 --> 00:38:58,730
actually a future astronaut rescuing the

886
00:39:05,080 --> 00:39:01,910
Mars rover spirit from from Troy at home

887
00:39:07,860 --> 00:39:05,090
plate out of its it's tough spot with a

888
00:39:11,890 --> 00:39:07,870

little bit of a winch next slide

889
00:39:14,620 --> 00:39:11,900
what about risk going to space is risky

890
00:39:17,380 --> 00:39:14,630
sitting on top of millions of pounds of

891
00:39:21,460 --> 00:39:17,390
explosive fuel is not exactly the same

892
00:39:24,820 --> 00:39:21,470
mnestheus and the further out we go the

893
00:39:27,250 --> 00:39:24,830
higher that risk is going to be people

894
00:39:29,260 --> 00:39:27,260
thrive on risk but in the end we have to

895
00:39:31,720 --> 00:39:29,270
take risks that are important and you

896
00:39:34,300 --> 00:39:31,730
know from my personally in my just

897
00:39:36,010 --> 00:39:34,310
making you know the Hubble mission was

898
00:39:38,260 --> 00:39:36,020
something that was worth risking my my

899
00:39:40,300 --> 00:39:38,270
life for and as this Houston Chronicle

900
00:39:42,310 --> 00:39:40,310
editorial says the Hubble repair mission

901
00:39:45,220 --> 00:39:42,320
showcases the value of manned

902
00:39:47,500 --> 00:39:45,230
spaceflight and we take these risks when

903
00:39:49,480 --> 00:39:47,510
the outcome when the reward is really

904
00:39:52,290 --> 00:39:49,490
great and this is another metric we can

905
00:39:54,880 --> 00:39:52,300
use to decide on where to go next slide

906
00:39:57,580 --> 00:39:54,890
of course you know I'm gonna pick my

907
00:40:00,400 --> 00:39:57,590
favorite experiment and the experiment

908
00:40:02,440 --> 00:40:00,410
is the Hubble Space Telescope by having

909
00:40:04,270 --> 00:40:02,450
this wonderful combination of humans

910
00:40:07,270 --> 00:40:04,280
that are adaptive that bring their

911
00:40:09,400 --> 00:40:07,280
insight on the scene we've been able to

912
00:40:11,800 --> 00:40:09,410
upgrade the Hubble Space Telescope and

913
00:40:13,330 --> 00:40:11,810

really rejuvenate it and expand its

914
00:40:16,000 --> 00:40:13,340
capabilities many fold

915
00:40:20,610 --> 00:40:16,010
5 times in space here installing the

916
00:40:22,840 --> 00:40:20,620
advanced camera for surveys in 2002 this

917
00:40:25,870 --> 00:40:22,850
remarkable ability of having the Space

918
00:40:27,610 --> 00:40:25,880
Shuttle and people is what enabled the

919
00:40:29,800 --> 00:40:27,620
Hubble to make many of the discoveries

920
00:40:32,140 --> 00:40:29,810
that it's made to date and will continue

921
00:40:34,390 --> 00:40:32,150
to do for many years we have a real

922
00:40:36,820 --> 00:40:34,400
opportunity with this new plan to

923
00:40:39,100 --> 00:40:36,830
develop new technologies alongside

924
00:40:41,140 --> 00:40:39,110
the requirements for science so that

925
00:40:43,060 --> 00:40:41,150
together they're much more powerful than

926
00:40:45,620 --> 00:40:43,070
they would be if we weren't to combine

927
00:40:47,539 --> 00:40:45,630
you know the human robotic

928
00:40:50,480 --> 00:40:47,549
for human exploration with the

929
00:40:52,249 --> 00:40:50,490
scientific motivation next slide so just

930
00:40:54,019 --> 00:40:52,259
some examples from from very recent

931
00:40:56,420 --> 00:40:54,029
history in January the Hubble Space

932
00:40:58,609 --> 00:40:56,430
Telescope observed what's probably the

933
00:41:00,140 --> 00:40:58,619
first collision that we've observed in

934
00:41:02,569 --> 00:41:00,150
the asteroid belt things collide over

935
00:41:04,519 --> 00:41:02,579
you know long timescales all the time of

936
00:41:06,259 --> 00:41:04,529
course that's what broke them all up but

937
00:41:08,390 --> 00:41:06,269
here's a photograph with the Hubble

938
00:41:10,160 --> 00:41:08,400

Space Telescope of the result of one of

939
00:41:12,289 --> 00:41:10,170
those cosmic collisions in the asteroid

940
00:41:14,150 --> 00:41:12,299
belt it may be a collision like this

941
00:41:16,609 --> 00:41:14,160
that caused something to come in and hit

942
00:41:19,599 --> 00:41:16,619
the earth 65 million years ago in the

943
00:41:22,849 --> 00:41:19,609
middle slide you see actually the first

944
00:41:24,859 --> 00:41:22,859
visible light image of a planet around a

945
00:41:27,230 --> 00:41:24,869
nearby star in this case around formal

946
00:41:28,940 --> 00:41:27,240
hot and so we actually imaged the

947
00:41:31,309 --> 00:41:28,950
planets that's in the little inset and

948
00:41:33,019 --> 00:41:31,319
on the right is a picture that we never

949
00:41:35,440 --> 00:41:33,029
imagined we could make when we launched

950
00:41:38,509 --> 00:41:35,450
Hubble and that's a photograph of

951
00:41:40,999 --> 00:41:38,519
galaxies as they were six hundred

952
00:41:42,620 --> 00:41:41,009
million years after the Big Bang the

953
00:41:44,599 --> 00:41:42,630
light from those galaxies has travelled

954
00:41:46,069 --> 00:41:44,609
for over thirteen billion years to reach

955
00:41:47,480 --> 00:41:46,079
Earth were seen some of the first

956
00:41:52,370 --> 00:41:47,490
galaxies that formed in the universe

957
00:41:54,259 --> 00:41:52,380
next slide this budget also fully funds

958
00:41:56,660 --> 00:41:54,269
the James Webb Space Telescope the next

959
00:41:58,880 --> 00:41:56,670
Very Large Telescope and that's going to

960
00:42:00,710 --> 00:41:58,890
extend our ability to answer these

961
00:42:02,359 --> 00:42:00,720
fundamental questions you know what was

962
00:42:04,670 --> 00:42:02,369
the first light when did the first stars

963
00:42:08,059 --> 00:42:04,680

turn on in the universe how did those

964
00:42:10,220 --> 00:42:08,069
stars form into galaxies the births of

965
00:42:12,829 --> 00:42:10,230
stars and planets occurs tightly

966
00:42:14,450 --> 00:42:12,839
shrouded in the dust and gas of these

967
00:42:16,670 --> 00:42:14,460
star forming regions the beautiful

968
00:42:18,289 --> 00:42:16,680
things like the Eagle Nebula and the

969
00:42:19,910 --> 00:42:18,299
James Webb Space Telescope will be able

970
00:42:21,890 --> 00:42:19,920
to peer into those regions where stars

971
00:42:24,710 --> 00:42:21,900
are formed and we'll also be able to

972
00:42:26,630 --> 00:42:24,720
study planets and perhaps start looking

973
00:42:28,460 --> 00:42:26,640
for the origins and the environments

974
00:42:33,079 --> 00:42:28,470
where life might form on another planet

975
00:42:34,999 --> 00:42:33,089
next slide the next step though beyond

976
00:42:36,829 --> 00:42:35,009
the James Webb Space Telescope if we

977
00:42:39,650 --> 00:42:36,839
really want to be the generation that

978
00:42:41,359 --> 00:42:39,660
can answer that question are we alone

979
00:42:43,069 --> 00:42:41,369
we're gonna need yet another telescope

980
00:42:45,200 --> 00:42:43,079
and this is something that could be

981
00:42:47,269 --> 00:42:45,210
enabled by the development of a heavy

982
00:42:49,099 --> 00:42:47,279
lift booster with a much larger fairing

983
00:42:51,319 --> 00:42:49,109
that could take a telescope even bigger

984
00:42:53,450 --> 00:42:51,329
than the James Webb Space Telescope one

985
00:42:55,970 --> 00:42:53,460
that would be required to image this

986
00:42:58,430 --> 00:42:55,980
very faint light of a pale blue dot and

987
00:43:01,040 --> 00:42:58,440
then using physics to

988
00:43:03,890 --> 00:43:01,050

there's oxygen and water and methane and

989
00:43:05,740 --> 00:43:03,900
maybe other organic compounds in the

990
00:43:09,319 --> 00:43:05,750
atmosphere of that planet that would

991
00:43:12,200 --> 00:43:09,329
conclusively in principle find out we're

992
00:43:14,540 --> 00:43:12,210
not alone and of course here's a fake

993
00:43:17,270 --> 00:43:14,550
Time magazine cover saying you know we

994
00:43:18,740 --> 00:43:17,280
are not alone we're right on the fringe

995
00:43:23,599 --> 00:43:18,750
of being able to do that with the

996
00:43:28,130 --> 00:43:23,609
next-generation telescope and I think

997
00:43:35,960 --> 00:43:28,140
that's June twenty twenty eight next

998
00:43:38,960 --> 00:43:35,970
slide what we can discuss that as we

999
00:43:40,940 --> 00:43:38,970
service the Hubble with this modular

1000
00:43:42,530 --> 00:43:40,950
architecture with the ability to go to

1001
00:43:44,839 --> 00:43:42,540
further destinations we have the

1002
00:43:47,000 --> 00:43:44,849
opportunity to build modular systems

1003
00:43:49,520 --> 00:43:47,010
such that we could service these new big

1004
00:43:51,140 --> 00:43:49,530
telescopes and other spacecraft the way

1005
00:43:52,970 --> 00:43:51,150
that we've serve is so successfully the

1006
00:43:57,130 --> 00:43:52,980
Hubble Space Telescope vastly expanding

1007
00:44:01,880 --> 00:43:59,390
course in the end much of it's about

1008
00:44:05,000 --> 00:44:01,890
inspiration we have lots of complex

1009
00:44:06,290 --> 00:44:05,010
challenges in our world and we often say

1010
00:44:08,300 --> 00:44:06,300
well technology will solve those

1011
00:44:09,859 --> 00:44:08,310
problems well we're the scientists and

1012
00:44:13,130 --> 00:44:09,869
engineers that are going to solve those

1013
00:44:15,260 --> 00:44:13,140

problems where do they come from NASA is

1014
00:44:17,510 --> 00:44:15,270
a very powerful engine for inspiring

1015
00:44:20,569 --> 00:44:17,520
students and I think there's a strong

1016
00:44:23,120 --> 00:44:20,579
commitment from this administration to

1017
00:44:25,130 --> 00:44:23,130
support that and science is one of those

1018
00:44:29,510 --> 00:44:25,140
things that kids get very excited about

1019
00:44:31,250 --> 00:44:29,520
next slide of course it's a lot about

1020
00:44:33,079 --> 00:44:31,260
the NASA team and this NASA team is

1021
00:44:34,670 --> 00:44:33,089
truly excellent that folks that I've

1022
00:44:37,220 --> 00:44:34,680
worked with are truly the best and the

1023
00:44:40,069 --> 00:44:37,230
best best of the best and I'm convinced

1024
00:44:43,099 --> 00:44:40,079
with this new opportunity we'll be able

1025
00:44:45,380 --> 00:44:43,109
to kick-start exploration and do

1026
00:44:48,290 --> 00:44:45,390
wonderful things but it all comes back

1027
00:44:51,410 --> 00:44:48,300
to Florida next slide this is a picture

1028
00:44:54,559 --> 00:44:51,420
I took of my crew I may have taken it a

1029
00:44:57,470 --> 00:44:54,569
Florida not quite a year ago and the

1030
00:45:00,950 --> 00:44:57,480
question is how do we proceed so hit the

1031
00:45:02,960 --> 00:45:00,960
mouse if you would I think the key is

1032
00:45:05,540 --> 00:45:02,970
cost-effective low Earth orbit

1033
00:45:07,790 --> 00:45:05,550
transportation as we've heard the

1034
00:45:09,440 --> 00:45:07,800
journey always starts and ends through

1035
00:45:11,180 --> 00:45:09,450
low Earth orbit and we need it to be

1036
00:45:12,200 --> 00:45:11,190
cost-effective so we can afford to do

1037
00:45:14,390 --> 00:45:12,210
these other things

1038
00:45:15,770 --> 00:45:14,400

the heavy lift is critical the heavy

1039
00:45:18,230 --> 00:45:15,780
lift is critical in terms of exploration

1040
00:45:20,059 --> 00:45:18,240
but also in terms of science to be able

1041
00:45:22,790 --> 00:45:20,069
to bring up the large payloads to be

1042
00:45:24,410 --> 00:45:22,800
able to assemble them in space I think a

1043
00:45:25,790 --> 00:45:24,420
modular exploration architecture is

1044
00:45:27,470 --> 00:45:25,800
critical so that we can do things like

1045
00:45:30,230 --> 00:45:27,480
space servicing and we can visit just

1046
00:45:33,109 --> 00:45:30,240
different destinations in a way that's

1047
00:45:34,670 --> 00:45:33,119
cost effective in terms of inspiration

1048
00:45:37,190 --> 00:45:34,680
we do need frequent and compelling

1049
00:45:38,750 --> 00:45:37,200
missions and we also need those creative

1050
00:45:41,180 --> 00:45:38,760
partnerships NASA with our international

1051
00:45:43,220 --> 00:45:41,190
partners science is the international

1052
00:45:45,349 --> 00:45:43,230
language of peace it is going to be a

1053
00:45:46,970 --> 00:45:45,359
planet-wide effort to do some of these

1054
00:45:49,280 --> 00:45:46,980
very hard tackle some of these hard

1055
00:45:50,839 --> 00:45:49,290
problems but also partners in government

1056
00:45:53,690 --> 00:45:50,849
with our contractors our commercial and

1057
00:45:55,670 --> 00:45:53,700
academic institutions but in the end

1058
00:46:00,049 --> 00:45:55,680
it's not all about Florida it's also

1059
00:46:02,510 --> 00:46:00,059
about Congress next slide I actually

1060
00:46:04,250 --> 00:46:02,520
wrote this down one day in the house

1061
00:46:05,630 --> 00:46:04,260
science subcommittee room there's two

1062
00:46:07,549 --> 00:46:05,640
things written on the wall and I think

1063
00:46:09,020 --> 00:46:07,559

this one's very forward-looking and I've

1064
00:46:11,180 --> 00:46:09,030
modified it slightly but it's from

1065
00:46:13,970 --> 00:46:11,190
Tennyson for I dipped into the future

1066
00:46:16,370 --> 00:46:13,980
far as human eyes could see saw the

1067
00:46:19,099 --> 00:46:16,380
vision of new worlds and all the wonder

1068
00:46:21,260 --> 00:46:19,109
that would be I'm often asked to

1069
00:46:23,390 --> 00:46:21,270
summarize things in 25 words or less and

1070
00:46:27,980 --> 00:46:23,400
I think I'm only gonna use four so she'd

1071
00:46:33,559 --> 00:46:27,990
click the mouse I think this new plan

1072
00:46:35,680 --> 00:46:33,569
supports science and cue up the words if

1073
00:46:38,960 --> 00:46:35,690
you click the mouse one more time

1074
00:46:41,150 --> 00:46:38,970
innovation innovate explore discover and

1075
00:46:47,099 --> 00:46:41,160
inspire and I'll leave it with that

1076
00:46:51,780 --> 00:46:49,420
thank you very much John I think we've

1077
00:46:54,250 --> 00:46:51,790
just heard and seen three extraordinary

1078
00:46:56,050 --> 00:46:54,260
presentations from three extraordinary

1079
00:46:58,750 --> 00:46:56,060
people there are some other

1080
00:47:01,300 --> 00:46:58,760
extraordinary people throughout the

1081
00:47:03,730 --> 00:47:01,310
audience in fact I suspect everybody in

1082
00:47:06,820 --> 00:47:03,740
this room is an extraordinary person I

1083
00:47:08,830 --> 00:47:06,830
want to direct a few questions to some

1084
00:47:11,260 --> 00:47:08,840
of the folks that that I've noticed in

1085
00:47:12,550 --> 00:47:11,270
the audience and of course it's not

1086
00:47:14,950 --> 00:47:12,560
surprising that I noticed right away

1087
00:47:18,609 --> 00:47:14,960
Buzz Aldrin sitting in the front row

1088
00:47:22,300 --> 00:47:18,619

buzz you were the second person to set

1089
00:47:24,580 --> 00:47:22,310
foot on the moon quite a while ago but

1090
00:47:27,070 --> 00:47:24,590
you're also a remarkable example of

1091
00:47:28,990 --> 00:47:27,080
looking forward and not just backwards I

1092
00:47:30,790 --> 00:47:29,000
know that from some extraordinarily

1093
00:47:32,410 --> 00:47:30,800
interesting conversations with you

1094
00:47:38,890 --> 00:47:32,420
what's what's your take on what we've

1095
00:47:43,410 --> 00:47:38,900
been talking about today I have a great

1096
00:47:50,050 --> 00:47:43,420
appreciation for all of the professorial

1097
00:47:55,120 --> 00:47:50,060
remarks I tried being a professor for a

1098
00:47:59,260 --> 00:47:55,130
while and I just got tired of wanting to

1099
00:48:03,070 --> 00:47:59,270
go over the obvious I have always wanted

1100
00:48:05,200 --> 00:48:03,080
to go over the unobvious I think that

1101
00:48:10,060 --> 00:48:05,210
started when I was maybe a second

1102
00:48:14,650 --> 00:48:10,070
lieutenant in Korean War I didn't move

1103
00:48:19,380 --> 00:48:14,660
up a flight I wanted to get into

1104
00:48:21,970 --> 00:48:19,390
operations squadron operations so and

1105
00:48:24,880 --> 00:48:21,980
one guy didn't come back from a mission

1106
00:48:27,550 --> 00:48:24,890
he's a second lieutenant I took his

1107
00:48:30,670 --> 00:48:27,560
place in assistant squadron ops then I

1108
00:48:33,099 --> 00:48:30,680
got into assistant group ops and I met

1109
00:48:36,450 --> 00:48:33,109
John Glenn who was an ops officer and

1110
00:48:39,280 --> 00:48:36,460
one squadron and I told him how many

1111
00:48:42,370 --> 00:48:39,290
f-86s he could put on the Yalu River

1112
00:48:47,070 --> 00:48:42,380
this gives you a little bit of power

1113
00:48:49,540 --> 00:48:47,080

when as a youngster you begin to tell

1114
00:48:51,310 --> 00:48:49,550
but his squadron commander one time

1115
00:48:59,740 --> 00:48:51,320
really got pissed off at because he

1116
00:49:08,470 --> 00:49:04,330
the statute of limitations is in

1117
00:49:14,230 --> 00:49:08,480
reflecting back clearly I made a

1118
00:49:16,960 --> 00:49:14,240
decision not to get into perfecting the

1119
00:49:20,380 --> 00:49:16,970
present and that's a test pilot

1120
00:49:23,040 --> 00:49:20,390
I had an desire to look at the big

1121
00:49:27,400 --> 00:49:23,050
picture how can we do things better and

1122
00:49:30,910 --> 00:49:27,410
when I found out between alert with

1123
00:49:34,839 --> 00:49:30,920
nuclear weapons and in Germany that the

1124
00:49:36,580 --> 00:49:34,849
magazine in 1959 said to be an astronaut

1125
00:49:40,390 --> 00:49:36,590
you had to be a test pilot I thought I'd

1126
00:49:43,390 --> 00:49:40,400
really missed the boat but education

1127
00:49:47,050 --> 00:49:43,400
made the difference at MIT and I I'm

1128
00:49:52,839 --> 00:49:47,060
happy that two people up here have been

1129
00:49:57,070 --> 00:49:52,849
through course 16 you were mit awesome

1130
00:50:02,020 --> 00:49:57,080
Wow we we really outnumber Stanford I'll

1131
00:50:08,859 --> 00:50:02,030
have to tell my wife about that so I

1132
00:50:11,950 --> 00:50:08,869
feel that I am an enabler to the places

1133
00:50:14,650 --> 00:50:11,960
we want to go how do you do it is has

1134
00:50:16,270 --> 00:50:14,660
been the challenge for me if we want to

1135
00:50:21,990 --> 00:50:16,280
go to certain places we had the

1136
00:50:29,980 --> 00:50:24,990
recently I had the occasion to

1137
00:50:33,300 --> 00:50:29,990
re-examine what made Apollo work having

1138
00:50:36,040 --> 00:50:33,310

studied rendezvous at MIT of course I

1139
00:50:38,530 --> 00:50:36,050
and many other people would say well

1140
00:50:44,250 --> 00:50:38,540
what made Apollo work was lunar orbit

1141
00:50:47,170 --> 00:50:44,260
rendezvous I see John Jay King has said

1142
00:50:49,870 --> 00:50:47,180
and re-examining that I believe what

1143
00:50:52,390 --> 00:50:49,880
really made it work was specializing the

1144
00:50:54,640 --> 00:50:52,400
spacecraft we developed a spacecraft

1145
00:50:57,400 --> 00:50:54,650
specially to go from earth to the moon

1146
00:51:00,780 --> 00:50:57,410
and back again then we developed a

1147
00:51:03,730 --> 00:51:00,790
spacecraft to to land now you have to

1148
00:51:06,710 --> 00:51:03,740
make that work for human beings and you

1149
00:51:10,550 --> 00:51:06,720
need to make rendezvous work

1150
00:51:13,370 --> 00:51:10,560
had a great admiration for John who bolt

1151
00:51:16,790 --> 00:51:13,380
for a long time and that's what prompted

1152
00:51:18,650 --> 00:51:16,800
me to try and improve on what he did and

1153
00:51:21,140 --> 00:51:18,660
wouldn't it be nice if you could have

1154
00:51:22,970 --> 00:51:21,150
something that just kept going back and

1155
00:51:26,330 --> 00:51:22,980
forth from earth to the moon

1156
00:51:28,700 --> 00:51:26,340
well it's not that easy and then it was

1157
00:51:31,070 --> 00:51:28,710
painful to my ego to find out that if

1158
00:51:34,130 --> 00:51:31,080
even if you did do that it really wasn't

1159
00:51:37,010 --> 00:51:34,140
very useful for taking people from the

1160
00:51:43,310 --> 00:51:37,020
surface of one place and taking them to

1161
00:51:46,210 --> 00:51:43,320
the other so Tom Paine said to me why

1162
00:51:48,470 --> 00:51:46,220
don't you look at Mars I was very

1163
00:51:51,710 --> 00:51:48,480

daunted by that because I knew how

1164
00:51:54,020 --> 00:51:51,720
complicated Earth to Mars would be but

1165
00:51:58,120 --> 00:51:54,030
if you take the seat of your pants and

1166
00:52:02,180 --> 00:51:58,130
and look at orbital motion that way

1167
00:52:05,089 --> 00:52:02,190
that's what led to opening up the way of

1168
00:52:07,370 --> 00:52:05,099
using gravity assist which had been used

1169
00:52:09,310 --> 00:52:07,380
to go further and further away so maybe

1170
00:52:12,740 --> 00:52:09,320
don't go further and further away but

1171
00:52:16,910 --> 00:52:12,750
make a cycling orbit out of it I got

1172
00:52:19,730 --> 00:52:16,920
exposed to something called NIH not the

1173
00:52:22,700 --> 00:52:19,740
National Institute of Health but not

1174
00:52:25,520 --> 00:52:22,710
invented here and if you have a good

1175
00:52:28,550 --> 00:52:25,530
idea and the government didn't think of

1176
00:52:29,810 --> 00:52:28,560
it it probably isn't a good idea to the

1177
00:52:34,280 --> 00:52:29,820
government because they didn't think of

1178
00:52:40,060 --> 00:52:34,290
it and I think that's true for industry

1179
00:52:43,220 --> 00:52:40,070
also I would say that we need to look at

1180
00:52:49,820 --> 00:52:43,230
implementing further missions by how we

1181
00:52:53,810 --> 00:52:49,830
can implement them and every mission

1182
00:52:57,560 --> 00:52:53,820
that I've seen going to Mars goes direct

1183
00:53:02,420 --> 00:52:57,570
to Mars doesn't stop anywhere else but

1184
00:53:05,750 --> 00:53:02,430
the design reference mission that was so

1185
00:53:08,210 --> 00:53:05,760
useful in Apollo 1 mission and we kept

1186
00:53:11,660 --> 00:53:08,220
doing it over and over again the design

1187
00:53:16,040 --> 00:53:11,670
reference mission to go to Mars goes to

1188
00:53:20,000 --> 00:53:16,050

Mars but I was aware of a study that had

1189
00:53:20,570 --> 00:53:20,010
been made a long time ago of what can

1190
00:53:24,230 --> 00:53:20,580
you get

1191
00:53:29,630 --> 00:53:24,240
of different possible missions we can

1192
00:53:32,870 --> 00:53:29,640
fly by Mars we can land on Mars or we

1193
00:53:37,820 --> 00:53:32,880
can almost land on Mars and see what we

1194
00:53:43,360 --> 00:53:37,830
can do and that brings me to this moon

1195
00:53:50,990 --> 00:53:43,370
rock it's not from the moon but it's a

1196
00:53:54,800 --> 00:53:51,000
replica of a Mars moon Phobos if you are

1197
00:53:56,420 --> 00:53:54,810
able to put humans on Fobus so what what

1198
00:53:59,150 --> 00:53:56,430
do you get out of it well it's easier to

1199
00:54:00,980 --> 00:53:59,160
get there from a delta B standpoint is

1200
00:54:03,710 --> 00:54:00,990
easier to get to focus and it is to the

1201
00:54:07,940 --> 00:54:03,720
surface of our Moon just takes a little

1202
00:54:12,290 --> 00:54:07,950
bit longer now what can you do when you

1203
00:54:14,390 --> 00:54:12,300
get there I ask Steve Squyres because I

1204
00:54:16,940 --> 00:54:14,400
had some ideas that if you had people

1205
00:54:18,920 --> 00:54:16,950
there that might be quite useful since

1206
00:54:21,620 --> 00:54:18,930
they can transmit to the robot and

1207
00:54:25,610 --> 00:54:21,630
control it directly whereas the closest

1208
00:54:28,310 --> 00:54:25,620
of robot is on Mars to the to earth is

1209
00:54:30,680 --> 00:54:28,320
four minutes and it couldn't can be as

1210
00:54:35,510 --> 00:54:30,690
much as 20 minutes if it's on the

1211
00:54:40,730 --> 00:54:35,520
opposite side and as a result any way to

1212
00:54:45,770 --> 00:54:40,740
get to the point five years of spirit

1213
00:54:46,700 --> 00:54:45,780

and opportunity on Mars according to

1214
00:54:49,850 --> 00:54:46,710
Steve Squyres

1215
00:54:53,470 --> 00:54:49,860
could have been done in one week if we

1216
00:54:57,650 --> 00:54:53,480
had humans on the moon of Mars Phobos or

1217
00:55:00,890 --> 00:54:57,660
on the surface but I think in orbit

1218
00:55:03,440 --> 00:55:00,900
there means you can relate to other

1219
00:55:05,330 --> 00:55:03,450
orbits and as you move around something

1220
00:55:07,910 --> 00:55:05,340
as always you're always going to be able

1221
00:55:33,390 --> 00:55:07,920
to see what you're looking at down there

1222
00:55:42,550 --> 00:55:39,280
are you there are just lots of steps

1223
00:55:44,500 --> 00:55:42,560
outward and one of them is going out and

1224
00:55:46,270 --> 00:55:44,510
coming back a year later that doesn't

1225
00:55:49,780 --> 00:55:46,280
get to another object but it allows you

1226
00:55:52,089 --> 00:55:49,790
a free return trajectory and you can

1227
00:55:54,910 --> 00:55:52,099
take that free return trajectory and if

1228
00:55:56,980 --> 00:55:54,920
the engine quits at any point you're

1229
00:55:59,500 --> 00:55:56,990
still coming back except it's not as big

1230
00:56:01,660 --> 00:55:59,510
in orbit but if you design it to fly by

1231
00:56:04,180 --> 00:56:01,670
a comet just think what you can do and

1232
00:56:08,859 --> 00:56:04,190
on the free return trajectory that goes

1233
00:56:12,190 --> 00:56:08,869
close by a comet not too close but La

1234
00:56:13,810 --> 00:56:12,200
Crosse Mission says let's do something

1235
00:56:16,540 --> 00:56:13,820
with the upper-stage that's going along

1236
00:56:18,339 --> 00:56:16,550
with you let's crash it into the into

1237
00:56:20,260 --> 00:56:18,349
the comet as you fly by and take

1238
00:56:21,940 --> 00:56:20,270

pictures of it you can see that Buzz

1239
00:56:24,849 --> 00:56:21,950
Aldrin is still an endless source of

1240
00:56:33,280 --> 00:56:24,859
ideas for which for which we're grateful

1241
00:56:36,250 --> 00:56:33,290
I want to ask Laurie lechon who is the

1242
00:56:38,410 --> 00:56:36,260
NASA deputy associate administrator to

1243
00:56:39,790 --> 00:56:38,420
reflect on what we heard from Scott and

1244
00:56:41,680 --> 00:56:39,800
John about the interaction between

1245
00:56:43,480 --> 00:56:41,690
humans and robots and what we learned

1246
00:56:45,070 --> 00:56:43,490
from exploring with each by telling us a

1247
00:56:47,800 --> 00:56:45,080
little bit about NASA's plans going

1248
00:56:49,599 --> 00:56:47,810
forward in that in that dimension Thanks

1249
00:56:52,079 --> 00:56:49,609
thanks very much I'm the deputy

1250
00:56:54,160 --> 00:56:52,089
associate administrator for exploration

1251
00:56:55,480 --> 00:56:54,170
the exploration systems Mission

1252
00:56:57,070 --> 00:56:55,490
Directorate I'm happy to be up here to

1253
00:57:00,130 --> 00:56:57,080
present some balance as I went to

1254
00:57:04,150 --> 00:57:00,140
Caltech not MIT so we need some

1255
00:57:05,950 --> 00:57:04,160
diversity and schools here so obviously

1256
00:57:07,540 --> 00:57:05,960
as we heard really eloquently today from

1257
00:57:10,320 --> 00:57:07,550
the President and from the panel the

1258
00:57:12,880 --> 00:57:10,330
goal of this this human spaceflight

1259
00:57:15,070 --> 00:57:12,890
endeavor is to really create a sustained

1260
00:57:16,960 --> 00:57:15,080
capability to send humans into the solar

1261
00:57:19,030 --> 00:57:16,970
system to stay and whether your interest

1262
00:57:20,620 --> 00:57:19,040
is in science or in economic development

1263
00:57:22,780 --> 00:57:20,630

or in you know long-term human

1264
00:57:24,550 --> 00:57:22,790
habitation on other worlds there are

1265
00:57:26,680 --> 00:57:24,560
many interesting destinations as we've

1266
00:57:27,280 --> 00:57:26,690
heard about today there are asteroids

1267
00:57:29,230 --> 00:57:27,290
and obvious

1268
00:57:33,760 --> 00:57:29,240
Slean Mars and even the moon has a lot

1269
00:57:36,820 --> 00:57:33,770
of interesting secrets toot in to unlock

1270
00:57:38,740 --> 00:57:36,830
in the future with humans and robots so

1271
00:57:41,500 --> 00:57:38,750
one of the exciting things in this

1272
00:57:43,390 --> 00:57:41,510
program is a set of robotic precursor

1273
00:57:45,130 --> 00:57:43,400
missions that are going to give us the

1274
00:57:47,110 --> 00:57:45,140
knowledge we need ultimately to create

1275
00:57:47,860 --> 00:57:47,120
the sustained human capability in the

1276
00:57:50,950 --> 00:57:47,870
solar system

1277
00:57:52,660 --> 00:57:50,960
so at esmd in the in the last couple of

1278
00:57:54,460 --> 00:57:52,670
months we've been putting plans together

1279
00:57:55,240 --> 00:57:54,470
for these robotic precursors and I

1280
00:57:56,620 --> 00:57:55,250
thought I would just take the

1281
00:57:58,360 --> 00:57:56,630
opportunity to tell you a little bit

1282
00:58:00,580 --> 00:57:58,370
more about them about what we're

1283
00:58:03,660 --> 00:58:00,590
thinking so that the basic objectives

1284
00:58:05,980 --> 00:58:03,670
here would be to find safe and

1285
00:58:08,830 --> 00:58:05,990
interesting sites to visit to have these

1286
00:58:11,170 --> 00:58:08,840
robotic precursors be Scouts to

1287
00:58:13,510 --> 00:58:11,180
understand the resources that would be

1288
00:58:15,190 --> 00:58:13,520

there for humans that so that they could

1289
00:58:17,650 --> 00:58:15,200
one day live off the land on these

1290
00:58:19,480 --> 00:58:17,660
objects and to also understand the

1291
00:58:21,490 --> 00:58:19,490
hazards that exist in these places that

1292
00:58:24,520 --> 00:58:21,500
we want to go with humans so we're

1293
00:58:25,960 --> 00:58:24,530
looking at several different approaches

1294
00:58:28,450 --> 00:58:25,970
to getting this kind of information

1295
00:58:30,310 --> 00:58:28,460
whether they be standalone missions of

1296
00:58:32,830 --> 00:58:30,320
sort of medium class up to eight hundred

1297
00:58:35,950 --> 00:58:32,840
million dollars or so also some small

1298
00:58:37,600 --> 00:58:35,960
quick getaway kind of missions that we

1299
00:58:39,220 --> 00:58:37,610
call we're calling them exploration

1300
00:58:42,010 --> 00:58:39,230
Scouts that could be quick turnaround

1301
00:58:43,570 --> 00:58:42,020
missions also tons of opportunity for

1302
00:58:45,370 --> 00:58:43,580
international and commercial

1303
00:58:48,400 --> 00:58:45,380
participation and this robotic precursor

1304
00:58:49,870 --> 00:58:48,410
program or we could have payloads on

1305
00:58:51,280 --> 00:58:49,880
international missions we can partner

1306
00:58:53,680 --> 00:58:51,290
with the commercial community with their

1307
00:58:55,000 --> 00:58:53,690
capabilities to get this information for

1308
00:58:57,660 --> 00:58:55,010
us and the kinds of things we're talking

1309
00:59:00,580 --> 00:58:57,670
about are following up on the exciting

1310
00:59:03,820 --> 00:59:00,590
discoveries of LRO and LCROSS that that

1311
00:59:06,190 --> 00:59:03,830
hint at water on the moon and can we

1312
00:59:08,440 --> 00:59:06,200
actually extract that or other resources

1313
00:59:10,540 --> 00:59:08,450

and utilize them can we operate robots

1314
00:59:12,190 --> 00:59:10,550
on the moon remotely to get at that

1315
00:59:14,980 --> 00:59:12,200
human robotic partnership that had

1316
00:59:17,560 --> 00:59:14,990
Crowley talked about so eloquently

1317
00:59:19,300 --> 00:59:17,570
either from here on earth or even from

1318
00:59:22,750 --> 00:59:19,310
the ISS we will be looking at missions

1319
00:59:25,270 --> 00:59:22,760
that can do that on Mars can we get at

1320
00:59:26,530 --> 00:59:25,280
the the toxicity of that dust I would

1321
00:59:27,940 --> 00:59:26,540
argue we could actually do that with a

1322
00:59:29,230 --> 00:59:27,950
sample return mission that doesn't even

1323
00:59:31,150 --> 00:59:29,240
land you could fly through that

1324
00:59:33,310 --> 00:59:31,160
atmosphere and sweep up some dust and do

1325
00:59:35,140 --> 00:59:33,320
your first Mars round-trip really soon

1326
00:59:37,480 --> 00:59:35,150
as a great Pathfinder to future human

1327
00:59:39,880 --> 00:59:37,490
round trips and in 2018 the Mars

1328
00:59:41,019 --> 00:59:39,890
Opportunity is the most energetically

1329
00:59:42,640 --> 00:59:41,029
favorable at about

1330
00:59:44,620 --> 00:59:42,650
thirty years it'll be a great

1331
00:59:46,299 --> 00:59:44,630
opportunity for us to test new landing

1332
00:59:48,309 --> 00:59:46,309
technologies that will allow us to break

1333
00:59:50,109 --> 00:59:48,319
the one-ton barrier that the Mars

1334
00:59:52,120 --> 00:59:50,119
Science Lab has is going to just

1335
00:59:53,439 --> 00:59:52,130
approach up we have got to land more

1336
00:59:55,749 --> 00:59:53,449
mass on the surface of Mars if we're

1337
00:59:57,339 --> 00:59:55,759
going to send humans so in 2018 we're

1338
01:00:00,669 --> 00:59:57,349

hoping it'll be part of an international

1339
01:00:01,870 --> 01:00:00,679
armada of missions to Mars to prove out

1340
01:00:04,029 --> 01:00:01,880
some of those human precursor

1341
01:00:05,380 --> 01:00:04,039
capabilities and asteroids there's so

1342
01:00:07,899 --> 01:00:05,390
much more that we need to learn about

1343
01:00:09,939 --> 01:00:07,909
how what they all look like what are the

1344
01:00:12,729 --> 01:00:09,949
diversity of possible targets there how

1345
01:00:16,179 --> 01:00:12,739
would we operate around them so bottom

1346
01:00:17,890 --> 01:00:16,189
line is I think the details of where we

1347
01:00:19,839 --> 01:00:17,900
go and when are going to be driven by

1348
01:00:22,029 --> 01:00:19,849
the discoveries we make in the next few

1349
01:00:23,469 --> 01:00:22,039
years with this robotic precursor

1350
01:00:24,669 --> 01:00:23,479
program and with the technology

1351
01:00:26,409 --> 01:00:24,679
development programs that are in this

1352
01:00:29,559 --> 01:00:26,419
budget we're really excited to get

1353
01:00:31,209 --> 01:00:29,569
started and get going thank you Laurie

1354
01:00:32,949 --> 01:00:31,219
we have about two minutes left I see

1355
01:00:36,009 --> 01:00:32,959
Bill Nye the Science Guy sitting in the

1356
01:00:37,989 --> 01:00:36,019
front row and I want him as a world

1357
01:00:40,779 --> 01:00:37,999
renowned expert on inspiring kids to

1358
01:00:43,359 --> 01:00:40,789
tell us whether we can inspire kids with

1359
01:00:45,209 --> 01:00:43,369
this vision going forward absolutely we

1360
01:00:49,419 --> 01:00:45,219
can inspire our kids if you want to know

1361
01:00:52,509 --> 01:00:49,429
why we're gonna go to Mars ask your kid

1362
01:00:55,659 --> 01:00:52,519
ask your grandkid and he or she will

1363
01:00:58,539 --> 01:00:55,669

tell you now buzz is it true that if I'm

1364
01:01:02,319 --> 01:00:58,549
on Phobos with enough mobility in my

1365
01:01:05,979 --> 01:01:02,329
spacesuit I can put a tennis ball or

1366
01:01:08,799 --> 01:01:05,989
baseball-sized rock into orbit right you

1367
01:01:10,659 --> 01:01:08,809
can throw it into orbit yeah we

1368
01:01:12,219 --> 01:01:10,669
encourage you to turn the rock when you

1369
01:01:14,079 --> 01:01:12,229
reach back don't go like this you want

1370
01:01:15,669 --> 01:01:14,089
to turn your fingers so you're gonna

1371
01:01:18,669 --> 01:01:15,679
have to have proper mobility in your

1372
01:01:20,349 --> 01:01:18,679
glove so yes if you ask a kid why we're

1373
01:01:22,029 --> 01:01:20,359
gonna go to Mars and he or she will tell

1374
01:01:26,409 --> 01:01:22,039
you the whole thing is there's two

1375
01:01:29,739 --> 01:01:26,419
questions or three brother Scott where

1376
01:01:31,329 --> 01:01:29,749
did we come from are we alone if you

1377
01:01:32,769 --> 01:01:31,339
want to answer those two questions if

1378
01:01:36,279 --> 01:01:32,779
you want to get closer to those answers

1379
01:01:38,890 --> 01:01:36,289
Mars is the next destination it's that's

1380
01:01:42,969 --> 01:01:38,900
it so let's go have a look and in order

1381
01:01:44,319 --> 01:01:42,979
to do that we have to have programs that

1382
01:01:46,989 --> 01:01:44,329
are not also not only sustainable

1383
01:01:49,929 --> 01:01:46,999
economically but politically so that

1384
01:01:51,999 --> 01:01:49,939
each time we achieve a goal the public

1385
01:01:54,489 --> 01:01:52,009
people taxpayers and voters will sustain

1386
01:01:55,059 --> 01:01:54,499
it let's change the world thank you very

1387
01:01:58,839 --> 01:01:55,069
much

1388
01:02:00,819 --> 01:01:58,849

and and thank you thank you Bill and I

1389
01:02:03,430 --> 01:02:00,829
want to thank all of the panelists we

1390
01:02:04,960 --> 01:02:03,440
now need to call it to a close and go on

1391
01:02:06,670 --> 01:02:04,970
to the next stage but there's been a

1392
01:02:09,069 --> 01:02:06,680
terrific session I apologize to those

1393
01:02:10,539 --> 01:02:09,079
who would have I know added to the

1394
01:02:12,069 --> 01:02:10,549
richness of this discussion with their