
NASA
FUTURE FORUM
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1
00:00:04,550 --> 00:00:02,230
today america's space program is alive

2
00:00:05,910 --> 00:00:04,560
and vital and it's filled with people

3
00:00:07,349 --> 00:00:05,920
like many of you who sit in this

4
00:00:10,230 --> 00:00:07,359
audience or people that you've been

5
00:00:12,310 --> 00:00:10,240
seeing on television and uh and you're

6
00:00:14,709 --> 00:00:12,320
gonna see right now because we have a

7
00:00:17,029 --> 00:00:14,719
special treat that i'm not sure senator

8
00:00:18,870 --> 00:00:17,039
glenn he probably is beginning to to get

9
00:00:19,830 --> 00:00:18,880
a hint that something's funny is going

10
00:00:22,230 --> 00:00:19,840
on here

11
00:00:23,670 --> 00:00:22,240
but it's it this is an honor for me to

12
00:00:26,070 --> 00:00:23,680
be able to introduce commander dan

13
00:00:27,750 --> 00:00:26,080

burbank and flight engineer don pettit

14
00:00:30,150 --> 00:00:27,760
live from the international space

15
00:00:33,350 --> 00:00:30,160
station uh to have just a chat with the

16
00:00:34,870 --> 00:00:33,360
senator so crew how do you read me

17
00:00:36,150 --> 00:00:34,880
charlie we've got you loud and clear

18
00:00:37,110 --> 00:00:36,160
welcome aboard the international space

19
00:00:46,950 --> 00:00:37,120
station

20
00:00:50,470 --> 00:00:49,029
hey i'd just like to say that uh we know

21
00:00:52,229 --> 00:00:50,480
you have an awful lot on your plate for

22
00:00:54,069 --> 00:00:52,239
the next couple of days and and we're

23
00:00:56,470 --> 00:00:54,079
delighted just to get a chance to be

24
00:00:58,709 --> 00:00:56,480
here at the uh the opening and uh to

25
00:01:01,270 --> 00:00:58,719
maybe just uh take a few moments to

26
00:01:03,910 --> 00:01:01,280
commemorate senator glenn's flight 50

27
00:01:06,550 --> 00:01:03,920
years ago today uh friendship seven was

28
00:01:08,870 --> 00:01:06,560
orbiting uh planet earth and that helped

29
00:01:12,789 --> 00:01:08,880
in a very big way paved the way for

30
00:01:15,030 --> 00:01:12,799
america to uh to become a space power

31
00:01:16,469 --> 00:01:15,040
and to uh to go to the moon and to do

32
00:01:18,710 --> 00:01:16,479
the things that we're doing right now on

33
00:01:20,550 --> 00:01:18,720
the international space station and we

34
00:01:22,789 --> 00:01:20,560
hope it's also going to help set us to

35
00:01:25,030 --> 00:01:22,799
set the stage for us down the road to do

36
00:01:27,030 --> 00:01:25,040
even greater things

37
00:01:28,550 --> 00:01:27,040
well dan and don uh i thank you both

38
00:01:30,950 --> 00:01:28,560

very much but we're gonna turn the

39
00:01:33,030 --> 00:01:30,960
tables on senator glenn right now if

40
00:01:35,910 --> 00:01:33,040
it's okay with you he's been getting

41
00:01:37,429 --> 00:01:35,920
pummeled with questions and uh he is

42
00:01:39,350 --> 00:01:37,439
probably the biggest champion of the

43
00:01:41,030 --> 00:01:39,360
international space station so i'd like

44
00:01:42,310 --> 00:01:41,040
to give him an opportunity to kind of

45
00:01:44,550 --> 00:01:42,320
pummel you

46
00:01:46,789 --> 00:01:44,560
with some questions about life up there

47
00:01:48,630 --> 00:01:46,799
since he's he's campaigning already for

48
00:01:49,350 --> 00:01:48,640
a trip to station so i want i want you

49
00:01:55,830 --> 00:01:49,360
to

50
00:01:57,429 --> 00:01:55,840
of questions for them or some comments

51
00:02:02,789 --> 00:01:57,439
to them you guys are not floating you

52
00:02:05,590 --> 00:02:03,990
you're not you're

53
00:02:07,109 --> 00:02:05,600
how are you secured there you got a belt

54
00:02:08,550 --> 00:02:07,119
on senator glenn it's great to talk with

55
00:02:10,630 --> 00:02:08,560
you welcome aboard

56
00:02:12,630 --> 00:02:10,640
thank you

57
00:02:14,470 --> 00:02:12,640
andy's going to hand my head to me on a

58
00:02:16,470 --> 00:02:14,480
platter if i'm not careful with this uh

59
00:02:17,510 --> 00:02:16,480
talk about going to the station

60
00:02:19,510 --> 00:02:17,520
but

61
00:02:20,790 --> 00:02:19,520
no i know you're floating around that's

62
00:02:22,949 --> 00:02:20,800
one of the things you can do up there in

63
00:02:24,390 --> 00:02:22,959

one of the zero-g environment of course

64
00:02:25,750 --> 00:02:24,400
is while you're up there to begin with

65
00:02:27,830 --> 00:02:25,760
to do the research that can be done

66
00:02:29,910 --> 00:02:27,840
there uh what are you doing hanging on

67
00:02:31,589 --> 00:02:29,920
are you tethered

68
00:02:33,030 --> 00:02:31,599
actually i've got one foot underneath a

69
00:02:35,270 --> 00:02:33,040
bungee another foot underneath a

70
00:02:37,990 --> 00:02:35,280
handrail i think don right now is free

71
00:02:41,190 --> 00:02:38,000
floating and behind us is andre kuipers

72
00:02:43,830 --> 00:02:41,200
european space agency uh dutch astronaut

73
00:02:45,750 --> 00:02:43,840
with us and uh andre's uh basically

74
00:02:47,509 --> 00:02:45,760
free-floating as well it took us a

75
00:02:49,110 --> 00:02:47,519
little while to kind of get our space

76
00:02:50,949 --> 00:02:49,120
legs so to speak but

77
00:02:53,190 --> 00:02:50,959
everybody's pretty comfortable

78
00:02:54,470 --> 00:02:53,200
managing their orientation in any number

79
00:02:56,390 --> 00:02:54,480
of ways

80
00:02:58,390 --> 00:02:56,400
do you have any estimate i don't know

81
00:03:00,550 --> 00:02:58,400
whether you know the exact number of

82
00:03:02,229 --> 00:03:00,560
research experiments you have on board

83
00:03:06,949 --> 00:03:02,239
right now do you have a

84
00:03:10,790 --> 00:03:08,869
i knew he was going to give me the gun

85
00:03:13,350 --> 00:03:10,800
we have well over a hundred

86
00:03:16,550 --> 00:03:13,360
and they all come with an acronym that

87
00:03:18,550 --> 00:03:16,560
uh you either have no vowels in them so

88
00:03:20,790 --> 00:03:18,560

it makes it really hard to pronounce

89
00:03:21,589 --> 00:03:20,800
or you can't remember what all the all

90
00:03:22,390 --> 00:03:21,599
the

91
00:03:24,470 --> 00:03:22,400
uh

92
00:03:27,270 --> 00:03:24,480
words all the letters stood for in the

93
00:03:29,430 --> 00:03:27,280
first place however i i would like to

94
00:03:31,670 --> 00:03:29,440
say that that the experiments we have

95
00:03:34,550 --> 00:03:31,680
we've got a whole ensemble of life

96
00:03:37,509 --> 00:03:34,560
science experiments that basically probe

97
00:03:39,270 --> 00:03:37,519
the gravity knob for life since it

98
00:03:41,670 --> 00:03:39,280
evolved on earth

99
00:03:43,270 --> 00:03:41,680
under constant gravity and now all of a

100
00:03:45,830 --> 00:03:43,280
sudden we can change the magnitude of

101
00:03:48,470 --> 00:03:45,840
gravity by a factor of a million and we

102
00:03:50,550 --> 00:03:48,480
can look at what the effects are on

103
00:03:52,470 --> 00:03:50,560
living organisms including human beings

104
00:03:55,750 --> 00:03:52,480
under that and then we have physical

105
00:03:59,030 --> 00:03:55,760
science experiments growing crystals

106
00:04:02,070 --> 00:03:59,040
looking at surface tension and other

107
00:04:03,910 --> 00:04:02,080
related phenomena that gravity masks and

108
00:04:05,589 --> 00:04:03,920
then combustion experiments i did a

109
00:04:08,070 --> 00:04:05,599
whole suite of combustion experiments

110
00:04:09,429 --> 00:04:08,080
this morning it was really fascinating

111
00:04:11,030 --> 00:04:09,439
yeah are you

112
00:04:13,190 --> 00:04:11,040
are you able to

113
00:04:15,190 --> 00:04:13,200

keep combustion going with less fuel

114
00:04:16,390 --> 00:04:15,200
required i know that that was one of the

115
00:04:18,629 --> 00:04:16,400
things that they

116
00:04:20,870 --> 00:04:18,639
came up on columbia before it was

117
00:04:21,670 --> 00:04:20,880
destroyed

118
00:04:23,670 --> 00:04:21,680
uh

119
00:04:25,749 --> 00:04:23,680
you know that i don't know i do know

120
00:04:27,590 --> 00:04:25,759
that you have to you have to fan the

121
00:04:28,469 --> 00:04:27,600
flames if you want to keep them going up

122
00:04:31,830 --> 00:04:28,479
here

123
00:04:34,310 --> 00:04:31,840
we're looking at forced convection and

124
00:04:36,710 --> 00:04:34,320
the the fuel that i was looking at this

125
00:04:38,390 --> 00:04:36,720
morning with help from

126
00:04:40,150 --> 00:04:38,400
folks from

127
00:04:42,790 --> 00:04:40,160
nasa glenn

128
00:04:46,070 --> 00:04:42,800
was ethylene we're looking at 20

129
00:04:48,790 --> 00:04:46,080
ethylene and and burning that in air

130
00:04:51,909 --> 00:04:48,800
under forced convection and looking at

131
00:04:57,189 --> 00:04:51,919
at uh when you get separation of the

132
00:04:58,870 --> 00:04:57,199
flame from the fixture that holds it

133
00:04:59,830 --> 00:04:58,880
that's that's very interesting i've

134
00:05:02,070 --> 00:04:59,840
thought the

135
00:05:03,990 --> 00:05:02,080
those energy experiments that were

136
00:05:05,670 --> 00:05:04,000
started on columbia

137
00:05:07,029 --> 00:05:05,680
i thought were fascinating and they had

138
00:05:09,350 --> 00:05:07,039

a lot of uh

139
00:05:12,550 --> 00:05:09,360
important future maybe right here on

140
00:05:14,230 --> 00:05:12,560
earth the uh

141
00:05:16,950 --> 00:05:14,240
i don't know whether people here in the

142
00:05:19,830 --> 00:05:16,960
audience right here today realize but

143
00:05:21,350 --> 00:05:19,840
you know a candle has a flame goes up

144
00:05:23,029 --> 00:05:21,360
because it the air is heated and the

145
00:05:24,390 --> 00:05:23,039
convection goes up and pulls the flame

146
00:05:26,390 --> 00:05:24,400
up but in space

147
00:05:28,230 --> 00:05:26,400
when something burns it just collects in

148
00:05:29,590 --> 00:05:28,240
a big cloud around it so you get a whole

149
00:05:31,749 --> 00:05:29,600
different set of

150
00:05:34,150 --> 00:05:31,759
burning and combustion principles and

151
00:05:35,110 --> 00:05:34,160
anything you can't duplicate that here

152
00:05:36,870 --> 00:05:35,120
on earth

153
00:05:39,110 --> 00:05:36,880
and there were some of the indications

154
00:05:42,710 --> 00:05:39,120
where that that we might be able to have

155
00:05:44,550 --> 00:05:42,720
combustion with far less use of fuel

156
00:05:46,390 --> 00:05:44,560
on some of the columbia experiments and

157
00:05:49,270 --> 00:05:46,400
that's what you're you're continuing

158
00:05:52,310 --> 00:05:49,280
that right now i guess is that correct

159
00:05:54,710 --> 00:05:52,320
uh yes senator glenn and and i find it

160
00:05:56,629 --> 00:05:54,720
philosophically interesting that that

161
00:05:58,309 --> 00:05:56,639
civilization started

162
00:06:02,070 --> 00:05:58,319
with fire

163
00:06:04,710 --> 00:06:02,080

and learning how to use fire and it's uh

164
00:06:07,909 --> 00:06:04,720
served us well for millennia

165
00:06:09,590 --> 00:06:07,919
and and we are slowly refining our

166
00:06:11,189 --> 00:06:09,600
understanding of what fire is because

167
00:06:12,950 --> 00:06:11,199
fire will work whether or not you really

168
00:06:14,150 --> 00:06:12,960
understand all the details of the

169
00:06:17,110 --> 00:06:14,160
chemistry

170
00:06:19,110 --> 00:06:17,120
and what we're doing now is again using

171
00:06:21,749 --> 00:06:19,120
a reduced gravity environment which

172
00:06:22,950 --> 00:06:21,759
changes the dynamics of combustion so

173
00:06:27,029 --> 00:06:22,960
that we can

174
00:06:30,309 --> 00:06:27,039
dissect even more detail out from how

175
00:06:32,550 --> 00:06:30,319
fire works which is obviously a needed

176
00:06:35,270 --> 00:06:32,560
element even as we

177
00:06:37,350 --> 00:06:35,280
leave planet earth and go off into the

178
00:06:40,629 --> 00:06:37,360
go away from the planet

179
00:06:42,790 --> 00:06:40,639
hey dan we've got a number of very young

180
00:06:44,469 --> 00:06:42,800
students here with us and i know i was

181
00:06:45,670 --> 00:06:44,479
watching you earlier it may have been a

182
00:06:47,510 --> 00:06:45,680
replay but

183
00:06:49,749 --> 00:06:47,520
the first handshake between a humanoid

184
00:06:51,589 --> 00:06:49,759
robot and a human

185
00:06:55,270 --> 00:06:51,599
in space can you talk a little bit about

186
00:06:57,189 --> 00:06:55,280
uh r2 and and whether r2 is behaving or

187
00:06:59,270 --> 00:06:57,199
or is developing a mind of its own

188
00:07:01,350 --> 00:06:59,280

already

189
00:07:03,909 --> 00:07:01,360
yeah we were talking about that there's

190
00:07:05,990 --> 00:07:03,919
we wanted to make sure that all three uh

191
00:07:08,230 --> 00:07:06,000
laws of robotics had been incorporated

192
00:07:09,909 --> 00:07:08,240
but but in all seriousness uh a couple

193
00:07:11,749 --> 00:07:09,919
of days ago we had

194
00:07:13,430 --> 00:07:11,759
robonaut r2

195
00:07:15,430 --> 00:07:13,440
out here in the lab and we were

196
00:07:17,189 --> 00:07:15,440
basically doing some checkouts on it and

197
00:07:19,350 --> 00:07:17,199
at this stage really it's a technology

198
00:07:20,870 --> 00:07:19,360
development program and the idea is that

199
00:07:22,230 --> 00:07:20,880
all the interfaces all the things that

200
00:07:24,550 --> 00:07:22,240
we have on space station that we

201
00:07:27,670 --> 00:07:24,560
interact with are all designed for

202
00:07:28,790 --> 00:07:27,680
humans for human hands for human arm

203
00:07:31,350 --> 00:07:28,800
length for

204
00:07:33,909 --> 00:07:31,360
for uh the parallax that human eyes

205
00:07:35,749 --> 00:07:33,919
provide and essentially robonaut has the

206
00:07:37,670 --> 00:07:35,759
same functionality the same you know

207
00:07:40,950 --> 00:07:37,680
capability as far as interacting with

208
00:07:43,589 --> 00:07:40,960
hardware so it all affords down the road

209
00:07:45,670 --> 00:07:43,599
a very good opportunity to take the

210
00:07:46,869 --> 00:07:45,680
tasks that are routine and perhaps some

211
00:07:49,110 --> 00:07:46,879
of the tasks that might be more

212
00:07:51,830 --> 00:07:49,120
dangerous for crew members to do and

213
00:07:54,150 --> 00:07:51,840

basically help offload us and uh and

214
00:07:56,230 --> 00:07:54,160
share those tasks with uh with a

215
00:07:58,790 --> 00:07:56,240
an anthropoid

216
00:08:00,710 --> 00:07:58,800
robot and ultimately i think it also has

217
00:08:02,950 --> 00:08:00,720
a lot of promise for doing space walks

218
00:08:05,110 --> 00:08:02,960
and these those can be of course one of

219
00:08:06,790 --> 00:08:05,120
the most dangerous things we do in space

220
00:08:09,270 --> 00:08:06,800
now put the three of you guys on the

221
00:08:11,510 --> 00:08:09,280
spot because i don't think the senator

222
00:08:13,029 --> 00:08:11,520
has ever been asked a question

223
00:08:13,749 --> 00:08:13,039
from space

224
00:08:15,510 --> 00:08:13,759
so

225
00:08:18,710 --> 00:08:15,520
how about if the three of you put your

226
00:08:20,629 --> 00:08:18,720
heads together play like your newsman

227
00:08:22,710 --> 00:08:20,639
and give us a question

228
00:08:27,350 --> 00:08:22,720
that's really rough for him

229
00:08:32,790 --> 00:08:29,670
and annie's sweating beads

230
00:08:36,149 --> 00:08:32,800
so senator glenn did you ever really

231
00:08:38,469 --> 00:08:36,159
find out what the fireflies were on

232
00:08:39,269 --> 00:08:38,479
your first orbit

233
00:08:41,350 --> 00:08:39,279
yeah

234
00:08:42,949 --> 00:08:41,360
we did i think the uh

235
00:08:44,470 --> 00:08:42,959
you know scott carpenter on the second

236
00:08:46,790 --> 00:08:44,480
flight was able to hit the side of the

237
00:08:48,949 --> 00:08:46,800
spacecraft the capsule and send the

238
00:08:50,310 --> 00:08:48,959

whole shower about and the uh the

239
00:08:51,670 --> 00:08:50,320
scientists working on this they could

240
00:08:53,590 --> 00:08:51,680
relate them to the

241
00:08:55,910 --> 00:08:53,600
uh water dripping out through the heat

242
00:08:58,070 --> 00:08:55,920
exchanger which was a controlled thing

243
00:09:01,350 --> 00:08:58,080
and then they just collected in a large

244
00:09:02,710 --> 00:09:01,360
cloud around the around the spacecraft

245
00:09:04,470 --> 00:09:02,720
the one thing i don't know that

246
00:09:07,509 --> 00:09:04,480
scientists have ever figured out yet is

247
00:09:09,110 --> 00:09:07,519
why the glowing luminous color

248
00:09:11,269 --> 00:09:09,120
water particles will go out and freeze

249
00:09:12,710 --> 00:09:11,279
and the light comes from the sun

250
00:09:15,110 --> 00:09:12,720
and through the earth's atmosphere and

251
00:09:17,110 --> 00:09:15,120
back out to the spacecraft again

252
00:09:19,030 --> 00:09:17,120
and what what changes the light in that

253
00:09:21,430 --> 00:09:19,040
what is refracted there so that when it

254
00:09:23,750 --> 00:09:21,440
hit these frozen particles they glow

255
00:09:25,190 --> 00:09:23,760
sort of a glowing luminous color

256
00:09:27,030 --> 00:09:25,200
and i don't know that we ever figured

257
00:09:29,430 --> 00:09:27,040
that one out not if we do i don't know

258
00:09:30,550 --> 00:09:29,440
what the answer was on it but

259
00:09:31,670 --> 00:09:30,560
they were not

260
00:09:33,590 --> 00:09:31,680
they weren't anything that was going to

261
00:09:36,310 --> 00:09:33,600
do me any harm so i wasn't too concerned

262
00:09:38,550 --> 00:09:36,320
about them

263
00:09:40,310 --> 00:09:38,560

if you guys had an opportunity to uh to

264
00:09:42,150 --> 00:09:40,320
bring this since he's bugging me all the

265
00:09:44,790 --> 00:09:42,160
time if he had an opportunity to bring

266
00:09:46,949 --> 00:09:44,800
him up for say a couple of months stint

267
00:09:49,269 --> 00:09:46,959
on station

268
00:09:51,829 --> 00:09:49,279
okay annie i'm just kidding

269
00:09:53,750 --> 00:09:51,839
uh which experiment that you're doing

270
00:10:05,590 --> 00:09:53,760
now would you most like to hand off to

271
00:10:09,750 --> 00:10:06,949
we know one thing that we didn't talk

272
00:10:10,949 --> 00:10:09,760
about already which i think is a key

273
00:10:12,470 --> 00:10:10,959
thing that we're doing onboard space

274
00:10:14,870 --> 00:10:12,480
station right now we do a lot of the

275
00:10:16,069 --> 00:10:14,880
life sciences and physical sciences

276
00:10:17,509 --> 00:10:16,079
but one thing that we're doing on

277
00:10:18,389 --> 00:10:17,519
station really i think falls in the

278
00:10:20,310 --> 00:10:18,399
category

279
00:10:22,870 --> 00:10:20,320
of engineering development technology

280
00:10:24,550 --> 00:10:22,880
development and i think this is some of

281
00:10:26,150 --> 00:10:24,560
the key things that will help us leave

282
00:10:27,910 --> 00:10:26,160
low earth orbit go on to the moon

283
00:10:29,750 --> 00:10:27,920
asteroids and onto mars

284
00:10:31,910 --> 00:10:29,760
and i think one of the things that we

285
00:10:33,910 --> 00:10:31,920
learn an awful lot about every day that

286
00:10:35,990 --> 00:10:33,920
we get a chance to interact with it is

287
00:10:38,630 --> 00:10:36,000
the regenerative environmental control

288
00:10:40,550 --> 00:10:38,640

system that we have here so i think

289
00:10:42,870 --> 00:10:40,560
based on his experience the center's

290
00:10:45,110 --> 00:10:42,880
experience it would be really neat very

291
00:10:47,750 --> 00:10:45,120
interesting to get a chance to work with

292
00:10:49,750 --> 00:10:47,760
him on the systems that we have to

293
00:10:51,670 --> 00:10:49,760
provide that capability if we we spend

294
00:10:53,590 --> 00:10:51,680
so much time sometimes focused on the

295
00:10:55,829 --> 00:10:53,600
details of those tasks it would be

296
00:10:58,069 --> 00:10:55,839
really good to have a big picture look

297
00:11:00,470 --> 00:10:58,079
on about that and also from somebody who

298
00:11:03,350 --> 00:11:00,480
has thought about leaving low-earth

299
00:11:06,069 --> 00:11:03,360
orbit from the perspective of lawmakers

300
00:11:08,470 --> 00:11:06,079
in our government

301
00:11:09,990 --> 00:11:08,480
and really what dan meant to say was

302
00:11:12,389 --> 00:11:10,000
when he's talking about the regenerative

303
00:11:15,670 --> 00:11:12,399
life support system that's a fancy word

304
00:11:18,710 --> 00:11:15,680
for our toilet and so he wants to put

305
00:11:21,269 --> 00:11:18,720
senator glenn busy fixing the plumbing

306
00:11:28,710 --> 00:11:22,870
that's exactly what i thought i was

307
00:11:32,550 --> 00:11:30,710
and and i think now now that don's

308
00:11:36,150 --> 00:11:32,560
pointed it out i may find myself

309
00:11:37,750 --> 00:11:36,160
replaced outright with the senator

310
00:11:39,670 --> 00:11:37,760
you got anything else for them

311
00:11:42,389 --> 00:11:39,680
one other question do you have any uh

312
00:11:46,790 --> 00:11:42,399
plant growth studies on board right now

313
00:11:51,670 --> 00:11:48,230

well uh

314
00:11:53,509 --> 00:11:51,680
just just as a a little uh investigation

315
00:11:55,430 --> 00:11:53,519
on the side i've been growing a few

316
00:11:58,069 --> 00:11:55,440
plants and

317
00:11:59,990 --> 00:11:58,079
as senator glenn i was able to get a

318
00:12:01,269 --> 00:12:00,000
zucchini plant

319
00:12:03,750 --> 00:12:01,279
to bloom

320
00:12:06,230 --> 00:12:03,760
and it bloomed on valentine's day and i

321
00:12:08,949 --> 00:12:06,240
had a special conference with my wife

322
00:12:11,350 --> 00:12:08,959
and i presented her with uh with a

323
00:12:14,150 --> 00:12:11,360
zucchini flower i mean it's it's not a

324
00:12:17,350 --> 00:12:14,160
rose it's not a lily it's it's not a

325
00:12:19,350 --> 00:12:17,360
carnation it was a zucchini blossom uh

326
00:12:21,750 --> 00:12:19,360
but and and she could only see it on the

327
00:12:23,990 --> 00:12:21,760
downlink video but i did

328
00:12:25,990 --> 00:12:24,000
pick that blossom and i i stuck it in

329
00:12:27,670 --> 00:12:26,000
our world atlas i'm pressing it between

330
00:12:29,350 --> 00:12:27,680
pages and i'm going to bring that home

331
00:12:31,030 --> 00:12:29,360
and give it to her

332
00:12:34,790 --> 00:12:31,040
that's good

333
00:12:39,430 --> 00:12:37,030
hey we're here for a future forum so for

334
00:12:41,590 --> 00:12:39,440
the next one go ahead just so everybody

335
00:12:42,949 --> 00:12:41,600
here i wonder about how far around the

336
00:12:44,310 --> 00:12:42,959
earth they've traveled just while we've

337
00:12:45,829 --> 00:12:44,320
been talking to them

338
00:12:46,949 --> 00:12:45,839

probably a fourth of the distance around

339
00:12:49,190 --> 00:12:46,959
the earth

340
00:12:51,670 --> 00:12:49,200
just in the time we've been talking

341
00:12:53,670 --> 00:12:51,680
either of you watching the map

342
00:12:55,829 --> 00:12:53,680
and i'd say that's about right

343
00:13:00,069 --> 00:12:55,839
so it's it's been basically yeah fourth

344
00:13:03,829 --> 00:13:01,590
well in the order of about 10 000

345
00:13:06,310 --> 00:13:03,839
kilometers thereabouts yeah quick

346
00:13:07,990 --> 00:13:06,320
question for you as i was saying we're

347
00:13:11,350 --> 00:13:08,000
here for a future forum for the next day

348
00:13:13,670 --> 00:13:11,360
and a half um you know what just from

349
00:13:16,310 --> 00:13:13,680
what you've seen so far

350
00:13:17,829 --> 00:13:16,320
what would you like to be a topic that

351
00:13:21,030 --> 00:13:17,839
this group

352
00:13:23,110 --> 00:13:21,040
considers in terms of where should we be

353
00:13:24,949 --> 00:13:23,120
20 years from now or 30 years from now

354
00:13:26,870 --> 00:13:24,959
based on what you've what you've seen

355
00:13:33,430 --> 00:13:26,880
and experienced this time and you know i

356
00:13:38,389 --> 00:13:35,350
well i i think there's a lot of aspects

357
00:13:40,790 --> 00:13:38,399
to that and and i think one thing that

358
00:13:42,870 --> 00:13:40,800
uh one of the biggest challenges that we

359
00:13:44,629 --> 00:13:42,880
have on board space station that we've

360
00:13:46,310 --> 00:13:44,639
probably had in any spacecraft before

361
00:13:48,470 --> 00:13:46,320
and it's something that with the space

362
00:13:49,910 --> 00:13:48,480
shuttle we really didn't have this case

363
00:13:51,670 --> 00:13:49,920

and the space shuttle every time we flew

364
00:13:54,069 --> 00:13:51,680
it we returned it to the factory in

365
00:13:56,230 --> 00:13:54,079
essence we returned it to the people who

366
00:13:59,189 --> 00:13:56,240
knew how to build it on board space

367
00:14:01,110 --> 00:13:59,199
station right now astronauts have to be

368
00:14:02,710 --> 00:14:01,120
essentially jacks of all trade we need

369
00:14:04,069 --> 00:14:02,720
to be able to fix anything and

370
00:14:06,470 --> 00:14:04,079
everything that happens we need to

371
00:14:08,710 --> 00:14:06,480
essentially be professional technicians

372
00:14:10,870 --> 00:14:08,720
on a par with the people that for

373
00:14:13,509 --> 00:14:10,880
decades have have put

374
00:14:15,509 --> 00:14:13,519
their heart and soul into into taking

375
00:14:17,269 --> 00:14:15,519
care of incredibly complicated and

376
00:14:19,670 --> 00:14:17,279
exotic vehicles in the form of the space

377
00:14:21,189 --> 00:14:19,680
shuttle if we leave low earth orbit one

378
00:14:23,110 --> 00:14:21,199
of the key things one of the most

379
00:14:25,910 --> 00:14:23,120
important things i think we need to have

380
00:14:28,150 --> 00:14:25,920
is we need to have the capability to

381
00:14:30,550 --> 00:14:28,160
to essentially cut the umbilical to be

382
00:14:32,230 --> 00:14:30,560
able to maintain

383
00:14:35,189 --> 00:14:32,240
spacecraft to the degree that if

384
00:14:36,310 --> 00:14:35,199
something breaks you can replace a part

385
00:14:38,310 --> 00:14:36,320
outright you need to be able to

386
00:14:40,629 --> 00:14:38,320
fabricate a part you can't be you cannot

387
00:14:42,470 --> 00:14:40,639
bring with you all the pieces and parts

388
00:14:43,829 --> 00:14:42,480

that you might anticipate that might

389
00:14:46,230 --> 00:14:43,839
break over the course of a couple of

390
00:14:47,750 --> 00:14:46,240
year mission so we re one of the key

391
00:14:50,389 --> 00:14:47,760
technologies and it's something that i

392
00:14:52,389 --> 00:14:50,399
think is a unique need for space flight

393
00:14:54,949 --> 00:14:52,399
is to find some way to be able to

394
00:14:57,910 --> 00:14:54,959
fabricate parts that we can replace and

395
00:14:59,829 --> 00:14:57,920
to be able to do those things obviously

396
00:15:01,189 --> 00:14:59,839
in conjunction with the with the ground

397
00:15:04,069 --> 00:15:01,199
that's going to help you talk you

398
00:15:06,389 --> 00:15:04,079
through those things uh uh remotely but

399
00:15:09,030 --> 00:15:06,399
the fabrication part in the in the in

400
00:15:12,629 --> 00:15:09,040
the repair capability is uh is one of

401
00:15:15,350 --> 00:15:12,639
the biggest challenges i think we have

402
00:15:16,790 --> 00:15:15,360
and then i i think that uh

403
00:15:19,030 --> 00:15:16,800
one one

404
00:15:22,310 --> 00:15:19,040
aspect of going away from earth that we

405
00:15:24,949 --> 00:15:22,320
need to to think hard about is do we

406
00:15:27,189 --> 00:15:24,959
take everything with us on the mission

407
00:15:29,990 --> 00:15:27,199
from planet earth do we lift everything

408
00:15:32,629 --> 00:15:30,000
we need from earth's gravity well or do

409
00:15:35,509 --> 00:15:32,639
we figure out how to take

410
00:15:38,470 --> 00:15:35,519
materials from elsewhere and use them to

411
00:15:41,350 --> 00:15:38,480
enable missions and this all boils down

412
00:15:43,030 --> 00:15:41,360
to what i refer to as the tyranny of the

413
00:15:44,949 --> 00:15:43,040

rocket equation

414
00:15:47,509 --> 00:15:44,959
and what the

415
00:15:49,670 --> 00:15:47,519
what the engineering implications are to

416
00:15:53,110 --> 00:15:49,680
the rocket equation for the designing

417
00:15:55,590 --> 00:15:53,120
for the design of our rockets that we

418
00:15:57,670 --> 00:15:55,600
launched from the surface of earth and

419
00:16:00,870 --> 00:15:57,680
and the implications of how much payload

420
00:16:03,269 --> 00:16:00,880
can any given rocket take up and what do

421
00:16:05,430 --> 00:16:03,279
you use for that payload and when you

422
00:16:08,310 --> 00:16:05,440
look at at

423
00:16:11,509 --> 00:16:08,320
building bases elsewhere it's going to

424
00:16:12,870 --> 00:16:11,519
take hundreds of tons of material

425
00:16:15,350 --> 00:16:12,880
to

426
00:16:17,110 --> 00:16:15,360
build and maintain a base and and how do

427
00:16:20,710 --> 00:16:17,120
we get those hundreds of tons of

428
00:16:22,470 --> 00:16:20,720
material up into space and and i i think

429
00:16:24,949 --> 00:16:22,480
we need to do some serious thinking

430
00:16:27,350 --> 00:16:24,959
about the rocket equation maybe

431
00:16:28,949 --> 00:16:27,360
alternate ways to try to get things into

432
00:16:31,670 --> 00:16:28,959
space that don't necessarily use the

433
00:16:34,230 --> 00:16:31,680
rocket equation and

434
00:16:35,749 --> 00:16:34,240
possibly think about getting materials a

435
00:16:39,189 --> 00:16:35,759
brute force and ignorance materials that

436
00:16:41,030 --> 00:16:39,199
we need by the multi-ton uh from uh

437
00:16:44,069 --> 00:16:41,040
other than planet earth

438
00:16:49,990 --> 00:16:44,079

don you um let me ask you one one go

439
00:16:53,030 --> 00:16:51,590
yes as an international uh

440
00:16:55,110 --> 00:16:53,040
representative of the international

441
00:16:56,069 --> 00:16:55,120
partner i think it would be nice uh to

442
00:16:58,949 --> 00:16:56,079
add

443
00:17:00,710 --> 00:16:58,959
the question to the future uh forum uh

444
00:17:02,949 --> 00:17:00,720
how the future is going to be in the

445
00:17:04,870 --> 00:17:02,959
sense of international cooperation we

446
00:17:08,069 --> 00:17:04,880
work together with a lot of partners

447
00:17:10,710 --> 00:17:08,079
here now and uh i'm curious what the

448
00:17:13,909 --> 00:17:10,720
forum thinks about uh going beyond earth

449
00:17:16,309 --> 00:17:13,919
orbit uh as an international effort

450
00:17:18,309 --> 00:17:16,319
fantastic i i appreciate that because

451
00:17:19,750 --> 00:17:18,319
i'm thinking about it let me we don't

452
00:17:21,990 --> 00:17:19,760
have a lot of time left but let me ask

453
00:17:22,949 --> 00:17:22,000
you all to just tell the all of us if

454
00:17:25,750 --> 00:17:22,959
you can

455
00:17:27,429 --> 00:17:25,760
uh you know we are getting ready to send

456
00:17:29,990 --> 00:17:27,439
the first private

457
00:17:32,710 --> 00:17:30,000
uh spacecraft up to get ready to bring

458
00:17:35,190 --> 00:17:32,720
you supplies what type of training are

459
00:17:36,630 --> 00:17:35,200
you doing to stay ready there on board

460
00:17:37,590 --> 00:17:36,640
in case

461
00:17:39,590 --> 00:17:37,600
you know

462
00:17:45,590 --> 00:17:39,600
the dragon or cygnus happens to get

463
00:17:48,870 --> 00:17:47,270

that's a great question it's it's really

464
00:17:51,430 --> 00:17:48,880
important for us to be able to maintain

465
00:17:52,950 --> 00:17:51,440
currency and uh and that comes right

466
00:17:55,590 --> 00:17:52,960
down to the piloting skills of being

467
00:17:58,710 --> 00:17:55,600
able to do a robotics uh capture of a

468
00:18:01,270 --> 00:17:58,720
free-flying vehicle and um should should

469
00:18:03,510 --> 00:18:01,280
spacex dragon make it here during my my

470
00:18:05,430 --> 00:18:03,520
watch and i hope it does um the way

471
00:18:08,630 --> 00:18:05,440
we're staying or keeping ourselves

472
00:18:11,909 --> 00:18:08,640
current is by practicing using a program

473
00:18:13,909 --> 00:18:11,919
called robot and that is essentially a

474
00:18:17,029 --> 00:18:13,919
robotic simulator that uses some of the

475
00:18:18,789 --> 00:18:17,039
tools we already have developed

476
00:18:20,870 --> 00:18:18,799
at johnson space center by folks that

477
00:18:23,110 --> 00:18:20,880
work in the virtual reality lab there

478
00:18:24,870 --> 00:18:23,120
and those tools allow us to essentially

479
00:18:26,870 --> 00:18:24,880
simulate the environment

480
00:18:28,630 --> 00:18:26,880
right down to the dynamics of how the

481
00:18:30,470 --> 00:18:28,640
space station robotic arm works the

482
00:18:33,350 --> 00:18:30,480
dynamics of the motion control system of

483
00:18:35,669 --> 00:18:33,360
dragon and uh in very high fidelity

484
00:18:37,350 --> 00:18:35,679
graphics and it allows us to essentially

485
00:18:39,270 --> 00:18:37,360
go through all of the crew coordination

486
00:18:41,430 --> 00:18:39,280
skills and the monkey skills of flying

487
00:18:42,470 --> 00:18:41,440
the arm right up to capture we can do it

488
00:18:44,470 --> 00:18:42,480

multiple times

489
00:18:46,150 --> 00:18:44,480
in addition to that we can also do dry

490
00:18:48,470 --> 00:18:46,160
run captures using the real space

491
00:18:49,990 --> 00:18:48,480
station robotic arm to grapple fixtures

492
00:18:53,110 --> 00:18:50,000
on space station that's something we

493
00:18:55,190 --> 00:18:53,120
have done a couple of weeks ago

494
00:18:57,110 --> 00:18:55,200
hey i want to thank you guys i know it's

495
00:18:59,590 --> 00:18:57,120
uh you know you you're really busy up

496
00:19:01,590 --> 00:18:59,600
there i appreciate you taking time to to

497
00:19:02,950 --> 00:19:01,600
just uh help us

498
00:19:04,470 --> 00:19:02,960
entertain this crowd here and i'm going

499
00:19:06,390 --> 00:19:04,480
to turn it over to senator glenn for a

500
00:19:07,750 --> 00:19:06,400
final farewell well this is really a

501
00:19:08,950 --> 00:19:07,760
great surprise this morning i didn't

502
00:19:11,029 --> 00:19:08,960
know i was going to have the honor of

503
00:19:12,390 --> 00:19:11,039
talking to you guys up there and i i

504
00:19:14,710 --> 00:19:12,400
just was sitting here thinking a minute

505
00:19:17,110 --> 00:19:14,720
ago about the how technology has gone

506
00:19:18,470 --> 00:19:17,120
ahead so rapidly in the space age

507
00:19:20,549 --> 00:19:18,480
because here we are watching high

508
00:19:22,470 --> 00:19:20,559
definition television here and you guys

509
00:19:23,909 --> 00:19:22,480
coming through perfectly

510
00:19:25,990 --> 00:19:23,919
back in the mercury days we had to go

511
00:19:27,750 --> 00:19:26,000
over each station on the ground apart

512
00:19:28,789 --> 00:19:27,760
and couldn't even keep communications

513
00:19:31,350 --> 00:19:28,799

now we have

514
00:19:33,510 --> 00:19:31,360
the tdrs technical data relay satellite

515
00:19:35,190 --> 00:19:33,520
that you relay through so you have

516
00:19:37,190 --> 00:19:35,200
constant communication around the earth

517
00:19:38,789 --> 00:19:37,200
it's just amazing that we can sit here

518
00:19:40,470 --> 00:19:38,799
and talk to you back and forth so thank

519
00:19:43,029 --> 00:19:40,480
you very much for helping kick off our

520
00:19:44,950 --> 00:19:43,039
forum it's really great congratulations

521
00:19:54,150 --> 00:19:44,960
to all of you thank you

522
00:19:57,669 --> 00:19:56,390
and i guess from the ohio state

523
00:20:00,310 --> 00:19:57,679
university

524
00:20:02,870 --> 00:20:00,320
i'm learning you're okay the home of the

525
00:20:05,190 --> 00:20:02,880
buckeyes uh we're gonna pass it back to

526
00:20:06,789 --> 00:20:05,200
houston and and let you guys go about go

527
00:20:08,230 --> 00:20:06,799
about your work but thanks again this

528
00:20:12,630 --> 00:20:08,240
has just been incredible for us thanks

529
00:20:18,070 --> 00:20:14,230
thank you so much it's been an honor and