1
00:00:12,150 --> 00:00:10,070
imagine a place where drugs treat tumors

2
00:00:14,629 --> 00:00:12,160
and patients experience fewer side

3
00:00:16,870 --> 00:00:14,639
effects from traditional chemotherapy a

4
00:00:18,310 --> 00:00:16,880
place where scientists unravel genes to

5
00:00:20,470 --> 00:00:18,320
cure diseases

6
00:00:23,349 --> 00:00:20,480
a place where we learn how to make bones

7
00:00:25,509 --> 00:00:23,359
and muscles grow stronger as we age

8
00:00:27,670 --> 00:00:25,519
satellites refuel in orbit saving

9
00:00:30,470 --> 00:00:27,680
companies billions of dollars

10
00:00:32,630 --> 00:00:30,480
robots perform dangerous tasks

11
00:00:34,950 --> 00:00:32,640
scientists discover the mysteries of

12
00:00:36,630 --> 00:00:34,960
dark matter leading to new technologies

13
00:00:38,709 --> 00:00:36,640

that change the world

14
00:00:40,790 --> 00:00:38,719
we monitor and manage earth's precious

15
00:00:42,950 --> 00:00:40,800
resources and take advantage of those

16
00:00:45,190 --> 00:00:42,960
resources in space to explore farther

17
00:00:46,950 --> 00:00:45,200
away from home where a new commercial

18
00:00:48,950 --> 00:00:46,960
marketplace thrives

19
00:00:50,950 --> 00:00:48,960
where people from many nations work

20
00:00:52,150 --> 00:00:50,960
together peacefully for the good of all

21
00:00:56,790 --> 00:00:52,160
humanity

22
00:00:59,110 --> 00:00:56,800
and the springboard for future journeys

23
00:01:01,110 --> 00:00:59,120
into deep space a place where we're

24
00:01:03,830 --> 00:01:01,120
living off the earth working for the

25
00:01:05,750 --> 00:01:03,840
earth so look up marvel at the third

26
00:01:07,670 --> 00:01:05,760
brightest object in our sky

27
00:01:24,310 --> 00:01:07,680
the international space station we're

28
00:01:29,350 --> 00:01:26,789
good morning everybody welcome to our

29
00:01:31,030 --> 00:01:29,360
destination station iss technology forum

30
00:01:32,789 --> 00:01:31,040
we're here at the marshall space flight

31
00:01:34,630 --> 00:01:32,799
center in huntsville alabama it's my

32
00:01:36,710 --> 00:01:34,640
first time in alabama so i'm excited

33
00:01:38,710 --> 00:01:36,720
this is new for me uh this is the second

34
00:01:41,350 --> 00:01:38,720
destination station that we've done so

35
00:01:42,789 --> 00:01:41,360
thanks so much for joining us here today

36
00:01:45,109 --> 00:01:42,799
so the international space station the

37
00:01:47,429 --> 00:01:45,119
first piece launched in 1998 humans have

38
00:01:49,270 --> 00:01:47,439

been on board since the year 2000 so

39
00:01:51,670 --> 00:01:49,280
something i always like to point out

40
00:01:53,749 --> 00:01:51,680
there are probably people in this room

41
00:01:55,590 --> 00:01:53,759
who as long as they have been alive

42
00:01:57,590 --> 00:01:55,600
humans have been living and working in

43
00:01:59,429 --> 00:01:57,600
space we are truly a space faring

44
00:02:00,950 --> 00:01:59,439
species that blows my mind every time i

45
00:02:02,550 --> 00:02:00,960
just think about it so

46
00:02:04,789 --> 00:02:02,560
let that soak in for a minute and then

47
00:02:06,469 --> 00:02:04,799
we're going to continue on the this the

48
00:02:08,550 --> 00:02:06,479
international space station it's this

49
00:02:10,309 --> 00:02:08,560
platform for unparalleled science

50
00:02:11,750 --> 00:02:10,319
research and technology development

51
00:02:14,070 --> 00:02:11,760
technology is what we're going to focus

52
00:02:15,750 --> 00:02:14,080
on today and whenever we think of space

53
00:02:18,070 --> 00:02:15,760
flight we think about the technologies

54
00:02:19,910 --> 00:02:18,080
that power it there's a 300 foot beacon

55
00:02:22,869 --> 00:02:19,920
of technology standing right outside

56
00:02:24,470 --> 00:02:22,879
this building so it's it's not easy to

57
00:02:25,910 --> 00:02:24,480
forget about that when we're thinking

58
00:02:28,070 --> 00:02:25,920
about space flight

59
00:02:29,589 --> 00:02:28,080
i'm joined by some of the men and women

60
00:02:32,790 --> 00:02:29,599
who are behind a lot of the great

61
00:02:34,070 --> 00:02:32,800
projects taking place right now in space

62
00:02:35,910 --> 00:02:34,080
and they're going to be able to give

63
00:02:38,790 --> 00:02:35,920

some fantastic insight take some

64
00:02:40,070 --> 00:02:38,800
questions from myself and more of you

65
00:02:41,750 --> 00:02:40,080
we're also going to be taking questions

66
00:02:44,309 --> 00:02:41,760
on social media but real quick joining

67
00:02:45,990 --> 00:02:44,319
me today i have jeff sheehan who's the

68
00:02:47,910 --> 00:02:46,000
senior technologist from our space

69
00:02:49,110 --> 00:02:47,920
technology mission directorate

70
00:02:51,350 --> 00:02:49,120
all the way down from headquarters i

71
00:02:54,150 --> 00:02:51,360
guess so thanks for making the trip jeff

72
00:02:55,589 --> 00:02:54,160
i have robin gayton's and i have to read

73
00:02:57,589 --> 00:02:55,599
these titles because in true nasa

74
00:02:58,869 --> 00:02:57,599
fashion we have some pretty fantastic

75
00:03:00,790 --> 00:02:58,879
titles too

76
00:03:02,550 --> 00:03:00,800
and robin is uh the system and

77
00:03:04,869 --> 00:03:02,560
technology demonstration manager from

78
00:03:06,949 --> 00:03:04,879
nasa headquarters in the iss division

79
00:03:09,270 --> 00:03:06,959
next to her jose benavides the chief

80
00:03:11,589 --> 00:03:09,280
engineer of the spheres project and we

81
00:03:14,070 --> 00:03:11,599
have richard reinhart the principal

82
00:03:15,990 --> 00:03:14,080
investigator for the scan testbed all

83
00:03:17,509 --> 00:03:16,000
the way down from nasa's glenn research

84
00:03:19,589 --> 00:03:17,519
center in cleveland and all the way on

85
00:03:21,750 --> 00:03:19,599
the end there nikki werkheiser who is

86
00:03:23,589 --> 00:03:21,760
the project manager for nasa's 3d

87
00:03:26,390 --> 00:03:23,599
printing and zero g right here at

88
00:03:27,910 --> 00:03:26,400

marshall so like i said i'll start off

89
00:03:30,149 --> 00:03:27,920
with a couple of questions and i want to

90
00:03:31,509 --> 00:03:30,159
get questions from everyone here joining

91
00:03:33,110 --> 00:03:31,519
us in the audience we'll take some

92
00:03:35,190 --> 00:03:33,120
questions from social media if you're

93
00:03:37,670 --> 00:03:35,200
following online you can tweet your

94
00:03:39,589 --> 00:03:37,680
questions with the hashtag asknasa and

95
00:03:41,990 --> 00:03:39,599
we'll be able to direct it to our expert

96
00:03:42,869 --> 00:03:42,000
panelists here

97
00:03:44,229 --> 00:03:42,879
so

98
00:03:45,270 --> 00:03:44,239
first though

99
00:03:46,949 --> 00:03:45,280
you know if we're going to talk about

100
00:03:49,110 --> 00:03:46,959
the international space station it would

101
00:03:50,630 --> 00:03:49,120
be best to hear from somebody on board

102
00:03:52,949 --> 00:03:50,640
the international space station so in

103
00:03:55,270 --> 00:03:52,959
space right now nasa astronaut reid

104
00:03:56,710 --> 00:03:55,280
wiseman prepared a little message for us

105
00:04:00,390 --> 00:03:56,720
so why don't we hear from reed real

106
00:04:04,070 --> 00:04:01,750
greetings from the international space

107
00:04:06,630 --> 00:04:04,080
station i'm expedition 41 flight

108
00:04:08,789 --> 00:04:06,640
engineer reid wiseman of nasa

109
00:04:10,309 --> 00:04:08,799
living on this amazing laboratory has

110
00:04:12,070 --> 00:04:10,319
taught me how much we need to learn

111
00:04:13,110 --> 00:04:12,080
before we can travel to an asteroid or

112
00:04:14,710 --> 00:04:13,120
mars

113
00:04:16,629 --> 00:04:14,720

not only does a human body operate

114
00:04:18,629 --> 00:04:16,639
differently so does almost everything

115
00:04:21,030 --> 00:04:18,639
else including the technologies to help

116
00:04:22,790 --> 00:04:21,040
humans survive in space

117
00:04:24,629 --> 00:04:22,800
the station is the only place where we

118
00:04:26,830 --> 00:04:24,639
can test these critical technologies in

119
00:04:29,189 --> 00:04:26,840
the environment where these systems will

120
00:04:31,270 --> 00:04:29,199
operate we're testing communication

121
00:04:33,749 --> 00:04:31,280
systems learning how to control robots

122
00:04:34,870 --> 00:04:33,759
in space and using 3d printing to build

123
00:04:37,510 --> 00:04:34,880
tools

124
00:04:39,990 --> 00:04:37,520
i hope today's destination station iss

125
00:04:41,830 --> 00:04:40,000
technology forum inspires you to test a

126
00:04:44,070 --> 00:04:41,840
new technology that benefits space

127
00:04:46,150 --> 00:04:44,080
travel and the citizens of earth

128
00:04:52,310 --> 00:04:46,160
all the best for me and my crewmates on

129
00:04:56,469 --> 00:04:54,390
and i know we all wish we could do that

130
00:04:58,550 --> 00:04:56,479
right now like

131
00:05:00,550 --> 00:04:58,560
at least i know i do okay so we'll go

132
00:05:02,230 --> 00:05:00,560
ahead and get started again i'll ask a

133
00:05:03,590 --> 00:05:02,240
couple of questions and then i'm putting

134
00:05:05,510 --> 00:05:03,600
it on you guys i'm coming to the

135
00:05:07,029 --> 00:05:05,520
audience and you're gonna come up with

136
00:05:08,150 --> 00:05:07,039
uh some really great stuff for these

137
00:05:10,629 --> 00:05:08,160
guys up here so they don't have to

138
00:05:11,749 --> 00:05:10,639

listen to me talk the entire time so

139
00:05:14,070 --> 00:05:11,759
jeff

140
00:05:16,390 --> 00:05:14,080
you're first up so you work in the

141
00:05:17,350 --> 00:05:16,400
office of space technology and if you

142
00:05:19,510 --> 00:05:17,360
haven't caught on yet you're going to

143
00:05:22,230 --> 00:05:19,520
hear the word technology a lot today

144
00:05:24,469 --> 00:05:22,240
that is the focus can you explain why

145
00:05:26,629 --> 00:05:24,479
the space station is such an ideal

146
00:05:28,230 --> 00:05:26,639
facility to be testing these new

147
00:05:30,629 --> 00:05:28,240
technologies that are going to take us

148
00:05:32,469 --> 00:05:30,639
even farther out sure well thanks uh

149
00:05:34,230 --> 00:05:32,479
it's great to be here great to be in

150
00:05:36,070 --> 00:05:34,240
huntsville i spent several years at the

151
00:05:38,469 --> 00:05:36,080
marshall space flight center i'm kind of

152
00:05:40,150 --> 00:05:38,479
on loan from there to headquarters my

153
00:05:41,830 --> 00:05:40,160
bosses here got tired of me and said why

154
00:05:42,950 --> 00:05:41,840
don't you go to headquarters for a while

155
00:05:45,350 --> 00:05:42,960
but um

156
00:05:47,029 --> 00:05:45,360
the the space station's relatively close

157
00:05:49,510 --> 00:05:47,039
it's only a couple hundred miles away

158
00:05:52,790 --> 00:05:49,520
and i came down from dc yesterday that's

159
00:05:54,629 --> 00:05:52,800
700 miles away and so uh it's fairly

160
00:05:56,550 --> 00:05:54,639
close by and certainly when you compare

161
00:05:58,950 --> 00:05:56,560
it with going to

162
00:06:01,189 --> 00:05:58,960
an asteroid going to mars

163
00:06:02,550 --> 00:06:01,199

it's very very close by it's like going

164
00:06:04,870 --> 00:06:02,560
to your next door neighbor compared to

165
00:06:07,510 --> 00:06:04,880
going to dc and so

166
00:06:08,790 --> 00:06:07,520
it obviously takes a rocket trip to get

167
00:06:12,150 --> 00:06:08,800
there and you've got to accelerate

168
00:06:14,710 --> 00:06:12,160
yourself to 17 500

169
00:06:16,550 --> 00:06:14,720
miles an hour and and miles a second and

170
00:06:17,670 --> 00:06:16,560
you go and you have to catch miles an

171
00:06:20,150 --> 00:06:17,680
hour and you have to catch up with that

172
00:06:22,309 --> 00:06:20,160
thing uh and rendezvous with it and dock

173
00:06:24,309 --> 00:06:22,319
and climb aboard but

174
00:06:26,790 --> 00:06:24,319
relatively compared to going to deep

175
00:06:29,029 --> 00:06:26,800
space it's close by so we can get people

176
00:06:31,270 --> 00:06:29,039
there we can get equipment there we can

177
00:06:33,430 --> 00:06:31,280
take experiments like like those that

178
00:06:35,830 --> 00:06:33,440
are being overseen by my colleagues here

179
00:06:38,230 --> 00:06:35,840
on the panel to the space station and

180
00:06:40,230 --> 00:06:38,240
test out the technologies in the

181
00:06:41,749 --> 00:06:40,240
microgravity environment

182
00:06:44,070 --> 00:06:41,759
that's the one thing we have a really

183
00:06:46,870 --> 00:06:44,080
hard time recreating on earth we can

184
00:06:49,029 --> 00:06:46,880
build big vacuum chambers and use pumps

185
00:06:51,350 --> 00:06:49,039
to take the atmosphere out of those

186
00:06:53,350 --> 00:06:51,360
chambers and so we can simulate the lack

187
00:06:55,430 --> 00:06:53,360
of atmosphere in space we can heat

188
00:06:58,150 --> 00:06:55,440

things up we can cool things down but

189
00:07:00,390 --> 00:06:58,160
what we can't do for more than 30

190
00:07:02,870 --> 00:07:00,400
seconds on an airplane flight that goes

191
00:07:05,110 --> 00:07:02,880
over a big steep parabola and puts you

192
00:07:07,350 --> 00:07:05,120
in free fall briefly

193
00:07:09,670 --> 00:07:07,360
what we can't do is recreate the

194
00:07:11,670 --> 00:07:09,680
microgravity environment and as as the

195
00:07:13,430 --> 00:07:11,680
astronaut mentioned so many of the

196
00:07:15,990 --> 00:07:13,440
things we do on earth all of our

197
00:07:17,990 --> 00:07:16,000
manufacturing process all of our growth

198
00:07:19,909 --> 00:07:18,000
processes in our body

199
00:07:21,589 --> 00:07:19,919
maintenance processes they depend on

200
00:07:24,390 --> 00:07:21,599
gravity we grew up in a gravity

201
00:07:26,870 --> 00:07:24,400
environment and we evolved that way and

202
00:07:28,950 --> 00:07:26,880
and so when you are without

203
00:07:31,029 --> 00:07:28,960
the influence of gravity

204
00:07:33,430 --> 00:07:31,039
the way you make things and the way the

205
00:07:35,749 --> 00:07:33,440
process is going inside your body change

206
00:07:37,270 --> 00:07:35,759
and so to study that and to study the

207
00:07:38,870 --> 00:07:37,280
effects of that and if we think about

208
00:07:40,790 --> 00:07:38,880
going to deep space

209
00:07:43,510 --> 00:07:40,800
and trips that are going to last many

210
00:07:45,589 --> 00:07:43,520
months maybe a year and a half for that

211
00:07:48,150 --> 00:07:45,599
kind of time frame we need to look at

212
00:07:50,869 --> 00:07:48,160
the long-term effects of these

213
00:07:52,390 --> 00:07:50,879

changes and so the space station being

214
00:07:53,350 --> 00:07:52,400
relatively close

215
00:07:55,270 --> 00:07:53,360
being

216
00:07:56,950 --> 00:07:55,280
relatively easy to access compared to

217
00:07:58,550 --> 00:07:56,960
going to mars

218
00:08:00,869 --> 00:07:58,560
gives us the opportunity and so it's an

219
00:08:03,830 --> 00:08:00,879
ideal laboratory for for that kind of

220
00:08:05,990 --> 00:08:03,840
technology development and demonstration

221
00:08:07,350 --> 00:08:06,000
right and a technology i know very near

222
00:08:10,309 --> 00:08:07,360
and dear to the hearts of a lot of the

223
00:08:11,350 --> 00:08:10,319
astronauts because it keeps them alive

224
00:08:14,550 --> 00:08:11,360
and

225
00:08:16,230 --> 00:08:14,560
other thing you guys might hear a lot of

226
00:08:17,430 --> 00:08:16,240
acronyms we're going to try to minimize

227
00:08:19,270 --> 00:08:17,440
that but

228
00:08:21,589 --> 00:08:19,280
we will also try to explain every single

229
00:08:24,629 --> 00:08:21,599
one so robin start off tell us about

230
00:08:26,869 --> 00:08:24,639
eclipse what does it stand for and how

231
00:08:29,830 --> 00:08:26,879
was this how are these the technologies

232
00:08:31,670 --> 00:08:29,840
that comprise e-class so important not

233
00:08:33,350 --> 00:08:31,680
only for the space station but when we

234
00:08:34,230 --> 00:08:33,360
start heading towards mars

235
00:08:35,750 --> 00:08:34,240
sure

236
00:08:38,149 --> 00:08:35,760
so eclipse

237
00:08:40,870 --> 00:08:38,159
stands for environmental control and

238
00:08:42,709 --> 00:08:40,880

life support systems and basically

239
00:08:45,110 --> 00:08:42,719
it's all the machines that keep the crew

240
00:08:47,910 --> 00:08:45,120
alive inside a closed spacecraft so here

241
00:08:50,230 --> 00:08:47,920
on earth we recycle the atmosphere

242
00:08:52,550 --> 00:08:50,240
through plants and our water through

243
00:08:54,630 --> 00:08:52,560
oceans and evaporation

244
00:08:56,870 --> 00:08:54,640
we can't do that in a closed spacecraft

245
00:08:57,990 --> 00:08:56,880
so we need machines to do that

246
00:09:01,030 --> 00:08:58,000
so

247
00:09:04,310 --> 00:09:01,040
eclis recycles put takes the carbon

248
00:09:06,870 --> 00:09:04,320
dioxide out of the air and puts oxygen

249
00:09:08,710 --> 00:09:06,880
back in the air for the crew to breathe

250
00:09:10,949 --> 00:09:08,720
keeps the atmosphere comfortable for the

251
00:09:12,790 --> 00:09:10,959
crew removes contaminants

252
00:09:15,350 --> 00:09:12,800
and then we recycle

253
00:09:17,829 --> 00:09:15,360
all the water all the water

254
00:09:19,910 --> 00:09:17,839
including urine sweat

255
00:09:21,350 --> 00:09:19,920
we've had our regenerative ecosystem

256
00:09:23,430 --> 00:09:21,360
some of the parts which were built right

257
00:09:26,949 --> 00:09:23,440
here at the marshall space flight center

258
00:09:29,030 --> 00:09:26,959
on board the space station since 2009

259
00:09:32,550 --> 00:09:29,040
and that's the primary reason we were

260
00:09:35,430 --> 00:09:32,560
able to go from three crew to six crew

261
00:09:38,150 --> 00:09:35,440
because recycling the water

262
00:09:39,829 --> 00:09:38,160
enabled us to support more people on the

263
00:09:41,670 --> 00:09:39,839

station versus having to keep bringing

264
00:09:43,750 --> 00:09:41,680
up water from the earth

265
00:09:45,829 --> 00:09:43,760
and enable us to do all the great

266
00:09:47,990 --> 00:09:45,839
research that we're able to do with more

267
00:09:50,230 --> 00:09:48,000
astronauts on the space station

268
00:09:52,470 --> 00:09:50,240
so it's a really important system uh

269
00:09:54,710 --> 00:09:52,480
that the crew depends on and will be

270
00:09:57,910 --> 00:09:54,720
even more important as we go further

271
00:09:59,190 --> 00:09:57,920
away from earth and you you guys always

272
00:10:00,470 --> 00:09:59,200
test the system here on the ground

273
00:10:02,310 --> 00:10:00,480
before you make the astronauts do it

274
00:10:04,069 --> 00:10:02,320
right you're the brave men and women

275
00:10:05,990 --> 00:10:04,079
turning yesterday's coffee into

276
00:10:07,990 --> 00:10:06,000
tomorrow's coffee we did and i have

277
00:10:09,269 --> 00:10:08,000
drank the water and it's perfectly fine

278
00:10:11,110 --> 00:10:09,279
it's actually cleaner than your tap

279
00:10:13,030 --> 00:10:11,120
water

280
00:10:15,350 --> 00:10:13,040
all right well next up jose and you have

281
00:10:16,470 --> 00:10:15,360
a project very near and dear to my heart

282
00:10:19,190 --> 00:10:16,480
because

283
00:10:21,509 --> 00:10:19,200
anyone who's ever seen star wars

284
00:10:22,310 --> 00:10:21,519
the original star wars

285
00:10:24,470 --> 00:10:22,320
will

286
00:10:27,190 --> 00:10:24,480
instantly recognize the spheres project

287
00:10:28,630 --> 00:10:27,200
spheres is it's a fascinating technology

288
00:10:30,069 --> 00:10:28,640

demonstration happening on board the

289
00:10:32,389 --> 00:10:30,079
station why don't you just tell us a

290
00:10:34,389 --> 00:10:32,399
little bit about you know what it's and

291
00:10:35,350 --> 00:10:34,399
there are many iterations of spheres why

292
00:10:36,790 --> 00:10:35,360
don't you just tell us a little bit

293
00:10:39,670 --> 00:10:36,800
about what that project's been doing

294
00:10:42,389 --> 00:10:39,680
it's been on board for years too so it's

295
00:10:43,910 --> 00:10:42,399
uh yeah so uh the spheres uh small

296
00:10:45,910 --> 00:10:43,920
satellites operate inside the space

297
00:10:47,509 --> 00:10:45,920
station originally designed as a

298
00:10:49,350 --> 00:10:47,519
satellite type

299
00:10:50,949 --> 00:10:49,360
platform for studying uh those kinds of

300
00:10:53,750 --> 00:10:50,959
technologies where we're looking at

301
00:10:55,590 --> 00:10:53,760
automated docking formation flight

302
00:10:57,590 --> 00:10:55,600
guidance navigation control type

303
00:10:59,670 --> 00:10:57,600
algorithms where we're learning how to

304
00:11:01,350 --> 00:10:59,680
control satellites in a

305
00:11:02,949 --> 00:11:01,360
failure tolerant environment and that's

306
00:11:03,750 --> 00:11:02,959
where we can really take advantage of

307
00:11:05,430 --> 00:11:03,760
the

308
00:11:07,670 --> 00:11:05,440
unique environment

309
00:11:09,269 --> 00:11:07,680
of a research lab in microgravity on the

310
00:11:10,790 --> 00:11:09,279
space station

311
00:11:12,069 --> 00:11:10,800
and just like i said there's there's a

312
00:11:13,430 --> 00:11:12,079
bunch of different kinds what are just

313
00:11:15,110 --> 00:11:13,440

some of the different

314
00:11:16,710 --> 00:11:15,120
so aside from just you know formation

315
00:11:18,550 --> 00:11:16,720
flying things like that there's a lot of

316
00:11:20,069 --> 00:11:18,560
like really cool electromagnetic

317
00:11:21,350 --> 00:11:20,079
technologies that you guys are testing

318
00:11:22,870 --> 00:11:21,360
out right now

319
00:11:24,389 --> 00:11:22,880
uh yeah originally developed to study

320
00:11:25,750 --> 00:11:24,399
these kind of control algorithms that

321
00:11:27,590 --> 00:11:25,760
that's run its course but we've had

322
00:11:28,550 --> 00:11:27,600
additional investigations take place

323
00:11:30,389 --> 00:11:28,560
that

324
00:11:33,110 --> 00:11:30,399
attach new hardware to the spheres to

325
00:11:34,870 --> 00:11:33,120
study all kinds of things from fluid

326
00:11:36,710 --> 00:11:34,880
movement movement

327
00:11:40,069 --> 00:11:36,720
fuels and microgravity environments you

328
00:11:42,630 --> 00:11:40,079
can imagine that takes place in rockets

329
00:11:44,389 --> 00:11:42,640
vision based for uh navigation using

330
00:11:46,310 --> 00:11:44,399
cameras to know what where you are in

331
00:11:48,310 --> 00:11:46,320
your environment as well as

332
00:11:49,670 --> 00:11:48,320
electromagnetic formation flight using

333
00:11:52,310 --> 00:11:49,680
these big ring

334
00:11:55,670 --> 00:11:52,320
uh that that generates magnetic fields

335
00:11:57,269 --> 00:11:55,680
to actuate against each other as well as

336
00:11:59,509 --> 00:11:57,279
smartphones that are attaching to the

337
00:12:01,670 --> 00:11:59,519
spheres to turn these spheres into more

338
00:12:03,430 --> 00:12:01,680

robotic type applications that can

339
00:12:04,949 --> 00:12:03,440
assist the astronaut so all kinds of

340
00:12:06,629 --> 00:12:04,959
different investigations from

341
00:12:09,190 --> 00:12:06,639
investigators from around the country

342
00:12:10,310 --> 00:12:09,200
utilize the spheres as a platform

343
00:12:11,509 --> 00:12:10,320
to study all these different

344
00:12:14,389 --> 00:12:11,519
technologies that we're going to need

345
00:12:16,150 --> 00:12:14,399
for long duration space flight

346
00:12:17,670 --> 00:12:16,160
all right well and again two two more

347
00:12:19,110 --> 00:12:17,680
from me and then i'm going to start

348
00:12:20,870 --> 00:12:19,120
looking for questions so we're going to

349
00:12:22,629 --> 00:12:20,880
have microphones

350
00:12:24,150 --> 00:12:22,639
out there in the audience if you have a

351
00:12:25,990 --> 00:12:24,160
question you just need to raise your

352
00:12:28,150 --> 00:12:26,000
hand wait for the microphone and then

353
00:12:29,430 --> 00:12:28,160
we'll be able to hear it so

354
00:12:31,190 --> 00:12:29,440
my next one

355
00:12:34,150 --> 00:12:31,200
down to you rich

356
00:12:35,829 --> 00:12:34,160
communications obviously a huge thing

357
00:12:37,829 --> 00:12:35,839
not only in the day-to-day operations of

358
00:12:38,710 --> 00:12:37,839
the station but when we start heading to

359
00:12:40,710 --> 00:12:38,720
mars

360
00:12:42,069 --> 00:12:40,720
it's a much bigger challenge than it is

361
00:12:43,590 --> 00:12:42,079
than what we have to deal with right now

362
00:12:45,350 --> 00:12:43,600
you start talking about major

363
00:12:48,069 --> 00:12:45,360

communication delays

364
00:12:50,389 --> 00:12:48,079
so the scan testbed the project that

365
00:12:51,590 --> 00:12:50,399
you're working on how is that helping to

366
00:12:54,310 --> 00:12:51,600
change how we're going to be

367
00:12:56,550 --> 00:12:54,320
transmitting data you know across the

368
00:12:58,150 --> 00:12:56,560
solar system eventually

369
00:13:00,629 --> 00:12:58,160
sure so scan is another one of these

370
00:13:02,949 --> 00:13:00,639
nasa acronyms scan stands for space

371
00:13:04,629 --> 00:13:02,959
communications and navigation

372
00:13:06,150 --> 00:13:04,639
it's an experimental communication

373
00:13:07,990 --> 00:13:06,160
system installed on the trust of

374
00:13:09,350 --> 00:13:08,000
international space station

375
00:13:11,590 --> 00:13:09,360
and it's comprised of three

376
00:13:13,110 --> 00:13:11,600
software-defined radios or sdrs you

377
00:13:14,790 --> 00:13:13,120
might hear me say that's the acronym for

378
00:13:16,470 --> 00:13:14,800
software-defined radio

379
00:13:18,629 --> 00:13:16,480
but what's different about these radios

380
00:13:19,430 --> 00:13:18,639
compared to today's radios

381
00:13:21,269 --> 00:13:19,440
that

382
00:13:22,949 --> 00:13:21,279
perform one function or one set of

383
00:13:24,870 --> 00:13:22,959
functions for the life of the mission

384
00:13:26,150 --> 00:13:24,880
you turn the radio on it performs that

385
00:13:28,550 --> 00:13:26,160
set of functions for the life of the

386
00:13:30,870 --> 00:13:28,560
mission nothing happens to it

387
00:13:33,269 --> 00:13:30,880
with a software defined radio we define

388
00:13:35,829 --> 00:13:33,279

many of the functions that produce

389
00:13:37,590 --> 00:13:35,839
signals that transmit from the antenna

390
00:13:38,550 --> 00:13:37,600
or functions that occur to the receive

391
00:13:40,150 --> 00:13:38,560
signal

392
00:13:42,150 --> 00:13:40,160
all in software

393
00:13:43,750 --> 00:13:42,160
and a software that runs on processors

394
00:13:45,829 --> 00:13:43,760
much like your computers or on

395
00:13:47,509 --> 00:13:45,839
specialized hardware

396
00:13:49,030 --> 00:13:47,519
but all these functions

397
00:13:50,389 --> 00:13:49,040
in the group of functions in the group

398
00:13:51,509 --> 00:13:50,399
of software i might refer to as a

399
00:13:55,590 --> 00:13:51,519
waveform

400
00:13:57,430 --> 00:13:55,600
in software are reconfigurable on orbit

401
00:13:59,509 --> 00:13:57,440
once the hardware is launched into space

402
00:14:00,949 --> 00:13:59,519
which is just a brand new capability

403
00:14:01,670 --> 00:14:00,959
that missions will have available to

404
00:14:03,269 --> 00:14:01,680
them

405
00:14:04,470 --> 00:14:03,279
so to put this in context i'll give two

406
00:14:05,750 --> 00:14:04,480
examples

407
00:14:07,590 --> 00:14:05,760
the first is i'm going to launch a

408
00:14:09,430 --> 00:14:07,600
mission to low earth orbit i have no

409
00:14:10,230 --> 00:14:09,440
intention of reconfiguring my radio i

410
00:14:11,829 --> 00:14:10,240
have no

411
00:14:13,750 --> 00:14:11,839
intention of changing my software but i

412
00:14:15,189 --> 00:14:13,760
get on orbit and i find i have an

413
00:14:16,150 --> 00:14:15,199

interference problem maybe an

414
00:14:18,710 --> 00:14:16,160
instrument's changed or the

415
00:14:20,069 --> 00:14:18,720
communication system has a problem

416
00:14:22,150 --> 00:14:20,079
i can correct

417
00:14:23,910 --> 00:14:22,160
or change my software

418
00:14:25,670 --> 00:14:23,920
to get out of the way of that interfere

419
00:14:27,670 --> 00:14:25,680
maybe i can save the mission maybe i can

420
00:14:29,350 --> 00:14:27,680
increase the data return maybe i can

421
00:14:30,790 --> 00:14:29,360
help solve the problem by changing that

422
00:14:33,350 --> 00:14:30,800
software so it's great for risk

423
00:14:35,509 --> 00:14:33,360
mitigation and problem solving

424
00:14:36,629 --> 00:14:35,519
on the other side say we're going out to

425
00:14:38,150 --> 00:14:36,639
mars

426
00:14:39,590 --> 00:14:38,160
and i need a particular waveform a

427
00:14:40,870 --> 00:14:39,600
particular set of functions for that

428
00:14:43,509 --> 00:14:40,880
cruise phase because it's going to take

429
00:14:44,870 --> 00:14:43,519
me six to 12 months to get there

430
00:14:46,790 --> 00:14:44,880
and once i get there i'll do my

431
00:14:48,389 --> 00:14:46,800
operational waveform

432
00:14:51,189 --> 00:14:48,399
well in this case i have to carry a box

433
00:14:53,269 --> 00:14:51,199
if i use a legacy radio or today's radio

434
00:14:55,350 --> 00:14:53,279
one box to do that easy way form that

435
00:14:56,790 --> 00:14:55,360
cruise phase waveform and maybe a

436
00:14:59,750 --> 00:14:56,800
different box for my operational

437
00:15:01,030 --> 00:14:59,760
waveform with a software defined radio i

438
00:15:03,590 --> 00:15:01,040

can program

439
00:15:05,269 --> 00:15:03,600
my radio to do my cruise waveform and

440
00:15:06,870 --> 00:15:05,279
then when i get on station i can

441
00:15:09,030 --> 00:15:06,880
reconfigure that software to do my

442
00:15:10,389 --> 00:15:09,040
operational waveform now maybe i can

443
00:15:11,670 --> 00:15:10,399
reduce the number of boxes in my

444
00:15:15,030 --> 00:15:11,680
spacecraft

445
00:15:16,389 --> 00:15:15,040
maybe save cost or money there

446
00:15:17,990 --> 00:15:16,399
but then i can reconfigure and that'll

447
00:15:20,150 --> 00:15:18,000
give me the capability that i need on

448
00:15:22,150 --> 00:15:20,160
orbit so there i intentionally change my

449
00:15:23,430 --> 00:15:22,160
software and also because it's six to

450
00:15:25,430 --> 00:15:23,440
twelve months to get on orbit i don't

451
00:15:27,269 --> 00:15:25,440
need my operational waveform for six to

452
00:15:29,269 --> 00:15:27,279
12 months so i have that much longer to

453
00:15:31,590 --> 00:15:29,279
develop that software so a lot more a

454
00:15:33,189 --> 00:15:31,600
lot more flexibility and again

455
00:15:34,870 --> 00:15:33,199
one of the running themes anytime we're

456
00:15:36,949 --> 00:15:34,880
going to be heading out to mars is you

457
00:15:39,110 --> 00:15:36,959
got to be flexible you got to be able to

458
00:15:41,430 --> 00:15:39,120
adapt because we've

459
00:15:43,910 --> 00:15:41,440
never sent humans to mars yet

460
00:15:46,470 --> 00:15:43,920
and we're gonna need to be ready for any

461
00:15:47,509 --> 00:15:46,480
possible situation so my last one for

462
00:15:49,110 --> 00:15:47,519
right now

463
00:15:51,030 --> 00:15:49,120

all the way down to you nikki and you're

464
00:15:53,110 --> 00:15:51,040
involved in something that

465
00:15:54,389 --> 00:15:53,120
i mean not only in space it's a very

466
00:15:55,910 --> 00:15:54,399
huge technology

467
00:15:58,230 --> 00:15:55,920
right now just down here on the ground

468
00:16:00,389 --> 00:15:58,240
that's 3d printing so

469
00:16:02,949 --> 00:16:00,399
we're taking it into microgravity now

470
00:16:05,269 --> 00:16:02,959
what what is 3d printing going to offer

471
00:16:07,829 --> 00:16:05,279
not only the station itself but future

472
00:16:10,310 --> 00:16:07,839
missions into deep space absolutely and

473
00:16:12,310 --> 00:16:10,320
that's a great question so we all know

474
00:16:13,829 --> 00:16:12,320
3d printing has actually been around for

475
00:16:16,310 --> 00:16:13,839
quite some time on the ground through

476
00:16:18,470 --> 00:16:16,320
rapid prototyping and other technologies

477
00:16:20,629 --> 00:16:18,480
and it's it's rapidly evolving on the

478
00:16:23,110 --> 00:16:20,639
ground as well and at nasa where we're

479
00:16:25,189 --> 00:16:23,120
taking those uh current and involving

480
00:16:27,910 --> 00:16:25,199
technologies and adapting them to

481
00:16:31,189 --> 00:16:27,920
microgravity uh just like we talked

482
00:16:33,509 --> 00:16:31,199
about here reid and several folks here

483
00:16:35,189 --> 00:16:33,519
space station is the only platform

484
00:16:36,389 --> 00:16:35,199
available where we can actually test

485
00:16:38,069 --> 00:16:36,399
this fully

486
00:16:40,790 --> 00:16:38,079
so the first 3d printer that we just

487
00:16:42,870 --> 00:16:40,800
launched last month yay on spacex4 it's

488
00:16:45,110 --> 00:16:42,880

on on orbit now we're getting geared up

489
00:16:46,389 --> 00:16:45,120
to do our first print it is a technology

490
00:16:49,189 --> 00:16:46,399
demonstration

491
00:16:51,110 --> 00:16:49,199
and that's a critical point because

492
00:16:52,550 --> 00:16:51,120
we've done all the foundational work we

493
00:16:54,870 --> 00:16:52,560
can do on the ground we have ground

494
00:16:57,269 --> 00:16:54,880
tested we have uh between nasa and the

495
00:17:00,069 --> 00:16:57,279
company made in space we have flown over

496
00:17:02,389 --> 00:17:00,079
500 parabolas on the aptly and

497
00:17:04,069 --> 00:17:02,399
effectively called vomit comet

498
00:17:06,470 --> 00:17:04,079
and so we have a lot of really good

499
00:17:08,630 --> 00:17:06,480
foundational data and all of this points

500
00:17:10,870 --> 00:17:08,640
to the fact and it appears that the

501
00:17:12,549 --> 00:17:10,880
parts we print in microgravity are

502
00:17:14,549 --> 00:17:12,559
analogous to those that we print on the

503
00:17:17,029 --> 00:17:14,559
ground there are even some areas where

504
00:17:19,350 --> 00:17:17,039
we feel like microgravity will help

505
00:17:22,309 --> 00:17:19,360
we see things like overhang and sag when

506
00:17:23,990 --> 00:17:22,319
we print on the ground but the exciting

507
00:17:25,750 --> 00:17:24,000
part of this is

508
00:17:27,350 --> 00:17:25,760
this is a technology demonstration and

509
00:17:29,669 --> 00:17:27,360
it's the unknown unknowns of

510
00:17:31,750 --> 00:17:29,679
microgravity where we learn the most and

511
00:17:34,390 --> 00:17:31,760
space station is the only platform in

512
00:17:37,110 --> 00:17:34,400
the universe that can reveal those so

513
00:17:39,510 --> 00:17:37,120

the first actual fully 3d printed part

514
00:17:42,070 --> 00:17:39,520
in microgravity can only take place at

515
00:17:43,990 --> 00:17:42,080
this day and time on space station and

516
00:17:45,590 --> 00:17:44,000
obviously this is a technology just like

517
00:17:47,190 --> 00:17:45,600
all of my colleagues discussed with

518
00:17:49,750 --> 00:17:47,200
their technologies here

519
00:17:52,150 --> 00:17:49,760
every one of them require hardware and

520
00:17:54,470 --> 00:17:52,160
hardware we need to be able to evolve on

521
00:17:55,669 --> 00:17:54,480
long-term missions things break things

522
00:17:58,870 --> 00:17:55,679
get lost

523
00:18:01,510 --> 00:17:58,880
so the capability to be able to make

524
00:18:02,710 --> 00:18:01,520
what you need when you need it on demand

525
00:18:05,590 --> 00:18:02,720
in space

526
00:18:08,710 --> 00:18:05,600
is incredibly exciting but it is also a

527
00:18:11,110 --> 00:18:08,720
fundamental enabler to ensuring that we

528
00:18:14,070 --> 00:18:11,120
have sustainability in an affordable and

529
00:18:16,710 --> 00:18:14,080
realistic way for exploration missions

530
00:18:19,110 --> 00:18:16,720
to places like mars so we are extremely

531
00:18:21,750 --> 00:18:19,120
excited to have the space station as the

532
00:18:24,070 --> 00:18:21,760
test bed for this technology uh to be

533
00:18:27,350 --> 00:18:24,080
able to adapt to space station as well

534
00:18:28,870 --> 00:18:27,360
as for any exploration mission

535
00:18:31,590 --> 00:18:28,880
okay

536
00:18:33,510 --> 00:18:31,600
and now it's your guys's turn so

537
00:18:35,590 --> 00:18:33,520
if you have a question raise your hand

538
00:18:38,070 --> 00:18:35,600

we'll run a microphone over to you again

539
00:18:40,150 --> 00:18:38,080
wait until you get the microphone

540
00:18:42,630 --> 00:18:40,160
who who's my first victim

541
00:18:49,270 --> 00:18:42,640
who's who wants to go first right up

542
00:18:57,270 --> 00:18:51,350
with the

543
00:18:59,510 --> 00:18:57,280
recycles water but since your body takes

544
00:19:01,270 --> 00:18:59,520
in water how much

545
00:19:03,909 --> 00:19:01,280
how often would you still need to bring

546
00:19:05,750 --> 00:19:03,919
up water for it to replenish the system

547
00:19:07,830 --> 00:19:05,760
since you're losing some every time it

548
00:19:10,310 --> 00:19:07,840
recycles and

549
00:19:12,789 --> 00:19:10,320
how would you take that up and how much

550
00:19:15,350 --> 00:19:12,799
would you take up

551
00:19:17,430 --> 00:19:15,360
that's a good question

552
00:19:19,750 --> 00:19:17,440
there you go okay

553
00:19:23,350 --> 00:19:19,760
right now on space station

554
00:19:25,110 --> 00:19:23,360
we can recycle about 85 80 percent of

555
00:19:27,669 --> 00:19:25,120
our urine

556
00:19:29,830 --> 00:19:27,679
and about and all of the rest of the

557
00:19:32,150 --> 00:19:29,840
water all the sweat water so all

558
00:19:34,150 --> 00:19:32,160
together about 90 percent of the water

559
00:19:37,190 --> 00:19:34,160
gets recycled on space station with the

560
00:19:38,710 --> 00:19:37,200
technology that we currently have

561
00:19:40,710 --> 00:19:38,720
what's left over

562
00:19:44,390 --> 00:19:40,720
that we can't recover

563
00:19:47,750 --> 00:19:44,400

is a really icky dark brown

564
00:19:49,430 --> 00:19:47,760
concentrated urine we call brine

565
00:19:52,549 --> 00:19:49,440
one of the technologies that we're

566
00:19:54,789 --> 00:19:52,559
trying to develop for future missions

567
00:19:57,909 --> 00:19:54,799
is a brine processor so that we can get

568
00:20:00,789 --> 00:19:57,919
that last 10 percent or so water even

569
00:20:01,669 --> 00:20:00,799
for future missions to mars but right

570
00:20:03,350 --> 00:20:01,679
now

571
00:20:05,430 --> 00:20:03,360
you're right we have to resupply that

572
00:20:07,510 --> 00:20:05,440
water some of that water

573
00:20:09,510 --> 00:20:07,520
comes up in the form of food when they

574
00:20:12,549 --> 00:20:09,520
send the water up they freeze dry some

575
00:20:14,710 --> 00:20:12,559
of it but it still contains some water

576
00:20:16,470 --> 00:20:14,720
and then we have resupply vehicles right

577
00:20:18,789 --> 00:20:16,480
now to the space station that bring up

578
00:20:20,630 --> 00:20:18,799
some water

579
00:20:22,710 --> 00:20:20,640
for future missions if we're going to

580
00:20:24,390 --> 00:20:22,720
send crews to mars that's about a three

581
00:20:25,430 --> 00:20:24,400
year round trip we're going to have to

582
00:20:27,270 --> 00:20:25,440
take

583
00:20:30,390 --> 00:20:27,280
whatever we can't recover three years

584
00:20:32,789 --> 00:20:30,400
worth of water with us

585
00:20:35,270 --> 00:20:32,799
all right so no no small task you want

586
00:20:37,990 --> 00:20:35,280
to jump in well i just wanted to

587
00:20:39,590 --> 00:20:38,000
just one to two there we go

588
00:20:41,029 --> 00:20:39,600

i just wanted to mention the a

589
00:20:43,430 --> 00:20:41,039
complimentary

590
00:20:44,870 --> 00:20:43,440
technology area to

591
00:20:47,350 --> 00:20:44,880
the environmental control and life

592
00:20:49,190 --> 00:20:47,360
support system is that of in-situ

593
00:20:50,310 --> 00:20:49,200
resource utilization

594
00:20:53,110 --> 00:20:50,320
and so

595
00:20:55,190 --> 00:20:53,120
as we send rovers to mars as we learn

596
00:20:57,430 --> 00:20:55,200
about what's on the surface there what

597
00:21:00,789 --> 00:20:57,440
sort of resources are there is there

598
00:21:03,510 --> 00:21:00,799
water ice that we can access relatively

599
00:21:05,590 --> 00:21:03,520
easily on mars or on the moon

600
00:21:07,510 --> 00:21:05,600
we can start to think about how can we

601
00:21:08,470 --> 00:21:07,520
recover that and use it and to get our

602
00:21:09,990 --> 00:21:08,480
water

603
00:21:10,789 --> 00:21:10,000
that way so that we wouldn't have to

604
00:21:13,750 --> 00:21:10,799
take

605
00:21:16,789 --> 00:21:13,760
resupply if we will try to close the

606
00:21:19,590 --> 00:21:16,799
loop so as robin pointed out so that we

607
00:21:21,590 --> 00:21:19,600
get as much of that water that we put in

608
00:21:23,590 --> 00:21:21,600
back out for reuse

609
00:21:24,870 --> 00:21:23,600
but the little bit we maybe can't

610
00:21:27,190 --> 00:21:24,880
recover

611
00:21:29,270 --> 00:21:27,200
maybe we can get that from the surface

612
00:21:31,669 --> 00:21:29,280
and ultimately maybe we get all of our

613
00:21:33,990 --> 00:21:31,679

water needs and our breathing oxygen

614
00:21:35,830 --> 00:21:34,000
needs from resources that are on the

615
00:21:38,230 --> 00:21:35,840
surface so that's a whole other

616
00:21:40,070 --> 00:21:38,240
technology area kind of a complement to

617
00:21:41,830 --> 00:21:40,080
the life support

618
00:21:42,630 --> 00:21:41,840
technologies

619
00:21:44,789 --> 00:21:42,640
okay

620
00:21:46,549 --> 00:21:44,799
great question to start it off who's

621
00:21:49,990 --> 00:21:46,559
next

622
00:21:53,510 --> 00:21:51,750
i'm on okay my name is michael goodman

623
00:21:55,990 --> 00:21:53,520
i'm a nasa marshal of the science

624
00:21:57,669 --> 00:21:56,000
research office my question is for nikki

625
00:21:59,990 --> 00:21:57,679
and that is uh

626
00:22:02,870 --> 00:22:00,000
what our example of the types of things

627
00:22:05,669 --> 00:22:02,880
you'll be uh manufacturing with the 3d

628
00:22:07,430 --> 00:22:05,679
uh printing in space and can you give an

629
00:22:09,190 --> 00:22:07,440
example or tell me a little bit about

630
00:22:11,830 --> 00:22:09,200
the different protocols that will have

631
00:22:14,149 --> 00:22:11,840
to be utilized in microgravity and 3d

632
00:22:16,630 --> 00:22:14,159
printing versus what would be done uh

633
00:22:17,750 --> 00:22:16,640
here on earth sure i'd be happy i'd be

634
00:22:20,549 --> 00:22:17,760
happy too let me see if i'm like there

635
00:22:22,630 --> 00:22:20,559
we go okay so um the type of things that

636
00:22:23,909 --> 00:22:22,640
we'll be printing in the very beginning

637
00:22:25,669 --> 00:22:23,919
are going to be things that don't look

638
00:22:27,590 --> 00:22:25,679

terribly exciting to the layman right

639
00:22:28,789 --> 00:22:27,600
but we're super excited about we're

640
00:22:31,110 --> 00:22:28,799
going to be doing

641
00:22:33,750 --> 00:22:31,120
tinsel specimens flexure compression

642
00:22:34,950 --> 00:22:33,760
range coupons those very first parts

643
00:22:37,350 --> 00:22:34,960
that we print

644
00:22:39,510 --> 00:22:37,360
we have done a ton of detailed analysis

645
00:22:41,270 --> 00:22:39,520
on the ground to understand the material

646
00:22:43,190 --> 00:22:41,280
and mechanical properties for those

647
00:22:44,870 --> 00:22:43,200
parts so that when we bring back we'll

648
00:22:46,310 --> 00:22:44,880
bring back those very first parts to

649
00:22:48,070 --> 00:22:46,320
coupons and we'll be able to compare

650
00:22:49,909 --> 00:22:48,080
them to the ground controls and that's

651
00:22:52,149 --> 00:22:49,919
how we'll have publishable

652
00:22:54,070 --> 00:22:52,159
conclusive data that shows if we do see

653
00:22:55,510 --> 00:22:54,080
any differences in microgravity and how

654
00:22:56,870 --> 00:22:55,520
we print

655
00:22:58,549 --> 00:22:56,880
the best thing about additive

656
00:23:00,870 --> 00:22:58,559
manufacturing which is the formal name

657
00:23:02,630 --> 00:23:00,880
for 3d printing is that

658
00:23:04,470 --> 00:23:02,640
you can really create

659
00:23:05,750 --> 00:23:04,480
unusual

660
00:23:08,070 --> 00:23:05,760
different than you can with traditional

661
00:23:10,870 --> 00:23:08,080
manufacturing parts in the way that you

662
00:23:12,710 --> 00:23:10,880
design so design optimization is a key

663
00:23:14,630 --> 00:23:12,720

and understanding how the printing

664
00:23:16,390 --> 00:23:14,640
process works in microgravity if it is

665
00:23:18,710 --> 00:23:16,400
different due to lack of convection or

666
00:23:20,230 --> 00:23:18,720
any other properties will affect how we

667
00:23:22,549 --> 00:23:20,240
design as well as the material

668
00:23:24,230 --> 00:23:22,559
characteristics now from there

669
00:23:27,029 --> 00:23:24,240
we get to the really exciting part once

670
00:23:29,750 --> 00:23:27,039
we have that data and we've started what

671
00:23:31,669 --> 00:23:29,760
i call a utilization catalog and we have

672
00:23:32,870 --> 00:23:31,679
buckets and categories of things that we

673
00:23:34,310 --> 00:23:32,880
will be printing

674
00:23:36,070 --> 00:23:34,320
just like i mentioned my colleagues here

675
00:23:37,590 --> 00:23:36,080
i'm hoping to print some some parts for

676
00:23:39,590 --> 00:23:37,600
them as a matter of fact

677
00:23:40,870 --> 00:23:39,600
but things like replacement parts for

678
00:23:43,669 --> 00:23:40,880
eclipse

679
00:23:45,909 --> 00:23:43,679
filters things for science payloads such

680
00:23:47,110 --> 00:23:45,919
as sample containers i just happen to

681
00:23:49,350 --> 00:23:47,120
bring one

682
00:23:50,870 --> 00:23:49,360
we have a lot of the more science we do

683
00:23:53,750 --> 00:23:50,880
just like on the ground we have a lot of

684
00:23:56,390 --> 00:23:53,760
ancillary hardware and disposable uh

685
00:23:57,990 --> 00:23:56,400
type things syringes and containers

686
00:23:59,590 --> 00:23:58,000
the idea is eventually we don't want to

687
00:24:01,110 --> 00:23:59,600
have to fly those up we want the crew to

688
00:24:02,630 --> 00:24:01,120

be able to go over push a button and say

689
00:24:05,029 --> 00:24:02,640
yeah i need three syringes i need three

690
00:24:07,510 --> 00:24:05,039
sample containers i need four tweezers

691
00:24:10,310 --> 00:24:07,520
um and also and actually how we build

692
00:24:12,070 --> 00:24:10,320
science payloads or parts of payloads if

693
00:24:14,630 --> 00:24:12,080
you think about it every single thing we

694
00:24:16,470 --> 00:24:14,640
launch and this is so ingrained in us

695
00:24:19,110 --> 00:24:16,480
we have to design it so that the

696
00:24:21,350 --> 00:24:19,120
structure survives launch loads which

697
00:24:23,269 --> 00:24:21,360
usually means more mass and a different

698
00:24:24,789 --> 00:24:23,279
design than what we would do necessarily

699
00:24:26,390 --> 00:24:24,799
if we could make that part in

700
00:24:28,310 --> 00:24:26,400
microgravity

701
00:24:30,470 --> 00:24:28,320
so we're having a lot of fun thinking of

702
00:24:33,269 --> 00:24:30,480
how we would design parts that we

703
00:24:35,190 --> 00:24:33,279
launched today if we could produce them

704
00:24:36,310 --> 00:24:35,200
in microgravity how would we design them

705
00:24:38,549 --> 00:24:36,320
differently

706
00:24:40,390 --> 00:24:38,559
also understanding the the

707
00:24:41,830 --> 00:24:40,400
the mechanical aspects of the addi

708
00:24:43,669 --> 00:24:41,840
manufacturing and the materials that

709
00:24:45,909 --> 00:24:43,679
we're printing with the first material

710
00:24:48,789 --> 00:24:45,919
we're printing with is an abs plastic

711
00:24:50,950 --> 00:24:48,799
which is what legos are made out of um

712
00:24:52,789 --> 00:24:50,960
so we've tested that in detail so when

713
00:24:54,789 --> 00:24:52,799

we print a wrench for example it may not

714
00:24:57,110 --> 00:24:54,799
look exactly like the the wrench you go

715
00:24:59,269 --> 00:24:57,120
get at your local supply store it may be

716
00:25:00,630 --> 00:24:59,279
shorter and squatter we may we have ways

717
00:25:02,070 --> 00:25:00,640
that we can take advantage of the

718
00:25:04,310 --> 00:25:02,080
mechanical properties and strength of

719
00:25:06,470 --> 00:25:04,320
that material so to me one of the most

720
00:25:08,149 --> 00:25:06,480
exciting parts about this and i really

721
00:25:09,990 --> 00:25:08,159
encourage those high school students and

722
00:25:11,830 --> 00:25:10,000
college students out there today to

723
00:25:13,990 --> 00:25:11,840
consider a career path in this area

724
00:25:16,310 --> 00:25:14,000
whether it's for space or on the ground

725
00:25:18,549 --> 00:25:16,320
but how to design in a way that we can

726
00:25:21,190 --> 00:25:18,559
optimize the capabilities that added

727
00:25:25,190 --> 00:25:21,200
manufacturing provides us and for space

728
00:25:25,200 --> 00:25:29,990
all right thank you nikki

729
00:25:33,430 --> 00:25:32,149
uh i'll follow that up with another 3d

730
00:25:34,310 --> 00:25:33,440
printing question

731
00:25:35,269 --> 00:25:34,320
um

732
00:25:37,830 --> 00:25:35,279
so

733
00:25:39,430 --> 00:25:37,840
you mentioned a few advantages to 3d

734
00:25:41,430 --> 00:25:39,440
printing in zero gravity obviously there

735
00:25:43,190 --> 00:25:41,440
are a lot of there are a few

736
00:25:44,070 --> 00:25:43,200
trouble spots i guess i think i

737
00:25:45,430 --> 00:25:44,080
obviously wouldn't have a team of

738
00:25:46,470 --> 00:25:45,440

scientists working on it if it wasn't

739
00:25:48,310 --> 00:25:46,480
difficult

740
00:25:50,230 --> 00:25:48,320
um

741
00:25:52,789 --> 00:25:50,240
what are some of the advantages to

742
00:25:54,630 --> 00:25:52,799
printing in xerogen how do you plan on

743
00:25:55,590 --> 00:25:54,640
do you have plans to leverage them such

744
00:25:57,430 --> 00:25:55,600
as

745
00:25:59,350 --> 00:25:57,440
the fact that your z-axis is now

746
00:26:00,950 --> 00:25:59,360
arbitrary

747
00:26:02,149 --> 00:26:00,960
exactly so

748
00:26:04,549 --> 00:26:02,159
these are things that we spend a lot of

749
00:26:07,990 --> 00:26:04,559
time postulating and hypothesizing again

750
00:26:09,909 --> 00:26:08,000
i'll reiterate it's a technology demo so

751
00:26:11,830 --> 00:26:09,919
it's the unknown unknowns that i'm kind

752
00:26:14,070 --> 00:26:11,840
of most eager to see what we get we do

753
00:26:16,310 --> 00:26:14,080
have on the 3d printer tech demo we have

754
00:26:18,070 --> 00:26:16,320
two windows and we'll have high def

755
00:26:19,510 --> 00:26:18,080
cameras aimed at the prints while

756
00:26:21,430 --> 00:26:19,520
they're taking place so we'll be

757
00:26:23,190 --> 00:26:21,440
watching live from the ground and we'll

758
00:26:25,830 --> 00:26:23,200
be especially interested in seeing how

759
00:26:28,710 --> 00:26:25,840
the layer upon layer is being deposited

760
00:26:30,149 --> 00:26:28,720
things like the bead size taking in the

761
00:26:31,510 --> 00:26:30,159
the thermal properties in terms of

762
00:26:33,430 --> 00:26:31,520
making sure you have

763
00:26:35,029 --> 00:26:33,440

fans where they need we have lack of

764
00:26:36,710 --> 00:26:35,039
convection

765
00:26:39,029 --> 00:26:36,720
so these are things we've all thought

766
00:26:41,190 --> 00:26:39,039
out and i did mention there's a couple

767
00:26:43,110 --> 00:26:41,200
areas we feel like it might help us

768
00:26:45,590 --> 00:26:43,120
um and then there are other areas that

769
00:26:47,430 --> 00:26:45,600
we we are postulating but we'll need to

770
00:26:49,350 --> 00:26:47,440
watch the most important thing and what

771
00:26:51,830 --> 00:26:49,360
we've seen from the parabolic flights is

772
00:26:53,430 --> 00:26:51,840
that the first layer that we lay on the

773
00:26:55,110 --> 00:26:53,440
print structure

774
00:26:56,630 --> 00:26:55,120
is really a critical juncture and we see

775
00:26:58,230 --> 00:26:56,640
that on the ground as well and we're

776
00:27:00,230 --> 00:26:58,240
very interested in seeing if that's any

777
00:27:03,029 --> 00:27:00,240
different in microgravity and then the

778
00:27:04,710 --> 00:27:03,039
first layer that binds to the the first

779
00:27:07,029 --> 00:27:04,720
bead that we have laid

780
00:27:08,549 --> 00:27:07,039
that's going to be critical

781
00:27:10,630 --> 00:27:08,559
and we'll see how it turns out i will

782
00:27:13,510 --> 00:27:10,640
mention that all the items that we're

783
00:27:16,390 --> 00:27:13,520
going to print we are loading on the

784
00:27:18,389 --> 00:27:16,400
we have a shareable nasa.gov website

785
00:27:19,590 --> 00:27:18,399
we'll be loading all the files there so

786
00:27:21,110 --> 00:27:19,600
anybody on the ground that wants to

787
00:27:22,230 --> 00:27:21,120
print the same parts on the ground can

788
00:27:24,630 --> 00:27:22,240

do so

789
00:27:25,830 --> 00:27:24,640
and all of the data that we produce will

790
00:27:27,510 --> 00:27:25,840
be shareable

791
00:27:28,789 --> 00:27:27,520
one thing we ran into with such things

792
00:27:30,870 --> 00:27:28,799
as materials and the different

793
00:27:32,549 --> 00:27:30,880
feedstocks and the different printers

794
00:27:34,789 --> 00:27:32,559
there's a lot of data out there but a

795
00:27:36,070 --> 00:27:34,799
lot of it is proprietary a lot of these

796
00:27:37,510 --> 00:27:36,080
are commercial companies that have been

797
00:27:39,909 --> 00:27:37,520
working on these technologies for quite

798
00:27:41,430 --> 00:27:39,919
some time um so what we're doing will

799
00:27:43,190 --> 00:27:41,440
all be publishable and i really

800
00:27:45,190 --> 00:27:43,200
encourage folks out there we'll make

801
00:27:49,110 --> 00:27:45,200
sure those websites are available to

802
00:27:51,110 --> 00:27:49,120
participate along with us

803
00:27:52,630 --> 00:27:51,120
all right who's coming up next we got it

804
00:27:54,149 --> 00:27:52,640
all right first one from the right side

805
00:27:56,830 --> 00:27:54,159
of the room

806
00:27:58,630 --> 00:27:56,840
uh good morning uh i'm lee root from the

807
00:28:00,549 --> 00:27:58,640
huntsvilletimesale.com thanks for uh

808
00:28:04,230 --> 00:28:00,559
coming and doing this so follow up a

809
00:28:06,310 --> 00:28:04,240
guest to the eclipse system

810
00:28:09,110 --> 00:28:06,320
living in microgravity seems to be hard

811
00:28:11,669 --> 00:28:09,120
on the human body we keep hearing about

812
00:28:13,830 --> 00:28:11,679
effects on vision effects on bones

813
00:28:16,149 --> 00:28:13,840

effects on more and more things what

814
00:28:17,350 --> 00:28:16,159
kind of text technology are you looking

815
00:28:20,870 --> 00:28:17,360
at now

816
00:28:22,549 --> 00:28:20,880
for long term missions in space

817
00:28:25,830 --> 00:28:22,559
how are we going to

818
00:28:27,990 --> 00:28:25,840
adapt our systems so our bodies can

819
00:28:32,389 --> 00:28:28,000
can stand going up for as long as we're

820
00:28:36,389 --> 00:28:34,070
you're right there's a lot of things

821
00:28:39,029 --> 00:28:36,399
we're learning about humans in space for

822
00:28:41,590 --> 00:28:39,039
long-duration missions and our we have a

823
00:28:44,149 --> 00:28:41,600
whole human research program

824
00:28:46,549 --> 00:28:44,159
at nasa to address those risks and we're

825
00:28:48,630 --> 00:28:46,559
trying to retire all those risks

826
00:28:49,830 --> 00:28:48,640
on the space station as much as possible

827
00:28:52,070 --> 00:28:49,840
you mentioned

828
00:28:54,630 --> 00:28:52,080
the intracranial pressure in the vision

829
00:28:58,870 --> 00:28:56,470
the the long-term effects of

830
00:29:02,230 --> 00:28:58,880
microgravity on the body

831
00:29:04,630 --> 00:29:02,240
we have exercise equipment that

832
00:29:06,549 --> 00:29:04,640
we counteract those effects with that

833
00:29:08,710 --> 00:29:06,559
exercise equipment on the space station

834
00:29:10,470 --> 00:29:08,720
is pretty large

835
00:29:13,590 --> 00:29:10,480
for future missions where we want to

836
00:29:15,430 --> 00:29:13,600
take a spacecraft to mars we've got to

837
00:29:17,990 --> 00:29:15,440
reduce the mass of that equipment make

838
00:29:19,990 --> 00:29:18,000

it as small as possible we want when the

839
00:29:22,230 --> 00:29:20,000
crews eventually arrive at the mars

840
00:29:23,909 --> 00:29:22,240
surface we want them to be able to get

841
00:29:25,990 --> 00:29:23,919
out of the spacecraft and be able to

842
00:29:28,470 --> 00:29:26,000
walk on the surface without being weak

843
00:29:29,669 --> 00:29:28,480
and have muscle atrophy so that's really

844
00:29:31,830 --> 00:29:29,679
important

845
00:29:34,230 --> 00:29:31,840
and we've got folks working on those

846
00:29:36,389 --> 00:29:34,240
technologies as well

847
00:29:38,870 --> 00:29:36,399
as far as the ecosystem we've learned

848
00:29:40,389 --> 00:29:38,880
some things for example the crew loses

849
00:29:42,070 --> 00:29:40,399
more calcium

850
00:29:43,990 --> 00:29:42,080
on orbit than they did on the ground

851
00:29:45,350 --> 00:29:44,000
that's one of the issues that kind of

852
00:29:47,510 --> 00:29:45,360
surprised us

853
00:29:49,590 --> 00:29:47,520
to be honest and we had to adapt our

854
00:29:51,669 --> 00:29:49,600
ecosystem

855
00:29:54,310 --> 00:29:51,679
that calcium showed up in the urine and

856
00:29:56,950 --> 00:29:54,320
caused some hardware problems for us and

857
00:29:59,269 --> 00:29:56,960
and we had to adapt our system now we're

858
00:30:01,029 --> 00:29:59,279
working on ways to counteract that

859
00:30:02,950 --> 00:30:01,039
so the longer we test these things on

860
00:30:04,950 --> 00:30:02,960
the space station the more we learn

861
00:30:07,029 --> 00:30:04,960
ultimately we want to get

862
00:30:09,990 --> 00:30:07,039
our mars eclipse system on the space

863
00:30:12,149 --> 00:30:10,000

station in about the next five years

864
00:30:13,269 --> 00:30:12,159
and test it for at least two or three

865
00:30:14,389 --> 00:30:13,279
years

866
00:30:16,310 --> 00:30:14,399
so we're

867
00:30:18,549 --> 00:30:16,320
making to make sure it's reliable and

868
00:30:21,510 --> 00:30:18,559
it's ready to go when we need it for the

869
00:30:27,269 --> 00:30:23,269
okay

870
00:30:33,590 --> 00:30:28,389
hi

871
00:30:34,470 --> 00:30:33,600
and uh you kind of just answered robin

872
00:30:37,350 --> 00:30:34,480
my

873
00:30:39,590 --> 00:30:37,360
you how soon are you

874
00:30:41,830 --> 00:30:39,600
how close are you to making a mars ready

875
00:30:42,630 --> 00:30:41,840
version of the eclipse system

876
00:30:44,549 --> 00:30:42,640
um

877
00:30:46,470 --> 00:30:44,559
so again you said about five years and

878
00:30:48,149 --> 00:30:46,480
then testing it for two years and then

879
00:30:49,830 --> 00:30:48,159
my second question would be how will you

880
00:30:51,029 --> 00:30:49,840
leverage some of the upcoming orion

881
00:30:53,029 --> 00:30:51,039
flights

882
00:30:54,549 --> 00:30:53,039
like em2

883
00:30:56,549 --> 00:30:54,559
going around the moon will you try to

884
00:30:58,630 --> 00:30:56,559
test some of that technology there or

885
00:31:00,470 --> 00:30:58,640
will you try to just leverage

886
00:31:01,669 --> 00:31:00,480
normal technologies bringing along all

887
00:31:04,789 --> 00:31:01,679
the water that's needed for those

888
00:31:06,070 --> 00:31:04,799

missions thanks great um first of all uh

889
00:31:07,990 --> 00:31:06,080
one more thing

890
00:31:10,149 --> 00:31:08,000
right now our space station i mentioned

891
00:31:10,950 --> 00:31:10,159
our water recycling system recycles

892
00:31:12,870 --> 00:31:10,960
about

893
00:31:14,710 --> 00:31:12,880
90 percent of the water

894
00:31:16,950 --> 00:31:14,720
we're working on technologies that will

895
00:31:19,190 --> 00:31:16,960
get that last 10 percent on our air

896
00:31:21,909 --> 00:31:19,200
system for space station right now we

897
00:31:24,149 --> 00:31:21,919
can recover about half of the oxygen

898
00:31:26,870 --> 00:31:24,159
from carbon dioxide in other words we

899
00:31:29,350 --> 00:31:26,880
recycle about 50 percent of the air

900
00:31:31,190 --> 00:31:29,360
so we are working on technologies to

901
00:31:33,830 --> 00:31:31,200
further close that loop we want to

902
00:31:35,669 --> 00:31:33,840
recover as much oxygen as possible so we

903
00:31:37,830 --> 00:31:35,679
don't have to bring up

904
00:31:39,830 --> 00:31:37,840
oxygen so those are the kinds of things

905
00:31:41,669 --> 00:31:39,840
we want to work on in the next five

906
00:31:42,710 --> 00:31:41,679
years hopefully and get them up to space

907
00:31:45,110 --> 00:31:42,720
station

908
00:31:47,190 --> 00:31:45,120
and and test those how we're going to

909
00:31:49,990 --> 00:31:47,200
use the orion mission

910
00:31:52,630 --> 00:31:50,000
the orion mission is designed for uh 30

911
00:31:55,110 --> 00:31:52,640
days or less about so we don't need to

912
00:31:58,149 --> 00:31:55,120
recycle as much on orion it's also a

913
00:31:58,950 --> 00:31:58,159

small spacecraft so we don't have our

914
00:32:03,110 --> 00:31:58,960
big

915
00:32:05,110 --> 00:32:03,120
water processor for example on an orion

916
00:32:07,350 --> 00:32:05,120
but we have some key technologies on

917
00:32:09,029 --> 00:32:07,360
orion and our and our regenerative

918
00:32:11,110 --> 00:32:09,039
carbon dioxide removal that will be

919
00:32:13,029 --> 00:32:11,120
tested we have some critical

920
00:32:15,190 --> 00:32:13,039
environmental monitoring capabilities

921
00:32:16,870 --> 00:32:15,200
that will be tested on in orion

922
00:32:18,950 --> 00:32:16,880
and so we are going to leverage the

923
00:32:21,430 --> 00:32:18,960
orion to test some of those some fire

924
00:32:23,830 --> 00:32:21,440
safety things that are new

925
00:32:25,509 --> 00:32:23,840
uh for for a small closed spacecraft

926
00:32:27,509 --> 00:32:25,519
we're going to be testing on the orion

927
00:32:28,389 --> 00:32:27,519
so it's going to be things on space

928
00:32:30,549 --> 00:32:28,399
station

929
00:32:33,990 --> 00:32:30,559
for more of our long duration life

930
00:32:36,710 --> 00:32:34,000
support systems things on orion for that

931
00:32:39,190 --> 00:32:36,720
that go across any any spacecraft we're

932
00:32:40,830 --> 00:32:39,200
going to have in our smaller spacecraft

933
00:32:43,269 --> 00:32:40,840
life support

934
00:32:45,590 --> 00:32:43,279
systems all right we've got another one

935
00:32:47,830 --> 00:32:45,600
up here

936
00:32:49,269 --> 00:32:47,840
i've got another question about the 3d

937
00:32:51,830 --> 00:32:49,279
printing

938
00:32:54,310 --> 00:32:51,840

um you guys are probably expected to be

939
00:32:59,590 --> 00:32:54,320
more or less time efficient than the

940
00:33:02,870 --> 00:33:01,029
is it going to be controlled by the

941
00:33:05,430 --> 00:33:02,880
ground or by the astronauts in this

942
00:33:06,630 --> 00:33:05,440
business thank you for asking um so a

943
00:33:08,149 --> 00:33:06,640
lot of people ask us what's the

944
00:33:10,230 --> 00:33:08,159
difference between this 3d printer and

945
00:33:11,990 --> 00:33:10,240
what you could buy off the ground and

946
00:33:13,509 --> 00:33:12,000
the company we're working with made in

947
00:33:15,830 --> 00:33:13,519
space through the small business

948
00:33:17,509 --> 00:33:15,840
innovation and research program

949
00:33:20,070 --> 00:33:17,519
one of the first trades they did is can

950
00:33:21,190 --> 00:33:20,080
we just go buy a printer off the ground

951
00:33:22,549 --> 00:33:21,200
to be honest with you a lot of the

952
00:33:24,710 --> 00:33:22,559
printing the technical printing

953
00:33:27,669 --> 00:33:24,720
processes the extrusion process is

954
00:33:30,789 --> 00:33:27,679
actually very analogous but in terms of

955
00:33:32,950 --> 00:33:30,799
automation and being able to

956
00:33:34,789 --> 00:33:32,960
take advantage of remote operations

957
00:33:36,870 --> 00:33:34,799
which we absolutely need to do also to

958
00:33:39,909 --> 00:33:36,880
limit astronaut time

959
00:33:42,230 --> 00:33:39,919
and as well as a safety protocol that

960
00:33:44,549 --> 00:33:42,240
was a couple the the key factors on on

961
00:33:46,870 --> 00:33:44,559
why this printer has been specifically

962
00:33:48,789 --> 00:33:46,880
adapted for space so the only thing the

963
00:33:50,710 --> 00:33:48,799

astronauts have to do on this printer is

964
00:33:52,630 --> 00:33:50,720
obviously install it

965
00:33:54,310 --> 00:33:52,640
and then they have to remove the part

966
00:33:55,350 --> 00:33:54,320
from the print tray once it has been

967
00:33:57,029 --> 00:33:55,360
printed

968
00:33:58,710 --> 00:33:57,039
everything else like i mentioned we'll

969
00:34:00,310 --> 00:33:58,720
have live video watching the prints we

970
00:34:02,310 --> 00:34:00,320
can turn the printer on and off we can

971
00:34:03,669 --> 00:34:02,320
control the prints start the print stop

972
00:34:05,350 --> 00:34:03,679
the print

973
00:34:07,990 --> 00:34:05,360
we can do all of that from the ground

974
00:34:10,310 --> 00:34:08,000
and we do have live video of the prince

975
00:34:13,750 --> 00:34:10,320
as we continue on to mars i would like

976
00:34:19,430 --> 00:34:16,869
this printer is a very first step to a

977
00:34:21,829 --> 00:34:19,440
lot larger suite of capabilities for

978
00:34:23,669 --> 00:34:21,839
sustainable exploration

979
00:34:25,349 --> 00:34:23,679
so we have an in-space manufacturing

980
00:34:27,829 --> 00:34:25,359
initiative at nasa

981
00:34:29,750 --> 00:34:27,839
and that we include things like a

982
00:34:31,589 --> 00:34:29,760
recycler for example we get the question

983
00:34:32,790 --> 00:34:31,599
a lot that comes up

984
00:34:34,550 --> 00:34:32,800
well what if you stop to fly all the

985
00:34:35,510 --> 00:34:34,560
feedstock well that's a very valid

986
00:34:37,349 --> 00:34:35,520
question

987
00:34:40,069 --> 00:34:37,359
feedstock is mass and you're reliable on

988
00:34:41,589 --> 00:34:40,079

it at this point and so

989
00:34:44,149 --> 00:34:41,599
you do have to be able to recycle the

990
00:34:46,389 --> 00:34:44,159
parts we've awarded two phase one sbirs

991
00:34:47,510 --> 00:34:46,399
to small companies this past year who

992
00:34:49,030 --> 00:34:47,520
have already

993
00:34:51,270 --> 00:34:49,040
developed hardware where they are

994
00:34:53,750 --> 00:34:51,280
turning printed parts back into usable

995
00:34:56,629 --> 00:34:53,760
feedstock with multiple materials

996
00:34:59,190 --> 00:34:56,639
um and the real exciting day comes when

997
00:35:01,190 --> 00:34:59,200
jeff had mentioned in situ resource

998
00:35:03,510 --> 00:35:01,200
when we can use something like martian

999
00:35:05,109 --> 00:35:03,520
regolith or lunar regolith to make the

1000
00:35:07,030 --> 00:35:05,119
parts that we need

1001
00:35:08,870 --> 00:35:07,040
including such things as additive

1002
00:35:10,470 --> 00:35:08,880
construction we actually have another

1003
00:35:12,310 --> 00:35:10,480
nasa project where we're working with

1004
00:35:13,670 --> 00:35:12,320
large-scale printers such as contour

1005
00:35:16,630 --> 00:35:13,680
crafting

1006
00:35:18,870 --> 00:35:16,640
to be able to print things such as small

1007
00:35:21,510 --> 00:35:18,880
habitat structures radiation shielding

1008
00:35:23,349 --> 00:35:21,520
storage shelters and landing pads

1009
00:35:25,829 --> 00:35:23,359
and we're testing

1010
00:35:27,670 --> 00:35:25,839
regular simulant for mars and the moon

1011
00:35:29,190 --> 00:35:27,680
as our feed stock

1012
00:35:31,030 --> 00:35:29,200
so these are all capabilities that we'll

1013
00:35:32,310 --> 00:35:31,040

need in conjunction and

1014
00:35:34,470 --> 00:35:32,320
and as you mentioned the remote

1015
00:35:36,950 --> 00:35:34,480
operations is going to be a key aspect

1016
00:35:42,150 --> 00:35:38,870
okay

1017
00:35:42,160 --> 00:35:46,550
somebody grab the mic and jump in

1018
00:35:50,790 --> 00:35:48,790
i had a question for jose i'm alan boyle

1019
00:35:52,950 --> 00:35:50,800
with nbc news i wanted to hear a little

1020
00:35:55,270 --> 00:35:52,960
bit more about spears and

1021
00:35:56,790 --> 00:35:55,280
the next generation free-flying

1022
00:35:58,710 --> 00:35:56,800
robots

1023
00:36:01,109 --> 00:35:58,720
what do you see is the schedule for

1024
00:36:02,950 --> 00:36:01,119
using spheres and its successors on the

1025
00:36:05,990 --> 00:36:02,960
space station

1026
00:36:08,550 --> 00:36:06,000
uh good question uh so spheres as is has

1027
00:36:10,550 --> 00:36:08,560
proven uh very durable uh for long

1028
00:36:12,790 --> 00:36:10,560
duration use uh they've been up there

1029
00:36:15,109 --> 00:36:12,800
for eight years now and uh they keep

1030
00:36:16,710 --> 00:36:15,119
keep on ticking uh they've

1031
00:36:18,470 --> 00:36:16,720
been fixed there have been some issues

1032
00:36:20,710 --> 00:36:18,480
but we've been able to go up and debug

1033
00:36:22,950 --> 00:36:20,720
certain issues so they're expected to

1034
00:36:24,870 --> 00:36:22,960
actually work for for a while yet for

1035
00:36:26,790 --> 00:36:24,880
another few years

1036
00:36:28,630 --> 00:36:26,800
but a good question we are looking there

1037
00:36:31,190 --> 00:36:28,640
are projects looking at what is the next

1038
00:36:33,109 --> 00:36:31,200

version what's the next uh free flyer

1039
00:36:35,030 --> 00:36:33,119
going up to space station and uh there's

1040
00:36:38,550 --> 00:36:35,040
all kinds of ideas that are going into

1041
00:36:40,470 --> 00:36:38,560
that uh to better enhance the freefire's

1042
00:36:43,270 --> 00:36:40,480
ability to assist the astronauts with

1043
00:36:45,510 --> 00:36:43,280
various tasks make

1044
00:36:46,470 --> 00:36:45,520
these tasks and iss more automated you

1045
00:36:48,630 --> 00:36:46,480
know there's a lot of things the

1046
00:36:50,069 --> 00:36:48,640
astronauts do that

1047
00:36:51,349 --> 00:36:50,079
that could be automated and save

1048
00:36:53,910 --> 00:36:51,359
astronaut time

1049
00:36:55,510 --> 00:36:53,920
a very precious resource so

1050
00:36:57,270 --> 00:36:55,520
yeah making them more renewable making

1051
00:36:58,710 --> 00:36:57,280
the propulsion renewable

1052
00:36:59,430 --> 00:36:58,720
these kind of things are being looked at

1053
00:37:01,030 --> 00:36:59,440
for

1054
00:37:02,950 --> 00:37:01,040
the next free flow going up the space

1055
00:37:04,870 --> 00:37:02,960
station and there are projects looking

1056
00:37:07,990 --> 00:37:04,880
at that right now

1057
00:37:09,670 --> 00:37:08,000
and if i can just jump in real quick you

1058
00:37:11,430 --> 00:37:09,680
have a project up there right now that

1059
00:37:13,430 --> 00:37:11,440
these spheres are actually using a piece

1060
00:37:14,710 --> 00:37:13,440
of technology every single person in

1061
00:37:16,230 --> 00:37:14,720
this room probably has either in their

1062
00:37:17,990 --> 00:37:16,240
pocket or their hand right now and

1063
00:37:20,230 --> 00:37:18,000

that's smart phones

1064
00:37:23,270 --> 00:37:20,240
uh yeah that's right uh the uh there's

1065
00:37:25,190 --> 00:37:23,280
uh one project uh out of nasa ames

1066
00:37:26,950 --> 00:37:25,200
that's attaching a smartphones to these

1067
00:37:29,349 --> 00:37:26,960
spheres to be able to control the

1068
00:37:31,030 --> 00:37:29,359
spheres from the ground uh but what

1069
00:37:34,390 --> 00:37:31,040
these smartphones actually do is turn

1070
00:37:36,870 --> 00:37:34,400
these spheres into more uh robotic type

1071
00:37:37,990 --> 00:37:36,880
application where again we can control

1072
00:37:39,109 --> 00:37:38,000
from the ground the astronaut can

1073
00:37:41,030 --> 00:37:39,119
control from the

1074
00:37:43,510 --> 00:37:41,040
space station and we can do more

1075
00:37:45,430 --> 00:37:43,520
research in these collaborative type uh

1076
00:37:47,750 --> 00:37:45,440
scenarios where the astronauts and

1077
00:37:49,510 --> 00:37:47,760
robots can work hand in hand on all

1078
00:37:51,750 --> 00:37:49,520
kinds of different tasks that will be

1079
00:37:55,510 --> 00:37:51,760
needed for long duration space flight so

1080
00:37:57,270 --> 00:37:55,520
for example uh environmental surveys

1081
00:37:58,790 --> 00:37:57,280
inventory control

1082
00:38:00,550 --> 00:37:58,800
camera movement i mean it'd be really

1083
00:38:01,990 --> 00:38:00,560
great if operators on the ground were

1084
00:38:04,069 --> 00:38:02,000
able to

1085
00:38:05,990 --> 00:38:04,079
control a camera that can go anywhere in

1086
00:38:08,310 --> 00:38:06,000
space station so these are a lot of the

1087
00:38:10,950 --> 00:38:08,320
tasks that we're looking at with spheres

1088
00:38:12,390 --> 00:38:10,960

and um

1089
00:38:13,990 --> 00:38:12,400
and yeah

1090
00:38:16,069 --> 00:38:14,000
actually there's actually a this this

1091
00:38:17,510 --> 00:38:16,079
year so that investigation was last year

1092
00:38:20,069 --> 00:38:17,520
just this year there's a new smartphone

1093
00:38:22,630 --> 00:38:20,079
going up uh called project tango it's a

1094
00:38:25,190 --> 00:38:22,640
google smartphone that just launched uh

1095
00:38:26,470 --> 00:38:25,200
earlier this year and uh the next test

1096
00:38:28,710 --> 00:38:26,480
session for that's gonna take place here

1097
00:38:30,390 --> 00:38:28,720
in the next couple weeks so uh be on the

1098
00:38:33,190 --> 00:38:30,400
lookout for that online we've got a

1099
00:38:34,870 --> 00:38:33,200
twitter account nasa.gov spheres also we

1100
00:38:36,790 --> 00:38:34,880
put a lot of information

1101
00:38:38,630 --> 00:38:36,800
and that's a really cool

1102
00:38:41,589 --> 00:38:38,640
smartphone google developed and it's got

1103
00:38:44,310 --> 00:38:41,599
a connect like sensor that gives it an

1104
00:38:46,870 --> 00:38:44,320
ability to map its environment in 3d it

1105
00:38:48,550 --> 00:38:46,880
generates a point cloud map of its

1106
00:38:51,109 --> 00:38:48,560
environment so then it could navigate

1107
00:38:53,109 --> 00:38:51,119
throughout all of iss

1108
00:38:55,030 --> 00:38:53,119
without being limited and it can do this

1109
00:38:57,109 --> 00:38:55,040
using the special connect like like i

1110
00:38:58,710 --> 00:38:57,119
said connect like sensor

1111
00:39:00,870 --> 00:38:58,720
together with the camera to do vision

1112
00:39:02,710 --> 00:39:00,880
based navigation because currently the

1113
00:39:05,430 --> 00:39:02,720

spheres are limited to the small volume

1114
00:39:07,109 --> 00:39:05,440
inside the gem module of iss using five

1115
00:39:09,750 --> 00:39:07,119
beacons it locates itself within this

1116
00:39:12,470 --> 00:39:09,760
particular area but using vision-based

1117
00:39:14,710 --> 00:39:12,480
uh navigation it can navigate across iss

1118
00:39:16,790 --> 00:39:14,720
as would be needed for assistive type

1119
00:39:19,190 --> 00:39:16,800
robots for the astronauts

1120
00:39:21,270 --> 00:39:19,200
all right very cool evolution next one

1121
00:39:23,910 --> 00:39:21,280
right here and then i think someone will

1122
00:39:25,510 --> 00:39:23,920
get him next so you right now

1123
00:39:28,630 --> 00:39:25,520
frank waring with aviation week for

1124
00:39:30,390 --> 00:39:28,640
richard the the scan is is radio based

1125
00:39:31,589 --> 00:39:30,400
programmable radio

1126
00:39:34,550 --> 00:39:31,599
um

1127
00:39:36,950 --> 00:39:34,560
are you doing work with uh laser com

1128
00:39:39,990 --> 00:39:36,960
programmable laser com for planetary

1129
00:39:41,349 --> 00:39:40,000
exploration to get more bandwidth

1130
00:39:43,270 --> 00:39:41,359
um

1131
00:39:45,589 --> 00:39:43,280
certainly the uh

1132
00:39:48,150 --> 00:39:45,599
as was mentioned optical communications

1133
00:39:49,270 --> 00:39:48,160
uses a laser beam uh as a medium of

1134
00:39:50,470 --> 00:39:49,280
transmission as opposed to the

1135
00:39:51,990 --> 00:39:50,480
software-defined radios that we're

1136
00:39:54,310 --> 00:39:52,000
operating our radio frequency or

1137
00:39:55,670 --> 00:39:54,320
electromagnetic based uh but nasa is

1138
00:39:57,750 --> 00:39:55,680

doing a number of things in optical

1139
00:39:59,589 --> 00:39:57,760
communications in fact on space station

1140
00:40:01,510 --> 00:39:59,599
there's an optical payload entitled

1141
00:40:03,829 --> 00:40:01,520
optical payload for laser comp studies

1142
00:40:05,750 --> 00:40:03,839
or opals and that's sort of scratching

1143
00:40:07,829 --> 00:40:05,760
the surface of what laser com can do so

1144
00:40:09,270 --> 00:40:07,839
it's a laser onboard space station that

1145
00:40:11,589 --> 00:40:09,280
communicates directly to a ground

1146
00:40:12,790 --> 00:40:11,599
station on the earth

1147
00:40:14,550 --> 00:40:12,800
there's a

1148
00:40:16,710 --> 00:40:14,560
relay satellite also being developed at

1149
00:40:18,790 --> 00:40:16,720
this optical communications the

1150
00:40:20,230 --> 00:40:18,800
laser comm relay satellite or relay

1151
00:40:22,150 --> 00:40:20,240
demonstration

1152
00:40:23,670 --> 00:40:22,160
so this will give us infrastructure and

1153
00:40:25,670 --> 00:40:23,680
space so that when low earth orbit

1154
00:40:29,430 --> 00:40:25,680
satellites which are optical terminal

1155
00:40:30,470 --> 00:40:29,440
based can relay their data back to earth

1156
00:40:32,230 --> 00:40:30,480
and the

1157
00:40:33,109 --> 00:40:32,240
the bandwidth question the data rate

1158
00:40:35,109 --> 00:40:33,119
question

1159
00:40:37,190 --> 00:40:35,119
where we're doing hundreds of megabits

1160
00:40:39,430 --> 00:40:37,200
today over rf and maybe your cable

1161
00:40:40,630 --> 00:40:39,440
system does 20 or 30 megabits to your

1162
00:40:42,309 --> 00:40:40,640
desktop

1163
00:40:44,630 --> 00:40:42,319

rf will get us hundreds of megabits

1164
00:40:45,910 --> 00:40:44,640
multi-hundreds optical communication

1165
00:40:47,829 --> 00:40:45,920
systems will give us thousands of

1166
00:40:48,790 --> 00:40:47,839
megabits it'll be an order of magnitude

1167
00:40:50,550 --> 00:40:48,800
more

1168
00:40:52,790 --> 00:40:50,560
and there's a second optical terminal

1169
00:40:54,309 --> 00:40:52,800
being considered for space station

1170
00:40:55,750 --> 00:40:54,319
which not only will give us optical

1171
00:40:57,270 --> 00:40:55,760
communications direct to ground but it

1172
00:40:59,190 --> 00:40:57,280
will also give us that low earth orbit

1173
00:41:00,790 --> 00:40:59,200
relay satellite and as nikki mentioned

1174
00:41:01,750 --> 00:41:00,800
earlier that we can only investigate on

1175
00:41:03,030 --> 00:41:01,760
station

1176
00:41:04,470 --> 00:41:03,040
will give us the low earth orbit

1177
00:41:06,150 --> 00:41:04,480
satellite to use with that relay

1178
00:41:08,390 --> 00:41:06,160
satellite so those are all being

1179
00:41:12,710 --> 00:41:08,400
developed at this time and should be

1180
00:41:16,710 --> 00:41:14,309
the radios for those systems will be

1181
00:41:19,589 --> 00:41:16,720
programmable radios as well

1182
00:41:22,550 --> 00:41:19,599
there's one other piece by my dad it's

1183
00:41:24,710 --> 00:41:22,560
the deep space optical com so in space

1184
00:41:27,430 --> 00:41:24,720
technology mission directorate which i

1185
00:41:29,190 --> 00:41:27,440
represent i have the happy experience of

1186
00:41:31,670 --> 00:41:29,200
being able to work with all these

1187
00:41:33,349 --> 00:41:31,680
people here and and a hundred more doing

1188
00:41:35,030 --> 00:41:33,359

the different technologies needed for

1189
00:41:37,270 --> 00:41:35,040
space exploration

1190
00:41:38,870 --> 00:41:37,280
we have the laser communication relay

1191
00:41:41,910 --> 00:41:38,880
demonstration

1192
00:41:43,190 --> 00:41:41,920
project which which was mentioned that's

1193
00:41:45,270 --> 00:41:43,200
from from

1194
00:41:47,670 --> 00:41:45,280
in earth orbit but then we also have a

1195
00:41:49,990 --> 00:41:47,680
deep space optical com looking at the

1196
00:41:53,270 --> 00:41:50,000
unique features of communicating over

1197
00:41:54,069 --> 00:41:53,280
very long distances mars and beyond and

1198
00:41:55,510 --> 00:41:54,079
uh

1199
00:41:57,750 --> 00:41:55,520
all the

1200
00:42:00,230 --> 00:41:57,760
particular problems that that presents

1201
00:42:01,750 --> 00:42:00,240
in terms of the the rate that bodies are

1202
00:42:05,349 --> 00:42:01,760
moving with respect to each other and

1203
00:42:08,630 --> 00:42:05,359
how you acquire the signal and

1204
00:42:11,670 --> 00:42:08,640
and transmit the data and so

1205
00:42:14,230 --> 00:42:11,680
we've actually offered that technology

1206
00:42:16,870 --> 00:42:14,240
it's one of a suite of technologies that

1207
00:42:19,030 --> 00:42:16,880
we're making available to

1208
00:42:20,630 --> 00:42:19,040
people who are proposing for the next

1209
00:42:22,550 --> 00:42:20,640
discovery mission

1210
00:42:24,550 --> 00:42:22,560
uh so nasa is saying here are some

1211
00:42:27,190 --> 00:42:24,560
technologies we're developing if you

1212
00:42:29,750 --> 00:42:27,200
want to use these in your architecture

1213
00:42:32,390 --> 00:42:29,760

for your discovery mission concept we'll

1214
00:42:34,550 --> 00:42:32,400
continue developing these technologies

1215
00:42:36,870 --> 00:42:34,560
and provide them actually so

1216
00:42:39,750 --> 00:42:36,880
lots going on in optical com i have one

1217
00:42:41,349 --> 00:42:39,760
more thing to add dan sorry um

1218
00:42:44,069 --> 00:42:41,359
there's also an additional system that's

1219
00:42:46,150 --> 00:42:44,079
being investigated that combines the rf

1220
00:42:47,750 --> 00:42:46,160
attributes of the system and the optical

1221
00:42:49,910 --> 00:42:47,760
parts of a system and when you mention

1222
00:42:52,069 --> 00:42:49,920
the reprogrammable radio the radios will

1223
00:42:54,470 --> 00:42:52,079
be configured to operate waveforms that

1224
00:42:56,470 --> 00:42:54,480
i mentioned earlier either over rf or

1225
00:42:57,990 --> 00:42:56,480
optical and the idea of combining the

1226
00:42:59,349 --> 00:42:58,000
systems is trying to reduce mass on

1227
00:43:01,910 --> 00:42:59,359
these systems especially when they go to

1228
00:43:03,589 --> 00:43:01,920
b space that the same antenna the same

1229
00:43:05,750 --> 00:43:03,599
aperture that's used to send

1230
00:43:07,670 --> 00:43:05,760
electromagnetic signals can have this

1231
00:43:09,430 --> 00:43:07,680
laser or a telescope integrated with it

1232
00:43:11,270 --> 00:43:09,440
to conduct the optical communications

1233
00:43:13,109 --> 00:43:11,280
with the same aperture so that's being

1234
00:43:15,349 --> 00:43:13,119
that's more of a technology project

1235
00:43:16,470 --> 00:43:15,359
underway now

1236
00:43:22,630 --> 00:43:16,480
all right thanks guys i think we're

1237
00:43:27,190 --> 00:43:24,470
i'm evan coy from grissom high school

1238
00:43:30,309 --> 00:43:27,200

and another question for robin vao eclas

1239
00:43:32,309 --> 00:43:30,319
and well not necessarily for eclis but

1240
00:43:33,990 --> 00:43:32,319
for more so life support in general

1241
00:43:37,030 --> 00:43:34,000
based on jeff's comment on the

1242
00:43:37,750 --> 00:43:37,040
possibility of water being on mars

1243
00:43:39,030 --> 00:43:37,760
and

1244
00:43:41,109 --> 00:43:39,040
for super

1245
00:43:43,270 --> 00:43:41,119
future life support for the possibility

1246
00:43:46,069 --> 00:43:43,280
of using nuclear fission if there is

1247
00:43:47,030 --> 00:43:46,079
water on mars to create more oxygen

1248
00:43:50,630 --> 00:43:47,040
like

1249
00:43:55,430 --> 00:43:53,109
wow we need to recruit you so leave your

1250
00:43:57,990 --> 00:43:55,440
name afterwards stick around some great

1251
00:44:00,470 --> 00:43:58,000
ideas yeah

1252
00:44:02,950 --> 00:44:00,480
definitely uh as jeff mentioned our

1253
00:44:04,150 --> 00:44:02,960
in-situ resource utilization folks are

1254
00:44:06,150 --> 00:44:04,160
looking at

1255
00:44:09,349 --> 00:44:06,160
what what kinds of resources we can use

1256
00:44:10,470 --> 00:44:09,359
for mars water is a great example you

1257
00:44:12,550 --> 00:44:10,480
know where

1258
00:44:14,390 --> 00:44:12,560
we might build a habitat would there be

1259
00:44:16,630 --> 00:44:14,400
water available that we could use for

1260
00:44:18,390 --> 00:44:16,640
the ecosystem

1261
00:44:20,150 --> 00:44:18,400
also

1262
00:44:22,470 --> 00:44:20,160
nuclear power

1263
00:44:24,069 --> 00:44:22,480

is is also a technology area that we're

1264
00:44:25,750 --> 00:44:24,079
working on that will be very important

1265
00:44:27,670 --> 00:44:25,760
when we get to the surface of mars so we

1266
00:44:29,270 --> 00:44:27,680
have power to run all our habitats and

1267
00:44:31,589 --> 00:44:29,280
all our things there

1268
00:44:34,150 --> 00:44:31,599
and in addition as you might know you

1269
00:44:37,510 --> 00:44:34,160
probably do mars has a carbon dioxide

1270
00:44:39,910 --> 00:44:37,520
mostly atmosphere so that's a great

1271
00:44:42,069 --> 00:44:39,920
resource for us once we get to mars to

1272
00:44:45,109 --> 00:44:42,079
take that carbon dioxide and just

1273
00:44:47,670 --> 00:44:45,119
extract the oxygen from it

1274
00:44:49,349 --> 00:44:47,680
and so we can use that for the crew

1275
00:44:51,510 --> 00:44:49,359
rather than having to

1276
00:44:53,430 --> 00:44:51,520
electrolyze water into hydrogen and

1277
00:44:55,670 --> 00:44:53,440
oxygen right now which is what we do to

1278
00:44:56,950 --> 00:44:55,680
create the oxygen for the crew so that's

1279
00:44:58,390 --> 00:44:56,960
another

1280
00:45:01,270 --> 00:44:58,400
advantage of

1281
00:45:03,910 --> 00:45:01,280
we can use on the surface of mars

1282
00:45:05,589 --> 00:45:03,920
we so we have a demonstration that's

1283
00:45:08,950 --> 00:45:05,599
actually going to mars

1284
00:45:10,790 --> 00:45:08,960
on the mars 2020 rover it's the next

1285
00:45:12,630 --> 00:45:10,800
generation rover kind of like the one

1286
00:45:13,829 --> 00:45:12,640
that we put on the surface of mars two

1287
00:45:15,030 --> 00:45:13,839
years ago

1288
00:45:17,750 --> 00:45:15,040

and

1289
00:45:20,550 --> 00:45:17,760
it will do what robin said it will suck

1290
00:45:23,349 --> 00:45:20,560
in the carbon dioxide atmosphere on mars

1291
00:45:26,550 --> 00:45:23,359
and produce oxygen so it'll be an actual

1292
00:45:28,550 --> 00:45:26,560
demonstration on mars of taking the

1293
00:45:30,630 --> 00:45:28,560
resources we find there and turning it

1294
00:45:32,550 --> 00:45:30,640
into something we can either breathe or

1295
00:45:34,870 --> 00:45:32,560
use as a rocket propellant to get us

1296
00:45:36,710 --> 00:45:34,880
home

1297
00:45:38,390 --> 00:45:36,720
very exciting

1298
00:45:39,829 --> 00:45:38,400
hello everyone my name is jennifer lopez

1299
00:45:40,630 --> 00:45:39,839
from huffington post thank you so much

1300
00:45:42,470 --> 00:45:40,640
for

1301
00:45:44,470 --> 00:45:42,480
telling us about your your work it's it

1302
00:45:47,190 --> 00:45:44,480
all sounds incredible and exciting i've

1303
00:45:48,470 --> 00:45:47,200
two questions uh first for jose if you

1304
00:45:50,150 --> 00:45:48,480
can just tell us a little bit more about

1305
00:45:52,069 --> 00:45:50,160
the zero robotics program the

1306
00:45:53,430 --> 00:45:52,079
competition with medical middle and high

1307
00:45:55,349 --> 00:45:53,440
school students

1308
00:45:56,390 --> 00:45:55,359
uh and then also for for nikki i just

1309
00:45:58,069 --> 00:45:56,400
wanted to see if you can talk a little

1310
00:45:59,750 --> 00:45:58,079
bit more about the materials it was

1311
00:46:01,990 --> 00:45:59,760
interesting when you when you mentioned

1312
00:46:04,630 --> 00:46:02,000
uh the abs so just curious if you're

1313
00:46:05,910 --> 00:46:04,640

able to divulge any bit a bit more about

1314
00:46:08,710 --> 00:46:05,920
what's in the pipeline or if there's

1315
00:46:11,750 --> 00:46:08,720
anything you know to use with the uh pla

1316
00:46:14,230 --> 00:46:11,760
or any other materials thank you

1317
00:46:15,349 --> 00:46:14,240
yeah xerobotics is actually one of our

1318
00:46:17,910 --> 00:46:15,359
one of our

1319
00:46:20,390 --> 00:46:17,920
exciting uh investigations uh and

1320
00:46:23,349 --> 00:46:20,400
programs that we work with on spheres

1321
00:46:25,349 --> 00:46:23,359
and yeah it's a very very much like

1322
00:46:27,190 --> 00:46:25,359
the the first robotics program if you've

1323
00:46:29,750 --> 00:46:27,200
ever heard of that where high school

1324
00:46:31,910 --> 00:46:29,760
students get to form teams and program

1325
00:46:34,630 --> 00:46:31,920
the spheres and get to operate that on

1326
00:46:36,950 --> 00:46:34,640
the space station so it's very exciting

1327
00:46:39,270 --> 00:46:36,960
there's a website up where students can

1328
00:46:40,870 --> 00:46:39,280
communicate and get involved this

1329
00:46:43,030 --> 00:46:40,880
happens every year with both middle

1330
00:46:46,390 --> 00:46:43,040
school and high school students and they

1331
00:46:48,309 --> 00:46:46,400
form teams they sign up and they have a

1332
00:46:50,069 --> 00:46:48,319
very good interactive environment online

1333
00:46:51,829 --> 00:46:50,079
where they can program the spheres for

1334
00:46:54,470 --> 00:46:51,839
the first time they're learning to how

1335
00:46:55,670 --> 00:46:54,480
to program how to

1336
00:46:58,390 --> 00:46:55,680
they're learning for the first time how

1337
00:47:00,390 --> 00:46:58,400
to program a computer and um they have a

1338
00:47:03,270 --> 00:47:00,400

very interactive environment online

1339
00:47:05,030 --> 00:47:03,280
where they can do that and then at the

1340
00:47:07,829 --> 00:47:05,040
conclusion of the event watch their

1341
00:47:10,470 --> 00:47:07,839
technology their code run on the space

1342
00:47:13,109 --> 00:47:10,480
station live where we have a televised

1343
00:47:15,510 --> 00:47:13,119
event and the astronauts in some cases

1344
00:47:17,750 --> 00:47:15,520
narrate the the whole competition where

1345
00:47:19,750 --> 00:47:17,760
the students are programming the spheres

1346
00:47:22,069 --> 00:47:19,760
to navigate and

1347
00:47:23,670 --> 00:47:22,079
control against the game where for

1348
00:47:25,589 --> 00:47:23,680
example they might program the spheres

1349
00:47:28,630 --> 00:47:25,599
to go around an asteroid to man

1350
00:47:30,390 --> 00:47:28,640
asteroids or to repel an asteroid from

1351
00:47:31,750 --> 00:47:30,400
destroying the earth and these kind of

1352
00:47:33,430 --> 00:47:31,760
games where they get to have fun

1353
00:47:34,790 --> 00:47:33,440
programming the spheres

1354
00:47:36,950 --> 00:47:34,800
and then watch the real thing on the

1355
00:47:38,470 --> 00:47:36,960
space station so very exciting very

1356
00:47:40,950 --> 00:47:38,480
great way of reaching out to the next

1357
00:47:42,790 --> 00:47:40,960
generation of engineers and scientists

1358
00:47:44,470 --> 00:47:42,800
and getting that integrated with real

1359
00:47:46,230 --> 00:47:44,480
technology happening on the space

1360
00:47:48,390 --> 00:47:46,240
station so very exciting we have a lot

1361
00:47:50,230 --> 00:47:48,400
of fun supporting it every year from

1362
00:47:53,430 --> 00:47:50,240
nasa ames we do a lot of the operations

1363
00:47:54,390 --> 00:47:53,440

a lot of the integration and then mit as

1364
00:47:56,790 --> 00:47:54,400
uh

1365
00:47:59,670 --> 00:47:56,800
so far has been the per key pers people

1366
00:48:01,270 --> 00:47:59,680
involved with leading the effort and uh

1367
00:48:02,630 --> 00:48:01,280
getting all the students together a lot

1368
00:48:04,390 --> 00:48:02,640
of the educators as well there's

1369
00:48:07,910 --> 00:48:04,400
educators across the country that

1370
00:48:09,510 --> 00:48:07,920
organize the schools into teams and and

1371
00:48:11,030 --> 00:48:09,520
uh as well the curriculum involved

1372
00:48:12,309 --> 00:48:11,040
there's a lot of things we we teach the

1373
00:48:14,630 --> 00:48:12,319
students how to do for the first time so

1374
00:48:16,870 --> 00:48:14,640
it's a great educational uh endeavor and

1375
00:48:19,270 --> 00:48:16,880
i didn't advise anybody to take a look

1376
00:48:21,349 --> 00:48:19,280
online

1377
00:48:23,109 --> 00:48:21,359
and regarding materials obviously that

1378
00:48:24,390 --> 00:48:23,119
is extremely fundamental to this work

1379
00:48:27,030 --> 00:48:24,400
and we have spent a lot of time with

1380
00:48:28,790 --> 00:48:27,040
these discussions um from the start i'll

1381
00:48:31,109 --> 00:48:28,800
talk about the technology demonstration

1382
00:48:32,790 --> 00:48:31,119
as i mentioned uses abs

1383
00:48:34,309 --> 00:48:32,800
the next generation printer which is

1384
00:48:36,470 --> 00:48:34,319
already under development we've already

1385
00:48:38,630 --> 00:48:36,480
taken a lot of the lessons learned in

1386
00:48:40,870 --> 00:48:38,640
designing the technology demonstration

1387
00:48:42,790 --> 00:48:40,880
and applied those to the next iteration

1388
00:48:45,109 --> 00:48:42,800

the next printer will have a larger

1389
00:48:46,950 --> 00:48:45,119
build volume it will use additional

1390
00:48:49,670 --> 00:48:46,960
materials it will be even more

1391
00:48:50,950 --> 00:48:49,680
autonomous um and the type of materials

1392
00:48:55,030 --> 00:48:50,960
at this point that we're kind of

1393
00:48:56,710 --> 00:48:55,040
narrowing down on include ultum 9085

1394
00:48:58,230 --> 00:48:56,720
which is used a lot today many of you

1395
00:48:59,430 --> 00:48:58,240
might be familiar is a very very strong

1396
00:49:02,390 --> 00:48:59,440
plastic

1397
00:49:04,069 --> 00:49:02,400
it's got very great flammability ratings

1398
00:49:05,750 --> 00:49:04,079
faa has used it quite a bit for things

1399
00:49:08,150 --> 00:49:05,760
like airline seats

1400
00:49:10,870 --> 00:49:08,160
and we also use it since early shuttle

1401
00:49:12,390 --> 00:49:10,880
days for a lot of our eva tools

1402
00:49:13,750 --> 00:49:12,400
another material we're very interested

1403
00:49:15,510 --> 00:49:13,760
in is peak

1404
00:49:17,430 --> 00:49:15,520
so we're doing a lot of trades on those

1405
00:49:19,190 --> 00:49:17,440
two for the next facility now the

1406
00:49:21,109 --> 00:49:19,200
question comes up a lot okay plastics

1407
00:49:23,430 --> 00:49:21,119
what about metals and that's where i

1408
00:49:25,190 --> 00:49:23,440
think it gets a lot of fun too because

1409
00:49:26,950 --> 00:49:25,200
the metals technologies for in-space

1410
00:49:29,270 --> 00:49:26,960
applications are a lot more challenging

1411
00:49:31,109 --> 00:49:29,280
quite frankly than the plastics

1412
00:49:33,349 --> 00:49:31,119
we try to approach this from an

1413
00:49:36,069 --> 00:49:33,359

applications perspective what do i need

1414
00:49:37,589 --> 00:49:36,079
to make what customers do i have and how

1415
00:49:39,109 --> 00:49:37,599
that part as i mentioned may not look

1416
00:49:41,190 --> 00:49:39,119
like what we're flying now it may not be

1417
00:49:43,190 --> 00:49:41,200
that metal wrench so where are the areas

1418
00:49:44,549 --> 00:49:43,200
where i know we'll need metals at some

1419
00:49:47,349 --> 00:49:44,559
point and where are the areas that we

1420
00:49:49,589 --> 00:49:47,359
can focus to on stronger plastics

1421
00:49:51,510 --> 00:49:49,599
another area is is carbon reinforced

1422
00:49:53,829 --> 00:49:51,520
plastics or even using that in some of

1423
00:49:56,230 --> 00:49:53,839
the propulsion components we call that

1424
00:49:57,910 --> 00:49:56,240
the four space area i work in space and

1425
00:49:59,829 --> 00:49:57,920
we have floor space and we share all our

1426
00:50:02,470 --> 00:49:59,839
materials data obviously

1427
00:50:03,990 --> 00:50:02,480
um so the question becomes

1428
00:50:05,510 --> 00:50:04,000
if we're going to progress to metals and

1429
00:50:07,670 --> 00:50:05,520
what are the types of technologies we

1430
00:50:09,670 --> 00:50:07,680
can use for those as well and things

1431
00:50:11,349 --> 00:50:09,680
like structures or when you talk about

1432
00:50:12,470 --> 00:50:11,359
going external

1433
00:50:14,710 --> 00:50:12,480
in space and you look at the

1434
00:50:17,589 --> 00:50:14,720
environmental aspects

1435
00:50:19,270 --> 00:50:17,599
metals obviously are superior there so

1436
00:50:20,630 --> 00:50:19,280
we've actually done an independent

1437
00:50:22,870 --> 00:50:20,640
assessment

1438
00:50:24,309 --> 00:50:22,880

with rollers institute if you if you're

1439
00:50:25,910 --> 00:50:24,319
interested in adding manufacturing i

1440
00:50:28,069 --> 00:50:25,920
highly recommend looking at the wallers

1441
00:50:30,309 --> 00:50:28,079
report which he puts out every year

1442
00:50:32,870 --> 00:50:30,319
he does an extensive survey and so we've

1443
00:50:34,630 --> 00:50:32,880
looked at all the existing

1444
00:50:36,150 --> 00:50:34,640
kind of known metals technologies out

1445
00:50:38,630 --> 00:50:36,160
there and then also some of the new

1446
00:50:40,710 --> 00:50:38,640
novel technologies another reason i'm

1447
00:50:42,710 --> 00:50:40,720
really excited about this work is this

1448
00:50:45,430 --> 00:50:42,720
is something that's going to continue to

1449
00:50:47,589 --> 00:50:45,440
evolve and and at a rapid pace i believe

1450
00:50:49,510 --> 00:50:47,599
for ground-based technologies

1451
00:50:51,910 --> 00:50:49,520
it's a disruptive technology and there's

1452
00:50:53,670 --> 00:50:51,920
definitely a commercial arena for it um

1453
00:50:55,829 --> 00:50:53,680
and so we're working closely with

1454
00:50:57,990 --> 00:50:55,839
academia and industry and other

1455
00:51:00,069 --> 00:50:58,000
government entities such as dod

1456
00:51:02,710 --> 00:51:00,079
as these technologies evolve on how to

1457
00:51:04,630 --> 00:51:02,720
take what is evolving and adapt it for

1458
00:51:06,390 --> 00:51:04,640
microgravity and that helps a lot in

1459
00:51:08,069 --> 00:51:06,400
terms of schedule but also quite frankly

1460
00:51:10,309 --> 00:51:08,079
in terms of cost working together as

1461
00:51:12,390 --> 00:51:10,319
this community so we've developed this

1462
00:51:13,910 --> 00:51:12,400
materials and

1463
00:51:15,190 --> 00:51:13,920

community that's interested in these

1464
00:51:17,349 --> 00:51:15,200
discussions and that's kind of where

1465
00:51:19,990 --> 00:51:17,359
we're at currently with the plastics

1466
00:51:21,910 --> 00:51:20,000
the ultim and the peak as a next step

1467
00:51:24,230 --> 00:51:21,920
abs is already used for quite a few

1468
00:51:26,150 --> 00:51:24,240
things on orbit as well a lot of the

1469
00:51:28,230 --> 00:51:26,160
ancillary hardware i mentioned as well

1470
00:51:30,230 --> 00:51:28,240
as some of the cubesat structures that

1471
00:51:31,829 --> 00:51:30,240
have been launched deployed from station

1472
00:51:33,670 --> 00:51:31,839
or abs

1473
00:51:35,750 --> 00:51:33,680
but we'll continue asking these

1474
00:51:37,510 --> 00:51:35,760
questions and kind of evolving as we

1475
00:51:39,270 --> 00:51:37,520
collect that data for the from the in

1476
00:51:41,270 --> 00:51:39,280
space test i mentioned we'll have that

1477
00:51:42,870 --> 00:51:41,280
shareable database we are publishing it

1478
00:51:44,549 --> 00:51:42,880
for the ground controls and for what we

1479
00:51:46,630 --> 00:51:44,559
do in space

1480
00:51:48,150 --> 00:51:46,640
also if i may take the liberty since we

1481
00:51:49,190 --> 00:51:48,160
talked about challenges and student

1482
00:51:51,270 --> 00:51:49,200
involvement

1483
00:51:53,670 --> 00:51:51,280
i did want to mention we also have

1484
00:51:55,990 --> 00:51:53,680
the first future engineers

1485
00:51:58,069 --> 00:51:56,000
3d printing and space challenge

1486
00:51:59,510 --> 00:51:58,079
we just kicked it off through a space

1487
00:52:01,829 --> 00:51:59,520
act agreement between nasa and the

1488
00:52:04,390 --> 00:52:01,839

american society of mechanical engineers

1489
00:52:05,430 --> 00:52:04,400
it's open to through 12 through december

1490
00:52:08,390 --> 00:52:05,440
15th

1491
00:52:10,470 --> 00:52:08,400
the grand prize i want to mention is the

1492
00:52:12,710 --> 00:52:10,480
to design a part that the crew can use

1493
00:52:15,109 --> 00:52:12,720
on orbit we say a crew tool but that can

1494
00:52:17,670 --> 00:52:15,119
include medical hardware

1495
00:52:19,990 --> 00:52:17,680
daily usage type items

1496
00:52:22,309 --> 00:52:20,000
payload parts and of course handheld

1497
00:52:23,990 --> 00:52:22,319
tools the the winning student will

1498
00:52:25,750 --> 00:52:24,000
actually the part they design will be

1499
00:52:27,430 --> 00:52:25,760
printed on the printer in space while

1500
00:52:29,349 --> 00:52:27,440
they watch live from mission control

1501
00:52:30,710 --> 00:52:29,359
which i think is pretty amazing and

1502
00:52:32,630 --> 00:52:30,720
there are some other very exciting

1503
00:52:34,630 --> 00:52:32,640
prizes such as 3d printers for schools

1504
00:52:35,990 --> 00:52:34,640
and things like that so sorry but i

1505
00:52:37,990 --> 00:52:36,000
wanted to take the liberty dimension

1506
00:52:39,349 --> 00:52:38,000
it's so important that we get student

1507
00:52:41,510 --> 00:52:39,359
involvement

1508
00:52:43,670 --> 00:52:41,520
because as much as i want to go to mars

1509
00:52:45,750 --> 00:52:43,680
i'm quite frankly probably too old it's

1510
00:52:46,790 --> 00:52:45,760
going to be one of you guys and i want

1511
00:52:49,910 --> 00:52:46,800
to make sure we have that next

1512
00:52:51,270 --> 00:52:49,920
generation excited and ready to go

1513
00:52:52,710 --> 00:52:51,280

all right thank you nikki and since

1514
00:52:54,630 --> 00:52:52,720
we're running out of time i don't want

1515
00:52:56,390 --> 00:52:54,640
to neglect our social media followers so

1516
00:52:57,910 --> 00:52:56,400
i think shannon's standing by with at

1517
00:52:59,670 --> 00:52:57,920
least one or two questions and again

1518
00:53:01,270 --> 00:52:59,680
just for everybody in here if we don't

1519
00:53:02,790 --> 00:53:01,280
get to your question today these guys

1520
00:53:05,589 --> 00:53:02,800
are going to be sticking around after

1521
00:53:06,870 --> 00:53:05,599
the show so you can hunt them down and

1522
00:53:08,710 --> 00:53:06,880
ask them your question and they will

1523
00:53:10,790 --> 00:53:08,720
answer

1524
00:53:13,510 --> 00:53:10,800
okay so this one's coming to us from

1525
00:53:16,870 --> 00:53:13,520
twitter and the question is how many

1526
00:53:24,710 --> 00:53:16,880
people can currently live aboard the iss

1527
00:53:29,190 --> 00:53:26,790
okay

1528
00:53:33,270 --> 00:53:29,200
right now we have the ability for six

1529
00:53:36,470 --> 00:53:33,280
crew to live permanently on on iss uh we

1530
00:53:39,030 --> 00:53:36,480
have had up to nine with uh crew

1531
00:53:41,589 --> 00:53:39,040
rotation so new crew comes up and before

1532
00:53:44,309 --> 00:53:41,599
the existing crew leaves we have had

1533
00:53:45,270 --> 00:53:44,319
nine for a short period of time

1534
00:53:47,270 --> 00:53:45,280
um

1535
00:53:49,829 --> 00:53:47,280
we could probably support more that's

1536
00:53:51,510 --> 00:53:49,839
that's what we uh that's our current

1537
00:53:52,870 --> 00:53:51,520
rotation though

1538
00:53:54,230 --> 00:53:52,880

all right cool question and next one

1539
00:53:56,549 --> 00:53:54,240
shannon

1540
00:53:57,589 --> 00:53:56,559
okay and this question is also from

1541
00:54:00,150 --> 00:53:57,599
twitter

1542
00:54:03,349 --> 00:54:00,160
for the 3d printer are we looking at a

1543
00:54:05,829 --> 00:54:03,359
way to recycle and reuse the material so

1544
00:54:08,309 --> 00:54:05,839
that old parts can be remade into new

1545
00:54:10,230 --> 00:54:08,319
parts absolutely so i'm i'm pretty tough

1546
00:54:11,910 --> 00:54:10,240
on our guys about if we have replacement

1547
00:54:13,109 --> 00:54:11,920
parts and also as i mentioned for our

1548
00:54:14,470 --> 00:54:13,119
feed stock

1549
00:54:16,069 --> 00:54:14,480
it's a tough argument to sell to

1550
00:54:17,910 --> 00:54:16,079
headquarters hey let me fly this printer

1551
00:54:19,990 --> 00:54:17,920
but i'm also going to fly you know 50

1552
00:54:21,990 --> 00:54:20,000
pounds of backup feed stock and

1553
00:54:23,589 --> 00:54:22,000
replacement parts so actually many of

1554
00:54:26,069 --> 00:54:23,599
our components for the printer and the

1555
00:54:28,069 --> 00:54:26,079
print tray itself is 3d printed

1556
00:54:29,910 --> 00:54:28,079
as well as the extruder casing is a

1557
00:54:31,430 --> 00:54:29,920
replacement part that we can 3d print on

1558
00:54:32,710 --> 00:54:31,440
the printer so i think it's kind of a

1559
00:54:35,349 --> 00:54:32,720
cool do loop when you start to think

1560
00:54:36,870 --> 00:54:35,359
about if we can print a new printer

1561
00:54:38,630 --> 00:54:36,880
print replacement parts for a printer

1562
00:54:40,309 --> 00:54:38,640
and that's exactly where we're heading

1563
00:54:43,430 --> 00:54:40,319

but that first fundamental goal

1564
00:54:46,150 --> 00:54:43,440
obviously is to take existing materials

1565
00:54:48,230 --> 00:54:46,160
on space stations such as

1566
00:54:51,829 --> 00:54:48,240
we use a ton of volume for packing

1567
00:54:54,630 --> 00:54:51,839
materials foams and plastic bags and

1568
00:54:57,109 --> 00:54:54,640
for for launch packing so if we can take

1569
00:54:59,270 --> 00:54:57,119
those sorts of materials and recycle

1570
00:55:00,470 --> 00:54:59,280
those into a usable feedstock and that

1571
00:55:02,069 --> 00:55:00,480
is something that we're working on

1572
00:55:04,309 --> 00:55:02,079
through our sbir program that i

1573
00:55:06,870 --> 00:55:04,319
mentioned earlier as well as the one we

1574
00:55:08,950 --> 00:55:06,880
awarded this past year to two companies

1575
00:55:11,910 --> 00:55:08,960
to take the parts that we've printed

1576
00:55:13,430 --> 00:55:11,920
we're looking at abs ultum and and peak

1577
00:55:15,030 --> 00:55:13,440
for those as well

1578
00:55:16,950 --> 00:55:15,040
and turn those back into usable

1579
00:55:18,789 --> 00:55:16,960
feedstock of course we have interesting

1580
00:55:21,030 --> 00:55:18,799
material studies to continue from there

1581
00:55:22,630 --> 00:55:21,040
on how many times can you recycle and do

1582
00:55:24,470 --> 00:55:22,640
you start to see degradation and when do

1583
00:55:26,390 --> 00:55:24,480
you see degradation so

1584
00:55:27,910 --> 00:55:26,400
like i said every thread we pull there's

1585
00:55:29,510 --> 00:55:27,920
a lot of exciting questions that we're

1586
00:55:30,950 --> 00:55:29,520
working

1587
00:55:32,470 --> 00:55:30,960
all right and i just want to mention

1588
00:55:34,470 --> 00:55:32,480

real quick everyone follow me on social

1589
00:55:36,549 --> 00:55:34,480
media or with ipads

1590
00:55:38,549 --> 00:55:36,559
or android we have a new app launching

1591
00:55:41,510 --> 00:55:38,559
this week it's called iss research

1592
00:55:43,030 --> 00:55:41,520
explorer can actually learn about the

1593
00:55:44,470 --> 00:55:43,040
thousands of experiments that have taken

1594
00:55:46,230 --> 00:55:44,480
place onboard station the hundreds

1595
00:55:48,230 --> 00:55:46,240
taking place right now

1596
00:55:50,710 --> 00:55:48,240
and again it's iss reach research

1597
00:55:52,230 --> 00:55:50,720
explorer it's coming out this week um so

1598
00:55:53,829 --> 00:55:52,240
we're just about out of time i think we

1599
00:55:56,069 --> 00:55:53,839
only have about four minutes left or so

1600
00:55:58,630 --> 00:55:56,079
so i want to pose one final question to

1601
00:56:00,710 --> 00:55:58,640
everyone up here um just you know give

1602
00:56:02,950 --> 00:56:00,720
your give your closing thoughts

1603
00:56:05,030 --> 00:56:02,960
and really it's on the importance of the

1604
00:56:06,789 --> 00:56:05,040
international space station for taking

1605
00:56:08,069 --> 00:56:06,799
us tomorrow so when you when you think

1606
00:56:10,069 --> 00:56:08,079
when we have boots on the ground and

1607
00:56:11,910 --> 00:56:10,079
people are looking back at planet earth

1608
00:56:13,670 --> 00:56:11,920
from millions of miles away what do you

1609
00:56:17,270 --> 00:56:13,680
think the station's legacy will have

1610
00:56:19,349 --> 00:56:17,280
been to get us there well i think

1611
00:56:20,870 --> 00:56:19,359
the legacy of the station in getting us

1612
00:56:23,349 --> 00:56:20,880
into deep space

1613
00:56:25,829 --> 00:56:23,359

will be providing that test bed

1614
00:56:26,789 --> 00:56:25,839
to really wring out the technologies you

1615
00:56:29,670 --> 00:56:26,799
know that's

1616
00:56:30,870 --> 00:56:29,680
top level getting to mars is is about

1617
00:56:32,309 --> 00:56:30,880
getting there

1618
00:56:34,069 --> 00:56:32,319
it's about landing there which pretty

1619
00:56:35,589 --> 00:56:34,079
complicated thing actually mars has just

1620
00:56:36,630 --> 00:56:35,599
enough atmosphere to be annoying some

1621
00:56:38,789 --> 00:56:36,640
people think

1622
00:56:40,870 --> 00:56:38,799
it's it's about living there gonna set

1623
00:56:43,430 --> 00:56:40,880
up shop on mars and then about getting

1624
00:56:44,470 --> 00:56:43,440
home so get there land there live there

1625
00:56:47,589 --> 00:56:44,480
leave there

1626
00:56:49,670 --> 00:56:47,599
and the technologies we need to do that

1627
00:56:51,670 --> 00:56:49,680
which will sustain us over months and

1628
00:56:53,750 --> 00:56:51,680
years in deep space

1629
00:56:56,710 --> 00:56:53,760
can be tested out on the space station

1630
00:56:58,309 --> 00:56:56,720
provides the premier laboratory that

1631
00:57:01,829 --> 00:56:58,319
deal laboratory really the only

1632
00:57:03,829 --> 00:57:01,839
laboratory for determining some of the

1633
00:57:06,870 --> 00:57:03,839
effects the space environment will have

1634
00:57:08,870 --> 00:57:06,880
on our on the technologies we need to

1635
00:57:11,589 --> 00:57:08,880
take humans into deep space so that'll

1636
00:57:13,829 --> 00:57:11,599
be the legacy in my view and robin

1637
00:57:16,470 --> 00:57:13,839
i agree with jeff that's uh so important

1638
00:57:18,549 --> 00:57:16,480

we've got 10 years right now before the

1639
00:57:21,030 --> 00:57:18,559
end of space station and we've

1640
00:57:23,910 --> 00:57:21,040
seems like maybe a long time but it's

1641
00:57:25,829 --> 00:57:23,920
it's not when you are thinking about all

1642
00:57:27,109 --> 00:57:25,839
the work we still need to do using space

1643
00:57:29,190 --> 00:57:27,119
station

1644
00:57:30,789 --> 00:57:29,200
in addition to the technologies the

1645
00:57:32,230 --> 00:57:30,799
legacy of the space station is the

1646
00:57:34,630 --> 00:57:32,240
international partnership that we've

1647
00:57:35,670 --> 00:57:34,640
built that will hopefully continue as we

1648
00:57:37,589 --> 00:57:35,680
go do

1649
00:57:39,829 --> 00:57:37,599
future missions with our international

1650
00:57:41,349 --> 00:57:39,839
partners all the great benefits to

1651
00:57:43,430 --> 00:57:41,359
humanity they've come out of the space

1652
00:57:45,270 --> 00:57:43,440
station the research even the water

1653
00:57:47,190 --> 00:57:45,280
recycling system

1654
00:57:48,710 --> 00:57:47,200
has spun off into

1655
00:57:51,270 --> 00:57:48,720
ground-based systems that are being used

1656
00:57:53,270 --> 00:57:51,280
for disaster relief here on earth so

1657
00:57:56,950 --> 00:57:53,280
all of those things in addition to the

1658
00:57:58,630 --> 00:57:56,960
technology are going to be important

1659
00:58:00,710 --> 00:57:58,640
uh yeah i think uh spheres can

1660
00:58:03,510 --> 00:58:00,720
contribute to some of that legacy uh in

1661
00:58:05,109 --> 00:58:03,520
the in this in such that uh spheres is

1662
00:58:06,789 --> 00:58:05,119
actually one of the fewer

1663
00:58:08,710 --> 00:58:06,799

uh science payloads that's been in

1664
00:58:10,630 --> 00:58:08,720
continuous operation off and on for

1665
00:58:12,710 --> 00:58:10,640
about eight years now and we've learned

1666
00:58:15,430 --> 00:58:12,720
a lot about that experience how how to

1667
00:58:18,069 --> 00:58:15,440
write procedures how to build teams how

1668
00:58:19,750 --> 00:58:18,079
to support that kind of payload over a

1669
00:58:21,910 --> 00:58:19,760
long duration which is needed for for

1670
00:58:23,510 --> 00:58:21,920
long duration space flight and then also

1671
00:58:25,670 --> 00:58:23,520
in the area of robotics i think there's

1672
00:58:27,829 --> 00:58:25,680
a lot spheres has to say about

1673
00:58:28,870 --> 00:58:27,839
about researching well how do humans and

1674
00:58:30,549 --> 00:58:28,880
robots

1675
00:58:33,190 --> 00:58:30,559
work with each other how do you optimize

1676
00:58:35,829 --> 00:58:33,200
that relationship and that team such

1677
00:58:37,589 --> 00:58:35,839
that robots and humans can work together

1678
00:58:39,829 --> 00:58:37,599
and automate a lot of the tasks that the

1679
00:58:41,349 --> 00:58:39,839
humans don't always have to do

1680
00:58:44,870 --> 00:58:41,359
so very very important for long-duration

1681
00:58:46,950 --> 00:58:44,880
space travel where um robots are just a

1682
00:58:50,309 --> 00:58:46,960
critical critical application and rich

1683
00:58:52,230 --> 00:58:50,319
and nikki i need to ask you to go quick

1684
00:58:53,589 --> 00:58:52,240
the legacy that i see for space station

1685
00:58:55,030 --> 00:58:53,599
is really the long-term presence of

1686
00:58:56,950 --> 00:58:55,040
humans in space

1687
00:58:58,470 --> 00:58:56,960
and getting to such a point where it's

1688
00:59:00,470 --> 00:58:58,480

almost routine

1689
00:59:01,829 --> 00:59:00,480
to uh go back several hundred miles to

1690
00:59:03,030 --> 00:59:01,839
space station and back that we have the

1691
00:59:06,069 --> 00:59:03,040
confidence and we've overcome the

1692
00:59:08,150 --> 00:59:06,079
challenges to go further out

1693
00:59:09,430 --> 00:59:08,160
so i'm southern but i can talk fast you

1694
00:59:10,870 --> 00:59:09,440
know the credit card commercials the

1695
00:59:12,230 --> 00:59:10,880
bottom line at the end where they say

1696
00:59:16,549 --> 00:59:12,240
it's priceless

1697
00:59:19,750 --> 00:59:16,559
can test in a microgravity environment

1698
00:59:21,510 --> 00:59:19,760
that's isolated to live and work operate

1699
00:59:23,990 --> 00:59:21,520
on a daily basis

1700
00:59:25,990 --> 00:59:24,000
that's what station's about

1701
00:59:27,349 --> 00:59:26,000
all right and thanks to all of you for

1702
00:59:29,270 --> 00:59:27,359
joining me thanks to everyone here in

1703
00:59:31,109 --> 00:59:29,280
our audience again enjoy the rest of the

1704
00:59:33,270 --> 00:59:31,119
tech forum come track these guys down if

1705
00:59:35,190 --> 00:59:33,280
you have any additional questions

1706
00:59:37,190 --> 00:59:35,200
international space station

1707
00:59:39,510 --> 00:59:37,200
up there since 1998 going to be there

1708
00:59:41,829 --> 00:59:39,520
for at least 10 more years very exciting

1709
00:59:43,270 --> 00:59:41,839
time for humanity in space and as always

1710
00:59:44,630 --> 00:59:43,280
if you want to learn more about the

1711
00:59:46,390 --> 00:59:44,640
stuff we've been talking about or

1712
00:59:48,710 --> 00:59:46,400
anything else about the station go to