1
00:00:00,210 --> 00:00:04,070
[Music]

2
00:00:06,070 --> 00:00:05,030
ten

3
00:00:07,030 --> 00:00:06,080
nine

4
00:00:07,990 --> 00:00:07,040
eight

5
00:00:08,950 --> 00:00:08,000
seven

6
00:00:09,990 --> 00:00:08,960
six

7
00:00:11,030 --> 00:00:10,000
five

8
00:00:11,990 --> 00:00:11,040
four

9
00:00:12,950 --> 00:00:12,000
three

10
00:00:14,930 --> 00:00:12,960
two

11
00:00:32,709 --> 00:00:14,940
one

12
00:00:35,750 --> 00:00:32,719
[Music]

13
00:00:38,549 --> 00:00:35,760

hi everybody welcome to another episode

14
00:00:40,150 --> 00:00:38,559
of nasa in silicon valley live i am your

15
00:00:42,150 --> 00:00:40,160
host tiffany blake

16
00:00:43,270 --> 00:00:42,160
if this is your first time tuning in to

17
00:00:45,830 --> 00:00:43,280
the show

18
00:00:48,150 --> 00:00:45,840
the uh nasa and silicon valley live is a

19
00:00:49,990 --> 00:00:48,160
conversational show out of nasa's ames

20
00:00:52,869 --> 00:00:50,000
research center where we talk about all

21
00:00:56,150 --> 00:00:52,879
the nerdy nasa news you need to know um

22
00:00:59,430 --> 00:00:56,160
today with me i have the awesome abby

23
00:01:02,150 --> 00:00:59,440
tabor hello tiffany yes hi everybody i'm

24
00:01:05,109 --> 00:01:02,160
your co-host today abby tabor and we are

25
00:01:07,830 --> 00:01:05,119
simultaneously live right now on twitch

26
00:01:09,429 --> 00:01:07,840
youtube facebook and periscope but if

27
00:01:10,950 --> 00:01:09,439
you want to join in the chat and leave

28
00:01:12,870 --> 00:01:10,960
questions for our awesome guests today

29
00:01:15,270 --> 00:01:12,880
you need to do that on twitch so go to

30
00:01:16,789 --> 00:01:15,280
www.twitch.tv

31
00:01:18,789 --> 00:01:16,799
nasa

32
00:01:22,310 --> 00:01:18,799
so today i'm really excited we're

33
00:01:24,550 --> 00:01:22,320
talking about space robots space robots

34
00:01:26,469 --> 00:01:24,560
i'm excited this is going to be fun and

35
00:01:28,550 --> 00:01:26,479
we have a couple of amazing guests here

36
00:01:30,710 --> 00:01:28,560
today so why don't we go ahead and meet

37
00:01:32,950 --> 00:01:30,720
them can you guys tell us your name what

38
00:01:35,510 --> 00:01:32,960

you do here at ames sure um i'm maria

39
00:01:37,190 --> 00:01:35,520
boilette i'm a robotics engineer and i

40
00:01:38,550 --> 00:01:37,200
build space robots

41
00:01:40,870 --> 00:01:38,560
pretty sweet

42
00:01:43,109 --> 00:01:40,880
all right yeah and i'm terry fong i'm

43
00:01:44,789 --> 00:01:43,119
the chief roboticist here at nasa ames

44
00:01:46,149 --> 00:01:44,799
and i dream up the robots that maria

45
00:01:48,069 --> 00:01:46,159
then has to go build

46
00:01:50,789 --> 00:01:48,079
but awesome job descriptions i know

47
00:01:52,389 --> 00:01:50,799
right thanks for joining us you guys um

48
00:01:54,230 --> 00:01:52,399
before we get into the show i want to

49
00:01:57,670 --> 00:01:54,240
remind our audience about this really

50
00:02:00,469 --> 00:01:57,680
cool clock we have here yes exactly this

51
00:02:02,789 --> 00:02:00,479
lovely item that we have for you today

52
00:02:05,990 --> 00:02:02,799
is our moon countdown clock so five

53
00:02:08,150 --> 00:02:06,000
years from now in 2024 we're planning to

54
00:02:10,389 --> 00:02:08,160
send humans to the moon as part of our

55
00:02:13,190 --> 00:02:10,399
artemis program and this clock is

56
00:02:16,390 --> 00:02:13,200
counting down the days hours minutes and

57
00:02:18,229 --> 00:02:16,400
seconds until 2024 when the first woman

58
00:02:20,630 --> 00:02:18,239
and the next man will walk on the moon's

59
00:02:22,150 --> 00:02:20,640
south pole so pretty exciting we'll talk

60
00:02:24,390 --> 00:02:22,160
more about that later in the show but if

61
00:02:27,030 --> 00:02:24,400
you want to learn more meanwhile you can

62
00:02:30,229 --> 00:02:27,040
visit www.nasa.gov

63
00:02:32,229 --> 00:02:30,239

artemis all right okay let's get started

64
00:02:34,390 --> 00:02:32,239
okay i'm excited

65
00:02:36,630 --> 00:02:34,400
so um i think let's start with just the

66
00:02:39,270 --> 00:02:36,640
basics like what's the history of you

67
00:02:40,710 --> 00:02:39,280
know humans and robots in space

68
00:02:43,110 --> 00:02:40,720
sorry can you tell us a little bit sure

69
00:02:44,630 --> 00:02:43,120
you know i mean nasa has used robots in

70
00:02:46,390 --> 00:02:44,640
space for a long time to carry out

71
00:02:48,470 --> 00:02:46,400
planetary exploration we've sent robots

72
00:02:50,630 --> 00:02:48,480
to mars um and we still have robots on

73
00:02:51,830 --> 00:02:50,640
mars today of course but um in parallel

74
00:02:53,910 --> 00:02:51,840
to that there's been this real

75
00:02:57,030 --> 00:02:53,920
development for actually for a long time

76
00:02:59,190 --> 00:02:57,040
of robots that work with humans um and

77
00:03:00,869 --> 00:02:59,200
they are used uh you know outside of uh

78
00:03:02,790 --> 00:03:00,879
spacecraft like outside of the space

79
00:03:04,470 --> 00:03:02,800
station um and more recently we've been

80
00:03:06,070 --> 00:03:04,480
working with robots inside of spacecraft

81
00:03:08,149 --> 00:03:06,080
as well right working a little bit

82
00:03:09,750 --> 00:03:08,159
closer together right yeah really

83
00:03:11,670 --> 00:03:09,760
awesome so

84
00:03:12,390 --> 00:03:11,680
how about we talk a little bit about you

85
00:03:13,990 --> 00:03:12,400
know

86
00:03:15,030 --> 00:03:14,000
how they work together yeah like what

87
00:03:17,270 --> 00:03:15,040
yeah

88
00:03:19,509 --> 00:03:17,280

how exactly do robots and humans

89
00:03:21,190 --> 00:03:19,519
interact yeah well i think i think a

90
00:03:23,910 --> 00:03:21,200
great thing about when you talk about

91
00:03:25,509 --> 00:03:23,920
robots and humans together it's not just

92
00:03:27,270 --> 00:03:25,519
oh how how do i make that robot you know

93
00:03:29,270 --> 00:03:27,280
just go off and do something but there's

94
00:03:31,350 --> 00:03:29,280
a whole notion of you know humans and

95
00:03:32,869 --> 00:03:31,360
robots working as a team and it's

96
00:03:34,309 --> 00:03:32,879
something i think we're going to see

97
00:03:37,030 --> 00:03:34,319
much more of as we go forward in the

98
00:03:39,750 --> 00:03:37,040
future this whole idea that we can use

99
00:03:41,990 --> 00:03:39,760
uh robots uh to work together with

100
00:03:44,390 --> 00:03:42,000
humans to perform work in space or on

101
00:03:45,830 --> 00:03:44,400
planetary surfaces uh and the idea is

102
00:03:47,670 --> 00:03:45,840
you might have all kinds of different

103
00:03:49,910 --> 00:03:47,680
robots and all kinds of humans working

104
00:03:51,830 --> 00:03:49,920
together with those robots right and the

105
00:03:54,149 --> 00:03:51,840
same way that a team for example a

106
00:03:55,670 --> 00:03:54,159
football team has specialists yeah you

107
00:03:57,270 --> 00:03:55,680
play to the strengths of the different

108
00:03:59,589 --> 00:03:57,280
members of the team so in this case you

109
00:04:01,350 --> 00:03:59,599
play the strengths of the humans versus

110
00:04:03,830 --> 00:04:01,360
the robots okay robots are good at

111
00:04:05,270 --> 00:04:03,840
certain things humans are better at

112
00:04:06,869 --> 00:04:05,280
other things so right they're not

113
00:04:09,110 --> 00:04:06,879

necessarily doing the same job at the

114
00:04:12,710 --> 00:04:09,120
same time exactly yeah you were telling

115
00:04:15,350 --> 00:04:12,720
us earlier about the 3ds oh that's right

116
00:04:17,830 --> 00:04:15,360
it's pretty common phrase in in robotics

117
00:04:19,189 --> 00:04:17,840
uh the 3ds which is dull dirty and

118
00:04:20,710 --> 00:04:19,199
dangerous

119
00:04:23,830 --> 00:04:20,720
those are the cases where you want to

120
00:04:25,189 --> 00:04:23,840
send a robot in um rather than a human

121
00:04:26,469 --> 00:04:25,199
um you know if it's something really

122
00:04:27,990 --> 00:04:26,479
boring to do you got to take a whole

123
00:04:30,070 --> 00:04:28,000
bunch of measurements it's probably

124
00:04:32,390 --> 00:04:30,080
better to send a robot who doesn't mind

125
00:04:34,710 --> 00:04:32,400
doing those sorts of tasks

126
00:04:37,350 --> 00:04:34,720
or you know if it's if it's something

127
00:04:38,150 --> 00:04:37,360
where it's a dangerous situation again

128
00:04:49,909 --> 00:04:38,160
you

129
00:04:54,310 --> 00:04:51,830
so could a dangerous job be something

130
00:04:56,390 --> 00:04:54,320
out in space like leaving oh sure yeah

131
00:04:58,390 --> 00:04:56,400
yeah i mean i think beyond just uh

132
00:05:00,070 --> 00:04:58,400
dangerous i mean there are some things

133
00:05:01,350 --> 00:05:00,080
you know like maria was saying that um

134
00:05:03,670 --> 00:05:01,360
you know really plays the strength of

135
00:05:06,310 --> 00:05:03,680
robots um you know there are some things

136
00:05:08,629 --> 00:05:06,320
that require moving very large um pieces

137
00:05:10,870 --> 00:05:08,639
of equipment or other things in space

138
00:05:13,510 --> 00:05:10,880

that are you know just too massive or

139
00:05:14,950 --> 00:05:13,520
too heavy for for a human to move yeah

140
00:05:16,870 --> 00:05:14,960
and something can take longer yeah it

141
00:05:19,270 --> 00:05:16,880
might take longer to be very precise

142
00:05:21,189 --> 00:05:19,280
placement right so you can

143
00:05:23,350 --> 00:05:21,199
place the items very precisely with a

144
00:05:25,670 --> 00:05:23,360
robot but just like in any any team you

145
00:05:28,070 --> 00:05:25,680
know i think if you have a combination

146
00:05:29,590 --> 00:05:28,080
of humans and robots that can work well

147
00:05:31,270 --> 00:05:29,600
together right you know that allows you

148
00:05:34,070 --> 00:05:31,280
to do much more than just you know any

149
00:05:36,150 --> 00:05:34,080
individual thing or person by themselves

150
00:05:38,230 --> 00:05:36,160
yeah right and um

151
00:05:39,749 --> 00:05:38,240
an example i think of the precision that

152
00:05:41,189 --> 00:05:39,759
you're talking about you guys told us

153
00:05:45,270 --> 00:05:41,199
the international space station was

154
00:05:47,670 --> 00:05:45,280
assembled by robots right wow humans

155
00:05:49,189 --> 00:05:47,680
yes my teams exactly right it's always

156
00:05:52,070 --> 00:05:49,199
going to be teams all right it's a great

157
00:05:54,070 --> 00:05:52,080
example yeah awesome yeah cool so we

158
00:05:56,070 --> 00:05:54,080
have robots working outside of

159
00:05:58,469 --> 00:05:56,080
spacecraft robots working inside of

160
00:06:00,550 --> 00:05:58,479
spacecraft right so let's talk about

161
00:06:02,390 --> 00:06:00,560
some of those what are some historical

162
00:06:03,830 --> 00:06:02,400
robots that have worked on

163
00:06:06,469 --> 00:06:03,840

space station or

164
00:06:07,350 --> 00:06:06,479
with the space shuttle it was a canada

165
00:06:09,110 --> 00:06:07,360
arm

166
00:06:10,550 --> 00:06:09,120
onboard space shuttle it's a 50-foot

167
00:06:12,629 --> 00:06:10,560
robot arm

168
00:06:15,110 --> 00:06:12,639
that was used for things like uh which

169
00:06:16,550 --> 00:06:15,120
we see right now i used to deploy things

170
00:06:20,550 --> 00:06:16,560
like satellites

171
00:06:23,189 --> 00:06:20,560
to very precisely uh place uh equipment

172
00:06:24,469 --> 00:06:23,199
for example when when uh

173
00:06:26,309 --> 00:06:24,479
when we were integrating the space

174
00:06:28,390 --> 00:06:26,319
station yeah this is this was actually a

175
00:06:31,350 --> 00:06:28,400
pretty big arm it's like a 50 foot long

176
00:06:32,950 --> 00:06:31,360
arm wow and i was able to move uh 32 000

177
00:06:35,430 --> 00:06:32,960
pounds that's basically like moving a

178
00:06:38,230 --> 00:06:35,440
school bus like pick up and move and

179
00:06:40,390 --> 00:06:38,240
position a school bus

180
00:06:42,469 --> 00:06:40,400
that size object around yeah so that's a

181
00:06:44,150 --> 00:06:42,479
pretty big robot yeah and it could also

182
00:06:45,430 --> 00:06:44,160
fit you know to building something like

183
00:06:55,350 --> 00:06:45,440
you know yeah

184
00:06:59,830 --> 00:06:58,070
[Laughter]

185
00:07:08,390 --> 00:06:59,840
it gives the astronaut leverage as well

186
00:07:13,270 --> 00:07:10,950
fascinating all right uh here's a cool

187
00:07:14,950 --> 00:07:13,280
one robonaut 2. you guys know that i

188
00:07:16,309 --> 00:07:14,960

remember so you know

189
00:07:17,990 --> 00:07:16,319
we mentioned earlier that robots can

190
00:07:20,870 --> 00:07:18,000
work outside or inside of spacecraft so

191
00:07:22,469 --> 00:07:20,880
robonaut 2 uh was a a humanoid robot

192
00:07:24,230 --> 00:07:22,479
that we sent up a few years ago to the

193
00:07:25,990 --> 00:07:24,240
space station um in the picture you can

194
00:07:27,589 --> 00:07:26,000
see here it's holding something which

195
00:07:30,070 --> 00:07:27,599
looks like a magic wand but that's

196
00:07:32,629 --> 00:07:30,080
actually um an airflow measurement

197
00:07:34,309 --> 00:07:32,639
device um it actually has a great name

198
00:07:35,430 --> 00:07:34,319
well the device actually is called the

199
00:07:37,029 --> 00:07:35,440
the sensor is actually called a

200
00:07:39,350 --> 00:07:37,039
velocicalc

201
00:07:40,950 --> 00:07:39,360
it's really meant to to be used inside

202
00:07:42,870 --> 00:07:40,960
the space station for monitoring airflow

203
00:07:45,029 --> 00:07:42,880
and here we were doing some experiments

204
00:07:46,950 --> 00:07:45,039
to see how a robot like

205
00:07:49,110 --> 00:07:46,960
robonaut 2 could carry out tasks which

206
00:07:51,270 --> 00:07:49,120
are normally done by humans right those

207
00:07:53,110 --> 00:07:51,280
humanoid robots can use the same tools

208
00:07:54,629 --> 00:07:53,120
as astronauts so you don't have to

209
00:07:55,430 --> 00:07:54,639
retool everything

210
00:07:58,469 --> 00:07:55,440
that

211
00:07:59,749 --> 00:07:58,479
velocicalc instrument is usually used by

212
00:08:01,990 --> 00:07:59,759
astronauts so

213
00:08:03,510 --> 00:08:02,000

robonaut because it has hands can

214
00:08:04,629 --> 00:08:03,520
actually hold it and use it the same way

215
00:08:06,230 --> 00:08:04,639
an astronaut

216
00:08:07,830 --> 00:08:06,240
and the benefit of course of you know a

217
00:08:09,749 --> 00:08:07,840
robot for doing this kind of jobs it

218
00:08:11,670 --> 00:08:09,759
doesn't get tired of holding something

219
00:08:13,030 --> 00:08:11,680
and it can do it many times over and

220
00:08:15,110 --> 00:08:13,040
over and it's not going to complain

221
00:08:16,790 --> 00:08:15,120
[Laughter]

222
00:08:18,309 --> 00:08:16,800
not to say that not to say that

223
00:08:19,909 --> 00:08:18,319
astronauts might complain about things i

224
00:08:21,749 --> 00:08:19,919
mean frankly if i was in space i

225
00:08:29,029 --> 00:08:21,759
wouldn't care what i would say hey take

226
00:08:34,949 --> 00:08:31,589
so what about some current robots in

227
00:08:38,149 --> 00:08:34,959
space that we have um so

228
00:08:39,909 --> 00:08:38,159
there's spheres uh which is a

229
00:08:41,829 --> 00:08:39,919
test bed actually i have a model here

230
00:08:43,110 --> 00:08:41,839
let me

231
00:08:46,710 --> 00:08:43,120
and this one's near and dear to our

232
00:08:48,070 --> 00:08:46,720
heart here in ames of course right it is

233
00:08:50,630 --> 00:08:48,080
right

234
00:08:52,710 --> 00:08:50,640
so this is a model of the spheres which

235
00:08:54,630 --> 00:08:52,720
are currently on orbit there's three of

236
00:08:57,110 --> 00:08:54,640
them on the space station

237
00:08:59,990 --> 00:08:57,120
um and they've been used as a test bed

238
00:09:02,710 --> 00:09:00,000

for guest scientists so um developers

239
00:09:05,590 --> 00:09:02,720
technology developers on um on earth

240
00:09:07,350 --> 00:09:05,600
like from academia from commercial

241
00:09:09,110 --> 00:09:07,360
from inside of nasa have developed

242
00:09:11,269 --> 00:09:09,120
technologies that they would like to fly

243
00:09:14,150 --> 00:09:11,279
in zero g and so they can actually

244
00:09:16,310 --> 00:09:14,160
deploy it on a spheres which would then

245
00:09:18,550 --> 00:09:16,320
fly them around inside a space station

246
00:09:20,070 --> 00:09:18,560
so what we see here um is actually the

247
00:09:23,190 --> 00:09:20,080
mounting point where you can

248
00:09:24,310 --> 00:09:23,200
put a payload on oh yeah yeah these uh

249
00:09:26,310 --> 00:09:24,320
you know one interesting thing about

250
00:09:28,310 --> 00:09:26,320
these is that they they fly around by

251
00:09:30,550 --> 00:09:28,320
using actually carbon dioxide so there's

252
00:09:32,949 --> 00:09:30,560
normally a tank that plugs into these

253
00:09:35,269 --> 00:09:32,959
and they have uh little little nozzles

254
00:09:37,509 --> 00:09:35,279
basically um which release controlled

255
00:09:38,630 --> 00:09:37,519
puffs of carbon dioxide yeah so

256
00:09:40,870 --> 00:09:38,640
basically these are these little

257
00:09:42,870 --> 00:09:40,880
circular really

258
00:09:45,110 --> 00:09:42,880
it basically puffs its way around inside

259
00:09:47,190 --> 00:09:45,120
of space station oh cool wow

260
00:09:49,829 --> 00:09:47,200
very cool and they've been on orbit for

261
00:09:52,070 --> 00:09:49,839
over a decade yeah really yeah helping

262
00:09:54,230 --> 00:09:52,080
astronauts for over a decade

263
00:09:56,070 --> 00:09:54,240

researchers here you know researchers

264
00:09:57,829 --> 00:09:56,080
everywhere all around the world yeah

265
00:09:59,670 --> 00:09:57,839
that's awesome so yes it's kind of the

266
00:10:02,470 --> 00:09:59,680
size of a volleyball we've been saying

267
00:10:04,870 --> 00:10:02,480
right it flies itself around it holds

268
00:10:07,509 --> 00:10:04,880
experiments okay and as as if that

269
00:10:09,910 --> 00:10:07,519
wasn't enough you guys upgraded your

270
00:10:12,710 --> 00:10:09,920
spheres at one point right yes

271
00:10:13,829 --> 00:10:12,720
so um we have a project called smart

272
00:10:16,230 --> 00:10:13,839
spheres

273
00:10:18,710 --> 00:10:16,240
where we uh we wanted to see what we

274
00:10:20,790 --> 00:10:18,720
could do to improve uh the the compute

275
00:10:22,069 --> 00:10:20,800
power on board the sensing power on

276
00:10:23,829 --> 00:10:22,079
board because

277
00:10:26,790 --> 00:10:23,839
these were built you know 14 15 years

278
00:10:28,069 --> 00:10:26,800
ago so um so the sensors the the

279
00:10:30,710 --> 00:10:28,079
computer

280
00:10:31,990 --> 00:10:30,720
very old very out of date and so we

281
00:10:35,190 --> 00:10:32,000
wanted to be able to kind of speed them

282
00:10:37,430 --> 00:10:35,200
up and try uh some robotics uh

283
00:10:39,190 --> 00:10:37,440
experiments on board and so we actually

284
00:10:41,030 --> 00:10:39,200
flew this which i'm not sure do you want

285
00:10:43,110 --> 00:10:41,040
to maybe hold that one up there

286
00:10:45,430 --> 00:10:43,120
this is a uh this is a you might

287
00:10:47,670 --> 00:10:45,440
recognize this as a smartphone and

288
00:10:49,110 --> 00:10:47,680

this was actually a nexus s smartphone

289
00:10:52,949 --> 00:10:49,120
um which you probably can't find

290
00:10:57,430 --> 00:10:54,630
yeah this was really state of the art

291
00:10:58,470 --> 00:10:57,440
back in like 2010

292
00:10:59,829 --> 00:10:58,480
and you know we had to make some

293
00:11:01,590 --> 00:10:59,839
modifications it doesn't look like the

294
00:11:03,750 --> 00:11:01,600
off-the-shelf thing although i will say

295
00:11:04,870 --> 00:11:03,760
this started off um you know at a local

296
00:11:07,350 --> 00:11:04,880
electronics store it was actually

297
00:11:08,550 --> 00:11:07,360
purchased um in an electronic store in

298
00:11:10,150 --> 00:11:08,560
the store and

299
00:11:12,630 --> 00:11:10,160
we bought this this is what we need yeah

300
00:11:17,110 --> 00:11:12,640
we need one of these here um can we sign

301
00:11:20,710 --> 00:11:19,269
um you know you know you worry about uh

302
00:11:22,389 --> 00:11:20,720
obviously people worry about breaking

303
00:11:23,990 --> 00:11:22,399
their smartphones and you know

304
00:11:25,430 --> 00:11:24,000
they cover their screens and of course

305
00:11:26,949 --> 00:11:25,440
we worry about that but we didn't want

306
00:11:28,470 --> 00:11:26,959
the shards if they were i need to fly

307
00:11:30,870 --> 00:11:28,480
off right so there's actually some

308
00:11:32,550 --> 00:11:30,880
teflon tape on here um it's got this

309
00:11:33,750 --> 00:11:32,560
very you know sort of sleek battery pack

310
00:11:35,829 --> 00:11:33,760
here because we had some concerns about

311
00:11:37,670 --> 00:11:35,839
putting lithium you know

312
00:11:38,550 --> 00:11:37,680
battery pack into space and those kinds

313
00:11:40,069 --> 00:11:38,560

of things

314
00:11:43,590 --> 00:11:40,079
but the great thing about this is it's

315
00:11:45,670 --> 00:11:43,600
very compact it gave us cameras and

316
00:11:48,230 --> 00:11:45,680
built-in accelerometers it has high

317
00:11:49,750 --> 00:11:48,240
bandwidth uh wireless data transfer oh

318
00:11:51,430 --> 00:11:49,760
yeah um

319
00:11:59,120 --> 00:11:51,440
all these great kind of things like sort

320
00:12:05,190 --> 00:12:02,389
[Laughter]

321
00:12:06,470 --> 00:12:05,200
also the fun fact about spheres is that

322
00:12:08,870 --> 00:12:06,480
it was

323
00:12:10,550 --> 00:12:08,880
based on an idea from star wars right

324
00:12:13,910 --> 00:12:10,560
that's right yes

325
00:12:16,230 --> 00:12:13,920
this is uh based on the training droid

326
00:12:18,949 --> 00:12:16,240
in the first star wars movie when luke

327
00:12:21,590 --> 00:12:18,959
is learning how to use a lightsaber

328
00:12:25,910 --> 00:12:21,600
that's hilarious that's so great

329
00:12:29,990 --> 00:12:28,150
this actually came up um you know from

330
00:12:31,590 --> 00:12:30,000
the original place where spheres was

331
00:12:33,750 --> 00:12:31,600
developed and that was at mit and

332
00:12:35,829 --> 00:12:33,760
professor dave miller challenged his you

333
00:12:37,509 --> 00:12:35,839
know his his engineering class hey you

334
00:12:39,269 --> 00:12:37,519
know here's here's the thing in star

335
00:12:40,949 --> 00:12:39,279
wars can you build me one i want one

336
00:12:43,030 --> 00:12:40,959
from myself

337
00:12:43,750 --> 00:12:43,040
make me one yes students

338
00:12:45,350 --> 00:12:43,760

yeah

339
00:12:47,750 --> 00:12:45,360
excellent all right so that's one that

340
00:12:49,990 --> 00:12:47,760
we particularly love there are a few

341
00:12:50,949 --> 00:12:50,000
others that are currently i think on the

342
00:12:52,629 --> 00:12:50,959
station

343
00:12:54,389 --> 00:12:52,639
that we could talk about and share some

344
00:12:56,389 --> 00:12:54,399
pictures um you showed us before canada

345
00:13:00,310 --> 00:12:56,399
arm there's canada arm two two that's

346
00:13:02,389 --> 00:13:00,320
right right right and it's a 58-foot

347
00:13:05,190 --> 00:13:02,399
robotic arm on the

348
00:13:07,430 --> 00:13:05,200
outside of uh the space station and it's

349
00:13:09,750 --> 00:13:07,440
used for multiple purposes but it also

350
00:13:11,190 --> 00:13:09,760
it's used to dock the commercial uh

351
00:13:13,750 --> 00:13:11,200
commercial cargo

352
00:13:16,550 --> 00:13:13,760
vehicles so what we see here is that um

353
00:13:19,590 --> 00:13:16,560
it's being used to dock the the spacex

354
00:13:21,670 --> 00:13:19,600
uh dragon capsule yeah and this arm is

355
00:13:23,590 --> 00:13:21,680
is even as maria said it's even longer

356
00:13:26,389 --> 00:13:23,600
than the original canada arm which was

357
00:13:28,710 --> 00:13:26,399
on the on the space shuttle this one um

358
00:13:30,949 --> 00:13:28,720
also um is a really big arm it can

359
00:13:33,750 --> 00:13:30,959
actually move um you know eight times

360
00:13:35,670 --> 00:13:33,760
more wow than the original one yeah so

361
00:13:37,110 --> 00:13:35,680
you always want more right

362
00:13:38,550 --> 00:13:37,120
so it's not just one school bus this

363
00:13:41,350 --> 00:13:38,560

could actually move eight school buses

364
00:13:42,949 --> 00:13:41,360
at a time well because it moves space

365
00:13:45,110 --> 00:13:42,959
station modules

366
00:13:46,550 --> 00:13:45,120
actually needs to be able to do that and

367
00:13:48,150 --> 00:13:46,560
it's really cool the way it can inch

368
00:13:50,069 --> 00:13:48,160
worm around the station so it can

369
00:13:52,150 --> 00:13:50,079
wherever it needs to be deployed they

370
00:13:55,350 --> 00:13:52,160
sort of it there are holding spots

371
00:13:58,470 --> 00:13:55,360
around the outside of the modules so it

372
00:13:59,910 --> 00:13:58,480
it inch warms itself across oh that's

373
00:14:01,269 --> 00:13:59,920
amazing

374
00:14:02,870 --> 00:14:01,279
that's great i can picture that yeah

375
00:14:04,550 --> 00:14:02,880
well it's a really fascinating robot

376
00:14:05,990 --> 00:14:04,560
because it's actually a collection of

377
00:14:07,910 --> 00:14:06,000
you know a bunch of different robots

378
00:14:09,430 --> 00:14:07,920
that fit together and there's the big

379
00:14:10,790 --> 00:14:09,440
arm itself

380
00:14:13,189 --> 00:14:10,800
but there's also

381
00:14:15,590 --> 00:14:13,199
a separate set of robot arms that can

382
00:14:18,069 --> 00:14:15,600
attach to the end and those those arms

383
00:14:19,910 --> 00:14:18,079
form the system called dexter

384
00:14:22,150 --> 00:14:19,920
or if you like acronyms it's the the

385
00:14:24,949 --> 00:14:22,160
spdm the special purpose dexterous

386
00:14:24,959 --> 00:14:28,790
dexter was good exactly

387
00:14:34,150 --> 00:14:31,030
but it's basically allows this large arm

388
00:14:36,310 --> 00:14:34,160

to have the ability to to do fine quote

389
00:14:38,470 --> 00:14:36,320
fine dexterous motions so you have two

390
00:14:40,310 --> 00:14:38,480
smaller arms attached to this bigger arm

391
00:14:42,629 --> 00:14:40,320
and those go into a mobile base and so

392
00:14:44,150 --> 00:14:42,639
now you have this big large system that

393
00:14:46,470 --> 00:14:44,160
can really move all kinds of things

394
00:14:47,350 --> 00:14:46,480
around outside of the space station

395
00:14:48,949 --> 00:14:47,360
wow

396
00:14:52,470 --> 00:14:48,959
pretty handy yeah

397
00:14:55,670 --> 00:14:52,480
that sounds good um what about simon

398
00:14:57,910 --> 00:14:55,680
simon with a c simon with a c yes

399
00:15:00,389 --> 00:14:57,920
that was built by the uh german space

400
00:15:02,629 --> 00:15:00,399
agency and an airbus

401
00:15:04,150 --> 00:15:02,639
and there we see it yes

402
00:15:07,750 --> 00:15:04,160
simon uh

403
00:15:10,790 --> 00:15:07,760
it's uh meant to be a personal assistant

404
00:15:13,030 --> 00:15:10,800
uh to astronauts um on the station so we

405
00:15:15,189 --> 00:15:13,040
see him there with alexander gerst who

406
00:15:16,790 --> 00:15:15,199
was a commander on the station about a

407
00:15:19,350 --> 00:15:16,800
year ago last summer

408
00:15:21,269 --> 00:15:19,360
and they ran an experiment uh simon

409
00:15:23,990 --> 00:15:21,279
actually runs watson

410
00:15:26,310 --> 00:15:24,000
uh so it's similar to you know the smart

411
00:15:29,509 --> 00:15:26,320
speakers that you know

412
00:15:32,069 --> 00:15:29,519
add something to my shopping list or

413
00:15:33,269 --> 00:15:32,079

play my favorite song

414
00:15:35,990 --> 00:15:33,279
that kind of thing

415
00:15:38,389 --> 00:15:36,000
i imagine that's true yes and it is yeah

416
00:15:40,230 --> 00:15:38,399
the idea is that they it can be helpful

417
00:15:42,629 --> 00:15:40,240
on you know if they need to have a

418
00:15:44,389 --> 00:15:42,639
procedure brought up um so

419
00:15:46,629 --> 00:15:44,399
you know help them with uh different

420
00:15:48,550 --> 00:15:46,639
tasks that they're doing and

421
00:15:49,749 --> 00:15:48,560
yeah your personal robotic assistant

422
00:15:51,430 --> 00:15:49,759
exactly

423
00:15:54,389 --> 00:15:51,440
you just have to you just you know it's

424
00:15:55,910 --> 00:15:54,399
voice commanded yeah yeah so that seems

425
00:15:57,590 --> 00:15:55,920
handy it's floating around your space

426
00:16:00,230 --> 00:15:57,600
station yeah you call that what you need

427
00:16:03,189 --> 00:16:00,240
from it awesome exactly um i think we

428
00:16:06,230 --> 00:16:03,199
have another here ant ball

429
00:16:09,269 --> 00:16:06,240
the most adorable you've ever seen

430
00:16:11,670 --> 00:16:09,279
there we go and fun so it ball was built

431
00:16:13,590 --> 00:16:11,680
by the japanese space agency um and it's

432
00:16:15,269 --> 00:16:13,600
meant to be basically a floating camera

433
00:16:17,910 --> 00:16:15,279
it can move around uh inside the

434
00:16:19,990 --> 00:16:17,920
japanese experiment module um and take

435
00:16:23,749 --> 00:16:20,000
over some of the sort of videography

436
00:16:26,470 --> 00:16:23,759
chores of astronaut so a lot of times

437
00:16:28,629 --> 00:16:26,480
astronauts need to document activities

438
00:16:30,949 --> 00:16:28,639

uh you know so they're filming other

439
00:16:32,949 --> 00:16:30,959
astronauts doing things and so

440
00:16:34,150 --> 00:16:32,959
this little robot can take take over

441
00:16:37,430 --> 00:16:34,160
that job

442
00:16:39,509 --> 00:16:37,440
oh awesome great yeah i have a question

443
00:16:40,870 --> 00:16:39,519
here before we go to our rapid fire

444
00:16:42,470 --> 00:16:40,880
questions we're going to take as many as

445
00:16:43,749 --> 00:16:42,480
possible um

446
00:16:45,829 --> 00:16:43,759
but

447
00:16:47,189 --> 00:16:45,839
shamley wants to know would robots on

448
00:16:49,509 --> 00:16:47,199
the international space station be

449
00:16:50,949 --> 00:16:49,519
controlled by houston or command here on

450
00:16:53,430 --> 00:16:50,959
earth or would they be in the hands of

451
00:16:55,430 --> 00:16:53,440
the astronaut aboard the station all of

452
00:16:58,150 --> 00:16:55,440
the above yes

453
00:17:00,310 --> 00:16:58,160
exactly i mean i just like there's no

454
00:17:02,230 --> 00:17:00,320
one perfect robot uh you know for

455
00:17:04,309 --> 00:17:02,240
everything there's there's not one you

456
00:17:06,230 --> 00:17:04,319
know specific way that any of these

457
00:17:07,990 --> 00:17:06,240
robots would be operated you know they

458
00:17:10,230 --> 00:17:08,000
could be controlled from from the earth

459
00:17:12,069 --> 00:17:10,240
they could operate uh you know

460
00:17:14,390 --> 00:17:12,079
autonomously or they could be you know

461
00:17:17,350 --> 00:17:14,400
operated also by astronauts so

462
00:17:21,029 --> 00:17:19,189
and actually so spheres that we were

463
00:17:22,549 --> 00:17:21,039

looking at a minute ago it does do some

464
00:17:23,350 --> 00:17:22,559
things autonomously on space station

465
00:17:25,429 --> 00:17:23,360
right

466
00:17:27,669 --> 00:17:25,439
and to a certain extent yeah we have

467
00:17:30,830 --> 00:17:27,679
video of it docking and undocking

468
00:17:32,230 --> 00:17:30,840
oh no not no spheres oh really

469
00:17:33,430 --> 00:17:32,240
okay welcome to all those spheres you

470
00:17:35,190 --> 00:17:33,440
know some of the experiments that we've

471
00:17:37,750 --> 00:17:35,200
done with spheres you know we've we've

472
00:17:39,830 --> 00:17:37,760
tried to allow it to operate uh um and

473
00:17:40,870 --> 00:17:39,840
fly around inside the space station uh

474
00:17:42,870 --> 00:17:40,880
by itself

475
00:17:45,029 --> 00:17:42,880
it can be used to carry out things like

476
00:17:48,310 --> 00:17:45,039
uh interior surveys it can fly back and

477
00:17:49,830 --> 00:17:48,320
forth um to very specific locations take

478
00:17:51,350 --> 00:17:49,840
readings at those locations and then fly

479
00:17:52,630 --> 00:17:51,360
on yeah

480
00:17:54,470 --> 00:17:52,640
do a video of that maybe that's what i

481
00:17:56,870 --> 00:17:54,480
was thinking of yes yeah yeah let's see

482
00:17:57,990 --> 00:17:56,880
if we can get that spheres video oh look

483
00:17:59,990 --> 00:17:58,000
there it is

484
00:18:01,029 --> 00:18:00,000
so there you see a smart spheres this is

485
00:18:03,110 --> 00:18:01,039
yeah this was actually a different

486
00:18:05,430 --> 00:18:03,120
smartphone so we we worked with not just

487
00:18:06,549 --> 00:18:05,440
the nexus s but this was a project tango

488
00:18:09,110 --> 00:18:06,559

smartphone

489
00:18:10,630 --> 00:18:09,120
um that we we worked on in partnership

490
00:18:13,110 --> 00:18:10,640
with our friends next door over at

491
00:18:14,549 --> 00:18:13,120
google um and here is a picture there's

492
00:18:15,909 --> 00:18:14,559
a video here you can actually see a

493
00:18:17,590 --> 00:18:15,919
smartphone on the front of spheres it's

494
00:18:19,190 --> 00:18:17,600
flying around inside of the space

495
00:18:20,950 --> 00:18:19,200
station it's actually going back and

496
00:18:22,710 --> 00:18:20,960
forward back and forth flying kind of a

497
00:18:24,310 --> 00:18:22,720
lawnmower pattern and this is what

498
00:18:26,150 --> 00:18:24,320
mission control sees so you can see

499
00:18:28,549 --> 00:18:26,160
video coming down from the smartphone

500
00:18:30,390 --> 00:18:28,559
cameras you can see uh what looks like a

501
00:18:32,390 --> 00:18:30,400
video game on the right side you can see

502
00:18:33,909 --> 00:18:32,400
the path that it's flying and the way

503
00:18:35,510 --> 00:18:33,919
points that it's going back and forth

504
00:18:36,390 --> 00:18:35,520
between so here's flying towards point

505
00:18:38,070 --> 00:18:36,400
seven

506
00:18:39,590 --> 00:18:38,080
um at the lower right there there's an

507
00:18:41,590 --> 00:18:39,600
image that shows the

508
00:18:43,669 --> 00:18:41,600
representation of what the camera scene

509
00:18:44,950 --> 00:18:43,679
that kind of blue thing and this allows

510
00:18:46,950 --> 00:18:44,960
us to have a really good understanding

511
00:18:48,549 --> 00:18:46,960
of the robot um in its environment and

512
00:18:50,789 --> 00:18:48,559
what it's doing at any given time oh

513
00:18:52,950 --> 00:18:50,799

yeah yeah awesome that's so cool so

514
00:18:57,270 --> 00:18:52,960
there's your answer to that yeah we have

515
00:19:00,310 --> 00:18:57,280
a comment from snowden says i like heart

516
00:19:05,990 --> 00:19:03,430
it doesn't hurt robots

517
00:19:08,830 --> 00:19:06,000
yeah there were some others

518
00:19:11,430 --> 00:19:08,840
go canada was excited about

519
00:19:13,830 --> 00:19:11,440
canada are some others we could jump

520
00:19:15,190 --> 00:19:13,840
right into our rapid fire question

521
00:19:17,110 --> 00:19:15,200
session right answer some quick

522
00:19:19,909 --> 00:19:17,120
questions yeah absolutely emphasis on

523
00:19:21,830 --> 00:19:19,919
the quick yeah we'll try to get a lot in

524
00:19:24,549 --> 00:19:21,840
all right tiffany do you have one yes i

525
00:19:26,070 --> 00:19:24,559
have one so uh let's say for spheres how

526
00:19:27,430 --> 00:19:26,080
long did it take to actually create the

527
00:19:29,590 --> 00:19:27,440
robot

528
00:19:32,390 --> 00:19:29,600
actually designed that yeah

529
00:19:34,710 --> 00:19:32,400
well um as i said this this was a a

530
00:19:36,230 --> 00:19:34,720
project that started at mit with uh with

531
00:19:38,870 --> 00:19:36,240
actually an undergraduate engineering

532
00:19:41,510 --> 00:19:38,880
class um and so the students worked on

533
00:19:43,029 --> 00:19:41,520
that extensively that led to a number of

534
00:19:45,750 --> 00:19:43,039
different prototypes and eventually

535
00:19:47,350 --> 00:19:45,760
those were sent up to the space station

536
00:19:49,029 --> 00:19:47,360
but you know the reality is that it's

537
00:19:50,710 --> 00:19:49,039
hard to say exactly how long it takes to

538
00:19:53,110 --> 00:19:50,720

build something because you have to

539
00:19:54,710 --> 00:19:53,120
design it test it um there are a lot of

540
00:19:56,310 --> 00:19:54,720
things for the space station that we're

541
00:19:57,990 --> 00:19:56,320
concerned about in terms of making sure

542
00:19:59,669 --> 00:19:58,000
things are safe right of course um in

543
00:20:01,029 --> 00:19:59,679
terms of like materials and how it

544
00:20:02,149 --> 00:20:01,039
operates and all those kinds of things

545
00:20:04,630 --> 00:20:02,159
so

546
00:20:05,909 --> 00:20:04,640
that and then of course once they get on

547
00:20:07,029 --> 00:20:05,919
the space station you know just because

548
00:20:07,909 --> 00:20:07,039
you get there right it doesn't mean

549
00:20:08,710 --> 00:20:07,919
you're finished

550
00:20:10,630 --> 00:20:08,720
right

551
00:20:11,909 --> 00:20:10,640
in fact every single research happens

552
00:20:13,590 --> 00:20:11,919
every single robot that goes up into

553
00:20:15,510 --> 00:20:13,600
space we're still learning how to

554
00:20:18,390 --> 00:20:15,520
improve and make them better

555
00:20:20,789 --> 00:20:18,400
so sweet that's cool all right uh a

556
00:20:23,510 --> 00:20:20,799
comment about int ball from airplane man

557
00:20:26,950 --> 00:20:23,520
1997. so cute

558
00:20:29,990 --> 00:20:26,960
i agree we all agreed right now

559
00:20:33,990 --> 00:20:32,230
the jp guy has a question about

560
00:20:35,909 --> 00:20:34,000
learning and training to do things like

561
00:20:37,669 --> 00:20:35,919
you guys do is it possible to learn

562
00:20:39,510 --> 00:20:37,679
robotics by self-study and tinkering

563
00:20:41,350 --> 00:20:39,520

with machines what books or resources

564
00:20:43,510 --> 00:20:41,360
would you suggest

565
00:20:46,549 --> 00:20:43,520
uh yes i would say i would say so

566
00:20:50,630 --> 00:20:46,559
robotics is it's very broad field so you

567
00:20:52,310 --> 00:20:50,640
can contribute to a robotics project

568
00:20:53,350 --> 00:20:52,320
you know without any kind of background

569
00:20:55,710 --> 00:20:53,360
almost

570
00:20:58,070 --> 00:20:55,720
you know product designers uh you know

571
00:21:01,430 --> 00:20:58,080
programmers uh electrical engineers

572
00:21:03,029 --> 00:21:01,440
mechanical engineers so really

573
00:21:05,669 --> 00:21:03,039
it's whatever you love to do you know

574
00:21:08,549 --> 00:21:05,679
what what would you prefer to to do and

575
00:21:11,110 --> 00:21:08,559
then you know you can contribute then to

576
00:21:12,470 --> 00:21:11,120
yeah a robotics team that's awesome

577
00:21:14,549 --> 00:21:12,480
that's good news could do a lot of

578
00:21:16,310 --> 00:21:14,559
different things yeah and i i think a

579
00:21:18,070 --> 00:21:16,320
great thing today which didn't exist a

580
00:21:20,470 --> 00:21:18,080
few years ago is there a lot of online

581
00:21:22,070 --> 00:21:20,480
classes you can take in robotics and so

582
00:21:23,990 --> 00:21:22,080
i think learning by yourself is totally

583
00:21:25,110 --> 00:21:24,000
possible there are even open source

584
00:21:26,870 --> 00:21:25,120
robotics projects that you can

585
00:21:27,990 --> 00:21:26,880
contribute to

586
00:21:30,549 --> 00:21:28,000
and so i think the important thing is

587
00:21:32,230 --> 00:21:30,559
just to get involved and not worry about

588
00:21:35,110 --> 00:21:32,240

whether or not this is in a university

589
00:21:37,270 --> 00:21:35,120
or at home i mean you can build your own

590
00:21:38,950 --> 00:21:37,280
robots at home get a little raspberry pi

591
00:21:46,549 --> 00:21:38,960
and

592
00:21:48,870 --> 00:21:46,559
get started yeah yeah nice some more um

593
00:21:50,789 --> 00:21:48,880
twitch prime queer to your back i saw

594
00:21:52,710 --> 00:21:50,799
the floating square robot assistant

595
00:21:54,710 --> 00:21:52,720
astorby or maybe it was the other one i

596
00:21:59,690 --> 00:21:54,720
forgot the name the assistant robots

597
00:22:03,190 --> 00:22:01,830
[Music]

598
00:22:04,549 --> 00:22:03,200
wanted to get that in there since you

599
00:22:06,390 --> 00:22:04,559
anticipated

600
00:22:08,789 --> 00:22:06,400
another robot

601
00:22:10,870 --> 00:22:08,799
and of course we had the space tv net

602
00:22:12,549 --> 00:22:10,880
says on the iss do they

603
00:22:14,070 --> 00:22:12,559
have something they can talk to or ask

604
00:22:16,149 --> 00:22:14,080
questions like alexa or google home and

605
00:22:18,149 --> 00:22:16,159
of course that was simon that's the idea

606
00:22:21,350 --> 00:22:18,159
behind simon yeah exactly yeah you guys

607
00:22:23,510 --> 00:22:21,360
yeah those things are needed there too

608
00:22:25,350 --> 00:22:23,520
here's a good question godzilla asks can

609
00:22:27,669 --> 00:22:25,360
we expect robots to take over the role

610
00:22:30,390 --> 00:22:27,679
of astronauts on spacewalks and conduct

611
00:22:31,990 --> 00:22:30,400
things such as maintenance well i think

612
00:22:34,470 --> 00:22:32,000
you know maintenance is one of those

613
00:22:36,710 --> 00:22:34,480

things that we really want to see robots

614
00:22:39,350 --> 00:22:36,720
uh you know take on an increasing role

615
00:22:41,750 --> 00:22:39,360
because so much of the time of

616
00:22:43,430 --> 00:22:41,760
astronauts today is spent doing uh

617
00:22:45,350 --> 00:22:43,440
preventive and corrective maintenance

618
00:22:47,270 --> 00:22:45,360
onboard the space station

619
00:22:49,190 --> 00:22:47,280
and so we'd love to have robots be able

620
00:22:50,870 --> 00:22:49,200
to take spacewalks but you know right

621
00:22:52,390 --> 00:22:50,880
now we have these large arms that are

622
00:22:53,990 --> 00:22:52,400
actually used to do some amount of

623
00:22:54,870 --> 00:22:54,000
maintenance external to the space

624
00:22:57,029 --> 00:22:54,880
station

625
00:22:58,870 --> 00:22:57,039
without astronauts

626
00:23:00,390 --> 00:22:58,880
awesome it makes sense yeah

627
00:23:01,909 --> 00:23:00,400
do you have another one you want to hit

628
00:23:04,710 --> 00:23:01,919
uh

629
00:23:06,070 --> 00:23:04,720
let's see here

630
00:23:20,549 --> 00:23:06,080
there's a question about robotics

631
00:23:25,029 --> 00:23:22,549
and it's a middle school and high school

632
00:23:27,110 --> 00:23:25,039
um software competition so awesome the

633
00:23:29,750 --> 00:23:27,120
preliminaries are done in simulation uh

634
00:23:32,149 --> 00:23:29,760
you you program uh the spheres to

635
00:23:33,190 --> 00:23:32,159
perform certain tasks uh the so the

636
00:23:35,270 --> 00:23:33,200
preliminary rounds are done in the

637
00:23:36,630 --> 00:23:35,280
simulation and then the finalists get to

638
00:23:38,070 --> 00:23:36,640

fly their code

639
00:23:40,230 --> 00:23:38,080
on the spheres on the international

640
00:23:41,830 --> 00:23:40,240
space station oh wow for real yes

641
00:23:44,149 --> 00:23:41,840
excellent yeah middle and high school

642
00:23:46,549 --> 00:23:44,159
middle and high school yeah yeah it gets

643
00:23:48,070 --> 00:23:46,559
started early yeah yeah

644
00:23:50,149 --> 00:23:48,080
i was not sending code to the space

645
00:23:53,430 --> 00:23:50,159
station when i was in middle school it

646
00:23:57,510 --> 00:23:55,110
i don't want to say my age but there

647
00:23:58,870 --> 00:23:57,520
wasn't a space

648
00:24:01,669 --> 00:23:58,880
that might have been part of the problem

649
00:24:05,110 --> 00:24:01,679
that was part of the problem yes exactly

650
00:24:09,669 --> 00:24:06,950
well here's another question here we uh

651
00:24:12,230 --> 00:24:09,679
for cali cama uh do you see a point

652
00:24:14,230 --> 00:24:12,240
where robot robotics will be able to

653
00:24:15,430 --> 00:24:14,240
perform enough tasks where humans won't

654
00:24:17,750 --> 00:24:15,440
be needed

655
00:24:19,750 --> 00:24:17,760
um on the iss

656
00:24:21,510 --> 00:24:19,760
you know i i'm often asked that question

657
00:24:23,269 --> 00:24:21,520
about you know you know the relative

658
00:24:26,390 --> 00:24:23,279
strengths and weaknesses of humans and

659
00:24:28,070 --> 00:24:26,400
robots and i i think that you know we

660
00:24:29,590 --> 00:24:28,080
will always have humans involved in

661
00:24:33,029 --> 00:24:29,600
space i mean partially because you know

662
00:24:35,190 --> 00:24:33,039
we as humans want to also explore um but

663
00:24:36,710 --> 00:24:35,200

it's also the case too that you know we

664
00:24:39,269 --> 00:24:36,720
can't do everything by ourselves and

665
00:24:40,549 --> 00:24:39,279
just like any you know team um you know

666
00:24:42,070 --> 00:24:40,559
there's more than one

667
00:24:43,830 --> 00:24:42,080
one person involved and i think there'll

668
00:24:46,230 --> 00:24:43,840
be more than you know one human and one

669
00:24:47,830 --> 00:24:46,240
robot and more than just robots really i

670
00:24:51,029 --> 00:24:47,840
think the future is humans and robots

671
00:24:53,029 --> 00:24:51,039
together yeah yeah awesome yeah cool how

672
00:24:55,110 --> 00:24:53,039
about one more question from the chat

673
00:24:58,230 --> 00:24:55,120
okay before we move on

674
00:25:00,310 --> 00:24:58,240
which i have now lost spacetvnet hello

675
00:25:02,789 --> 00:25:00,320
wants to know what animal shape is the

676
00:25:04,630 --> 00:25:02,799
best for robots in zero gravity

677
00:25:06,789 --> 00:25:04,640
is there an animal

678
00:25:08,149 --> 00:25:06,799
nature inspiration

679
00:25:09,909 --> 00:25:08,159
for the shapes that work there seems to

680
00:25:11,909 --> 00:25:09,919
be a lot of spheres

681
00:25:13,830 --> 00:25:11,919
is there a reason for that yeah well but

682
00:25:15,909 --> 00:25:13,840
i think part of that is you know we we

683
00:25:17,750 --> 00:25:15,919
like at least for flying robots to have

684
00:25:20,470 --> 00:25:17,760
some sort of symmetry to them because

685
00:25:23,110 --> 00:25:20,480
they can fly in any direction in space

686
00:25:25,590 --> 00:25:23,120
um sometimes i think robot design draws

687
00:25:27,510 --> 00:25:25,600
inspiration from animals um

688
00:25:29,510 --> 00:25:27,520

biology has obviously evolved all kinds

689
00:25:31,350 --> 00:25:29,520
of different shapes different forms and

690
00:25:32,950 --> 00:25:31,360
we'd like to take advantage of that yeah

691
00:25:34,630 --> 00:25:32,960
but we also sometimes draw inspiration

692
00:25:37,430 --> 00:25:34,640
you know as we said from like science

693
00:25:39,350 --> 00:25:37,440
fiction um you know the idea that people

694
00:25:41,190 --> 00:25:39,360
come up with in hollywood for robots i

695
00:25:44,390 --> 00:25:41,200
mean sometimes like hey we should use

696
00:25:46,470 --> 00:25:44,400
the work we should that could work

697
00:25:48,310 --> 00:25:46,480
shape also um it depends on what

698
00:25:50,070 --> 00:25:48,320
functionality you're looking for so you

699
00:25:53,750 --> 00:25:50,080
build it so that it's most efficient at

700
00:25:55,590 --> 00:25:53,760
the job that you want to accomplish so

701
00:25:57,590 --> 00:25:55,600
that's what drives it that drives the

702
00:25:59,110 --> 00:25:57,600
show all right yeah that makes sense

703
00:26:01,110 --> 00:25:59,120
yeah well speaking of science fiction

704
00:26:03,269 --> 00:26:01,120
okay my question for you is we see

705
00:26:04,630 --> 00:26:03,279
robots all over in movies and tv shows

706
00:26:05,669 --> 00:26:04,640
comics everything what are your

707
00:26:07,830 --> 00:26:05,679
favorites

708
00:26:10,390 --> 00:26:07,840
oh that's easy i mean for me you know my

709
00:26:12,950 --> 00:26:10,400
favorite robot is a canine which comes

710
00:26:16,390 --> 00:26:12,960
from doctor who yeah canine was the

711
00:26:18,149 --> 00:26:16,400
doctor's robot dog and uh had basically

712
00:26:20,789 --> 00:26:18,159
you know a super computer built in

713
00:26:23,269 --> 00:26:20,799

inside and a little laser in its nose

714
00:26:26,470 --> 00:26:23,279
but um yeah canine no question have you

715
00:26:29,029 --> 00:26:26,480
built a dog robot yet i have not uh but

716
00:26:30,950 --> 00:26:29,039
if somebody had one you know well

717
00:26:35,510 --> 00:26:30,960
i have to say that one of our previous

718
00:26:38,470 --> 00:26:35,520
robots in our group was named cain

719
00:26:39,909 --> 00:26:38,480
after the doctor who robot yes nice

720
00:26:41,669 --> 00:26:39,919
excellent nice

721
00:26:43,110 --> 00:26:41,679
yeah and i have to say i don't really

722
00:26:45,110 --> 00:26:43,120
play favorites i don't really have a

723
00:26:47,269 --> 00:26:45,120
favorite robot i'm sorry

724
00:26:48,470 --> 00:26:47,279
i have my favorites are real robots so

725
00:26:50,149 --> 00:26:48,480
yeah

726
00:26:51,750 --> 00:26:50,159
i have some favorites among them i mean

727
00:26:53,430 --> 00:26:51,760
someone like you in your position that's

728
00:26:56,149 --> 00:26:53,440
fair i think

729
00:26:58,310 --> 00:26:56,159
all right well speaking of your

730
00:27:00,630 --> 00:26:58,320
favorites well now let's come to that in

731
00:27:02,950 --> 00:27:00,640
just a moment okay so we wanted to talk

732
00:27:05,350 --> 00:27:02,960
about characteristics yeah like what

733
00:27:07,510 --> 00:27:05,360
kind of qualities do you look for in a

734
00:27:09,430 --> 00:27:07,520
robot yeah right

735
00:27:11,350 --> 00:27:09,440
you know we look for we look for robots

736
00:27:12,549 --> 00:27:11,360
that can really help out especially when

737
00:27:13,430 --> 00:27:12,559
we're talking about humans and robots in

738
00:27:15,990 --> 00:27:13,440

space

739
00:27:17,510 --> 00:27:16,000
um to really work well together

740
00:27:19,190 --> 00:27:17,520
and i think just like here on earth

741
00:27:21,510 --> 00:27:19,200
there's no single

742
00:27:23,350 --> 00:27:21,520
definition of what a team is the same is

743
00:27:25,669 --> 00:27:23,360
true in space in fact we could have

744
00:27:28,389 --> 00:27:25,679
robots that work uh say before humans or

745
00:27:30,630 --> 00:27:28,399
robots that work after humans um or

746
00:27:32,389 --> 00:27:30,640
maybe even in parallel or in support so

747
00:27:34,630 --> 00:27:32,399
the idea is that you could have a team

748
00:27:35,750 --> 00:27:34,640
in all kinds of you know different

749
00:27:37,990 --> 00:27:35,760
settings

750
00:27:40,470 --> 00:27:38,000
and so sometimes we build robots to do

751
00:27:41,669 --> 00:27:40,480
things that might take a long period of

752
00:27:42,950 --> 00:27:41,679
time and you have them work either

753
00:27:44,389 --> 00:27:42,960
before or after

754
00:27:47,510 --> 00:27:44,399
other times we want robots that can

755
00:27:49,909 --> 00:27:47,520
interact um more sort of like human

756
00:27:51,510 --> 00:27:49,919
uh pacing so just like we're talking

757
00:27:54,789 --> 00:27:51,520
we'd like robots that can react to us

758
00:27:57,669 --> 00:27:54,799
too okay right right do you remember the

759
00:28:01,350 --> 00:27:57,679
other day terry yeah his comparison to

760
00:28:02,950 --> 00:28:01,360
like raising a kid oh yeah yeah i should

761
00:28:04,710 --> 00:28:02,960
say that you know

762
00:28:06,549 --> 00:28:04,720
and marie and i we spend you know all of

763
00:28:08,950 --> 00:28:06,559

our time here at work you know thinking

764
00:28:11,269 --> 00:28:08,960
about and trying to build robots and uh

765
00:28:13,990 --> 00:28:11,279
you know sometimes i'll admit it's it's

766
00:28:16,710 --> 00:28:14,000
frustrating because um it's it's not

767
00:28:18,710 --> 00:28:16,720
unlike you know trying to raise kids um

768
00:28:19,510 --> 00:28:18,720
you want them to grow up to be you know

769
00:28:21,750 --> 00:28:19,520
good

770
00:28:22,470 --> 00:28:21,760
autonomous team members and to work with

771
00:28:26,549 --> 00:28:22,480
you

772
00:28:27,669 --> 00:28:26,559
sure if it's more or less challenging

773
00:28:29,190 --> 00:28:27,679
than trying to build robots to do the

774
00:28:31,830 --> 00:28:29,200
same thing

775
00:28:34,389 --> 00:28:31,840
i will say that my kids have grown up to

776
00:28:35,430 --> 00:28:34,399
be you know far more uh autonomous and

777
00:28:36,470 --> 00:28:35,440
independent

778
00:28:37,510 --> 00:28:36,480
robots

779
00:28:39,029 --> 00:28:37,520
that's a little bit just a

780
00:28:45,140 --> 00:28:39,039
disappointment because i want my robots

781
00:28:45,150 --> 00:28:55,029
[Laughter]

782
00:29:00,310 --> 00:28:57,110
why did my robot vacuum cleaner choose

783
00:29:03,750 --> 00:29:00,320
to get wedged under the couch

784
00:29:03,760 --> 00:29:08,630
a day in the life of building robots

785
00:29:08,640 --> 00:29:21,590
well should we talk about one of your

786
00:29:24,389 --> 00:29:22,950
that's right this is what we call this

787
00:29:28,950 --> 00:29:24,399
our stunt double

788
00:29:34,310 --> 00:29:31,750

um in general these robots are called

789
00:29:36,630 --> 00:29:34,320
astrobee or astrobees uh but they each

790
00:29:39,669 --> 00:29:36,640
have their own name and and the color

791
00:29:41,269 --> 00:29:39,679
yes so uh this stunt double model you

792
00:29:43,990 --> 00:29:41,279
see is you know let me turn it so you

793
00:29:47,190 --> 00:29:44,000
can see the color better is orange

794
00:29:49,590 --> 00:29:47,200
and it's called killer killer bee

795
00:29:52,310 --> 00:29:49,600
but we also have three of these

796
00:29:55,029 --> 00:29:52,320
on space station currently and they are

797
00:29:57,830 --> 00:29:55,039
named bumble which is blue

798
00:30:00,389 --> 00:29:57,840
honey which is yellow and queen which is

799
00:30:02,389 --> 00:30:00,399
green so cute so uh

800
00:30:04,070 --> 00:30:02,399
when we see them we see them on camera

801
00:30:06,549 --> 00:30:04,080
we always know which one it is of course

802
00:30:09,110 --> 00:30:06,559
on the color yeah so yeah so this is

803
00:30:11,190 --> 00:30:09,120
this is my my favorite robot um we just

804
00:30:14,710 --> 00:30:11,200
finished building these and launching

805
00:30:16,230 --> 00:30:14,720
them yeah um very exciting yeah

806
00:30:19,990 --> 00:30:16,240
here it's maria's favorite robot because

807
00:30:22,549 --> 00:30:20,000
the past four years of my life

808
00:30:24,630 --> 00:30:22,559
nothing but after me yes exactly

809
00:30:26,470 --> 00:30:24,640
fair enough when you ask how long it

810
00:30:28,470 --> 00:30:26,480
takes to build something well astrobe

811
00:30:30,950 --> 00:30:28,480
well it's been now almost five years

812
00:30:32,630 --> 00:30:30,960
since we started but um but we i mean we

813
00:30:35,029 --> 00:30:32,640

finished building them and launching

814
00:30:36,310 --> 00:30:35,039
them within those five years so so

815
00:30:38,149 --> 00:30:36,320
they're and they're now starting to

816
00:30:38,950 --> 00:30:38,159
operate within those five years so about

817
00:30:41,029 --> 00:30:38,960
like

818
00:30:43,750 --> 00:30:41,039
little over four years to build

819
00:30:45,110 --> 00:30:43,760
uh the actual flight units all right um

820
00:30:46,870 --> 00:30:45,120
and so i can i can tell you a little bit

821
00:30:48,549 --> 00:30:46,880
about how these work and usually the

822
00:30:51,909 --> 00:30:48,559
number one question i get when talking

823
00:30:54,789 --> 00:30:51,919
about asterisks was how do they move in

824
00:30:57,029 --> 00:30:54,799
right yeah so first of all astrobee only

825
00:30:58,789 --> 00:30:57,039
works inside the space station because

826
00:31:01,430 --> 00:30:58,799
it needs air

827
00:31:04,149 --> 00:31:01,440
it's fan based propulsion um

828
00:31:05,509 --> 00:31:04,159
there are two fans on board uh this sort

829
00:31:07,029 --> 00:31:05,519
of circular

830
00:31:08,070 --> 00:31:07,039
yeah we can turn it yeah you can see it

831
00:31:10,630 --> 00:31:08,080
better

832
00:31:13,190 --> 00:31:10,640
there we go um the circular opening that

833
00:31:15,350 --> 00:31:13,200
you see on the side maybe scooch it

834
00:31:17,909 --> 00:31:15,360
that way a little there we go

835
00:31:19,350 --> 00:31:17,919
steering here okay so the circular thing

836
00:31:21,509 --> 00:31:19,360
is the circulation looks kind of like a

837
00:31:23,830 --> 00:31:21,519
speaker that's a there's an impeller fan

838
00:31:25,430 --> 00:31:23,840

in there so that pulls air in

839
00:31:27,909 --> 00:31:25,440
and lightly pressurizes the the

840
00:31:29,830 --> 00:31:27,919
propulsion module and then those grills

841
00:31:32,310 --> 00:31:29,840
that you see there's there's two on

842
00:31:33,990 --> 00:31:32,320
every side so there's 12 total that's

843
00:31:35,590 --> 00:31:34,000
right

844
00:31:37,830 --> 00:31:35,600
there's abby's fingers coming in this

845
00:31:41,590 --> 00:31:39,669
so those are the nozzles and they open

846
00:31:43,430 --> 00:31:41,600
and close releasing some of that

847
00:31:45,590 --> 00:31:43,440
pressurized air

848
00:31:47,669 --> 00:31:45,600
and that's how it pushes itself

849
00:31:50,070 --> 00:31:47,679
around the space station all right so

850
00:31:53,350 --> 00:31:50,080
yeah it's it's very light pressure it's

851
00:31:55,830 --> 00:31:53,360
only about 0.1 psi over the ambient uh

852
00:31:57,190 --> 00:31:55,840
station pressure so very safe it's not

853
00:31:58,630 --> 00:31:57,200
going to you know blow up or anything

854
00:31:59,990 --> 00:31:58,640
yeah

855
00:32:01,110 --> 00:32:00,000
they will

856
00:32:03,110 --> 00:32:01,120
in fact we've seen it when it's

857
00:32:06,230 --> 00:32:03,120
operating on orbit we'll see like hair

858
00:32:11,190 --> 00:32:08,549
so yeah you can definitely see

859
00:32:13,269 --> 00:32:11,200
the air is moving yeah um but it's it's

860
00:32:15,509 --> 00:32:13,279
not gonna like push them out of the way

861
00:32:18,070 --> 00:32:15,519
they're way too massive for this to push

862
00:32:19,830 --> 00:32:18,080
yeah yeah cool all right and then of

863
00:32:20,950 --> 00:32:19,840

course uh the other question we always

864
00:32:23,029 --> 00:32:20,960
get is

865
00:32:24,870 --> 00:32:23,039
how does it uh how does it know where it

866
00:32:26,870 --> 00:32:24,880
is you know how does it move and

867
00:32:31,590 --> 00:32:26,880
navigate and not crash into the walls

868
00:32:35,909 --> 00:32:33,110
section that you see

869
00:32:38,470 --> 00:32:35,919
right there yeah is uh is the the heart

870
00:32:41,269 --> 00:32:38,480
and soul of it it's the core module uh

871
00:32:43,750 --> 00:32:41,279
inside are three um cell phone class

872
00:32:47,590 --> 00:32:43,760
computers so pretty much the same as as

873
00:32:51,509 --> 00:32:47,600
your cell phone um and it uses uh a

874
00:32:55,830 --> 00:32:53,110
there we go a set of cameras but the

875
00:32:58,070 --> 00:32:55,840
main camera the navigation camera on

876
00:33:01,029 --> 00:32:58,080
this end right there

877
00:33:03,590 --> 00:33:01,039
it uses that camera to look at features

878
00:33:05,830 --> 00:33:03,600
inside the space station okay so it has

879
00:33:07,269 --> 00:33:05,840
a map that it keeps on board

880
00:33:09,190 --> 00:33:07,279
of features it knows where those you

881
00:33:11,110 --> 00:33:09,200
know features should be in the station

882
00:33:13,110 --> 00:33:11,120
and then as it's flying around it

883
00:33:16,710 --> 00:33:13,120
compares what it currently sees to that

884
00:33:18,549 --> 00:33:16,720
map to you know figure out where it is

885
00:33:20,149 --> 00:33:18,559
just like you know humans recognize

886
00:33:22,070 --> 00:33:20,159
landmarks to understand

887
00:33:24,950 --> 00:33:22,080
where we are this does that but in a

888
00:33:27,029 --> 00:33:24,960

much more precise manner and uh you know

889
00:33:28,710 --> 00:33:27,039
i i think the other thing that maria was

890
00:33:30,549 --> 00:33:28,720
kind of you know pointing at is that

891
00:33:31,350 --> 00:33:30,559
we've added a whole bunch of cameras on

892
00:33:33,350 --> 00:33:31,360
here

893
00:33:35,269 --> 00:33:33,360
that's really enable it to fly around

894
00:33:36,710 --> 00:33:35,279
and know where it is some of these are

895
00:33:38,789 --> 00:33:36,720
optimized for really sort of like the

896
00:33:40,710 --> 00:33:38,799
close-in docking that you might want to

897
00:33:43,350 --> 00:33:40,720
do with a robot where you need a lot of

898
00:33:45,190 --> 00:33:43,360
accuracy um and others are for just sort

899
00:33:47,110 --> 00:33:45,200
of like free flight where you're really

900
00:33:48,789 --> 00:33:47,120
just trying to worry about hey am i

901
00:33:50,710 --> 00:33:48,799
going to you know be in the center of a

902
00:33:52,710 --> 00:33:50,720
module or near a wall and that kind of

903
00:33:55,430 --> 00:33:52,720
thing yeah and then the last thing i'd

904
00:33:57,430 --> 00:33:55,440
like to point out on this model um

905
00:34:00,230 --> 00:33:57,440
and part of the main purpose of this

906
00:34:01,990 --> 00:34:00,240
robot is to carry payloads we are

907
00:34:03,190 --> 00:34:02,000
actually going to be replacing the

908
00:34:05,190 --> 00:34:03,200
spheres

909
00:34:07,350 --> 00:34:05,200
that we saw earlier

910
00:34:10,149 --> 00:34:07,360
of to carry around other experiments

911
00:34:11,990 --> 00:34:10,159
okay and so uh there's a lot of open

912
00:34:14,389 --> 00:34:12,000
space um you can start seeing my hand

913
00:34:16,710 --> 00:34:14,399

coming through right there

914
00:34:20,310 --> 00:34:16,720
in the bottom and then the top right

915
00:34:22,869 --> 00:34:20,320
allows other technologies to plug into

916
00:34:24,869 --> 00:34:22,879
this robot and we will fly you around

917
00:34:27,510 --> 00:34:24,879
wherever you want to go on space station

918
00:34:29,589 --> 00:34:27,520
uh take your experiment your equipment

919
00:34:31,990 --> 00:34:29,599
yeah uh we'll take you around space

920
00:34:32,629 --> 00:34:32,000
station how cool is that yeah test it

921
00:34:37,510 --> 00:34:32,639
out

922
00:34:39,349 --> 00:34:37,520
i got a great you know mechanism or a

923
00:34:41,190 --> 00:34:39,359
sensor or something else that could be

924
00:34:43,750 --> 00:34:41,200
built for astro b and you can go to

925
00:34:44,909 --> 00:34:43,760
www.nasa.gov

926
00:34:46,950 --> 00:34:44,919
astro b

927
00:34:48,550 --> 00:34:46,960
a-s-t-r-o-b-e-e and you'll find all

928
00:34:50,629 --> 00:34:48,560
kinds of information about the astro b

929
00:34:52,950 --> 00:34:50,639
guest science program

930
00:34:54,950 --> 00:34:52,960
and that tells people about you know the

931
00:34:57,750 --> 00:34:54,960
physical size of the payload bays you

932
00:34:59,510 --> 00:34:57,760
know how you can really develop software

933
00:35:00,710 --> 00:34:59,520
for this and actually some of some of

934
00:35:02,870 --> 00:35:00,720
our interesting experiments are just

935
00:35:05,430 --> 00:35:02,880
going to be just purely software that

936
00:35:07,430 --> 00:35:05,440
people write and we upload into one or

937
00:35:10,630 --> 00:35:07,440
more of the processors on board do you

938
00:35:13,270 --> 00:35:10,640

want to show them our payload oh sure

939
00:35:14,790 --> 00:35:13,280
yeah we have um one of the payloads um

940
00:35:17,829 --> 00:35:14,800
is is this

941
00:35:19,349 --> 00:35:17,839
it's a uh it's actually a robot arm

942
00:35:21,510 --> 00:35:19,359
you can see the gripper here and we can

943
00:35:25,109 --> 00:35:21,520
open the gripper up here

944
00:35:26,710 --> 00:35:25,119
actually you can hear the motors um

945
00:35:28,390 --> 00:35:26,720
i love that

946
00:35:39,190 --> 00:35:28,400
it's a robot

947
00:35:42,630 --> 00:35:40,870
but this is this is a payload for astro

948
00:35:44,390 --> 00:35:42,640
b just like any other and it can plug in

949
00:35:45,589 --> 00:35:44,400
on the handsome maria i'll just show you

950
00:35:47,510 --> 00:35:45,599
where it would go

951
00:35:49,829 --> 00:35:47,520
like right in here in the top payload

952
00:35:51,430 --> 00:35:49,839
bay we just slot it in here all right

953
00:35:52,790 --> 00:35:51,440
all right right and then we have a

954
00:35:54,950 --> 00:35:52,800
couple of levers here that the

955
00:35:56,829 --> 00:35:54,960
astronauts can can

956
00:35:59,430 --> 00:35:56,839
switch to lock it into

957
00:36:01,670 --> 00:35:59,440
place and so it ends up how would

958
00:36:03,829 --> 00:36:01,680
actually use the purging arm oh so it

959
00:36:05,430 --> 00:36:03,839
has it has this gripper uh on the front

960
00:36:08,390 --> 00:36:05,440
here and um you know i can actually open

961
00:36:09,750 --> 00:36:08,400
this up here um this is designed to uh

962
00:36:14,950 --> 00:36:09,760
really you know reach in and grab

963
00:36:18,710 --> 00:36:16,790

but inside the space station um there

964
00:36:20,230 --> 00:36:18,720
are all these handrails that are all

965
00:36:21,910 --> 00:36:20,240
over inside the space station and the

966
00:36:23,589 --> 00:36:21,920
astronauts actually reach out they grab

967
00:36:25,510 --> 00:36:23,599
on to them to hold on

968
00:36:28,550 --> 00:36:25,520
hold themselves in position or to push

969
00:36:30,150 --> 00:36:28,560
themselves uh on onto the next area and

970
00:36:31,430 --> 00:36:30,160
we can take advantage of all the

971
00:36:33,670 --> 00:36:31,440
handrails there

972
00:36:35,349 --> 00:36:33,680
for astro b to grab onto um and that's

973
00:36:37,750 --> 00:36:35,359
why we refer to this actually as the

974
00:36:39,589 --> 00:36:37,760
perching arm you know it's meant to

975
00:36:40,950 --> 00:36:39,599
perch onto things inside the space

976
00:36:42,710 --> 00:36:40,960
station right right when astrid grabs

977
00:36:47,670 --> 00:36:42,720
hold of the handrail we can turn the

978
00:36:51,990 --> 00:36:49,750
yeah and because there's a camera we

979
00:36:54,230 --> 00:36:52,000
have a high def camera on the front end

980
00:36:55,990 --> 00:36:54,240
um and the perching arm here would be

981
00:36:58,390 --> 00:36:56,000
off the back end

982
00:37:00,630 --> 00:36:58,400
right we can use this then as a pan tilt

983
00:37:02,870 --> 00:37:00,640
unit to point the camera wherever we

984
00:37:04,390 --> 00:37:02,880
want okay yeah so you can actually still

985
00:37:06,390 --> 00:37:04,400
move the cam even though the robot is

986
00:37:08,310 --> 00:37:06,400
kind of grabbed onto something and not

987
00:37:09,910 --> 00:37:08,320
flying around you can still point the

988
00:37:12,230 --> 00:37:09,920

camera and move the camera around so it

989
00:37:14,870 --> 00:37:12,240
can still be working yeah exactly right

990
00:37:17,750 --> 00:37:14,880
i have a question here from

991
00:37:20,230 --> 00:37:17,760
mdm phd what serious mission aspects can

992
00:37:23,030 --> 00:37:20,240
be worked by robots such as estrobe oh

993
00:37:25,270 --> 00:37:23,040
well all kinds of things um you know

994
00:37:27,430 --> 00:37:25,280
this in addition to being a research

995
00:37:29,910 --> 00:37:27,440
platform um you know that's a going to

996
00:37:31,910 --> 00:37:29,920
follow onto spheres um is also for us

997
00:37:33,270 --> 00:37:31,920
meant to be something we can test out uh

998
00:37:35,430 --> 00:37:33,280
various things that we would like future

999
00:37:38,230 --> 00:37:35,440
robots to do inside of uh you know

1000
00:37:40,710 --> 00:37:38,240
spacecraft or maybe even future habitats

1001
00:37:42,790 --> 00:37:40,720
on on planets so for example um this

1002
00:37:44,710 --> 00:37:42,800
robot is going to carry a different

1003
00:37:46,790 --> 00:37:44,720
payload built by our friends down at

1004
00:37:49,190 --> 00:37:46,800
nasa johnson in texas

1005
00:37:51,349 --> 00:37:49,200
that's an rfid

1006
00:37:53,349 --> 00:37:51,359
scanner so basically we can go around

1007
00:37:55,910 --> 00:37:53,359
and use the free flying robot to take

1008
00:37:57,910 --> 00:37:55,920
inventory of things that we have tagged

1009
00:37:59,109 --> 00:37:57,920
with you know little little tags just

1010
00:38:00,470 --> 00:37:59,119
like in your credit card just like in

1011
00:38:01,750 --> 00:38:00,480
your credit card or you might have

1012
00:38:03,109 --> 00:38:01,760
against

1013
00:38:05,030 --> 00:38:03,119

grocery stores

1014
00:38:07,109 --> 00:38:05,040
just to do inventory so inventory is a

1015
00:38:09,030 --> 00:38:07,119
great task for robots

1016
00:38:11,430 --> 00:38:09,040
another is just monitoring the

1017
00:38:13,430 --> 00:38:11,440
environment just trying to assess you

1018
00:38:14,870 --> 00:38:13,440
know like light levels or sound levels

1019
00:38:16,150 --> 00:38:14,880
or air quality

1020
00:38:18,870 --> 00:38:16,160
and so we could put different sensors

1021
00:38:20,470 --> 00:38:18,880
onto astr b and do that um you know all

1022
00:38:23,030 --> 00:38:20,480
kinds of interesting things that you can

1023
00:38:24,550 --> 00:38:23,040
use a robot for to really you know help

1024
00:38:26,470 --> 00:38:24,560
take care of the environment inside of

1025
00:38:27,990 --> 00:38:26,480
your spacecraft and in kind of freeing

1026
00:38:29,190 --> 00:38:28,000
up the time for the astronauts right

1027
00:38:30,790 --> 00:38:29,200
because they spend a lot of time doing

1028
00:38:33,270 --> 00:38:30,800
tasks like the inventory and the

1029
00:38:34,390 --> 00:38:33,280
monitoring and if you have a robot doing

1030
00:38:35,910 --> 00:38:34,400
that

1031
00:38:37,910 --> 00:38:35,920
it you know frees them up to do other

1032
00:38:40,069 --> 00:38:37,920
things right yeah is that kind of the i

1033
00:38:41,670 --> 00:38:40,079
think that's the purpose yeah i think i

1034
00:38:42,950 --> 00:38:41,680
think today um

1035
00:38:45,430 --> 00:38:42,960
maybe we'll talk about this more and

1036
00:38:47,270 --> 00:38:45,440
later on in the show here but uh you

1037
00:38:48,950 --> 00:38:47,280
know today on the space station it's a

1038
00:38:50,310 --> 00:38:48,960

place where we have you know astronauts

1039
00:38:52,150 --> 00:38:50,320
all the time it's been continuously

1040
00:38:53,750 --> 00:38:52,160
manned for a long time now

1041
00:38:55,349 --> 00:38:53,760
but the astronauts actually spend a lot

1042
00:38:57,349 --> 00:38:55,359
of their time doing maintenance a lot of

1043
00:38:59,510 --> 00:38:57,359
routine maintenance um some of it is

1044
00:39:01,190 --> 00:38:59,520
just you know preventive you know it's

1045
00:39:03,030 --> 00:39:01,200
time to actually you know change an air

1046
00:39:04,069 --> 00:39:03,040
filter um some of it is correct because

1047
00:39:05,990 --> 00:39:04,079
something broke

1048
00:39:08,069 --> 00:39:06,000
um and we'd like to try to use robots to

1049
00:39:09,109 --> 00:39:08,079
help uh take care of those tasks so that

1050
00:39:10,710 --> 00:39:09,119
you know the astronauts don't have to

1051
00:39:14,069 --> 00:39:10,720
spend so much of their time doing that

1052
00:39:16,710 --> 00:39:14,079
right right right all right well i have

1053
00:39:18,650 --> 00:39:16,720
a couple comments about aster v

1054
00:39:22,470 --> 00:39:18,660
that's one weird looking r2d2

1055
00:39:24,470 --> 00:39:22,480
[Laughter]

1056
00:39:26,630 --> 00:39:24,480
okay i want one

1057
00:39:27,990 --> 00:39:26,640
and oh it's kind of like a companion

1058
00:39:29,109 --> 00:39:28,000
cube

1059
00:39:30,950 --> 00:39:29,119
yes

1060
00:39:33,750 --> 00:39:30,960
we've it's been pointed out to us the

1061
00:39:34,870 --> 00:39:33,760
the resemblance uh in the past yeah

1062
00:39:36,069 --> 00:39:34,880
thank you

1063
00:39:38,710 --> 00:39:36,079

all right

1064
00:39:41,750 --> 00:39:38,720
we have a question here uh that says how

1065
00:39:43,190 --> 00:39:41,760
do you charge or recharge the astro b

1066
00:39:44,390 --> 00:39:43,200
that's an excellent question we didn't

1067
00:39:47,190 --> 00:39:44,400
even get to that you could turn the

1068
00:39:50,390 --> 00:39:47,200
robot around and uh yeah so uh astro b

1069
00:39:51,589 --> 00:39:50,400
actually has a docking station on uh on

1070
00:39:54,069 --> 00:39:51,599
space station

1071
00:39:56,150 --> 00:39:54,079
um that lets us uh the robot can

1072
00:39:59,030 --> 00:39:56,160
actually autonomously plug itself in so

1073
00:40:01,270 --> 00:39:59,040
it's kind of your roomba in space

1074
00:40:04,230 --> 00:40:01,280
i can go out and fly these sorties where

1075
00:40:06,150 --> 00:40:04,240
it takes measurements and uh

1076
00:40:08,390 --> 00:40:06,160
does guest science and then when it

1077
00:40:10,230 --> 00:40:08,400
starts the power starts to run low um it

1078
00:40:12,710 --> 00:40:10,240
has a docking port on the back which we

1079
00:40:15,109 --> 00:40:12,720
see here um and it can actually back

1080
00:40:17,589 --> 00:40:15,119
itself into its its docking station and

1081
00:40:19,670 --> 00:40:17,599
recharge um and we also give it an

1082
00:40:22,309 --> 00:40:19,680
ethernet connection to the space station

1083
00:40:24,230 --> 00:40:22,319
uh local area network when we do that so

1084
00:40:26,470 --> 00:40:24,240
we get a little bit of higher bandwidth

1085
00:40:32,950 --> 00:40:26,480
on on communication oh yeah okay so you

1086
00:40:35,829 --> 00:40:33,829
yeah

1087
00:40:39,109 --> 00:40:35,839
should we check out the video of that

1088
00:40:43,829 --> 00:40:40,950

oh here we go this is so this is

1089
00:40:45,030 --> 00:40:43,839
astorby's first autonomous undock

1090
00:40:46,710 --> 00:40:45,040
um

1091
00:40:49,270 --> 00:40:46,720
we see uh

1092
00:40:51,109 --> 00:40:49,280
astronaut david there uh giving us the

1093
00:40:53,670 --> 00:40:51,119
play-by-play that's not a toothbrush

1094
00:40:55,990 --> 00:40:53,680
he's holding that's actually microphone

1095
00:40:57,990 --> 00:40:56,000
and everybody was excited by that first

1096
00:41:00,630 --> 00:40:58,000
autonomous motion and then here we see

1097
00:41:03,270 --> 00:41:00,640
it docking this is our first autonomous

1098
00:41:05,030 --> 00:41:03,280
docking motion so it just backed itself

1099
00:41:06,710 --> 00:41:05,040
up into the dock we'll see a little

1100
00:41:08,710 --> 00:41:06,720
light come on telling us that there we

1101
00:41:11,349 --> 00:41:08,720
go we've got a good connection

1102
00:41:14,069 --> 00:41:11,359
um and this was big celebration uh for

1103
00:41:16,790 --> 00:41:14,079
us uh the team running this uh and and

1104
00:41:18,829 --> 00:41:16,800
crew was very excited too so yeah

1105
00:41:20,870 --> 00:41:18,839
christina was very excited by that as

1106
00:41:22,470 --> 00:41:20,880
well awesome big steps

1107
00:41:24,630 --> 00:41:22,480
very big steps

1108
00:41:28,390 --> 00:41:24,640
yeah what did the astronauts say about

1109
00:41:31,670 --> 00:41:29,750
you know you know really positive

1110
00:41:34,790 --> 00:41:31,680
comments for them i mean for them really

1111
00:41:37,589 --> 00:41:34,800
it's it's a new teammate in space um and

1112
00:41:39,589 --> 00:41:37,599
uh you know i recall that the first time

1113
00:41:41,430 --> 00:41:39,599

um you know that ashrae was at least the

1114
00:41:43,670 --> 00:41:41,440
first astro b was unboxed it was kind of

1115
00:41:44,870 --> 00:41:43,680
like like you know christmas in space

1116
00:41:46,630 --> 00:41:44,880
yeah

1117
00:41:48,870 --> 00:41:46,640
hey look what i got i got a i got a new

1118
00:41:50,550 --> 00:41:48,880
teammate i got a new roommate all in one

1119
00:41:53,030 --> 00:41:50,560
and i can teach you how to actually you

1120
00:41:54,470 --> 00:41:53,040
know be a good good roommate

1121
00:41:55,910 --> 00:41:54,480
you know you get your new cell phone and

1122
00:41:58,550 --> 00:41:55,920
you're pulling out all the boxes that

1123
00:41:59,510 --> 00:41:58,560
was very exciting yeah very shiny new

1124
00:42:04,150 --> 00:41:59,520
yeah

1125
00:42:06,309 --> 00:42:04,160
have to read the manual

1126
00:42:07,990 --> 00:42:06,319
can i just play with it yeah so we've

1127
00:42:09,670 --> 00:42:08,000
certainly had that we when we were first

1128
00:42:11,750 --> 00:42:09,680
building it was very much a concern that

1129
00:42:13,910 --> 00:42:11,760
we would be good teammates that we would

1130
00:42:15,750 --> 00:42:13,920
be for instance too loud you know we

1131
00:42:18,069 --> 00:42:15,760
want to stay quiet and we don't want to

1132
00:42:19,910 --> 00:42:18,079
be annoying

1133
00:42:22,150 --> 00:42:19,920
so because of the fans it's going to

1134
00:42:24,150 --> 00:42:22,160
make a constant noise so we want to you

1135
00:42:25,910 --> 00:42:24,160
know minimize that and so far the

1136
00:42:27,829 --> 00:42:25,920
feedback we've gotten from

1137
00:42:29,990 --> 00:42:27,839
from astronauts is that it's it's very

1138
00:42:31,109 --> 00:42:30,000

reasonable it's not too loud and it's

1139
00:42:33,270 --> 00:42:31,119
they actually kind of like it because

1140
00:42:35,109 --> 00:42:33,280
they can hear it coming

1141
00:42:35,730 --> 00:42:35,119
you can't sneak up on them

1142
00:42:37,510 --> 00:42:35,740
exactly

1143
00:42:39,750 --> 00:42:37,520
[Laughter]

1144
00:42:41,910 --> 00:42:39,760
you had some other fun things to say the

1145
00:42:44,150 --> 00:42:41,920
other day about um the astronauts are

1146
00:42:45,190 --> 00:42:44,160
guiding it around i think sort of that's

1147
00:42:47,510 --> 00:42:45,200
right

1148
00:42:49,910 --> 00:42:47,520
yes uh one of the first activities we

1149
00:42:51,589 --> 00:42:49,920
had to do is is build the map of the

1150
00:42:53,430 --> 00:42:51,599
inside of the space station right we

1151
00:42:55,190 --> 00:42:53,440
have models on the ground but you need

1152
00:42:57,030 --> 00:42:55,200
to know what it really looks like you

1153
00:43:00,630 --> 00:42:57,040
know from the robot's point of view

1154
00:43:03,030 --> 00:43:00,640
right so um astronaut david uh was uh

1155
00:43:05,270 --> 00:43:03,040
actually flying us manually flying us

1156
00:43:07,190 --> 00:43:05,280
around so that we could collect imagery

1157
00:43:08,309 --> 00:43:07,200
data while he was moving us around

1158
00:43:11,109 --> 00:43:08,319
because we don't know where we are yet

1159
00:43:13,190 --> 00:43:11,119
so we can't fly ourselves right so he

1160
00:43:14,309 --> 00:43:13,200
manually moved us back and forth and he

1161
00:43:19,990 --> 00:43:14,319
it was great he said it was like

1162
00:43:23,349 --> 00:43:21,750
excellent i must say it was really

1163
00:43:25,829 --> 00:43:23,359

interesting and like exciting watching

1164
00:43:27,829 --> 00:43:25,839
you guys you know do these you know

1165
00:43:29,270 --> 00:43:27,839
tests in the lab here and just the

1166
00:43:31,510 --> 00:43:29,280
excitement i mean the astronauts are

1167
00:43:33,349 --> 00:43:31,520
excited and then the team's excited here

1168
00:43:39,109 --> 00:43:33,359
it's really really cool to experience

1169
00:43:42,069 --> 00:43:40,710
we have spent a lot of time you know

1170
00:43:44,150 --> 00:43:42,079
working through the design and

1171
00:43:46,069 --> 00:43:44,160
development of astro b and certainly i

1172
00:43:48,069 --> 00:43:46,079
think for the team you know seeing it in

1173
00:43:50,069 --> 00:43:48,079
space was just hugely you know really

1174
00:43:52,390 --> 00:43:50,079
rewarding it was really great to see

1175
00:43:54,309 --> 00:43:52,400
that you know actually happen i can give

1176
00:43:55,910 --> 00:43:54,319
you some breaking news that just

1177
00:43:57,349 --> 00:43:55,920
yesterday morning very early in the

1178
00:43:59,990 --> 00:43:57,359
morning

1179
00:44:02,710 --> 00:44:00,000
we uh we had a test with astro b with

1180
00:44:04,630 --> 00:44:02,720
with bumble the blue the blue robot uh

1181
00:44:06,470 --> 00:44:04,640
flying it around it flew itself it

1182
00:44:08,710 --> 00:44:06,480
autonomously operated it ran a whole

1183
00:44:11,190 --> 00:44:08,720
bunch of plans you know undocked itself

1184
00:44:13,030 --> 00:44:11,200
flew around came back to doc

1185
00:44:14,630 --> 00:44:13,040
it went really great yeah it was just a

1186
00:44:17,670 --> 00:44:14,640
wonderful activity to see that

1187
00:44:19,829 --> 00:44:17,680
independence it really is like a kid

1188
00:44:23,829 --> 00:44:19,839

yeah just a couple months ago

1189
00:44:26,710 --> 00:44:25,109
the thing there is we don't want to wait

1190
00:44:32,690 --> 00:44:26,720
you know 20 years for it to grow up and

1191
00:44:37,750 --> 00:44:36,150
[Laughter]

1192
00:44:39,990 --> 00:44:37,760
yeah

1193
00:44:41,510 --> 00:44:40,000
all right so we've been talking about

1194
00:44:43,670 --> 00:44:41,520
how these robots are helping astronauts

1195
00:44:45,349 --> 00:44:43,680
today right so what about looking a

1196
00:44:47,670 --> 00:44:45,359
little bit ahead because right now nasa

1197
00:44:49,910 --> 00:44:47,680
is busy working to get humans to the

1198
00:44:51,910 --> 00:44:49,920
moon in 2024 that's the artemis burger

1199
00:44:54,309 --> 00:44:51,920
right could you maybe

1200
00:44:56,550 --> 00:44:54,319
summarize for people what artemis is all

1201
00:44:58,390 --> 00:44:56,560
about and then yeah so i mean artemis is

1202
00:45:00,790 --> 00:44:58,400
certainly a first step of you know

1203
00:45:02,950 --> 00:45:00,800
extending human presence beyond just uh

1204
00:45:04,230 --> 00:45:02,960
you know earth and earth orbit

1205
00:45:05,990 --> 00:45:04,240
you know our goal here is of course to

1206
00:45:08,309 --> 00:45:06,000
get people back to the moon um you know

1207
00:45:10,069 --> 00:45:08,319
by 2024 and to do that we're building a

1208
00:45:12,710 --> 00:45:10,079
number of different systems you know new

1209
00:45:14,710 --> 00:45:12,720
spacecraft new landers and this really

1210
00:45:17,430 --> 00:45:14,720
interesting thing called the gateway

1211
00:45:19,270 --> 00:45:17,440
you know it's meant to be an orbiting

1212
00:45:20,069 --> 00:45:19,280
sort of mini space station around the

1213
00:45:22,230 --> 00:45:20,079

moon

1214
00:45:23,670 --> 00:45:22,240
and it's a place that we're building not

1215
00:45:25,190 --> 00:45:23,680
just because we want something to orbit

1216
00:45:25,990 --> 00:45:25,200
the moon but it's really a jumping off

1217
00:45:28,470 --> 00:45:26,000
point

1218
00:45:30,069 --> 00:45:28,480
to go beyond the moon and also to be a

1219
00:45:32,870 --> 00:45:30,079
place where you can you know carry out

1220
00:45:35,030 --> 00:45:32,880
experiments beyond earth orbit a place

1221
00:45:36,710 --> 00:45:35,040
where you can you know use that to go to

1222
00:45:38,870 --> 00:45:36,720
and from the lunar surface

1223
00:45:40,470 --> 00:45:38,880
um but unlike the space station it's

1224
00:45:42,069 --> 00:45:40,480
meant to be a place where you know will

1225
00:45:44,150 --> 00:45:42,079
only occasionally be there at least at

1226
00:45:46,230 --> 00:45:44,160
first okay and so if you're only there

1227
00:45:48,150 --> 00:45:46,240
for say you know a few weeks of the year

1228
00:45:49,510 --> 00:45:48,160
what happens rest the time well it's

1229
00:45:50,870 --> 00:45:49,520
like having a vacation home you still

1230
00:45:52,550 --> 00:45:50,880
need to take care of that yeah maintain

1231
00:45:54,069 --> 00:45:52,560
it you need to you know do caretaking

1232
00:45:55,510 --> 00:45:54,079
and uh you know at least in my opinion i

1233
00:45:58,309 --> 00:45:55,520
think the very best way of doing that is

1234
00:45:59,349 --> 00:45:58,319
to to make use of robots

1235
00:46:00,470 --> 00:45:59,359
you know maybe they'll be a little

1236
00:46:01,510 --> 00:46:00,480
lonely because they're there by

1237
00:46:03,510 --> 00:46:01,520
themselves

1238
00:46:05,270 --> 00:46:03,520

but they can take care of the place

1239
00:46:11,349 --> 00:46:05,280
make sure the lights are on and they

1240
00:46:14,710 --> 00:46:12,550
we have an animation of the gateway it

1241
00:46:16,710 --> 00:46:14,720
might be fun for people to see that um

1242
00:46:18,390 --> 00:46:16,720
and i think you just answered pluto

1243
00:46:20,069 --> 00:46:18,400
nine's question could you explain how

1244
00:46:21,990 --> 00:46:20,079
the role of robotics could be on the

1245
00:46:22,950 --> 00:46:22,000
planet yeah you see a robot arm right

1246
00:46:24,870 --> 00:46:22,960
right there

1247
00:46:27,109 --> 00:46:24,880
actually we talked earlier about robots

1248
00:46:28,870 --> 00:46:27,119
being inside and outside of station so

1249
00:46:31,589 --> 00:46:28,880
and i think the same thing is true about

1250
00:46:33,510 --> 00:46:31,599
uh the gateway uh certainly um we expect

1251
00:46:34,630 --> 00:46:33,520
there to be an external robot arm you

1252
00:46:37,670 --> 00:46:34,640
can see that right there in the

1253
00:46:39,430 --> 00:46:37,680
animation um and i think at some point

1254
00:46:42,230 --> 00:46:39,440
in the future hopefully not too distant

1255
00:46:43,829 --> 00:46:42,240
future we'll see robots inside

1256
00:46:45,910 --> 00:46:43,839
performing some of these uh these

1257
00:46:48,309 --> 00:46:45,920
caretaking right tasks

1258
00:46:50,470 --> 00:46:48,319
um and i think beyond that too of course

1259
00:46:52,470 --> 00:46:50,480
you know here um you know at nasa we

1260
00:46:54,710 --> 00:46:52,480
have spent quite a bit of time you know

1261
00:46:56,710 --> 00:46:54,720
researching and studying you know how

1262
00:46:59,109 --> 00:46:56,720
humans and robots can work together on

1263
00:47:00,870 --> 00:46:59,119

planetary surfaces right

1264
00:47:02,630 --> 00:47:00,880
as we get you know people back to the

1265
00:47:04,870 --> 00:47:02,640
moon i fully expect there to be be

1266
00:47:06,390 --> 00:47:04,880
robots there as well and there are the

1267
00:47:08,950 --> 00:47:06,400
ideas that you could have humans and

1268
00:47:10,710 --> 00:47:08,960
robots uh doing things on the surface

1269
00:47:12,390 --> 00:47:10,720
maybe the robots are doing scouting

1270
00:47:14,710 --> 00:47:12,400
maybe they're setting up uh you know

1271
00:47:17,270 --> 00:47:14,720
infrastructure like uh communication

1272
00:47:18,790 --> 00:47:17,280
arrays solar panels uh maybe

1273
00:47:21,190 --> 00:47:18,800
habitats yeah maybe

1274
00:47:23,030 --> 00:47:21,200
build landing pads um and they're you

1275
00:47:24,549 --> 00:47:23,040
know really i think the

1276
00:47:26,150 --> 00:47:24,559
honestly the sky's the limit about the

1277
00:47:28,549 --> 00:47:26,160
things you can think about for ways for

1278
00:47:30,549 --> 00:47:28,559
humans and robots to team right um as we

1279
00:47:31,910 --> 00:47:30,559
carry out future exploration

1280
00:47:33,670 --> 00:47:31,920
yeah i think we have a question here

1281
00:47:37,589 --> 00:47:33,680
from and you know to what you're

1282
00:47:40,790 --> 00:47:37,599
speaking about airplane man 1997 uh

1283
00:47:42,950 --> 00:47:40,800
will we have robots in deep space

1284
00:47:44,950 --> 00:47:42,960
um on other planets that will help

1285
00:47:46,309 --> 00:47:44,960
humans you know explore those planets

1286
00:47:48,470 --> 00:47:46,319
that we've never you know explored

1287
00:47:50,470 --> 00:47:48,480
before yeah absolutely i mean we we have

1288
00:47:52,549 --> 00:47:50,480

robots today on mars but at some point

1289
00:47:54,630 --> 00:47:52,559
in time we'll have humans there as well

1290
00:47:56,309 --> 00:47:54,640
you know and i think um at least right

1291
00:47:58,630 --> 00:47:56,319
now the the current focus on the moon is

1292
00:47:59,910 --> 00:47:58,640
a great opportunity of not just for nasa

1293
00:48:02,470 --> 00:47:59,920
but for the for you know the entire

1294
00:48:04,390 --> 00:48:02,480
world to learn how to really live and

1295
00:48:06,069 --> 00:48:04,400
work uh you know on another planetary

1296
00:48:07,829 --> 00:48:06,079
surface on the moon right and then we

1297
00:48:08,950 --> 00:48:07,839
can use all the things that we learn

1298
00:48:11,190 --> 00:48:08,960
everything that we've developed and

1299
00:48:13,430 --> 00:48:11,200
tested and apply that to other places

1300
00:48:15,190 --> 00:48:13,440
such as mars very great kind of continue

1301
00:48:16,710 --> 00:48:15,200
the teaming that you you talked about

1302
00:48:18,630 --> 00:48:16,720
earlier right

1303
00:48:20,470 --> 00:48:18,640
in other words

1304
00:48:22,870 --> 00:48:20,480
yeah exactly did you guys already talk a

1305
00:48:25,109 --> 00:48:22,880
little bit about the before in parallel

1306
00:48:27,030 --> 00:48:25,119
and after kind of ideas yeah terry sort

1307
00:48:28,870 --> 00:48:27,040
of covered uh yeah a bit of that with

1308
00:48:31,510 --> 00:48:28,880
talking about scouting and preparing

1309
00:48:33,349 --> 00:48:31,520
infrastructure uh sort of the after is

1310
00:48:34,710 --> 00:48:33,359
you can uh you know crew's only gonna be

1311
00:48:36,150 --> 00:48:34,720
there for a certain amount of time you

1312
00:48:38,710 --> 00:48:36,160
know that the humans will probably then

1313
00:48:41,190 --> 00:48:38,720

go home after a few months or a year

1314
00:48:43,750 --> 00:48:41,200
maybe uh and then you want the robots

1315
00:48:46,150 --> 00:48:43,760
will stay behind so they can continue to

1316
00:48:47,829 --> 00:48:46,160
do some of the work that the astronauts

1317
00:48:50,230 --> 00:48:47,839
started yeah for instance we talked

1318
00:48:51,910 --> 00:48:50,240
about those tedious you know jobs yes

1319
00:48:53,190 --> 00:48:51,920
taking lots of measurements so they

1320
00:49:06,870 --> 00:48:53,200
could go in there and really

1321
00:49:10,150 --> 00:49:08,470
several years ago we had a research

1322
00:49:12,549 --> 00:49:10,160
project here at nasa ames called the

1323
00:49:14,710 --> 00:49:12,559
robotic follow-up project and maria was

1324
00:49:16,309 --> 00:49:14,720
actually the the project manager for

1325
00:49:18,390 --> 00:49:16,319
that okay um and that was really all

1326
00:49:20,950 --> 00:49:18,400
about exactly that you know we we sent

1327
00:49:23,270 --> 00:49:20,960
out uh some astronauts uh into the field

1328
00:49:28,950 --> 00:49:23,280
and they had handheld uh you know

1329
00:49:33,109 --> 00:49:30,870
a simulated site it guess what we call a

1330
00:49:35,109 --> 00:49:33,119
planetary analog you know so a location

1331
00:49:37,270 --> 00:49:35,119
on earth that has features that are

1332
00:49:38,630 --> 00:49:37,280
similar exactly to places that we care

1333
00:49:39,829 --> 00:49:38,640
about on the moon or mars and this

1334
00:49:42,069 --> 00:49:39,839
particular case was in the canadian

1335
00:49:43,990 --> 00:49:42,079
arctic oh wow um this wonderfully

1336
00:49:46,950 --> 00:49:44,000
interesting place called devon island

1337
00:49:49,430 --> 00:49:46,960
and on there is a large 20 kilometer you

1338
00:49:51,750 --> 00:49:49,440

know 12 meter or 12 mile or so diameter

1339
00:49:53,670 --> 00:49:51,760
uh impact structure you know a big giant

1340
00:49:55,670 --> 00:49:53,680
crater

1341
00:49:56,630 --> 00:49:55,680
we had simulated astronauts

1342
00:49:58,549 --> 00:49:56,640
doing

1343
00:50:01,270 --> 00:49:58,559
some mapping work there some field

1344
00:50:03,510 --> 00:50:01,280
geology work um and then after they were

1345
00:50:05,510 --> 00:50:03,520
done you know they came back home we

1346
00:50:06,710 --> 00:50:05,520
looked at the robots

1347
00:50:11,430 --> 00:50:06,720
and then we sent the robots so the

1348
00:50:15,270 --> 00:50:12,790
study they humans able to like for

1349
00:50:17,030 --> 00:50:15,280
instance use a ground penetrating radar

1350
00:50:19,030 --> 00:50:17,040
and sweep over the ground you're just

1351
00:50:20,470 --> 00:50:19,040
going back and forth yeah basically

1352
00:50:23,349 --> 00:50:20,480
mowing the lawn

1353
00:50:25,589 --> 00:50:23,359
with the gprs so yeah taking you know

1354
00:50:26,630 --> 00:50:25,599
thousands of measurements that frankly

1355
00:50:29,109 --> 00:50:26,640
would have been

1356
00:50:31,910 --> 00:50:29,119
really tedious really um you know

1357
00:50:33,910 --> 00:50:31,920
difficult i think for humans to do yeah

1358
00:50:35,670 --> 00:50:33,920
right yeah very cool how did it do did

1359
00:50:37,670 --> 00:50:35,680
it do well it did its job well on its

1360
00:50:41,109 --> 00:50:37,680
own it didn't slack off after the humans

1361
00:50:44,230 --> 00:50:41,119
left well you know

1362
00:50:46,150 --> 00:50:44,240
another another set of readings really

1363
00:50:49,030 --> 00:50:46,160

i don't think so i'm gonna take a break

1364
00:50:50,470 --> 00:50:49,040
yeah i mean robots robots um they they

1365
00:50:52,069 --> 00:50:50,480
might run out of energy but right you

1366
00:50:52,790 --> 00:50:52,079
know they still need care and feeding as

1367
00:50:55,750 --> 00:50:52,800
well

1368
00:50:57,990 --> 00:50:55,760
yeah yeah that's true okay yeah so that

1369
00:51:00,390 --> 00:50:58,000
was the after example of this

1370
00:51:02,230 --> 00:51:00,400
before during and after humans are there

1371
00:51:04,470 --> 00:51:02,240
which is kind of like surgery you told

1372
00:51:06,069 --> 00:51:04,480
me the other day yeah we already do this

1373
00:51:07,589 --> 00:51:06,079
it's like surgery too you know i mean

1374
00:51:09,270 --> 00:51:07,599
you know obviously the brain surgeon's

1375
00:51:10,470 --> 00:51:09,280
not going to do everything end to end

1376
00:51:11,750 --> 00:51:10,480
you know there's someone who's doing

1377
00:51:13,589 --> 00:51:11,760
preparation

1378
00:51:16,069 --> 00:51:13,599
and they get the patient ready and the

1379
00:51:18,710 --> 00:51:16,079
operating room ready and then

1380
00:51:20,150 --> 00:51:18,720
the brain surgeon comes in you know

1381
00:51:21,270 --> 00:51:20,160
they leave and then somebody cleans up

1382
00:51:23,670 --> 00:51:21,280
afterwards

1383
00:51:25,750 --> 00:51:23,680
you know and i i think um you know the

1384
00:51:27,510 --> 00:51:25,760
idea that humans working with robots in

1385
00:51:28,710 --> 00:51:27,520
space you know it might they might

1386
00:51:30,470 --> 00:51:28,720
follow that same kind of model you have

1387
00:51:32,470 --> 00:51:30,480
robots that are doing things ahead of

1388
00:51:34,630 --> 00:51:32,480

time and maybe takes a long time

1389
00:51:36,870 --> 00:51:34,640
and then the humans arrive and do the

1390
00:51:37,910 --> 00:51:36,880
parts that require humans and you know

1391
00:51:39,670 --> 00:51:37,920
afterwards

1392
00:51:45,589 --> 00:51:39,680
yeah the robots come back and they say

1393
00:51:49,030 --> 00:51:47,349
forever

1394
00:51:51,510 --> 00:51:49,040
i can do this much quicker

1395
00:51:53,270 --> 00:51:51,520
right here's an example used maybe

1396
00:51:54,710 --> 00:51:53,280
airplane man 1997 wants to know should

1397
00:51:56,390 --> 00:51:54,720
there be a robot that follows people

1398
00:51:58,150 --> 00:51:56,400
around to make sure areas are safe when

1399
00:52:00,150 --> 00:51:58,160
we're on mars for example

1400
00:52:02,069 --> 00:52:00,160
perhaps the moon yeah there have been

1401
00:52:04,549 --> 00:52:02,079
other projects here at nasa that have

1402
00:52:06,309 --> 00:52:04,559
looked at the idea of of robots doing

1403
00:52:08,950 --> 00:52:06,319
scouting or skill where they're really

1404
00:52:11,510 --> 00:52:08,960
scouting you know not you know years in

1405
00:52:13,109 --> 00:52:11,520
advance but just ahead of humans or

1406
00:52:14,870 --> 00:52:13,119
maybe robots that are just behind them

1407
00:52:17,349 --> 00:52:14,880
carrying tools or

1408
00:52:19,349 --> 00:52:17,359
supplies yeah um i think that kind of

1409
00:52:21,829 --> 00:52:19,359
you know real-time support is also

1410
00:52:24,630 --> 00:52:21,839
really of interest too yeah

1411
00:52:25,910 --> 00:52:24,640
all three yeah all right um

1412
00:52:28,549 --> 00:52:25,920
we've got lots of questions so we're

1413
00:52:31,270 --> 00:52:28,559

gonna definitely save time for those uh

1414
00:52:33,589 --> 00:52:31,280
some comments like the life is yours

1415
00:52:35,829 --> 00:52:33,599
calls astr be space roomba

1416
00:52:37,829 --> 00:52:35,839
yeah yeah

1417
00:52:39,190 --> 00:52:37,839
we thought of that too we've

1418
00:52:40,870 --> 00:52:39,200
we've had other comments too that you

1419
00:52:42,870 --> 00:52:40,880
know uh people have said hey you know

1420
00:52:43,670 --> 00:52:42,880
you the the spheres robots that you guys

1421
00:52:45,510 --> 00:52:43,680
have been working with obviously

1422
00:52:47,270 --> 00:52:45,520
inspired by star wars and you know some

1423
00:52:50,309 --> 00:52:47,280
some people have said well you know your

1424
00:52:54,069 --> 00:52:50,319
new robot is a cube you know so was that

1425
00:52:58,549 --> 00:52:54,079
inspired by that other you know show

1426
00:52:58,559 --> 00:53:02,069
what are its intentions

1427
00:53:05,910 --> 00:53:03,910
so far it's been very good it's very

1428
00:53:07,650 --> 00:53:05,920
benign right

1429
00:53:09,589 --> 00:53:07,660
hasn't tried to assimilate everybody

1430
00:53:12,710 --> 00:53:09,599
[Laughter]

1431
00:53:14,390 --> 00:53:12,720
exactly i just want to make that clear

1432
00:53:17,109 --> 00:53:14,400
we uh have a question well we have a

1433
00:53:18,710 --> 00:53:17,119
question here from uh coffee fx saying

1434
00:53:20,549 --> 00:53:18,720
what are the biggest challenges in

1435
00:53:21,990 --> 00:53:20,559
building a robot designed to operate in

1436
00:53:23,750 --> 00:53:22,000
a space environment yeah that's a great

1437
00:53:26,790 --> 00:53:23,760
question so actually one of our biggest

1438
00:53:29,829 --> 00:53:26,800

challenges in it comes from operating

1439
00:53:31,430 --> 00:53:29,839
near humans in safety right of course so

1440
00:53:33,750 --> 00:53:31,440
you know we could probably make a robot

1441
00:53:34,710 --> 00:53:33,760
that can fly real fast and

1442
00:53:36,470 --> 00:53:34,720
but

1443
00:53:38,630 --> 00:53:36,480
you know there are windows on space

1444
00:53:39,910 --> 00:53:38,640
station so we don't want to actually

1445
00:53:41,510 --> 00:53:39,920
break

1446
00:53:43,270 --> 00:53:41,520
that would not be good that would not be

1447
00:53:45,670 --> 00:53:43,280
good so actually it's been pretty

1448
00:53:49,829 --> 00:53:45,680
challenging coming up with a propulsion

1449
00:53:51,670 --> 00:53:49,839
system that's very nimble um responsive

1450
00:53:53,990 --> 00:53:51,680
uh moves us at like a reasonable rate

1451
00:53:57,109 --> 00:53:54,000
can move a reasonable amount of mass and

1452
00:53:58,790 --> 00:53:57,119
yet is safe right um so

1453
00:54:01,270 --> 00:53:58,800
you know those considerations really

1454
00:54:02,390 --> 00:54:01,280
make it a challenge

1455
00:54:04,870 --> 00:54:02,400
are there i don't know are there

1456
00:54:07,910 --> 00:54:04,880
hardware considerations like

1457
00:54:11,349 --> 00:54:07,920
does it have to be extra sturdy

1458
00:54:13,829 --> 00:54:11,359
there are all sorts of

1459
00:54:15,750 --> 00:54:13,839
the space station environment um is it's

1460
00:54:16,790 --> 00:54:15,760
actually a nice gentle environment i

1461
00:54:18,230 --> 00:54:16,800
mean there's

1462
00:54:20,069 --> 00:54:18,240
there's there's very little gravity and

1463
00:54:22,230 --> 00:54:20,079

there's really microgravity there

1464
00:54:23,910 --> 00:54:22,240
essentially zero gravity um and it's

1465
00:54:25,270 --> 00:54:23,920
like an office environment you know it's

1466
00:54:28,230 --> 00:54:25,280
short-sleeved it's you know it's

1467
00:54:30,790 --> 00:54:28,240
temperature control right temperature

1468
00:54:32,549 --> 00:54:30,800
but the problem is getting there because

1469
00:54:35,109 --> 00:54:32,559
to get there you have to get on a rocket

1470
00:54:37,190 --> 00:54:35,119
right and a rocket shakes you and shakes

1471
00:54:38,870 --> 00:54:37,200
you and shakes you and so some of what

1472
00:54:41,109 --> 00:54:38,880
we did over the past couple years was

1473
00:54:42,549 --> 00:54:41,119
trying to design astro b to survive

1474
00:54:44,789 --> 00:54:42,559
really the shock of

1475
00:54:46,950 --> 00:54:44,799
being blashed to the space station yeah

1476
00:54:48,630 --> 00:54:46,960
yeah so we had to do vibration testing

1477
00:54:51,270 --> 00:54:48,640
and make sure that it still worked after

1478
00:54:53,270 --> 00:54:51,280
we shook it yeah yeah that was yeah so

1479
00:54:55,510 --> 00:54:53,280
there are structural constraints um

1480
00:54:56,950 --> 00:54:55,520
electricity electrical as well your

1481
00:54:58,390 --> 00:54:56,960
systems you have to make sure that

1482
00:54:59,109 --> 00:54:58,400
you're not going to shock any you know

1483
00:55:01,030 --> 00:54:59,119
right

1484
00:55:03,430 --> 00:55:01,040
that touches you yeah

1485
00:55:05,190 --> 00:55:03,440
or kind of bring down any other system

1486
00:55:06,789 --> 00:55:05,200
on the space station so you have to play

1487
00:55:08,309 --> 00:55:06,799
nice with all the other systems on the

1488
00:55:10,150 --> 00:55:08,319

space station yeah so

1489
00:55:12,230 --> 00:55:10,160
you know uh you have to look at radiate

1490
00:55:14,150 --> 00:55:12,240
like do you are you radiating noise you

1491
00:55:16,309 --> 00:55:14,160
know are you going to interfere with the

1492
00:55:17,990 --> 00:55:16,319
other systems on space station a lot of

1493
00:55:20,150 --> 00:55:18,000
consideration and of course we control

1494
00:55:21,750 --> 00:55:20,160
um asterovy from the ground from mission

1495
00:55:23,910 --> 00:55:21,760
control right and so that means we're

1496
00:55:25,670 --> 00:55:23,920
sending you know data back back and

1497
00:55:27,670 --> 00:55:25,680
forth and on the space station it's

1498
00:55:29,349 --> 00:55:27,680
being you know set across the the

1499
00:55:30,950 --> 00:55:29,359
wireless network the wi-fi network on

1500
00:55:39,430 --> 00:55:30,960
space station so of course you don't

1501
00:55:39,440 --> 00:55:47,270
[Laughter]

1502
00:55:49,990 --> 00:55:48,390
i know i've talked to you guys about

1503
00:55:51,829 --> 00:55:50,000
this i'm you know taking what you guys

1504
00:55:53,430 --> 00:55:51,839
learned from spheres and applying that

1505
00:55:56,390 --> 00:55:53,440
to astro b

1506
00:55:58,950 --> 00:55:56,400
um in your design and testing for

1507
00:56:00,789 --> 00:55:58,960
you know yeah absolutely so uh

1508
00:56:02,950 --> 00:56:00,799
one of our considerations was we didn't

1509
00:56:05,030 --> 00:56:02,960
want to have astronauts have to put

1510
00:56:07,349 --> 00:56:05,040
these gas canisters into astronomy

1511
00:56:09,030 --> 00:56:07,359
that's that's a chore that we're adding

1512
00:56:10,710 --> 00:56:09,040
to the chores then yeah the astronauts

1513
00:56:12,390 --> 00:56:10,720

take care of the robot so we made an

1514
00:56:14,309 --> 00:56:12,400
all-electric system and that can just

1515
00:56:16,309 --> 00:56:14,319
plug itself in and the only consumable

1516
00:56:17,990 --> 00:56:16,319
is electricity you know battery power

1517
00:56:20,309 --> 00:56:18,000
yeah it's got this docking station that

1518
00:56:21,349 --> 00:56:20,319
can go recharge itself yeah um

1519
00:56:22,789 --> 00:56:21,359
you know i guess the other thing too

1520
00:56:25,510 --> 00:56:22,799
that we should have pointed out about

1521
00:56:26,309 --> 00:56:25,520
the spheres is that in addition to this

1522
00:56:28,230 --> 00:56:26,319
you know

1523
00:56:30,150 --> 00:56:28,240
carbon dioxide propulsion which is in a

1524
00:56:32,230 --> 00:56:30,160
little tank that should change out um it

1525
00:56:34,950 --> 00:56:32,240
requires uh basically these uh these

1526
00:56:36,390 --> 00:56:34,960
eight pack of double a batteries yeah um

1527
00:56:38,390 --> 00:56:36,400
and of course that what that means is

1528
00:56:39,990 --> 00:56:38,400
that the spheres couldn't really run for

1529
00:56:41,910 --> 00:56:40,000
a particularly long time you know maybe

1530
00:56:43,670 --> 00:56:41,920
an hour or two and then you know

1531
00:56:45,750 --> 00:56:43,680
someone's gonna come over and

1532
00:56:48,870 --> 00:56:45,760
changed the tank and changed the

1533
00:56:50,390 --> 00:56:48,880
batteries and so astro b of core part of

1534
00:56:52,150 --> 00:56:50,400
the design was

1535
00:56:53,829 --> 00:56:52,160
let's get away from all that let's let

1536
00:56:55,750 --> 00:56:53,839
it just recharge itself right and then

1537
00:56:58,230 --> 00:56:55,760
spheres also was not allowed to operate

1538
00:57:00,309 --> 00:56:58,240

by itself because the materials are not

1539
00:57:02,950 --> 00:57:00,319
are there's some flammable materials so

1540
00:57:05,430 --> 00:57:02,960
it had to have human oversight at all

1541
00:57:08,470 --> 00:57:05,440
times yeah in case it burst into flame i

1542
00:57:08,480 --> 00:57:13,190
it hasn't happened

1543
00:57:17,510 --> 00:57:15,190
so all the materials on astrobee are

1544
00:57:19,430 --> 00:57:17,520
either flame retardant or they're

1545
00:57:22,069 --> 00:57:19,440
they're such a small amount that they

1546
00:57:23,430 --> 00:57:22,079
aren't a hazard or we cover them with a

1547
00:57:26,710 --> 00:57:23,440
flame retardant

1548
00:57:28,870 --> 00:57:26,720
material oh yeah that's pretty cool yeah

1549
00:57:31,990 --> 00:57:28,880
um you were talking about communicating

1550
00:57:33,589 --> 00:57:32,000
with the robots so here's maybe a bigger

1551
00:57:34,950 --> 00:57:33,599
general question are these robots

1552
00:57:37,190 --> 00:57:34,960
designed to communicate directly with

1553
00:57:38,230 --> 00:57:37,200
the dsn and can you tell us what the dsn

1554
00:57:43,750 --> 00:57:38,240
is

1555
00:57:46,390 --> 00:57:43,760
it's what nasa and and frankly i believe

1556
00:57:49,270 --> 00:57:46,400
all uh space-faring countries use to

1557
00:57:51,190 --> 00:57:49,280
communicate to spacecraft uh robotic or

1558
00:57:54,309 --> 00:57:51,200
human uh in space

1559
00:57:56,390 --> 00:57:54,319
uh you know i think uh as we see robots

1560
00:57:57,990 --> 00:57:56,400
going to other places along with humans

1561
00:58:00,870 --> 00:57:58,000
then there'll be you know more and more

1562
00:58:01,750 --> 00:58:00,880
use of of the the dsn for communications

1563
00:58:03,190 --> 00:58:01,760

uh

1564
00:58:05,750 --> 00:58:03,200
on the space station of course we don't

1565
00:58:08,710 --> 00:58:05,760
use the dsn because it's in earth orbit

1566
00:58:11,190 --> 00:58:08,720
uh we instead use another system um it's

1567
00:58:15,109 --> 00:58:11,200
called tdrs td-rs

1568
00:58:17,430 --> 00:58:16,309
i wasn't worried you were going to ask

1569
00:58:19,910 --> 00:58:17,440
me

1570
00:58:21,190 --> 00:58:19,920
tracking and data relays satellite

1571
00:58:22,309 --> 00:58:21,200
system i think

1572
00:58:24,309 --> 00:58:22,319
but basically it's a set of

1573
00:58:26,470 --> 00:58:24,319
communication satellites in earth orbit

1574
00:58:29,510 --> 00:58:26,480
and it relays the signals from the space

1575
00:58:30,630 --> 00:58:29,520
station um to the ground to mission

1576
00:58:32,309 --> 00:58:30,640
control

1577
00:58:34,150 --> 00:58:32,319
and so we use that to communicate to and

1578
00:58:36,390 --> 00:58:34,160
from the space station

1579
00:58:38,630 --> 00:58:36,400
all right perfect

1580
00:58:40,950 --> 00:58:38,640
um yeah it's interesting there there are

1581
00:58:42,950 --> 00:58:40,960
uh dropouts in calm um between the space

1582
00:58:44,549 --> 00:58:42,960
station and the ground oh yeah um so we

1583
00:58:46,789 --> 00:58:44,559
also designed astrophy to be able to

1584
00:58:49,030 --> 00:58:46,799
operate through those dropouts when it

1585
00:58:50,789 --> 00:58:49,040
can't oh okay to the ground so that's

1586
00:58:53,190 --> 00:58:50,799
you know the autonomous nature of the

1587
00:58:54,910 --> 00:58:53,200
master right can carry on you can carry

1588
00:58:57,030 --> 00:58:54,920

on doing what it was carry on

1589
00:58:58,309 --> 00:58:57,040
[Laughter]

1590
00:59:00,710 --> 00:58:58,319
excellent

1591
00:59:02,710 --> 00:59:00,720
uh we actually have some questions about

1592
00:59:04,630 --> 00:59:02,720
career paths into robotics and things

1593
00:59:06,549 --> 00:59:04,640
like that can you guys kind of share how

1594
00:59:08,069 --> 00:59:06,559
you got into robotics and you know

1595
00:59:09,910 --> 00:59:08,079
education you have people who are

1596
00:59:12,150 --> 00:59:09,920
interested in you know what kind of you

1597
00:59:13,510 --> 00:59:12,160
know programs were you in in school and

1598
00:59:15,270 --> 00:59:13,520
internships and things like that so

1599
00:59:17,190 --> 00:59:15,280
first off i might be a little bit biased

1600
00:59:18,180 --> 00:59:17,200
but you know i think that everybody

1601
00:59:21,109 --> 00:59:18,190
should be a roboticist

1602
00:59:23,750 --> 00:59:21,119
[Laughter]

1603
00:59:25,510 --> 00:59:23,760
and uh i i think partially is because it

1604
00:59:28,230 --> 00:59:25,520
is really fun uh working with with

1605
00:59:30,390 --> 00:59:28,240
robots yeah and as maria said earlier i

1606
00:59:32,309 --> 00:59:30,400
mean robotics and covers a lot of

1607
00:59:34,630 --> 00:59:32,319
different kinds of domains lots of

1608
00:59:37,030 --> 00:59:34,640
different areas of study and so there's

1609
00:59:39,190 --> 00:59:37,040
not one single path that you can go down

1610
00:59:41,109 --> 00:59:39,200
or have to go down and you can if you

1611
00:59:42,390 --> 00:59:41,119
like you know computers you can be a

1612
00:59:43,829 --> 00:59:42,400
complete this from computer science

1613
00:59:45,589 --> 00:59:43,839

point of view if you like mechanical

1614
00:59:47,510 --> 00:59:45,599
design you know mechanical engineering

1615
00:59:49,349 --> 00:59:47,520
or electrical engineering we need you

1616
00:59:50,150 --> 00:59:49,359
all

1617
00:59:52,630 --> 00:59:50,160
yeah

1618
00:59:55,109 --> 00:59:52,640
somebody wanted to know

1619
00:59:56,309 --> 00:59:55,119
if you can use programmers

1620
00:59:58,630 --> 00:59:56,319
yes

1621
01:00:02,789 --> 00:59:58,640
yeah alex the unica do web developers

1622
01:00:04,710 --> 01:00:02,799
help in robotics oh yeah definitely yeah

1623
01:00:05,990 --> 01:00:04,720
because one of the key things we we

1624
01:00:07,750 --> 01:00:06,000
worry about is you know how do we

1625
01:00:09,270 --> 01:00:07,760
understand what the robot is doing and

1626
01:00:11,349 --> 01:00:09,280
how do we communicate to that how do we

1627
01:00:12,950 --> 01:00:11,359
command it and so in addition to

1628
01:00:14,870 --> 01:00:12,960
building the robot system itself we'll

1629
01:00:17,190 --> 01:00:14,880
build user interfaces you know all the

1630
01:00:19,109 --> 01:00:17,200
interfaces that run admission control

1631
01:00:21,030 --> 01:00:19,119
that talk to spacecraft well some of

1632
01:00:23,109 --> 01:00:21,040
those are custom interfaces some of them

1633
01:00:24,630 --> 01:00:23,119
are just run on web browsers they might

1634
01:00:26,870 --> 01:00:24,640
be web applications

1635
01:00:28,950 --> 01:00:26,880
and so i think the answer is definitely

1636
01:00:30,789 --> 01:00:28,960
yes um you know you can get involved if

1637
01:00:33,510 --> 01:00:30,799
you do web programming hey you could do

1638
01:00:35,990 --> 01:00:33,520

that for a robot too absolutely yeah

1639
01:00:37,589 --> 01:00:36,000
very good good news next gds system is

1640
01:00:39,430 --> 01:00:37,599
web-based yeah

1641
01:00:41,670 --> 01:00:39,440
that's the software design here so yeah

1642
01:00:44,150 --> 01:00:41,680
we have actually a ground data system

1643
01:00:46,069 --> 01:00:44,160
that uh that we use for science playing

1644
01:00:49,190 --> 01:00:46,079
so mission science planning yeah that's

1645
01:00:52,230 --> 01:00:49,200
web-based cool all right so a resounding

1646
01:00:55,109 --> 01:00:54,069
a couple people have asked about the

1647
01:00:57,910 --> 01:00:55,119
cost

1648
01:00:58,950 --> 01:00:57,920
of space robots and when do you consider

1649
01:01:00,870 --> 01:00:58,960
that that was the question do you

1650
01:01:02,789 --> 01:01:00,880
consider the cost before or after and

1651
01:01:04,630 --> 01:01:02,799
yeah so you know in terms of like you

1652
01:01:05,829 --> 01:01:04,640
know the robots themselves these days at

1653
01:01:07,510 --> 01:01:05,839
least for the ones inside of space

1654
01:01:08,950 --> 01:01:07,520
station which is just like being in an

1655
01:01:11,190 --> 01:01:08,960
office or a home

1656
01:01:12,870 --> 01:01:11,200
um you know the the the components

1657
01:01:15,109 --> 01:01:12,880
actually are not the main cost the main

1658
01:01:17,109 --> 01:01:15,119
cost has to do with the the time spent

1659
01:01:19,430 --> 01:01:17,119
developing and then building and

1660
01:01:21,910 --> 01:01:19,440
engineering the engineering time but uh

1661
01:01:22,950 --> 01:01:21,920
you know astro b as maria said uses a

1662
01:01:26,230 --> 01:01:22,960
set of

1663
01:01:28,309 --> 01:01:26,240

basically uh smartphone class processors

1664
01:01:29,589 --> 01:01:28,319
and we use off-the-shelf software as

1665
01:01:32,870 --> 01:01:29,599
well uh

1666
01:01:35,270 --> 01:01:32,880
astrobeat runs uh both android and linux

1667
01:01:37,270 --> 01:01:35,280
in terms of operating system and uh and

1668
01:01:40,309 --> 01:01:37,280
so it's not you know like we've custom

1669
01:01:42,390 --> 01:01:40,319
crafted our own unique you know set of

1670
01:01:43,990 --> 01:01:42,400
of of software some of the hardware

1671
01:01:45,109 --> 01:01:44,000
obviously is unique i mean astro b

1672
01:01:47,829 --> 01:01:45,119
doesn't look like anything you'd buy in

1673
01:01:49,190 --> 01:01:47,839
a store right the machine parts exactly

1674
01:01:50,710 --> 01:01:49,200
yeah well print actually a lot of

1675
01:01:53,270 --> 01:01:50,720
asterisks

1676
01:01:54,630 --> 01:01:53,280
yes exactly but if you open it up a lot

1677
01:01:57,349 --> 01:01:54,640
of the insides you're like oh i

1678
01:01:58,630 --> 01:01:57,359
recognize that i could buy that

1679
01:02:00,230 --> 01:01:58,640
all right cool

1680
01:02:02,230 --> 01:02:00,240
um

1681
01:02:04,630 --> 01:02:02,240
i have one that i like i'm curious about

1682
01:02:06,789 --> 01:02:04,640
too the jp guy asks is it possible to

1683
01:02:08,940 --> 01:02:06,799
create self-sterilizing robots to

1684
01:02:10,080 --> 01:02:08,950
prevent contamination during exercise

1685
01:02:12,549 --> 01:02:10,090
[Applause]

1686
01:02:16,069 --> 01:02:12,559
[Music]

1687
01:02:18,150 --> 01:02:16,079
so one a possible payload for astor b in

1688
01:02:21,190 --> 01:02:18,160

the near future uh we had some folks

1689
01:02:23,270 --> 01:02:21,200
come in to talk to us about um it's just

1690
01:02:24,789 --> 01:02:23,280
equipment for sterilizing oh really

1691
01:02:26,789 --> 01:02:24,799
inside the space station it's basically

1692
01:02:27,750 --> 01:02:26,799
ultraviolet light i think uv light yeah

1693
01:02:33,190 --> 01:02:27,760
uvc

1694
01:02:34,870 --> 01:02:33,200
basically like a panel of leds

1695
01:02:36,789 --> 01:02:34,880
that you just go and hold it up against

1696
01:02:38,549 --> 01:02:36,799
the or near a surface and the light will

1697
01:02:40,710 --> 01:02:38,559
sterilize it so

1698
01:02:42,870 --> 01:02:40,720
yes

1699
01:02:44,390 --> 01:02:42,880
we can sterilize things yeah i think we

1700
01:02:46,950 --> 01:02:44,400
can sterilize each other you know one

1701
01:02:48,549 --> 01:02:46,960
aspect could sterilize the other one

1702
01:02:50,470 --> 01:02:48,559
yeah i think if people go hiking you

1703
01:02:52,309 --> 01:02:50,480
know they do have these uh water

1704
01:02:53,829 --> 01:02:52,319
sterilizing systems yeah you have one oh

1705
01:02:56,390 --> 01:02:53,839
yeah

1706
01:02:59,109 --> 01:02:56,400
gonna

1707
01:03:01,990 --> 01:02:59,119
kill off bacteria and exactly

1708
01:03:04,069 --> 01:03:02,000
that could work it could work absolutely

1709
01:03:06,230 --> 01:03:04,079
nice

1710
01:03:08,549 --> 01:03:06,240
you have a comment here from uh wala

1711
01:03:11,430 --> 01:03:08,559
post very cool y'all

1712
01:03:14,630 --> 01:03:11,440
absolutely thank you

1713
01:03:18,150 --> 01:03:14,640

um here's a question from rastar

1714
01:03:19,670 --> 01:03:18,160
are there any crawling robots um

1715
01:03:22,549 --> 01:03:19,680
robots that could easily manipulate

1716
01:03:23,910 --> 01:03:22,559
things rather than flying um because

1717
01:03:26,870 --> 01:03:23,920
that uses you know a certain kind of

1718
01:03:28,390 --> 01:03:26,880
energy yeah yeah well i mean we saw some

1719
01:03:30,710 --> 01:03:28,400
of the other robots that nasa has worked

1720
01:03:33,029 --> 01:03:30,720
with in the past earlier on the show um

1721
01:03:34,630 --> 01:03:33,039
you know i i certainly think that all

1722
01:03:36,710 --> 01:03:34,640
kinds of robots are needed

1723
01:03:39,349 --> 01:03:36,720
of course and of course you know robots

1724
01:03:40,470 --> 01:03:39,359
like like like robonaut too um we had a

1725
01:03:43,270 --> 01:03:40,480
few years ago i mean those were designed

1726
01:03:45,109 --> 01:03:43,280
to be humanoid robonaut 2 actually

1727
01:03:46,789 --> 01:03:45,119
at one point was going to have a pair of

1728
01:03:48,710 --> 01:03:46,799
these climbing limbs

1729
01:03:49,750 --> 01:03:48,720
so uh oh well the legs look kind of

1730
01:03:51,349 --> 01:03:49,760
backwards so the knees were kind of

1731
01:03:52,210 --> 01:03:51,359
backwards basically yeah it's not

1732
01:03:53,670 --> 01:03:52,220
natural

1733
01:03:55,990 --> 01:03:53,680
[Applause]

1734
01:03:57,589 --> 01:03:56,000
but that would allow robonauts to really

1735
01:03:59,589 --> 01:03:57,599
like climb all over the inside of space

1736
01:04:02,230 --> 01:03:59,599
station so it would have two arms and

1737
01:04:04,069 --> 01:04:02,240
two legs or two limbs and then you could

1738
01:04:06,069 --> 01:04:04,079

use all four of those to climb around

1739
01:04:07,910 --> 01:04:06,079
now unfortunately we we had some some

1740
01:04:10,150 --> 01:04:07,920
problems with the electrical system and

1741
01:04:11,589 --> 01:04:10,160
we brought robonaut two back down but

1742
01:04:14,710 --> 01:04:11,599
maybe in the future you'll see systems

1743
01:04:16,630 --> 01:04:14,720
like robonaut 2 um that can climb yeah

1744
01:04:19,029 --> 01:04:16,640
and actually for ground exploration

1745
01:04:22,230 --> 01:04:19,039
again there are snake robots and you

1746
01:04:26,150 --> 01:04:22,240
know that again bio-inspired you know

1747
01:04:27,990 --> 01:04:26,160
inspired by insects and yeah that you

1748
01:04:30,710 --> 01:04:28,000
know move across the ground in different

1749
01:04:33,029 --> 01:04:30,720
ways and are can be very efficient

1750
01:04:35,270 --> 01:04:33,039
and so there's a lot of work developing

1751
01:04:37,029 --> 01:04:35,280
these uh sort of bio-inspired robots

1752
01:04:39,029 --> 01:04:37,039
that's cool that's kind of related to

1753
01:04:41,109 --> 01:04:39,039
this one the life is yours asks would a

1754
01:04:43,349 --> 01:04:41,119
robot like the boston dynamic ones work

1755
01:04:45,750 --> 01:04:43,359
on mars and the moon

1756
01:04:47,589 --> 01:04:45,760
can you describe a little yeah so i mean

1757
01:04:49,190 --> 01:04:47,599
obviously boston dynamics has created

1758
01:04:50,470 --> 01:04:49,200
lots of really interesting videos

1759
01:04:53,109 --> 01:04:50,480
showing their robots doing everything

1760
01:04:55,589 --> 01:04:53,119
from gymnastics to all kinds of things

1761
01:04:56,789 --> 01:04:55,599
uh you know with running and jumping and

1762
01:04:58,789 --> 01:04:56,799
hopping and

1763
01:05:00,630 --> 01:04:58,799

you know quite honestly you know nasa

1764
01:05:03,270 --> 01:05:00,640
has interest in those things those kinds

1765
01:05:04,630 --> 01:05:03,280
of of you know robot capabilities

1766
01:05:07,270 --> 01:05:04,640
because there are places that are just

1767
01:05:09,109 --> 01:05:07,280
not suited to wheels um there are places

1768
01:05:11,190 --> 01:05:09,119
where maybe you can't fly if there's no

1769
01:05:13,430 --> 01:05:11,200
atmosphere um you know astro b for

1770
01:05:15,510 --> 01:05:13,440
example does require air and the mars

1771
01:05:16,870 --> 01:05:15,520
helicopter requires air on mars you

1772
01:05:18,789 --> 01:05:16,880
can't really have that kind of flying

1773
01:05:20,710 --> 01:05:18,799
robot on the moon um

1774
01:05:23,430 --> 01:05:20,720
without atmosphere yeah exactly and

1775
01:05:25,910 --> 01:05:23,440
while like the the boston dynamics robot

1776
01:05:27,990 --> 01:05:25,920
um doesn't require air to move it it's

1777
01:05:30,069 --> 01:05:28,000
probably designed to operate in air for

1778
01:05:34,309 --> 01:05:30,079
things like cooling so you couldn't just

1779
01:05:38,789 --> 01:05:36,549
that's good yeah so you'd have to do

1780
01:05:40,630 --> 01:05:38,799
some redesign so that would be capable

1781
01:05:43,029 --> 01:05:40,640
of operating on those other in those

1782
01:05:46,230 --> 01:05:43,039
other environments but the method of

1783
01:05:48,549 --> 01:05:46,240
locomotion certainly yeah we would we're

1784
01:05:50,870 --> 01:05:48,559
looking at walking and crawling robots

1785
01:05:52,470 --> 01:05:50,880
and jumping and hopping in exactly yeah

1786
01:05:56,870 --> 01:05:52,480
yeah we'll see

1787
01:05:59,109 --> 01:05:56,880
stay tuned um a couple people have asked

1788
01:06:00,950 --> 01:05:59,119

again i think it's about astro b how do

1789
01:06:03,430 --> 01:06:00,960
these robots propel themselves in zero

1790
01:06:05,430 --> 01:06:03,440
gravity in a spaceship so could you just

1791
01:06:07,829 --> 01:06:05,440
review quickly

1792
01:06:09,109 --> 01:06:07,839
it's a fan based system um you know this

1793
01:06:11,109 --> 01:06:09,119
our particular robot there are other

1794
01:06:14,549 --> 01:06:11,119
ways of propelling yourself yeah uh

1795
01:06:16,630 --> 01:06:14,559
inside a space uh space station but um

1796
01:06:19,829 --> 01:06:16,640
astrobee in particular is fan based it

1797
01:06:21,109 --> 01:06:19,839
has uh impeller front actually can we

1798
01:06:22,789 --> 01:06:21,119
just bring it back up on the table real

1799
01:06:23,750 --> 01:06:22,799
quick here

1800
01:06:25,270 --> 01:06:23,760
all right

1801
01:06:27,349 --> 01:06:25,280
so actually right there is might be good

1802
01:06:29,990 --> 01:06:27,359
so i can actually point at things yeah

1803
01:06:32,630 --> 01:06:30,000
so um again this circular opening here

1804
01:06:34,870 --> 01:06:32,640
there is an impeller fan let me move my

1805
01:06:36,630 --> 01:06:34,880
head here

1806
01:06:38,789 --> 01:06:36,640
okay there we go this is better so now i

1807
01:06:40,789 --> 01:06:38,799
can actually tuck the microphone um so

1808
01:06:44,309 --> 01:06:40,799
this circular part here there's a fan

1809
01:06:46,549 --> 01:06:44,319
inside here and that brings the air into

1810
01:06:48,390 --> 01:06:46,559
this sort of sort of like a box almost

1811
01:06:49,910 --> 01:06:48,400
on the end of the robot this um this

1812
01:06:52,309 --> 01:06:49,920
sort of black section

1813
01:06:55,349 --> 01:06:52,319

um and then it goes

1814
01:06:58,710 --> 01:06:55,359
it so it lightly pressurizes um the box

1815
01:06:59,990 --> 01:06:58,720
and then these grilles right here they

1816
01:07:01,750 --> 01:07:00,000
look like the vents in your car yeah

1817
01:07:03,910 --> 01:07:01,760
they look like little vents

1818
01:07:05,910 --> 01:07:03,920
um there's a nozzle behind that right

1819
01:07:08,230 --> 01:07:05,920
the grill is to keep um astronaut

1820
01:07:10,630 --> 01:07:08,240
fingers from going in again

1821
01:07:12,549 --> 01:07:10,640
that's why the grill is there but um but

1822
01:07:14,870 --> 01:07:12,559
behind there are these um

1823
01:07:16,069 --> 01:07:14,880
nozzles that have flappers that open and

1824
01:07:18,710 --> 01:07:16,079
close

1825
01:07:20,150 --> 01:07:18,720
and so that it that lets air out

1826
01:07:21,510 --> 01:07:20,160
and you have different amounts of air

1827
01:07:22,470 --> 01:07:21,520
different amounts right you open it a

1828
01:07:24,710 --> 01:07:22,480
little bit you get a little bit of air

1829
01:07:27,990 --> 01:07:24,720
you open it wide to get more air um and

1830
01:07:30,150 --> 01:07:28,000
then so that the air moving out pushes

1831
01:07:32,950 --> 01:07:30,160
the robot in the opposite direction this

1832
01:07:35,270 --> 01:07:32,960
is the whole magic of zero g right

1833
01:07:37,190 --> 01:07:35,280
you're floating and it's the you know

1834
01:07:38,069 --> 01:07:37,200
equal and opposite reaction

1835
01:07:40,309 --> 01:07:38,079
so

1836
01:07:42,390 --> 01:07:40,319
that's how we we propel ourselves around

1837
01:07:45,750 --> 01:07:42,400
space station awesome yeah

1838
01:07:48,150 --> 01:07:45,760

apollo mg asks is it gyro stabilized and

1839
01:07:50,549 --> 01:07:48,160
what does that mean it's partially quote

1840
01:07:52,390 --> 01:07:50,559
gyro stabilized because you know you

1841
01:07:54,390 --> 01:07:52,400
have fans here and there's actually a

1842
01:07:55,829 --> 01:07:54,400
fan on both sides so it's counter

1843
01:07:56,710 --> 01:07:55,839
rotating

1844
01:07:58,549 --> 01:07:56,720
and

1845
01:08:00,710 --> 01:07:58,559
what's fascinating is that depending on

1846
01:08:03,270 --> 01:08:00,720
how fast we spin this you know we can

1847
01:08:05,589 --> 01:08:03,280
change how stable is in space so

1848
01:08:08,630 --> 01:08:05,599
as we do docking for example and we want

1849
01:08:10,390 --> 01:08:08,640
to move in very precisely um and very

1850
01:08:12,150 --> 01:08:10,400
you know was very smooth motion will

1851
01:08:14,230 --> 01:08:12,160
basically spin up the robot and you can

1852
01:08:16,550 --> 01:08:14,240
actually hear it get louder yeah

1853
01:08:18,229 --> 01:08:16,560
and it becomes more stable because it's

1854
01:08:19,990 --> 01:08:18,239
using its fans and how fast they're

1855
01:08:21,829 --> 01:08:20,000
spinning to stabilize it it also gets a

1856
01:08:23,749 --> 01:08:21,839
little more control authority because

1857
01:08:25,269 --> 01:08:23,759
there's a little more pressure a touch

1858
01:08:27,349 --> 01:08:25,279
more pressure so it can actually push

1859
01:08:29,910 --> 01:08:27,359
itself a little bit harder right ah that

1860
01:08:30,950 --> 01:08:29,920
makes sense yeah all right nice

1861
01:08:31,910 --> 01:08:30,960
um

1862
01:08:34,309 --> 01:08:31,920
there's

1863
01:08:36,870 --> 01:08:34,319

it keeps coming in right now we have one

1864
01:08:38,630 --> 01:08:36,880
question from ill inc

1865
01:08:41,430 --> 01:08:38,640
are robots good for tending the growing

1866
01:08:43,110 --> 01:08:41,440
of plants in space oh you know um this

1867
01:08:45,990 --> 01:08:43,120
is actually a super timely question

1868
01:08:48,950 --> 01:08:46,000
because well yeah so good job yeah three

1869
01:08:51,829 --> 01:08:48,960
weeks ago i went to a nasa workshop on

1870
01:08:53,510 --> 01:08:51,839
how robots could be used to help grow

1871
01:08:54,550 --> 01:08:53,520
crops in space

1872
01:08:56,870 --> 01:08:54,560
and

1873
01:08:58,550 --> 01:08:56,880
it's fascinating you think about all the

1874
01:09:00,070 --> 01:08:58,560
challenges that you know would be

1875
01:09:03,590 --> 01:09:00,080
associated with doing that i mean

1876
01:09:05,510 --> 01:09:03,600
planting and monitoring and tending and

1877
01:09:07,669 --> 01:09:05,520
harvesting and then processing

1878
01:09:09,749 --> 01:09:07,679
afterwards yeah um so i think it's a

1879
01:09:12,070 --> 01:09:09,759
great area for research and development

1880
01:09:14,070 --> 01:09:12,080
um not ready today

1881
01:09:15,829 --> 01:09:14,080
but um if we want to send humans

1882
01:09:17,590 --> 01:09:15,839
especially in the deep space we can't

1883
01:09:18,870 --> 01:09:17,600
just package all the food right they're

1884
01:09:20,390 --> 01:09:18,880
not just gonna be eating you know out of

1885
01:09:22,709 --> 01:09:20,400
microwavable things

1886
01:09:24,309 --> 01:09:22,719
they're going to need fresh food and um

1887
01:09:26,789 --> 01:09:24,319
it's really as anybody who's grown

1888
01:09:29,669 --> 01:09:26,799

anything um knows it takes a lot of

1889
01:09:31,669 --> 01:09:29,679
effort and so i think robots definitely

1890
01:09:33,990 --> 01:09:31,679
are needed for that

1891
01:09:37,910 --> 01:09:34,000
cool some are already being used on

1892
01:09:39,590 --> 01:09:37,920
earth yeah to tend uh crops yeah so yeah

1893
01:09:41,590 --> 01:09:39,600
yeah and to attend the environment

1894
01:09:43,590 --> 01:09:41,600
there's this whole uh a new interesting

1895
01:09:45,430 --> 01:09:43,600
uh you know category called vertical

1896
01:09:46,709 --> 01:09:45,440
farming um you know what people want to

1897
01:09:49,189 --> 01:09:46,719
like grow

1898
01:09:51,110 --> 01:09:49,199
um really crops inside their homes or

1899
01:09:53,349 --> 01:09:51,120
their apartments and uh in small space

1900
01:09:54,630 --> 01:09:53,359
small space right exactly so how can you

1901
01:09:57,189 --> 01:09:54,640
grow vertically you have all these

1902
01:09:59,270 --> 01:09:57,199
different like shelves and like uh like

1903
01:10:01,590 --> 01:09:59,280
hydroponics that go into

1904
01:10:02,790 --> 01:10:01,600
um you know help grow plants grow but

1905
01:10:04,470 --> 01:10:02,800
the problem is you still have to take

1906
01:10:06,229 --> 01:10:04,480
care of the system itself you know

1907
01:10:08,229 --> 01:10:06,239
things always get clogged things need to

1908
01:10:09,189 --> 01:10:08,239
get harvested um

1909
01:10:10,229 --> 01:10:09,199
so i think we're going to need robots

1910
01:10:12,470 --> 01:10:10,239
for that

1911
01:10:13,910 --> 01:10:12,480
all right nice uh here's an interesting

1912
01:10:16,709 --> 01:10:13,920
one um

1913
01:10:19,110 --> 01:10:16,719

phone things to what types of prehensile

1914
01:10:21,669 --> 01:10:19,120
tasks do robots perform in space i.e

1915
01:10:22,870 --> 01:10:21,679
gripping and grasping tasks

1916
01:10:25,430 --> 01:10:22,880
is that

1917
01:10:27,830 --> 01:10:25,440
well so we already talked about the

1918
01:10:30,790 --> 01:10:27,840
perching arm arm yes they can grip onto

1919
01:10:33,430 --> 01:10:30,800
things and yes uh save energy by doing

1920
01:10:36,070 --> 01:10:33,440
that um also we we've been looking at

1921
01:10:38,630 --> 01:10:36,080
prehensile tasks that like a rover

1922
01:10:41,270 --> 01:10:38,640
and a wheeled robot uh can do when it's

1923
01:10:42,950 --> 01:10:41,280
on uh a planetary surface

1924
01:10:43,750 --> 01:10:42,960
for instance it can dig a trench right

1925
01:10:45,430 --> 01:10:43,760
if you

1926
01:10:47,030 --> 01:10:45,440
you drive three of the wheels and your

1927
01:10:48,470 --> 01:10:47,040
fourth one you just kind of you turn it

1928
01:10:50,070 --> 01:10:48,480
sideways and spin it a little bit

1929
01:10:52,870 --> 01:10:50,080
differently you can actually

1930
01:10:54,630 --> 01:10:52,880
dig a trench um so for instance say you

1931
01:10:56,229 --> 01:10:54,640
want to lay some cables you know that

1932
01:10:58,390 --> 01:10:56,239
you then bury

1933
01:11:00,070 --> 01:10:58,400
around the habitat uh you could use the

1934
01:11:01,830 --> 01:11:00,080
robot to dig the trenches to put the

1935
01:11:03,270 --> 01:11:01,840
cables in yeah okay

1936
01:11:04,790 --> 01:11:03,280
and that's kind of a gripping task

1937
01:11:06,310 --> 01:11:04,800
because it's holding that's no it's not

1938
01:11:08,149 --> 01:11:06,320

good it's no there's no gripping it's

1939
01:11:09,910 --> 01:11:08,159
prehensile so there's no no no not

1940
01:11:11,590 --> 01:11:09,920
non-preheating oh sorry non-pronounce it

1941
01:11:13,830 --> 01:11:11,600
yeah yeah that's right i mean but in

1942
01:11:16,149 --> 01:11:13,840
terms of of grasping things you know we

1943
01:11:17,750 --> 01:11:16,159
said earlier that astro b only has a an

1944
01:11:19,669 --> 01:11:17,760
arm for perching

1945
01:11:20,950 --> 01:11:19,679
um but obviously other systems like

1946
01:11:23,510 --> 01:11:20,960
robonaut 2

1947
01:11:25,990 --> 01:11:23,520
um or even on the you know the canadarm2

1948
01:11:28,070 --> 01:11:26,000
with its dexter system you know has the

1949
01:11:29,830 --> 01:11:28,080
ability to really reach out and and

1950
01:11:31,830 --> 01:11:29,840
physically interact with things you know

1951
01:11:34,229 --> 01:11:31,840
maybe you're going to try to to unscrew

1952
01:11:36,229 --> 01:11:34,239
something or to swap out uh some module

1953
01:11:37,270 --> 01:11:36,239
which needs to be changed for repair

1954
01:11:40,149 --> 01:11:37,280
purposes

1955
01:11:41,750 --> 01:11:40,159
the our gripper is pretty limited yeah

1956
01:11:44,709 --> 01:11:41,760
but there are but they're developing the

1957
01:11:46,630 --> 01:11:44,719
stanford is actually developing a gecko

1958
01:11:49,030 --> 01:11:46,640
inspired gripper

1959
01:11:50,790 --> 01:11:49,040
for our our extra perching for after

1960
01:11:52,870 --> 01:11:50,800
being fabulous it's already actually on

1961
01:11:55,030 --> 01:11:52,880
orbit it launched yeah it just launched

1962
01:11:57,990 --> 01:11:55,040
um and so they're looking at being able

1963
01:11:59,669 --> 01:11:58,000

to um perch on any surface yeah that's

1964
01:12:01,430 --> 01:11:59,679
right the universal gripper i mean you

1965
01:12:04,070 --> 01:12:01,440
think about you know geckos they can you

1966
01:12:05,189 --> 01:12:04,080
know adhere to any kind of surface um

1967
01:12:09,110 --> 01:12:05,199
this

1968
01:12:11,910 --> 01:12:10,229
not so thrilled about that when they're

1969
01:12:14,709 --> 01:12:11,920
in in your home

1970
01:12:17,430 --> 01:12:14,719
they keep the bugs down

1971
01:12:19,189 --> 01:12:17,440
so this so this new this new robot hand

1972
01:12:20,950 --> 01:12:19,199
basically is meant to be the universal

1973
01:12:23,030 --> 01:12:20,960
thing so it can stick to any kind of

1974
01:12:24,470 --> 01:12:23,040
surface any kind of shape

1975
01:12:25,910 --> 01:12:24,480
um and that's one of the things that

1976
01:12:28,390 --> 01:12:25,920
over the next several months we're

1977
01:12:30,550 --> 01:12:28,400
hoping to see tested with astrophy

1978
01:12:31,510 --> 01:12:30,560
very cool yeah

1979
01:12:32,950 --> 01:12:31,520
all right

1980
01:12:35,430 --> 01:12:32,960
because we're going to have to finish

1981
01:12:36,709 --> 01:12:35,440
soon aren't we yeah

1982
01:12:38,950 --> 01:12:36,719
do you have a favorite question or

1983
01:12:41,510 --> 01:12:38,960
should i throw one out there uh you go

1984
01:12:43,990 --> 01:12:41,520
first okay

1985
01:12:46,390 --> 01:12:44,000
so how could you perform real life tests

1986
01:12:48,550 --> 01:12:46,400
parabolic flights perhaps that's nearly

1987
01:12:50,630 --> 01:12:48,560
testing like with punch punch cards cost

1988
01:12:52,709 --> 01:12:50,640

wise well how would you how do you test

1989
01:12:55,110 --> 01:12:52,719
these space robots on earth

1990
01:12:58,070 --> 01:12:55,120
uh well so astrobee we test it on a

1991
01:13:00,390 --> 01:12:58,080
granite table it's kind of an uh upside

1992
01:13:01,270 --> 01:13:00,400
down air hockey table

1993
01:13:02,550 --> 01:13:01,280
where

1994
01:13:04,630 --> 01:13:02,560
instead of the air coming out of the

1995
01:13:06,550 --> 01:13:04,640
table it comes out of a puck and the

1996
01:13:07,910 --> 01:13:06,560
robot sits on top of this puck

1997
01:13:10,630 --> 01:13:07,920
[Music]

1998
01:13:12,550 --> 01:13:10,640
it floats on the puck so it's able to

1999
01:13:15,350 --> 01:13:12,560
slide around slides around it's like a

2000
01:13:16,709 --> 01:13:15,360
frictionless surface so it can simulate

2001
01:13:18,229 --> 01:13:16,719
uh what it's like to fly on

2002
01:13:20,950 --> 01:13:18,239
unfortunately we can only do two

2003
01:13:22,550 --> 01:13:20,960
dimensions not three yeah we don't have

2004
01:13:34,790 --> 01:13:22,560
enough thrust to actually lift up off

2005
01:13:39,430 --> 01:13:36,870
nasa johnson we have these kind of

2006
01:13:48,550 --> 01:13:39,440
gantry crane systems that are used as

2007
01:13:52,149 --> 01:13:49,910
you know the effects of gravity so you

2008
01:13:53,669 --> 01:13:52,159
attach something you hang it from it um

2009
01:13:55,750 --> 01:13:53,679
and then basically how you program the

2010
01:13:57,830 --> 01:13:55,760
crane to move around you know simulates

2011
01:13:59,430 --> 01:13:57,840
it being you know basically in in zero

2012
01:14:01,350 --> 01:13:59,440
gravity okay it's just that you can't

2013
01:14:03,189 --> 01:14:01,360

use the propulsion system when you're on

2014
01:14:04,870 --> 01:14:03,199
that right oh yeah yeah that's yeah it

2015
01:14:07,110 --> 01:14:04,880
doesn't it doesn't move it commands the

2016
01:14:08,950 --> 01:14:07,120
crane to move it as if the

2017
01:14:09,669 --> 01:14:08,960
propulsion system worked okay that's

2018
01:14:10,950 --> 01:14:09,679
cool

2019
01:14:12,870 --> 01:14:10,960
but the other thing too is you know

2020
01:14:15,270 --> 01:14:12,880
since uh since the comment uh mentioned

2021
01:14:16,950 --> 01:14:15,280
parabolic flights and we did do some

2022
01:14:19,350 --> 01:14:16,960
tests uh you know a few years ago with

2023
01:14:21,430 --> 01:14:19,360
spheres uh the smart spheres you know

2024
01:14:24,310 --> 01:14:21,440
and sort of this you know

2025
01:14:26,830 --> 01:14:24,320
vomit combat parabolic flights um and

2026
01:14:28,950 --> 01:14:26,840
they briefly mimic

2027
01:14:31,669 --> 01:14:28,960
yeah we're talking about like 15 15 to

2028
01:14:33,510 --> 01:14:31,679
20 seconds at most periods and so you

2029
01:14:35,189 --> 01:14:33,520
know from uh from an engineering you

2030
01:14:36,550 --> 01:14:35,199
know point of view it's really hard to

2031
01:14:38,229 --> 01:14:36,560
say okay let's get ready let's get ready

2032
01:14:40,630 --> 01:14:38,239
and then that comes like what can we

2033
01:14:46,149 --> 01:14:40,640
learn in 15 seconds yeah and you do this

2034
01:14:50,310 --> 01:14:47,910
it's really tough i mean it's it's

2035
01:14:52,390 --> 01:14:50,320
probably the highest fidelity way we can

2036
01:14:54,310 --> 01:14:52,400
you know simulate uh you know here on

2037
01:14:57,189 --> 01:14:54,320
earth right right on earth you know by

2038
01:14:59,430 --> 01:14:57,199

flying but it's it's really hard yeah

2039
01:15:01,430 --> 01:14:59,440
yeah well thank you guys so much for

2040
01:15:03,830 --> 01:15:01,440
joining us today um i think that's about

2041
01:15:05,750 --> 01:15:03,840
all the time we have today um a huge

2042
01:15:08,470 --> 01:15:05,760
thanks to everyone who joined us in the

2043
01:15:22,600 --> 01:15:08,480
chat today um thanks for watching we'll