



HUBBLE

hangouts

The Exciting Possibilities of 3D Printing in Zero-G

Thursday October 16, 2014, 3pm EDT 7pm GMT

1
00:00:10,350 --> 00:00:08,099
hello everybody and welcome to today's

2
00:00:11,790 --> 00:00:10,360
Hubble hang out my name is Tony Darnell

3
00:00:13,770 --> 00:00:11,800
I work at the Space Telescope Science

4
00:00:15,900 --> 00:00:13,780
Institute and we haven't really good

5
00:00:21,269 --> 00:00:15,910
hangout plan fee today we're gonna be

6
00:00:24,599 --> 00:00:21,279
talking about 3d printing in space I've

7
00:00:26,790 --> 00:00:24,609
been dying to do that okay so with and

8
00:00:28,319 --> 00:00:26,800
we have with us today Jason Donna he's

9
00:00:29,969 --> 00:00:28,329
the chief technology officer from made

10
00:00:32,190 --> 00:00:29,979
in space and he's going to tell us all

11
00:00:36,210 --> 00:00:32,200
about what the future looks like for

12
00:00:38,100 --> 00:00:36,220
printing up when zero g and but before i

13
00:00:40,170 --> 00:00:38,110

get started let me tell you we're

14

00:00:41,670 --> 00:00:40,180

looking to hat get your questions and

15

00:00:44,550 --> 00:00:41,680

comments and you can do it in all the

16

00:00:47,910 --> 00:00:44,560

usual ways twitter using Hubble hang out

17

00:00:50,340 --> 00:00:47,920

hashtag you can comment on the youtube

18

00:00:52,770 --> 00:00:50,350

channel you can comment on our event

19

00:00:54,720 --> 00:00:52,780

page and you can also use the Q&A app so

20

00:00:57,780 --> 00:00:54,730

we're monitoring all those things and we

21

00:00:59,160 --> 00:00:57,790

really hope that you will use those now

22

00:01:01,830 --> 00:00:59,170

i've been doing these hangouts for a

23

00:01:05,609 --> 00:01:01,840

while and i can't believe that i haven't

24

00:01:08,370 --> 00:01:05,619

been asking you guys to please follow or

25

00:01:10,620 --> 00:01:08,380

subscribe to our youtube channel if you

26

00:01:12,749 --> 00:01:10,630

want to get notified of more of these

27

00:01:14,249 --> 00:01:12,759

events or things like that please go to

28

00:01:16,379 --> 00:01:14,259

Hubble site channel on youtube and

29

00:01:18,450 --> 00:01:16,389

subscribe and you'll be able to get

30

00:01:20,309 --> 00:01:18,460

notifications when we go live so hope

31

00:01:22,980 --> 00:01:20,319

you'll do that and also follow us on

32

00:01:25,529 --> 00:01:22,990

twitter we're at hubble telescope so you

33

00:01:28,410 --> 00:01:25,539

can follow us there as well we also have

34

00:01:31,410 --> 00:01:28,420

a Facebook page hubble telescope on on

35

00:01:33,749 --> 00:01:31,420

that you can also follow so like us or

36

00:01:35,879 --> 00:01:33,759

follow us on that as well and we would

37

00:01:37,529 --> 00:01:35,889

very much appreciate it so there are

38

00:01:39,179 --> 00:01:37,539

many Hubble telescopes on Facebook

39

00:01:41,489 --> 00:01:39,189

they'll go for the verified one because

40

00:01:44,279 --> 00:01:41,499

that's that's us that's there's like

41

00:01:47,910 --> 00:01:44,289

five different Hubble Space I know and

42

00:01:49,499 --> 00:01:47,920

we verified one yes then now the Hubble

43

00:01:51,749 --> 00:01:49,509

I guess we relate to the game in

44

00:01:53,160 --> 00:01:51,759

facebook it was before my time but yeah

45

00:01:55,410 --> 00:01:53,170

there's a lot of Facebook pages out

46

00:01:58,559 --> 00:01:55,420

there that it's and many are Hubble

47

00:02:00,629 --> 00:01:58,569

Space Telescope of Facebook pages they

48

00:02:02,219 --> 00:02:00,639

have a lot more likes than us too so we

49

00:02:03,690 --> 00:02:02,229

one would like to try and catch up so we

50

00:02:06,089 --> 00:02:03,700

hope you'll do that so yeah that's a

51
00:02:08,430 --> 00:02:06,099
good point Scott thanks so which brings

52
00:02:10,620 --> 00:02:08,440
me to the people of my introductions

53
00:02:13,050 --> 00:02:10,630
with me as I as always is dr. carol

54
00:02:14,010 --> 00:02:13,060
christian she is the HST the Hubble

55
00:02:17,490 --> 00:02:14,020
Space Telescope

56
00:02:19,740 --> 00:02:17,500
outreach scientist hi Carol welcome and

57
00:02:23,460 --> 00:02:19,750
also scott lewis from know the cosmos

58
00:02:25,650 --> 00:02:23,470
calm and he's basically dinner known

59
00:02:27,030 --> 00:02:25,660
everywhere on the internet so thank you

60
00:02:30,570 --> 00:02:27,040
all i don't know about everywhere that's

61
00:02:32,370 --> 00:02:30,580
scary let's let's do with the good nerdy

62
00:02:35,220 --> 00:02:32,380
part to the internet i was thinkin that

63
00:02:38,340 --> 00:02:35,230

all right oh oh that's right yeah good

64

00:02:40,680 --> 00:02:38,350

clarification yeah okay so as i

65

00:02:42,510 --> 00:02:40,690

mentioned earlier jason dunn he's the

66

00:02:47,580 --> 00:02:42,520

co-founder and chief technology officer

67

00:02:48,780 --> 00:02:47,590

of made in space and you and he is here

68

00:02:50,160 --> 00:02:48,790

to talk to us today about 3d printing

69

00:02:52,010 --> 00:02:50,170

and some of the things they're doing now

70

00:02:54,330 --> 00:02:52,020

you'll remember a couple of weeks ago

71

00:02:56,670 --> 00:02:54,340

carol scott and i did a hangout on 3d

72

00:02:58,050 --> 00:02:56,680

printing that as part of the stuff that

73

00:03:01,260 --> 00:02:58,060

Carol would have been working on with

74

00:03:02,910 --> 00:03:01,270

education materials and and and you know

75

00:03:06,600 --> 00:03:02,920

visually impaired education things like

76

00:03:08,910 --> 00:03:06,610

that and Jason though is working with

77

00:03:12,180 --> 00:03:08,920

his team his company on something

78

00:03:14,400 --> 00:03:12,190

completely different so Jason welcome to

79

00:03:16,800 --> 00:03:14,410

our hangout and thanks for having me

80

00:03:20,610 --> 00:03:16,810

here it's a pleasure why don't you tell

81

00:03:23,730 --> 00:03:20,620

us a little bit about why what what what

82

00:03:25,140 --> 00:03:23,740

made in space is doing and you're you

83

00:03:27,240 --> 00:03:25,150

you helped co-found it along with I

84

00:03:28,230 --> 00:03:27,250

think to other people is that right tell

85

00:03:31,620 --> 00:03:28,240

us what you're doing on what your

86

00:03:34,680 --> 00:03:31,630

company is all about yeah be happy to so

87

00:03:36,750 --> 00:03:34,690

we started main space a little over four

88

00:03:39,150 --> 00:03:36,760

years ago now in the summer of two

89

00:03:42,270 --> 00:03:39,160

thousand ten really myself and my

90

00:03:45,810 --> 00:03:42,280

co-founders came together because we all

91

00:03:47,310 --> 00:03:45,820

believe that humanity needs to live in

92

00:03:50,550 --> 00:03:47,320

more places than just here on the

93

00:03:52,260 --> 00:03:50,560

surface of planet Earth and and we also

94

00:03:54,390 --> 00:03:52,270

believe that that can happen you know

95

00:03:56,370 --> 00:03:54,400

relatively soon as long as the right

96

00:04:00,180 --> 00:03:56,380

people start focusing attention on it so

97

00:04:01,890 --> 00:04:00,190

for us we care a lot about expanding our

98

00:04:04,410 --> 00:04:01,900

reach throughout the solar system and

99

00:04:06,030 --> 00:04:04,420

through that we kind of start looking

100

00:04:09,030 --> 00:04:06,040

all the problems why aren't we doing

101

00:04:11,280 --> 00:04:09,040

that today and identified that you know

102

00:04:13,890 --> 00:04:11,290

we can really live off the land so to

103

00:04:16,140 --> 00:04:13,900

speak and manufacture the things we need

104

00:04:19,320 --> 00:04:16,150

wherever we go we could actually enable

105

00:04:21,930 --> 00:04:19,330

a more rapid pace of sending humans to

106

00:04:24,330 --> 00:04:21,940

other planets and building new plan that

107

00:04:26,100 --> 00:04:24,340

you know new worlds of our own so we

108

00:04:27,930 --> 00:04:26,110

start focusing on space manufacturing

109

00:04:31,800 --> 00:04:27,940

and in 2010

110

00:04:35,460 --> 00:04:31,810

that idea was widely left up to science

111

00:04:37,260 --> 00:04:35,470

fiction some nasta roadmaps had it set a

112

00:04:40,410 --> 00:04:37,270

much further out than you know a few

113

00:04:43,770 --> 00:04:40,420

years later but we we took a different

114

00:04:46,640 --> 00:04:43,780

approach and we looked at how the 3d

115

00:04:49,260 --> 00:04:46,650

printing technology could enable

116

00:04:51,870 --> 00:04:49,270

basically robotic manufacturing in a way

117

00:04:53,760 --> 00:04:51,880

that we haven't had before and like I

118

00:04:56,430 --> 00:04:53,770

like how you put it with living off the

119

00:04:58,320 --> 00:04:56,440

land that's really cool now this is also

120

00:05:00,990 --> 00:04:58,330

this is also driven in part by annick by

121

00:05:02,790 --> 00:05:01,000

something that NASA is doing right there

122

00:05:05,040 --> 00:05:02,800

they had any 3d yet they're calling it

123

00:05:06,360 --> 00:05:05,050

the 3d printing in zero-g technology

124

00:05:10,050 --> 00:05:06,370

demonstration or something like that

125

00:05:13,680 --> 00:05:10,060

yeah so absolutely so the basically the

126

00:05:16,320 --> 00:05:13,690

way the way this worked out is we we

127

00:05:18,900 --> 00:05:16,330

helped reinvigorate NASA in a way we

128

00:05:21,450 --> 00:05:18,910

showed them that as a commercial company

129

00:05:23,340 --> 00:05:21,460

there was actually a business model for

130

00:05:25,590 --> 00:05:23,350

space manufacturing and that's what made

131

00:05:27,240 --> 00:05:25,600

in space would be pursuing and through

132

00:05:30,780 --> 00:05:27,250

that we developed some partnerships with

133

00:05:32,790 --> 00:05:30,790

NASA we took in 2011 we did zero gravity

134

00:05:35,340 --> 00:05:32,800

flights and I believe we even have some

135

00:05:37,530 --> 00:05:35,350

some footage there to show maybe later

136

00:05:39,810 --> 00:05:37,540

of us testing 3d printers in zero

137

00:05:42,300 --> 00:05:39,820

gravity and and then we went to design

138

00:05:45,510 --> 00:05:42,310

one for the space stage and the you know

139

00:05:48,270 --> 00:05:45,520

the really exciting thing is just last

140

00:05:50,220 --> 00:05:48,280

month made in space and nasa launched

141

00:05:52,860 --> 00:05:50,230

the first 3d printer to the space

142

00:05:54,570 --> 00:05:52,870

station so this made in space printer is

143

00:05:56,670 --> 00:05:54,580

up there it would work with NASA to

144

00:05:59,010 --> 00:05:56,680

create a technology demonstration

145

00:06:01,290 --> 00:05:59,020

mission out of this and it's called just

146

00:06:04,740 --> 00:06:01,300

like you said Tony the 3d printing in

147

00:06:07,560 --> 00:06:04,750

zero-g experiment and with a we caught

148

00:06:09,720 --> 00:06:07,570

3d print for short 3d print is really

149

00:06:11,430 --> 00:06:09,730

it's really exciting and for a lot of

150

00:06:14,400 --> 00:06:11,440

reasons but the one I'll say right now

151
00:06:16,260 --> 00:06:14,410
is that up until this point in time

152
00:06:18,150 --> 00:06:16,270
there's only been one way to get

153
00:06:20,550 --> 00:06:18,160
hardware into space and that's been

154
00:06:22,140 --> 00:06:20,560
launching it on rocket and now today

155
00:06:24,540 --> 00:06:22,150
with the 3d printer on the space station

156
00:06:27,330 --> 00:06:24,550
there's actually an entirely new way to

157
00:06:29,610 --> 00:06:27,340
get hardware there we in fact just email

158
00:06:32,280 --> 00:06:29,620
the digital file to our 3d printer and

159
00:06:33,780 --> 00:06:32,290
print it out so you think that's

160
00:06:35,250 --> 00:06:33,790
paradigm shift well I'm going to get to

161
00:06:37,080 --> 00:06:35,260
that in just a minute because to me it

162
00:06:38,279 --> 00:06:37,090
seems like you know mass is mass and

163
00:06:39,690 --> 00:06:38,289

you're going to have to get something up

164

00:06:41,040 --> 00:06:39,700

there to make the print things out of

165

00:06:41,670 --> 00:06:41,050

but we'll get to that in just a sec why

166

00:06:43,650 --> 00:06:41,680

what

167

00:06:45,900 --> 00:06:43,660

uh one let's take a step back though and

168

00:06:48,420 --> 00:06:45,910

let's talk a little bit about what 3d

169

00:06:50,610 --> 00:06:48,430

printing is and in particular what is

170

00:06:52,379 --> 00:06:50,620

your what sets your printer apart from

171

00:06:53,999 --> 00:06:52,389

say the one that we talked about a few

172

00:06:55,890 --> 00:06:54,009

weeks ago with what Carol's got going in

173

00:06:57,779 --> 00:06:55,900

the background and everybody knows carol

174

00:07:00,180 --> 00:06:57,789

always has something printing in the

175

00:07:05,340 --> 00:07:00,190

background all of our hangout so so

176

00:07:08,490 --> 00:07:05,350

probably it mine is really cheap what go

177

00:07:10,800 --> 00:07:08,500

ahead Jason yeah it's a really good

178

00:07:13,350 --> 00:07:10,810

question when we started this this

179

00:07:15,930 --> 00:07:13,360

company and set the the goal of this put

180

00:07:17,999 --> 00:07:15,940

a 3d printer on the space station we we

181

00:07:20,520 --> 00:07:18,009

had a really big hope that a commercial

182

00:07:23,400 --> 00:07:20,530

3d printer would do the job because as a

183

00:07:25,439 --> 00:07:23,410

company what we really want to get to is

184

00:07:27,390 --> 00:07:25,449

the point where anybody on planet earth

185

00:07:29,129 --> 00:07:27,400

can send their hardware to space by

186

00:07:31,950 --> 00:07:29,139

printing it there we want to open the

187

00:07:34,140 --> 00:07:31,960

doors to space this way so getting a

188

00:07:36,990 --> 00:07:34,150

printer there quick was was our goal we

189

00:07:39,480 --> 00:07:37,000

um we took these commercial printers on

190

00:07:42,240 --> 00:07:39,490

the zero-g flights and we tested over a

191

00:07:44,070 --> 00:07:42,250

dozen different printers and then built

192

00:07:46,290 --> 00:07:44,080

some new printers of our own but through

193

00:07:48,540 --> 00:07:46,300

that entire process we did over over

194

00:07:49,680 --> 00:07:48,550

three hours of zero gravity time and we

195

00:07:51,480 --> 00:07:49,690

found that none of the commercial

196

00:07:54,330 --> 00:07:51,490

printers would work we had to modify

197

00:07:56,129 --> 00:07:54,340

them significantly and you know to get

198

00:07:57,930 --> 00:07:56,139

thermal settings right to get the

199

00:08:00,000 --> 00:07:57,940

mechanical settings right I'll do all

200

00:08:01,439 --> 00:08:00,010

the things you would imagine but then on

201
00:08:03,870 --> 00:08:01,449
top of that just to build a printer that

202
00:08:05,279 --> 00:08:03,880
could survive launch to the space

203
00:08:06,899 --> 00:08:05,289
station to meet all the safety

204
00:08:09,089 --> 00:08:06,909
requirements to work on the space

205
00:08:12,270 --> 00:08:09,099
station not to you know the outgassing

206
00:08:14,310 --> 00:08:12,280
can be harmful for the crew and the EMI

207
00:08:16,290 --> 00:08:14,320
and the things like that we actually had

208
00:08:18,689 --> 00:08:16,300
to just go down a road of developing an

209
00:08:21,029 --> 00:08:18,699
entirely new type of printer one that's

210
00:08:24,149 --> 00:08:21,039
much more rugged and reliable it's

211
00:08:27,120 --> 00:08:24,159
extremely safe and it's really easy to

212
00:08:28,469 --> 00:08:27,130
use in fact there's only one button on

213
00:08:30,839 --> 00:08:28,479

the entire printer and that's the on

214

00:08:33,569 --> 00:08:30,849

switch everything else is controlled at

215

00:08:36,089 --> 00:08:33,579

our ground station here in Mountain View

216

00:08:37,829 --> 00:08:36,099

California so we actually operate the

217

00:08:39,569 --> 00:08:37,839

printer from the ground oh so you went

218

00:08:43,409 --> 00:08:39,579

to the apple design school then right

219

00:08:45,030 --> 00:08:43,419

one button is all you need Hughes where

220

00:08:47,190 --> 00:08:45,040

you guys running into when you're in the

221

00:08:49,050 --> 00:08:47,200

the vomit comet as it were doing your

222

00:08:51,810 --> 00:08:49,060

ear research what you said that you're

223

00:08:53,819 --> 00:08:51,820

doing 12 different different commercial

224

00:08:55,199 --> 00:08:53,829

printers of did you see a common issue

225

00:08:56,850 --> 00:08:55,209

among them all that

226

00:09:00,600 --> 00:08:56,860

you needed really address so you get it

227

00:09:02,189 --> 00:09:00,610

mmhmm yeah so the there's there's

228

00:09:06,569 --> 00:09:02,199

definitely kind of a wide range there

229

00:09:07,889 --> 00:09:06,579

but the basic point is you know we had

230

00:09:10,650 --> 00:09:07,899

to figure out is how to get surface

231

00:09:11,939 --> 00:09:10,660

tension to dominate so everybody would

232

00:09:13,799 --> 00:09:11,949

everybody jump straight to the point

233

00:09:17,460 --> 00:09:13,809

well how do you how do you lay down one

234

00:09:20,249 --> 00:09:17,470

layer at a time of plastic if gravity is

235

00:09:21,929 --> 00:09:20,259

not there so for us it was a lot of fine

236

00:09:24,269 --> 00:09:21,939

tune adjustments to make sure that

237

00:09:27,359 --> 00:09:24,279

surface tension alone could hold

238

00:09:29,220 --> 00:09:27,369

these layers in place and to do that

239

00:09:31,410 --> 00:09:29,230

requires a redesign of the entire

240

00:09:34,259 --> 00:09:31,420

printer in a way because the current

241

00:09:36,299 --> 00:09:34,269

printers today we're designed inherently

242

00:09:38,220 --> 00:09:36,309

with gravity in mind so gravity there is

243

00:09:40,079 --> 00:09:38,230

there to hold build platforms in place

244

00:09:43,109 --> 00:09:40,089

and belts and pulleys move appropriately

245

00:09:45,210 --> 00:09:43,119

with gravity so remove of gravity things

246

00:09:46,949 --> 00:09:45,220

start floating around and even if it's

247

00:09:48,989 --> 00:09:46,959

floating by a fraction of a millimeter

248

00:09:51,780 --> 00:09:48,999

back and forth that can screw up a whole

249

00:09:53,369 --> 00:09:51,790

print so we added me to first and

250

00:09:55,439 --> 00:09:53,379

foremost figure out how to fix the

251
00:09:57,419 --> 00:09:55,449
printers to be more rugged and and you

252
00:09:59,549 --> 00:09:57,429
could you know shake them around and

253
00:10:01,169 --> 00:09:59,559
they'll still print in fact we do that

254
00:10:03,689 --> 00:10:01,179
now we can take our printer wallets

255
00:10:05,340 --> 00:10:03,699
pretty shake it turn it upside down do

256
00:10:07,769 --> 00:10:05,350
whatever one is just you know this

257
00:10:08,999 --> 00:10:07,779
really rugged machine so how'd you do

258
00:10:11,639 --> 00:10:09,009
that what how'd you solve the problem

259
00:10:16,889 --> 00:10:11,649
what exactly is doing or is that some

260
00:10:18,960 --> 00:10:16,899
dietary it gets towards a the area of

261
00:10:21,720 --> 00:10:18,970
the proprietary like secret sauce of

262
00:10:23,369 --> 00:10:21,730
what we've done eight unicorn is

263
00:10:26,699 --> 00:10:23,379

essentially what it came down to right

264

00:10:29,850 --> 00:10:26,709

space unicorns have space unicorns that

265

00:10:32,579 --> 00:10:29,860

that that's part of it minor

266

00:10:35,489 --> 00:10:32,589

complication talk about know so we yeah

267

00:10:37,350 --> 00:10:35,499

there's a lot of it's a lot of like you

268

00:10:40,139 --> 00:10:37,360

know redesigning thinking of it with

269

00:10:41,579 --> 00:10:40,149

different requirements we um the thermal

270

00:10:43,679 --> 00:10:41,589

characteristics that's an interesting

271

00:10:45,689 --> 00:10:43,689

one because if you we all know that hot

272

00:10:48,150 --> 00:10:45,699

air rises in the rooms that were sitting

273

00:10:50,970 --> 00:10:48,160

in right now but if you remove gravity

274

00:10:53,549 --> 00:10:50,980

hot air doesn't rise there's no buoyancy

275

00:10:56,100 --> 00:10:53,559

effects so hot there just stays around

276
00:10:58,949 --> 00:10:56,110
the area where it's created so we had to

277
00:11:00,600 --> 00:10:58,959
figure out how to thermally control the

278
00:11:04,350 --> 00:11:00,610
print environment which is also another

279
00:11:05,909 --> 00:11:04,360
important one so you have a you had to

280
00:11:08,319 --> 00:11:05,919
invent things that sounds like to get

281
00:11:10,960 --> 00:11:08,329
all of this stuff to work so I suppose

282
00:11:12,400 --> 00:11:10,970
yeah it's a lot like then that's pretty

283
00:11:14,619 --> 00:11:12,410
typical of a lot of things that you know

284
00:11:16,739 --> 00:11:14,629
isn't its involvement with NASA about

285
00:11:19,119 --> 00:11:16,749
technologies just have to be invented

286
00:11:20,739 --> 00:11:19,129
why is net so NASA is interested in

287
00:11:22,389 --> 00:11:20,749
doing this because they want to be able

288
00:11:24,189 --> 00:11:22,399

to print things or they want to

289

00:11:26,949 --> 00:11:24,199

manufacture things in space that's the

290

00:11:29,919 --> 00:11:26,959

that's the driver for it but um I guess

291

00:11:32,379 --> 00:11:29,929

my question is how how is it really i

292

00:11:36,329 --> 00:11:32,389

mean you didn't really thought you

293

00:11:39,369 --> 00:11:36,339

solved the problem of you know launching

294

00:11:41,169 --> 00:11:39,379

parts individual parts in space but you

295

00:11:43,629 --> 00:11:41,179

did you didn't sound to me like and i

296

00:11:45,999 --> 00:11:43,639

don't know how i also say this i don't

297

00:11:47,919 --> 00:11:46,009

think the problem of getting mass up

298

00:11:51,009 --> 00:11:47,929

into orbit has been solved you still got

299

00:11:54,519 --> 00:11:51,019

to have whatever it is that your printer

300

00:11:59,530 --> 00:11:54,529

is using right to be up there and that

301
00:12:01,840 --> 00:11:59,540
is not you know 00 wait and i wantam

302
00:12:05,619 --> 00:12:01,850
Adam yeah well I mean you brought that

303
00:12:08,259 --> 00:12:05,629
up Tony um we we identified that problem

304
00:12:10,299 --> 00:12:08,269
from really from day one because it's

305
00:12:13,179 --> 00:12:10,309
one thing to say hey it's great that the

306
00:12:14,799 --> 00:12:13,189
printer is in space there are problem

307
00:12:17,609 --> 00:12:14,809
even if you have to send the raw

308
00:12:19,840 --> 00:12:17,619
material it's still beneficial because

309
00:12:21,939 --> 00:12:19,850
when you're when you don't have to

310
00:12:24,039 --> 00:12:21,949
design your card we're to survive launch

311
00:12:26,019 --> 00:12:24,049
and you remove the requirement of it

312
00:12:27,280 --> 00:12:26,029
having it with stance several times the

313
00:12:28,989 --> 00:12:27,290

force of gravity and all these

314

00:12:30,970 --> 00:12:28,999

vibrational loads you can actually

315

00:12:35,139 --> 00:12:30,980

redesign your space structures to be

316

00:12:37,119 --> 00:12:35,149

extremely delicate in a way so imagine

317

00:12:39,129 --> 00:12:37,129

something that only has to work in zero

318

00:12:41,590 --> 00:12:39,139

gravity it doesn't have to support its

319

00:12:43,840 --> 00:12:41,600

own weight so just by sending the raw

320

00:12:46,359 --> 00:12:43,850

material in its like most condensed form

321

00:12:48,400 --> 00:12:46,369

we can actually let that material go

322

00:12:50,979 --> 00:12:48,410

much longer way by building what we call

323

00:12:53,619 --> 00:12:50,989

zero gravity structures so that's um

324

00:12:54,970 --> 00:12:53,629

that's number one so even today with the

325

00:12:57,359 --> 00:12:54,980

printer there and just launching the

326

00:13:01,119 --> 00:12:57,369

feedstock there's still a net benefit

327

00:13:03,189 --> 00:13:01,129

also time just the fact of just getting

328

00:13:05,199 --> 00:13:03,199

things to space quicker we can by

329

00:13:07,929 --> 00:13:05,209

printing there we can we can shortcut

330

00:13:09,759 --> 00:13:07,939

the entire process of launch manifests

331

00:13:12,009 --> 00:13:09,769

and all those things so hardware to

332

00:13:14,530 --> 00:13:12,019

space in in days to weeks is incredibly

333

00:13:17,139 --> 00:13:14,540

beneficial now still wasn't good enough

334

00:13:19,359 --> 00:13:17,149

for us we recognize it at the end of the

335

00:13:22,120 --> 00:13:19,369

day we still don't want to be dependent

336

00:13:25,120 --> 00:13:22,130

on earth if we send

337

00:13:27,070 --> 00:13:25,130

crew to Mars to live on Mars and we rely

338

00:13:28,750 --> 00:13:27,080

on earth dependency and have to keep

339

00:13:31,000 --> 00:13:28,760

launching rocket after rocket of

340

00:13:34,180 --> 00:13:31,010

resupply we really then solve the

341

00:13:37,090 --> 00:13:34,190

problem of living off the land so when

342

00:13:39,300 --> 00:13:37,100

we start to look at the past couple

343

00:13:41,770 --> 00:13:39,310

years is how can we actually produce

344

00:13:44,470 --> 00:13:41,780

feedstock for the 3d printer on the

345

00:13:46,870 --> 00:13:44,480

space station and we started developing

346

00:13:49,930 --> 00:13:46,880

a new piece of technology that we call

347

00:13:52,810 --> 00:13:49,940

redo and redo for the fact that you can

348

00:13:54,850 --> 00:13:52,820

take a 3d printed part and redo it turn

349

00:13:57,670 --> 00:13:54,860

it right back into the feedstock oh wow

350

00:13:59,680 --> 00:13:57,680

that is awesome yeah so redo is it's

351
00:14:02,170 --> 00:13:59,690
under development right now it's in our

352
00:14:04,480 --> 00:14:02,180
lab and it you actually use it for our

353
00:14:06,520 --> 00:14:04,490
3d printer feedstock work we're we're

354
00:14:08,200 --> 00:14:06,530
getting to the point where in our lab

355
00:14:09,790 --> 00:14:08,210
here in Mountain View we don't have to

356
00:14:12,910 --> 00:14:09,800
buy feedstock anymore we just keep

357
00:14:15,280 --> 00:14:12,920
reusing what we already have by redoing

358
00:14:16,870 --> 00:14:15,290
it now the interesting thing is once we

359
00:14:19,060 --> 00:14:16,880
start diving into this problem we

360
00:14:22,690 --> 00:14:19,070
realized that the space station has a

361
00:14:25,810 --> 00:14:22,700
lot of plastic waste a lot of the the

362
00:14:27,730 --> 00:14:25,820
food comes up in polyethylene bags the

363
00:14:31,540 --> 00:14:27,740

packaging foam all these things are

364

00:14:33,670 --> 00:14:31,550

actually a polymer and we redesign redo

365

00:14:35,020 --> 00:14:33,680

to actually take plastic waste on the

366

00:14:38,050 --> 00:14:35,030

space station and turn that into

367

00:14:42,700 --> 00:14:38,060

filament as well so really neat because

368

00:14:45,460 --> 00:14:42,710

what this is is a really useful form of

369

00:14:48,250 --> 00:14:45,470

what we call is are you or in situ

370

00:14:50,020 --> 00:14:48,260

resource utilization so end of the day

371

00:14:52,300 --> 00:14:50,030

we're actually turning waste on the

372

00:14:54,310 --> 00:14:52,310

space station in upcycling it turning

373

00:14:56,590 --> 00:14:54,320

into something more useful that's

374

00:14:59,890 --> 00:14:56,600

amazing so so this there's a question

375

00:15:03,430 --> 00:14:59,900

right now I that space station to make a

376

00:15:05,500 --> 00:15:03,440

new stuff what I I said you can scuttle

377

00:15:07,150 --> 00:15:05,510

butt the space station to make new stuff

378

00:15:08,290 --> 00:15:07,160

once you have enough large up there you

379

00:15:10,210 --> 00:15:08,300

just like oh I don't like this

380

00:15:11,950 --> 00:15:10,220

experiment well if I gonna park what'd

381

00:15:18,250 --> 00:15:11,960

you do with my experiment I I agree

382

00:15:19,690 --> 00:15:18,260

printed it up for a new culture so this

383

00:15:22,210 --> 00:15:19,700

is related to a question jonathan peters

384

00:15:23,770 --> 00:15:22,220

is asking on the Q&A have what types of

385

00:15:25,030 --> 00:15:23,780

materials does a printer use and you've

386

00:15:27,760 --> 00:15:25,040

already said that you've got this redo

387

00:15:30,340 --> 00:15:27,770

that's in development you're looking at

388

00:15:32,980 --> 00:15:30,350

recycling or reusing the waste material

389

00:15:35,590 --> 00:15:32,990

that's already on the space station what

390

00:15:39,370 --> 00:15:35,600

is there a base stock that you use just

391

00:15:42,550 --> 00:15:39,380

commonly yeah we uh the printer that is

392

00:15:45,129 --> 00:15:42,560

on the space station today is an ABS

393

00:15:46,980 --> 00:15:45,139

printer so a lot like the 3d printers

394

00:15:50,079 --> 00:15:46,990

that were all used to using in our homes

395

00:15:52,150 --> 00:15:50,089

we're printing with ABS main reason why

396

00:15:53,889 --> 00:15:52,160

there is because this is it it like we

397

00:15:56,079 --> 00:15:53,899

mentioned the technology demonstration

398

00:15:58,150 --> 00:15:56,089

and we need a really good way to compare

399

00:16:00,910 --> 00:15:58,160

our printer works in space compared to

400

00:16:03,819 --> 00:16:00,920

one on the ground so using abs we can

401
00:16:06,309 --> 00:16:03,829
compare against a wide wide amount of

402
00:16:08,740 --> 00:16:06,319
data on the ground now that actually

403
00:16:10,569 --> 00:16:08,750
isn't the end-all be-all we can't you

404
00:16:13,180 --> 00:16:10,579
know build everything we need out of ABS

405
00:16:14,860 --> 00:16:13,190
plastic so made in space will launch a

406
00:16:17,290 --> 00:16:14,870
second printer next year it's a

407
00:16:19,269 --> 00:16:17,300
commercial facilities so that's where

408
00:16:21,400 --> 00:16:19,279
all the viewers here if they get excited

409
00:16:23,769 --> 00:16:21,410
and want to build hardware and space by

410
00:16:26,139 --> 00:16:23,779
you know giving us the digital file and

411
00:16:27,490 --> 00:16:26,149
3d printing it it will most likely get

412
00:16:29,949 --> 00:16:27,500
printed on the second printer which

413
00:16:32,019 --> 00:16:29,959

flies next year and it's it does a wide

414

00:16:35,050 --> 00:16:32,029

arrangement of materials so we have

415

00:16:37,210 --> 00:16:35,060

space qualified polymers if you want to

416

00:16:39,100 --> 00:16:37,220

build a CubeSat for instance we can

417

00:16:41,679 --> 00:16:39,110

build that and put it out in the vacuum

418

00:16:44,019 --> 00:16:41,689

we've developed materials that can be

419

00:16:45,460 --> 00:16:44,029

used for biological experiments and

420

00:16:47,980 --> 00:16:45,470

other experiments you do on the space

421

00:16:50,410 --> 00:16:47,990

station so really how much or whatever

422

00:16:52,929 --> 00:16:50,420

you like it's designed to do those

423

00:16:56,829 --> 00:16:52,939

materials nice that's that's really

424

00:16:59,110 --> 00:16:56,839

amazing so I understand the importance

425

00:17:02,949 --> 00:16:59,120

or that where you know the savings of

426
00:17:04,329 --> 00:17:02,959
not having to anticipate you know which

427
00:17:05,500 --> 00:17:04,339
spare part you're going to need when

428
00:17:06,819 --> 00:17:05,510
you're up in space and making sure that

429
00:17:08,470 --> 00:17:06,829
they're all launched I can see the

430
00:17:10,329 --> 00:17:08,480
weight savings there and I also now see

431
00:17:13,500 --> 00:17:10,339
that you especially with redo you'll be

432
00:17:16,149 --> 00:17:13,510
able to remake some of these parts uh

433
00:17:18,699 --> 00:17:16,159
yeah and you're also saving weight from

434
00:17:20,169 --> 00:17:18,709
being able to not when making the part

435
00:17:22,569 --> 00:17:20,179
in space it doesn't have to be as heavy

436
00:17:26,230 --> 00:17:22,579
as when you make it here on earth what

437
00:17:28,810 --> 00:17:26,240
um how I guess is anything being made

438
00:17:31,690 --> 00:17:28,820

now right I mean that as they sort have

439

00:17:33,940 --> 00:17:31,700

they started using the printer yet the

440

00:17:38,110 --> 00:17:33,950

the printer has not been turned on yet

441

00:17:40,360 --> 00:17:38,120

it's a it's basically this printer goes

442

00:17:41,980 --> 00:17:40,370

inside of the microgravity science

443

00:17:43,659 --> 00:17:41,990

glovebox in fact I'll know how well you

444

00:17:46,240 --> 00:17:43,669

can see the image behind me on the wall

445

00:17:49,180 --> 00:17:46,250

but it might look like I'm inside of the

446

00:17:52,330 --> 00:17:49,190

space station the msg the

447

00:17:54,130 --> 00:17:52,340

so somewhere up in the corner and it's a

448

00:17:55,870 --> 00:17:54,140

it's what it sounds like it's a glove

449

00:17:58,000 --> 00:17:55,880

box that you can put it in experiment

450

00:18:00,270 --> 00:17:58,010

into and and and the astronauts have

451

00:18:02,950 --> 00:18:00,280

this like safety containment around it

452

00:18:04,570 --> 00:18:02,960

now the glove box also gets used for a

453

00:18:06,970 --> 00:18:04,580

lot of other experiments if you've been

454

00:18:10,240 --> 00:18:06,980

following what launched on on space

455

00:18:12,040 --> 00:18:10,250

explorer with our printer there was the

456

00:18:14,080 --> 00:18:12,050

road and habitat there's a bunch of

457

00:18:16,840 --> 00:18:14,090

other experiments so we're basically in

458

00:18:18,670 --> 00:18:16,850

the waiting line to get into the glove

459

00:18:21,250 --> 00:18:18,680

box and so it should be it should be

460

00:18:23,200 --> 00:18:21,260

really soon and you know fingers crossed

461

00:18:26,080 --> 00:18:23,210

so we started seeing parts printed in

462

00:18:28,630 --> 00:18:26,090

the near future okay I have a question

463

00:18:31,060 --> 00:18:28,640

actually about the parts and you you

464

00:18:32,530 --> 00:18:31,070

touch upon it a little bit so you've

465

00:18:34,660 --> 00:18:32,540

been thinking about not only you know

466

00:18:36,670 --> 00:18:34,670

every which way and being able to print

467

00:18:39,700 --> 00:18:36,680

but my experience with my cheap little

468

00:18:41,860 --> 00:18:39,710

printer and we don't use abs because ma

469

00:18:43,750 --> 00:18:41,870

I have no environmental control in my

470

00:18:47,830 --> 00:18:43,760

office some days 100 degrees in

471

00:18:50,410 --> 00:18:47,840

sometimes it's 50 so we use PLA but it

472

00:18:53,440 --> 00:18:50,420

with either technology and your I know

473

00:18:56,050 --> 00:18:53,450

your you've thought about this is that

474

00:18:58,660 --> 00:18:56,060

you get these threads and you get and

475

00:19:00,640 --> 00:18:58,670

sometimes the parts need to be polished

476

00:19:03,520 --> 00:19:00,650

and things like that so I assume that

477

00:19:05,830 --> 00:19:03,530

you're addressing those because can't be

478

00:19:08,170 --> 00:19:05,840

you know sanding stuff on the space

479

00:19:10,630 --> 00:19:08,180

station and how that stuff go everywhere

480

00:19:12,340 --> 00:19:10,640

so good point yeah making making the

481

00:19:15,070 --> 00:19:12,350

parts a little more perfect that the

482

00:19:18,940 --> 00:19:15,080

ones I'm printing must be part of your

483

00:19:20,290 --> 00:19:18,950

strategy yeah it's a it's a good

484

00:19:22,420 --> 00:19:20,300

question Carol it's something that

485

00:19:25,810 --> 00:19:22,430

anybody who's working with 3d printers

486

00:19:27,760 --> 00:19:25,820

today already understands so um we had

487

00:19:30,010 --> 00:19:27,770

to address that from in several

488

00:19:31,950 --> 00:19:30,020

different ways the the fact is is we

489

00:19:34,390 --> 00:19:31,960

can't have a printer that is it is

490

00:19:36,280 --> 00:19:34,400

breaking off little pieces of plastic

491

00:19:38,530 --> 00:19:36,290

and letting it float around because at

492

00:19:40,660 --> 00:19:38,540

the moment the Astron opens the door of

493

00:19:42,670 --> 00:19:40,670

the printer and those pieces start

494

00:19:44,290 --> 00:19:42,680

floating out they get stuck in all the

495

00:19:48,430 --> 00:19:44,300

nooks and crannies of the space station

496

00:19:50,260 --> 00:19:48,440

so we've built it's a really

497

00:19:53,410 --> 00:19:50,270

sophisticated type of environmental

498

00:19:56,310 --> 00:19:53,420

control it's something that can recycle

499

00:19:59,110 --> 00:19:56,320

the the harmful gases being created so

500

00:20:01,990 --> 00:19:59,120

you know off gassing of things like

501
00:20:02,890 --> 00:20:02,000
styrene that come out of a print but it

502
00:20:04,870 --> 00:20:02,900
also captures

503
00:20:07,690 --> 00:20:04,880
particulates and it controls the the

504
00:20:09,340 --> 00:20:07,700
temperature of the print volume so so

505
00:20:11,080 --> 00:20:09,350
you know the end of the day the best way

506
00:20:13,440 --> 00:20:11,090
to get a really good print is to control

507
00:20:19,720 --> 00:20:13,450
that volume have the right temperature

508
00:20:21,040 --> 00:20:19,730
settings and things like that um used we

509
00:20:23,020 --> 00:20:21,050
mentioned this briefly and Scott asked

510
00:20:26,290 --> 00:20:23,030
you about this also about the the

511
00:20:28,420 --> 00:20:26,300
testing that was done how long did you

512
00:20:30,340 --> 00:20:28,430
guys I mean what was it like in the in

513
00:20:32,380 --> 00:20:30,350

the vomit comet to to test all of this

514

00:20:34,300 --> 00:20:32,390

stuff and was it difficult to get

515

00:20:39,910 --> 00:20:34,310

everything set up in there and do the

516

00:20:43,480 --> 00:20:39,920

testing um yeah so there's a lot of fun

517

00:20:48,340 --> 00:20:43,490

stuff I can say about the the weightless

518

00:20:50,740 --> 00:20:48,350

wonder I don't have like yeah honestly

519

00:20:53,140 --> 00:20:50,750

like my the one thing I always say to

520

00:20:56,620 --> 00:20:53,150

anyone whenever I talk about this is if

521

00:21:00,000 --> 00:20:56,630

you ever get the chance to go do it this

522

00:21:03,490 --> 00:21:00,010

is being weightless is it's one of the

523

00:21:05,350 --> 00:21:03,500

best experience I've ever felt I've um

524

00:21:07,480 --> 00:21:05,360

through this test program we've done

525

00:21:10,630 --> 00:21:07,490

with NASA I've now spent an entire hour

526

00:21:12,460 --> 00:21:10,640

of my life being weightless it's a

527

00:21:16,780 --> 00:21:12,470

really quick weight loss program if you

528

00:21:21,010 --> 00:21:16,790

need one so do your evo zipper its

529

00:21:22,600 --> 00:21:21,020

harbors come right back on yeah twenty

530

00:21:24,340 --> 00:21:22,610

seconds of being weightless and then

531

00:21:28,210 --> 00:21:24,350

next 20 seconds you're about twice your

532

00:21:30,190 --> 00:21:28,220

weight so it's a reasonable it's a

533

00:21:31,960 --> 00:21:30,200

really incredible experience being in

534

00:21:33,790 --> 00:21:31,970

being weightless you you realize that

535

00:21:36,730 --> 00:21:33,800

you have a new dimension you can there's

536

00:21:38,800 --> 00:21:36,740

no such thing as down anymore it's just

537

00:21:41,320 --> 00:21:38,810

it's wild to let your you know to

538

00:21:42,880 --> 00:21:41,330

experience that but for us we ended

539

00:21:47,770 --> 00:21:42,890

design we had also be doing real science

540

00:21:50,200 --> 00:21:47,780

so we build our experiment specifically

541

00:21:53,830 --> 00:21:50,210

to make sure that it could run is

542

00:21:56,410 --> 00:21:53,840

autonomously as possible so that if any

543

00:21:58,450 --> 00:21:56,420

of us were maybe having too much fun or

544

00:22:02,830 --> 00:21:58,460

maybe not having enough fun and getting

545

00:22:04,420 --> 00:22:02,840

sick directly logo keep going so um you

546

00:22:06,670 --> 00:22:04,430

know the good thing about 3d printers is

547

00:22:08,260 --> 00:22:06,680

you can you know usually turn them on

548

00:22:11,260 --> 00:22:08,270

and they just keep you know they do

549

00:22:14,470 --> 00:22:11,270

their job so we built the experiments so

550

00:22:16,750 --> 00:22:14,480

that it's basically if we roll the video

551
00:22:18,460 --> 00:22:16,760
you'll see it maybe we already did roll

552
00:22:21,730 --> 00:22:18,470
yeah but I'm living in let's go ahead

553
00:22:24,190 --> 00:22:21,740
and do this uh jeez Kelly of Kelly I can

554
00:22:26,500 --> 00:22:24,200
talk about why while I goes is that okay

555
00:22:30,700 --> 00:22:26,510
yeah yeah yeah go ahead Kelly's got it

556
00:22:32,530 --> 00:22:30,710
up I think yeah narrate this so so

557
00:22:37,420 --> 00:22:32,540
you'll see the box on the left it's our

558
00:22:39,460 --> 00:22:37,430
experiment box it holds about three to

559
00:22:42,490 --> 00:22:39,470
four different experiments at a time so

560
00:22:45,010 --> 00:22:42,500
we designed it really specifically to be

561
00:22:47,200 --> 00:22:45,020
modular we constantly every every we do

562
00:22:50,050 --> 00:22:47,210
our flight we get down we fix something

563
00:22:52,600 --> 00:22:50,060

we put in a new experiment and it's part

564

00:22:54,940 --> 00:22:52,610

of our philosophy as a company that it's

565

00:22:58,180 --> 00:22:54,950

important to iterate early and iterate

566

00:23:00,630 --> 00:22:58,190

often so it's probably too that credit

567

00:23:03,490 --> 00:23:00,640

that we have Hardware in space only a

568

00:23:06,670 --> 00:23:03,500

year after kicking off the actual flight

569

00:23:09,850 --> 00:23:06,680

mission with NASA so iterating quickly

570

00:23:12,040 --> 00:23:09,860

is important to us so we did like I said

571

00:23:13,690 --> 00:23:12,050

over three hours of total zero gravity

572

00:23:16,210 --> 00:23:13,700

time but we've tested dozens of

573

00:23:19,810 --> 00:23:16,220

different experiments and and tweak

574

00:23:22,450 --> 00:23:19,820

things as we go so that's the experiment

575

00:23:25,090 --> 00:23:22,460

box you'll see that it's really quick

576

00:23:27,970 --> 00:23:25,100

you get like 20 seconds of zero-g and

577

00:23:30,070 --> 00:23:27,980

then you're back into 2g and the way we

578

00:23:31,680 --> 00:23:30,080

we figured it out we actually in the

579

00:23:34,630 --> 00:23:31,690

beginning we were we were building

580

00:23:36,400 --> 00:23:34,640

software that would a motion sensors

581

00:23:39,760 --> 00:23:36,410

that would turn the printer pause the

582

00:23:42,670 --> 00:23:39,770

printer between the 2g pull outs so they

583

00:23:44,200 --> 00:23:42,680

would only print during 0g and we got

584

00:23:46,270 --> 00:23:44,210

some useful data but then we realized

585

00:23:48,160 --> 00:23:46,280

that it would be way better if we could

586

00:23:50,440 --> 00:23:48,170

just turn the printer on when we start

587

00:23:52,390 --> 00:23:50,450

flying and then turn it off when we land

588

00:23:54,700 --> 00:23:52,400

at the runway and just have the printer

589

00:23:57,250 --> 00:23:54,710

print the whole time without any problem

590

00:23:58,930 --> 00:23:57,260

so at the end of the day when we had

591

00:24:00,910 --> 00:23:58,940

figured out is a way to make these

592

00:24:03,580 --> 00:24:00,920

printers just operate in zero gravity

593

00:24:06,010 --> 00:24:03,590

but also in 2 g's and everywhere in

594

00:24:08,160 --> 00:24:06,020

between so it's that's why I was saying

595

00:24:10,990 --> 00:24:08,170

earlier it's a very rugged printer that

596

00:24:13,510 --> 00:24:11,000

it was just part of our the way we

597

00:24:16,240 --> 00:24:13,520

tested it was it was made it easier for

598

00:24:18,460 --> 00:24:16,250

us to do it that way but now we have we

599

00:24:20,440 --> 00:24:18,470

call it gravity independent 3d printing

600

00:24:22,270 --> 00:24:20,450

it's not just a zero-g printer I like

601
00:24:24,040 --> 00:24:22,280
that you can print anywhere and it

602
00:24:26,920 --> 00:24:24,050
actually turns out to be really

603
00:24:30,130 --> 00:24:26,930
beneficial on our end because we have a

604
00:24:30,649 --> 00:24:30,140
3d printer in our lab that is basically

605
00:24:32,599 --> 00:24:30,659
I

606
00:24:37,039 --> 00:24:32,609
nicole the one on the space station and

607
00:24:39,440 --> 00:24:37,049
because gravity doesn't really cause an

608
00:24:41,450 --> 00:24:39,450
issue in the printing process that means

609
00:24:43,729 --> 00:24:41,460
that anything we print in our lab should

610
00:24:45,440 --> 00:24:43,739
be just the same as how prints on the

611
00:24:48,259 --> 00:24:45,450
space station so we have a really good

612
00:24:49,369 --> 00:24:48,269
comparison and it allows people to come

613
00:24:53,180 --> 00:24:49,379

in who want to print on Space Station

614

00:24:54,649 --> 00:24:53,190

try it out on our printer first cool

615

00:24:57,229 --> 00:24:54,659

okay we got a lot of questions coming in

616

00:24:58,969 --> 00:24:57,239

from the QA applet John Jonathan I'm

617

00:25:01,060 --> 00:24:58,979

going to get to your follow-up in just a

618

00:25:04,759 --> 00:25:01,070

minute but Rebecca Rodriguez is asking

619

00:25:06,769 --> 00:25:04,769

has regolith with additives been

620

00:25:10,239 --> 00:25:06,779

considered for feedstock in the long run

621

00:25:13,849 --> 00:25:10,249

is that part of the NASA vision oh

622

00:25:15,379 --> 00:25:13,859

that's a cool run Rebecca we you know

623

00:25:17,029 --> 00:25:15,389

it's definitely part of the maiden space

624

00:25:19,729 --> 00:25:17,039

decision and I would say it's part of

625

00:25:23,509 --> 00:25:19,739

NASA's as well you can find you can find

626
00:25:27,259 --> 00:25:23,519
some things NASA's done in terms of ice

627
00:25:28,609 --> 00:25:27,269
are you and and regular printing and

628
00:25:31,729 --> 00:25:28,619
things like that but I'll tell you a

629
00:25:33,619 --> 00:25:31,739
little bit about what we've done we a

630
00:25:35,899 --> 00:25:33,629
little over a year ago as we were

631
00:25:37,460 --> 00:25:35,909
building our 3d printer for space we we

632
00:25:40,369 --> 00:25:37,470
wondered could we make our printer

633
00:25:42,950 --> 00:25:40,379
actually print with regular so we took

634
00:25:44,389 --> 00:25:42,960
the basically the same exact printer

635
00:25:48,019 --> 00:25:44,399
that's on the space station and we

636
00:25:50,839 --> 00:25:48,029
modified it so that it could so they can

637
00:25:55,039 --> 00:25:50,849
print something of like a composite like

638
00:25:59,419 --> 00:25:55,049

a concrete but we used a lunar simulate

639

00:26:01,639 --> 00:25:59,429

so JSC 1a we mix it with with a binder

640

00:26:02,899 --> 00:26:01,649

and a binder that actually we could

641

00:26:05,359 --> 00:26:02,909

produce on the moon if we were living

642

00:26:07,190 --> 00:26:05,369

there and then with a really small

643

00:26:10,310 --> 00:26:07,200

amount of water that theoretically you

644

00:26:12,529 --> 00:26:10,320

could harvest from lunar soil so the IDS

645

00:26:15,019 --> 00:26:12,539

completely is our are you is you get the

646

00:26:17,299 --> 00:26:15,029

dirt you get the you grow your your

647

00:26:19,249 --> 00:26:17,309

binder and you get the water and we we

648

00:26:22,039 --> 00:26:19,259

made our printer print those samples so

649

00:26:25,430 --> 00:26:22,049

um you know we've printed these really

650

00:26:27,080 --> 00:26:25,440

little bricks basically of regolith but

651
00:26:29,299 --> 00:26:27,090
imagine just scale up the printer in

652
00:26:33,049 --> 00:26:29,309
size put it on the moon and and add some

653
00:26:35,299 --> 00:26:33,059
other subsystems to harvest resources

654
00:26:38,839 --> 00:26:35,309
and whatnot and we you have the ability

655
00:26:40,849 --> 00:26:38,849
to actually build you know bricks on the

656
00:26:43,730 --> 00:26:40,859
moon and we think that's cool because

657
00:26:46,250 --> 00:26:43,740
what this would enable is yeah

658
00:26:47,990 --> 00:26:46,260
robotic Commission get to the point

659
00:26:49,430 --> 00:26:48,000
where before you send humans you've

660
00:26:52,370 --> 00:26:49,440
already sent a robot that built them a

661
00:26:56,000 --> 00:26:52,380
habitat that's amazing that's good

662
00:26:57,830 --> 00:26:56,010
question Rebecca thank you so Philip

663
00:26:59,930 --> 00:26:57,840

keen on the Q&A app is also asking

664

00:27:01,910 --> 00:26:59,940

question I'd like to know as well have

665

00:27:03,799 --> 00:27:01,920

you think hi Jason have you figured out

666

00:27:06,220 --> 00:27:03,809

the price for researchers to use the

667

00:27:09,460 --> 00:27:06,230

commercial printer when it gets there

668

00:27:14,540 --> 00:27:09,470

it's gonna cost to do use this thing

669

00:27:15,860 --> 00:27:14,550

sell a good question not surprised we

670

00:27:20,419 --> 00:27:15,870

know we know each other that's a rice

671

00:27:24,110 --> 00:27:20,429

field but yeah so you know him okay yes

672

00:27:26,299 --> 00:27:24,120

so this is this is one of those golden

673

00:27:29,570 --> 00:27:26,309

questions people people are ready to use

674

00:27:31,760 --> 00:27:29,580

the printer we've got a lot of people

675

00:27:34,360 --> 00:27:31,770

actually kind of lined up with their

676
00:27:37,880 --> 00:27:34,370
ideas and and and parts ready to print

677
00:27:41,180 --> 00:27:37,890
the pricing question is not public yet

678
00:27:44,690 --> 00:27:41,190
but what I can say is that it's that

679
00:27:47,030 --> 00:27:44,700
it's extremely reasonable we've it were

680
00:27:48,590 --> 00:27:47,040
definitely like at the end of the day

681
00:27:53,240 --> 00:27:48,600
what we're doing and what we want to do

682
00:27:55,040 --> 00:27:53,250
is make it so that a much larger group

683
00:27:57,680 --> 00:27:55,050
of people have access to space than

684
00:27:59,150 --> 00:27:57,690
previously if we can't do that then we

685
00:28:01,669 --> 00:27:59,160
don't feel like we've accomplished our

686
00:28:04,880 --> 00:28:01,679
mission because the at the end of the

687
00:28:06,950 --> 00:28:04,890
day space to is is pretty prohibitive

688
00:28:10,220 --> 00:28:06,960

it's expensive it's costly it's why it's

689

00:28:12,710 --> 00:28:10,230

largely been a government-run industry

690

00:28:14,480 --> 00:28:12,720

but we feel like if we can if we can

691

00:28:16,280 --> 00:28:14,490

make it more accessible we'll start to

692

00:28:19,280 --> 00:28:16,290

see innovation happen like we haven't

693

00:28:21,980 --> 00:28:19,290

seen before in space so for all the

694

00:28:24,080 --> 00:28:21,990

individuals the researchers the small

695

00:28:27,410 --> 00:28:24,090

companies out there using the printer

696

00:28:29,210 --> 00:28:27,420

will not be you know it will be within

697

00:28:31,580 --> 00:28:29,220

the cost range that that can be

698

00:28:33,950 --> 00:28:31,590

affording okay well I don't related note

699

00:28:35,810 --> 00:28:33,960

then it would seem to me like you're

700

00:28:37,310 --> 00:28:35,820

going to have to do kind of like what we

701
00:28:38,419 --> 00:28:37,320
do at the Institute for deciding who

702
00:28:40,910 --> 00:28:38,429
gets to use the Hubble Space Telescope

703
00:28:42,919 --> 00:28:40,920
we have a time allocation committee wut

704
00:28:45,049 --> 00:28:42,929
m8 way there certain criterion that the

705
00:28:47,330 --> 00:28:45,059
scientists use to decide what what to

706
00:28:49,310 --> 00:28:47,340
give Hubble time to what are you going

707
00:28:51,020 --> 00:28:49,320
to do how are you going to decide who

708
00:28:54,250 --> 00:28:51,030
gets to use it what are the criterion

709
00:28:57,470 --> 00:28:54,260
like any have you thought about that yet

710
00:29:00,799 --> 00:28:57,480
uh yeah we're we're actually working

711
00:29:02,960 --> 00:29:00,809
nasa work with NASA for most of these

712
00:29:08,360 --> 00:29:02,970
things and this one's a pretty important

713
00:29:11,030 --> 00:29:08,370

one because you know nASA has you know

714

00:29:12,110 --> 00:29:11,040

lots of processes for what can fly on

715

00:29:16,130 --> 00:29:12,120

the space station there's a lot of

716

00:29:17,840 --> 00:29:16,140

safety processes there too so what we've

717

00:29:19,610 --> 00:29:17,850

had to do you know we've created a

718

00:29:22,789 --> 00:29:19,620

completely new way to get hardware there

719

00:29:25,039 --> 00:29:22,799

and the question that it has to be asked

720

00:29:26,750 --> 00:29:25,049

is well if you know if you want to send

721

00:29:28,460 --> 00:29:26,760

a wrench to the space station today that

722

00:29:31,370 --> 00:29:28,470

wrench has to go through testing on the

723

00:29:32,510 --> 00:29:31,380

ground it goes to a safety review panel

724

00:29:35,270 --> 00:29:32,520

who make sure it's safe for the

725

00:29:37,400 --> 00:29:35,280

astronauts so what do you do when that

726

00:29:39,320 --> 00:29:37,410

wrench is printed in space how do you

727

00:29:41,600 --> 00:29:39,330

know that you actually printed the thing

728

00:29:44,750 --> 00:29:41,610

that you wanted to print so we've been

729

00:29:46,640 --> 00:29:44,760

developing kind of a new process that we

730

00:29:48,830 --> 00:29:46,650

can that we work with NASA on to make

731

00:29:51,049 --> 00:29:48,840

sure that whatever we build is is the

732

00:29:52,850 --> 00:29:51,059

thing we want to build but it's that

733

00:29:56,570 --> 00:29:52,860

process it will start to build the queue

734

00:29:58,880 --> 00:29:56,580

of who gets who prints first but aside

735

00:30:02,930 --> 00:29:58,890

from that it's really like a lot of it

736

00:30:05,090 --> 00:30:02,940

is is you know first come for a servant

737

00:30:07,700 --> 00:30:05,100

way who comes to us and is ready to go

738

00:30:11,539 --> 00:30:07,710

and we have a queue of people lined up

739

00:30:15,440 --> 00:30:11,549

ready to print so go ahead ready for you

740

00:30:17,510 --> 00:30:15,450

know open invitation to use the printer

741

00:30:20,270 --> 00:30:17,520

you you mentioned something that

742

00:30:22,460 --> 00:30:20,280

actually had a question about was when

743

00:30:24,620 --> 00:30:22,470

you're going to be printing things in

744

00:30:29,000 --> 00:30:24,630

zero gravity of microgravity out there

745

00:30:31,220 --> 00:30:29,010

is it like how let's see what's the word

746

00:30:32,900 --> 00:30:31,230

I want to use here how accurate are you

747

00:30:34,970 --> 00:30:32,910

going to be able to rate it as I know

748

00:30:36,919 --> 00:30:34,980

when we're sending stuff up into space

749

00:30:38,030 --> 00:30:36,929

especially for science experiments we

750

00:30:40,970 --> 00:30:38,040

need to make sure that they're

751

00:30:42,260 --> 00:30:40,980

rigorously tested too yes withstand

752

00:30:43,940 --> 00:30:42,270

launch which you're going to be able to

753

00:30:46,010 --> 00:30:43,950

get through but to make sure that it's

754

00:30:47,539 --> 00:30:46,020

actually scientifically accurate for

755

00:30:49,970 --> 00:30:47,549

what you're going to be using it for

756

00:30:52,760 --> 00:30:49,980

right now are you just looking for you

757

00:30:54,799 --> 00:30:52,770

know a scaffolding or something I like

758

00:30:57,289 --> 00:30:54,809

that more rugged and then in the future

759

00:30:59,299 --> 00:30:57,299

be able to more fine-tuned it or is

760

00:31:01,549 --> 00:30:59,309

there a way that you'll be able to rate

761

00:31:06,110 --> 00:31:01,559

it for different scientific levels of

762

00:31:08,899 --> 00:31:06,120

accuracy yeah the answer is is yes the

763

00:31:11,450 --> 00:31:08,909

uh you know there's a couple ways to

764

00:31:13,100 --> 00:31:11,460

look at we have there's we have a

765

00:31:15,260 --> 00:31:13,110

since we control the printer from the

766

00:31:17,450 --> 00:31:15,270

ground we have the ability to control a

767

00:31:20,120 --> 00:31:17,460

lot of the settings so in terms of

768

00:31:21,980 --> 00:31:20,130

quality resolution things like that we

769

00:31:25,100 --> 00:31:21,990

have control over that so depending on

770

00:31:29,060 --> 00:31:25,110

the demands of that part we can control

771

00:31:30,590 --> 00:31:29,070

how well it prints and and so on um but

772

00:31:33,889 --> 00:31:30,600

it's important to remember that this is

773

00:31:35,389 --> 00:31:33,899

the first step I mean this is like the

774

00:31:37,940 --> 00:31:35,399

tip of the iceberg for space

775

00:31:39,740 --> 00:31:37,950

manufacturing so as made in space moves

776

00:31:41,510 --> 00:31:39,750

forward with technology development it

777

00:31:44,090 --> 00:31:41,520

will get better and better and better so

778

00:31:47,060 --> 00:31:44,100

today it does a percentage of things

779

00:31:48,950 --> 00:31:47,070

NASA estimated that this printer can do

780

00:31:50,380 --> 00:31:48,960

thirty percent of all the parks that

781

00:31:53,690 --> 00:31:50,390

have already broken on the space station

782

00:31:55,970 --> 00:31:53,700

so actually a surprisingly good number

783

00:31:58,639 --> 00:31:55,980

of things could be fixed with a 3d

784

00:32:00,200 --> 00:31:58,649

printer like this but but we're moving

785

00:32:01,639 --> 00:32:00,210

forward towards you know much more than

786

00:32:05,060 --> 00:32:01,649

that percentage and we want to get to

787

00:32:07,510 --> 00:32:05,070

the point where you know that's not just

788

00:32:11,000 --> 00:32:07,520

for fixing and upkeep and crew

789

00:32:12,560 --> 00:32:11,010

utilization is for experimenters to

790

00:32:14,690 --> 00:32:12,570

build better experiments you know today

791

00:32:16,100 --> 00:32:14,700

we when we put an experiment on the

792

00:32:17,720 --> 00:32:16,110

space station we have to launch it

793

00:32:19,760 --> 00:32:17,730

already hoping that it just works

794

00:32:21,409 --> 00:32:19,770

because if it doesn't it would cost

795

00:32:23,539 --> 00:32:21,419

millions of dollars ever to launch the

796

00:32:25,490 --> 00:32:23,549

next version so we were working with

797

00:32:27,649 --> 00:32:25,500

experimenters now to design their

798

00:32:29,450 --> 00:32:27,659

experiments so that they're already 3d

799

00:32:32,360 --> 00:32:29,460

printed so that when something changes

800

00:32:34,220 --> 00:32:32,370

if you need a larger microfluidic

801
00:32:36,350 --> 00:32:34,230
channel or you need a lot of you know a

802
00:32:37,669 --> 00:32:36,360
different size petri dish or so on you

803
00:32:39,889 --> 00:32:37,679
print that out after you've already

804
00:32:41,740 --> 00:32:39,899
tested the first one so enabling

805
00:32:44,360 --> 00:32:41,750
iteration to happen for science is

806
00:32:47,000 --> 00:32:44,370
obviously the the key towards

807
00:32:49,430 --> 00:32:47,010
breakthrough and it's those things that

808
00:32:51,680 --> 00:32:49,440
we want to you know make happen I was

809
00:32:53,779 --> 00:32:51,690
going to say that you know in discussion

810
00:32:55,909 --> 00:32:53,789
astronomers have to think in very long

811
00:32:58,039 --> 00:32:55,919
timescales about building new telescopes

812
00:33:00,680 --> 00:32:58,049
that are going to go in space and the

813
00:33:03,500 --> 00:33:00,690

thought of at least 3d printing part of

814

00:33:05,210 --> 00:33:03,510

these parts for those telescopes and

815

00:33:06,950 --> 00:33:05,220

also refurbishment because we're how

816

00:33:09,440 --> 00:33:06,960

will people so we love the idea of

817

00:33:11,330 --> 00:33:09,450

having a telescope you can refurbish so

818

00:33:14,600 --> 00:33:11,340

it's very much of interest to the

819

00:33:16,940 --> 00:33:14,610

astronomical community on very relevant

820

00:33:19,639 --> 00:33:16,950

to the humble James Webb at last

821

00:33:21,950 --> 00:33:19,649

community but another thing that you

822

00:33:24,740 --> 00:33:21,960

made me think of is I know you're not

823

00:33:26,210 --> 00:33:24,750

doing it today but but remember

824

00:33:28,610 --> 00:33:26,220

we first said we were going to go to

825

00:33:31,100 --> 00:33:28,620

space remember how they said oh the

826

00:33:34,280 --> 00:33:31,110

stuff you manufacture and space is going

827

00:33:35,990 --> 00:33:34,290

to be like amazing compared to what is

828

00:33:40,040 --> 00:33:36,000

made on the ground because it won't be

829

00:33:43,040 --> 00:33:40,050

constrained by gravity so I if you guys

830

00:33:45,470 --> 00:33:43,050

had discussions of things that could be

831

00:33:48,320 --> 00:33:45,480

manufactured that possibly could be of

832

00:33:51,290 --> 00:33:48,330

use to people on the ground that would

833

00:33:52,940 --> 00:33:51,300

be better manufactured in debate number

834

00:33:54,920 --> 00:33:52,950

we're supposed to all have bald perfect

835

00:33:56,900 --> 00:33:54,930

ball bearings because they working

836

00:33:59,120 --> 00:33:56,910

perfectly man your final its face

837

00:34:02,600 --> 00:33:59,130

remember that I mean I'm showing my age

838

00:34:06,980 --> 00:34:02,610

but no you're I guess mine to them

839

00:34:09,230 --> 00:34:06,990

because I remember that that is a that's

840

00:34:12,909 --> 00:34:09,240

always been kind of one of the biggest

841

00:34:15,680 --> 00:34:12,919

things for us was to figure out not just

842

00:34:18,110 --> 00:34:15,690

not just what can we build in space 4

843

00:34:21,980 --> 00:34:18,120

space but what can we build in space for

844

00:34:23,869 --> 00:34:21,990

Earth and um there's definitely some

845

00:34:25,580 --> 00:34:23,879

really interesting things there you know

846

00:34:28,700 --> 00:34:25,590

obviously like you know ball bearings

847

00:34:31,430 --> 00:34:28,710

cool example but what are the things

848

00:34:33,260 --> 00:34:31,440

that you can't that you can actually use

849

00:34:35,990 --> 00:34:33,270

zero gravity to your advantage to build

850

00:34:37,909 --> 00:34:36,000

um not needing you know not needing

851

00:34:40,850 --> 00:34:37,919

things like support structure as as an

852

00:34:42,980 --> 00:34:40,860

example we've had we've had a lot of

853

00:34:46,190 --> 00:34:42,990

interests actually from people coming to

854

00:34:48,580 --> 00:34:46,200

us with ideas there most of them you

855

00:34:51,710 --> 00:34:48,590

know we we sign a lot of you know

856

00:34:54,050 --> 00:34:51,720

agreements with these groups you know

857

00:34:56,869 --> 00:34:54,060

who only talked about their ideas one of

858

00:34:58,430 --> 00:34:56,879

the more interesting ones that i can say

859

00:35:01,790 --> 00:34:58,440

a little bit about was had to do with

860

00:35:04,370 --> 00:35:01,800

fuel cell technology somebody had found

861

00:35:07,130 --> 00:35:04,380

a way to make more efficient fuel cells

862

00:35:09,950 --> 00:35:07,140

if they were manufactured in zoo and

863

00:35:13,580 --> 00:35:09,960

then bringing those parts down so so we

864

00:35:16,310 --> 00:35:13,590

think there's probably time will tell I

865

00:35:18,530 --> 00:35:16,320

think but as we as we get the machines

866

00:35:19,880 --> 00:35:18,540

operating and start to learn exactly you

867

00:35:23,120 --> 00:35:19,890

know the correct material and

868

00:35:26,120 --> 00:35:23,130

resolutions and so on we'll see that

869

00:35:27,620 --> 00:35:26,130

happen okay i want to get over to

870

00:35:30,950 --> 00:35:27,630

youtube there's some comments coming in

871

00:35:33,290 --> 00:35:30,960

Craig Landon is asking any ideas as to

872

00:35:36,350 --> 00:35:33,300

how any of these materials might perform

873

00:35:38,180 --> 00:35:36,360

in solar radiation anything outside the

874

00:35:40,339 --> 00:35:38,190

ISS that is similar in

875

00:35:42,950 --> 00:35:40,349

position or due to be tested so how does

876

00:35:45,349 --> 00:35:42,960

this how does this stuff work out in

877

00:35:50,690 --> 00:35:45,359

space i mean the ring with irradiated

878

00:35:54,440 --> 00:35:50,700

environment yep um so this the the

879

00:35:57,680 --> 00:35:54,450

printer itself is it stays inside of the

880

00:36:00,260 --> 00:35:57,690

space station so it operates it you know

881

00:36:01,579 --> 00:36:00,270

in the the atmosphere of the space

882

00:36:04,760 --> 00:36:01,589

station at the pressure and the

883

00:36:07,339 --> 00:36:04,770

temperature and things like that so it's

884

00:36:08,960 --> 00:36:07,349

a you know for the sake of developing a

885

00:36:12,099 --> 00:36:08,970

printer that works in space we had to

886

00:36:14,780 --> 00:36:12,109

solve zero gravity it's the main problem

887

00:36:16,880 --> 00:36:14,790

but it's it's really the question is

888

00:36:19,490 --> 00:36:16,890

really you know how do you build parts

889

00:36:22,190 --> 00:36:19,500

that you can then take out into space so

890

00:36:24,920 --> 00:36:22,200

we've you know right now the first

891

00:36:28,069 --> 00:36:24,930

printer does abs and we all know that

892

00:36:30,319 --> 00:36:28,079

ABS out gases so can what can actually

893

00:36:31,849 --> 00:36:30,329

put out in space it was there was a bee

894

00:36:33,589 --> 00:36:31,859

acid you know if it's if it's out

895

00:36:36,280 --> 00:36:33,599

gassing too much maybe you don't use it

896

00:36:38,569 --> 00:36:36,290

for very many things so that's why we

897

00:36:40,910 --> 00:36:38,579

we've been working for our second

898

00:36:42,980 --> 00:36:40,920

printer that launches next year the

899

00:36:46,190 --> 00:36:42,990

ability to do new types of materials so

900

00:36:48,349 --> 00:36:46,200

we have space qualified polymers and

901
00:36:49,819 --> 00:36:48,359
polymer composites that we can we can

902
00:36:53,390 --> 00:36:49,829
manufacture with and take them out and

903
00:36:54,559 --> 00:36:53,400
they'll work just fine so and that's you

904
00:36:56,630 --> 00:36:54,569
know there's there's still a lot of

905
00:36:58,760 --> 00:36:56,640
testing there you can do we've done a

906
00:37:00,200 --> 00:36:58,770
lot of testing the lab but there's some

907
00:37:02,450 --> 00:37:00,210
things you just can't actually know

908
00:37:06,800 --> 00:37:02,460
until you get into the actual space

909
00:37:09,260 --> 00:37:06,810
environment to test it out okay so let

910
00:37:10,670 --> 00:37:09,270
me get it let me get to back to the Q&A

911
00:37:12,710 --> 00:37:10,680
app we have jonathan peters he had a

912
00:37:15,920 --> 00:37:12,720
follow-up question to his what did you

913
00:37:18,170 --> 00:37:15,930

use to make a stuff out of and he goes

914

00:37:20,089 --> 00:37:18,180

are there plans to test physical

915

00:37:25,520 --> 00:37:20,099

strength durability of objects printed

916

00:37:28,069 --> 00:37:25,530

in zero-g in different gravities um well

917

00:37:30,559 --> 00:37:28,079

what I feel like what I can say is we've

918

00:37:33,980 --> 00:37:30,569

taken the printers not just on the

919

00:37:36,380 --> 00:37:33,990

zero-gravity parabolas with NASA but

920

00:37:38,870 --> 00:37:36,390

we've also done lunar and Martian so the

921

00:37:42,800 --> 00:37:38,880

art printer itself actually already is

922

00:37:44,630 --> 00:37:42,810

designed for on the moon and on Mars ok

923

00:37:47,569 --> 00:37:44,640

young good question thanks Jonathan

924

00:37:50,390 --> 00:37:47,579

Phillip keen is back and he's also

925

00:37:52,069 --> 00:37:50,400

asking you have you seen the news that

926

00:37:54,049 --> 00:37:52,079

ISA that ISA will be

927

00:37:55,849 --> 00:37:54,059

testing metal casting machines on a

928

00:37:57,410 --> 00:37:55,859

sounding rocket looks like they want to

929

00:38:00,769 --> 00:37:57,420

manufacture titanium parts and

930

00:38:06,699 --> 00:38:00,779

microgravity too yeah interesting stuff

931

00:38:08,839 --> 00:38:06,709

so so you know like any other good idea

932

00:38:10,880 --> 00:38:08,849

there's always going to be more than one

933

00:38:12,380 --> 00:38:10,890

group that that wants to pursue it and I

934

00:38:15,920 --> 00:38:12,390

think that's important to see the

935

00:38:18,589 --> 00:38:15,930

technology advanced quickly because you

936

00:38:22,160 --> 00:38:18,599

know we started this company because we

937

00:38:24,019 --> 00:38:22,170

want humans living in space so the more

938

00:38:25,910 --> 00:38:24,029

people trying to focus on solving those

939

00:38:28,219 --> 00:38:25,920

problems better we've talked a lot with

940

00:38:31,519 --> 00:38:28,229

ISA I you know our goals really align

941

00:38:33,140 --> 00:38:31,529

well with them that for instance the

942

00:38:34,009 --> 00:38:33,150

printer that we're putting on this that

943

00:38:35,479 --> 00:38:34,019

you know the printer on the space

944

00:38:38,329 --> 00:38:35,489

station today and then definitely the

945

00:38:40,699 --> 00:38:38,339

next one is designed for anyone to use

946

00:38:43,069 --> 00:38:40,709

so that definitely goes for all the

947

00:38:45,949 --> 00:38:43,079

other space agencies already on on Space

948

00:38:51,579 --> 00:38:45,959

Station so we'll see you know II cuzn

949

00:38:54,499 --> 00:38:51,589

and Jackson and so on cool okay so um

950

00:38:55,940 --> 00:38:54,509

Eric charland is commented also he says

951
00:38:57,319 --> 00:38:55,950
gotta admire the patience of these guys

952
00:38:59,989 --> 00:38:57,329
would take me a half a second after

953
00:39:01,249 --> 00:38:59,999
receiving it to turn on a 3d printer so

954
00:39:02,779 --> 00:39:01,259
I guess that he's talked about the

955
00:39:05,180 --> 00:39:02,789
patience of the astronauts a they have

956
00:39:08,779 --> 00:39:05,190
to have to wait for the cows laughingly

957
00:39:11,239 --> 00:39:08,789
we actually video you can watch a reid

958
00:39:12,559 --> 00:39:11,249
wiseman right before he launched and he

959
00:39:14,120 --> 00:39:12,569
you know he's up there right now so he's

960
00:39:16,759 --> 00:39:14,130
likely the one to operate the printer

961
00:39:19,849 --> 00:39:16,769
and he was so excited about it he in

962
00:39:21,920 --> 00:39:19,859
this interview he says you know NASA

963
00:39:26,559 --> 00:39:21,930

better be careful because we're gonna

964

00:39:29,420 --> 00:39:26,569

use up all the ink he's a ball today

965

00:39:31,549 --> 00:39:29,430

that's good yeah I gotta you know to

966

00:39:32,900 --> 00:39:31,559

follow up on a comment that or the what

967

00:39:34,459 --> 00:39:32,910

carol was saying about you know

968

00:39:35,809 --> 00:39:34,469

astronomers wanting you know excited

969

00:39:37,939 --> 00:39:35,819

being excited about using this i mean

970

00:39:39,739 --> 00:39:37,949

already we're talking about you know

971

00:39:42,920 --> 00:39:39,749

after jwst the James Webb Space

972

00:39:46,999 --> 00:39:42,930

Telescope launching these giant 8 meter

973

00:39:49,249 --> 00:39:47,009

and 16 meter telescopes um I wonder you

974

00:39:50,839 --> 00:39:49,259

know for me I know that's the far future

975

00:39:54,349 --> 00:39:50,849

but that would be the kind of thing that

976

00:39:56,059 --> 00:39:54,359

I think it would excite me about this as

977

00:39:59,120 --> 00:39:56,069

well as not only can we go into space

978

00:40:00,410 --> 00:39:59,130

and we can you know manufacture parts

979

00:40:02,329 --> 00:40:00,420

and things like that up there and live

980

00:40:04,580 --> 00:40:02,339

off the land as you say but we can also

981

00:40:06,440 --> 00:40:04,590

put things up in space that are

982

00:40:08,960 --> 00:40:06,450

really hard to put up there like 16

983

00:40:15,110 --> 00:40:08,970

meter telescopes just being able to

984

00:40:18,320 --> 00:40:15,120

print one out point would be yep so you

985

00:40:20,750 --> 00:40:18,330

look for the history of humans putting

986

00:40:22,610 --> 00:40:20,760

things into space we've only we've done

987

00:40:25,400 --> 00:40:22,620

it exactly the same way we've always put

988

00:40:27,290 --> 00:40:25,410

things on the top of chemical rockets

989

00:40:29,210 --> 00:40:27,300

and launch them there that obviously

990

00:40:30,920 --> 00:40:29,220

puts the you know a lot of burden

991

00:40:33,290 --> 00:40:30,930

there's like it we already mentioned

992

00:40:35,240 --> 00:40:33,300

there's the constraints of the G load

993

00:40:37,610 --> 00:40:35,250

and the vibration load but the other

994

00:40:41,540 --> 00:40:37,620

thing is we're constrained to the volume

995

00:40:43,610 --> 00:40:41,550

of the fairing of spacecraft so so we've

996

00:40:45,980 --> 00:40:43,620

reached we've done a lot in terms of

997

00:40:48,380 --> 00:40:45,990

getting really clever about how we build

998

00:40:51,140 --> 00:40:48,390

things that can fit into a rocket and

999

00:40:52,640 --> 00:40:51,150

then deploy open well that's yet JW seas

1000

00:40:55,940 --> 00:40:52,650

are not prime example of that it had

1001
00:40:57,980 --> 00:40:55,950
them all folded up origami yeah one of

1002
00:41:00,350 --> 00:40:57,990
the best examples so but we've still

1003
00:41:03,710 --> 00:41:00,360
reached in in many ways to physical

1004
00:41:05,930 --> 00:41:03,720
limits of what we can do so this the

1005
00:41:08,720 --> 00:41:05,940
idea of space manufacturing gets around

1006
00:41:10,940 --> 00:41:08,730
that problem entirely we we can remove

1007
00:41:14,390 --> 00:41:10,950
the constraint of the launch fairing and

1008
00:41:16,760 --> 00:41:14,400
start to build things that don't have to

1009
00:41:18,770 --> 00:41:16,770
rely on deployment mechanisms and and

1010
00:41:21,080 --> 00:41:18,780
other things like that just build the

1011
00:41:23,240 --> 00:41:21,090
the large shapes that you needed to

1012
00:41:25,040 --> 00:41:23,250
begin with so you said they're not

1013
00:41:27,590 --> 00:41:25,050

starting yet you're waiting for your

1014

00:41:28,790 --> 00:41:27,600

turn in the glove box um how are you

1015

00:41:31,100 --> 00:41:28,800

going to let people how are we going to

1016

00:41:32,990 --> 00:41:31,110

know that this is but you know what's

1017

00:41:35,180 --> 00:41:33,000

the best way for us to keep in track

1018

00:41:37,810 --> 00:41:35,190

keep track of what what's going on in

1019

00:41:41,150 --> 00:41:37,820

the status is well uh twitter feed

1020

00:41:43,970 --> 00:41:41,160

follow our twitter i'm at made in space

1021

00:41:47,210 --> 00:41:43,980

we we're keeping keeping everybody up to

1022

00:41:50,090 --> 00:41:47,220

date there and our facebook it's a we

1023

00:41:53,210 --> 00:41:50,100

are made in space so our social media is

1024

00:41:55,910 --> 00:41:53,220

is really um you know when we hear news

1025

00:41:58,070 --> 00:41:55,920

we share it so that's probably number

1026
00:42:01,420 --> 00:41:58,080
one NASA is doing a lot of work there to

1027
00:42:04,070 --> 00:42:01,430
to to let everybody know about this so

1028
00:42:06,620 --> 00:42:04,080
they'll be you know we expect that it

1029
00:42:09,410 --> 00:42:06,630
will be a good amount of heads up before

1030
00:42:13,550 --> 00:42:09,420
the printer starts printing this is this

1031
00:42:17,120 --> 00:42:13,560
is a it's an incredibly historical event

1032
00:42:18,260 --> 00:42:17,130
for Humanity there's it's been up you

1033
00:42:20,750 --> 00:42:18,270
know this will be the first

1034
00:42:23,000 --> 00:42:20,760
time as a species we've ever made faq

1035
00:42:25,460 --> 00:42:23,010
shirt off a planet earth and we want

1036
00:42:28,580 --> 00:42:25,470
everybody to share in that occasion

1037
00:42:30,110 --> 00:42:28,590
because it's you know this is I think

1038
00:42:32,240 --> 00:42:30,120

it'll go down as a really important

1039

00:42:34,250 --> 00:42:32,250

piece in history I agree in Jonathan I

1040

00:42:35,540 --> 00:42:34,260

but Jonathan and Phillip are just you

1041

00:42:38,030 --> 00:42:35,550

guys are blowing up I thank you for all

1042

00:42:39,440 --> 00:42:38,040

the comments uh so Jonathan's like is

1043

00:42:41,570 --> 00:42:39,450

the next I beat you to this one I think

1044

00:42:44,090 --> 00:42:41,580

jonathan is the next version going to be

1045

00:42:45,710 --> 00:42:44,100

able to print glassware and if so are we

1046

00:42:47,210 --> 00:42:45,720

expecting better telescopes and we just

1047

00:42:48,800 --> 00:42:47,220

we just talked about this but what about

1048

00:42:50,590 --> 00:42:48,810

the glass part of it is that says that a

1049

00:42:54,080 --> 00:42:50,600

material that perhaps is in the future

1050

00:42:55,940 --> 00:42:54,090

so um it's a pretty cool question there

1051
00:42:57,860 --> 00:42:55,950
the quit you know like there's a few

1052
00:43:01,150 --> 00:42:57,870
pieces of that if we want to talk about

1053
00:43:03,620 --> 00:43:01,160
optics you know printing optical element

1054
00:43:05,510 --> 00:43:03,630
you know that's a tricky problem we a

1055
00:43:08,060 --> 00:43:05,520
lot of what we've done as a company as

1056
00:43:11,600 --> 00:43:08,070
we look at where technology is headed

1057
00:43:14,270 --> 00:43:11,610
and anticipate when it will be ready to

1058
00:43:17,630 --> 00:43:14,280
actually go into real applications so in

1059
00:43:20,240 --> 00:43:17,640
2010 we we realize that we could work on

1060
00:43:22,310 --> 00:43:20,250
this fdm style of 3d printing and get it

1061
00:43:24,980 --> 00:43:22,320
ready for space if you if you start

1062
00:43:27,920 --> 00:43:24,990
looking at what's out there um you know

1063
00:43:29,600 --> 00:43:27,930

in industry and research for optics type

1064

00:43:32,180 --> 00:43:29,610

of printing there's still a lot of

1065

00:43:34,790 --> 00:43:32,190

challenges to overcome but it will it

1066

00:43:36,410 --> 00:43:34,800

will it will get there and until them

1067

00:43:38,690 --> 00:43:36,420

there's always things that will have to

1068

00:43:41,480 --> 00:43:38,700

launch that we just can't print up you

1069

00:43:43,730 --> 00:43:41,490

know and we can't print transistors and

1070

00:43:45,260 --> 00:43:43,740

and circuit boards and everything yet so

1071

00:43:47,060 --> 00:43:45,270

there's things that you have to launch

1072

00:43:50,450 --> 00:43:47,070

and they're things that you can print

1073

00:43:52,250 --> 00:43:50,460

over time though our view is that one

1074

00:43:54,980 --> 00:43:52,260

day everything in space will be made in

1075

00:43:56,420 --> 00:43:54,990

space and won't every at every point in

1076
00:43:58,520 --> 00:43:56,430
time there'll be something that you

1077
00:44:00,890 --> 00:43:58,530
don't have to launch because you can 3d

1078
00:44:02,630 --> 00:44:00,900
print it so if you can print it there

1079
00:44:04,400 --> 00:44:02,640
you will it will just make more sense

1080
00:44:05,720 --> 00:44:04,410
and with the printer on the space

1081
00:44:07,760 --> 00:44:05,730
station day there's already something

1082
00:44:09,710 --> 00:44:07,770
that can be printed it's actually a lot

1083
00:44:11,240 --> 00:44:09,720
of things those things don't have to get

1084
00:44:13,670 --> 00:44:11,250
launched anymore and the second printer

1085
00:44:15,980 --> 00:44:13,680
will expand upon that and so on so I

1086
00:44:18,380 --> 00:44:15,990
hope it's soon that we see you know

1087
00:44:21,410 --> 00:44:18,390
optics and optical elements and things

1088
00:44:24,140 --> 00:44:21,420

like that but it's a lot of development

1089

00:44:26,180 --> 00:44:24,150

needed well personally I was gonna I was

1090

00:44:27,710 --> 00:44:26,190

just going to interject that that once

1091

00:44:30,680 --> 00:44:27,720

you've decided that you can manufacture

1092

00:44:32,120 --> 00:44:30,690

in space there's no reason to you know

1093

00:44:33,980 --> 00:44:32,130

restrict yourself to one

1094

00:44:35,840 --> 00:44:33,990

sheen you can have a machine that does

1095

00:44:37,640 --> 00:44:35,850

metals and another one that does sort of

1096

00:44:40,580 --> 00:44:37,650

plastic materials so that you can

1097

00:44:43,490 --> 00:44:40,590

optimize the machine what you understand

1098

00:44:46,160 --> 00:44:43,500

the zero g or Moulton you know if G

1099

00:44:47,840 --> 00:44:46,170

independent stuff you can think about oh

1100

00:44:49,550 --> 00:44:47,850

I need metal parts over here and they

1101
00:44:51,500 --> 00:44:49,560
need plastic parts over here and I need

1102
00:44:53,750 --> 00:44:51,510
chocolate over here and then you can

1103
00:44:55,790 --> 00:44:53,760
print what you want I'm always a jungle

1104
00:45:00,580 --> 00:44:55,800
yeah i would i would want one that

1105
00:45:02,660 --> 00:45:00,590
prince chief editors yeah you would

1106
00:45:04,570 --> 00:45:02,670
especially if i'm in Mars and i haven't

1107
00:45:07,310 --> 00:45:04,580
had a had a cheeseburger in a while

1108
00:45:09,680 --> 00:45:07,320
Scott I want to meet me ask you am I am

1109
00:45:12,560 --> 00:45:09,690
I missing any comments or questions here

1110
00:45:14,330 --> 00:45:12,570
that I think we've got a all of them

1111
00:45:16,460 --> 00:45:14,340
taking care for the most part of ones

1112
00:45:20,780 --> 00:45:16,470
that we've already answered before they

1113
00:45:23,960 --> 00:45:20,790

ask them so yeah yeah okay um let's see

1114

00:45:26,930 --> 00:45:23,970

ask about the bit so we had a video but

1115

00:45:29,600 --> 00:45:26,940

we had some other imagery oh yeah we

1116

00:45:31,880 --> 00:45:29,610

have it would it would be nice to take a

1117

00:45:33,470 --> 00:45:31,890

look at some of those yeah if you can

1118

00:45:36,820 --> 00:45:33,480

can you put up some of those and what

1119

00:45:40,010 --> 00:45:36,830

have Jason talk about design photos

1120

00:45:42,980 --> 00:45:40,020

moment it shot up for the first printer

1121

00:45:44,900 --> 00:45:42,990

it's a nice like you can see some

1122

00:45:48,500 --> 00:45:44,910

hardware in the background and yeah

1123

00:45:50,900 --> 00:45:48,510

there it is so this is this is actually

1124

00:45:54,160 --> 00:45:50,910

the printer in the foreground that's the

1125

00:45:56,960 --> 00:45:54,170

printer that is on Space Station today

1126
00:45:59,300 --> 00:45:56,970
and then in the background is the

1127
00:46:01,730 --> 00:45:59,310
microgravity science glovebox the msg

1128
00:46:03,500 --> 00:46:01,740
that's what we that's where what the

1129
00:46:06,080 --> 00:46:03,510
printer goes in the space station so

1130
00:46:10,400 --> 00:46:06,090
this picture was taken at NASA Marshall

1131
00:46:13,370 --> 00:46:10,410
flight Marshall Flight Center so at

1132
00:46:15,410 --> 00:46:13,380
Marshall that's that's where our main

1133
00:46:18,230 --> 00:46:15,420
contract goes through it's our

1134
00:46:20,660 --> 00:46:18,240
partnership with NASA and we work really

1135
00:46:23,330 --> 00:46:20,670
hand-in-hand with NASA Marshall to

1136
00:46:27,680 --> 00:46:23,340
develop this entire first 3d printer

1137
00:46:29,090 --> 00:46:27,690
program so made in space does the design

1138
00:46:32,030 --> 00:46:29,100

and development of the hardware and

1139

00:46:35,510 --> 00:46:32,040

software electronics and so on and then

1140

00:46:37,580 --> 00:46:35,520

NASA Marshall helped with the testing

1141

00:46:40,190 --> 00:46:37,590

and the qualification of the system as

1142

00:46:42,470 --> 00:46:40,200

well as that's where the payload

1143

00:46:45,660 --> 00:46:42,480

Operations Center is for Space Station

1144

00:46:49,770 --> 00:46:45,670

so we are able to go there and test

1145

00:46:53,240 --> 00:46:49,780

out the printer in the simulated msg

1146

00:46:55,530 --> 00:46:53,250

scenario so really good partnership and

1147

00:46:57,480 --> 00:46:55,540

it's one of those examples of how

1148

00:47:00,839 --> 00:46:57,490

government and commercial works really

1149

00:47:02,730 --> 00:47:00,849

well together okay one show there we go

1150

00:47:07,410 --> 00:47:02,740

here's another one now here's a close-up

1151

00:47:09,180 --> 00:47:07,420

of of the printer actually looks really

1152

00:47:12,030 --> 00:47:09,190

close up on my screen I can only see

1153

00:47:14,490 --> 00:47:12,040

part of it but uh so let me pop it out a

1154

00:47:18,059 --> 00:47:14,500

couple things here on the left is a

1155

00:47:20,490 --> 00:47:18,069

smaller box and there you go so that the

1156

00:47:23,460 --> 00:47:20,500

box on the left is our electronics and

1157

00:47:27,240 --> 00:47:23,470

computer that's a it's our power supply

1158

00:47:29,760 --> 00:47:27,250

it's the notes that the all the

1159

00:47:31,980 --> 00:47:29,770

electronics and the sensor packages and

1160

00:47:35,490 --> 00:47:31,990

things like that that's what plugs into

1161

00:47:36,839 --> 00:47:35,500

the glove box and then multiple then we

1162

00:47:38,940 --> 00:47:36,849

have two ports that plug into the

1163

00:47:41,549 --> 00:47:38,950

printer so you can see the switch on the

1164

00:47:42,839 --> 00:47:41,559

back left of the electronics box that

1165

00:47:44,819 --> 00:47:42,849

like I was saying it's the only switch

1166

00:47:48,089 --> 00:47:44,829

on the entire printer the entire thing

1167

00:47:50,670 --> 00:47:48,099

is definitely looks a little special

1168

00:47:53,730 --> 00:47:50,680

compared to a printer here you're used

1169

00:47:56,400 --> 00:47:53,740

to seeing the surface it's made of

1170

00:48:00,870 --> 00:47:56,410

aerospace grade aluminum that's coated

1171

00:48:03,660 --> 00:48:00,880

in nickel plated its nickel plated so

1172

00:48:06,089 --> 00:48:03,670

that that makes it safe to use on Space

1173

00:48:09,990 --> 00:48:06,099

Station it doesn't scratch it doesn't

1174

00:48:12,000 --> 00:48:10,000

leak EMI um feedstock cartridge is that

1175

00:48:13,890 --> 00:48:12,010

box on the left of the printer that

1176
00:48:16,289 --> 00:48:13,900
comes in and out so it's replaceable and

1177
00:48:18,870 --> 00:48:16,299
then there's a door so the door has a

1178
00:48:20,309 --> 00:48:18,880
window and there's cameras it will look

1179
00:48:22,530 --> 00:48:20,319
through the window while we print but

1180
00:48:25,319 --> 00:48:22,540
the entire printer is is closed in so it

1181
00:48:27,089 --> 00:48:25,329
keeps the outgassing inside of there and

1182
00:48:31,140 --> 00:48:27,099
we who are environmental environmental

1183
00:48:33,030 --> 00:48:31,150
control inside the box great yep

1184
00:48:38,640 --> 00:48:33,040
anything else we have do you have

1185
00:48:41,069 --> 00:48:38,650
anything else rkelly nope oh that's the

1186
00:48:46,530 --> 00:48:41,079
song yeah so let me know part coming off

1187
00:48:48,630 --> 00:48:46,540
a printer a basically the printer remove

1188
00:48:51,660 --> 00:48:48,640

is you know the entire print rate comes

1189

00:48:53,609 --> 00:48:51,670

in and out we've made every step along

1190

00:48:56,250 --> 00:48:53,619

the way we've worked with NASA to really

1191

00:48:58,800 --> 00:48:56,260

make it easy for the astronauts to use

1192

00:49:01,140 --> 00:48:58,810

and to reduce the time spent using so

1193

00:49:03,810 --> 00:49:01,150

what you know when we first started most

1194

00:49:05,610 --> 00:49:03,820

most people think while they build a 3d

1195

00:49:08,790 --> 00:49:05,620

printer for for the astronauts and let's

1196

00:49:12,000 --> 00:49:08,800

have all these you know the gizmos and

1197

00:49:15,210 --> 00:49:12,010

all these good thing features but it

1198

00:49:17,340 --> 00:49:15,220

really had to be really simple the

1199

00:49:19,080 --> 00:49:17,350

astronauts time is depending how you

1200

00:49:23,130 --> 00:49:19,090

look at it it's about fifty thousand

1201
00:49:25,700 --> 00:49:23,140
dollars an hour so making it complex and

1202
00:49:27,920 --> 00:49:25,710
arby's not something we could do so

1203
00:49:31,710 --> 00:49:27,930
actually the printer is really easy

1204
00:49:34,170 --> 00:49:31,720
doesn't require calibration so Carol you

1205
00:49:35,160 --> 00:49:34,180
know everything your your desktop

1206
00:49:38,040 --> 00:49:35,170
printer you probably have to calibrate

1207
00:49:40,560 --> 00:49:38,050
it make sure your Z alignments correct

1208
00:49:44,070 --> 00:49:40,570
and the print trays absolutely yeah we

1209
00:49:47,400 --> 00:49:44,080
have stds we don't do that the printer

1210
00:49:49,500 --> 00:49:47,410
is just built to not need the

1211
00:49:51,450 --> 00:49:49,510
calibration it launches calibrated and

1212
00:49:53,610 --> 00:49:51,460
it will get its writ once they put it in

1213
00:49:56,100 --> 00:49:53,620

they'll turn it on and all they have to

1214

00:49:59,220 --> 00:49:56,110

do is plug it in turn it on and we do

1215

00:50:04,520 --> 00:49:59,230

everything else okay I so at the end of

1216

00:50:12,630 --> 00:50:09,830

without we printed it printed out oh

1217

00:50:14,160 --> 00:50:12,640

yeah bill Keane's gotik Mickey mechanics

1218

00:50:16,320 --> 00:50:14,170

a good point here when he comments and

1219

00:50:17,940 --> 00:50:16,330

you know traditionally glass and mirrors

1220

00:50:19,260 --> 00:50:17,950

have been made with gravity dependent

1221

00:50:20,820 --> 00:50:19,270

processes that's a good point the

1222

00:50:22,860 --> 00:50:20,830

figures and mirrors and things like that

1223

00:50:26,280 --> 00:50:22,870

are all more or less dependent on

1224

00:50:28,620 --> 00:50:26,290

gravity and the release the process is

1225

00:50:30,570 --> 00:50:28,630

used to make those figures so that that

1226

00:50:33,330 --> 00:50:30,580

is going to be an interesting you don't

1227

00:50:35,430 --> 00:50:33,340

have to because the optical design if

1228

00:50:37,620 --> 00:50:35,440

you make a perfect optical design you

1229

00:50:41,010 --> 00:50:37,630

can have a perfect object the problem is

1230

00:50:43,770 --> 00:50:41,020

that designers have to worry about the

1231

00:50:46,200 --> 00:50:43,780

gravity effect in the materials will sag

1232

00:50:48,540 --> 00:50:46,210

or whatever and so they accommodate that

1233

00:50:50,550 --> 00:50:48,550

in design but optical designers would

1234

00:50:52,860 --> 00:50:50,560

love to make something that's a perfect

1235

00:50:54,930 --> 00:50:52,870

optical design that doesn't sag out of

1236

00:50:57,600 --> 00:50:54,940

the materials made out of that's right a

1237

00:50:59,190 --> 00:50:57,610

wonderful really large telescope mirrors

1238

00:51:01,260 --> 00:50:59,200

like way ground-based telescopes and

1239

00:51:03,780 --> 00:51:01,270

stuff actually can flow a little bit I

1240

00:51:06,180 --> 00:51:03,790

remember a story I heard a long time ago

1241

00:51:07,140 --> 00:51:06,190

I don't know if this is urban legend I

1242

00:51:09,210 --> 00:51:07,150

have never been a mcdonald observatory

1243

00:51:11,610 --> 00:51:09,220

but there are actually bullet holes in

1244

00:51:12,059 --> 00:51:11,620

the primary mirror at McDonald's herba

1245

00:51:14,309 --> 00:51:12,069

Tory

1246

00:51:16,229 --> 00:51:14,319

we're and they it just didn't crack or

1247

00:51:18,779 --> 00:51:16,239

break the glass at all it just it just

1248

00:51:19,890 --> 00:51:18,789

went right through so interesting

1249

00:51:21,900 --> 00:51:19,900

interesting properties of glass

1250

00:51:26,009 --> 00:51:21,910

especially when you're really large so

1251

00:51:28,140 --> 00:51:26,019

that's a good point okay so um it so

1252

00:51:30,749 --> 00:51:28,150

what it you've told us a little bit I

1253

00:51:32,489 --> 00:51:30,759

given us a glimpse about about your

1254

00:51:34,319 --> 00:51:32,499

company and you've told us what you're

1255

00:51:36,959 --> 00:51:34,329

doing with 3d printing in the near term

1256

00:51:38,309 --> 00:51:36,969

what what do you what do you have in the

1257

00:51:40,109 --> 00:51:38,319

wings what else are you working on that

1258

00:51:43,680 --> 00:51:40,119

you'd like us to know about and for the

1259

00:51:45,719 --> 00:51:43,690

lot for the distant future well look I

1260

00:51:49,319 --> 00:51:45,729

think what's most important and most

1261

00:51:51,449 --> 00:51:49,329

exciting is that is that we you know

1262

00:51:53,189 --> 00:51:51,459

from here on out they'll always be a new

1263

00:51:55,259 --> 00:51:53,199

way to get things into space aside from

1264

00:51:57,209 --> 00:51:55,269

launching them and for us that's

1265

00:52:00,120 --> 00:51:57,219

important because we want we want

1266

00:52:02,370 --> 00:52:00,130

everybody on the planet to use this

1267

00:52:05,969 --> 00:52:02,380

printer in a way if they can we want to

1268

00:52:07,650 --> 00:52:05,979

connect the world to space we want new

1269

00:52:10,170 --> 00:52:07,660

initiatives in space to be spawned

1270

00:52:13,680 --> 00:52:10,180

because there's a new faster cheaper way

1271

00:52:16,229 --> 00:52:13,690

to get things there that's important for

1272

00:52:18,900 --> 00:52:16,239

us we've we've had you know some really

1273

00:52:22,349 --> 00:52:18,910

exciting ideas we've had people talking

1274

00:52:24,359 --> 00:52:22,359

to us about building cube sets with the

1275

00:52:26,609 --> 00:52:24,369

3d printer so imagine not needing to

1276

00:52:28,890 --> 00:52:26,619

build your cube sat on the ground and

1277

00:52:31,620 --> 00:52:28,900

said just having it built there and tell

1278

00:52:36,140 --> 00:52:31,630

us what cube SATs are oh yeah sorry so I

1279

00:52:41,489 --> 00:52:38,819

CubeSat it's it's a 10 centimeter cube

1280

00:52:44,609 --> 00:52:41,499

it's a small little satellite but packed

1281

00:52:46,620 --> 00:52:44,619

inside is the latest technology you know

1282

00:52:48,630 --> 00:52:46,630

keeping up with Moore's law in a way we

1283

00:52:50,699 --> 00:52:48,640

can everything that's in your cell phone

1284

00:52:53,160 --> 00:52:50,709

could be a satellite so imagine putting

1285

00:52:56,009 --> 00:52:53,170

that technology into a little box and

1286

00:52:58,439 --> 00:52:56,019

putting in space it's what today there's

1287

00:53:01,289 --> 00:52:58,449

it's a revolution because of where that

1288

00:53:03,299 --> 00:53:01,299

technology's headed but it's still it's

1289

00:53:06,420 --> 00:53:03,309

still timely manner it's a very hands-on

1290

00:53:09,269 --> 00:53:06,430

manner to build even these really small

1291

00:53:11,789 --> 00:53:09,279

satellites and you know when I was in

1292

00:53:14,430 --> 00:53:11,799

college several years ago I built a keep

1293

00:53:16,620 --> 00:53:14,440

that just like a lot of aerospace

1294

00:53:18,089 --> 00:53:16,630

engineering students do it's really good

1295

00:53:20,339 --> 00:53:18,099

exercise to learn how to build

1296

00:53:23,910 --> 00:53:20,349

satellites but they never they never

1297

00:53:25,230 --> 00:53:23,920

really flew arzga roof today it's that's

1298

00:53:27,750 --> 00:53:25,240

starting to change EB SATs are

1299

00:53:30,960 --> 00:53:27,760

flying a lot there's companies that are

1300

00:53:34,350 --> 00:53:30,970

launching you know in the hundreds of

1301

00:53:37,350 --> 00:53:34,360

cute sets in a year and that's changing

1302

00:53:39,570 --> 00:53:37,360

how we do satellites how we how we look

1303

00:53:42,900 --> 00:53:39,580

at our earth how we do science and space

1304

00:53:44,970 --> 00:53:42,910

and so on so one of the exciting things

1305

00:53:46,590 --> 00:53:44,980

is we could we can actually just build

1306

00:53:49,500 --> 00:53:46,600

those on the space station with the

1307

00:53:51,810 --> 00:53:49,510

printer so now what I'm excited about is

1308

00:53:53,940 --> 00:53:51,820

for the future students who instead of

1309

00:53:55,560 --> 00:53:53,950

spending a year building akita on the

1310

00:53:58,320 --> 00:53:55,570

ground they said spend all that time

1311

00:54:00,600 --> 00:53:58,330

designing a mission and have their boots

1312

00:54:01,800 --> 00:54:00,610

at bill on the man really fast and

1313

00:54:04,650 --> 00:54:01,810

launched and then they get to do a

1314

00:54:08,640 --> 00:54:04,660

mission and you know that's that's

1315

00:54:10,470 --> 00:54:08,650

actually possible now forth for anybody

1316

00:54:13,140 --> 00:54:10,480

to have their own space mission so

1317

00:54:16,890 --> 00:54:13,150

that's something that I see coming to

1318

00:54:18,870 --> 00:54:16,900

the zoo and and as a company you know we

1319

00:54:21,900 --> 00:54:18,880

what we've done is we've done a couple

1320

00:54:23,810 --> 00:54:21,910

things you we reduce earth dependency

1321

00:54:26,370 --> 00:54:23,820

for astronauts that's number one so

1322

00:54:28,290 --> 00:54:26,380

astron people in space today are less

1323

00:54:30,810 --> 00:54:28,300

dependent on earth they can when they

1324

00:54:33,770 --> 00:54:30,820

need something whether it's emergency

1325

00:54:36,330 --> 00:54:33,780

fix or a new tool or anything like that

1326

00:54:39,870 --> 00:54:36,340

the chances are it can actually be 3d

1327

00:54:41,640 --> 00:54:39,880

printed in space we don't need to launch

1328

00:54:44,190 --> 00:54:41,650

an entire rocket to bring them a new

1329

00:54:45,630 --> 00:54:44,200

wrench and that's important for Space

1330

00:54:49,500 --> 00:54:45,640

Station but it's absolutely necessary

1331

00:54:52,890 --> 00:54:49,510

for a Mars mission yeah we need if we

1332

00:54:55,200 --> 00:54:52,900

really want to do a Mars mission or or

1333

00:54:58,170 --> 00:54:55,210

even a moon mission and put people in

1334

00:55:00,840 --> 00:54:58,180

the moon we need to get off of the

1335

00:55:03,420 --> 00:55:00,850

paradigm that the only way to do it is

1336

00:55:07,590 --> 00:55:03,430

to have the ability to keep relaunching

1337

00:55:09,720 --> 00:55:07,600

rockets so so our technology will always

1338

00:55:13,650 --> 00:55:09,730

be wherever there's humans in space from

1339

00:55:15,840 --> 00:55:13,660

here on out and and then well if along

1340

00:55:17,430 --> 00:55:15,850

with it anybody else on earth will be

1341

00:55:19,530 --> 00:55:17,440

able to go along because they'll be able

1342

00:55:23,910 --> 00:55:19,540

to send their things there you know at

1343

00:55:26,609 --> 00:55:23,920

the speed of light co Adam synergies

1344

00:55:28,050 --> 00:55:26,619

back and hey Adam he goes he's

1345

00:55:29,370 --> 00:55:28,060

confirming what I just said it's true

1346

00:55:30,480 --> 00:55:29,380

there are several bullet holes in the

1347

00:55:33,480 --> 00:55:30,490

primary mirror of the Large Telescope

1348

00:55:35,820 --> 00:55:33,490

and McDonald Observatory courtesy of a

1349

00:55:37,560 --> 00:55:35,830

crazy Texan employee in the seventies

1350

00:55:38,900 --> 00:55:37,570

yeah I don't recall who I heard it from

1351

00:55:40,339 --> 00:55:38,910

but yeah there's

1352

00:55:47,599 --> 00:55:40,349

right into them down the tube of the

1353

00:55:49,370 --> 00:55:47,609

telescope so it's absolutely sure all

1354

00:55:50,059 --> 00:55:49,380

right let's see here Scotty you want to

1355

00:55:52,579 --> 00:55:50,069

help me make sure I'm not missing

1356

00:55:54,470 --> 00:55:52,589

anybody Oh Phillip is commenting the VLT

1357

00:55:58,370 --> 00:55:54,480

mirrors float on magnets that's right a

1358

00:56:01,130 --> 00:55:58,380

very large telescope in in Chile let's

1359

00:56:02,329 --> 00:56:01,140

see jonathan peters is asking i wanna

1360

00:56:04,069 --> 00:56:02,339

get it to a couple more before we're

1361

00:56:06,829 --> 00:56:04,079

running out of time here is it possible

1362

00:56:10,490 --> 00:56:06,839

to print aerogel materials from this or

1363

00:56:12,529 --> 00:56:10,500

future devices yeah you know we probably

1364

00:56:15,049 --> 00:56:12,539

will see future devices do exotic

1365

00:56:18,650 --> 00:56:15,059

materials like aerogel and the the

1366

00:56:20,960 --> 00:56:18,660

printers are Joe aerogel is awesome

1367

00:56:22,460 --> 00:56:20,970

you're is off you really got it like

1368

00:56:25,010 --> 00:56:22,470

Google and look at a picture of it

1369

00:56:27,380 --> 00:56:25,020

you'll probably think it's photoshopped

1370

00:56:31,039 --> 00:56:27,390

image but it's just this incredible

1371

00:56:34,400 --> 00:56:31,049

material that's extremely light it can

1372

00:56:35,599 --> 00:56:34,410

it has really high you know temperatures

1373

00:56:37,640 --> 00:56:35,609

that it can withstand so that you'll

1374

00:56:40,549 --> 00:56:37,650

find a picture of a match burning

1375

00:56:42,620 --> 00:56:40,559

sitting on top of this stuff um but it's

1376

00:56:44,980 --> 00:56:42,630

you know works really well for for

1377

00:56:48,049 --> 00:56:44,990

things like insulators and so on so

1378

00:56:50,420 --> 00:56:48,059

exotic materials are are always in the

1379

00:56:52,760 --> 00:56:50,430

realm of where research is for 3d

1380

00:56:56,990 --> 00:56:52,770

printing the printer that's on the space

1381

00:56:59,059 --> 00:56:57,000

station today does thermoplastics so and

1382

00:57:02,329 --> 00:56:59,069

a thermoplastic is a type of plastic

1383

00:57:04,460 --> 00:57:02,339

that you can melt and form and then ream

1384

00:57:08,769 --> 00:57:04,470

ill and that's that's kind of important

1385

00:57:11,660 --> 00:57:08,779

for the way that process works cool

1386

00:57:14,660 --> 00:57:11,670

let's see jonathan peters is also

1387

00:57:16,609 --> 00:57:14,670

commenting in space chocolate and space

1388

00:57:20,450 --> 00:57:16,619

cheeburger don't forget space g bugga

1389

00:57:22,430 --> 00:57:20,460

you can manufacture last one you can

1390

00:57:25,700 --> 00:57:22,440

manufacture plastic lenses with stereo

1391

00:57:28,430 --> 00:57:25,710

lithography which is fluid printing good

1392

00:57:30,319 --> 00:57:28,440

for telescopes maybe yep yeah good i

1393

00:57:33,799 --> 00:57:30,329

think it's that you know that my little

1394

00:57:36,410 --> 00:57:33,809

comment there is well absolutely but

1395

00:57:38,180 --> 00:57:36,420

we've when we started this process we

1396

00:57:39,740 --> 00:57:38,190

our goal was how can we get

1397

00:57:43,010 --> 00:57:39,750

manufacturing the space of the quickest

1398

00:57:46,010 --> 00:57:43,020

and and i also have an impact so we

1399

00:57:49,039 --> 00:57:46,020

identified that the tight this fused

1400

00:57:50,779 --> 00:57:49,049

deposition modeling or fdm style 3d

1401
00:57:52,700 --> 00:57:50,789
printing it's really an extrusion based

1402
00:57:55,250 --> 00:57:52,710
printing where you have a solid fly

1403
00:57:57,470 --> 00:57:55,260
lastic feedstock and you melted through

1404
00:58:00,740 --> 00:57:57,480
a nozzle so it's like imagine like a hot

1405
00:58:03,170 --> 00:58:00,750
glue gun that was something that we saw

1406
00:58:04,940 --> 00:58:03,180
at the highest potential just working in

1407
00:58:07,370 --> 00:58:04,950
zero gravity we didn't have to control a

1408
00:58:10,240 --> 00:58:07,380
fluid we have to control a powder of

1409
00:58:12,770 --> 00:58:10,250
metal and it also would be useful

1410
00:58:16,280 --> 00:58:12,780
astronauts can use it people could use

1411
00:58:18,020 --> 00:58:16,290
it so that was our path there's we would

1412
00:58:20,510 --> 00:58:18,030
definitely are working now on many other

1413
00:58:22,790 --> 00:58:20,520

technologies so I mentioned for one the

1414

00:58:26,120 --> 00:58:22,800

lunar printing we were making sure our

1415

00:58:28,099 --> 00:58:26,130

technology could be used on the moon but

1416

00:58:30,440 --> 00:58:28,109

you know we have to keep developing new

1417

00:58:32,120 --> 00:58:30,450

technologies or we will never get the

1418

00:58:33,829 --> 00:58:32,130

full picture of space manufacturing

1419

00:58:35,300 --> 00:58:33,839

awesome well that's we're going to I

1420

00:58:37,000 --> 00:58:35,310

guess well that'll be a good place to

1421

00:58:39,710 --> 00:58:37,010

close it there we're running out of time

1422

00:58:41,810 --> 00:58:39,720

Jason Dunn he's the co-founder and the

1423

00:58:44,420 --> 00:58:41,820

chief technology officer of made in

1424

00:58:45,770 --> 00:58:44,430

space a company that is currently

1425

00:58:47,960 --> 00:58:45,780

working with NASA to test this

1426

00:58:50,540 --> 00:58:47,970

technology of manufacturing out in

1427

00:58:55,190 --> 00:58:50,550

zero-g their website is made in space

1428

00:58:57,380 --> 00:58:55,200

dot u dot us right based on us and you

1429

00:58:59,990 --> 00:58:57,390

can follow these guys and at made his

1430

00:59:01,220 --> 00:59:00,000

faith and keep in Jason I hope we can

1431

00:59:03,290 --> 00:59:01,230

have you back and you'll talk to us

1432

00:59:05,000 --> 00:59:03,300

again about how things are going and but

1433

00:59:07,370 --> 00:59:05,010

and how it went after you get some

1434

00:59:09,560 --> 00:59:07,380

results I would love to thanks for

1435

00:59:12,920 --> 00:59:09,570

having awesome that's great thank you so

1436

00:59:15,200 --> 00:59:12,930

much that's for the up okay well guys I

1437

00:59:18,050 --> 00:59:15,210

guess that's it for now next week we're

1438

00:59:20,210 --> 00:59:18,060

going to be talking about comet siding

1439

00:59:22,520 --> 00:59:20,220

spring I believe for the Hubble you're

1440

00:59:24,230 --> 00:59:22,530

supposed to be looking at it I guess

1441

00:59:27,710 --> 00:59:24,240

this weekend it's looking at isn't right

1442

00:59:29,300 --> 00:59:27,720

up in ok so we'll be talking about what

1443

00:59:30,589 --> 00:59:29,310

it sees and we'll have images to show

1444

00:59:32,359 --> 00:59:30,599

you and hopefully there will be some

1445

00:59:35,839 --> 00:59:32,369

cool stuff that comes out of that so

1446

00:59:37,849 --> 00:59:35,849

until then we would like you to follow

1447

00:59:39,800 --> 00:59:37,859

us on all the follow us on Facebook and

1448

00:59:42,829 --> 00:59:39,810

Twitter and all of that in our help and

1449

00:59:45,109 --> 00:59:42,839

our YouTube channel is publicité channel

1450

00:59:47,750 --> 00:59:45,119

so please subscribe to us there Carol

1451

00:59:51,230 --> 00:59:47,760

Scott another one in the back the guy