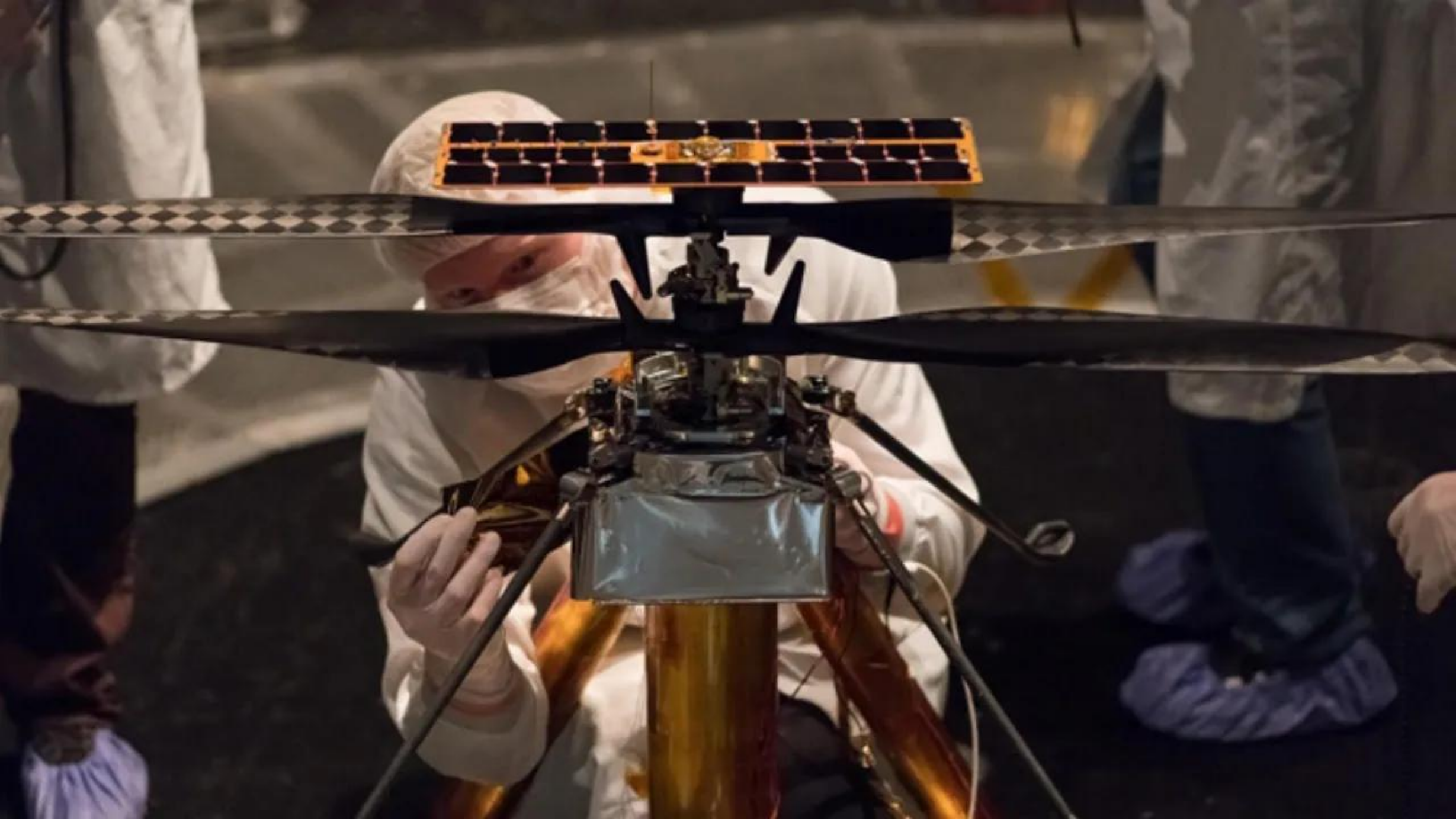

1
00:00:02,790 --> 00:00:00,870
[Music]

2
00:00:04,390 --> 00:00:02,800
nasa's jet propulsion laboratory

3
00:00:07,030 --> 00:00:04,400
presents

4
00:00:09,030 --> 00:00:07,040
the von carmen lecture a series of talks

5
00:00:09,750 --> 00:00:09,040
by scientists and engineers who are

6
00:00:13,190 --> 00:00:09,760
exploring

7
00:00:20,390 --> 00:00:13,200
our planet our solar system and all that

8
00:00:24,230 --> 00:00:22,310
we are starting to straighten up and fly

9
00:00:25,589 --> 00:00:24,240
right maneuver where the spacecraft will

10
00:00:27,349 --> 00:00:25,599
jettison the entry

11
00:00:29,349 --> 00:00:27,359
balance masses in preparation for

12
00:00:29,990 --> 00:00:29,359
parachute deploy and to roll over to

13
00:00:34,150 --> 00:00:30,000

give the radar

14
00:00:39,670 --> 00:00:37,430
complicated indicate shoe deploy

15
00:00:41,430 --> 00:00:39,680
the navigation has confirmed that the

16
00:00:43,670 --> 00:00:41,440
parachute has deployed and we are seeing

17
00:00:45,670 --> 00:00:43,680
significant deceleration

18
00:00:48,549 --> 00:00:45,680
in the velocity our current velocity is

19
00:00:50,389 --> 00:00:48,559
450 meters per second at an altitude of

20
00:00:53,189 --> 00:00:50,399
about 12 kilometers from the surface of

21
00:00:57,189 --> 00:00:55,750
heat shield set press advance has now

22
00:00:58,549 --> 00:00:57,199
slowed to subsonic

23
00:01:00,709 --> 00:00:58,559
speeds and the heat shield has been

24
00:01:02,389 --> 00:01:00,719
separated this allows

25
00:01:04,469 --> 00:01:02,399
both the radar and the cameras to get

26
00:01:07,109 --> 00:01:04,479
their first look at the surface

27
00:01:08,950 --> 00:01:07,119
current velocity is 145 meters per

28
00:01:11,030 --> 00:01:08,960
second and an altitude of about

29
00:01:27,749 --> 00:01:11,040
10 km nine and a half kilometers above

30
00:01:32,069 --> 00:01:30,069
now filter converge velocity solution

31
00:01:34,950 --> 00:01:32,079
3.3 meters per second

32
00:01:35,990 --> 00:01:34,960
altitude 7.4 kilometers now has radar

33
00:01:38,230 --> 00:01:36,000
lock on the ground

34
00:01:39,270 --> 00:01:38,240
current velocity is about 100 meters per

35
00:01:46,069 --> 00:01:39,280
second

36
00:01:49,910 --> 00:01:47,990
perseverance is continuing to descend on

37
00:01:52,789 --> 00:01:49,920
the parachute we are coming

38
00:01:54,230 --> 00:01:52,799

up on the initialization of terrain

39
00:01:56,069 --> 00:01:54,240
relative navigation

40
00:01:58,389 --> 00:01:56,079
and subsequently the priming of the

41
00:02:00,709 --> 00:01:58,399
landing engines our current velocity is

42
00:02:07,350 --> 00:02:00,719
about 90 meters per second at an

43
00:02:11,350 --> 00:02:09,749
ovf valid we have confirmation that the

44
00:02:12,710 --> 00:02:11,360
lander vision system has produced a

45
00:02:14,869 --> 00:02:12,720
valid solution

46
00:02:16,070 --> 00:02:14,879
and part of terrain relative navigation

47
00:02:19,510 --> 00:02:16,080
priming

48
00:02:25,990 --> 00:02:19,520
pba is nominal we have timing of the

49
00:02:29,670 --> 00:02:28,710
back shell set current velocity is 83

50
00:02:32,630 --> 00:02:29,680
meters per second

51
00:02:33,430 --> 00:02:32,640
at about 2.6 kilometers from the surface

52
00:02:34,869 --> 00:02:33,440
mars

53
00:02:36,470 --> 00:02:34,879
we have confirmation that the back shell

54
00:02:38,070 --> 00:02:36,480
has separated

55
00:02:40,550 --> 00:02:38,080
we are currently performing the divert

56
00:02:41,430 --> 00:02:40,560
maneuver current velocity is about 75

57
00:02:44,150 --> 00:02:41,440
meters per second

58
00:02:45,990 --> 00:02:44,160
at an altitude of about a kilometer off

59
00:02:50,229 --> 00:02:46,000
the surface of mars

60
00:02:52,470 --> 00:02:50,239
here in safety bravo we have completed

61
00:02:54,949 --> 00:02:52,480
our terrain relative navigation

62
00:02:57,350 --> 00:02:54,959
current speed is about 30 meters per

63
00:03:01,509 --> 00:02:57,360

second altitude of about 300 meters

64
00:03:05,270 --> 00:03:03,830
we have started our constant velocity

65
00:03:07,990 --> 00:03:05,280
accordion which means we are

66
00:03:12,390 --> 00:03:08,000
conducting the sky crane about to

67
00:03:12,400 --> 00:03:16,070
skytrain maneuver has started

68
00:03:16,080 --> 00:03:24,229
about 20 meters off the surface

69
00:03:30,229 --> 00:03:27,270
we're getting signals from mro

70
00:03:31,110 --> 00:03:30,239
tango delta touchdown confirmed

71
00:03:34,149 --> 00:03:31,120
perseverance

72
00:03:39,230 --> 00:03:34,159
faithfully on the surface of mars

73
00:03:39,240 --> 00:03:44,830
[Music]

74
00:03:48,390 --> 00:03:46,470
life hello

75
00:03:50,070 --> 00:03:48,400
and welcome to another edition of the

76
00:03:52,630 --> 00:03:50,080
2021 virtual

77
00:03:54,229 --> 00:03:52,640
von carmen lecture series i am nikki

78
00:03:56,070 --> 00:03:54,239
weirich from jpl's office of

79
00:03:57,910 --> 00:03:56,080
communications and education

80
00:03:59,589 --> 00:03:57,920
and i will be your host for our topic

81
00:04:02,550 --> 00:03:59,599
tonight helicopters

82
00:04:05,350 --> 00:04:02,560
in space many of you took the chance to

83
00:04:07,990 --> 00:04:05,360
join us on february 18th as we watch the

84
00:04:09,030 --> 00:04:08,000
perseverance rover successfully land on

85
00:04:11,429 --> 00:04:09,040
mars

86
00:04:12,789 --> 00:04:11,439
with this landing the helicopter

87
00:04:15,670 --> 00:04:12,799
ingenuity has also

88
00:04:17,189 --> 00:04:15,680

arrived safely on the red planet as a

89
00:04:19,430 --> 00:04:17,199
technology demonstration

90
00:04:20,469 --> 00:04:19,440
the helicopter is set to test the first

91
00:04:22,710 --> 00:04:20,479
powered flight

92
00:04:25,189 --> 00:04:22,720
on another planet it takes both

93
00:04:26,790 --> 00:04:25,199
ingenuity and perseverance to fly a

94
00:04:28,550 --> 00:04:26,800
helicopter on mars

95
00:04:49,140 --> 00:04:28,560
so let's take a moment to see what this

96
00:05:41,350 --> 00:05:05,500
[Music]

97
00:05:44,390 --> 00:05:43,350
wow just incredible footage we have

98
00:05:47,110 --> 00:05:44,400
there

99
00:05:48,230 --> 00:05:47,120
joining us this evening as co-host is

100
00:05:50,790 --> 00:05:48,240
sarah marcotte

101
00:05:52,870 --> 00:05:50,800
public engagement specialist for nasa's

102
00:05:54,469 --> 00:05:52,880
mars exploration program

103
00:05:56,790 --> 00:05:54,479
sarah brings over two decades of

104
00:05:59,189 --> 00:05:56,800
experience at out-of-school environments

105
00:06:01,270 --> 00:05:59,199
working to connect learners of all ages

106
00:06:05,270 --> 00:06:01,280
to current scientific research

107
00:06:07,350 --> 00:06:05,280
hi sarah hello nikki

108
00:06:09,830 --> 00:06:07,360
so uh my role tonight is i will be

109
00:06:12,550 --> 00:06:09,840
taking your questions from social media

110
00:06:14,870 --> 00:06:12,560
so keep those questions coming in the

111
00:06:17,270 --> 00:06:14,880
chat wherever you're watching tonight

112
00:06:18,710 --> 00:06:17,280
and i'm sure you're as excited as i am

113
00:06:20,790 --> 00:06:18,720

about the helicopter's

114
00:06:22,950 --> 00:06:20,800
first flight so i want to make sure that

115
00:06:25,029 --> 00:06:22,960
you know where you can find out

116
00:06:26,710 --> 00:06:25,039
all the background information so that

117
00:06:29,749 --> 00:06:26,720
you'll be ready when hell

118
00:06:31,590 --> 00:06:29,759
and ingenuity lifts off the ground we

119
00:06:35,029 --> 00:06:31,600
have a website of course

120
00:06:38,550 --> 00:06:35,039
which is go.nasa.gov

121
00:06:41,110 --> 00:06:38,560
ingenuity now on those pages you'll find

122
00:06:42,469 --> 00:06:41,120
all sorts of interesting things so that

123
00:06:44,710 --> 00:06:42,479
you can learn about this

124
00:06:45,749 --> 00:06:44,720
historic mission there's beautiful

125
00:06:48,550 --> 00:06:45,759
animations

126
00:06:50,469 --> 00:06:48,560
there's images of the helicopter as it

127
00:06:52,870 --> 00:06:50,479
was being built in the clean room at

128
00:06:55,990 --> 00:06:52,880
nasa's jet propulsion laboratory

129
00:06:57,909 --> 00:06:56,000
there's cool quick facts there's

130
00:06:59,350 --> 00:06:57,919
a helicopter model and there's

131
00:07:02,150 --> 00:06:59,360
activities for kids

132
00:07:03,830 --> 00:07:02,160
so that's the best place to go to learn

133
00:07:06,629 --> 00:07:03,840
about the helicopter

134
00:07:06,950 --> 00:07:06,639
and of course when the helicopter sends

135
00:07:09,909 --> 00:07:06,960
back

136
00:07:12,070 --> 00:07:09,919
images that it takes during its flight

137
00:07:14,469 --> 00:07:12,080
those images will be on that webpage

138
00:07:16,150 --> 00:07:14,479

as well so i'm excited to see your

139
00:07:16,550 --> 00:07:16,160
questions i see they're already coming

140
00:07:29,029 --> 00:07:16,560
in

141
00:07:30,790 --> 00:07:29,039
difficulties tonight or small failures

142
00:07:32,309 --> 00:07:30,800
we ask for your patience and please do

143
00:07:33,830 --> 00:07:32,319
stick with us we'll get them sorted out

144
00:07:35,749 --> 00:07:33,840
as soon as we can

145
00:07:37,430 --> 00:07:35,759
remember this is your space program we

146
00:07:37,830 --> 00:07:37,440
want you to get involved as sarah was

147
00:07:39,990 --> 00:07:37,840
saying

148
00:07:41,510 --> 00:07:40,000
please put those questions in the chat

149
00:07:44,309 --> 00:07:41,520
if you're watching on youtube

150
00:07:46,070 --> 00:07:44,319
youtube facebook live linkedin ask

151
00:07:48,309 --> 00:07:46,080
questions in the chat box and our social

152
00:07:49,110 --> 00:07:48,319
media team will bring up as many as we

153
00:07:50,629 --> 00:07:49,120
can

154
00:07:52,629 --> 00:07:50,639
and if you don't see the chat box please

155
00:07:54,710 --> 00:07:52,639
make sure you refresh your page and it

156
00:07:56,869 --> 00:07:54,720
should be right there for you

157
00:07:57,990 --> 00:07:56,879
our first speaker tonight started his

158
00:07:59,909 --> 00:07:58,000
jpl career

159
00:08:02,150 --> 00:07:59,919
writing software for the deep space

160
00:08:03,749 --> 00:08:02,160
network he worked on flight software for

161
00:08:05,830 --> 00:08:03,759
the curiosity rover

162
00:08:08,230 --> 00:08:05,840
and is now the mars helicopter

163
00:08:12,070 --> 00:08:08,240

operations lead at jpl

164
00:08:15,270 --> 00:08:12,080
please welcome timothy cannon hi tim

165
00:08:17,029 --> 00:08:15,280
hi good evening everyone thanks so much

166
00:08:18,550 --> 00:08:17,039
for being with us tonight tim

167
00:08:20,469 --> 00:08:18,560
can you tell us a little bit about who

168
00:08:23,909 --> 00:08:20,479
you are and how you got to work on this

169
00:08:25,430 --> 00:08:23,919
project and let's bring up image three

170
00:08:27,749 --> 00:08:25,440
well first of all i want to congratulate

171
00:08:29,430 --> 00:08:27,759
perseverance and doing a great job

172
00:08:31,029 --> 00:08:29,440
and bringing the ingenuity helicopter

173
00:08:32,230 --> 00:08:31,039
into a nice soft landing on the surface

174
00:08:34,630 --> 00:08:32,240
of mars

175
00:08:36,389 --> 00:08:34,640
so i worked at jpl for a number of

176
00:08:37,670 --> 00:08:36,399
projects over the years i started in the

177
00:08:40,310 --> 00:08:37,680
deep space network

178
00:08:42,070 --> 00:08:40,320
i worked on the cassini project and most

179
00:08:44,710 --> 00:08:42,080
recently before the helicopter i worked

180
00:08:46,389 --> 00:08:44,720
on the curiosity rover flight software

181
00:08:47,990 --> 00:08:46,399
as a matter of fact much of my software

182
00:08:50,550 --> 00:08:48,000
that i wrote for curiosity is now

183
00:08:53,030 --> 00:08:50,560
running on perseverance as well

184
00:08:54,470 --> 00:08:53,040
so most recently our group had developed

185
00:08:55,990 --> 00:08:54,480
a set of software that we used on a

186
00:08:57,590 --> 00:08:56,000
number of projects internally so i was

187
00:09:00,389 --> 00:08:57,600
asked to be the software lead

188
00:09:02,070 --> 00:09:00,399

for the helicopter and we had a team of

189
00:09:04,070 --> 00:09:02,080
four or five programmers that put the

190
00:09:06,230 --> 00:09:04,080
software together and tested it

191
00:09:07,190 --> 00:09:06,240
and since we operate the helicopter via

192
00:09:09,110 --> 00:09:07,200
the software

193
00:09:11,110 --> 00:09:09,120
i was asked to be the operations lead to

194
00:09:14,949 --> 00:09:11,120
actually operate the helicopter once we

195
00:09:18,389 --> 00:09:16,630
it's an incredible story of how you

196
00:09:19,910 --> 00:09:18,399
ended up where you are today

197
00:09:22,630 --> 00:09:19,920
but let's talk a little bit about the

198
00:09:24,070 --> 00:09:22,640
helicopter how do you build a helicopter

199
00:09:26,389 --> 00:09:24,080
that's going to be able to fly

200
00:09:28,790 --> 00:09:26,399
on mars and if we could see image 4

201
00:09:30,389 --> 00:09:28,800
please

202
00:09:31,670 --> 00:09:30,399
well when you design a helicopter for

203
00:09:33,430 --> 00:09:31,680
mars you have to keep in mind the

204
00:09:35,269 --> 00:09:33,440
environments you're going to fly in

205
00:09:37,590 --> 00:09:35,279
mars has a very thin atmosphere so we

206
00:09:39,030 --> 00:09:37,600
need to design it to be very lightweight

207
00:09:40,870 --> 00:09:39,040
the blades are very lightweight they

208
00:09:43,110 --> 00:09:40,880
spin very quickly

209
00:09:45,110 --> 00:09:43,120
and also because we are so far from

210
00:09:46,949 --> 00:09:45,120
earth you can't have a joystick and just

211
00:09:48,710 --> 00:09:46,959
fly it like you would a drone at home

212
00:09:49,990 --> 00:09:48,720
we had to write the software so it could

213
00:09:52,389 --> 00:09:50,000

fly itself we

214
00:09:54,230 --> 00:09:52,399
basically get a set of instructions and

215
00:09:55,829 --> 00:09:54,240
the helicopter takes off and flies to

216
00:09:57,670 --> 00:09:55,839
the places we tell it to

217
00:09:59,190 --> 00:09:57,680
and we had an extensive test program

218
00:10:00,870 --> 00:09:59,200
here on earth where we

219
00:10:02,710 --> 00:10:00,880
did many flights in a special chamber

220
00:10:04,310 --> 00:10:02,720
jpl to prove that our software would

221
00:10:06,630 --> 00:10:04,320
work when we got to mars

222
00:10:08,069 --> 00:10:06,640
so we're very excited to be finally here

223
00:10:09,750 --> 00:10:08,079
and actually able to

224
00:10:13,750 --> 00:10:09,760
execute these flights on the surface of

225
00:10:17,269 --> 00:10:15,910
it's incredible and i can't wait for the

226
00:10:18,870 --> 00:10:17,279
chance to see all of that

227
00:10:20,550 --> 00:10:18,880
um we're actually gonna bring the

228
00:10:23,350 --> 00:10:20,560
audience in right now and let them

229
00:10:24,790 --> 00:10:23,360
ask the next question for tim so sarah

230
00:10:29,030 --> 00:10:24,800
i'm sure they're excited out there

231
00:10:35,269 --> 00:10:32,470
so elitia on linkedin is asking

232
00:10:35,990 --> 00:10:35,279
what are or what is one of the greatest

233
00:10:40,310 --> 00:10:36,000
challenges

234
00:10:44,550 --> 00:10:42,550
well as i mentioned before the

235
00:10:46,230 --> 00:10:44,560
atmosphere is super thin

236
00:10:47,590 --> 00:10:46,240
and so you can't design a helicopter

237
00:10:50,230 --> 00:10:47,600
like you do on earth

238
00:10:51,110 --> 00:10:50,240

and so we had to do very new kinds of

239
00:10:52,949 --> 00:10:51,120
algorithms

240
00:10:55,430 --> 00:10:52,959
in the software we had to design

241
00:10:57,110 --> 00:10:55,440
hardware especially for flying on mars

242
00:10:59,030 --> 00:10:57,120
and so all of that was challenged we did

243
00:11:00,470 --> 00:10:59,040
things that have never been done before

244
00:11:02,069 --> 00:11:00,480
it's shorter right brother moment in

245
00:11:03,030 --> 00:11:02,079
that we get to go to a planet somewhere

246
00:11:04,710 --> 00:11:03,040
outside of earth

247
00:11:06,710 --> 00:11:04,720
and try a helicopter there that's never

248
00:11:07,829 --> 00:11:06,720
been tried before so we had to do

249
00:11:14,949 --> 00:11:07,839
special

250
00:11:16,550 --> 00:11:14,959
it happen

251
00:11:18,230 --> 00:11:16,560
sarah let's do one more question from

252
00:11:20,470 --> 00:11:18,240
the audience for tim

253
00:11:21,910 --> 00:11:20,480
sure thing i like this one uh this is

254
00:11:23,750 --> 00:11:21,920
from margie on facebook

255
00:11:25,509 --> 00:11:23,760
and she's asking for her nine-year-old

256
00:11:28,710 --> 00:11:25,519
son jonah so we've got

257
00:11:30,790 --> 00:11:28,720
a young space fan out here so he says

258
00:11:33,030 --> 00:11:30,800
how will ingenuity fly in the different

259
00:11:35,910 --> 00:11:33,040
gravity

260
00:11:36,630 --> 00:11:35,920
well that's a great question and we

261
00:11:39,350 --> 00:11:36,640
designed it

262
00:11:41,190 --> 00:11:39,360
to be lightweight because mars has about

263
00:11:43,269 --> 00:11:41,200

one-third the gravity of earth

264
00:11:45,030 --> 00:11:43,279
and so we had to design that in when we

265
00:11:45,829 --> 00:11:45,040
did it it's actually too heavy to fly on

266
00:11:48,069 --> 00:11:45,839
earth

267
00:11:49,910 --> 00:11:48,079
and so we had a special mechanism when

268
00:11:52,230 --> 00:11:49,920
we tested it here on earth that would

269
00:11:54,310 --> 00:11:52,240
pull up on the top of the helicopter and

270
00:11:55,910 --> 00:11:54,320
simulate mars gravity so we could fly in

271
00:11:56,629 --> 00:11:55,920
a chamber that was pumped down to mars

272
00:11:58,150 --> 00:11:56,639
pressure

273
00:12:00,069 --> 00:11:58,160
and have a special mechanism that

274
00:12:02,230 --> 00:12:00,079
allowed us to simulate the gravity of

275
00:12:03,990 --> 00:12:02,240
mars and let it fly around the chamber

276
00:12:08,710 --> 00:12:04,000
so yes we had to keep in mind the

277
00:12:11,670 --> 00:12:10,069
it sounds like a lot of testing went

278
00:12:13,430 --> 00:12:11,680
into this project and thank you sarah

279
00:12:15,590 --> 00:12:13,440
for that great set of questions

280
00:12:16,710 --> 00:12:15,600
now as tim you alluded to earlier the

281
00:12:19,430 --> 00:12:16,720
helicopter of course

282
00:12:19,829 --> 00:12:19,440
had to get to mars somehow so joining us

283
00:12:22,629 --> 00:12:19,839
now

284
00:12:23,269 --> 00:12:22,639
is perseverance mars 2020 systems

285
00:12:26,550 --> 00:12:23,279
engineer

286
00:12:30,150 --> 00:12:26,560
dr farah alibay hi farah

287
00:12:31,110 --> 00:12:30,160
hi so this next question is actually for

288
00:12:33,190 --> 00:12:31,120

both of you

289
00:12:34,470 --> 00:12:33,200
what are the challenges of working on a

290
00:12:37,110 --> 00:12:34,480
mission like this

291
00:12:38,150 --> 00:12:37,120
separate but united let's pull up image

292
00:12:41,430 --> 00:12:38,160
number five and tim

293
00:12:44,470 --> 00:12:43,590
well as a research project that's how we

294
00:12:45,990 --> 00:12:44,480
started

295
00:12:47,990 --> 00:12:46,000
and so when we were doing all of our

296
00:12:48,870 --> 00:12:48,000
development and testing it was a very

297
00:12:51,670 --> 00:12:48,880
much a very

298
00:12:53,269 --> 00:12:51,680
fast rapid uh high high-paced

299
00:12:55,430 --> 00:12:53,279
environment where we would make changes

300
00:12:56,949 --> 00:12:55,440
we'd fix something we'd try it again

301
00:12:59,350 --> 00:12:56,959
and when you go to a project like the

302
00:13:01,030 --> 00:12:59,360
rover the perseverance rover everything

303
00:13:04,150 --> 00:13:01,040
is very structured

304
00:13:06,710 --> 00:13:04,160
and very regimented

305
00:13:07,190 --> 00:13:06,720
with lots of processes you have to do

306
00:13:09,030 --> 00:13:07,200
and

307
00:13:10,790 --> 00:13:09,040
farah has been a great harbor pilot i

308
00:13:12,310 --> 00:13:10,800
call her our harbor pilot she guided us

309
00:13:14,949 --> 00:13:12,320
through all the icebergs of

310
00:13:16,069 --> 00:13:14,959
big project land to to get us on the

311
00:13:17,829 --> 00:13:16,079
rover and to

312
00:13:19,590 --> 00:13:17,839
help us figure out how to run all these

313
00:13:19,990 --> 00:13:19,600

things together and it has been a

314
00:13:22,230 --> 00:13:20,000
challenge

315
00:13:24,230 --> 00:13:22,240
because we've all been remote with covid

316
00:13:25,670 --> 00:13:24,240
and working together with farah and

317
00:13:31,509 --> 00:13:25,680
the rest of the team has been a real

318
00:13:35,750 --> 00:13:32,870
i'm sure it's been a great learning

319
00:13:37,350 --> 00:13:35,760
experience too far how about for you

320
00:13:39,030 --> 00:13:37,360
yeah i mean as tim mentioned one of the

321
00:13:39,829 --> 00:13:39,040
craziest thing is tim and i have

322
00:13:42,949 --> 00:13:39,839
actually never

323
00:13:44,470 --> 00:13:42,959
met in person so i i joined the team you

324
00:13:45,590 --> 00:13:44,480
know i've been on the perseverance team

325
00:13:47,269 --> 00:13:45,600
for a long time

326
00:13:49,110 --> 00:13:47,279
but i actually only started working on

327
00:13:50,870 --> 00:13:49,120
the helicopter right around launch when

328
00:13:52,629 --> 00:13:50,880
we really started thinking

329
00:13:54,550 --> 00:13:52,639
well this thing's on its way to mars we

330
00:13:56,470 --> 00:13:54,560
better figure out how to operate it

331
00:13:58,550 --> 00:13:56,480
and so i was brought along and and you

332
00:14:00,230 --> 00:13:58,560
know we were deep in covet and i've been

333
00:14:01,670 --> 00:14:00,240
interacting with the team remotely and

334
00:14:03,590 --> 00:14:01,680
it's it's crazy because i feel like

335
00:14:05,269 --> 00:14:03,600
we've become close friends even though

336
00:14:07,030 --> 00:14:05,279
you know we've never actually physically

337
00:14:09,509 --> 00:14:07,040
met um but

338
00:14:10,069 --> 00:14:09,519

one of the challenges with helicopter is

339
00:14:11,670 --> 00:14:10,079
unlike

340
00:14:13,350 --> 00:14:11,680
other instruments for example on the

341
00:14:15,590 --> 00:14:13,360
rover typically we're used to bringing

342
00:14:17,829 --> 00:14:15,600
the instruments with us wherever we go

343
00:14:19,990 --> 00:14:17,839
whereas with ingenuity you know for the

344
00:14:21,829 --> 00:14:20,000
past few souls now on mars

345
00:14:24,069 --> 00:14:21,839
we've been looking for a place to drop

346
00:14:26,069 --> 00:14:24,079
it off right we we are looking for a

347
00:14:27,350 --> 00:14:26,079
flat environment where we can leave the

348
00:14:29,269 --> 00:14:27,360
helicopter and then

349
00:14:30,550 --> 00:14:29,279
an area for us to watch it from and take

350
00:14:32,150 --> 00:14:30,560
those videos

351
00:14:34,550 --> 00:14:32,160
because you know if you don't have a

352
00:14:35,990 --> 00:14:34,560
picture it didn't happen um and so

353
00:14:37,990 --> 00:14:36,000
so it's a little bit unique in that

354
00:14:39,590 --> 00:14:38,000
sense that you know we it's a different

355
00:14:40,629 --> 00:14:39,600
mission we're bringing it along with us

356
00:14:43,910 --> 00:14:40,639
it has its own

357
00:14:45,350 --> 00:14:43,920
needs um and we have to help it figure

358
00:14:46,230 --> 00:14:45,360
out you know we have to help it achieve

359
00:14:47,829 --> 00:14:46,240
its goals and

360
00:14:49,910 --> 00:14:47,839
and that's really what perseverance is

361
00:14:50,710 --> 00:14:49,920
there for in for this particular tech

362
00:14:52,629 --> 00:14:50,720
demo is

363
00:14:53,990 --> 00:14:52,639

we are there to set the stage for the

364
00:14:56,949 --> 00:14:54,000
first flight on mars

365
00:15:00,150 --> 00:14:56,959
um and help our our friend uh achieve

366
00:15:04,550 --> 00:15:02,150
i mean what a great example of teamwork

367
00:15:06,150 --> 00:15:04,560
especially during the times of kovid

368
00:15:07,829 --> 00:15:06,160
tim we're going to come back to you in a

369
00:15:09,110 --> 00:15:07,839
little bit for some more questions but

370
00:15:10,150 --> 00:15:09,120
right now we're going to keep chatting

371
00:15:12,389 --> 00:15:10,160
with farah

372
00:15:13,990 --> 00:15:12,399
who has been a systems engineer at jpl

373
00:15:15,910 --> 00:15:14,000
for the past seven years

374
00:15:18,230 --> 00:15:15,920
working on several missions including

375
00:15:19,350 --> 00:15:18,240
the insight mars lander and marco

376
00:15:20,870 --> 00:15:19,360
cubesats

377
00:15:22,790 --> 00:15:20,880
today one of her roles on the

378
00:15:24,310 --> 00:15:22,800
perseverance mission is to lead the

379
00:15:26,310 --> 00:15:24,320
operations interface

380
00:15:27,990 --> 00:15:26,320
with the mars helicopter technology

381
00:15:29,749 --> 00:15:28,000
demonstration

382
00:15:31,910 --> 00:15:29,759
so far you've had a pretty exciting

383
00:15:33,910 --> 00:15:31,920
month you're living on mars time right

384
00:15:36,629 --> 00:15:33,920
now can you explain what is mars time

385
00:15:39,590 --> 00:15:36,639
and why are you on it

386
00:15:41,350 --> 00:15:39,600
yeah so it's currently about 8 45 a.m

387
00:15:44,790 --> 00:15:41,360
for perseverance right now

388
00:15:46,790 --> 00:15:44,800

um which well so it's not 8 45 a.m for

389
00:15:48,470 --> 00:15:46,800
me but what i do right now and what the

390
00:15:49,269 --> 00:15:48,480
rest of the perseverance team is doing

391
00:15:51,509 --> 00:15:49,279
is that

392
00:15:53,430 --> 00:15:51,519
we are working during the martian night

393
00:15:56,389 --> 00:15:53,440
and that's what we call mars time

394
00:15:57,990 --> 00:15:56,399
so our rover is too far away from earth

395
00:15:59,829 --> 00:15:58,000
and so we can't just command it you know

396
00:16:01,749 --> 00:15:59,839
it's not like we sit behind our desks

397
00:16:02,790 --> 00:16:01,759
with joysticks driving them over i wish

398
00:16:05,030 --> 00:16:02,800
it was that way

399
00:16:06,870 --> 00:16:05,040
mars is way too far so when we send

400
00:16:09,030 --> 00:16:06,880
signals to mars you know they're radio

401
00:16:10,949 --> 00:16:09,040
signals they go at the speed of light

402
00:16:13,030 --> 00:16:10,959
but it's so far away that it takes about

403
00:16:13,749 --> 00:16:13,040
13 minutes right now for a signal to get

404
00:16:16,150 --> 00:16:13,759
from earth

405
00:16:17,269 --> 00:16:16,160
to mars and then another 13 minutes for

406
00:16:19,110 --> 00:16:17,279
it to get back

407
00:16:20,870 --> 00:16:19,120
so it'd be really long and boring day if

408
00:16:22,629 --> 00:16:20,880
we were sending a command and waiting

409
00:16:26,150 --> 00:16:22,639
each time for an answer

410
00:16:28,710 --> 00:16:26,160
so what we do instead is that each night

411
00:16:29,509 --> 00:16:28,720
the rover sends us information it sends

412
00:16:31,670 --> 00:16:29,519
us images

413
00:16:32,550 --> 00:16:31,680

it sends us data it tells us what it did

414
00:16:34,870 --> 00:16:32,560
that day

415
00:16:36,790 --> 00:16:34,880
we as a team analyze it so we go into

416
00:16:39,590 --> 00:16:36,800
work at about 6 p.m

417
00:16:40,870 --> 00:16:39,600
perseverance time every night and then

418
00:16:42,710 --> 00:16:40,880
we analyze the data

419
00:16:44,470 --> 00:16:42,720
we prepare a plan for the next day as a

420
00:16:45,509 --> 00:16:44,480
team and then we send it back up to the

421
00:16:47,509 --> 00:16:45,519
rover

422
00:16:49,509 --> 00:16:47,519
and we send it up before it wakes up in

423
00:16:51,829 --> 00:16:49,519
the morning at about 8 a.m

424
00:16:53,990 --> 00:16:51,839
so we work the martian night shift right

425
00:16:55,269 --> 00:16:54,000
which okay that seems fine you just

426
00:16:57,829 --> 00:16:55,279
shift your schedule

427
00:16:59,910 --> 00:16:57,839
well it's not that easy because a

428
00:17:03,269 --> 00:16:59,920
martian day which is we call it a

429
00:17:03,990 --> 00:17:03,279
saw is actually about 24 hours and 40

430
00:17:06,549 --> 00:17:04,000
minutes

431
00:17:07,429 --> 00:17:06,559
so it's just a little longer than earth

432
00:17:10,230 --> 00:17:07,439
so even though

433
00:17:12,309 --> 00:17:10,240
i start my day at the same time on mars

434
00:17:14,870 --> 00:17:12,319
every day at about 6 pm every day

435
00:17:16,630 --> 00:17:14,880
my start time on earth shifts by 40

436
00:17:17,590 --> 00:17:16,640
minutes every day so this morning for

437
00:17:20,150 --> 00:17:17,600
example

438
00:17:20,630 --> 00:17:20,160

my wake up time was about you know 4 30

439
00:17:23,270 --> 00:17:20,640
a.m

440
00:17:24,230 --> 00:17:23,280
tomorrow it'll be more like five to 5 10

441
00:17:25,990 --> 00:17:24,240
and so on

442
00:17:27,350 --> 00:17:26,000
so we're coming up this week and next

443
00:17:27,990 --> 00:17:27,360
week that's why i was able to join you

444
00:17:29,990 --> 00:17:28,000
today

445
00:17:31,590 --> 00:17:30,000
in in days where the martian night is

446
00:17:33,669 --> 00:17:31,600
lining up with the earth day

447
00:17:34,950 --> 00:17:33,679
but i just came out of doing the night

448
00:17:36,310 --> 00:17:34,960
shift of of

449
00:17:38,710 --> 00:17:36,320
having to wake up in the middle of the

450
00:17:40,549 --> 00:17:38,720
night so it's just a shifting schedule

451
00:17:41,830 --> 00:17:40,559
and we're doing that for the first 90

452
00:17:43,590 --> 00:17:41,840
days of the mission

453
00:17:45,270 --> 00:17:43,600
because those are critical times we need

454
00:17:47,029 --> 00:17:45,280
to be working every single day on the

455
00:17:47,430 --> 00:17:47,039
rover to get everything checked out to

456
00:17:49,669 --> 00:17:47,440
get

457
00:17:51,190 --> 00:17:49,679
the ingenuity mission done all of those

458
00:17:53,990 --> 00:17:51,200
key activities that everyone's so

459
00:17:57,430 --> 00:17:55,270
i mean that's definitely a lot of

460
00:17:58,870 --> 00:17:57,440
dedication that y'all's team are putting

461
00:18:01,430 --> 00:17:58,880
into this

462
00:18:03,270 --> 00:18:01,440
as we saw before the rover has safely

463
00:18:05,110 --> 00:18:03,280

made it to mars and that video is just

464
00:18:06,230 --> 00:18:05,120
incredible watching it land i never get

465
00:18:08,630 --> 00:18:06,240
tired of it

466
00:18:10,390 --> 00:18:08,640
can you explain your role in relation to

467
00:18:12,870 --> 00:18:10,400
the helicopter mission and let's pull up

468
00:18:15,270 --> 00:18:12,880
image six

469
00:18:16,549 --> 00:18:15,280
yeah so as tim mentioned my job

470
00:18:19,430 --> 00:18:16,559
basically is to

471
00:18:19,750 --> 00:18:19,440
it is to help accommodate the helicopter

472
00:18:21,430 --> 00:18:19,760
uh

473
00:18:23,190 --> 00:18:21,440
tech demo so and there's really two

474
00:18:24,310 --> 00:18:23,200
parts to this right now you can see in

475
00:18:26,230 --> 00:18:24,320
the picture actually

476
00:18:27,830 --> 00:18:26,240
the helicopter is tucked in under the

477
00:18:29,029 --> 00:18:27,840
belly of the rover it's actually

478
00:18:31,190 --> 00:18:29,039
horizontal

479
00:18:33,270 --> 00:18:31,200
below the rover it's connected right it

480
00:18:34,470 --> 00:18:33,280
gets it gets heat it gets we can

481
00:18:36,310 --> 00:18:34,480
communicate with it

482
00:18:38,630 --> 00:18:36,320
and we have to deploy it on the surface

483
00:18:41,190 --> 00:18:38,640
of mars so in the upcoming weeks here

484
00:18:42,789 --> 00:18:41,200
once we find a site that's suitable we

485
00:18:44,630 --> 00:18:42,799
are going to go through a deployment

486
00:18:46,870 --> 00:18:44,640
process where we go from

487
00:18:48,710 --> 00:18:46,880
the helicopter being horizontal to going

488
00:18:51,430 --> 00:18:48,720

all the way vertical

489
00:18:52,950 --> 00:18:51,440
and then there's the last the last day

490
00:18:54,950 --> 00:18:52,960
of our deployment

491
00:18:57,270 --> 00:18:54,960
is when we separate the helicopter from

492
00:18:57,669 --> 00:18:57,280
the rover and what's special about that

493
00:18:59,750 --> 00:18:57,679
day

494
00:19:01,669 --> 00:18:59,760
is that from the moment that we separate

495
00:19:03,909 --> 00:19:01,679
from the helicopter from the rover

496
00:19:06,150 --> 00:19:03,919
we have to drive off of it and expose

497
00:19:09,270 --> 00:19:06,160
the solar panels from the helicopter

498
00:19:11,430 --> 00:19:09,280
within 24 hours of that drop because

499
00:19:12,470 --> 00:19:11,440
if we don't drive off on time if we have

500
00:19:13,510 --> 00:19:12,480
any problem

501
00:19:15,830 --> 00:19:13,520
then there's a chance that the

502
00:19:17,110 --> 00:19:15,840
helicopter might not survive the martian

503
00:19:18,789 --> 00:19:17,120
night which is so cold

504
00:19:21,270 --> 00:19:18,799
because it needs that energy from the

505
00:19:21,990 --> 00:19:21,280
solar panels so my job has to be been to

506
00:19:25,909 --> 00:19:22,000
coordinate

507
00:19:28,230 --> 00:19:25,919
rover side activities

508
00:19:29,990 --> 00:19:28,240
to get that deployment done to drive off

509
00:19:31,110 --> 00:19:30,000
to do all of the imaging during the

510
00:19:33,430 --> 00:19:31,120
flights

511
00:19:35,350 --> 00:19:33,440
and to coordinate for example

512
00:19:37,510 --> 00:19:35,360
communicating with the helicopter

513
00:19:39,909 --> 00:19:37,520

the helicopter can't talk directly back

514
00:19:42,870 --> 00:19:39,919
to earth it has to send its signals

515
00:19:43,430 --> 00:19:42,880
through the rover and then to earth so

516
00:19:45,029 --> 00:19:43,440
there's a

517
00:19:46,870 --> 00:19:45,039
basically i call it sort of a dance

518
00:19:48,789 --> 00:19:46,880
there's a very careful dance that has to

519
00:19:51,110 --> 00:19:48,799
happen between the two projects

520
00:19:52,549 --> 00:19:51,120
and i'm i'm sort of the choreographer

521
00:19:54,150 --> 00:19:52,559
for those dances

522
00:19:55,669 --> 00:19:54,160
to make sure that everything happens

523
00:19:56,710 --> 00:19:55,679
everyone is right there when they need

524
00:20:01,110 --> 00:19:56,720
to be

525
00:20:04,390 --> 00:20:03,510
that seems really complicated and both

526
00:20:06,310 --> 00:20:04,400
you him tim

527
00:20:08,149 --> 00:20:06,320
have talked about how this isn't like

528
00:20:09,270 --> 00:20:08,159
using a joystick to command these

529
00:20:11,270 --> 00:20:09,280
spacecraft

530
00:20:13,430 --> 00:20:11,280
so how do you prepare for something like

531
00:20:15,990 --> 00:20:13,440
that and let's pull up video seven while

532
00:20:18,870 --> 00:20:16,000
you talk us through this

533
00:20:20,630 --> 00:20:18,880
so we test test test and test some more

534
00:20:22,950 --> 00:20:20,640
i can't tell you how much time i've

535
00:20:24,070 --> 00:20:22,960
spent in the mars yard at jpl in the

536
00:20:25,750 --> 00:20:24,080
past few months so

537
00:20:27,669 --> 00:20:25,760
so the mars yard is basically a big

538
00:20:28,950 --> 00:20:27,679

sandbox it looks like mars you're seeing

539
00:20:31,350 --> 00:20:28,960
it in the video there

540
00:20:34,549 --> 00:20:31,360
and we have a replica of both ingenuity

541
00:20:36,070 --> 00:20:34,559
and perseverance perseverance the

542
00:20:37,909 --> 00:20:36,080
replica for perseverance is called

543
00:20:40,630 --> 00:20:37,919
optimism and

544
00:20:41,350 --> 00:20:40,640
we use those earth you know those earth

545
00:20:44,710 --> 00:20:41,360
robots

546
00:20:47,990 --> 00:20:44,720
to test before we get to mars and

547
00:20:50,549 --> 00:20:48,000
we test everything all of the activities

548
00:20:52,789 --> 00:20:50,559
all of the sequences the timing to make

549
00:20:54,470 --> 00:20:52,799
sure that once we do it on mars

550
00:20:55,830 --> 00:20:54,480
it's not the first time it you know it

551
00:20:57,350 --> 00:20:55,840
should be boring by the time we do it on

552
00:20:59,110 --> 00:20:57,360
mars because we've done it so many times

553
00:21:00,070 --> 00:20:59,120
so the video that you're seeing here for

554
00:21:01,909 --> 00:21:00,080
example

555
00:21:03,669 --> 00:21:01,919
is what we hope the deployment day will

556
00:21:04,630 --> 00:21:03,679
look like on mars so we tested our

557
00:21:07,590 --> 00:21:04,640
deployment

558
00:21:09,029 --> 00:21:07,600
uh and we tested driving off of it and

559
00:21:10,549 --> 00:21:09,039
the other thing that we do is that we

560
00:21:13,669 --> 00:21:10,559
also test our people

561
00:21:15,270 --> 00:21:13,679
um so back in in late january we had a

562
00:21:16,789 --> 00:21:15,280
dress rehearsal

563
00:21:19,669 --> 00:21:16,799

for the day that we're going to drop the

564
00:21:21,590 --> 00:21:19,679
helicopter so we had all of our team

565
00:21:22,789 --> 00:21:21,600
you know in the control room and i was

566
00:21:25,190 --> 00:21:22,799
sending them data

567
00:21:26,789 --> 00:21:25,200
and and you know spoofing anomalies and

568
00:21:27,430 --> 00:21:26,799
things like that and people had to react

569
00:21:29,669 --> 00:21:27,440
to them and

570
00:21:30,789 --> 00:21:29,679
and do that go no goes and decide okay

571
00:21:32,950 --> 00:21:30,799
are we gonna drive off

572
00:21:34,710 --> 00:21:32,960
is the helicopter separated what's the

573
00:21:36,549 --> 00:21:34,720
health of the helicopter so

574
00:21:38,789 --> 00:21:36,559
um so that's really helped us build

575
00:21:41,190 --> 00:21:38,799
confidence in our ability to do this

576
00:21:42,789 --> 00:21:41,200
and you know i think we're as ready as

577
00:21:43,750 --> 00:21:42,799
we can be and we're really excited to

578
00:21:45,350 --> 00:21:43,760
get to do it

579
00:21:47,029 --> 00:21:45,360
for real on mars it's a little bit like

580
00:21:48,470 --> 00:21:47,039
you know when you've rehearsed for a

581
00:21:49,750 --> 00:21:48,480
show for a long time and then you're

582
00:21:53,750 --> 00:21:49,760
ready for prime time

583
00:21:58,230 --> 00:21:56,470
i love what you said about this being a

584
00:22:00,149 --> 00:21:58,240
boring moment because you've tested it

585
00:22:01,350 --> 00:22:00,159
so many times that you want to make sure

586
00:22:02,470 --> 00:22:01,360
that it's going to work and if it goes

587
00:22:03,990 --> 00:22:02,480
according to plan

588
00:22:05,510 --> 00:22:04,000

i guarantee it will not be a boring

589
00:22:08,149 --> 00:22:05,520
moment for any of us

590
00:22:09,510 --> 00:22:08,159
that's a great way to think about it

591
00:22:11,510 --> 00:22:09,520
we're actually going to get the audience

592
00:22:12,070 --> 00:22:11,520
involved again to ask our next question

593
00:22:13,750 --> 00:22:12,080
so

594
00:22:16,470 --> 00:22:13,760
sarah what are they asking out there for

595
00:22:20,390 --> 00:22:18,549
well i'm struggling because there are so

596
00:22:23,669 --> 00:22:20,400
many great questions coming in so

597
00:22:25,190 --> 00:22:23,679
i'm having a hard time deciding um but

598
00:22:27,350 --> 00:22:25,200
there were there are a couple themes

599
00:22:27,909 --> 00:22:27,360
emerging here and so i thought these

600
00:22:31,430 --> 00:22:27,919
were really

601
00:22:33,590 --> 00:22:31,440
interesting so um for pharah so

602
00:22:35,190 --> 00:22:33,600
kurt on linkedin is asking and it's also

603
00:22:36,470 --> 00:22:35,200
kind of related to what alicia on

604
00:22:39,669 --> 00:22:36,480
youtube is asking

605
00:22:42,149 --> 00:22:39,679
having to do with the um dust storms

606
00:22:44,149 --> 00:22:42,159
so how will ingenuity react to adverse

607
00:22:45,190 --> 00:22:44,159
environmental conditions such as dust

608
00:22:47,350 --> 00:22:45,200
storms

609
00:22:49,350 --> 00:22:47,360
um you know will they work and will the

610
00:22:52,310 --> 00:22:49,360
helicopter work in stormy weather

611
00:22:53,430 --> 00:22:52,320
what do you think so we're not even

612
00:22:55,510 --> 00:22:53,440
going to try and fly

613
00:22:57,029 --> 00:22:55,520

in stormy weathers one of the advantage

614
00:22:58,470 --> 00:22:57,039
of having perseverance

615
00:23:01,110 --> 00:22:58,480
is that we actually have a weather

616
00:23:03,029 --> 00:23:01,120
station on board the rover

617
00:23:05,669 --> 00:23:03,039
so we have wind sensors we have

618
00:23:07,830 --> 00:23:05,679
temperature and we've actually been

619
00:23:09,110 --> 00:23:07,840
very closely watching the temperature

620
00:23:10,470 --> 00:23:09,120
and and the winds

621
00:23:12,390 --> 00:23:10,480
since we landed we actually had a

622
00:23:14,549 --> 00:23:12,400
meeting today where we looked at the

623
00:23:16,149 --> 00:23:14,559
you know at the at the results that we

624
00:23:18,789 --> 00:23:16,159
have so far to try and see

625
00:23:19,750 --> 00:23:18,799
okay you know not just is there anything

626
00:23:21,990 --> 00:23:19,760
going on

627
00:23:23,909 --> 00:23:22,000
on mars right now but even what time of

628
00:23:25,909 --> 00:23:23,919
day do we think it's better to fly

629
00:23:27,270 --> 00:23:25,919
um the winds on mars as it turns out are

630
00:23:29,750 --> 00:23:27,280
really predictable

631
00:23:31,430 --> 00:23:29,760
um so on from a day-to-day basis there's

632
00:23:32,230 --> 00:23:31,440
times of data that are more windy than

633
00:23:34,390 --> 00:23:32,240
others

634
00:23:35,350 --> 00:23:34,400
um so we're trying to evaluate right now

635
00:23:37,110 --> 00:23:35,360
okay

636
00:23:38,870 --> 00:23:37,120
what the what are the patterns starting

637
00:23:39,909 --> 00:23:38,880
to look like and when do we think that

638
00:23:42,630 --> 00:23:39,919

we want to fly

639
00:23:42,950 --> 00:23:42,640
to avoid sort of the gustier times of

640
00:23:45,830 --> 00:23:42,960
day

641
00:23:46,149 --> 00:23:45,840
so um so yeah we we came prepared we're

642
00:23:48,630 --> 00:23:46,159
all

643
00:23:50,230 --> 00:23:48,640
with our own weather station in order to

644
00:23:55,110 --> 00:23:50,240
to figure that out and uh

645
00:23:58,789 --> 00:23:57,350
it's always good to be very prepared um

646
00:24:00,549 --> 00:23:58,799
i think we've got time for another

647
00:24:01,909 --> 00:24:00,559
question before we move on so sarah is

648
00:24:04,310 --> 00:24:01,919
there another one out there for pharah

649
00:24:07,510 --> 00:24:04,320
that we could ask sure

650
00:24:09,750 --> 00:24:07,520
sure so alithea on linkedin is wondering

651
00:24:12,390 --> 00:24:09,760
how do you balance a lightweight

652
00:24:15,190 --> 00:24:12,400
helicopter with a helicopter that can

653
00:24:16,870 --> 00:24:15,200
endure an impact i guess maybe when it

654
00:24:18,789 --> 00:24:16,880
comes back after a flight

655
00:24:20,070 --> 00:24:18,799
so how do you balance those two things

656
00:24:21,590 --> 00:24:20,080
got to be light but it's got to be

657
00:24:22,950 --> 00:24:21,600
strong

658
00:24:25,430 --> 00:24:22,960
yeah i mean that's all part of the

659
00:24:27,510 --> 00:24:25,440
challenges of designing things for mars

660
00:24:30,230 --> 00:24:27,520
is they have to be robust for the

661
00:24:32,230 --> 00:24:30,240
environment and they also have to be

662
00:24:33,430 --> 00:24:32,240
and they also have to meet constraints

663
00:24:35,909 --> 00:24:33,440

like light like

664
00:24:37,110 --> 00:24:35,919
light in this case so um so i'm sure

665
00:24:39,350 --> 00:24:37,120
that tim could actually

666
00:24:42,070 --> 00:24:39,360
provide a lot more detail into exactly

667
00:24:44,230 --> 00:24:42,080
how um how the helicopter was designed

668
00:24:45,350 --> 00:24:44,240
uh but i can tell you that with anything

669
00:24:47,590 --> 00:24:45,360
in engineering

670
00:24:50,070 --> 00:24:47,600
there's a lot of cycles of iteration

671
00:24:51,909 --> 00:24:50,080
right we probably we start with a design

672
00:24:53,510 --> 00:24:51,919
and then we test it out we try it again

673
00:24:55,510 --> 00:24:53,520
until it meets those requirements that's

674
00:24:57,830 --> 00:24:55,520
true for the helicopter that's true for

675
00:24:59,990 --> 00:24:57,840
the rover wheels for example right we we

676
00:25:03,110 --> 00:25:00,000
redesigned the wheels on this mission

677
00:25:04,710 --> 00:25:03,120
and we tested you know dozens of

678
00:25:06,470 --> 00:25:04,720
different types of wheels

679
00:25:08,149 --> 00:25:06,480
in order to get there and i'm sure it

680
00:25:08,470 --> 00:25:08,159
was the same story for the helicopter

681
00:25:10,310 --> 00:25:08,480
but

682
00:25:14,710 --> 00:25:10,320
maybe tim can can add a little bit of

683
00:25:17,510 --> 00:25:14,720
information here

684
00:25:19,350 --> 00:25:17,520
well sure thanks farah for the intro so

685
00:25:19,830 --> 00:25:19,360
the helicopter was designed to be both

686
00:25:22,310 --> 00:25:19,840
strong

687
00:25:23,990 --> 00:25:22,320
and light so it's made of carbon fiber

688
00:25:25,110 --> 00:25:24,000

in many cases which is really light but

689
00:25:27,830 --> 00:25:25,120
really strong

690
00:25:29,350 --> 00:25:27,840
the blades are can spin really fast and

691
00:25:31,110 --> 00:25:29,360
lift the weight of the helicopter but if

692
00:25:33,269 --> 00:25:31,120
you picked one up it would be about the

693
00:25:35,909 --> 00:25:33,279
weight of a sheet of paper so the whole

694
00:25:38,149 --> 00:25:35,919
helicopter weighs about four pounds

695
00:25:38,950 --> 00:25:38,159
but yet it's able to you know lift

696
00:25:41,110 --> 00:25:38,960
itself up

697
00:25:42,630 --> 00:25:41,120
and fly around and we did many tests of

698
00:25:43,830 --> 00:25:42,640
the legs you know the legs are springy

699
00:25:44,950 --> 00:25:43,840
so that if we

700
00:25:46,549 --> 00:25:44,960
bounce a little bit on landing they

701
00:25:47,990 --> 00:25:46,559
don't break and they're very stable they

702
00:25:49,590 --> 00:25:48,000
have a wide stance

703
00:25:51,750 --> 00:25:49,600
so that if we bounce a little one side

704
00:25:52,549 --> 00:25:51,760
we can recover and it's a very tough

705
00:25:54,870 --> 00:25:52,559
system

706
00:25:56,630 --> 00:25:54,880
so we spent a lot of time we had some

707
00:25:57,269 --> 00:25:56,640
advanced partners that helped us out

708
00:25:58,710 --> 00:25:57,279
that

709
00:26:00,549 --> 00:25:58,720
designed it so it could be strong and

710
00:26:02,470 --> 00:26:00,559
light at the same time so we're

711
00:26:06,390 --> 00:26:02,480
very confident that whatever mars can

712
00:26:11,029 --> 00:26:09,669
well in your confidence we trust so uh

713
00:26:12,549 --> 00:26:11,039

we are going to take a couple more

714
00:26:14,070 --> 00:26:12,559
questions from the audience in just a

715
00:26:17,110 --> 00:26:14,080
moment for both of you

716
00:26:19,430 --> 00:26:17,120
but i have one final question for you

717
00:26:20,310 --> 00:26:19,440
is this part of the dream of working at

718
00:26:22,149 --> 00:26:20,320
jpl

719
00:26:23,990 --> 00:26:22,159
you get to be a part of a unique first

720
00:26:25,510 --> 00:26:24,000
of its kind mission is that why you come

721
00:26:26,789 --> 00:26:25,520
to work at a place like this

722
00:26:30,070 --> 00:26:26,799
and tim why don't you take that one

723
00:26:31,669 --> 00:26:30,080
first we're gonna pull up image eight

724
00:26:33,430 --> 00:26:31,679
well sure it is definitely a dream i

725
00:26:35,430 --> 00:26:33,440
grew up in small town america

726
00:26:37,110 --> 00:26:35,440
and i grew up reading all the national

727
00:26:37,990 --> 00:26:37,120
geographic issues about the voyager

728
00:26:39,990 --> 00:26:38,000
probe and all the different

729
00:26:42,789 --> 00:26:40,000
outer planets that have visited i love

730
00:26:44,549 --> 00:26:42,799
to consume all kinds of astronomy books

731
00:26:46,710 --> 00:26:44,559
and i was generally a computer geek so

732
00:26:48,549 --> 00:26:46,720
all this stuff came together really well

733
00:26:50,310 --> 00:26:48,559
and i was able to get a job out of

734
00:26:51,669 --> 00:26:50,320
college at jpl and do really exciting

735
00:26:53,110 --> 00:26:51,679
things which is really culminating in

736
00:26:55,029 --> 00:26:53,120
this chance to do

737
00:26:56,789 --> 00:26:55,039
a first of a kind thing on mars which is

738
00:26:58,390 --> 00:26:56,799

to fly a helicopter which has never been

739
00:26:59,990 --> 00:26:58,400
done before so sure

740
00:27:01,750 --> 00:27:00,000
we're very nervous but we're confident

741
00:27:02,390 --> 00:27:01,760
in our helicopter and we're excited to

742
00:27:06,390 --> 00:27:02,400
go

743
00:27:08,149 --> 00:27:06,400
and we're really looking forward to it

744
00:27:09,990 --> 00:27:08,159
and how about for you farah is this part

745
00:27:11,430 --> 00:27:10,000
of the dream of working at jpl for you

746
00:27:14,070 --> 00:27:11,440
as well

747
00:27:16,630 --> 00:27:14,080
absolutely so for me you know my story

748
00:27:19,669 --> 00:27:16,640
is that my first summer at jpl was the

749
00:27:21,350 --> 00:27:19,679
summer of 2012 and i was in interned

750
00:27:23,430 --> 00:27:21,360
and intern during graduate school and

751
00:27:24,950 --> 00:27:23,440
the summer of 2012 for those of you who

752
00:27:27,029 --> 00:27:24,960
are space fans is the summer that

753
00:27:29,110 --> 00:27:27,039
curiosity landed on mars

754
00:27:31,190 --> 00:27:29,120
and i still remember that moment in the

755
00:27:33,190 --> 00:27:31,200
auditorium it was like late on a sunday

756
00:27:33,990 --> 00:27:33,200
evening and i was super nervous with my

757
00:27:36,230 --> 00:27:34,000
friends watching

758
00:27:37,190 --> 00:27:36,240
watching the landing but what was so

759
00:27:40,549 --> 00:27:37,200
incredible as an

760
00:27:42,549 --> 00:27:40,559
intern is to be on lab and to see

761
00:27:44,950 --> 00:27:42,559
you see these incredible people

762
00:27:47,029 --> 00:27:44,960
achieving the impossible right

763
00:27:49,190 --> 00:27:47,039

who sends a massive rover to mars and

764
00:27:50,070 --> 00:27:49,200
lowers it from a skycrane on the surface

765
00:27:51,830 --> 00:27:50,080
of mars and

766
00:27:53,430 --> 00:27:51,840
who's crazy enough to do that apparently

767
00:27:56,070 --> 00:27:53,440
people at jpl and i thought

768
00:27:57,750 --> 00:27:56,080
i want to be one of those crazy people

769
00:27:58,950 --> 00:27:57,760
and that is really you know when that it

770
00:28:02,389 --> 00:27:58,960
started i

771
00:28:04,310 --> 00:28:02,399
i knocked on every manager's job with my

772
00:28:05,909 --> 00:28:04,320
door with my resume and i was like i

773
00:28:07,990 --> 00:28:05,919
want to work here this is what i want to

774
00:28:10,070 --> 00:28:08,000
do i want to be part of a team like this

775
00:28:12,549 --> 00:28:10,080
i want to do these things

776
00:28:14,310 --> 00:28:12,559
um so uh so i was lucky enough to get a

777
00:28:17,350 --> 00:28:14,320
job back in 2014 and

778
00:28:18,870 --> 00:28:17,360
and this is my second was mission but um

779
00:28:21,029 --> 00:28:18,880
but with this one it's really coming

780
00:28:21,669 --> 00:28:21,039
full circle right perseverance is sort

781
00:28:24,310 --> 00:28:21,679
of the

782
00:28:26,470 --> 00:28:24,320
the big sister or for curiosity and it's

783
00:28:29,669 --> 00:28:26,480
it is that next big mission and it's

784
00:28:31,350 --> 00:28:29,679
so cool to be able to say that i am now

785
00:28:32,950 --> 00:28:31,360
part of the team that's making history

786
00:28:34,710 --> 00:28:32,960
right like i'm part of that team that's

787
00:28:37,510 --> 00:28:34,720
doing crazy things on mars

788
00:28:39,430 --> 00:28:37,520

um and it's it's super humbling too to

789
00:28:40,950 --> 00:28:39,440
have like come full circle that way and

790
00:28:43,750 --> 00:28:40,960
be part of that team and

791
00:28:44,950 --> 00:28:43,760
and what's special with ingenuity is you

792
00:28:47,750 --> 00:28:44,960
know with other missions

793
00:28:49,510 --> 00:28:47,760
at jpl we've had other rovers before so

794
00:28:50,710 --> 00:28:49,520
often when we have problems

795
00:28:52,230 --> 00:28:50,720
you know there's always someone to call

796
00:28:54,149 --> 00:28:52,240
we can call the person that did it on

797
00:28:56,870 --> 00:28:54,159
curiosity and ask like you know we have

798
00:28:58,789 --> 00:28:56,880
a similar problem here can you help me

799
00:29:00,470 --> 00:28:58,799
not the case with ingenuity no one's

800
00:29:02,149 --> 00:29:00,480
done this before there's no textbook

801
00:29:04,070 --> 00:29:02,159
there's no one to call

802
00:29:05,669 --> 00:29:04,080
we just gotta figure it out and that

803
00:29:07,350 --> 00:29:05,679
that is sort of like the best

804
00:29:09,190 --> 00:29:07,360
piece of engineering right there right

805
00:29:10,710 --> 00:29:09,200
like we we have to figure it out we

806
00:29:12,950 --> 00:29:10,720
figure it out as a team we

807
00:29:14,549 --> 00:29:12,960
come up with creative solutions and and

808
00:29:17,029 --> 00:29:14,559
you know we're we're the ones writing

809
00:29:19,190 --> 00:29:17,039
the textbooks right and and eventually

810
00:29:21,350 --> 00:29:19,200
i can't wait one day when you know

811
00:29:22,870 --> 00:29:21,360
hopefully that this all goes well and

812
00:29:24,470 --> 00:29:22,880
and you know when they will be the ones

813
00:29:25,590 --> 00:29:24,480

getting the phone calls will be the ones

814
00:29:27,029 --> 00:29:25,600
that people are going to

815
00:29:30,630 --> 00:29:27,039
reach out to when they want to fly the

816
00:29:33,830 --> 00:29:32,470
really incredible groundbreaking work

817
00:29:36,470 --> 00:29:33,840
that you both are doing

818
00:29:37,909 --> 00:29:36,480
and i am sure that social media is

819
00:29:39,750 --> 00:29:37,919
lighting up with questions

820
00:29:41,430 --> 00:29:39,760
for those of you that are still watching

821
00:29:42,870 --> 00:29:41,440
uh with us please make sure you put

822
00:29:44,549 --> 00:29:42,880
those in the chat

823
00:29:46,310 --> 00:29:44,559
and our social media team will bring

824
00:29:49,269 --> 00:29:46,320
them to us as quickly as possible

825
00:29:52,070 --> 00:29:49,279
we'll answer as many as we can sarah

826
00:29:54,549 --> 00:29:52,080
how's it looking out there

827
00:29:56,230 --> 00:29:54,559
oh there's plenty there's plenty can i

828
00:29:58,549 --> 00:29:56,240
ask one right now

829
00:29:59,590 --> 00:29:58,559
please no i gotta clear my deck here

830
00:30:02,070 --> 00:29:59,600
great um

831
00:30:02,710 --> 00:30:02,080
okay i don't know if his name is brian

832
00:30:05,190 --> 00:30:02,720
or brain

833
00:30:05,830 --> 00:30:05,200
i kind of hope it's brain but it's uh on

834
00:30:08,470 --> 00:30:05,840
linkedin

835
00:30:10,630 --> 00:30:08,480
uh this is a question for you tim how

836
00:30:11,990 --> 00:30:10,640
did you simulate the low gravity and low

837
00:30:15,350 --> 00:30:12,000
atmospheric pressure

838
00:30:17,750 --> 00:30:15,360

during testing on earth

839
00:30:19,669 --> 00:30:17,760
well jpl along with being a place that

840
00:30:21,029 --> 00:30:19,679
has cool spacecraft it also has cool

841
00:30:23,510 --> 00:30:21,039
ways to test things

842
00:30:25,510 --> 00:30:23,520
so there's a chamber at jpl it's 25 feet

843
00:30:26,789 --> 00:30:25,520
across and 70 feet high

844
00:30:29,190 --> 00:30:26,799
and they've used it for years for

845
00:30:31,029 --> 00:30:29,200
spacecraft to pump down

846
00:30:32,870 --> 00:30:31,039
and pump out the air to get it to either

847
00:30:34,870 --> 00:30:32,880
a pure vacuum or in our case we

848
00:30:36,070 --> 00:30:34,880
we pumped it down to one percent of

849
00:30:38,310 --> 00:30:36,080
earth's density

850
00:30:39,669 --> 00:30:38,320
so that's where the helicopter will fly

851
00:30:41,269 --> 00:30:39,679
so that's how we're able to get the

852
00:30:42,950 --> 00:30:41,279
equivalent atmosphere

853
00:30:44,389 --> 00:30:42,960
and we had some very clever engineers

854
00:30:44,870 --> 00:30:44,399
that came up with the design we called

855
00:30:47,750 --> 00:30:44,880
it our

856
00:30:48,389 --> 00:30:47,760
gravity offload mechanism and it was a

857
00:30:50,789 --> 00:30:48,399
it was a

858
00:30:52,389 --> 00:30:50,799
special computerized system that had a

859
00:30:53,750 --> 00:30:52,399
tether or a big cable that would come

860
00:30:54,789 --> 00:30:53,760
down and attach to the top of the

861
00:30:57,509 --> 00:30:54,799
helicopter

862
00:30:59,269 --> 00:30:57,519
and literally pull it up in a way that

863
00:31:01,350 --> 00:30:59,279

would simulate mars gravity

864
00:31:03,509 --> 00:31:01,360
so that way we had this chamber that

865
00:31:03,830 --> 00:31:03,519
could simu both simulate mars gravity

866
00:31:07,269 --> 00:31:03,840
and

867
00:31:09,350 --> 00:31:07,279
that's where we did

868
00:31:14,549 --> 00:31:09,360
almost three years of testing to get the

869
00:31:17,509 --> 00:31:16,310
that's uh quite a bit of dedication i

870
00:31:19,190 --> 00:31:17,519
mean you've already showcased that

871
00:31:20,789 --> 00:31:19,200
tonight how dedicated you've been but

872
00:31:22,470 --> 00:31:20,799
three years of testing that's quite

873
00:31:23,830 --> 00:31:22,480
dedicated sarah we've got time for a few

874
00:31:26,950 --> 00:31:23,840
more questions

875
00:31:27,909 --> 00:31:26,960
great excellent okay um this one is for

876
00:31:30,149 --> 00:31:27,919
you pharah

877
00:31:31,509 --> 00:31:30,159
uh pedro on linkedin so a lot of

878
00:31:32,149 --> 00:31:31,519
questions from linkedin tonight this is

879
00:31:34,789 --> 00:31:32,159
great

880
00:31:36,789 --> 00:31:34,799
um how will perseverance track ingenuity

881
00:31:40,230 --> 00:31:36,799
in the sky is there a beacon

882
00:31:41,590 --> 00:31:40,240
or object recognition that's a great

883
00:31:44,470 --> 00:31:41,600
question pedro so

884
00:31:45,350 --> 00:31:44,480
um so actually what we do is that we can

885
00:31:46,710 --> 00:31:45,360
localize

886
00:31:49,110 --> 00:31:46,720
the helicopter and we're going to keep

887
00:31:51,830 --> 00:31:49,120
track of where it is on the ground

888
00:31:53,590 --> 00:31:51,840

and then based on uh based on what we

889
00:31:55,350 --> 00:31:53,600
think the flights are going to be like

890
00:31:57,269 --> 00:31:55,360
we're going to set off field of view

891
00:31:58,630 --> 00:31:57,279
while enough on our cameras to be able

892
00:32:00,630 --> 00:31:58,640
to catch the flight so

893
00:32:02,470 --> 00:32:00,640
so when we drop off the helicopter we'll

894
00:32:03,190 --> 00:32:02,480
know exactly where it is and we'll have

895
00:32:05,750 --> 00:32:03,200
you know we keep

896
00:32:07,509 --> 00:32:05,760
really good maps of mars when we drive

897
00:32:08,470 --> 00:32:07,519
so we'll have a map of where we are and

898
00:32:11,190 --> 00:32:08,480
where it is

899
00:32:12,950 --> 00:32:11,200
and then as we drive away from it uh

900
00:32:15,430 --> 00:32:12,960
we'll be augmenting those maps and

901
00:32:17,509 --> 00:32:15,440
relocalizing using images every time so

902
00:32:18,710 --> 00:32:17,519
think of it as like i've set a pin on a

903
00:32:20,870 --> 00:32:18,720
map and i try and

904
00:32:22,149 --> 00:32:20,880
point back to it and based on my images

905
00:32:24,549 --> 00:32:22,159
i can sort of

906
00:32:26,230 --> 00:32:24,559
adjust a little bit what the error might

907
00:32:28,470 --> 00:32:26,240
be you know in my

908
00:32:30,230 --> 00:32:28,480
my position or what i think my position

909
00:32:33,029 --> 00:32:30,240
might be with the helicopter so

910
00:32:34,549 --> 00:32:33,039
so even at 100 meters away we'll know

911
00:32:36,470 --> 00:32:34,559
where the helicopter is and we'll be

912
00:32:37,909 --> 00:32:36,480
able to image it before its flight so we

913
00:32:39,269 --> 00:32:37,919

know exactly where it is

914
00:32:41,430 --> 00:32:39,279
and then the morning of that first

915
00:32:43,350 --> 00:32:41,440
flight for example we'll point all our

916
00:32:45,110 --> 00:32:43,360
cameras at it we have multiple cameras

917
00:32:46,549 --> 00:32:45,120
and we'll wait eagerly and we

918
00:32:48,549 --> 00:32:46,559
we're even going to take a video

919
00:32:49,350 --> 00:32:48,559
hopefully of the flight and then we

920
00:32:51,990 --> 00:32:49,360
should see that

921
00:32:53,509 --> 00:32:52,000
that helicopter um in our field of view

922
00:32:55,269 --> 00:32:53,519
and then when we're done and it lands

923
00:32:55,990 --> 00:32:55,279
we'll be able to relocalize again and

924
00:33:02,389 --> 00:32:56,000
figure out

925
00:33:09,029 --> 00:33:06,630
okay for tim here oh sorry about that i

926
00:33:10,870 --> 00:33:09,039
didn't mean to jump out there but i'm

927
00:33:14,470 --> 00:33:10,880
going in i'm going in

928
00:33:16,630 --> 00:33:14,480
great kirk on facebook um

929
00:33:18,470 --> 00:33:16,640
i thought this is for you tim uh does

930
00:33:21,509 --> 00:33:18,480
the helicopter have any smarts

931
00:33:23,830 --> 00:33:21,519
to adjust if its flight model is not

932
00:33:24,710 --> 00:33:23,840
exactly what it's discovering on mars

933
00:33:27,110 --> 00:33:24,720
basically is the

934
00:33:30,549 --> 00:33:27,120
can the helicopter make adjustments or

935
00:33:33,110 --> 00:33:30,559
learn learn along the way

936
00:33:34,950 --> 00:33:33,120
well certainly the software is we did a

937
00:33:37,509 --> 00:33:34,960
lot of testing on the flight algorithms

938
00:33:38,630 --> 00:33:37,519

we have a very talented guidance control

939
00:33:40,310 --> 00:33:38,640
team

940
00:33:42,149 --> 00:33:40,320
and they built the software to follow a

941
00:33:44,310 --> 00:33:42,159
set of waypoints so before the flight we

942
00:33:46,149 --> 00:33:44,320
get together as a team and we plan

943
00:33:47,830 --> 00:33:46,159
where we want the flight to go and then

944
00:33:49,029 --> 00:33:47,840
the software on board will take those

945
00:33:51,029 --> 00:33:49,039
waypoints

946
00:33:53,430 --> 00:33:51,039
and fly that trajectory and the software

947
00:33:54,870 --> 00:33:53,440
has the built-in smarts to adjust to

948
00:33:57,269 --> 00:33:54,880
environmental conditions it might

949
00:33:59,509 --> 00:33:57,279
encounter like gusts of wind

950
00:34:00,389 --> 00:33:59,519
or you know just deviations in the

951
00:34:02,310 --> 00:34:00,399
flight path it's

952
00:34:03,590 --> 00:34:02,320
it's very well designed to bring it back

953
00:34:05,350 --> 00:34:03,600
into alignment

954
00:34:07,669 --> 00:34:05,360
with the path that we had planned for it

955
00:34:09,190 --> 00:34:07,679
so that was part of the new

956
00:34:11,190 --> 00:34:09,200
development that we did for this project

957
00:34:14,069 --> 00:34:11,200
is they designed all new brand new

958
00:34:15,669 --> 00:34:14,079
algorithms that can handle the martian

959
00:34:17,829 --> 00:34:15,679
environment plus this mission that we

960
00:34:21,030 --> 00:34:17,839
gave it to fly along these trajectories

961
00:34:22,950 --> 00:34:21,040
and do what it needs to do because it's

962
00:34:24,629 --> 00:34:22,960
not only flying based on an inertial

963
00:34:25,909 --> 00:34:24,639

sensor it has a camera system that

964
00:34:28,470 --> 00:34:25,919
points downward

965
00:34:29,510 --> 00:34:28,480
we're taking pictures 30 times a second

966
00:34:31,510 --> 00:34:29,520
looking at features

967
00:34:33,669 --> 00:34:31,520
inside the camera the image of the

968
00:34:35,510 --> 00:34:33,679
camera and then track those features

969
00:34:37,829 --> 00:34:35,520
from frame to frame

970
00:34:39,669 --> 00:34:37,839
and that's how the helicopter is able to

971
00:34:41,190 --> 00:34:39,679
know which direction it's going and how

972
00:34:43,589 --> 00:34:41,200
fast along with the

973
00:34:45,190 --> 00:34:43,599
inertial sensor and even an altimeter so

974
00:34:52,869 --> 00:34:45,200
it's a pretty sophisticated little robot

975
00:34:56,629 --> 00:34:54,710
we have time for some more questions

976
00:35:00,630 --> 00:34:56,639
sarah so feel free to ask a couple

977
00:35:02,150 --> 00:35:00,640
of ways okay this is also for them

978
00:35:04,230 --> 00:35:02,160
because this is a little bit about

979
00:35:05,829 --> 00:35:04,240
the helicopter team and so i know that

980
00:35:06,790 --> 00:35:05,839
you've been on the helicopter team for a

981
00:35:09,270 --> 00:35:06,800
long time

982
00:35:10,150 --> 00:35:09,280
um so rhonda on facebook is wondering

983
00:35:13,349 --> 00:35:10,160
first of all how

984
00:35:15,030 --> 00:35:13,359
big the helicopter team is and then um

985
00:35:16,470 --> 00:35:15,040
sort of a related question from

986
00:35:19,109 --> 00:35:16,480
white-tailed jedi

987
00:35:20,390 --> 00:35:19,119
on youtube is who gets to pilot the

988
00:35:23,430 --> 00:35:20,400

helicopter every day

989
00:35:25,349 --> 00:35:23,440
how do you choose oh that's a great

990
00:35:27,109 --> 00:35:25,359
question so we had a team i would say at

991
00:35:29,190 --> 00:35:27,119
our peak we were probably 30 or 40

992
00:35:30,790 --> 00:35:29,200
different people all bringing different

993
00:35:33,349 --> 00:35:30,800
kinds of talents to the table

994
00:35:34,870 --> 00:35:33,359
i'm here because i'm representing

995
00:35:37,190 --> 00:35:34,880
operations but there's many other

996
00:35:39,589 --> 00:35:37,200
talented people on the project who did

997
00:35:41,109 --> 00:35:39,599
mechanical design the thermal design the

998
00:35:43,670 --> 00:35:41,119
power design

999
00:35:45,430 --> 00:35:43,680
and when you mention the pilot our chief

1000
00:35:48,150 --> 00:35:45,440
pilot hovard grip

1001
00:35:50,150 --> 00:35:48,160
is a very talented uh guidance engineer

1002
00:35:52,790 --> 00:35:50,160
he even flies planes for

1003
00:35:54,470 --> 00:35:52,800
fun so he's a naturally gifted guy for

1004
00:35:55,670 --> 00:35:54,480
doing this and he's the one

1005
00:35:57,670 --> 00:35:55,680
with his team that are going to be

1006
00:36:00,950 --> 00:35:57,680
planning each one of the flights

1007
00:36:02,710 --> 00:36:00,960
and so that's how it works is is

1008
00:36:04,310 --> 00:36:02,720
the guidance team gives me the path they

1009
00:36:07,190 --> 00:36:04,320
want to follow we

1010
00:36:09,270 --> 00:36:07,200
enter it into a series of commands that

1011
00:36:10,550 --> 00:36:09,280
that file of commands we give to far and

1012
00:36:11,430 --> 00:36:10,560
her team and they beam it up to the

1013
00:36:15,349 --> 00:36:11,440

rover

1014
00:36:16,150 --> 00:36:15,359
the helicopter and executes it and then

1015
00:36:26,230 --> 00:36:16,160
we

1016
00:36:27,990 --> 00:36:26,240
chew our fingernails to the bone

1017
00:36:29,910 --> 00:36:28,000
okay here's another question why don't

1018
00:36:33,510 --> 00:36:29,920
you try and take this pharah

1019
00:36:35,430 --> 00:36:33,520
um gabriel on linkedin is asking

1020
00:36:37,510 --> 00:36:35,440
so how does communication between the

1021
00:36:40,069 --> 00:36:37,520
mars instruments get affected

1022
00:36:41,349 --> 00:36:40,079
by the lack of the magnetic field that

1023
00:36:44,630 --> 00:36:41,359
is on mars

1024
00:36:46,710 --> 00:36:44,640
and um does the solar radiation

1025
00:36:49,589 --> 00:36:46,720
um affect the communication between the

1026
00:36:52,550 --> 00:36:49,599
helicopter and the rover

1027
00:36:54,470 --> 00:36:52,560
so we obviously you know the environment

1028
00:36:56,150 --> 00:36:54,480
on mars is is different from the one on

1029
00:36:57,990 --> 00:36:56,160
earth but one of the things that we did

1030
00:37:00,150 --> 00:36:58,000
on earth before we went to mars is that

1031
00:37:01,109 --> 00:37:00,160
we actually tested that communication we

1032
00:37:03,910 --> 00:37:01,119
do something called

1033
00:37:06,230 --> 00:37:03,920
electromagnetic interference testing and

1034
00:37:08,550 --> 00:37:06,240
so we put the rover in a special chamber

1035
00:37:09,430 --> 00:37:08,560
that's quiet like mars or as quiet as we

1036
00:37:11,190 --> 00:37:09,440
can get it

1037
00:37:12,550 --> 00:37:11,200
and um and one of the things that we had

1038
00:37:14,470 --> 00:37:12,560

to do actually is

1039
00:37:17,349 --> 00:37:14,480
we had to figure out if there were any

1040
00:37:18,870 --> 00:37:17,359
instruments on the rover like when we're

1041
00:37:20,710 --> 00:37:18,880
changing or switching things on the

1042
00:37:22,470 --> 00:37:20,720
rover whether any of that

1043
00:37:23,750 --> 00:37:22,480
magnetic noise that's created when you

1044
00:37:25,750 --> 00:37:23,760
use those instruments

1045
00:37:27,670 --> 00:37:25,760
might affect the link between the

1046
00:37:29,510 --> 00:37:27,680
helicopter and the rover

1047
00:37:31,430 --> 00:37:29,520
and so you know we're talking from the

1048
00:37:33,510 --> 00:37:31,440
helicopter to the rover using a radio

1049
00:37:34,950 --> 00:37:33,520
that has a certain signal and we want to

1050
00:37:36,310 --> 00:37:34,960
make sure that there's not noise in that

1051
00:37:38,150 --> 00:37:36,320
signal created by

1052
00:37:39,910 --> 00:37:38,160
other instruments on board and we

1053
00:37:40,950 --> 00:37:39,920
actually found that there's a few

1054
00:37:42,470 --> 00:37:40,960
instruments that

1055
00:37:44,790 --> 00:37:42,480
uh for example if we're moving our

1056
00:37:46,630 --> 00:37:44,800
motors that that creates just enough

1057
00:37:48,710 --> 00:37:46,640
noise that we can lose communication

1058
00:37:51,190 --> 00:37:48,720
with the rover we can lose packets

1059
00:37:53,030 --> 00:37:51,200
um so that's why we do that kind of

1060
00:37:54,630 --> 00:37:53,040
testing before we go so that we kind of

1061
00:37:57,349 --> 00:37:54,640
understand the behavior

1062
00:37:59,430 --> 00:37:57,359
and then when we get to mars um we're

1063
00:38:00,790 --> 00:37:59,440

gonna sort of restrict certain the usage

1064
00:38:02,630 --> 00:38:00,800
of certain things like we won't be

1065
00:38:04,230 --> 00:38:02,640
moving our arm all over while we're

1066
00:38:04,790 --> 00:38:04,240
talking to the helicopter so that we

1067
00:38:07,510 --> 00:38:04,800
know that

1068
00:38:08,950 --> 00:38:07,520
we can get a clean signal that way so um

1069
00:38:09,910 --> 00:38:08,960
so yeah it's definitely a test that

1070
00:38:12,069 --> 00:38:09,920
every single

1071
00:38:14,710 --> 00:38:12,079
um spacecraft goes through it's one of

1072
00:38:16,630 --> 00:38:14,720
the key tests that we do before launch

1073
00:38:18,790 --> 00:38:16,640
to figure out what's compatible with

1074
00:38:21,109 --> 00:38:18,800
what and make sure that we can

1075
00:38:27,030 --> 00:38:21,119
we can successfully communicate with our

1076
00:38:34,550 --> 00:38:31,990
okay do we have time for another one yep

1077
00:38:36,069 --> 00:38:34,560
you got it ron on linkedin is asking

1078
00:38:38,870 --> 00:38:36,079
will the helicopter

1079
00:38:39,829 --> 00:38:38,880
attempt to land atop higher elevation

1080
00:38:42,390 --> 00:38:39,839
features

1081
00:38:45,670 --> 00:38:42,400
or typically always return nearby the

1082
00:38:49,109 --> 00:38:45,680
rover i guess that's for you pharah

1083
00:38:50,950 --> 00:38:49,119
so um right now the plan is to is to

1084
00:38:52,630 --> 00:38:50,960
land at the same place so what we've

1085
00:38:54,390 --> 00:38:52,640
done or what we're doing on mars right

1086
00:38:57,430 --> 00:38:54,400
now is we're trying to identify

1087
00:38:59,910 --> 00:38:57,440
a flight zone so it's an area that's

1088
00:39:00,870 --> 00:38:59,920

about 30 meters across and about 100

1089
00:39:02,710 --> 00:39:00,880
meter long

1090
00:39:04,069 --> 00:39:02,720
and that is going to be our stage to

1091
00:39:05,829 --> 00:39:04,079
play on that's that's where the

1092
00:39:07,829 --> 00:39:05,839
helicopter is allowed to fly

1093
00:39:09,109 --> 00:39:07,839
and within that there's a little there's

1094
00:39:10,470 --> 00:39:09,119
an area that we might

1095
00:39:12,710 --> 00:39:10,480
you know that we're going to identify or

1096
00:39:14,390 --> 00:39:12,720
try and find that we'll have you know

1097
00:39:15,750 --> 00:39:14,400
we're looking for a flat area with

1098
00:39:18,150 --> 00:39:15,760
hardly any rocks

1099
00:39:19,589 --> 00:39:18,160
uh where the helicopter can land that's

1100
00:39:21,349 --> 00:39:19,599
kind of it's like landing pad right like

1101
00:39:21,990 --> 00:39:21,359
so if you have a helicopter on earth and

1102
00:39:24,069 --> 00:39:22,000
you

1103
00:39:25,670 --> 00:39:24,079
it can only really land in that flat

1104
00:39:27,990 --> 00:39:25,680
area with a big h on it

1105
00:39:29,910 --> 00:39:28,000
that's that's going to be our helicopter

1106
00:39:31,349 --> 00:39:29,920
on mars no big h but you know we'll have

1107
00:39:33,510 --> 00:39:31,359
our area where we're gonna

1108
00:39:35,030 --> 00:39:33,520
um be able to drop our helicopter and

1109
00:39:37,910 --> 00:39:35,040
fly to and from there so

1110
00:39:39,750 --> 00:39:37,920
so the goal is to is to always return to

1111
00:39:41,910 --> 00:39:39,760
that home base and then from there do

1112
00:39:43,349 --> 00:39:41,920
increasingly more complicated flights so

1113
00:39:45,430 --> 00:39:43,359

at the beginning we'll just go up and

1114
00:39:47,589 --> 00:39:45,440
down and then we'll go across

1115
00:39:49,430 --> 00:39:47,599
and then we'll see maybe uh maybe the

1116
00:39:49,670 --> 00:39:49,440
team the helicopter team will get sporty

1117
00:39:53,430 --> 00:39:49,680
and

1118
00:39:55,670 --> 00:39:53,440
current plan

1119
00:39:59,190 --> 00:39:55,680
but for now we're planning on landing at

1120
00:40:02,310 --> 00:40:00,630
break for you the current plan that's

1121
00:40:03,430 --> 00:40:02,320
that's brave i like that i like that

1122
00:40:05,510 --> 00:40:03,440
exciting supporting

1123
00:40:06,550 --> 00:40:05,520
there we've got time for just a couple

1124
00:40:11,030 --> 00:40:06,560
more questions

1125
00:40:13,589 --> 00:40:11,040
probably about two more okay

1126
00:40:14,390 --> 00:40:13,599
all right angelica from linkedin she's

1127
00:40:16,630 --> 00:40:14,400
getting it

1128
00:40:18,630 --> 00:40:16,640
um this for you tim so what is the

1129
00:40:22,390 --> 00:40:18,640
actual flight goal of the vehicle

1130
00:40:24,390 --> 00:40:22,400
um is it flight time is it distance

1131
00:40:25,910 --> 00:40:24,400
and is there a particular forward

1132
00:40:29,589 --> 00:40:25,920
velocity that um

1133
00:40:34,710 --> 00:40:32,950
well since this is a kind of a new a new

1134
00:40:36,309 --> 00:40:34,720
mission we've never done this before the

1135
00:40:37,910 --> 00:40:36,319
primary objective of this

1136
00:40:39,510 --> 00:40:37,920
mission is to characterize what it's

1137
00:40:40,950 --> 00:40:39,520
like to fly on mars

1138
00:40:43,349 --> 00:40:40,960

so we're going to be doing as far as

1139
00:40:45,430 --> 00:40:43,359
said a series of these increasingly

1140
00:40:47,349 --> 00:40:45,440
aggressive flights and we take lots of

1141
00:40:49,750 --> 00:40:47,359
data during those flights

1142
00:40:51,589 --> 00:40:49,760
and we analyze that data on the ground

1143
00:40:53,430 --> 00:40:51,599
to see how it performed

1144
00:40:55,270 --> 00:40:53,440
and then that's the kind of data that

1145
00:40:56,870 --> 00:40:55,280
will feed forward into future possible

1146
00:40:59,589 --> 00:40:56,880
helicopters that can do more

1147
00:41:02,150 --> 00:40:59,599
and have greater capability and so

1148
00:41:04,870 --> 00:41:02,160
that's really the objective is to

1149
00:41:07,030 --> 00:41:04,880
is to test how well it flies and so

1150
00:41:08,630 --> 00:41:07,040
we'll be doing these increasingly harder

1151
00:41:10,150 --> 00:41:08,640
flights to stress the system a little

1152
00:41:12,550 --> 00:41:10,160
more each time

1153
00:41:14,069 --> 00:41:12,560
and see you know how the data comes back

1154
00:41:15,430 --> 00:41:14,079
when we do those flights

1155
00:41:17,270 --> 00:41:15,440
and how it responds to those various

1156
00:41:19,750 --> 00:41:17,280
things in the environment like wind

1157
00:41:21,589 --> 00:41:19,760
and altitude and we're going to fly it

1158
00:41:23,030 --> 00:41:21,599
about five meters high

1159
00:41:24,950 --> 00:41:23,040
we're a little bit limited by our

1160
00:41:26,150 --> 00:41:24,960
altimeter the how far down it can see

1161
00:41:27,750 --> 00:41:26,160
and the camera system

1162
00:41:29,349 --> 00:41:27,760
so it'll be about five meters high and

1163
00:41:30,790 --> 00:41:29,359

we'll be flying two to three meters per

1164
00:41:32,069 --> 00:41:30,800
second horizontally when we do our

1165
00:41:33,510 --> 00:41:32,079
horizontal flights

1166
00:41:35,670 --> 00:41:33,520
so it's not going to exactly buzz the

1167
00:41:37,510 --> 00:41:35,680
tower so to speak but it's going to be

1168
00:41:39,109 --> 00:41:37,520
you know it's going to be faster than a

1169
00:41:41,670 --> 00:41:39,119
rover that's one of the promises of a

1170
00:41:43,670 --> 00:41:41,680
vehicle like this is that the rover

1171
00:41:45,430 --> 00:41:43,680
potentially could see a feature in the

1172
00:41:46,069 --> 00:41:45,440
distance that it thinks is very cool but

1173
00:41:47,990 --> 00:41:46,079
it could take

1174
00:41:49,510 --> 00:41:48,000
days or even a week to get there and

1175
00:41:51,030 --> 00:41:49,520
something like a helicopter could fly

1176
00:41:53,349 --> 00:41:51,040
over there in just a few

1177
00:41:55,349 --> 00:41:53,359
tens of seconds and analyze and inspect

1178
00:41:56,550 --> 00:41:55,359
it so that's part of what this mission

1179
00:41:58,710 --> 00:41:56,560
is about is to

1180
00:42:00,630 --> 00:41:58,720
do this groundbreaking work to see how

1181
00:42:03,750 --> 00:42:00,640
well it performs on mars so that

1182
00:42:07,589 --> 00:42:03,760
future generations of helicopters can do

1183
00:42:11,510 --> 00:42:09,670
i like that even more cool things in the

1184
00:42:12,309 --> 00:42:11,520
future and speaking of things in the

1185
00:42:15,030 --> 00:42:12,319
future we have

1186
00:42:17,430 --> 00:42:15,040
one final question sarah for our

1187
00:42:19,670 --> 00:42:17,440
speakers tonight

1188
00:42:21,109 --> 00:42:19,680

okay let's take it from facebook from

1189
00:42:23,750 --> 00:42:21,119
matt on facebook

1190
00:42:24,790 --> 00:42:23,760
asks will imagery from the helicopter be

1191
00:42:28,150 --> 00:42:24,800
used to help

1192
00:42:32,230 --> 00:42:28,160
percy navigate the martian terrain as it

1193
00:42:36,150 --> 00:42:34,950
and i can take that one so so thank you

1194
00:42:37,910 --> 00:42:36,160
i should have said that's probably a

1195
00:42:41,190 --> 00:42:37,920
good one for you

1196
00:42:42,390 --> 00:42:41,200
got the personality connection um in the

1197
00:42:45,349 --> 00:42:42,400
nominal plan

1198
00:42:45,829 --> 00:42:45,359
no um so what we're learning again at

1199
00:42:51,510 --> 00:42:45,839
tim

1200
00:42:52,870 --> 00:42:51,520
paving the way for future helicopters

1201
00:42:53,750 --> 00:42:52,880
for future missions we want to

1202
00:42:55,750 --> 00:42:53,760
demonstrate

1203
00:42:57,430 --> 00:42:55,760
that you know that helicopters can fly

1204
00:42:59,510 --> 00:42:57,440
on mars and and by the way

1205
00:43:01,190 --> 00:42:59,520
rovers started as technology

1206
00:43:03,030 --> 00:43:01,200
demonstrations too we had

1207
00:43:05,190 --> 00:43:03,040
that's where we started you know a small

1208
00:43:05,589 --> 00:43:05,200
team came up with a small rover on mars

1209
00:43:10,230 --> 00:43:05,599
and

1210
00:43:12,069 --> 00:43:10,240
right so

1211
00:43:13,430 --> 00:43:12,079
so we're really hoping that one day

1212
00:43:16,230 --> 00:43:13,440
ingenuity will be

1213
00:43:17,670 --> 00:43:16,240

that stepping stone also for for bigger

1214
00:43:20,309 --> 00:43:17,680
um helicopters but

1215
00:43:21,270 --> 00:43:20,319
but in this in this case you know the

1216
00:43:23,990 --> 00:43:21,280
the area

1217
00:43:25,589 --> 00:43:24,000
that um that ingenuity is flying over is

1218
00:43:27,589 --> 00:43:25,599
one that we've already imaged we

1219
00:43:29,190 --> 00:43:27,599
actually wanted to assess that area to

1220
00:43:31,829 --> 00:43:29,200
make sure that it was safe

1221
00:43:33,750 --> 00:43:31,839
um so that you know if if ingenuity

1222
00:43:35,430 --> 00:43:33,760
needs to do an emergency landing for

1223
00:43:37,030 --> 00:43:35,440
example we know that it's a safe area

1224
00:43:38,309 --> 00:43:37,040
that it doesn't have big boulders and

1225
00:43:40,550 --> 00:43:38,319
things like that so

1226
00:43:42,069 --> 00:43:40,560
so again at least you know per the

1227
00:43:44,309 --> 00:43:42,079
current playbook and who knows

1228
00:43:46,069 --> 00:43:44,319
what you know what the um what the team

1229
00:43:47,510 --> 00:43:46,079
is going to decide to do once

1230
00:43:49,349 --> 00:43:47,520
you know if we are successful with those

1231
00:43:51,109 --> 00:43:49,359
first few flights but for the first two

1232
00:43:53,349 --> 00:43:51,119
flights at least it's it's going to be

1233
00:43:55,030 --> 00:43:53,359
an area that we've already imaged

1234
00:43:57,030 --> 00:43:55,040
but it definitely is going to be really

1235
00:43:58,630 --> 00:43:57,040
interesting right to look at

1236
00:44:00,069 --> 00:43:58,640
the path that it takes and the images

1237
00:44:01,670 --> 00:44:00,079
that it takes and compare that to what

1238
00:44:02,950 --> 00:44:01,680

we know about the surface and

1239
00:44:05,510 --> 00:44:02,960
again that's going to help us learn

1240
00:44:07,430 --> 00:44:05,520
about what it what it's like to fly on

1241
00:44:09,510 --> 00:44:07,440
mars and and what it takes so

1242
00:44:10,710 --> 00:44:09,520
um so it's definitely you know going to

1243
00:44:13,750 --> 00:44:10,720
be something that we're looking forward

1244
00:44:18,390 --> 00:44:16,309
great ability to develop new technology

1245
00:44:19,589 --> 00:44:18,400
uh thanks for those wonderful questions

1246
00:44:21,030 --> 00:44:19,599
to all of you out there and thank you

1247
00:44:23,190 --> 00:44:21,040
sarah for presenting those to our

1248
00:44:25,589 --> 00:44:23,200
speakers but unfortunately that is

1249
00:44:27,109 --> 00:44:25,599
all the time we have today for questions

1250
00:44:29,589 --> 00:44:27,119
please join us next month

1251
00:44:30,470 --> 00:44:29,599
for our lecture and earth day special

1252
00:44:33,349 --> 00:44:30,480
science on

1253
00:44:34,630 --> 00:44:33,359
ice what ice says about past present and

1254
00:44:37,349 --> 00:44:34,640
future climate

1255
00:44:38,150 --> 00:44:37,359
i want to thank our speakers tim canham

1256
00:44:39,910 --> 00:44:38,160
and dr

1257
00:44:41,510 --> 00:44:39,920
farah olivei thank you so much for

1258
00:44:42,950 --> 00:44:41,520
joining us and discussing this very

1259
00:44:45,190 --> 00:44:42,960
exciting topic

1260
00:44:47,270 --> 00:44:45,200
also big thank you to our wonderful

1261
00:44:48,950 --> 00:44:47,280
questions co-host sarah marcotte

1262
00:44:50,790 --> 00:44:48,960
and everyone working behind the scenes

1263
00:44:52,470 --> 00:44:50,800

to make this possible tonight

1264
00:44:54,309 --> 00:44:52,480
and to all of you watching thank you for

1265
00:44:55,510 --> 00:44:54,319
taking the time to join us every month

1266
00:44:56,470 --> 00:44:55,520
and thank you for your wonderful

1267
00:44:57,990 --> 00:44:56,480
questions

1268
00:44:59,990 --> 00:44:58,000
if you've missed one or would like to

1269
00:45:01,270 --> 00:45:00,000
revisit any of our von carmen talks from

1270
00:45:04,390 --> 00:45:01,280
the past five years

1271
00:45:06,550 --> 00:45:04,400
they are available on jpl's youtube page

1272
00:45:08,470 --> 00:45:06,560
thank you again everyone be well have a

1273
00:45:22,790 --> 00:45:08,480
wonderful evening and we will see you