
DATA CONTROLLER
DEEP SPACE NETWORK

1
00:00:02,899 --> 00:00:01,370
one way or another you're gonna be on

2
00:00:07,099 --> 00:00:02,909
the ground in seven minutes we want it

3
00:00:08,600 --> 00:00:07,109
to be there safely I'm al Chen and I

4
00:00:10,310 --> 00:00:08,610
lead the landing team for Mars 2020

5
00:00:11,780 --> 00:00:10,320
actually said landing is all about

6
00:00:13,190 --> 00:00:11,790
getting the good club from the top of

7
00:00:15,049 --> 00:00:13,200
the atmosphere down to the bottom of

8
00:00:17,359 --> 00:00:15,059
safely hit the atmosphere going you know

9
00:00:18,740 --> 00:00:17,369
12 13,000 miles per hour we have to

10
00:00:20,060 --> 00:00:18,750
deploy supersonic parachute I mean

11
00:00:21,560 --> 00:00:20,070
that's all before we get down into power

12
00:00:23,390 --> 00:00:21,570
play see we have a new system that'll

13
00:00:24,830 --> 00:00:23,400

take over at this point it'll start

14
00:00:26,929 --> 00:00:24,840
taking images in the ground that'll let

15
00:00:28,759 --> 00:00:26,939
us figure out where we are in latitude

16
00:00:30,169 --> 00:00:28,769
and longitude jezero crater the site

17
00:00:32,269 --> 00:00:30,179
we're going to with Mars my 20 was

18
00:00:34,069 --> 00:00:32,279
actually rejected for curiosity because

19
00:00:35,810 --> 00:00:34,079
the site was considered too unsafe and

20
00:00:37,400 --> 00:00:35,820
really the train was way too rough but

21
00:00:39,110 --> 00:00:37,410
now we have the ability to land at these

22
00:00:40,729 --> 00:00:39,120
places that we never really could go to

23
00:00:42,290 --> 00:00:40,739
before the genzaburo crater site if you

24
00:00:44,090 --> 00:00:42,300
look at the space is pretty obviously a

25
00:00:46,040 --> 00:00:44,100
delta we think that Mars was habitable

26
00:00:48,229 --> 00:00:46,050
four billion years ago so the question

27
00:00:50,330 --> 00:00:48,239
is not just where was that life but also

28
00:00:52,310 --> 00:00:50,340
where could it be preserved for one more

29
00:00:54,200 --> 00:00:52,320
billion years for us to find it later I

30
00:00:56,029 --> 00:00:54,210
worked on curiosity for 10 years so this

31
00:00:57,410 --> 00:00:56,039
is a very familiar feeling I think I was

32
00:01:00,049 --> 00:00:57,420
too young the first time to really

33
00:01:03,139 --> 00:01:00,059
realize what was at stake big G's on the

34
00:01:04,640 --> 00:01:03,149
order of 11 12 14 we are in hard flight

35
00:01:06,350 --> 00:01:04,650
I've been on the other side of this - my

36
00:01:07,670 --> 00:01:06,360
wife was front and center on inside this

37
00:01:09,109 --> 00:01:07,680
is actually the same seat that my wife

38
00:01:11,260 --> 00:01:09,119

was sitting in for the inside landing

39
00:01:14,859 --> 00:01:11,270
the same seat that I was in actually

40
00:01:16,899 --> 00:01:14,869
back in 2012 for the Curiosity as well

41
00:01:20,440 --> 00:01:16,909
a lot of history for us in this room I

42
00:01:22,630 --> 00:01:20,450
shouted for mercy we would be uniquely

43
00:01:23,709 --> 00:01:22,640
positioned as two folks who were married

44
00:01:32,929 --> 00:01:23,719
to each other to know what it's like to

45
00:01:37,999 --> 00:01:34,789
with NASA's Jet Propulsion Laboratory

46
00:01:40,219 --> 00:01:38,009
JPL is where the Mars 2020 mission and

47
00:01:42,289 --> 00:01:40,229
perseverance rover are managed here in

48
00:01:45,109 --> 00:01:42,299
Southern California now getting to Mars

49
00:01:46,849 --> 00:01:45,119
is a test of perseverance in itself as

50
00:01:49,279 --> 00:01:46,859
we have been highlighting over the past

51
00:01:51,230 --> 00:01:49,289
couple of weeks it takes thousands of

52
00:01:53,569 --> 00:01:51,240
people working together to make this

53
00:01:55,969 --> 00:01:53,579
mission a success today we are with one

54
00:01:58,459 --> 00:01:55,979
of the many faces behind the spacecraft

55
00:02:01,429 --> 00:01:58,469
as the lead for the Mars 2020 missions

56
00:02:03,190 --> 00:02:01,439
entry descent and landing al chen has

57
00:02:05,899 --> 00:02:03,200
the important job of making sure

58
00:02:08,300 --> 00:02:05,909
perseverance touches down safely on Mars

59
00:02:09,050 --> 00:02:08,310
next year he joins us live to answer

60
00:02:11,029 --> 00:02:09,060
some questions

61
00:02:13,970 --> 00:02:11,039
now if you have any questions you can

62
00:02:16,009 --> 00:02:13,980
use the hashtag ask NASA or leave them

63
00:02:18,110 --> 00:02:16,019

right here in the YouTube chat now if

64
00:02:20,059 --> 00:02:18,120
you're not seeing the chat box just make

65
00:02:22,190 --> 00:02:20,069
sure that you refresh your page because

66
00:02:24,080 --> 00:02:22,200
we definitely want to hear from you in

67
00:02:26,150 --> 00:02:24,090
light of the times I'm talking to all in

68
00:02:29,270 --> 00:02:26,160
our homes as we are social distancing

69
00:02:33,349 --> 00:02:29,280
welcome out thank you very much for

70
00:02:36,650 --> 00:02:33,359
having me so out what does your title

71
00:02:38,809 --> 00:02:36,660
EDL or entry descent and landing phase

72
00:02:40,699 --> 00:02:38,819
lead mean and what are you doing to help

73
00:02:44,059 --> 00:02:40,709
the spacecraft land on the red planet

74
00:02:45,199 --> 00:02:44,069
safely the intranet sentient landing

75
00:02:47,030 --> 00:02:45,209
team is responsible for getting

76
00:02:48,589 --> 00:02:47,040
perseverance safely from the top of the

77
00:02:50,990 --> 00:02:48,599
atmosphere to wheels down in jezero

78
00:02:52,490 --> 00:02:51,000
crater that means dealing with a lot of

79
00:02:55,039 --> 00:02:52,500
the challenges that Mars can throw at

80
00:02:57,319 --> 00:02:55,049
you we get the atmosphere going 5.4

81
00:02:59,270 --> 00:02:57,329
kilometers per second 12 or 13,000 miles

82
00:03:00,620 --> 00:02:59,280
an hour and we have to deal with the

83
00:03:02,150 --> 00:03:00,630
heating right the spacecraft scripts got

84
00:03:03,680 --> 00:03:02,160
to survive the atmospheric heating the

85
00:03:05,569 --> 00:03:03,690
earth and I am exceeding that occurs

86
00:03:08,000 --> 00:03:05,579
with that when we get the heat shield

87
00:03:09,800 --> 00:03:08,010
going like the Sun while still doing

88
00:03:11,900 --> 00:03:09,810

that while traveling hypersonically the

89
00:03:13,129 --> 00:03:11,910
spacecraft's got to target the landing

90
00:03:15,199 --> 00:03:13,139
site we got to actually steer the

91
00:03:17,059 --> 00:03:15,209
vehicle propulsively to fly where we

92
00:03:20,990 --> 00:03:17,069
want to go and that just gets us down to

93
00:03:22,400 --> 00:03:21,000
were slow to you know about Mach 2 a

94
00:03:24,500 --> 00:03:22,410
little under 2 times the speed of sound

95
00:03:26,509 --> 00:03:24,510
where we deploy a massive supersonic

96
00:03:27,080 --> 00:03:26,519
parachute at that point we got to figure

97
00:03:28,640 --> 00:03:27,090
out where we are

98
00:03:30,050 --> 00:03:28,650
that means popping off the heat shield

99
00:03:32,150 --> 00:03:30,060
take a look at the ground with the radar

100
00:03:34,069 --> 00:03:32,160
and our new terrain relative navigation

101
00:03:36,140 --> 00:03:34,079
system and then trying to figure out

102
00:03:38,089 --> 00:03:36,150
when the best time is to to start

103
00:03:39,999 --> 00:03:38,099
powered flight that's usually when we

104
00:03:42,499 --> 00:03:40,009
get down to about 2 kilometers altitude

105
00:03:44,539 --> 00:03:42,509
so there will right low light up our

106
00:03:45,890 --> 00:03:44,549
rocket engines and fly down to about 20

107
00:03:48,319 --> 00:03:45,900
meters above the ground

108
00:03:49,729 --> 00:03:48,329
and slow down to about one and a half

109
00:03:51,920 --> 00:03:49,739
miles an hour point seven five meters

110
00:03:53,420 --> 00:03:51,930
per second and land the same way that

111
00:03:55,699 --> 00:03:53,430
curiosity did with the sky crane

112
00:03:57,280 --> 00:03:55,709
maneuver putting the perseverance Rover

113
00:03:59,300 --> 00:03:57,290

right on its wheels on the ground and

114
00:04:00,890 --> 00:03:59,310
the face crafts got to do that all

115
00:04:02,750 --> 00:04:00,900
autonomously right this we can't

116
00:04:04,429 --> 00:04:02,760
joystick it on the way in the

117
00:04:07,130 --> 00:04:04,439
spacecrafts on its own and has to it has

118
00:04:09,170 --> 00:04:07,140
to do that entire set of events on its

119
00:04:11,569 --> 00:04:09,180
own to help deal with those challenges

120
00:04:12,710 --> 00:04:11,579
we've spent over seven years my team's

121
00:04:14,569 --> 00:04:12,720
been working on this for over seven

122
00:04:16,640 --> 00:04:14,579
years to get those seven minutes of ETL

123
00:04:18,020 --> 00:04:16,650
to go right we needed to come up with a

124
00:04:19,340 --> 00:04:18,030
design that could get us to the places

125
00:04:21,580 --> 00:04:19,350
that we wanted to go the sites that

126
00:04:24,320 --> 00:04:21,590
folks wanted to go take this mission to

127
00:04:26,480 --> 00:04:24,330
for the the types of objectives we have

128
00:04:28,550 --> 00:04:26,490
once we're on the ground we also had to

129
00:04:29,980 --> 00:04:28,560
be sure that we could see we could take

130
00:04:32,480 --> 00:04:29,990
whatever Mars could throw at it

131
00:04:34,219 --> 00:04:32,490
different places have on Mars just like

132
00:04:35,540 --> 00:04:34,229
here on earth have different terrains we

133
00:04:38,420 --> 00:04:35,550
have to land on that means different

134
00:04:39,920 --> 00:04:38,430
sets of rocks and slopes and craters to

135
00:04:41,360 --> 00:04:39,930
deal with it also means that the weather

136
00:04:42,800 --> 00:04:41,370
is different different places so we have

137
00:04:44,839 --> 00:04:42,810
to deal with different types of

138
00:04:46,610 --> 00:04:44,849

atmospheres and structures that could

139
00:04:48,499 --> 00:04:46,620
occur at different places we've also

140
00:04:50,270 --> 00:04:48,509
done in that in their time a lot of

141
00:04:52,430 --> 00:04:50,280
testing we've been testing supersonic

142
00:04:53,870 --> 00:04:52,440
parachutes testing heat shields testing

143
00:04:56,000 --> 00:04:53,880
the materials that go on heat shields

144
00:04:57,260 --> 00:04:56,010
testing sensors all the sensors we need

145
00:04:59,659 --> 00:04:57,270
for the spacecraft to figure out what's

146
00:05:01,490 --> 00:04:59,669
going on testing our computers and the

147
00:05:03,379 --> 00:05:01,500
flight software but we can't test

148
00:05:05,779 --> 00:05:03,389
everything we can't test the whole thing

149
00:05:07,100 --> 00:05:05,789
and and like it would work on Mars

150
00:05:08,330 --> 00:05:07,110
because Earth is different it's just

151
00:05:09,890 --> 00:05:08,340
different in gravity different in

152
00:05:12,500 --> 00:05:09,900
atmosphere and the places are different

153
00:05:15,290 --> 00:05:12,510
too so we also have to fold in a lot of

154
00:05:16,520 --> 00:05:15,300
simulation work to help us understand if

155
00:05:19,159 --> 00:05:16,530
we're gonna make it successfully to the

156
00:05:21,649 --> 00:05:19,169
ground at jezero someone once told me

157
00:05:23,330 --> 00:05:21,659
right that a wise man once told me that

158
00:05:25,850 --> 00:05:23,340
you never stop testing or simulating in

159
00:05:27,589 --> 00:05:25,860
this case - you just run out of time so

160
00:05:27,890 --> 00:05:27,599
even though spacecrafts almost ready to

161
00:05:30,080 --> 00:05:27,900
launch

162
00:05:32,210 --> 00:05:30,090
you know we're bummed up and getting -

163
00:05:34,640 --> 00:05:32,220

getting to go to the pad next next month

164
00:05:36,529 --> 00:05:34,650
or so in the next month and a half we

165
00:05:38,540 --> 00:05:36,539
are still going to test and simulate

166
00:05:42,680 --> 00:05:38,550
until we run out of time in February

167
00:05:44,570 --> 00:05:42,690
about 280 days from now that's amazing

168
00:05:46,580 --> 00:05:44,580
out and I know that when we were talking

169
00:05:48,790 --> 00:05:46,590
earlier you said it's almost lessened

170
00:05:51,800 --> 00:05:48,800
doll you just keep shedding those pieces

171
00:05:53,870 --> 00:05:51,810
until you come prize of course the rover

172
00:05:55,550 --> 00:05:53,880
being in the middle of it all so it's

173
00:05:58,190 --> 00:05:55,560
very well choreographed but you said

174
00:06:00,410 --> 00:05:58,200
that the new EDL and treat descent

175
00:06:03,710 --> 00:06:00,420
landing camera system is really gonna

176
00:06:05,270 --> 00:06:03,720
help you guys out yeah we have an

177
00:06:07,730 --> 00:06:05,280
interest in landing camera system to

178
00:06:08,990 --> 00:06:07,740
help us do a couple things well with the

179
00:06:10,580 --> 00:06:09,000
system itself we'll show you what it's

180
00:06:11,750 --> 00:06:10,590
like to actually land on Mars we have

181
00:06:13,310 --> 00:06:11,760
cameras that will look up with the

182
00:06:14,780 --> 00:06:13,320
parachute we've never seen a supersonic

183
00:06:16,580 --> 00:06:14,790
parachute inflate on another planet

184
00:06:18,530 --> 00:06:16,590
before so we have three cameras looking

185
00:06:21,080 --> 00:06:18,540
up there and then we have the camera

186
00:06:22,850 --> 00:06:21,090
looking down from the descent stage at

187
00:06:23,900 --> 00:06:22,860
the rover and then one from the rover

188
00:06:26,630 --> 00:06:23,910

looking up the descent stage we can

189
00:06:28,730 --> 00:06:26,640
actually see us pay off the rover during

190
00:06:29,930 --> 00:06:28,740
sky crane I also have a camera on the

191
00:06:32,480 --> 00:06:29,940
bottom of the rover looking down at the

192
00:06:33,740 --> 00:06:32,490
ground rushing up to us so once we land

193
00:06:36,410 --> 00:06:33,750
we'll be able to get all that data back

194
00:06:39,250 --> 00:06:36,420
and use that to see exactly what what

195
00:06:42,100 --> 00:06:39,260
EDL looks like when you're on board and

196
00:06:44,090 --> 00:06:42,110
the rover was a recently named

197
00:06:47,540 --> 00:06:44,100
perseverance and what does that name

198
00:06:49,400 --> 00:06:47,550
mean to you personally well to me

199
00:06:50,960 --> 00:06:49,410
perseverance is all about sticking with

200
00:06:52,610 --> 00:06:50,970
it and you know if when you get knocked

201
00:06:54,170 --> 00:06:52,620
down getting back up again you know

202
00:06:56,270 --> 00:06:54,180
you've got to have a lot of focus here

203
00:06:58,100 --> 00:06:56,280
to work on these kind of things I worked

204
00:06:59,450 --> 00:06:58,110
on curiosity for 10 years to get that

205
00:07:01,700 --> 00:06:59,460
entry descent landing that's seven

206
00:07:03,260 --> 00:07:01,710
minutes of ETL to go right and it'll be

207
00:07:05,540 --> 00:07:03,270
over eight years for a lot of my team by

208
00:07:07,220 --> 00:07:05,550
time we land for this mission to get

209
00:07:08,480 --> 00:07:07,230
those seven minutes to go right and

210
00:07:10,100 --> 00:07:08,490
throughout that time right you have good

211
00:07:11,780 --> 00:07:10,110
days and you have bad days right and the

212
00:07:14,090 --> 00:07:11,790
the bad days make make you want to stop

213
00:07:15,830 --> 00:07:14,100

but you just got to pick yourself up and

214
00:07:16,820 --> 00:07:15,840
know that there's gonna be there's going

215
00:07:19,190 --> 00:07:16,830
to be challenges that you have to deal

216
00:07:23,540 --> 00:07:19,200
with push through those and yearly

217
00:07:25,550 --> 00:07:23,550
weight the next one that's awesome so

218
00:07:27,650 --> 00:07:25,560
now Mars 2020 is landing as you

219
00:07:29,720 --> 00:07:27,660
mentioned in your first answer in jezero

220
00:07:32,660 --> 00:07:29,730
crater now that site was actually deemed

221
00:07:35,060 --> 00:07:32,670
unsafe for previous Mars missions and

222
00:07:37,310 --> 00:07:35,070
MSL so tell me a little bit of what has

223
00:07:39,140 --> 00:07:37,320
changed for this mission now that you're

224
00:07:40,640 --> 00:07:39,150
landing at it it's not a parking lot you

225
00:07:41,990 --> 00:07:40,650
always say it's a little bit scarier

226
00:07:44,960 --> 00:07:42,000
when you're landing in a place like

227
00:07:46,850 --> 00:07:44,970
jezero crater yeah it's definitely a lot

228
00:07:48,590 --> 00:07:46,860
scarier in fact I was on the team right

229
00:07:50,390 --> 00:07:48,600
that assessed jezero is being unsafe for

230
00:07:52,250 --> 00:07:50,400
curiosity and even though our entry

231
00:07:54,560 --> 00:07:52,260
descent landing system looks the same

232
00:07:56,120 --> 00:07:54,570
from the outside we have a couple of

233
00:07:57,530 --> 00:07:56,130
capabilities that we've added that are

234
00:07:59,570 --> 00:07:57,540
pretty important under the hood things

235
00:08:02,180 --> 00:07:59,580
that you might not see when you watch

236
00:08:03,470 --> 00:08:02,190
the sequence of events but are important

237
00:08:05,720 --> 00:08:03,480
for letting us go to a place like des

238
00:08:07,320 --> 00:08:05,730

Rosiers safely it's the the only reason

239
00:08:09,540 --> 00:08:07,330
why I'm willing to go there now actually

240
00:08:11,450 --> 00:08:09,550
and these two capabilities are arranged

241
00:08:13,710 --> 00:08:11,460
Trigger and Turan relative navigation

242
00:08:15,450 --> 00:08:13,720
brain trigger is the ability to deploy

243
00:08:17,909 --> 00:08:15,460
the parachute based on navigated

244
00:08:19,260 --> 00:08:17,919
position back on curiosity we deployed

245
00:08:20,580 --> 00:08:19,270
the parachute just on reaching a

246
00:08:23,309 --> 00:08:20,590
velocity when you get to a certain

247
00:08:25,589 --> 00:08:23,319
velocity about Mach 1.75 deploy the

248
00:08:28,110 --> 00:08:25,599
parachute this time with perseverance

249
00:08:29,550 --> 00:08:28,120
will ask the spacecraft to figure out

250
00:08:31,409 --> 00:08:29,560
where it is as it's going throughout

251
00:08:33,509 --> 00:08:31,419
entry and when it not only gets to the

252
00:08:35,519 --> 00:08:33,519
right velocity but the right place will

253
00:08:36,810 --> 00:08:35,529
deploy the parachute in fact curiosity

254
00:08:39,509 --> 00:08:36,820
actually knew that it was a little bit

255
00:08:41,130 --> 00:08:39,519
past the parachute deploy target when it

256
00:08:42,959 --> 00:08:41,140
deployed its parachute but didn't really

257
00:08:44,759 --> 00:08:42,969
have any anything to do we couldn't do

258
00:08:46,769 --> 00:08:44,769
anything about it this time perseverance

259
00:08:48,509 --> 00:08:46,779
cat it'll use that information about

260
00:08:51,150 --> 00:08:48,519
where it is and deploy that parachute

261
00:08:52,500 --> 00:08:51,160
even more precisely that's allowing us

262
00:08:54,180 --> 00:08:52,510
to shrink our landing uncertainty

263
00:08:56,400 --> 00:08:54,190

ellipse where we could end up to about

264
00:08:58,530 --> 00:08:56,410
an 8 kilometer circle so we can land

265
00:09:00,960 --> 00:08:58,540
within 4 kilometers of a given target on

266
00:09:03,960 --> 00:09:00,970
Mars as that helps us fit into tight

267
00:09:05,639 --> 00:09:03,970
places like like jezero crater the

268
00:09:07,650 --> 00:09:05,649
second capability trained relative

269
00:09:09,540 --> 00:09:07,660
navigation is something that we've added

270
00:09:11,160 --> 00:09:09,550
to the system that happens while we're

271
00:09:12,180 --> 00:09:11,170
coming down on parachute after the

272
00:09:14,730 --> 00:09:12,190
parachute is deployed and the heat

273
00:09:16,380 --> 00:09:14,740
shells off and also in the beginning

274
00:09:19,019 --> 00:09:16,390
part of powered flight when we use those

275
00:09:20,670 --> 00:09:19,029
engines what's going on here is that on

276
00:09:22,170 --> 00:09:20,680
curiosity for example we deployed the

277
00:09:24,150 --> 00:09:22,180
parrot that deployed the heat shield and

278
00:09:26,310 --> 00:09:24,160
had a camera that took pictures of the

279
00:09:27,389 --> 00:09:26,320
ground rushing up at us but we didn't

280
00:09:29,040 --> 00:09:27,399
really use those pictures for anything

281
00:09:31,800 --> 00:09:29,050
we just kind of took that took that

282
00:09:33,689 --> 00:09:31,810
video and looked at it after landing but

283
00:09:37,139 --> 00:09:33,699
it was pretty cool but we didn't try to

284
00:09:38,730 --> 00:09:37,149
use it to help us land safely here with

285
00:09:40,740 --> 00:09:38,740
perseverance we'll take pictures on the

286
00:09:42,720 --> 00:09:40,750
way down just like just like curiosity

287
00:09:45,150 --> 00:09:42,730
did but we use those pictures to match

288
00:09:47,069 --> 00:09:45,160

up with an onboard map just like you or

289
00:09:48,960 --> 00:09:47,079
I can drive around town and kind of you

290
00:09:50,189 --> 00:09:48,970
know hold out a map or you know look for

291
00:09:51,630 --> 00:09:50,199
landmarks as you look outside the window

292
00:09:52,920 --> 00:09:51,640
and match them up with your map and

293
00:09:54,540 --> 00:09:52,930
figure out where you are

294
00:09:57,329 --> 00:09:54,550
that's what perseverance is going to do

295
00:09:58,740 --> 00:09:57,339
- so on the parachute we can we can take

296
00:10:00,660 --> 00:09:58,750
those pictures figure out where we are

297
00:10:02,550 --> 00:10:00,670
and then once we get off the parachute

298
00:10:06,000 --> 00:10:02,560
and use those rocket engines we can fly

299
00:10:07,170 --> 00:10:06,010
to the nearest safe place so that's a

300
00:10:09,120 --> 00:10:07,180
that's pretty important because in the

301
00:10:11,069 --> 00:10:09,130
past we had to ensure that anywhere we

302
00:10:13,680 --> 00:10:11,079
could land anywhere where the rover

303
00:10:16,710 --> 00:10:13,690
could come down was as parking-lot as

304
00:10:18,809 --> 00:10:16,720
possible as flat as boring as free of

305
00:10:20,519 --> 00:10:18,819
rocks or slopes or anything else things

306
00:10:22,769 --> 00:10:20,529
that would kill our Rover

307
00:10:24,449 --> 00:10:22,779
as possible but now with the ability to

308
00:10:26,189 --> 00:10:24,459
figure out exactly where we are and the

309
00:10:27,959 --> 00:10:26,199
ability to fly to places nearby and

310
00:10:30,059 --> 00:10:27,969
select the nearest reachable safe spot I

311
00:10:31,829 --> 00:10:30,069
no longer need the entire place to be a

312
00:10:34,229 --> 00:10:31,839
parking lot I can have lots of little

313
00:10:36,239 --> 00:10:34,239

tiny parking lots amongst all the big

314
00:10:37,859 --> 00:10:36,249
things that people want to see and in

315
00:10:40,019 --> 00:10:37,869
fact if you look to J's row and you see

316
00:10:41,839 --> 00:10:40,029
that that big Delta in the middle that's

317
00:10:43,979 --> 00:10:41,849
so interesting to our science books

318
00:10:45,419 --> 00:10:43,989
we're targeting right on the edge of

319
00:10:47,359 --> 00:10:45,429
that Delta and I can tell you that the

320
00:10:50,309 --> 00:10:47,369
edge of that Delta is a 60 to 80 meter

321
00:10:51,749 --> 00:10:50,319
tall cliff face but we have the ability

322
00:10:53,639 --> 00:10:51,759
because if we're coming right down there

323
00:10:55,019 --> 00:10:53,649
to divert one way or the other

324
00:10:57,239 --> 00:10:55,029
once we figured out where we are and

325
00:10:58,619 --> 00:10:57,249
land safely in the safe spots that are

326
00:11:02,549 --> 00:10:58,629
nearby like the landing strip that's

327
00:11:04,259 --> 00:11:02,559
right at the bottom the Delta well we're

328
00:11:06,479 --> 00:11:04,269
getting a lot of great questions on

329
00:11:08,069 --> 00:11:06,489
social media and one actually pertains

330
00:11:10,649 --> 00:11:08,079
to what you're just talking about right

331
00:11:13,169 --> 00:11:10,659
now a land manish on twitter asks are

332
00:11:15,509 --> 00:11:13,179
there any aspects of this mission or in

333
00:11:20,279 --> 00:11:15,519
the EDL system that you're particularly

334
00:11:22,259 --> 00:11:20,289
nervous about yeah it's a that's a tough

335
00:11:24,209 --> 00:11:22,269
question because so much has to go right

336
00:11:25,169 --> 00:11:24,219
in entry descent landing and you know

337
00:11:28,469 --> 00:11:25,179
you don't get partial credit really

338
00:11:29,939 --> 00:11:28,479

there's really very little that can that

339
00:11:30,749 --> 00:11:29,949
can go wrong and then you'll still make

340
00:11:35,609 --> 00:11:30,759
it

341
00:11:36,689 --> 00:11:35,619
test you know the the things that make

342
00:11:38,969 --> 00:11:36,699
us nervous about every mission I think

343
00:11:40,439 --> 00:11:38,979
are still true here we have the our

344
00:11:42,239 --> 00:11:40,449
supersonic parachute deploying in less

345
00:11:44,099 --> 00:11:42,249
than a second I'm inflating in less than

346
00:11:46,859 --> 00:11:44,109
a second under tremendous loads

347
00:11:48,239 --> 00:11:46,869
that's certainly nerve-wracking but it's

348
00:11:50,189 --> 00:11:48,249
hard to point to anything I mean and

349
00:11:51,419 --> 00:11:50,199
everything is is dangerous that you have

350
00:11:53,729 --> 00:11:51,429
to be careful about when Mars can throw

351
00:11:55,949 --> 00:11:53,739
at you too certainly while we understand

352
00:11:57,539 --> 00:11:55,959
the train very well at jezero there are

353
00:11:59,429 --> 00:11:57,549
many hazards there and we got to make

354
00:12:04,049 --> 00:11:59,439
sure that we land in those safe tiny

355
00:12:06,359 --> 00:12:04,059
parking lots that we can find Alliston

356
00:12:11,239 --> 00:12:06,369
zero on twitter also asks what are the

357
00:12:13,139 --> 00:12:11,249
self repairing abilities of the system

358
00:12:14,639 --> 00:12:13,149
so it's all for pairing I guess

359
00:12:16,229 --> 00:12:14,649
signatory descent landing there's not a

360
00:12:18,299 --> 00:12:16,239
whole lot that we have that self

361
00:12:20,969 --> 00:12:18,309
repairing we do have a system that's

362
00:12:22,649 --> 00:12:20,979
called a second chance that we because

363
00:12:24,419 --> 00:12:22,659

as some of you may know we actually have

364
00:12:27,479 --> 00:12:24,429
two sets of avionics on the on the

365
00:12:29,099 --> 00:12:27,489
spacecraft that we can switch between in

366
00:12:31,229 --> 00:12:29,109
the event of something going really bad

367
00:12:32,969 --> 00:12:31,239
during at recent landing we have the

368
00:12:34,680 --> 00:12:32,979
ability to switch to that backup string

369
00:12:37,499 --> 00:12:34,690
and that'll executing

370
00:12:39,689 --> 00:12:37,509
a much stripped down version of entry

371
00:12:41,040 --> 00:12:39,699
descent and landing that kind of removed

372
00:12:42,509 --> 00:12:41,050
some of the some of the other

373
00:12:45,900 --> 00:12:42,519
capabilities make sure that we try to

374
00:12:47,509 --> 00:12:45,910
land so that's basically about it we

375
00:12:50,519 --> 00:12:47,519
have the ability to deal with some

376
00:12:52,259 --> 00:12:50,529
faults that in the avionics system but

377
00:12:54,360 --> 00:12:52,269
there's really not much right we can't

378
00:12:55,980 --> 00:12:54,370
put the spacecraft in safe mode there's

379
00:12:58,710 --> 00:12:55,990
no going backwards we can't you know

380
00:13:01,199 --> 00:12:58,720
give up halfway through and go back to

381
00:13:02,670 --> 00:13:01,209
before entry we pretty much have to

382
00:13:05,210 --> 00:13:02,680
power through so there's not a lot of

383
00:13:08,370 --> 00:13:05,220
self repair that's possible during ETL

384
00:13:09,870 --> 00:13:08,380
well that's why you guys test a lot and

385
00:13:11,550 --> 00:13:09,880
I'm sure range trigger and terrain

386
00:13:13,410 --> 00:13:11,560
relative navigation as you explained

387
00:13:16,499 --> 00:13:13,420
earlier is really gonna help out now

388
00:13:18,900 --> 00:13:16,509

odds gun on YouTube asks what kind of

389
00:13:22,769 --> 00:13:18,910
materials do you use for the heat shield

390
00:13:25,139 --> 00:13:22,779
which of course is very protective the

391
00:13:26,670 --> 00:13:25,149
heat shield is has the same basic design

392
00:13:28,829 --> 00:13:26,680
the same thermal protection system

393
00:13:30,240 --> 00:13:28,839
material that curiosity did which is

394
00:13:32,400 --> 00:13:30,250
something called pica which is a

395
00:13:35,309 --> 00:13:32,410
phenolic impregnated carbon ablator

396
00:13:38,009 --> 00:13:35,319
so it's an ablative material that's put

397
00:13:39,749 --> 00:13:38,019
on the heat shield and tiles very much

398
00:13:45,720 --> 00:13:39,759
like what we've done on curiosity in the

399
00:13:47,819 --> 00:13:45,730
past and John on YouTube asks since EDL

400
00:13:50,639 --> 00:13:47,829
for perseverance is based on the

401
00:13:53,040 --> 00:13:50,649
strategy for curiosity can you highlight

402
00:13:56,449 --> 00:13:53,050
what the changes and upgrades have been

403
00:13:59,280 --> 00:13:56,459
that you've made in the last eight years

404
00:14:00,980 --> 00:13:59,290
one of the fun things about about

405
00:14:03,449 --> 00:14:00,990
perseverance actually is that you

406
00:14:05,100 --> 00:14:03,459
because it has so much commonality to

407
00:14:06,540 --> 00:14:05,110
curiosity you actually get a chance to

408
00:14:08,249 --> 00:14:06,550
make to fix some of the mistakes you

409
00:14:10,170 --> 00:14:08,259
make last time and we actually made a

410
00:14:11,850 --> 00:14:10,180
couple mistakes on on MSL and got away

411
00:14:13,980 --> 00:14:11,860
with it and have managed to fix them for

412
00:14:15,240 --> 00:14:13,990
Mars 2020 so in addition to the new

413
00:14:17,670 --> 00:14:15,250

capabilities like terrain relative

414
00:14:19,410 --> 00:14:17,680
navigation and range trigger we've

415
00:14:21,389 --> 00:14:19,420
managed to go back and take a look at

416
00:14:23,160 --> 00:14:21,399
some of the issues we had on curiosity

417
00:14:24,420 --> 00:14:23,170
noting which there was so super

418
00:14:27,030 --> 00:14:24,430
significant right we still made it

419
00:14:29,550 --> 00:14:27,040
safely without much problems but we had

420
00:14:32,040 --> 00:14:29,560
a chance to to really dig deep again and

421
00:14:33,689 --> 00:14:32,050
look at our design you know because just

422
00:14:35,939 --> 00:14:33,699
landing safely once isn't enough to

423
00:14:37,769 --> 00:14:35,949
prove that your system works so we spent

424
00:14:39,840 --> 00:14:37,779
a lot of time over the past years poring

425
00:14:41,939 --> 00:14:39,850
over the data from curiosity so we've

426
00:14:43,410 --> 00:14:41,949
made some changes the one of the things

427
00:14:45,030 --> 00:14:43,420
we noticed on curiosity is that we

428
00:14:47,250 --> 00:14:45,040
actually touched down a little slower

429
00:14:48,450 --> 00:14:47,260
than we had intended because we didn't

430
00:14:51,240 --> 00:14:48,460
get the local grab

431
00:14:52,470 --> 00:14:51,250
at Gale Crater correct Gale Crater is

432
00:14:54,120 --> 00:14:52,480
actually a pretty challenging site from

433
00:14:56,550 --> 00:14:54,130
a gravity modeling perspective it's a

434
00:14:57,600 --> 00:14:56,560
pretty deep hole with a pretty big

435
00:14:59,100 --> 00:14:57,610
mountain in the middle of it and we

436
00:15:00,510 --> 00:14:59,110
didn't get the local grabby right and as

437
00:15:00,840 --> 00:15:00,520
a result we actually touch down a little

438
00:15:02,760 --> 00:15:00,850

slower

439
00:15:04,500 --> 00:15:02,770
which is fine right that's not actually

440
00:15:06,360 --> 00:15:04,510
much of an issue it consumes a little

441
00:15:09,540 --> 00:15:06,370
bit more fuel but we've corrected that

442
00:15:12,300 --> 00:15:09,550
issue for for Mars 2020 so that we have

443
00:15:15,240 --> 00:15:12,310
a we think a much better higher fidelity

444
00:15:17,460 --> 00:15:15,250
model of Jezreel so we won't experience

445
00:15:18,660 --> 00:15:17,470
that problem again so that's just an

446
00:15:21,350 --> 00:15:18,670
example of the type of thing we've been

447
00:15:25,470 --> 00:15:21,360
we've been working on since curiosity

448
00:15:27,630 --> 00:15:25,480
and you've also been testing landing in

449
00:15:29,639 --> 00:15:27,640
the Mars atmosphere we talked earlier

450
00:15:31,350 --> 00:15:29,649
about surface pressure readings and

451
00:15:32,910 --> 00:15:31,360
you've protected the wind sensors a

452
00:15:35,850 --> 00:15:32,920
little bit more on the weather center

453
00:15:38,250 --> 00:15:35,860
that is actually on perserverence

454
00:15:42,840 --> 00:15:38,260
and Sonya on you to know what kind of

455
00:15:44,100 --> 00:15:42,850
atmosphere does Mars have Mars

456
00:15:45,449 --> 00:15:44,110
atmosphere is much thinner than that of

457
00:15:48,540 --> 00:15:45,459
Earth's it's about one percent the

458
00:15:50,639 --> 00:15:48,550
density of Earth and it's about 95

459
00:15:52,920 --> 00:15:50,649
percent carbon dioxide and five percent

460
00:15:54,720 --> 00:15:52,930
who cares it's mostly carbon dioxide

461
00:15:57,269 --> 00:15:54,730
it's very little other stuff that

462
00:16:00,000 --> 00:15:57,279
matters from a entry descent landing

463
00:16:01,560 --> 00:16:00,010

perspective so it's actually you know in

464
00:16:02,880 --> 00:16:01,570
some sense carbon dioxide from an

465
00:16:04,560 --> 00:16:02,890
aerodynamics perspective behave

466
00:16:07,170 --> 00:16:04,570
similarly it's the most of the density

467
00:16:10,410 --> 00:16:07,180
that's an issue for us and that's the

468
00:16:11,940 --> 00:16:10,420
that's the big difference for us and you

469
00:16:12,780 --> 00:16:11,950
had mentioned before for entry descent

470
00:16:16,050 --> 00:16:12,790
and landing

471
00:16:18,810 --> 00:16:16,060
how do winds play a variation when it

472
00:16:20,070 --> 00:16:18,820
comes to your landing techniques sure

473
00:16:21,360 --> 00:16:20,080
winds are definitely something that

474
00:16:23,310 --> 00:16:21,370
we're paying attention to and if you

475
00:16:24,990 --> 00:16:23,320
think getting the weather right is hard

476
00:16:27,360 --> 00:16:25,000
here on earth with our weather forecasts

477
00:16:28,829 --> 00:16:27,370
try forecasting the the weather at a

478
00:16:31,079 --> 00:16:28,839
place you've never been to with no

479
00:16:33,569 --> 00:16:31,089
weather satellites and all that in a

480
00:16:35,699 --> 00:16:33,579
season in the future so that's what our

481
00:16:37,530 --> 00:16:35,709
job is to win definitely pushes us

482
00:16:40,890 --> 00:16:37,540
around both literally and and

483
00:16:43,560 --> 00:16:40,900
figuratively we have a lot of events on

484
00:16:45,030 --> 00:16:43,570
the vehicle that are Mach sensitive so

485
00:16:46,230 --> 00:16:45,040
their their wind speed sensitive things

486
00:16:48,150 --> 00:16:46,240
like parachute deploy and heat shield

487
00:16:49,829 --> 00:16:48,160
separation so the wind certainly plays

488
00:16:52,139 --> 00:16:49,839

into a factor there but the biggest

489
00:16:54,360 --> 00:16:52,149
effect really for us in in entry descent

490
00:16:55,889 --> 00:16:54,370
landing is when we're on parachute we're

491
00:16:57,420 --> 00:16:55,899
kind of at the mercy of the wind when

492
00:16:59,100 --> 00:16:57,430
we're on were coming down on parachute

493
00:17:01,470 --> 00:16:59,110
we don't have the ability to steer the

494
00:17:02,280 --> 00:17:01,480
vehicle at that point so the wind

495
00:17:04,230 --> 00:17:02,290
uncertainty that we

496
00:17:05,970 --> 00:17:04,240
is a big contributor is perhaps the

497
00:17:07,590 --> 00:17:05,980
biggest contributor really to our

498
00:17:10,259 --> 00:17:07,600
uncertainty and where we touch down

499
00:17:13,350 --> 00:17:10,269
because that pushes us around so that a

500
00:17:15,449 --> 00:17:13,360
kilometer long or they kilometer circle

501
00:17:19,679 --> 00:17:15,459
of ellipse that we have is dominated by

502
00:17:21,419 --> 00:17:19,689
that by atmospheric uncertainty this is

503
00:17:23,909 --> 00:17:21,429
an interesting question from Trina on

504
00:17:27,750 --> 00:17:23,919
YouTube she wants to know what material

505
00:17:29,220 --> 00:17:27,760
is a supersonic parachute made of it's

506
00:17:31,980 --> 00:17:29,230
perhaps not that surprising but

507
00:17:34,590 --> 00:17:31,990
parachute materials mostly nylon there's

508
00:17:36,899 --> 00:17:34,600
also other other other materials in the

509
00:17:38,370 --> 00:17:36,909
background and others in the skeleton of

510
00:17:40,500 --> 00:17:38,380
the parachute for the broad cuddle is

511
00:17:43,710 --> 00:17:40,510
not we actually strengthen that

512
00:17:44,970 --> 00:17:43,720
parachute since MSL not because of

513
00:17:47,340 --> 00:17:44,980

anything that we saw on curiosity

514
00:17:49,230 --> 00:17:47,350
apologize curiosity was the Mars Science

515
00:17:51,389 --> 00:17:49,240
Laboratory mission so I drop into that

516
00:17:53,159 --> 00:17:51,399
every now and then but since curiosity

517
00:17:55,200 --> 00:17:53,169
we have done some additional parachute

518
00:17:57,330 --> 00:17:55,210
development work in the low density

519
00:17:59,399 --> 00:17:57,340
supersonic decelerator project and then

520
00:18:01,799 --> 00:17:59,409
made us think that perhaps we don't have

521
00:18:03,570 --> 00:18:01,809
we didn't have quite as much margin in

522
00:18:04,049 --> 00:18:03,580
what the parachutes could handle as we

523
00:18:07,950 --> 00:18:04,059
thought

524
00:18:09,659 --> 00:18:07,960
I'm so in the Mars 2020 had a program

525
00:18:12,720 --> 00:18:09,669
that tested our parachutes

526
00:18:14,310 --> 00:18:12,730
supersonically with launches on sounding

527
00:18:16,740 --> 00:18:14,320
rockets out of the Wallops Flight

528
00:18:21,149 --> 00:18:16,750
Facility over and over in the Virginia

529
00:18:22,590 --> 00:18:21,159
and Maryland area Connor on YouTube asks

530
00:18:26,430 --> 00:18:22,600
does perseverance have a backup

531
00:18:27,899 --> 00:18:26,440
parachute yeah it's just like if you

532
00:18:30,090 --> 00:18:27,909
skydive if you would have backup

533
00:18:31,919 --> 00:18:30,100
parachute but we do not

534
00:18:33,330 --> 00:18:31,929
pretty much everything has to work the

535
00:18:36,149 --> 00:18:33,340
first time for us and that includes only

536
00:18:39,570 --> 00:18:36,159
one parachute so yeah it's got to work

537
00:18:40,950 --> 00:18:39,580
perhaps why it jumped to mind when with

538
00:18:45,629 --> 00:18:40,960

that other question about one my nervous

539
00:18:47,730 --> 00:18:45,639
about precisely and that's why you do so

540
00:18:49,980 --> 00:18:47,740
much testing and that's why a maiya on

541
00:18:53,129 --> 00:18:49,990
youtube asks how do you actually test

542
00:18:54,570 --> 00:18:53,139
the EDL systems I know that it is a

543
00:18:56,899 --> 00:18:54,580
process and like you said you'll be

544
00:19:00,000 --> 00:18:56,909
testing up until the very last moment

545
00:19:02,009 --> 00:19:00,010
yeah they there's a there's a mantra JPL

546
00:19:04,409 --> 00:19:02,019
they like to say test as you fly and fly

547
00:19:05,850 --> 00:19:04,419
as you text but what happens when you

548
00:19:07,320 --> 00:19:05,860
can't test is you flying right you can't

549
00:19:08,789 --> 00:19:07,330
do an end-to-end test of the entry

550
00:19:10,710 --> 00:19:08,799
descent landing system even if you

551
00:19:12,720 --> 00:19:10,720
wanted to here on earth even if we you

552
00:19:14,369 --> 00:19:12,730
know had the resources to do it so much

553
00:19:16,049 --> 00:19:14,379
is different about earth between the

554
00:19:16,300 --> 00:19:16,059
atmosphere and the gravity and and all

555
00:19:24,640 --> 00:19:16,310
that

556
00:19:27,040 --> 00:19:24,650
entry descent and landing world to to

557
00:19:28,930 --> 00:19:27,050
say simulate as he fly and fly as you

558
00:19:30,250 --> 00:19:28,940
simulate that's not saying that we don't

559
00:19:31,930 --> 00:19:30,260
do a lot of testing we're doing a lot of

560
00:19:34,030 --> 00:19:31,940
testing at the component level we've

561
00:19:36,070 --> 00:19:34,040
hired engines so actually flown

562
00:19:38,170 --> 00:19:36,080
propellant through them and seeing how

563
00:19:39,760 --> 00:19:38,180

they behave we've tested the parachute

564
00:19:42,040 --> 00:19:39,770
individually we certainly tested parts

565
00:19:44,740 --> 00:19:42,050
of the heat shield material individually

566
00:19:46,480 --> 00:19:44,750
and the radar certainly we radar and

567
00:19:47,680 --> 00:19:46,490
lander vision system right the part of

568
00:19:49,870 --> 00:19:47,690
the training relative navigation system

569
00:19:51,730 --> 00:19:49,880
we were actually able to take out to the

570
00:19:53,230 --> 00:19:51,740
desert under a helicopter and fly over

571
00:19:54,850 --> 00:19:53,240
Mars like terrain and even more

572
00:19:58,060 --> 00:19:54,860
challenging conditions to show that it

573
00:19:59,920 --> 00:19:58,070
works um so we take those pieces and

574
00:20:01,930 --> 00:19:59,930
then model the tests in some sense to

575
00:20:03,340 --> 00:20:01,940
improve our models and then use them and

576
00:20:05,950 --> 00:20:03,350
put those models together into a

577
00:20:07,810 --> 00:20:05,960
simulation to do the end end testing so

578
00:20:09,580 --> 00:20:07,820
the answer really is we try to test as

579
00:20:10,630 --> 00:20:09,590
much as we can up to the level you know

580
00:20:12,460 --> 00:20:10,640
the highest level we can try to

581
00:20:15,810 --> 00:20:12,470
integrate as much as we can and then put

582
00:20:20,290 --> 00:20:15,820
the rest of it together in simulation

583
00:20:22,810 --> 00:20:20,300
and Yaroslav from YouTube wants to know

584
00:20:26,140 --> 00:20:22,820
will perseverance land on Mars at night

585
00:20:28,660 --> 00:20:26,150
or day or does it really matter okay

586
00:20:31,000 --> 00:20:28,670
we're gonna land about 3:30 p.m. local

587
00:20:32,410 --> 00:20:31,010
time on Mars I like to joke that it's

588
00:20:35,680 --> 00:20:32,420

always three o'clock on Mars to me

589
00:20:38,050 --> 00:20:35,690
because we like to land underneath our

590
00:20:39,910 --> 00:20:38,060
orbiters and our orders typically are

591
00:20:42,280 --> 00:20:39,920
going overhead every at the local time

592
00:20:43,540 --> 00:20:42,290
about 3 p.m. every day and for

593
00:20:46,060 --> 00:20:43,550
communication reasons we want to make

594
00:20:48,360 --> 00:20:46,070
sure that we are able to send data from

595
00:20:50,800 --> 00:20:48,370
entry descent landing and relay at home

596
00:20:52,660 --> 00:20:50,810
through missions like the Mars

597
00:20:54,730 --> 00:20:52,670
Reconnaissance Orbiter so typically

598
00:20:56,650 --> 00:20:54,740
we've tried to land at that local time

599
00:21:01,060 --> 00:20:56,660
to make sure that we can send that data

600
00:21:02,950 --> 00:21:01,070
home Isaiah has a great question from

601
00:21:05,760 --> 00:21:02,960
YouTube can you talk about how you use

602
00:21:08,440 --> 00:21:05,770
radar to help land is it similar to

603
00:21:11,980 --> 00:21:08,450
ultrasonic sensors for determining

604
00:21:14,200 --> 00:21:11,990
altitude yes so we definitely are using

605
00:21:16,090 --> 00:21:14,210
a radar just like curiosity did after

606
00:21:18,700 --> 00:21:16,100
that heat shield comes off we've the

607
00:21:20,590 --> 00:21:18,710
first thing we turn on is that radar to

608
00:21:23,410 --> 00:21:20,600
make sure that we get precise position

609
00:21:25,750 --> 00:21:23,420
and velocity that means that we get we

610
00:21:27,760 --> 00:21:25,760
get that we get our position our

611
00:21:28,990 --> 00:21:27,770
altitude from all the six beams that we

612
00:21:29,890 --> 00:21:29,000
have at the front of the descent stage

613
00:21:31,660 --> 00:21:29,900

point

614
00:21:34,300 --> 00:21:31,670
the ground that'll also give us velocity

615
00:21:37,450 --> 00:21:34,310
once we're down low to accuracies of

616
00:21:39,760 --> 00:21:37,460
about 0.1 meter per second or so so we

617
00:21:41,590 --> 00:21:39,770
get both velocity and altitude from that

618
00:21:46,060 --> 00:21:41,600
ka-band radar it's at the front of the

619
00:21:48,130 --> 00:21:46,070
descent stage and going back to when we

620
00:21:50,860 --> 00:21:48,140
talked about how it's like Russian dolls

621
00:21:53,110 --> 00:21:50,870
because you keep having to shed pieces

622
00:21:55,390 --> 00:21:53,120
of the vehicle as you go along like you

623
00:21:58,060 --> 00:21:55,400
said from 12,000 miles per hour to 2

624
00:22:02,560 --> 00:21:58,070
miles per hour in those 7 minutes can

625
00:22:05,020 --> 00:22:02,570
you talk about how the parachute doesn't

626
00:22:06,460 --> 00:22:05,030
come down on the landed Rover that's

627
00:22:08,050 --> 00:22:06,470
what Jim would like to know on youtube

628
00:22:10,080 --> 00:22:08,060
but there's many pieces that you want to

629
00:22:12,400 --> 00:22:10,090
make sure don't land on that Rover

630
00:22:13,630 --> 00:22:12,410
absolutely we're certainly from even

631
00:22:15,640 --> 00:22:13,640
before the start of entry descent

632
00:22:17,590 --> 00:22:15,650
landing casting off pieces that we don't

633
00:22:19,870 --> 00:22:17,600
need of the spacecraft anymore first

634
00:22:22,090 --> 00:22:19,880
with the crew stage which we actually

635
00:22:23,500 --> 00:22:22,100
steer away from a little bit with in the

636
00:22:25,390 --> 00:22:23,510
atmosphere we're flying away from the

637
00:22:27,940 --> 00:22:25,400
crew stage and the crews down smashes

638
00:22:29,860 --> 00:22:27,950

that come off before entry once we get

639
00:22:31,060 --> 00:22:29,870
down low of course once we deploy the

640
00:22:33,070 --> 00:22:31,070
parachute we have to drop that heat

641
00:22:35,920 --> 00:22:33,080
shield that heat shield typically goes a

642
00:22:37,900 --> 00:22:35,930
bit further down from where from where

643
00:22:39,490 --> 00:22:37,910
we're at and then I think specifically

644
00:22:41,410 --> 00:22:39,500
to the question there's the back schlump

645
00:22:43,150 --> 00:22:41,420
air chute which is a concern the

646
00:22:44,710 --> 00:22:43,160
backshell parachute we have a couple of

647
00:22:46,660 --> 00:22:44,720
things that we need to worry about first

648
00:22:48,280 --> 00:22:46,670
as we drop out and then start lighting

649
00:22:49,990 --> 00:22:48,290
up those engines is slowing down we

650
00:22:51,460 --> 00:22:50,000
don't want that back chill in parachute

651
00:22:53,380 --> 00:22:51,470
to hit us in the back of the head so

652
00:22:55,510 --> 00:22:53,390
that's kind of the the near-term problem

653
00:22:57,010 --> 00:22:55,520
so we actually do a different maneuver

654
00:22:58,690 --> 00:22:57,020
so while we're selecting a safe landing

655
00:23:00,220 --> 00:22:58,700
target we're usually flying a bit

656
00:23:01,810 --> 00:23:00,230
sideways of the direction we're flying

657
00:23:03,970 --> 00:23:01,820
to get out of the way of where the

658
00:23:05,710 --> 00:23:03,980
parachute and actual aren't going so

659
00:23:07,990 --> 00:23:05,720
that's part of the near-term avoidance

660
00:23:09,820 --> 00:23:08,000
is we select the landing target that's

661
00:23:11,710 --> 00:23:09,830
that's good from a landing safety

662
00:23:12,790 --> 00:23:11,720
perspective but we're also are dodging

663
00:23:14,860 --> 00:23:12,800

the back shell and parachute in that

664
00:23:16,420 --> 00:23:14,870
near-term and then in the long term this

665
00:23:18,190 --> 00:23:16,430
is back where the atmospheric

666
00:23:19,810 --> 00:23:18,200
uncertainty comes into play that back

667
00:23:21,760 --> 00:23:19,820
shell and parachute are floating around

668
00:23:22,930 --> 00:23:21,770
being pushed around by the wind so they

669
00:23:25,270 --> 00:23:22,940
can end up in a lot of different places

670
00:23:27,460 --> 00:23:25,280
so we also fly a minimum amount of

671
00:23:28,930 --> 00:23:27,470
distance to the side to make sure that

672
00:23:30,760 --> 00:23:28,940
we get far enough away from the back

673
00:23:32,290 --> 00:23:30,770
shell and parachute that they don't come

674
00:23:37,030 --> 00:23:32,300
down on us or we don't land on it

675
00:23:39,430 --> 00:23:37,040
depending on which one lands first as we

676
00:23:41,470 --> 00:23:39,440
said so well choreograph that's for sure

677
00:23:42,760 --> 00:23:41,480
now Robinson of Owen on Twitter asks

678
00:23:45,130 --> 00:23:42,770
what would you do if there was a

679
00:23:48,250 --> 00:23:45,140
massive dust storm raging on Mars when

680
00:23:49,330 --> 00:23:48,260
you want to land perseverance yeah

681
00:23:50,620 --> 00:23:49,340
that's a great question it's something

682
00:23:52,540 --> 00:23:50,630
we ask ourselves all the time and it's

683
00:23:54,610 --> 00:23:52,550
something that came up with the insight

684
00:23:56,740 --> 00:23:54,620
landing not that long ago since they

685
00:23:58,690 --> 00:23:56,750
actually had a dust storm in there and

686
00:24:00,850 --> 00:23:58,700
their opportunity the good news for us

687
00:24:03,100 --> 00:24:00,860
actually in in the 2020 opportunity

688
00:24:04,630 --> 00:24:03,110

watching in July and landing in February

689
00:24:06,940 --> 00:24:04,640
is that we get there in a good time of

690
00:24:09,220 --> 00:24:06,950
year we are not in global dust storm

691
00:24:11,770 --> 00:24:09,230
season or planned encircling dust storm

692
00:24:13,780 --> 00:24:11,780
season Network during that time so we've

693
00:24:16,570 --> 00:24:13,790
looked at the the history of dust storms

694
00:24:17,980 --> 00:24:16,580
at our landing site overall the record

695
00:24:19,990 --> 00:24:17,990
history really at Mars and there's never

696
00:24:22,480 --> 00:24:20,000
been a planet circling dust storm at

697
00:24:24,160 --> 00:24:22,490
that time that being said our vehicle is

698
00:24:26,500 --> 00:24:24,170
actually very capable of handling it if

699
00:24:29,830 --> 00:24:26,510
we needed to the biggest concern for us

700
00:24:31,330 --> 00:24:29,840
with with a dust storm is really about

701
00:24:32,560 --> 00:24:31,340
what it does to our atmospheric and

702
00:24:34,990 --> 00:24:32,570
certainty I told you about how that

703
00:24:36,340 --> 00:24:35,000
pushes around the dust in the atmosphere

704
00:24:37,660 --> 00:24:36,350
will push around our winds rain and

705
00:24:40,150 --> 00:24:37,670
winds is something we cook we care about

706
00:24:41,710 --> 00:24:40,160
it also affects the density but because

707
00:24:43,270 --> 00:24:41,720
we have a guided entry system a system

708
00:24:45,580 --> 00:24:43,280
that actually is adjusting to what

709
00:24:46,810 --> 00:24:45,590
atmosphere it sees as it goes in we're

710
00:24:48,790 --> 00:24:46,820
pretty confident that we can handle

711
00:24:50,650 --> 00:24:48,800
pretty big dust storms as long as we

712
00:24:53,980 --> 00:24:50,660
don't hit kind of the the storm front if

713
00:24:55,330 --> 00:24:53,990

you will of a dust storm if it's a you

714
00:24:57,100 --> 00:24:55,340
know as long as we're not so lucky that

715
00:24:59,080 --> 00:24:57,110
we manage to not just be there at the

716
00:25:00,790 --> 00:24:59,090
right time and right place to hit the

717
00:25:02,650 --> 00:25:00,800
front of a storm we feel pretty

718
00:25:04,540 --> 00:25:02,660
confident that we'd be okay but that

719
00:25:06,940 --> 00:25:04,550
being said we don't really expect a dust

720
00:25:09,280 --> 00:25:06,950
storm global dust storm anyway in our

721
00:25:14,080 --> 00:25:09,290
season at our site it just doesn't

722
00:25:15,610 --> 00:25:14,090
happen hasn't happened at Mars now

723
00:25:17,740 --> 00:25:15,620
cheryl has almost like a follow-up

724
00:25:19,420 --> 00:25:17,750
question to that on twitter and she says

725
00:25:22,090 --> 00:25:19,430
has the team done anything differently

726
00:25:25,990 --> 00:25:22,100
this time to protect perseverance from

727
00:25:28,900 --> 00:25:26,000
that Martian dust we haven't done a

728
00:25:30,190 --> 00:25:28,910
whole lot differently this time out you

729
00:25:31,960 --> 00:25:30,200
could also be thinking about the fact

730
00:25:34,570 --> 00:25:31,970
that on curiosity we blew around some

731
00:25:37,090 --> 00:25:34,580
pebbles and some ended up on the on the

732
00:25:39,220 --> 00:25:37,100
top the rover and maybe maybe it was

733
00:25:40,570 --> 00:25:39,230
related some damage certainly what we

734
00:25:42,340 --> 00:25:40,580
did was characterize what we saw in

735
00:25:43,810 --> 00:25:42,350
curiosity this isn't necessarily dust

736
00:25:45,370 --> 00:25:43,820
that's floating around the atmosphere

737
00:25:47,290 --> 00:25:45,380
the stuff that's kicked up around

738
00:25:49,180 --> 00:25:47,300

skycrane even though the sense Dage is

739
00:25:51,280 --> 00:25:49,190
pretty high and high enough that that

740
00:25:54,430 --> 00:25:51,290
we're not causing a ton of things lying

741
00:25:56,080 --> 00:25:54,440
around some some do so we made sure this

742
00:25:58,840 --> 00:25:56,090
time to make sure that the rover was

743
00:26:00,400 --> 00:25:58,850
design such that there shouldn't be too

744
00:26:01,870 --> 00:26:00,410
many vulnerabilities associated with

745
00:26:03,430 --> 00:26:01,880
those particles that we could be lifting

746
00:26:07,630 --> 00:26:03,440
through our engines being thrown around

747
00:26:09,400 --> 00:26:07,640
at the rover during sky crane and like

748
00:26:11,920 --> 00:26:09,410
we've mentioned before it seems very

749
00:26:13,990 --> 00:26:11,930
similar looking at MSL looking at

750
00:26:15,040 --> 00:26:14,000
curiosity and at perseverance but

751
00:26:16,870 --> 00:26:15,050
there's been some really great

752
00:26:19,600 --> 00:26:16,880
modifications to the wheels that'll be

753
00:26:21,910 --> 00:26:19,610
helpful absolutely those wheels are

754
00:26:23,260 --> 00:26:21,920
there's definitely little thicker I like

755
00:26:25,120 --> 00:26:23,270
to think of them as our landing gear and

756
00:26:29,320 --> 00:26:25,130
not so much as wheels but they were

757
00:26:31,900 --> 00:26:29,330
craters on our landing gear all right

758
00:26:35,380 --> 00:26:31,910
now we've also got a great question from

759
00:26:37,840 --> 00:26:35,390
Ross onic on YouTube asking in the

760
00:26:39,850 --> 00:26:37,850
unfortunate event of a failed landing is

761
00:26:42,340 --> 00:26:39,860
the video of the entry descent and

762
00:26:44,530 --> 00:26:42,350
landing being uploaded in real time to

763
00:26:47,670 --> 00:26:44,540

an orbiter so we can still see it or

764
00:26:50,110 --> 00:26:47,680
does it require a successful landing

765
00:26:52,180 --> 00:26:50,120
that's a great question unfortunately

766
00:26:54,820 --> 00:26:52,190
the the bandwidth that we have to send

767
00:26:56,350 --> 00:26:54,830
back from the vehicle during during

768
00:26:59,260 --> 00:26:56,360
entry descent landing the stream that we

769
00:27:00,250 --> 00:26:59,270
have is about 8 kilobits per second if

770
00:27:02,140 --> 00:27:00,260
you're old enough like me to remember

771
00:27:04,450 --> 00:27:02,150
dial-up that's even slower than a lot of

772
00:27:06,010 --> 00:27:04,460
people's dial-up back in the day so we

773
00:27:07,480 --> 00:27:06,020
don't have the ability to send back

774
00:27:09,520 --> 00:27:07,490
those pictures from the EDL camera

775
00:27:11,920 --> 00:27:09,530
system during entry descent landing we

776
00:27:13,120 --> 00:27:11,930
do have to land successfully that 8

777
00:27:14,890 --> 00:27:13,130
kilobits stream though is full

778
00:27:16,240 --> 00:27:14,900
chock-full of data that will help us

779
00:27:18,190 --> 00:27:16,250
figure out what's wrong that's the

780
00:27:20,410 --> 00:27:18,200
purpose really of the entry descent and

781
00:27:21,730 --> 00:27:20,420
landing comm is to make sure that if

782
00:27:23,050 --> 00:27:21,740
something goes wrong we know what

783
00:27:26,830 --> 00:27:23,060
happens so that we can fix it to the

784
00:27:30,360 --> 00:27:26,840
future now this isn't your first rodeo

785
00:27:33,210 --> 00:27:30,370
this will be your settle landing and

786
00:27:36,070 --> 00:27:33,220
Nicolas wants to know are there any

787
00:27:39,910 --> 00:27:36,080
communications involved with your entry

788
00:27:42,370 --> 00:27:39,920

system in terms of whether those

789
00:27:43,780 --> 00:27:42,380
communications involved during EDL the

790
00:27:45,580 --> 00:27:43,790
the one thing we should all keep in mind

791
00:27:47,770 --> 00:27:45,590
of course is that at least for our

792
00:27:49,600 --> 00:27:47,780
opportunity when we get there the

793
00:27:51,430 --> 00:27:49,610
one-way light time the time it takes for

794
00:27:52,930 --> 00:27:51,440
the radio waves to get from Mars is

795
00:27:55,870 --> 00:27:52,940
going to be about 10 and a half minutes

796
00:27:58,240 --> 00:27:55,880
so by the time that we find out that the

797
00:27:59,860 --> 00:27:58,250
spacecraft has hit the entry point it's

798
00:28:02,290 --> 00:27:59,870
gonna have been on the ground for about

799
00:28:04,090 --> 00:28:02,300
three and a half minutes given that ten

800
00:28:06,040 --> 00:28:04,100
and a half minute ten and a half minute

801
00:28:08,630 --> 00:28:06,050
delay so there is no choice ticking I

802
00:28:11,210 --> 00:28:08,640
mean try to imagine driving your

803
00:28:14,120 --> 00:28:11,220
your RC car with a ten minute delay

804
00:28:16,430 --> 00:28:14,130
between what you see and your commands

805
00:28:18,170 --> 00:28:16,440
back to it no spit you no perseverance

806
00:28:20,120 --> 00:28:18,180
is gonna have to do this on our own we

807
00:28:24,800 --> 00:28:20,130
have no ability to control it at that

808
00:28:27,380 --> 00:28:24,810
point we can get it ready before yes I'm

809
00:28:30,140 --> 00:28:27,390
sorry about that oh no that's okay

810
00:28:32,290 --> 00:28:30,150
yeah and now my on YouTube asks how much

811
00:28:34,940 --> 00:28:32,300
of the entire ADL system is

812
00:28:36,530 --> 00:28:34,950
pre-programmed and how much is changed

813
00:28:39,050 --> 00:28:36,540

on the fly which I guess is a nice

814
00:28:40,760 --> 00:28:39,060
follow up yeah that's a good pop I mean

815
00:28:43,310 --> 00:28:40,770
again the the entry descent landing

816
00:28:45,260 --> 00:28:43,320
sequence itself is pre-programmed and

817
00:28:47,300 --> 00:28:45,270
the spacecraft has to handle ID that

818
00:28:50,330 --> 00:28:47,310
being said it is pretty adjustable we

819
00:28:51,830 --> 00:28:50,340
can change things prior to entry if we

820
00:28:53,600 --> 00:28:51,840
need to we can adjust things like

821
00:28:56,930 --> 00:28:53,610
actually the landing target if we want

822
00:28:59,030 --> 00:28:56,940
to we can adjust we can adjust the

823
00:29:00,140 --> 00:28:59,040
parachute deploy conditions there's a

824
00:29:02,360 --> 00:29:00,150
lot of things that we can adjust with

825
00:29:04,700 --> 00:29:02,370
the vehicle and in fact that connects

826
00:29:06,680 --> 00:29:04,710
back to the activities before landing in

827
00:29:09,290 --> 00:29:06,690
that week before landing pretty much

828
00:29:10,730 --> 00:29:09,300
everything that we're doing is getting

829
00:29:12,800 --> 00:29:10,740
the spacecraft ready to land

830
00:29:14,780 --> 00:29:12,810
that means monitoring the spacecraft

831
00:29:16,040 --> 00:29:14,790
making sure that it's doing the things

832
00:29:17,660 --> 00:29:16,050
that need to do like heating up

833
00:29:19,880 --> 00:29:17,670
different elements of it warming them up

834
00:29:21,380 --> 00:29:19,890
for ETL it also means doing small

835
00:29:22,670 --> 00:29:21,390
maneuvers with the crew stage to make

836
00:29:25,010 --> 00:29:22,680
sure that were the right place to start

837
00:29:27,440 --> 00:29:25,020
ETL and it also means telling the

838
00:29:29,660 --> 00:29:27,450

spacecraft exactly where it is we kind

839
00:29:31,760 --> 00:29:29,670
of navigate during during cruise during

840
00:29:33,650 --> 00:29:31,770
that portion between launch and and

841
00:29:34,880 --> 00:29:33,660
hitting the top of the atmosphere by

842
00:29:36,890 --> 00:29:34,890
staring in the rear view mirror using

843
00:29:39,290 --> 00:29:36,900
the deep space network to do radiometric

844
00:29:41,120 --> 00:29:39,300
navigation using radio signals to

845
00:29:43,370 --> 00:29:41,130
understand where we are and we want to

846
00:29:44,930 --> 00:29:43,380
give the spacecraft the its best

847
00:29:46,610 --> 00:29:44,940
information about where it is at the

848
00:29:48,380 --> 00:29:46,620
start of EDL because it's going to use

849
00:29:53,420 --> 00:29:48,390
that to fly to the target in the

850
00:29:55,850 --> 00:29:53,430
atmosphere MTF see video channel on

851
00:29:58,220 --> 00:29:55,860
youtube asks how nervous will you be

852
00:30:00,200 --> 00:29:58,230
waiting for that signal to finally come

853
00:30:02,480 --> 00:30:00,210
back from perseverance excited to I'm

854
00:30:04,550 --> 00:30:02,490
sure yeah no it's definitely

855
00:30:06,020 --> 00:30:04,560
nerve-wracking right it's it's an open

856
00:30:07,760 --> 00:30:06,030
book it's a test that everyone gets to

857
00:30:09,830 --> 00:30:07,770
see the answer to and no one cares more

858
00:30:11,300 --> 00:30:09,840
than you I think at the time right it's

859
00:30:12,560 --> 00:30:11,310
nerve-wracking because you know you just

860
00:30:15,100 --> 00:30:12,570
go over all the things that could go

861
00:30:16,790 --> 00:30:15,110
wrong you know every minute right it's

862
00:30:18,890 --> 00:30:16,800
you know it's one of those situations

863
00:30:20,750 --> 00:30:18,900

where you want to believe that you've

864
00:30:22,040 --> 00:30:20,760
you know you can you can be there and be

865
00:30:22,440 --> 00:30:22,050
calm because you've done everything you

866
00:30:24,299 --> 00:30:22,450
can

867
00:30:25,590 --> 00:30:24,309
to make sure that you have a good day

868
00:30:27,840 --> 00:30:25,600
but you know there are things that are

869
00:30:29,609 --> 00:30:27,850
beyond your control you know things like

870
00:30:32,369 --> 00:30:29,619
the atmosphere at mars and another

871
00:30:34,889 --> 00:30:32,379
challenges that might be out there so

872
00:30:39,119 --> 00:30:34,899
you know you never can never feel really

873
00:30:41,220 --> 00:30:39,129
good until you're down safely yes I'm

874
00:30:43,259 --> 00:30:41,230
sure it's gonna feel very good now Jimin

875
00:30:45,539 --> 00:30:43,269
who's a six year old asks what is your

876
00:30:47,970 --> 00:30:45,549
favorite discovery or picture from

877
00:30:52,049 --> 00:30:47,980
curiosity and what are you looking

878
00:30:53,729 --> 00:30:52,059
forward to on perseverance I'm gonna

879
00:30:56,249 --> 00:30:53,739
cheat and actually say that my favorite

880
00:30:57,720 --> 00:30:56,259
picture is actually of curiosity from

881
00:31:00,149 --> 00:30:57,730
curiosity from the Mars Reconnaissance

882
00:31:02,789 --> 00:31:00,159
Orbiter there's a picture that people

883
00:31:04,169 --> 00:31:02,799
may have seen of Marshall concert

884
00:31:06,869 --> 00:31:04,179
orbiter which was providing us entry

885
00:31:08,609 --> 00:31:06,879
descent and communications but also took

886
00:31:10,259 --> 00:31:08,619
a picture of us on our way down with

887
00:31:12,330 --> 00:31:10,269
with curiosity you see that parachute

888
00:31:13,470 --> 00:31:12,340

deployed as we're descending so I think

889
00:31:15,419 --> 00:31:13,480
that's a that's certainly one of my

890
00:31:17,729 --> 00:31:15,429
favorite pictures but from the surface I

891
00:31:19,560 --> 00:31:17,739
loved seeing all the all the places that

892
00:31:21,419 --> 00:31:19,570
we've gone to in the years since right

893
00:31:22,440 --> 00:31:21,429
it's it's interesting to work on

894
00:31:25,080 --> 00:31:22,450
something for ten years

895
00:31:26,849 --> 00:31:25,090
land it and then kind of walk away but

896
00:31:29,399 --> 00:31:26,859
with the knowledge though that it's

897
00:31:31,169 --> 00:31:29,409
still going even even now we can still

898
00:31:33,330 --> 00:31:31,179
see pictures from curiosity every day so

899
00:31:34,769 --> 00:31:33,340
that's that's what I'm excited about but

900
00:31:36,299 --> 00:31:34,779
for perseverance I'm excited to get all

901
00:31:38,460 --> 00:31:36,309
that data that we're gonna get from the

902
00:31:40,320 --> 00:31:38,470
EDL camera system I really want to know

903
00:31:43,619 --> 00:31:40,330
what it looks like to to land on Mars

904
00:31:45,570 --> 00:31:43,629
while you're doing it that's pretty

905
00:31:47,580 --> 00:31:45,580
amazing it's gonna be great to see the

906
00:31:48,960 --> 00:31:47,590
first pictures ever of that well thank

907
00:31:50,820 --> 00:31:48,970
you so much for all of these who tuned

908
00:31:53,190 --> 00:31:50,830
in on social media your questions were

909
00:31:56,879 --> 00:31:53,200
awesome and thank you for joining us

910
00:31:57,979 --> 00:31:56,889
today al and good February thank you

911
00:32:01,259 --> 00:31:57,989
very much

912
00:32:03,690 --> 00:32:01,269
the launch period for Mars 2020 opens on

913
00:32:07,049 --> 00:32:03,700

July 17th and the rover is slated to

914
00:32:09,539 --> 00:32:07,059
land on the Red Planet February 18 20 21

915
00:32:11,849 --> 00:32:09,549
now for the latest on the mission follow

916
00:32:13,649 --> 00:32:11,859
us here at NASA persevere on both

917
00:32:15,720 --> 00:32:13,659
Twitter and Facebook and you can watch

918
00:32:19,229 --> 00:32:15,730
all of the behind the spacecraft video

919
00:32:20,909 --> 00:32:19,239
profiles they are on NASA 360s YouTube

920
00:32:23,820 --> 00:32:20,919
channel we're going to be doing these

921
00:32:26,700 --> 00:32:23,830
question and answers with Mars 2020 each

922
00:32:29,310 --> 00:32:26,710
Thursday at 1 p.m. Pacific 4 p.m.

923
00:32:31,440 --> 00:32:29,320
Eastern for the next few weeks as we are

924
00:32:33,149 --> 00:32:31,450
awaiting launch coming up in a couple of

925
00:32:33,779 --> 00:32:33,159
months if you want to explore the

926
00:32:35,639 --> 00:32:33,789
universe

927
00:32:38,070 --> 00:32:35,649
the comfort of your home check out our

928
00:32:41,009 --> 00:32:38,080
NASA at home activities for families and

929
00:32:44,489 --> 00:32:41,019
kids of all ages you can find them on

930
00:32:46,830 --> 00:32:44,499
the nasa.gov home page until then thank