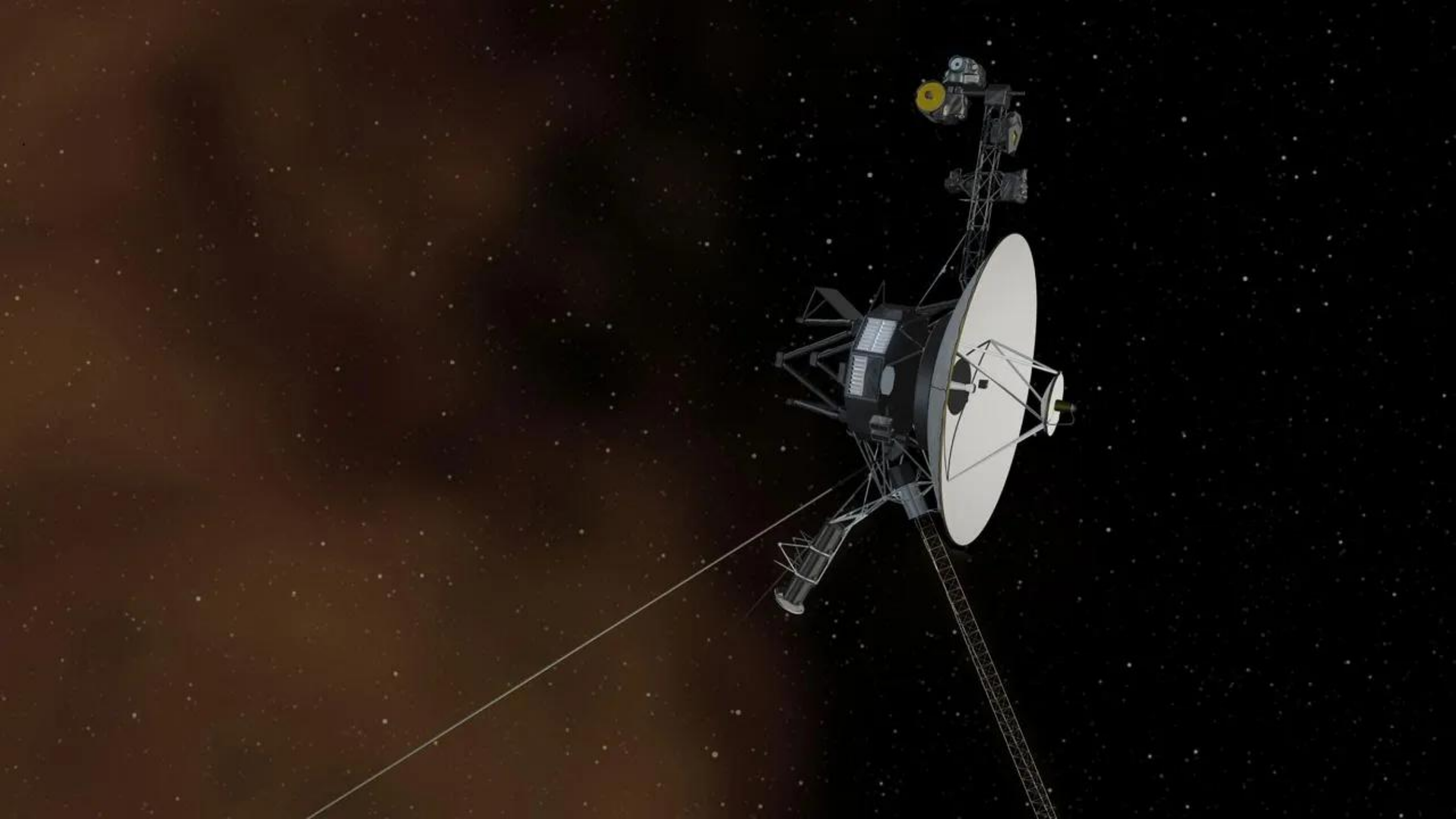

1
00:00:03,429 --> 00:00:01,510
[Music]

2
00:00:05,030 --> 00:00:03,439
nasa's jet propulsion laboratory

3
00:00:07,670 --> 00:00:05,040
presents

4
00:00:09,750 --> 00:00:07,680
the von karman lecture a series of talks

5
00:00:13,030 --> 00:00:09,760
by scientists and engineers who are

6
00:00:18,060 --> 00:00:13,040
exploring our planet our solar system

7
00:00:18,070 --> 00:00:30,710
[Music]

8
00:00:34,549 --> 00:00:32,549
hello everyone and a very pleasant good

9
00:00:36,310 --> 00:00:34,559
evening to you wherever you may be i am

10
00:00:38,549 --> 00:00:36,320
brian white from jpl's office of

11
00:00:41,670 --> 00:00:38,559
communications and education and welcome

12
00:00:44,389 --> 00:00:41,680
to the von carmen series tonight

13
00:00:47,430 --> 00:00:44,399

a discussion 45 years in the making

14
00:00:49,190 --> 00:00:47,440
in 1977 the twin voyager spacecraft left

15
00:00:52,470 --> 00:00:49,200
planet earth to meet a solar system

16
00:00:54,869 --> 00:00:52,480
alignment that only occurs every 176

17
00:00:56,470 --> 00:00:54,879
years and in doing so

18
00:00:58,630 --> 00:00:56,480
taught us more about our universe than

19
00:01:00,310 --> 00:00:58,640
we could have ever imagined over these

20
00:01:02,790 --> 00:01:00,320
generations an incredible team of

21
00:01:04,710 --> 00:01:02,800
engineers and scientists have guided and

22
00:01:06,950 --> 00:01:04,720
cared for these spacecraft keeping them

23
00:01:10,149 --> 00:01:06,960
operational through planetary encounters

24
00:01:12,149 --> 00:01:10,159
the heliopause and interstellar space

25
00:01:14,149 --> 00:01:12,159
voyager has captured our imagination

26
00:01:16,310 --> 00:01:14,159
it's expanded our universe understanding

27
00:01:17,990 --> 00:01:16,320
of the universe and inspired us to push

28
00:01:19,350 --> 00:01:18,000
beyond the limits of what was once

29
00:01:20,950 --> 00:01:19,360
thought possible

30
00:01:23,109 --> 00:01:20,960
i'd like to introduce our questions

31
00:01:24,710 --> 00:01:23,119
co-host tonight uh media relations

32
00:01:26,469 --> 00:01:24,720
specialist here at jpl please welcome

33
00:01:27,830 --> 00:01:26,479
calla cofield

34
00:01:30,230 --> 00:01:27,840
thanks brian

35
00:01:32,870 --> 00:01:30,240
and everyone watching remember that this

36
00:01:35,429 --> 00:01:32,880
is your space program we want you to be

37
00:01:37,590 --> 00:01:35,439
involved in the conversation tonight

38
00:01:40,550 --> 00:01:37,600

so if you're watching on youtube

39
00:01:42,870 --> 00:01:40,560
facebook live or linkedin ask questions

40
00:01:45,350 --> 00:01:42,880
in the chat box and our social media

41
00:01:47,670 --> 00:01:45,360
team will bring in as many as we can

42
00:01:49,910 --> 00:01:47,680
during our talk tonight if you do not

43
00:01:53,350 --> 00:01:49,920
see the chat box just refresh the page

44
00:01:57,109 --> 00:01:54,870
thank you very much cal we're looking

45
00:01:59,749 --> 00:01:57,119
forward to that q a tonight

46
00:02:01,190 --> 00:01:59,759
tonight we're joined by jpl's director

47
00:02:03,030 --> 00:02:01,200
for the interplanetary network

48
00:02:04,550 --> 00:02:03,040
directorate the home organization of

49
00:02:06,870 --> 00:02:04,560
nasa's deep space network and

50
00:02:09,109 --> 00:02:06,880
multi-mission ground system and services

51
00:02:10,869 --> 00:02:09,119
programs she has over 35 years of

52
00:02:12,869 --> 00:02:10,879
experience in spacecraft operations

53
00:02:14,070 --> 00:02:12,879
serving in project manager roles she has

54
00:02:15,910 --> 00:02:14,080
worked in the mission planning and

55
00:02:18,630 --> 00:02:15,920
uplink operations on the cassini mission

56
00:02:21,350 --> 00:02:18,640
to saturn the mars observer project in

57
00:02:23,270 --> 00:02:21,360
voyager 2's flyby of uranus and neptune

58
00:02:25,190 --> 00:02:23,280
she is the recipient of a nasa

59
00:02:27,110 --> 00:02:25,200
exceptional service medal nasa public

60
00:02:29,430 --> 00:02:27,120
service medal nasa's silver achievement

61
00:02:32,229 --> 00:02:29,440
medal and nasa outstanding leadership

62
00:02:34,229 --> 00:02:32,239
medal she is the project manager for the

63
00:02:37,589 --> 00:02:34,239

voyager interstellar mission a role she

64
00:02:39,350 --> 00:02:37,599
has had since 2010 please welcome

65
00:02:41,030 --> 00:02:39,360
suzanne dodd

66
00:02:43,270 --> 00:02:41,040
hi you suzanne

67
00:02:46,229 --> 00:02:43,280
hey brian how are you tonight

68
00:02:48,630 --> 00:02:46,239
i'm fantastic i love this spacecraft but

69
00:02:49,910 --> 00:02:48,640
let's get started with yeah let's get

70
00:02:51,910 --> 00:02:49,920
started with how you got here how did

71
00:02:54,470 --> 00:02:51,920
you get involved with voyager

72
00:02:57,910 --> 00:02:54,480
wow well voyager was the beginning of my

73
00:03:00,070 --> 00:02:57,920
career uh it's it's really

74
00:03:02,229 --> 00:03:00,080
fun to look back on it fun and a little

75
00:03:04,949 --> 00:03:02,239
bit scary to know how long i've been

76
00:03:07,750 --> 00:03:04,959
working but

77
00:03:09,750 --> 00:03:07,760
no i um i started working on voyager

78
00:03:10,670 --> 00:03:09,760
right out of college

79
00:03:16,229 --> 00:03:10,680
in

80
00:03:19,830 --> 00:03:16,239
ahead of my graduation

81
00:03:22,949 --> 00:03:19,840
and i joined the project um

82
00:03:25,030 --> 00:03:22,959
before the uranus encounter and i stayed

83
00:03:27,589 --> 00:03:25,040
on through the neptune encounter i i was

84
00:03:30,309 --> 00:03:27,599
not on at launch and i didn't was not

85
00:03:33,509 --> 00:03:30,319
involved with the jupiter or saturn

86
00:03:36,470 --> 00:03:33,519
flybys but but i i came in there was a

87
00:03:38,470 --> 00:03:36,480
five-year gap between um

88
00:03:40,869 --> 00:03:38,480

saturn and uranus and and so the

89
00:03:43,670 --> 00:03:40,879
staffing went down but then it came back

90
00:03:46,309 --> 00:03:43,680
up and i was on that that wave of people

91
00:03:49,910 --> 00:03:46,319
that came in to catch the last two

92
00:03:52,630 --> 00:03:50,869
um

93
00:03:55,750 --> 00:03:52,640
we've talked about this in our kind of

94
00:03:57,270 --> 00:03:55,760
planning preparation for this talk about

95
00:03:59,190 --> 00:03:57,280
that time in between but also by the

96
00:04:01,350 --> 00:03:59,200
time we visited jupiter and saturn there

97
00:04:03,350 --> 00:04:01,360
was an aspirational nature

98
00:04:06,710 --> 00:04:03,360
about this mission there is a kind of a

99
00:04:09,350 --> 00:04:06,720
long-term joyful goal about this

100
00:04:10,630 --> 00:04:09,360
um yeah yeah i think

101
00:04:14,630 --> 00:04:10,640
you know

102
00:04:17,749 --> 00:04:14,640
voyager is really nineteen

103
00:04:20,310 --> 00:04:17,759
mid 70s technology the heritage is is

104
00:04:22,150 --> 00:04:20,320
based on viking

105
00:04:23,430 --> 00:04:22,160
heritage and

106
00:04:26,150 --> 00:04:23,440
design

107
00:04:28,550 --> 00:04:26,160
and uh the one

108
00:04:29,430 --> 00:04:28,560
the one you mentioned in your intro that

109
00:04:30,629 --> 00:04:29,440
uh

110
00:04:31,510 --> 00:04:30,639
voyager

111
00:04:34,629 --> 00:04:31,520
was

112
00:04:36,790 --> 00:04:34,639
launched at this very unique opportunity

113
00:04:40,230 --> 00:04:36,800

to be able to get to all the outer

114
00:04:43,189 --> 00:04:40,240
planets of our solar system uh all

115
00:04:44,230 --> 00:04:43,199
jupiter saturn uranus and neptune

116
00:04:47,110 --> 00:04:44,240
so

117
00:04:49,270 --> 00:04:47,120
and then it would continue on out uh as

118
00:04:51,670 --> 00:04:49,280
we know now today not certainly when we

119
00:04:53,430 --> 00:04:51,680
launched it but as we know now today it

120
00:04:55,110 --> 00:04:53,440
it actually would cross into

121
00:04:58,070 --> 00:04:55,120
interstellar space

122
00:04:59,510 --> 00:04:58,080
so the aspiration is

123
00:05:03,029 --> 00:04:59,520
is is

124
00:05:04,870 --> 00:05:03,039
how can we build this spacecraft to

125
00:05:07,510 --> 00:05:04,880
to make that

126
00:05:12,070 --> 00:05:07,520
decades-long journey and

127
00:05:14,870 --> 00:05:12,080
what can we put on it to represent us

128
00:05:16,550 --> 00:05:14,880
uh to represent the earth and if you if

129
00:05:18,950 --> 00:05:16,560
you go to

130
00:05:20,870 --> 00:05:18,960
um image 21

131
00:05:23,749 --> 00:05:20,880
you know one of the key things is and

132
00:05:25,749 --> 00:05:23,759
this was done very late uh in the

133
00:05:26,870 --> 00:05:25,759
development of the mission but the gold

134
00:05:30,070 --> 00:05:26,880
record

135
00:05:33,990 --> 00:05:30,080
got put on to the onto the spacecraft

136
00:05:35,430 --> 00:05:34,000
uh it represents a time capsule of us

137
00:05:38,629 --> 00:05:35,440
here on earth

138
00:05:40,390 --> 00:05:38,639

um what we were feeling uh

139
00:05:42,629 --> 00:05:40,400
the different cultures the different

140
00:05:44,469 --> 00:05:42,639
music the different sounds of the planet

141
00:05:46,710 --> 00:05:44,479
earth and it was stuck on

142
00:05:49,670 --> 00:05:46,720
voyager both voyager spacecraft and and

143
00:05:53,430 --> 00:05:49,680
it was put on as a as a time capsule

144
00:05:55,990 --> 00:05:53,440
to be found sometime in the future

145
00:05:58,550 --> 00:05:56,000
by whatever beings might be out there

146
00:06:00,550 --> 00:05:58,560
and and um

147
00:06:02,629 --> 00:06:00,560
that part of doing that was an

148
00:06:06,230 --> 00:06:02,639
aspiration you know let's take a piece

149
00:06:08,230 --> 00:06:06,240
of us here on earth and send it out uh

150
00:06:12,309 --> 00:06:08,240
into interstellar space which which

151
00:06:16,710 --> 00:06:14,710
i we talk about that aspirational nature

152
00:06:18,070 --> 00:06:16,720
and we talk about 45 years later and

153
00:06:20,550 --> 00:06:18,080
we're still talking about it we're still

154
00:06:22,230 --> 00:06:20,560
communicating with it but if we could

155
00:06:25,510 --> 00:06:22,240
jump back in time

156
00:06:27,350 --> 00:06:25,520
um what really was voyager's original

157
00:06:28,790 --> 00:06:27,360
mission you kind of hinted at it but how

158
00:06:30,950 --> 00:06:28,800
did it start

159
00:06:35,189 --> 00:06:30,960
mission was only for four years it was

160
00:06:38,629 --> 00:06:35,199
just uh uh to fly by it was literally it

161
00:06:40,309 --> 00:06:38,639
was just a fly by um jupiter and saturn

162
00:06:42,469 --> 00:06:40,319
and that was its

163
00:06:44,309 --> 00:06:42,479

level one requirement that nasa had for

164
00:06:45,270 --> 00:06:44,319
it um

165
00:06:47,430 --> 00:06:45,280
but

166
00:06:49,749 --> 00:06:47,440
they knew if they put

167
00:06:52,150 --> 00:06:49,759
if they were successful they had a they

168
00:06:53,510 --> 00:06:52,160
had a key target of one of the moons at

169
00:06:55,749 --> 00:06:53,520
saturn and if they knew they were

170
00:06:57,189 --> 00:06:55,759
successful with voyager 1 flying by it

171
00:06:57,990 --> 00:06:57,199
then they could

172
00:06:59,990 --> 00:06:58,000
uh

173
00:07:02,870 --> 00:07:00,000
send voyager 2 on a slightly different

174
00:07:07,830 --> 00:07:02,880
trajectory which would get out to uranus

175
00:07:09,510 --> 00:07:07,840
and also out to um neptune and um

176
00:07:11,430 --> 00:07:09,520
that's exactly what happened we were

177
00:07:14,150 --> 00:07:11,440
successful with voyager 1 and getting

178
00:07:16,469 --> 00:07:14,160
all the science back that we wanted from

179
00:07:18,870 --> 00:07:16,479
from saturn and so voyager 2 was set on

180
00:07:19,990 --> 00:07:18,880
a different path that was able to

181
00:07:22,710 --> 00:07:20,000
acquire

182
00:07:24,469 --> 00:07:22,720
uh data from uranus and neptune and and

183
00:07:25,830 --> 00:07:24,479
think about it today you know uranus and

184
00:07:29,350 --> 00:07:25,840
neptune were

185
00:07:32,710 --> 00:07:29,360
in flybys in 86 and 89 we have not sent

186
00:07:34,309 --> 00:07:32,720
a spacecraft back to those prod planets

187
00:07:36,710 --> 00:07:34,319
since then

188
00:07:38,150 --> 00:07:36,720

um there's there's hopes that we can do

189
00:07:40,629 --> 00:07:38,160
that in the next

190
00:07:43,350 --> 00:07:40,639
10 to 15 years but

191
00:07:45,430 --> 00:07:43,360
um it's really amazing that that

192
00:07:48,230 --> 00:07:45,440
voyager was able to accomplish

193
00:07:51,990 --> 00:07:48,240
uh a flyby of four planets but also that

194
00:07:53,909 --> 00:07:52,000
that no one has sent a planet back there

195
00:07:55,990 --> 00:07:53,919
we didn't know anything about uranus or

196
00:07:57,749 --> 00:07:56,000
neptune uh what we would see what we

197
00:07:59,430 --> 00:07:57,759
would experience and

198
00:08:02,150 --> 00:07:59,440
everything that we know about that from

199
00:08:04,629 --> 00:08:02,160
a close flyby

200
00:08:08,309 --> 00:08:04,639
of the planet is is voyager data for

201
00:08:10,070 --> 00:08:08,319
those two uh planets in particular

202
00:08:11,589 --> 00:08:10,080
well let's kind of keep talking about

203
00:08:13,110 --> 00:08:11,599
that a little bit

204
00:08:14,790 --> 00:08:13,120
because

205
00:08:16,550 --> 00:08:14,800
the mission has changed kind of even

206
00:08:17,589 --> 00:08:16,560
with those original things there was it

207
00:08:19,830 --> 00:08:17,599
seemed like it was in the back of

208
00:08:22,309 --> 00:08:19,840
everybody's mind to keep going but how

209
00:08:25,189 --> 00:08:22,319
is it kept changing over the if you say

210
00:08:26,629 --> 00:08:25,199
four years and now 45 that's continuous

211
00:08:29,110 --> 00:08:26,639
change

212
00:08:32,550 --> 00:08:29,120
yeah certainly um

213
00:08:34,230 --> 00:08:32,560

you can you you can see it early on um

214
00:08:35,829 --> 00:08:34,240
you know i came on for the uranus

215
00:08:37,350 --> 00:08:35,839
encounter

216
00:08:39,589 --> 00:08:37,360
and since the mission was designed for

217
00:08:40,990 --> 00:08:39,599
jupiter and saturn we had to make

218
00:08:42,469 --> 00:08:41,000
adjustments to

219
00:08:44,949 --> 00:08:42,479
[Music]

220
00:08:47,110 --> 00:08:44,959
account for both the longer

221
00:08:49,670 --> 00:08:47,120
distances between the planet and the

222
00:08:52,310 --> 00:08:49,680
earth the communication distances

223
00:08:54,550 --> 00:08:52,320
we had to make adjustments

224
00:08:57,110 --> 00:08:54,560
for the light levels certainly neptune

225
00:08:59,829 --> 00:08:57,120
is a much uh the sun is much darker at

226
00:09:02,070 --> 00:08:59,839
neptune than it is at jupiter or saturn

227
00:09:04,790 --> 00:09:02,080
so we did some engineering changes to

228
00:09:07,670 --> 00:09:04,800
the software in order to adjust for the

229
00:09:10,949 --> 00:09:07,680
different light levels at those planets

230
00:09:12,230 --> 00:09:10,959
and um as you can continue out you

231
00:09:13,509 --> 00:09:12,240
certainly the biggest challenge that

232
00:09:15,350 --> 00:09:13,519
voyager has

233
00:09:16,949 --> 00:09:15,360
uh well i should say one of the biggest

234
00:09:18,630 --> 00:09:16,959
challenges voyager has we have a lot of

235
00:09:20,150 --> 00:09:18,640
challenges we're we're getting we're

236
00:09:23,590 --> 00:09:20,160
getting up there in years so we have a

237
00:09:26,550 --> 00:09:23,600
lot of challenges but um you know one of

238
00:09:29,750 --> 00:09:26,560

them is one of them is our our distance

239
00:09:31,269 --> 00:09:29,760
where uh ward you one is is 15 billion

240
00:09:34,949 --> 00:09:31,279
miles from us

241
00:09:36,630 --> 00:09:34,959
uh the one way light time there is is 21

242
00:09:37,509 --> 00:09:36,640
hours so

243
00:09:40,389 --> 00:09:37,519
uh

244
00:09:42,550 --> 00:09:40,399
we can't communicate very quickly with

245
00:09:45,990 --> 00:09:42,560
it and we and the data rates are very

246
00:09:48,150 --> 00:09:46,000
very low 160 bits per second is is the

247
00:09:51,509 --> 00:09:48,160
the data that we get back

248
00:09:54,710 --> 00:09:51,519
and we have to use nearly every antenna

249
00:09:57,990 --> 00:09:54,720
at a dsn complex so a 70 meter and three

250
00:09:59,030 --> 00:09:58,000
34 meter antennas all arrayed together

251
00:10:01,509 --> 00:09:59,040
to get

252
00:10:02,710 --> 00:10:01,519
get 160 bits back because of our

253
00:10:07,269 --> 00:10:02,720
distance

254
00:10:10,389 --> 00:10:07,279
challenge really uh requires the

255
00:10:12,949 --> 00:10:10,399
spacecraft to be very autonomous and um

256
00:10:15,190 --> 00:10:12,959
to have to have uh fault protection

257
00:10:18,630 --> 00:10:15,200
where it can um

258
00:10:21,430 --> 00:10:18,640
uh put itself in a safe state and

259
00:10:26,069 --> 00:10:21,440
not expect to be commanded right away

260
00:10:28,870 --> 00:10:26,079
uh and and um we have to have processes

261
00:10:31,110 --> 00:10:28,880
and procedures on the ground where where

262
00:10:33,110 --> 00:10:31,120
we can get enough information from this

263
00:10:35,750 --> 00:10:33,120

sort of trickle of data that we know how

264
00:10:36,630 --> 00:10:35,760
to to fix anything that might go go

265
00:10:38,790 --> 00:10:36,640
wrong

266
00:10:41,910 --> 00:10:38,800
um you know one of the things we did

267
00:10:43,990 --> 00:10:41,920
after the neptune flyby is we repurposed

268
00:10:46,230 --> 00:10:44,000
the the memory that was being used by

269
00:10:47,670 --> 00:10:46,240
all the imaging instruments so the

270
00:10:49,990 --> 00:10:47,680
instruments that would take pictures of

271
00:10:52,230 --> 00:10:50,000
the planets

272
00:10:53,910 --> 00:10:52,240
there's nothing to take pictures of

273
00:10:56,550 --> 00:10:53,920
where voyager is

274
00:10:57,269 --> 00:10:56,560
once it left neptune

275
00:11:00,870 --> 00:10:57,279
so

276
00:11:02,790 --> 00:11:00,880
instruments

277
00:11:04,790 --> 00:11:02,800
one that saves us power but two that

278
00:11:07,190 --> 00:11:04,800
saves us memory and we repurpose that

279
00:11:09,990 --> 00:11:07,200
memory to be able to put

280
00:11:12,230 --> 00:11:10,000
a standard routine of activities on the

281
00:11:15,110 --> 00:11:12,240
spacecraft so that the spacecraft just

282
00:11:16,949 --> 00:11:15,120
is in essentially a loop of executing

283
00:11:18,230 --> 00:11:16,959
all those activities over and over and

284
00:11:19,190 --> 00:11:18,240
over again

285
00:11:27,110 --> 00:11:19,200
um

286
00:11:29,590 --> 00:11:27,120
we're getting very limited on our power

287
00:11:30,870 --> 00:11:29,600
so where we've been turning off backup

288
00:11:32,949 --> 00:11:30,880

systems

289
00:11:34,870 --> 00:11:32,959
and uh

290
00:11:36,470 --> 00:11:34,880
doing some power management that

291
00:11:38,310 --> 00:11:36,480
involves uh

292
00:11:40,470 --> 00:11:38,320
only having certain systems alternating

293
00:11:42,230 --> 00:11:40,480
systems on and off with each other so

294
00:11:44,710 --> 00:11:42,240
they're not both on at the same time

295
00:11:45,750 --> 00:11:44,720
taking too much power and so that's it's

296
00:11:48,069 --> 00:11:45,760
a key

297
00:11:50,230 --> 00:11:48,079
um one of the key resources we manage

298
00:11:52,470 --> 00:11:50,240
now is is the power because the power

299
00:11:53,670 --> 00:11:52,480
margin levels are very low

300
00:11:55,190 --> 00:11:53,680
and the other one is actually the

301
00:11:56,389 --> 00:11:55,200
temperature because it's very cold where

302
00:11:59,590 --> 00:11:56,399
voyager is

303
00:12:00,870 --> 00:11:59,600
and uh we need the

304
00:12:03,269 --> 00:12:00,880
propellant

305
00:12:05,509 --> 00:12:03,279
that the the thrusters use in order to

306
00:12:07,829 --> 00:12:05,519
keep the antenna pointed at the earth we

307
00:12:09,430 --> 00:12:07,839
need that propellant not to freeze

308
00:12:11,430 --> 00:12:09,440
because if it did our antenna would

309
00:12:13,990 --> 00:12:11,440
would drift off the earth and then we

310
00:12:15,590 --> 00:12:14,000
wouldn't have any more communications so

311
00:12:18,150 --> 00:12:15,600
that's that kind of gives you an example

312
00:12:20,470 --> 00:12:18,160
brian of some of the things we we

313
00:12:22,310 --> 00:12:20,480

work with and and are challenged with

314
00:12:23,750 --> 00:12:22,320
today

315
00:12:25,509 --> 00:12:23,760
i want to i want to take a step back to

316
00:12:27,750 --> 00:12:25,519
some of the

317
00:12:29,829 --> 00:12:27,760
you talked about the imaging and and the

318
00:12:31,990 --> 00:12:29,839
neptune encounter um

319
00:12:33,910 --> 00:12:32,000
i i want to talk about that

320
00:12:35,829 --> 00:12:33,920
neptune encounter and kind of the vibe

321
00:12:37,910 --> 00:12:35,839
and the feel i don't know if there's

322
00:12:40,710 --> 00:12:37,920
there are too many things that kind of

323
00:12:42,389 --> 00:12:40,720
mimic that today with science and pop

324
00:12:45,910 --> 00:12:42,399
culture

325
00:12:48,710 --> 00:12:45,920
yeah i um it was just so such an

326
00:12:50,710 --> 00:12:48,720
electric atmosphere here at jpl and i

327
00:12:51,750 --> 00:12:50,720
think a lot of it had to do with a sense

328
00:12:55,269 --> 00:12:51,760
of

329
00:12:57,190 --> 00:12:55,279
one these were flybys right so so uh we

330
00:12:59,030 --> 00:12:57,200
never seen these planets and in

331
00:13:00,230 --> 00:12:59,040
particular neptune is is really one of

332
00:13:02,949 --> 00:13:00,240
my favorites

333
00:13:06,310 --> 00:13:02,959
um i got to be involved with um the

334
00:13:09,030 --> 00:13:06,320
closest approach sequence for that

335
00:13:10,870 --> 00:13:09,040
and it was it's really something i look

336
00:13:12,629 --> 00:13:10,880
back on as a highlight of my

337
00:13:13,590 --> 00:13:12,639
professional career

338
00:13:14,870 --> 00:13:13,600

um

339
00:13:16,230 --> 00:13:14,880
but the way they did the press

340
00:13:18,310 --> 00:13:16,240
conferences

341
00:13:20,870 --> 00:13:18,320
during the voyager days is the press

342
00:13:23,030 --> 00:13:20,880
actually came to jpl they don't do that

343
00:13:25,509 --> 00:13:23,040
anymore right everybody's kind of like

344
00:13:26,389 --> 00:13:25,519
we are right now everybody's zooming or

345
00:13:28,550 --> 00:13:26,399
you know

346
00:13:30,710 --> 00:13:28,560
talking through computers but they were

347
00:13:33,110 --> 00:13:30,720
there and they were in person

348
00:13:34,870 --> 00:13:33,120
and we actually have an example of that

349
00:13:38,470 --> 00:13:34,880
if we bring up image 11 we can kind of

350
00:13:42,629 --> 00:13:40,310
yeah so uh

351
00:13:45,110 --> 00:13:42,639
this image shows ed stone being

352
00:13:47,670 --> 00:13:45,120
interviewed by several press members and

353
00:13:49,990 --> 00:13:47,680
and it was about a two-week period where

354
00:13:51,110 --> 00:13:50,000
the they would have a 10 a.m press

355
00:13:52,389 --> 00:13:51,120
conference

356
00:13:53,590 --> 00:13:52,399
every morning

357
00:13:59,189 --> 00:13:53,600
and

358
00:14:01,430 --> 00:13:59,199
the latest images

359
00:14:03,829 --> 00:14:01,440
and and von carmen they did it in von

360
00:14:06,389 --> 00:14:03,839
carmen and the auditorium was full

361
00:14:08,949 --> 00:14:06,399
every day it was full um

362
00:14:10,949 --> 00:14:08,959
and you know before

363
00:14:12,949 --> 00:14:10,959

before that they had to bring in trail

364
00:14:17,030 --> 00:14:12,959
they brought trailers in for the press

365
00:14:19,030 --> 00:14:17,040
to to stay in and um you could see

366
00:14:20,629 --> 00:14:19,040
some of the really uh you know i would

367
00:14:22,389 --> 00:14:20,639
say walter cronk right but some of the

368
00:14:24,949 --> 00:14:22,399
more famous um

369
00:14:26,310 --> 00:14:24,959
you know reporters come and be

370
00:14:27,750 --> 00:14:26,320
interviewed and

371
00:14:30,949 --> 00:14:27,760
interviewing people on the mall or

372
00:14:34,150 --> 00:14:30,959
interviewing people out in the

373
00:14:36,230 --> 00:14:34,160
in front of the jpl sign as you drive in

374
00:14:37,910 --> 00:14:36,240
and uh you know there are a lot of

375
00:14:40,470 --> 00:14:37,920
reporters around there was a lot of

376
00:14:42,150 --> 00:14:40,480
scientists there was a lot of activities

377
00:14:44,150 --> 00:14:42,160
and it went on for about two weeks so

378
00:14:45,590 --> 00:14:44,160
it's you know it was really exciting day

379
00:14:47,590 --> 00:14:45,600
it was great to come to work i think

380
00:14:49,829 --> 00:14:47,600
everybody felt like it was fabulous to

381
00:14:51,829 --> 00:14:49,839
come to jpl and see all this and have

382
00:14:52,550 --> 00:14:51,839
all this excitement and activity going

383
00:14:57,990 --> 00:14:52,560
on

384
00:15:00,790 --> 00:14:58,000
that you're hooked i mean you never

385
00:15:01,750 --> 00:15:00,800
you don't get that feeling in very many

386
00:15:04,150 --> 00:15:01,760
um

387
00:15:06,389 --> 00:15:04,160
uh professions i would say and and i

388
00:15:09,350 --> 00:15:06,399

think if you if you're at all inclined

389
00:15:11,030 --> 00:15:09,360
to liking space uh just

390
00:15:13,110 --> 00:15:11,040
being able to see

391
00:15:16,710 --> 00:15:13,120
the work you've done

392
00:15:17,910 --> 00:15:16,720
uh having it execute um

393
00:15:19,189 --> 00:15:17,920
and you know you have to cross your

394
00:15:21,590 --> 00:15:19,199
fingers when you send commands to the

395
00:15:24,230 --> 00:15:21,600
spacecraft it doesn't always it doesn't

396
00:15:27,110 --> 00:15:24,240
always work but in this case you know it

397
00:15:28,949 --> 00:15:27,120
was very basically flawless for for

398
00:15:29,590 --> 00:15:28,959
essentially for the neptune encounter

399
00:15:30,629 --> 00:15:29,600
and

400
00:15:33,670 --> 00:15:30,639
just

401
00:15:34,710 --> 00:15:33,680
really rewarding to have your work

402
00:15:37,110 --> 00:15:34,720
um

403
00:15:38,870 --> 00:15:37,120
you know shown and people being excited

404
00:15:41,030 --> 00:15:38,880
about it and it's really the whole world

405
00:15:42,069 --> 00:15:41,040
i mean voyager has touched the whole

406
00:15:44,230 --> 00:15:42,079
world

407
00:15:46,790 --> 00:15:44,240
um and it's just led to so much more

408
00:15:48,870 --> 00:15:46,800
science discoveries

409
00:15:50,310 --> 00:15:48,880
i i want to i want to stay with neptune

410
00:15:52,310 --> 00:15:50,320
for a moment because i know you've got a

411
00:15:53,269 --> 00:15:52,320
little memorabilia from that encounter

412
00:15:54,949 --> 00:15:53,279
and i

413
00:15:57,269 --> 00:15:54,959

it made me very happy when you showed me

414
00:16:00,389 --> 00:15:57,279
i just want to show the world

415
00:16:03,269 --> 00:16:00,399
okay you want to see my so if you go

416
00:16:05,910 --> 00:16:03,279
actually go to picture uh

417
00:16:08,150 --> 00:16:05,920
13 right

418
00:16:10,470 --> 00:16:08,160
so one of the one of the other really

419
00:16:11,509 --> 00:16:10,480
fun parts about the neptune encounter

420
00:16:13,590 --> 00:16:11,519
was

421
00:16:15,749 --> 00:16:13,600
uh and this is a good image of it we had

422
00:16:18,470 --> 00:16:15,759
a party after the neptune encounter it

423
00:16:21,350 --> 00:16:18,480
was sponsored by the planetary society

424
00:16:23,030 --> 00:16:21,360
and that is actually chuck berry the the

425
00:16:26,790 --> 00:16:23,040
real chuck berry

426
00:16:30,069 --> 00:16:26,800
on the steps of the uh in front of the

427
00:16:31,990 --> 00:16:30,079
mall in front of our uh 180 which is the

428
00:16:32,790 --> 00:16:32,000
the building that the lab director lives

429
00:16:38,550 --> 00:16:32,800
in

430
00:16:41,030 --> 00:16:38,560
be good is the hit song on um

431
00:16:42,550 --> 00:16:41,040
on uh well i shouldn't say the hit song

432
00:16:43,749 --> 00:16:42,560
one of the songs

433
00:16:44,949 --> 00:16:43,759
on uh

434
00:16:49,269 --> 00:16:44,959
on

435
00:16:53,590 --> 00:16:49,279
they handed out at uh

436
00:16:57,430 --> 00:16:53,600
at that event is a little gold coin

437
00:16:59,430 --> 00:16:57,440
and uh it's it's uh

438
00:17:01,350 --> 00:16:59,440

signed or signed it should say there's

439
00:17:03,430 --> 00:17:01,360
it's limited edition so the back of it

440
00:17:05,909 --> 00:17:03,440
has a number on it you probably can't

441
00:17:06,710 --> 00:17:05,919
see that but i've i've kept this you

442
00:17:08,390 --> 00:17:06,720
know

443
00:17:11,829 --> 00:17:08,400
all along and

444
00:17:13,270 --> 00:17:11,839
it really reminds me a lot about how

445
00:17:16,470 --> 00:17:13,280
how much

446
00:17:19,110 --> 00:17:16,480
encounter

447
00:17:21,429 --> 00:17:19,120
means to me and means to me

448
00:17:23,829 --> 00:17:21,439
professionally but also um

449
00:17:25,669 --> 00:17:23,839
just you know as a human being and being

450
00:17:29,350 --> 00:17:25,679
feeling like you're able to

451
00:17:34,630 --> 00:17:29,360
contribute to society uh i you know you

452
00:17:37,110 --> 00:17:34,640
uh i think um yeah i i i had kids around

453
00:17:39,190 --> 00:17:37,120
right after that and you know their

454
00:17:40,310 --> 00:17:39,200
science books have pictures that voyager

455
00:17:42,549 --> 00:17:40,320
took in them

456
00:17:43,750 --> 00:17:42,559
they still do today because neptune is

457
00:17:45,750 --> 00:17:43,760
probably

458
00:17:48,870 --> 00:17:45,760
there's no other good images of neptune

459
00:17:49,830 --> 00:17:48,880
taken by a spacecraft voyager is it

460
00:17:51,909 --> 00:17:49,840
um

461
00:17:54,390 --> 00:17:51,919
so anyway it's just a

462
00:17:56,470 --> 00:17:54,400
it's it's very humbling and

463
00:17:59,190 --> 00:17:56,480

really fun to be part of the excitement

464
00:18:03,510 --> 00:17:59,200
of a planetary mission in i think

465
00:18:07,270 --> 00:18:05,590
it it does um

466
00:18:09,350 --> 00:18:07,280
i want to come back to that societal

467
00:18:11,430 --> 00:18:09,360
impact but i want to i want to stay with

468
00:18:15,510 --> 00:18:11,440
neptune for just a half second

469
00:18:17,830 --> 00:18:15,520
because that encounter happened and then

470
00:18:19,669 --> 00:18:17,840
how long until we got to interstellar

471
00:18:22,390 --> 00:18:19,679
space

472
00:18:24,950 --> 00:18:22,400
yeah um so then voyager encounter was in

473
00:18:26,789 --> 00:18:24,960
august of 1980 i'm sorry

474
00:18:30,070 --> 00:18:26,799
yeah the voyager encounter with neptune

475
00:18:31,270 --> 00:18:30,080
was in august of 1989.

476
00:18:33,990 --> 00:18:31,280
um

477
00:18:34,870 --> 00:18:34,000
i actually left the project after that

478
00:18:36,870 --> 00:18:34,880
and

479
00:18:39,430 --> 00:18:36,880
worked on mars observer i worked on

480
00:18:41,669 --> 00:18:39,440
cassini i worked on spitzer and i didn't

481
00:18:43,350 --> 00:18:41,679
come back till 20 years later

482
00:18:45,909 --> 00:18:43,360
and the project was still traveling

483
00:18:48,390 --> 00:18:45,919
through the heliosphere so when they

484
00:18:51,190 --> 00:18:48,400
when they sold the uh

485
00:18:54,150 --> 00:18:51,200
interstellar mission in 1990 they

486
00:18:56,710 --> 00:18:54,160
they basically said oh it's about 50 a.u

487
00:18:58,549 --> 00:18:56,720
we that's where we think the uh you'll

488
00:19:00,950 --> 00:18:58,559

cross uh

489
00:19:03,350 --> 00:19:00,960
the heliopause into interstellar space

490
00:19:04,870 --> 00:19:03,360
and and you know that's another

491
00:19:07,990 --> 00:19:04,880
i'll try to do the calculation that's

492
00:19:10,310 --> 00:19:08,000
another five to seven eight years or

493
00:19:12,310 --> 00:19:10,320
something like that well it was we

494
00:19:13,350 --> 00:19:12,320
crossed at 121

495
00:19:17,190 --> 00:19:13,360
a.u

496
00:19:20,470 --> 00:19:17,200
it took us 22 years to cross

497
00:19:22,390 --> 00:19:20,480
from 1990 tonight to 2012 before we

498
00:19:23,750 --> 00:19:22,400
crossed interstellar space

499
00:19:25,029 --> 00:19:23,760
um

500
00:19:27,669 --> 00:19:25,039
and i think voyager was kind of

501
00:19:28,630 --> 00:19:27,679
forgotten for probably all of those 20

502
00:19:30,789 --> 00:19:28,640
years

503
00:19:32,710 --> 00:19:30,799
we a lot of the same people worked on it

504
00:19:34,549 --> 00:19:32,720
obviously this the staff was very

505
00:19:36,310 --> 00:19:34,559
downsized from the

506
00:19:37,430 --> 00:19:36,320
the multiple hundreds of people that

507
00:19:40,070 --> 00:19:37,440
worked it

508
00:19:43,669 --> 00:19:40,080
during the neptune encounter i know it

509
00:19:44,789 --> 00:19:43,679
got skinny down to maybe 50 or 60

510
00:19:47,110 --> 00:19:44,799
for for

511
00:19:49,750 --> 00:19:47,120
for the next 10 years and and then it

512
00:19:52,789 --> 00:19:49,760
got skinny down to like about 15 and

513
00:19:56,230 --> 00:19:52,799

really where we are is in the 12 to 15

514
00:19:58,470 --> 00:19:56,240
range of of engineers

515
00:20:00,549 --> 00:19:58,480
who support voyager and voyager is two

516
00:20:02,549 --> 00:20:00,559
spacecrafts it's not just one spacecraft

517
00:20:05,190 --> 00:20:02,559
it's two spacecraft that are still

518
00:20:10,870 --> 00:20:07,830
so that's a that's a very small

519
00:20:12,470 --> 00:20:10,880
group of very very dedicated

520
00:20:15,029 --> 00:20:12,480
engineers with

521
00:20:15,830 --> 00:20:15,039
um really now a very unique knowledge

522
00:20:17,830 --> 00:20:15,840
set

523
00:20:18,630 --> 00:20:17,840
so um

524
00:20:26,149 --> 00:20:18,640
it's

525
00:20:27,669 --> 00:20:26,159
the the hard work of the

526
00:20:32,390 --> 00:20:27,679
current engineers who have been on the

527
00:20:36,070 --> 00:20:34,630
so let's let's talk about what that is

528
00:20:37,990 --> 00:20:36,080
today how do you

529
00:20:39,669 --> 00:20:38,000
with that decades of knowledge what is a

530
00:20:41,909 --> 00:20:39,679
general day in the life of the voyager

531
00:20:44,630 --> 00:20:41,919
team right now

532
00:20:46,789 --> 00:20:44,640
well um we have a daily status meeting

533
00:20:50,710 --> 00:20:46,799
which i think the project has done from

534
00:20:54,710 --> 00:20:52,950
most of the time you know it can run

535
00:20:56,710 --> 00:20:54,720
anywhere from five minutes it's like a

536
00:20:58,549 --> 00:20:56,720
morning meeting a morning tag up meeting

537
00:21:01,110 --> 00:20:58,559
it runs anywhere from five minutes if

538
00:21:03,590 --> 00:21:01,120

everything looks good to to an hour if

539
00:21:05,510 --> 00:21:03,600
we have longer discussions and and

540
00:21:08,310 --> 00:21:05,520
actually in the last

541
00:21:10,230 --> 00:21:08,320
couple years you know we we've we've

542
00:21:11,909 --> 00:21:10,240
we've made one of the meetings be more

543
00:21:14,390 --> 00:21:11,919
of an engineering focus meaning where

544
00:21:17,350 --> 00:21:14,400
their longer discussions about trade

545
00:21:19,110 --> 00:21:17,360
studies and uh things we're working on

546
00:21:19,990 --> 00:21:19,120
presentations on the different

547
00:21:21,750 --> 00:21:20,000
um

548
00:21:23,510 --> 00:21:21,760
uh engineering changes we could

549
00:21:25,350 --> 00:21:23,520
potentially do

550
00:21:27,350 --> 00:21:25,360
um but there's still these sort of

551
00:21:30,549 --> 00:21:27,360
five-minute stand-up status meetings

552
00:21:32,230 --> 00:21:30,559
that go on just just to check in what's

553
00:21:34,789 --> 00:21:32,240
what's the next set of commands we're

554
00:21:36,630 --> 00:21:34,799
doing how did the dsn perform during

555
00:21:37,909 --> 00:21:36,640
this last pass

556
00:21:40,789 --> 00:21:37,919
um

557
00:21:42,470 --> 00:21:40,799
yeah that's the

558
00:21:45,669 --> 00:21:42,480
and beyond that then i think the

559
00:21:48,230 --> 00:21:45,679
engineers spend their time doing

560
00:21:49,669 --> 00:21:48,240
um sequencing building the next sequence

561
00:21:51,510 --> 00:21:49,679
and then also

562
00:21:53,510 --> 00:21:51,520
um a lot of it now now it's a lot of

563
00:21:57,029 --> 00:21:53,520

analysis about how we can make this

564
00:21:59,990 --> 00:21:57,039
spacecraft last as long as possible and

565
00:22:03,830 --> 00:22:00,000
go ahead as far as we can

566
00:22:05,909 --> 00:22:03,840
into the interstellar medium

567
00:22:08,230 --> 00:22:05,919
well and as you've talked about with me

568
00:22:10,230 --> 00:22:08,240
before that it's also sending back still

569
00:22:12,230 --> 00:22:10,240
great science information there's it's

570
00:22:13,430 --> 00:22:12,240
still very much an alive mission in that

571
00:22:14,870 --> 00:22:13,440
sense too

572
00:22:17,110 --> 00:22:14,880
right right i mean we don't fly

573
00:22:19,029 --> 00:22:17,120
spacecraft just to fly spacecraft um

574
00:22:20,789 --> 00:22:19,039
yeah some some people probably wish we

575
00:22:22,230 --> 00:22:20,799
did but that's not that's not why nasa

576
00:22:23,750 --> 00:22:22,240
does that we fly spacecraft to get

577
00:22:26,789 --> 00:22:23,760
science data back

578
00:22:28,870 --> 00:22:26,799
so so as voyager traveled away

579
00:22:31,430 --> 00:22:28,880
um from neptune

580
00:22:32,710 --> 00:22:31,440
it got further and further away from the

581
00:22:35,590 --> 00:22:32,720
sun

582
00:22:38,310 --> 00:22:35,600
and um

583
00:22:41,029 --> 00:22:38,320
eventually in 2012 it it crossed the

584
00:22:42,470 --> 00:22:41,039
heliopause now the heliopause is

585
00:22:44,549 --> 00:22:42,480
is where

586
00:22:48,149 --> 00:22:44,559
the effects of the charged particles

587
00:22:50,070 --> 00:22:48,159
from our sun stop and we start sensing

588
00:22:53,510 --> 00:22:50,080

charged particles from interstellar

589
00:22:56,310 --> 00:22:53,520
space and interstellar space is really

590
00:22:59,350 --> 00:22:56,320
the gas and dust that's left over from

591
00:23:00,870 --> 00:22:59,360
exploded stars and uh

592
00:23:03,750 --> 00:23:00,880
uh

593
00:23:06,950 --> 00:23:03,760
you know that all the creation that's

594
00:23:09,750 --> 00:23:06,960
going on out there beyond our little

595
00:23:12,950 --> 00:23:09,760
cocoon of of the sun

596
00:23:15,750 --> 00:23:12,960
so voyager has taken data really

597
00:23:17,669 --> 00:23:15,760
actually really since the earth but all

598
00:23:20,710 --> 00:23:17,679
the way out to where it is now 15

599
00:23:23,590 --> 00:23:20,720
billion miles away it's taken data on

600
00:23:27,110 --> 00:23:23,600
how these charged particles change first

601
00:23:29,669 --> 00:23:27,120
first within our heliosphere and now as

602
00:23:32,310 --> 00:23:29,679
we go further and further away from our

603
00:23:33,590 --> 00:23:32,320
heliosphere how does the magnetic field

604
00:23:37,190 --> 00:23:33,600
of the sun

605
00:23:38,789 --> 00:23:37,200
interact with interstellar space

606
00:23:40,870 --> 00:23:38,799
what's the difference in the energy

607
00:23:42,549 --> 00:23:40,880
levels of these charged particles how

608
00:23:45,350 --> 00:23:42,559
many are there

609
00:23:48,870 --> 00:23:45,360
and um you know all all of those

610
00:23:50,630 --> 00:23:48,880
questions that voyager is answering

611
00:23:53,430 --> 00:23:50,640
impact sort of the shape of our

612
00:23:55,269 --> 00:23:53,440
heliosphere um traditionally the

613
00:23:57,350 --> 00:23:55,279

heliosphere has been viewed as a

614
00:24:00,070 --> 00:23:57,360
basically uh um

615
00:24:02,149 --> 00:24:00,080
like an ellipse or a comet shape where

616
00:24:04,710 --> 00:24:02,159
the sun is at one end and the

617
00:24:07,430 --> 00:24:04,720
interstellar wind is is blowing out the

618
00:24:09,430 --> 00:24:07,440
other other other direction

619
00:24:12,230 --> 00:24:09,440
but with foragers information we can

620
00:24:14,549 --> 00:24:12,240
take that data and and make a model

621
00:24:16,630 --> 00:24:14,559
where it's much rounder

622
00:24:18,710 --> 00:24:16,640
um and there's also a model where it's

623
00:24:20,950 --> 00:24:18,720
more like a croissant it kind of has two

624
00:24:26,470 --> 00:24:20,960
tails instead of one

625
00:24:26,480 --> 00:24:28,870
and

626
00:24:32,870 --> 00:24:31,590
it's it's the importance of the data now

627
00:24:34,230 --> 00:24:32,880
is that it's

628
00:24:37,430 --> 00:24:34,240
it's

629
00:24:39,350 --> 00:24:37,440
continuing to get that record of change

630
00:24:41,510 --> 00:24:39,360
over time

631
00:24:43,510 --> 00:24:41,520
and you know just like no spacecraft has

632
00:24:45,110 --> 00:24:43,520
gone back to uranus and neptune it's

633
00:24:47,110 --> 00:24:45,120
going to take 50 years for any

634
00:24:49,110 --> 00:24:47,120
spacecraft to get back to

635
00:24:53,029 --> 00:24:49,120
to where voyager is now

636
00:24:53,039 --> 00:24:56,549
okay

637
00:24:59,990 --> 00:24:58,230
this is kind of this this image right

638
00:25:02,870 --> 00:25:00,000

here sort of shows you has

639
00:25:04,950 --> 00:25:02,880
where as we're leaving uh what the

640
00:25:07,830 --> 00:25:04,960
different the color schemes represent

641
00:25:09,990 --> 00:25:07,840
sort of the different um

642
00:25:11,990 --> 00:25:10,000
the different aspects of

643
00:25:16,230 --> 00:25:12,000
the charged particles and the density of

644
00:25:18,630 --> 00:25:17,430
excellent

645
00:25:20,789 --> 00:25:18,640
i i'm

646
00:25:23,909 --> 00:25:20,799
just so amazed by the science that's

647
00:25:25,029 --> 00:25:23,919
still coming through i'm amazed by

648
00:25:27,430 --> 00:25:25,039
the team

649
00:25:29,190 --> 00:25:27,440
and as you mentioned before about

650
00:25:30,950 --> 00:25:29,200
their science books that have these

651
00:25:33,430 --> 00:25:30,960
images in it

652
00:25:35,990 --> 00:25:33,440
the societal impact of this

653
00:25:38,070 --> 00:25:36,000
you get some pretty fun

654
00:25:42,710 --> 00:25:38,080
fan mail

655
00:25:43,430 --> 00:25:42,720
with you yeah i do it is it is fun um i

656
00:25:47,190 --> 00:25:43,440
i

657
00:25:50,070 --> 00:25:47,200
saved uh

658
00:25:52,390 --> 00:25:50,080
i got a um

659
00:25:55,669 --> 00:25:52,400
i got a note from

660
00:25:57,990 --> 00:25:55,679
a young girl like a four-year-old girl

661
00:26:00,390 --> 00:25:58,000
in germany her mother actually wrote the

662
00:26:02,789 --> 00:26:00,400
note but it came with a picture it came

663
00:26:03,909 --> 00:26:02,799

with a picture of voyager 3

664
00:26:06,789 --> 00:26:03,919
and she

665
00:26:09,190 --> 00:26:06,799
she this this girl was describing all

666
00:26:11,909 --> 00:26:09,200
the instruments on on what that should

667
00:26:13,909 --> 00:26:11,919
be a voyager three and one of them was a

668
00:26:15,669 --> 00:26:13,919
uh a vacuum cleaner because we need to

669
00:26:16,870 --> 00:26:15,679
sweep up the dust and understand what's

670
00:26:19,430 --> 00:26:16,880
in the dust and

671
00:26:22,630 --> 00:26:19,440
and literally she's exactly right you

672
00:26:24,870 --> 00:26:22,640
know if you if you dumb down

673
00:26:27,269 --> 00:26:24,880
you know a fancy instrument it's a

674
00:26:28,870 --> 00:26:27,279
vacuum cleaner you know we want to we

675
00:26:30,470 --> 00:26:28,880
want to see what the dust particles are

676
00:26:31,909 --> 00:26:30,480
made of we want to capture some and see

677
00:26:33,909 --> 00:26:31,919
what they're made of that's not what

678
00:26:36,470 --> 00:26:33,919
voyager 102 are doing but it would be a

679
00:26:39,029 --> 00:26:36,480
great thing for voyager 3 to do

680
00:26:41,029 --> 00:26:39,039
um you know so i have i have a a

681
00:26:43,269 --> 00:26:41,039
four-year-old in germany which again

682
00:26:46,549 --> 00:26:43,279
shows the the wide range of people in

683
00:26:49,430 --> 00:26:46,559
the world that that uh look to voyager

684
00:26:50,870 --> 00:26:49,440
for their inspiration but i also get i

685
00:26:53,990 --> 00:26:50,880
get a a

686
00:26:55,110 --> 00:26:54,000
fan mail from a person a gentleman in

687
00:26:56,470 --> 00:26:55,120
um

688
00:26:57,590 --> 00:26:56,480

texas

689
00:26:59,750 --> 00:26:57,600
who

690
00:27:02,710 --> 00:26:59,760
is probably he didn't really give his

691
00:27:05,990 --> 00:27:02,720
age but i had to guess he's probably 80

692
00:27:08,149 --> 00:27:06,000
to 90. he sent me a five dollar bill he

693
00:27:10,630 --> 00:27:08,159
said i really really love the work that

694
00:27:13,029 --> 00:27:10,640
you're doing with voyager and i want to

695
00:27:15,830 --> 00:27:13,039
buy you a cup of coffee and a doughnut

696
00:27:18,950 --> 00:27:15,840
and he sent me a five dollar bill um i

697
00:27:21,590 --> 00:27:18,960
returned it uh with some nice

698
00:27:23,590 --> 00:27:21,600
with some nice swag and i said thank you

699
00:27:25,510 --> 00:27:23,600
so much i mean your your letter is

700
00:27:27,750 --> 00:27:25,520
enough to to

701
00:27:29,430 --> 00:27:27,760
to make me feel good about what i do and

702
00:27:31,830 --> 00:27:29,440
and thank you for your interest in

703
00:27:35,190 --> 00:27:31,840
voyager but it's

704
00:27:36,630 --> 00:27:35,200
i it's great it it's it's great

705
00:27:38,630 --> 00:27:36,640
i've had people send me pictures of

706
00:27:41,110 --> 00:27:38,640
their voyager tattoos

707
00:27:43,430 --> 00:27:41,120
um i won't go into too much detail here

708
00:27:45,110 --> 00:27:43,440
brian but

709
00:27:46,830 --> 00:27:45,120
there are people with voyager tattoos

710
00:27:48,470 --> 00:27:46,840
that are very proud of them

711
00:27:50,630 --> 00:27:48,480
so

712
00:27:52,230 --> 00:27:50,640
well i want to i want to get to that

713
00:27:54,149 --> 00:27:52,240

public i want to get to the folks that

714
00:27:57,110 --> 00:27:54,159
are that are tuning in right now and i

715
00:27:58,710 --> 00:27:57,120
want to see how the q a is is going so

716
00:28:00,070 --> 00:27:58,720
cala how's the conversation going out

717
00:28:02,549 --> 00:28:00,080
there

718
00:28:04,549 --> 00:28:02,559
we have so many wonderful questions

719
00:28:06,950 --> 00:28:04,559
coming in um people just want to know

720
00:28:08,789 --> 00:28:06,960
about every aspect of this mission

721
00:28:11,510 --> 00:28:08,799
there's a whole bunch of questions just

722
00:28:13,190 --> 00:28:11,520
about communicating with the spacecraft

723
00:28:17,029 --> 00:28:13,200
and you know how

724
00:28:19,510 --> 00:28:17,039
that's changing um so larae on twitter

725
00:28:21,350 --> 00:28:19,520
just asks what's the length of time to

726
00:28:23,029 --> 00:28:21,360
send and receive a message to the

727
00:28:25,110 --> 00:28:23,039
voyagers

728
00:28:28,149 --> 00:28:25,120
yeah i sort of alluded to that earlier

729
00:28:30,630 --> 00:28:28,159
but it's um for voyager 1 is traveling

730
00:28:32,230 --> 00:28:30,640
faster it it and it's further out

731
00:28:34,149 --> 00:28:32,240
voyager 2 is never going to catch

732
00:28:37,669 --> 00:28:34,159
voyager 1 so if we just

733
00:28:40,470 --> 00:28:37,679
talk about the furthest out mission um

734
00:28:42,149 --> 00:28:40,480
it's uh one-way light time so the time

735
00:28:46,549 --> 00:28:42,159
it takes a signal to go from the earth

736
00:28:48,470 --> 00:28:46,559
to the spacecraft is over 21 hours

737
00:28:52,310 --> 00:28:48,480
what that means that is that the round

738
00:28:53,990 --> 00:28:52,320

to right time is 42 hours so it's nearly

739
00:28:56,630 --> 00:28:54,000
two days from the time you send a

740
00:28:58,470 --> 00:28:56,640
command to the time you receive

741
00:29:00,710 --> 00:28:58,480
an answer from the spacecraft that it

742
00:29:02,230 --> 00:29:00,720
got the command

743
00:29:03,990 --> 00:29:02,240
and if you think about it you know

744
00:29:05,029 --> 00:29:04,000
talking to the moon is maybe three

745
00:29:06,789 --> 00:29:05,039
seconds

746
00:29:09,269 --> 00:29:06,799
talking to mars is

747
00:29:09,990 --> 00:29:09,279
is 20 minutes

748
00:29:12,789 --> 00:29:10,000
so

749
00:29:13,830 --> 00:29:12,799
you know we're measured in multiple days

750
00:29:15,269 --> 00:29:13,840
now

751
00:29:16,950 --> 00:29:15,279
um

752
00:29:19,990 --> 00:29:16,960
at very low data rates so we can't

753
00:29:22,549 --> 00:29:20,000
really say much either

754
00:29:24,230 --> 00:29:22,559
but that's that's a challenge and again

755
00:29:26,710 --> 00:29:24,240
it means that the spacecraft has to be

756
00:29:27,990 --> 00:29:26,720
very autonomous and do a lot on its on

757
00:29:29,269 --> 00:29:28,000
its own

758
00:29:30,789 --> 00:29:29,279
and that's how we've

759
00:29:32,470 --> 00:29:30,799
restructured the

760
00:29:36,549 --> 00:29:32,480
mission and for the spacecraft to be

761
00:29:41,990 --> 00:29:39,590
and on a similar note rob on facebook

762
00:29:44,230 --> 00:29:42,000
asks uh because you mentioned earlier

763
00:29:46,630 --> 00:29:44,240

that the the signal is getting fainter

764
00:29:47,830 --> 00:29:46,640
the further these things go from us and

765
00:29:50,230 --> 00:29:47,840
and you mentioned that you have to

766
00:29:53,830 --> 00:29:50,240
configure all of the antennas at these

767
00:29:55,830 --> 00:29:53,840
dsm sites so is there a limit how long

768
00:29:58,230 --> 00:29:55,840
do you think you'll be able to get a

769
00:30:01,909 --> 00:29:58,240
signal from voyager

770
00:30:02,710 --> 00:30:01,919
um there is a well there is a limit but

771
00:30:05,269 --> 00:30:02,720
uh

772
00:30:08,070 --> 00:30:05,279
there's also the ability to

773
00:30:09,830 --> 00:30:08,080
add add antennas in on the ground to

774
00:30:11,669 --> 00:30:09,840
array more antennas the deep space

775
00:30:12,789 --> 00:30:11,679
network is actually expanding they're

776
00:30:15,990 --> 00:30:12,799
putting in a

777
00:30:17,830 --> 00:30:16,000
a fourth 34 meter antenna at each of

778
00:30:21,430 --> 00:30:17,840
their sites

779
00:30:24,470 --> 00:30:21,440
and uh we'll be able to array four

780
00:30:28,070 --> 00:30:24,480
meters with a 70 meter and that gives us

781
00:30:29,029 --> 00:30:28,080
uh three or four or five more years

782
00:30:32,070 --> 00:30:29,039
and

783
00:30:33,590 --> 00:30:32,080
um but there is a limit there is a limit

784
00:30:37,269 --> 00:30:33,600
but uh

785
00:30:39,190 --> 00:30:37,279
we're probably not gonna hit that or if

786
00:30:41,750 --> 00:30:39,200
we get close to that let's let me just

787
00:30:44,149 --> 00:30:41,760
say it this way if we get close to that

788
00:30:46,470 --> 00:30:44,159

limit we'll just keep adding more assets

789
00:30:50,230 --> 00:30:46,480
on the ground we'll find a way to array

790
00:30:51,669 --> 00:30:50,240
other antennas you know we can array um

791
00:30:54,230 --> 00:30:51,679
maybe something like the very large

792
00:30:55,510 --> 00:30:54,240
array with the dsn we've done some of

793
00:30:57,190 --> 00:30:55,520
that in the past

794
00:30:59,350 --> 00:30:57,200
the neptune encounter actually they did

795
00:31:00,549 --> 00:30:59,360
some arraying of of of

796
00:31:02,950 --> 00:31:00,559
antennas

797
00:31:05,990 --> 00:31:02,960
that don't belong to the dsn with the

798
00:31:09,190 --> 00:31:06,000
dsn antennas just to get that very faint

799
00:31:11,590 --> 00:31:09,200
um signal of data out so i don't i don't

800
00:31:13,909 --> 00:31:11,600
think that the ground is going to be a

801
00:31:16,870 --> 00:31:13,919
limiting factor to the to the life of

802
00:31:21,509 --> 00:31:19,990
well on that note uh abigail on facebook

803
00:31:23,750 --> 00:31:21,519
asked a question that i'm sure a lot of

804
00:31:26,710 --> 00:31:23,760
people want to know how far do you think

805
00:31:27,750 --> 00:31:26,720
the voyagers will go

806
00:31:30,389 --> 00:31:27,760
well

807
00:31:32,149 --> 00:31:30,399
again there's two spacecraft so

808
00:31:35,430 --> 00:31:32,159
that in itself is amazing that we have

809
00:31:38,310 --> 00:31:35,440
both spacecraft operating um for 45

810
00:31:40,470 --> 00:31:38,320
years i certainly think um

811
00:31:43,830 --> 00:31:40,480
we can get to 50 years

812
00:31:46,789 --> 00:31:43,840
with with probably with both spacecraft

813
00:31:49,110 --> 00:31:46,799

and we're really we're really pushing i

814
00:31:51,029 --> 00:31:49,120
would say i would call it a stretch goal

815
00:31:51,909 --> 00:31:51,039
that's management speak right a stretch

816
00:31:54,789 --> 00:31:51,919
goal

817
00:31:57,269 --> 00:31:54,799
uh is to get voyager 1 to 200

818
00:31:58,789 --> 00:31:57,279
astronomical units and that would be 20

819
00:32:00,549 --> 00:31:58,799
35.

820
00:32:03,590 --> 00:32:00,559
and and that's going to

821
00:32:05,830 --> 00:32:03,600
take a lot of luck and good fortune and

822
00:32:07,110 --> 00:32:05,840
good engineering but it's possible

823
00:32:09,430 --> 00:32:07,120
nobody would have thought the voyage

824
00:32:12,230 --> 00:32:09,440
would last for 45 years so what's

825
00:32:13,590 --> 00:32:12,240
another what's another 15 years

826
00:32:15,350 --> 00:32:13,600
right

827
00:32:16,710 --> 00:32:15,360
so it certainly is possible but

828
00:32:18,710 --> 00:32:16,720
definitely we'll definitely make it to

829
00:32:21,029 --> 00:32:18,720
the 50th anniversary

830
00:32:23,990 --> 00:32:21,039
and come back and do another show

831
00:32:28,950 --> 00:32:26,389
all right i have a interesting question

832
00:32:31,909 --> 00:32:28,960
here from daniel on twitter who says why

833
00:32:34,710 --> 00:32:31,919
can't detroit get this kind of mileage

834
00:32:36,870 --> 00:32:34,720
uh so i guess i would maybe

835
00:32:41,110 --> 00:32:36,880
translate that as like how do you build

836
00:32:44,070 --> 00:32:41,120
a vehicle that lasts 45 years and 14

837
00:32:46,389 --> 00:32:44,080
billion miles okay so uh

838
00:32:47,990 --> 00:32:46,399

i think if you bring up image three it's

839
00:32:49,909 --> 00:32:48,000
probably the best picture of the

840
00:32:51,590 --> 00:32:49,919
spacecraft maybe but

841
00:32:54,789 --> 00:32:51,600
um you know i

842
00:32:57,509 --> 00:32:54,799
there's a book called voyager tales and

843
00:33:00,070 --> 00:32:57,519
it it was written in

844
00:33:03,029 --> 00:33:00,080
after the neptune flyby where it

845
00:33:04,549 --> 00:33:03,039
it did firsthand accounts of the people

846
00:33:07,269 --> 00:33:04,559
that worked on the project and people

847
00:33:09,029 --> 00:33:07,279
worked at jpl just kind of

848
00:33:10,470 --> 00:33:09,039
in their own words what they thought of

849
00:33:13,909 --> 00:33:10,480
the project and

850
00:33:17,509 --> 00:33:13,919
and when you read that you read

851
00:33:19,110 --> 00:33:17,519
multiple times where people would

852
00:33:21,590 --> 00:33:19,120
they knew the mission was

853
00:33:23,750 --> 00:33:21,600
supposed to be four years but if they

854
00:33:25,909 --> 00:33:23,760
had the opportunity to do anything that

855
00:33:28,470 --> 00:33:25,919
would make it last longer you know to

856
00:33:30,389 --> 00:33:28,480
get it to uranus to get it to neptune

857
00:33:32,310 --> 00:33:30,399
they would do that in the process of

858
00:33:35,509 --> 00:33:32,320
building the spacecraft

859
00:33:37,750 --> 00:33:35,519
so they would put in higher rater parts

860
00:33:38,710 --> 00:33:37,760
they would

861
00:33:41,269 --> 00:33:38,720
you know

862
00:33:44,230 --> 00:33:41,279
put extra

863
00:33:46,470 --> 00:33:44,240

shielding or do extra testing

864
00:33:49,110 --> 00:33:46,480
just to make the spacecraft as robust as

865
00:33:50,630 --> 00:33:49,120
possible and i think that points to

866
00:33:52,789 --> 00:33:50,640
the whole

867
00:33:54,149 --> 00:33:52,799
development team and engineering team at

868
00:33:56,230 --> 00:33:54,159
the time

869
00:33:59,029 --> 00:33:56,240
uh wanting to make this project a

870
00:34:01,590 --> 00:33:59,039
success and wanting to get it

871
00:34:03,269 --> 00:34:01,600
not only well at least get it out past

872
00:34:04,789 --> 00:34:03,279
neptune i'm not sure that anybody

873
00:34:07,509 --> 00:34:04,799
thought it would get into interstellar

874
00:34:12,069 --> 00:34:07,519
space and certainly not

875
00:34:13,909 --> 00:34:12,079
45 years worth of of lasting but um

876
00:34:15,829 --> 00:34:13,919
i think there was a real sense that we

877
00:34:17,829 --> 00:34:15,839
want to make this spacecraft as robust

878
00:34:19,909 --> 00:34:17,839
as possible and and we're going to do

879
00:34:22,470 --> 00:34:19,919
everything we can to do it and and that

880
00:34:27,349 --> 00:34:22,480
was from the lowest level engineer up to

881
00:34:29,840 --> 00:34:29,109
all right and i can't i can't speak the

882
00:34:32,389 --> 00:34:29,850
cars so

883
00:34:34,869 --> 00:34:32,399
[Laughter]

884
00:34:36,950 --> 00:34:34,879
i won't make you uh a question that

885
00:34:39,829 --> 00:34:36,960
multiple people have including randy on

886
00:34:43,589 --> 00:34:39,839
facebook is what's the most surprising

887
00:34:45,030 --> 00:34:43,599
thing that voyager has seen or done

888
00:34:47,030 --> 00:34:45,040

so that's a

889
00:34:49,349 --> 00:34:47,040
popular question but i also think it's

890
00:34:50,869 --> 00:34:49,359
in the eye of the beholder if you ask

891
00:34:52,950 --> 00:34:50,879
the different scientists who have worked

892
00:34:54,069 --> 00:34:52,960
on voyager they would give you it

893
00:34:55,349 --> 00:34:54,079
everyone will give you a different

894
00:34:56,310 --> 00:34:55,359
answer and i think

895
00:34:57,910 --> 00:34:56,320
um

896
00:34:59,589 --> 00:34:57,920
you know if you if

897
00:35:02,390 --> 00:34:59,599
it's i've heard i've listened to many

898
00:35:05,030 --> 00:35:02,400
talks by uh ed stone who is a project

899
00:35:06,310 --> 00:35:05,040
scientist here for the last 50 years

900
00:35:08,950 --> 00:35:06,320
um

901
00:35:10,069 --> 00:35:08,960
every er voyager

902
00:35:12,560 --> 00:35:10,079
uh

903
00:35:13,750 --> 00:35:12,570
every time voyager they had a question

904
00:35:15,589 --> 00:35:13,760
[Music]

905
00:35:17,829 --> 00:35:15,599
and voyager

906
00:35:19,750 --> 00:35:17,839
i'm trying to say this correctly voyager

907
00:35:20,630 --> 00:35:19,760
provided more questions than answers

908
00:35:22,390 --> 00:35:20,640
right

909
00:35:24,470 --> 00:35:22,400
every time they flew by a planet they

910
00:35:27,589 --> 00:35:24,480
saw something new whether it was

911
00:35:30,310 --> 00:35:27,599
volcanoes at io the first the first body

912
00:35:31,910 --> 00:35:30,320
outside of our earth that we saw active

913
00:35:32,710 --> 00:35:31,920

volcanoes on

914
00:35:36,390 --> 00:35:32,720
um

915
00:35:39,109 --> 00:35:36,400
you know rings around uh uranus and and

916
00:35:42,790 --> 00:35:39,119
neptune that we had never seen before

917
00:35:44,470 --> 00:35:42,800
um i think if you bring up uh image 15

918
00:35:47,270 --> 00:35:44,480
you can see

919
00:35:48,950 --> 00:35:47,280
um i personally like this image because

920
00:35:50,390 --> 00:35:48,960
it was one that i was involved with

921
00:35:52,950 --> 00:35:50,400
taking um

922
00:35:55,750 --> 00:35:52,960
but you can see this giant blue spot

923
00:35:56,470 --> 00:35:55,760
everybody knew that that that jupiter

924
00:35:59,030 --> 00:35:56,480
had

925
00:36:01,190 --> 00:35:59,040
a great red spot also neptune has a

926
00:36:04,390 --> 00:36:01,200
giant blue spot

927
00:36:06,790 --> 00:36:04,400
nobody knew that and so uh just

928
00:36:08,710 --> 00:36:06,800
just the interactions of the atmosphere

929
00:36:09,510 --> 00:36:08,720
and the ring systems

930
00:36:13,750 --> 00:36:09,520
um

931
00:36:17,270 --> 00:36:13,760
certainly every planet and every flyby

932
00:36:20,470 --> 00:36:17,280
had a discovery that was new and and

933
00:36:22,630 --> 00:36:20,480
and got us asking more questions about

934
00:36:24,470 --> 00:36:22,640
what what we knew about our solar system

935
00:36:25,510 --> 00:36:24,480
and the same is true for interstellar

936
00:36:27,030 --> 00:36:25,520
space

937
00:36:28,950 --> 00:36:27,040
um

938
00:36:30,710 --> 00:36:28,960

you know there's there were models uh i

939
00:36:32,069 --> 00:36:30,720
mentioned that you know the differences

940
00:36:34,150 --> 00:36:32,079
in the models of the shape of the

941
00:36:36,310 --> 00:36:34,160
heliosphere but there are also

942
00:36:38,710 --> 00:36:36,320
um models about the density of the

943
00:36:41,670 --> 00:36:38,720
plasma and how that changes as you go

944
00:36:43,349 --> 00:36:41,680
out from our heliosphere so that

945
00:36:45,349 --> 00:36:43,359
that um

946
00:36:47,750 --> 00:36:45,359
doesn't match what we thought before

947
00:36:50,069 --> 00:36:47,760
voyager got into interstellar space

948
00:36:51,670 --> 00:36:50,079
so we're we're rewriting

949
00:36:53,990 --> 00:36:51,680
you know scientific history or

950
00:36:55,829 --> 00:36:54,000
scientific discoveries

951
00:36:58,630 --> 00:36:55,839
um

952
00:37:01,030 --> 00:36:58,640
and i think i think voyager is a voyage

953
00:37:05,190 --> 00:37:01,040
of discovery and i think that's its real

954
00:37:09,750 --> 00:37:07,430
that's great thanks susie

955
00:37:12,710 --> 00:37:09,760
uh another question that a couple of

956
00:37:14,550 --> 00:37:12,720
people have asked uh including one one

957
00:37:17,109 --> 00:37:14,560
intuition on youtube

958
00:37:19,750 --> 00:37:17,119
uh has the rate of travel decreased or

959
00:37:21,109 --> 00:37:19,760
have the speed of the voyagers decreased

960
00:37:23,589 --> 00:37:21,119
over time

961
00:37:25,910 --> 00:37:23,599
now now that uh the voyagers have the

962
00:37:29,030 --> 00:37:25,920
same speed that they have from their

963
00:37:32,870 --> 00:37:29,040

last planetary flyby so for

964
00:37:33,829 --> 00:37:32,880
for voyager 1 it was this saturn flyby

965
00:37:36,790 --> 00:37:33,839
that

966
00:37:38,630 --> 00:37:36,800
has it left saturn and if at least as it

967
00:37:39,589 --> 00:37:38,640
left the gravitational pull of the

968
00:37:42,150 --> 00:37:39,599
planet

969
00:37:44,390 --> 00:37:42,160
um that's the speed that voyager 1 has

970
00:37:46,870 --> 00:37:44,400
and the speed that voyager 2 has is

971
00:37:48,870 --> 00:37:46,880
is from its flyby of neptune they don't

972
00:37:50,390 --> 00:37:48,880
they don't speed up or they don't speed

973
00:37:54,390 --> 00:37:50,400
you know speed down it's a constant

974
00:37:59,349 --> 00:37:56,870
okay susie a couple of people asked a

975
00:38:00,710 --> 00:37:59,359
question like this including my on

976
00:38:02,390 --> 00:38:00,720
facebook

977
00:38:04,310 --> 00:38:02,400
what's been because i know you've said

978
00:38:05,990 --> 00:38:04,320
that you know the voyagers are 45 years

979
00:38:08,390 --> 00:38:06,000
old and there have been challenges with

980
00:38:11,030 --> 00:38:08,400
keeping them going this long so what was

981
00:38:12,870 --> 00:38:11,040
the most exhausting uh day on the

982
00:38:17,990 --> 00:38:12,880
voyager mission for you

983
00:38:24,470 --> 00:38:20,390
an interesting question too um

984
00:38:27,829 --> 00:38:24,480
you know we we we have some long days

985
00:38:29,190 --> 00:38:27,839
when we're when we're trying when we get

986
00:38:31,510 --> 00:38:29,200
some data back that doesn't look like

987
00:38:32,630 --> 00:38:31,520
what we expect then we have to spend

988
00:38:34,710 --> 00:38:32,640

some

989
00:38:37,190 --> 00:38:34,720
long days talking about what's the next

990
00:38:40,390 --> 00:38:37,200
set of commands we want to to send to

991
00:38:42,310 --> 00:38:40,400
help diagnose what we might be seeing

992
00:38:44,470 --> 00:38:42,320
um

993
00:38:47,030 --> 00:38:44,480
and i think i think the voyager project

994
00:38:49,750 --> 00:38:47,040
is a constant balance now between

995
00:38:51,990 --> 00:38:49,760
the power margin and the

996
00:38:53,589 --> 00:38:52,000
the thermal and so we're always

997
00:38:55,109 --> 00:38:53,599
discussing that because you can imagine

998
00:38:56,470 --> 00:38:55,119
you could save power by turning

999
00:38:58,790 --> 00:38:56,480
something off

1000
00:39:02,230 --> 00:38:58,800
uh we have a digital tape recorder on

1001
00:39:06,150 --> 00:39:02,240
voyager 1. it still works we still use

1002
00:39:10,950 --> 00:39:09,190
but we could turn it off to save

1003
00:39:11,750 --> 00:39:10,960
power but we wouldn't want to do that

1004
00:39:15,190 --> 00:39:11,760
because

1005
00:39:16,390 --> 00:39:15,200
light bulb

1006
00:39:18,550 --> 00:39:16,400
a little bit you know if you turn your

1007
00:39:21,190 --> 00:39:18,560
lights off your house gets cold you can

1008
00:39:22,870 --> 00:39:21,200
use your light bulbs as heaters so so we

1009
00:39:25,589 --> 00:39:22,880
use certain parts of the spacecraft to

1010
00:39:27,349 --> 00:39:25,599
keep those propellant lines warm so we

1011
00:39:29,510 --> 00:39:27,359
we don't turn that

1012
00:39:30,710 --> 00:39:29,520
off all the way because we want the

1013
00:39:33,430 --> 00:39:30,720

warmth that's coming from the

1014
00:39:35,589 --> 00:39:33,440
electronics to keep the propellant lines

1015
00:39:37,589 --> 00:39:35,599
going so there's all there's a balance

1016
00:39:39,829 --> 00:39:37,599
and i think that's a that's been an

1017
00:39:41,430 --> 00:39:39,839
ongoing um

1018
00:39:43,589 --> 00:39:41,440
you know engineering tasks that we've

1019
00:39:48,470 --> 00:39:43,599
been working on to balance for

1020
00:39:54,230 --> 00:39:51,109
thank you susie all right we had uh one

1021
00:39:57,670 --> 00:39:54,240
more question uh

1022
00:40:00,470 --> 00:39:57,680
and i have lost who asked it uh uh sorry

1023
00:40:02,630 --> 00:40:00,480
uh crystal on facebook asks what will

1024
00:40:04,550 --> 00:40:02,640
happen when the power runs out so what

1025
00:40:06,870 --> 00:40:04,560
will actually happen you know when the

1026
00:40:08,309 --> 00:40:06,880
spacecraft uh have done as much as they

1027
00:40:11,270 --> 00:40:08,319
can do

1028
00:40:13,750 --> 00:40:11,280
yeah um the the transmitter on voyager

1029
00:40:15,190 --> 00:40:13,760
is about it's a 20 watt transmitter

1030
00:40:16,470 --> 00:40:15,200
basically it's about

1031
00:40:18,470 --> 00:40:16,480
you know the power level of your

1032
00:40:19,430 --> 00:40:18,480
refrigerator light bulb

1033
00:40:23,510 --> 00:40:19,440
um

1034
00:40:25,670 --> 00:40:23,520
but it will it takes about uh it

1035
00:40:28,309 --> 00:40:25,680
the the transmitter takes 20 watts of

1036
00:40:29,829 --> 00:40:28,319
power to operate i'm sorry i'm sorry i

1037
00:40:31,510 --> 00:40:29,839
said that right it takes 200 watts of

1038
00:40:32,630 --> 00:40:31,520

power to operate

1039
00:40:33,670 --> 00:40:32,640
um

1040
00:40:36,870 --> 00:40:33,680
and

1041
00:40:40,069 --> 00:40:36,880
once we get down to that level

1042
00:40:42,069 --> 00:40:40,079
uh we won't be able to get signals from

1043
00:40:45,510 --> 00:40:42,079
the spacecraft anymore

1044
00:40:46,950 --> 00:40:45,520
so we we will we talked about um

1045
00:40:49,589 --> 00:40:46,960
we've been turning off instrument

1046
00:40:51,589 --> 00:40:49,599
heaters now for the last three years

1047
00:40:53,349 --> 00:40:51,599
uh to save power and the instruments are

1048
00:40:54,950 --> 00:40:53,359
still operating which is remarkable

1049
00:40:59,190 --> 00:40:54,960
because they've they've dropped in

1050
00:41:01,109 --> 00:40:59,200
temperature by about 60 degrees celsius

1051
00:41:03,430 --> 00:41:01,119
so they're very very much colder colder

1052
00:41:05,270 --> 00:41:03,440
than what they were tested at and

1053
00:41:07,829 --> 00:41:05,280
colder than what they were designed to

1054
00:41:09,190 --> 00:41:07,839
operate at but they're still operating

1055
00:41:13,109 --> 00:41:09,200
which is another

1056
00:41:15,349 --> 00:41:13,119
remarkable thing about this spacecraft

1057
00:41:18,150 --> 00:41:15,359
but we will eventually be turning off

1058
00:41:20,790 --> 00:41:18,160
instruments as well to save power

1059
00:41:22,069 --> 00:41:20,800
and the last instrument

1060
00:41:23,910 --> 00:41:22,079
will leave on

1061
00:41:26,390 --> 00:41:23,920
and we just will eventually

1062
00:41:27,829 --> 00:41:26,400
not get a signal from the spacecraft

1063
00:41:29,190 --> 00:41:27,839

and that's how the mission's going to

1064
00:41:33,190 --> 00:41:29,200
end it's

1065
00:41:36,069 --> 00:41:33,200
we we could probably predict um

1066
00:41:38,790 --> 00:41:36,079
you know maybe within a year

1067
00:41:40,150 --> 00:41:38,800
when that happens but um

1068
00:41:42,710 --> 00:41:40,160
and that's assuming that we don't have

1069
00:41:44,390 --> 00:41:42,720
some other anomaly or something else

1070
00:41:46,630 --> 00:41:44,400
doesn't break but if it's if the

1071
00:41:48,550 --> 00:41:46,640
spacecraft's operating fine what's going

1072
00:41:49,670 --> 00:41:48,560
to happen is it just eventually will go

1073
00:41:54,630 --> 00:41:49,680
silent

1074
00:41:59,190 --> 00:41:57,190
that is going to be a very sad day um

1075
00:42:01,190 --> 00:41:59,200
it's actually a very sad moment because

1076
00:42:03,030 --> 00:42:01,200
this is all the time that we have

1077
00:42:04,550 --> 00:42:03,040
for our talk tonight

1078
00:42:06,069 --> 00:42:04,560
susie and all of our

1079
00:42:07,430 --> 00:42:06,079
meetings up until this point i could

1080
00:42:09,030 --> 00:42:07,440
have talked to you for hours and hours

1081
00:42:11,190 --> 00:42:09,040
and hours but i want to have a lot of

1082
00:42:12,630 --> 00:42:11,200
stuff i can keep going but

1083
00:42:13,829 --> 00:42:12,640
you'll have to have to have me back

1084
00:42:16,630 --> 00:42:13,839
brian

1085
00:42:18,069 --> 00:42:16,640
we'll always any time um

1086
00:42:20,069 --> 00:42:18,079
so folks that is all the time we have

1087
00:42:22,069 --> 00:42:20,079
for tonight if you join us next month

1088
00:42:24,550 --> 00:42:22,079

we're going to be talking about the owls

1089
00:42:26,309 --> 00:42:24,560
ocean worlds life surveyor i'd like to

1090
00:42:28,230 --> 00:42:26,319
thank kala and everyone behind the

1091
00:42:29,829 --> 00:42:28,240
scenes who make these talks possible but

1092
00:42:32,150 --> 00:42:29,839
most importantly tonight i would like to

1093
00:42:34,790 --> 00:42:32,160
thank the tremendous suzanne dodd for

1094
00:42:37,670 --> 00:42:34,800
sharing her passion her intellect and

1095
00:42:39,829 --> 00:42:37,680
her care for this transcendent mission

1096
00:42:41,270 --> 00:42:39,839
thank you to all of you for joining us

1097
00:42:42,550 --> 00:42:41,280
each and every month

1098
00:42:45,510 --> 00:42:42,560
stay safe