1
00:00:03,190 --> 00:00:01,270
[Music]

2
00:00:04,789 --> 00:00:03,200
nasa's jet propulsion laboratory

3
00:00:07,510 --> 00:00:04,799
presents

4
00:00:09,509 --> 00:00:07,520
the von carmen lecture a series of talks

5
00:00:12,790 --> 00:00:09,519
by scientists and engineers who are

6
00:00:17,950 --> 00:00:12,800
exploring our planet our solar system

7
00:00:23,429 --> 00:00:21,109
[Music]

8
00:00:24,870 --> 00:00:23,439
good evening everybody my name is mark

9
00:00:27,029 --> 00:00:24,880
grazie from jpl's office of

10
00:00:28,710 --> 00:00:27,039
communications and education

11
00:00:30,390 --> 00:00:28,720
and it's my pleasure to be your host

12
00:00:31,990 --> 00:00:30,400
welcome you and thank you for joining us

13
00:00:33,510 --> 00:00:32,000

for the september edition of the von

14
00:00:35,350 --> 00:00:33,520
carmen series

15
00:00:36,870 --> 00:00:35,360
our co-host today is my friend and

16
00:00:39,110 --> 00:00:36,880
colleague also from the office of

17
00:00:41,830 --> 00:00:39,120
communications and education miss nikki

18
00:00:44,150 --> 00:00:41,840
wyrick hello my friend

19
00:00:46,069 --> 00:00:44,160
hello thank you so much for having me

20
00:00:47,910 --> 00:00:46,079
tonight i'm super excited to be here and

21
00:00:50,150 --> 00:00:47,920
i'll be handling all of your questions

22
00:00:52,229 --> 00:00:50,160
this evening so please do remember this

23
00:00:54,389 --> 00:00:52,239
is your space program and we want you to

24
00:00:56,389 --> 00:00:54,399
be involved in the conversation as

25
00:00:58,869 --> 00:00:56,399
you're watching ask questions in the

26
00:01:00,950 --> 00:00:58,879
chat box and our social media team will

27
00:01:02,869 --> 00:01:00,960
bring in as many as we can to the talk

28
00:01:04,869 --> 00:01:02,879
tonight keep in mind if you don't see

29
00:01:08,230 --> 00:01:04,879
the chat make sure you refresh and it

30
00:01:11,190 --> 00:01:10,310
uh thank you very much nikki appreciate

31
00:01:13,429 --> 00:01:11,200
that

32
00:01:15,990 --> 00:01:13,439
so let's jump right in shall we so now

33
00:01:17,910 --> 00:01:16,000
many of you may know that one of nasa's

34
00:01:19,670 --> 00:01:17,920
goals is to search for life in our solar

35
00:01:21,590 --> 00:01:19,680
system and beyond

36
00:01:23,270 --> 00:01:21,600
but that's no small task

37
00:01:25,270 --> 00:01:23,280
we found places in our solar system

38
00:01:26,870 --> 00:01:25,280

where we believe that conditions exist

39
00:01:29,590 --> 00:01:26,880
that could potentially allow life to

40
00:01:32,230 --> 00:01:29,600
take hold but they're not nearby and of

41
00:01:34,550 --> 00:01:32,240
course the question what exactly is life

42
00:01:36,789 --> 00:01:34,560
can further complicate the issue

43
00:01:38,149 --> 00:01:36,799
but we've got to start somewhere right

44
00:01:40,630 --> 00:01:38,159
tonight we're going to be talking with

45
00:01:43,270 --> 00:01:40,640
dr mark ronkowitz a data scientist at

46
00:01:45,749 --> 00:01:43,280
jpl who currently leads a team building

47
00:01:48,550 --> 00:01:45,759
autonomy software to detect and

48
00:01:51,670 --> 00:01:48,560
characterize cell size life for the

49
00:01:54,310 --> 00:01:51,680
ocean world's life surveyor or owls

50
00:01:58,230 --> 00:01:54,320
project hey mark thanks for joining us

51
00:02:00,389 --> 00:01:58,240
tonight and hey happy birthday

52
00:02:02,709 --> 00:02:00,399
thanks hey mark nikki good to be with

53
00:02:04,630 --> 00:02:02,719
you guys

54
00:02:05,990 --> 00:02:04,640
we're thankful really grateful that you

55
00:02:07,590 --> 00:02:06,000
could join us tonight

56
00:02:08,630 --> 00:02:07,600
so before we get to you know too deep

57
00:02:09,749 --> 00:02:08,640
into this tell us a little bit about

58
00:02:11,910 --> 00:02:09,759
yourself how did you get to where you

59
00:02:14,470 --> 00:02:11,920
are

60
00:02:17,670 --> 00:02:14,480
sure um yes so i'm originally from the

61
00:02:19,830 --> 00:02:17,680
midwest i went to school at washington

62
00:02:22,550 --> 00:02:19,840
st louis during engineering and then

63
00:02:25,190 --> 00:02:22,560

after that i did neuroscience at

64
00:02:26,869 --> 00:02:25,200
university of washington in seattle

65
00:02:29,910 --> 00:02:26,879
and i like to say kind of towards the

66
00:02:31,830 --> 00:02:29,920
end of my phd i got just as interested

67
00:02:34,070 --> 00:02:31,840
in artificial neural networks as the

68
00:02:36,229 --> 00:02:34,080
biological ones i kind of got caught up

69
00:02:37,750 --> 00:02:36,239
in the machine learning and that data

70
00:02:40,070 --> 00:02:37,760
science craze that was really taking off

71
00:02:42,390 --> 00:02:40,080
in the in the mid 20 teens

72
00:02:44,309 --> 00:02:42,400
so after i graduated i went over to a

73
00:02:45,350 --> 00:02:44,319
small company in dc called development

74
00:02:46,790 --> 00:02:45,360
seed

75
00:02:48,229 --> 00:02:46,800
and worked there as a machine learning

76
00:02:50,550 --> 00:02:48,239
engineer

77
00:02:52,150 --> 00:02:50,560
we got to work on very fun projects like

78
00:02:53,509 --> 00:02:52,160
working on social good issues working

79
00:02:56,309 --> 00:02:53,519
with the world bank

80
00:02:57,190 --> 00:02:56,319
um red cross those type of organizations

81
00:02:58,070 --> 00:02:57,200
um

82
00:03:00,390 --> 00:02:58,080
but

83
00:03:02,149 --> 00:03:00,400
after that i i kind of felt this i guess

84
00:03:03,670 --> 00:03:02,159
i would call it like a calling almost i

85
00:03:05,430 --> 00:03:03,680
don't know i felt this feeling that i

86
00:03:07,509 --> 00:03:05,440
wanted to get more involved in in

87
00:03:09,350 --> 00:03:07,519
exploring some of the other places

88
00:03:12,229 --> 00:03:09,360

within the solar system so

89
00:03:13,350 --> 00:03:12,239
i hopped over to jpl uh two weeks before

90
00:03:15,270 --> 00:03:13,360
lockdown

91
00:03:17,509 --> 00:03:15,280
so i got to come in meet a few of my

92
00:03:19,030 --> 00:03:17,519
co-workers and go straight back home

93
00:03:22,710 --> 00:03:19,040
and then a couple weeks after that i got

94
00:03:24,790 --> 00:03:22,720
involved on the on the owls project

95
00:03:25,589 --> 00:03:24,800
well you picked a difficult one i'd say

96
00:03:27,750 --> 00:03:25,599
uh

97
00:03:29,350 --> 00:03:27,760
life looking for life is it's clearly

98
00:03:31,030 --> 00:03:29,360
challenging right so

99
00:03:34,630 --> 00:03:31,040
let's go here and ask what do you think

100
00:03:38,229 --> 00:03:36,550
yeah i think you know even we're just

101
00:03:40,869 --> 00:03:38,239
looking for you know just looking for a

102
00:03:42,949 --> 00:03:40,879
microscopic life um i think it's it's

103
00:03:44,869 --> 00:03:42,959
hard to overstate and and maybe even

104
00:03:48,229 --> 00:03:44,879
imagine how all the different ways that

105
00:03:49,509 --> 00:03:48,239
would affect us if we were to find life

106
00:03:51,830 --> 00:03:49,519
off earth

107
00:03:53,990 --> 00:03:51,840
so i mean even just from the scientific

108
00:03:55,990 --> 00:03:54,000
perspective think of like biology

109
00:03:56,869 --> 00:03:56,000
chemistry genetics like all these fields

110
00:03:58,949 --> 00:03:56,879
would be

111
00:04:00,550 --> 00:03:58,959
upset overnight they'd be you know have

112
00:04:03,190 --> 00:04:00,560
a brand new thing to look at that would

113
00:04:06,149 --> 00:04:03,200

be it'd be huge for the all those fields

114
00:04:08,470 --> 00:04:06,159
um but i mean even even society at large

115
00:04:10,390 --> 00:04:08,480
you think about uh like in the 15s and

116
00:04:12,869 --> 00:04:10,400
1600s um

117
00:04:14,229 --> 00:04:12,879
you know copernicus and galileo they're

118
00:04:15,990 --> 00:04:14,239
they're doing all this work and and

119
00:04:18,469 --> 00:04:16,000
saying like hey so it looks like in our

120
00:04:20,870 --> 00:04:18,479
data that actually the universe does not

121
00:04:23,189 --> 00:04:20,880
revolve literally around earth and those

122
00:04:26,070 --> 00:04:23,199
were like huge controversial

123
00:04:27,590 --> 00:04:26,080
statements and you know galileo actually

124
00:04:30,230 --> 00:04:27,600
faced like the court of the inquisition

125
00:04:32,469 --> 00:04:30,240
for pushing ideas like that so that was

126
00:04:34,310 --> 00:04:32,479
just to figure out like what was our

127
00:04:36,550 --> 00:04:34,320
spatial point in the universe that we

128
00:04:38,710 --> 00:04:36,560
sit at right so if if we were to

129
00:04:40,390 --> 00:04:38,720
discover we're actually also not alone

130
00:04:41,909 --> 00:04:40,400
in this universe and we found life you

131
00:04:44,469 --> 00:04:41,919
know we're looking within our own solar

132
00:04:46,150 --> 00:04:44,479
system that would be huge um that would

133
00:04:48,070 --> 00:04:46,160
that would really change a lot of how we

134
00:04:51,270 --> 00:04:48,080
conceive of ourselves

135
00:04:54,310 --> 00:04:53,110
that would be an amazing find to say the

136
00:04:57,270 --> 00:04:54,320
least i think

137
00:05:00,870 --> 00:04:57,280
so uh where are the places we're looking

138
00:05:01,749 --> 00:05:00,880

and i guess what makes that challenging

139
00:05:04,469 --> 00:05:01,759
yeah

140
00:05:07,029 --> 00:05:04,479
so we are kind of taking the strategy of

141
00:05:08,870 --> 00:05:07,039
follow the water um all life that we

142
00:05:11,110 --> 00:05:08,880
know of depends on liquid water to

143
00:05:13,590 --> 00:05:11,120
support its its chemistry

144
00:05:15,830 --> 00:05:13,600
um so there are a few places actually on

145
00:05:17,830 --> 00:05:15,840
our solar system um where we can find

146
00:05:19,270 --> 00:05:17,840
that so yeah this this is a perfect

147
00:05:20,070 --> 00:05:19,280
image here

148
00:05:22,150 --> 00:05:20,080
uh

149
00:05:23,510 --> 00:05:22,160
this is from the cassini probe that was

150
00:05:25,590 --> 00:05:23,520
out exploring saturn and some of its

151
00:05:27,990 --> 00:05:25,600
moons i think this picture came back in

152
00:05:29,830 --> 00:05:28,000
2015. don't quote me on that but when

153
00:05:31,029 --> 00:05:29,840
this came back this was like a huge holy

154
00:05:32,710 --> 00:05:31,039
cow moment

155
00:05:35,110 --> 00:05:32,720
for that for that science team so what

156
00:05:38,230 --> 00:05:35,120
you're looking at here is actually

157
00:05:41,510 --> 00:05:38,240
water geysers spraying out into space

158
00:05:42,950 --> 00:05:41,520
from from this moon enceladus

159
00:05:44,310 --> 00:05:42,960
and there's actually you can see a

160
00:05:46,230 --> 00:05:44,320
number of different geysers so there's

161
00:05:47,830 --> 00:05:46,240
these huge cracks in the south pole of

162
00:05:49,430 --> 00:05:47,840
enceladus and it's spraying this water

163
00:05:51,590 --> 00:05:49,440

out into space and what you know with a

164
00:05:53,189 --> 00:05:51,600
little bit more analysis

165
00:05:54,150 --> 00:05:53,199
what the

166
00:05:56,390 --> 00:05:54,160
scientists who are working on this

167
00:05:59,189 --> 00:05:56,400
figured out is that there are liquid

168
00:06:00,390 --> 00:05:59,199
oceans beneath this outer icy shell of

169
00:06:03,189 --> 00:06:00,400
enceladus

170
00:06:05,189 --> 00:06:03,199
and so that makes this a a pretty

171
00:06:07,990 --> 00:06:05,199
interesting and good target for us to go

172
00:06:10,469 --> 00:06:08,000
look for things like microscopic life if

173
00:06:12,390 --> 00:06:10,479
we if we want to go and and search the

174
00:06:13,909 --> 00:06:12,400
water there

175
00:06:15,510 --> 00:06:13,919
one of the challenging things there's a

176
00:06:17,909 --> 00:06:15,520
bunch and we'll get to them one of the

177
00:06:20,150 --> 00:06:17,919
challenging things is that enceladus is

178
00:06:22,150 --> 00:06:20,160
very far away from earth so like saturn

179
00:06:23,909 --> 00:06:22,160
itself can be up to

180
00:06:25,510 --> 00:06:23,919
10 times further away from earth than

181
00:06:28,070 --> 00:06:25,520
the sun is

182
00:06:29,990 --> 00:06:28,080
and and basically it is very difficult

183
00:06:31,430 --> 00:06:30,000
to communicate over those distances just

184
00:06:32,950 --> 00:06:31,440
because of the rules of physics and i

185
00:06:35,270 --> 00:06:32,960
will touch a little bit more on that

186
00:06:37,590 --> 00:06:35,280
later but if you think about exploring

187
00:06:39,670 --> 00:06:37,600
some of these places your ability to

188
00:06:43,909 --> 00:06:39,680

transmit information from them back home

189
00:06:47,430 --> 00:06:45,590
so let's

190
00:06:48,710 --> 00:06:47,440
step back a little bit i think and ask

191
00:06:50,710 --> 00:06:48,720
like well

192
00:06:51,749 --> 00:06:50,720
what do we know we have a definition for

193
00:06:52,629 --> 00:06:51,759
life

194
00:06:54,230 --> 00:06:52,639
and

195
00:06:56,870 --> 00:06:54,240
if we do like then how do we continue to

196
00:07:00,550 --> 00:06:58,469
yeah that's that's another one of the

197
00:07:02,550 --> 00:07:00,560
big challenges it's almost paradoxical

198
00:07:04,550 --> 00:07:02,560
because we're looking for life we don't

199
00:07:06,309 --> 00:07:04,560
have a good definition for it i mean you

200
00:07:07,510 --> 00:07:06,319
can find one in a dictionary but

201
00:07:10,390 --> 00:07:07,520
basically

202
00:07:11,990 --> 00:07:10,400
uh there is no good set of like check uh

203
00:07:13,350 --> 00:07:12,000
check boxes if you will they can go down

204
00:07:15,270 --> 00:07:13,360
and say like all right if i see these

205
00:07:16,790 --> 00:07:15,280
like 12 or 15 whatever number of

206
00:07:19,110 --> 00:07:16,800
conditions and i check all those boxes

207
00:07:21,029 --> 00:07:19,120
then i found life right

208
00:07:23,350 --> 00:07:21,039
that doesn't exist and basically it's

209
00:07:24,790 --> 00:07:23,360
because anytime you try to write down a

210
00:07:26,550 --> 00:07:24,800
definition of life

211
00:07:28,629 --> 00:07:26,560
every time you write some criteria you

212
00:07:30,950 --> 00:07:28,639
end up with um with 10 exceptions that

213
00:07:32,629 --> 00:07:30,960

go with it so it becomes this fetal

214
00:07:34,629 --> 00:07:32,639
exercise to try and figure out what

215
00:07:36,150 --> 00:07:34,639
exactly you know you're gonna

216
00:07:37,430 --> 00:07:36,160
you're looking for

217
00:07:40,070 --> 00:07:37,440
so

218
00:07:42,230 --> 00:07:40,080
the owls project is kind of it's built

219
00:07:43,990 --> 00:07:42,240
in a way upon that uh conundrum if you

220
00:07:46,150 --> 00:07:44,000
will that is a bit of a corn stone of

221
00:07:48,150 --> 00:07:46,160
the of the project and so the way we

222
00:07:50,790 --> 00:07:48,160
approach that then is say

223
00:07:53,670 --> 00:07:50,800
let's look for life in as many different

224
00:07:55,029 --> 00:07:53,680
ways as we can so we're you know we're

225
00:07:56,950 --> 00:07:55,039
interested in looking at microscopic

226
00:07:58,629 --> 00:07:56,960
organisms so you know we'll get into

227
00:07:59,909 --> 00:07:58,639
this but we have a whole bunch of

228
00:08:01,270 --> 00:07:59,919
instruments kind of on the chemistry

229
00:08:02,790 --> 00:08:01,280
side that are looking for very small

230
00:08:04,230 --> 00:08:02,800
scale things all the way up to the

231
00:08:07,270 --> 00:08:04,240
biology side that are actually looking

232
00:08:08,550 --> 00:08:07,280
for individual cells and the idea is you

233
00:08:10,390 --> 00:08:08,560
get as many

234
00:08:12,710 --> 00:08:10,400
different instruments looking for

235
00:08:14,390 --> 00:08:12,720
different signs of life as you can and

236
00:08:16,550 --> 00:08:14,400
so we we call those like we're looking

237
00:08:17,670 --> 00:08:16,560
for as many independent bio signatures

238
00:08:19,589 --> 00:08:17,680

as we can

239
00:08:21,430 --> 00:08:19,599
and the hope is that if you're if there

240
00:08:22,950 --> 00:08:21,440
is something there that you see it

241
00:08:24,390 --> 00:08:22,960
across a number of different instruments

242
00:08:26,230 --> 00:08:24,400
that are all looking in different ways

243
00:08:27,589 --> 00:08:26,240
and that's how you that's how you get to

244
00:09:00,470 --> 00:08:27,599
a

245
00:09:02,949 --> 00:09:00,480
developing

246
00:09:04,150 --> 00:09:02,959
onboard science autonomy so i'll break

247
00:09:05,750 --> 00:09:04,160
that down

248
00:09:06,949 --> 00:09:05,760
so we have autonomy in this case it's

249
00:09:08,389 --> 00:09:06,959
software

250
00:09:10,630 --> 00:09:08,399
it's going to be looking at data and

251
00:09:12,389 --> 00:09:10,640
making decisions based on that data

252
00:09:14,310 --> 00:09:12,399
it is on board

253
00:09:16,150 --> 00:09:14,320
it means it actually lives on board the

254
00:09:18,070 --> 00:09:16,160
spacecraft so it's running on board like

255
00:09:18,790 --> 00:09:18,080
our flight computers you know if we send

256
00:09:41,829 --> 00:09:18,800
a

257
00:09:43,590 --> 00:09:41,839
return of the mission

258
00:09:45,269 --> 00:09:43,600
so basically that just means

259
00:09:47,190 --> 00:09:45,279
you know in this image here we have our

260
00:09:48,310 --> 00:09:47,200
lander kind of on the left and it's

261
00:09:49,750 --> 00:09:48,320
pulling

262
00:09:50,790 --> 00:09:49,760
we feed in our water sample and we're

263
00:09:51,990 --> 00:09:50,800

going to feed that water sample to a

264
00:09:53,910 --> 00:09:52,000
bunch of different instruments like we

265
00:09:56,389 --> 00:09:53,920
talked about the autonomy is going to

266
00:09:58,470 --> 00:09:56,399
look at all that data on board and try

267
00:10:00,150 --> 00:09:58,480
to pull out what are the best nuggets

268
00:10:02,949 --> 00:10:00,160
what are the best

269
00:10:04,949 --> 00:10:02,959
passengers we see in this data and pull

270
00:10:06,470 --> 00:10:04,959
those out and then send just those

271
00:10:07,910 --> 00:10:06,480
little bits back to our scientists

272
00:10:10,150 --> 00:10:07,920
because remember earlier we talked about

273
00:10:12,230 --> 00:10:10,160
how it's really really difficult to

274
00:10:13,910 --> 00:10:12,240
transmit data back from these far away

275
00:10:16,150 --> 00:10:13,920
uh locations

276
00:10:18,389 --> 00:10:16,160
so that's kind of the you know stepping

277
00:10:19,990 --> 00:10:18,399
back that's what the this whole autonomy

278
00:10:21,430 --> 00:10:20,000
that the science autonomy we're building

279
00:10:22,870 --> 00:10:21,440
is trying to do

280
00:10:24,710 --> 00:10:22,880
it's trying to

281
00:10:26,630 --> 00:10:24,720
empower our scientists

282
00:10:28,150 --> 00:10:26,640
given that we can we can transmit such

283
00:10:30,230 --> 00:10:28,160
little data we need to make sure we

284
00:10:31,910 --> 00:10:30,240
transmit the best data we've found back

285
00:10:33,269 --> 00:10:31,920
to them to help them make those firm

286
00:10:35,670 --> 00:10:33,279
scientific conclusions about whether or

287
00:10:37,750 --> 00:10:35,680
not we see life

288
00:10:39,590 --> 00:10:37,760

so tell us a little bit more then about

289
00:10:41,829 --> 00:10:39,600
those actual complications you mentioned

290
00:10:44,230 --> 00:10:41,839
distance and what else like makes this

291
00:10:46,870 --> 00:10:44,240
so challenging

292
00:10:49,190 --> 00:10:46,880
yeah absolutely so the

293
00:10:51,269 --> 00:10:49,200
the distance pieces is really fun so if

294
00:10:52,470 --> 00:10:51,279
you um

295
00:10:53,990 --> 00:10:52,480
if you

296
00:10:57,190 --> 00:10:54,000
look at how much data that we can

297
00:10:59,030 --> 00:10:57,200
collect our very best case scenario we

298
00:11:02,069 --> 00:10:59,040
can transmit something like one one

299
00:11:03,350 --> 00:11:02,079
thousandth point one percent of the data

300
00:11:05,430 --> 00:11:03,360
back to earth

301
00:11:07,430 --> 00:11:05,440
that is like taking the entire

302
00:11:09,990 --> 00:11:07,440
hitchhiker's guide to the galaxy

303
00:11:11,030 --> 00:11:10,000
and condensing it down into a single

304
00:11:12,710 --> 00:11:11,040
tweet

305
00:11:14,310 --> 00:11:12,720
and so you gotta

306
00:11:16,630 --> 00:11:14,320
you to capture as much of the literary

307
00:11:18,949 --> 00:11:16,640
content as possible um the story arc the

308
00:11:20,790 --> 00:11:18,959
humor all the characters all this in a

309
00:11:22,710 --> 00:11:20,800
single tweet that's

310
00:11:23,829 --> 00:11:22,720
the that's our best case scenario we're

311
00:11:25,350 --> 00:11:23,839
probably going to be looking at

312
00:11:28,230 --> 00:11:25,360
something more like

313
00:11:29,910 --> 00:11:28,240

um 1 10 000 of information so like point

314
00:11:31,829 --> 00:11:29,920
zero one percent of the data we collect

315
00:11:33,190 --> 00:11:31,839
will be able to transmit back

316
00:11:34,630 --> 00:11:33,200
so

317
00:11:36,630 --> 00:11:34,640
that's the conditions we need to make

318
00:11:38,230 --> 00:11:36,640
sure that we enable our science team

319
00:11:39,509 --> 00:11:38,240
back here on earth to be able to make

320
00:11:41,590 --> 00:11:39,519
firm conclusions about whether or not

321
00:11:43,430 --> 00:11:41,600
they see signs of life

322
00:11:45,509 --> 00:11:43,440
so um we

323
00:11:47,990 --> 00:11:45,519
the autonomy itself it kind of goes and

324
00:11:50,550 --> 00:11:48,000
it kind of has three different um

325
00:11:52,150 --> 00:11:50,560
components to it i'll very just briefly

326
00:11:53,590 --> 00:11:52,160
go over so

327
00:11:55,590 --> 00:11:53,600
when the data comes in the first thing

328
00:11:57,030 --> 00:11:55,600
we'll do is a bunch of sanity checks

329
00:11:59,030 --> 00:11:57,040
essentially on the data we call this

330
00:11:59,990 --> 00:11:59,040
like a data quality estimate and it's

331
00:12:01,750 --> 00:12:00,000
just looking to make sure there's

332
00:12:03,190 --> 00:12:01,760
nothing off about the data if there is

333
00:12:05,269 --> 00:12:03,200
something that we don't want to spend

334
00:12:06,870 --> 00:12:05,279
trans or you know valuable transmission

335
00:12:08,310 --> 00:12:06,880
bandwidth on that

336
00:12:10,389 --> 00:12:08,320
on that data

337
00:12:12,870 --> 00:12:10,399
after it goes through those checks we

338
00:12:14,870 --> 00:12:12,880

go through this summarization step

339
00:12:17,269 --> 00:12:14,880
and so for each of the instruments

340
00:12:19,350 --> 00:12:17,279
the software is looking at this data and

341
00:12:21,350 --> 00:12:19,360
trying to extract out what are the

342
00:12:22,710 --> 00:12:21,360
important bios signatures that we might

343
00:12:25,110 --> 00:12:22,720
see in that data if it's there it needs

344
00:12:26,870 --> 00:12:25,120
to extract them and compress them

345
00:12:28,550 --> 00:12:26,880
and we work with the scientists quite a

346
00:12:30,230 --> 00:12:28,560
bit to get those all those algorithms

347
00:12:31,430 --> 00:12:30,240
owned

348
00:12:33,750 --> 00:12:31,440
after we've done that for all the

349
00:12:36,310 --> 00:12:33,760
instruments then the final step is to

350
00:12:38,310 --> 00:12:36,320
take all of our now summarized science

351
00:12:40,150 --> 00:12:38,320
data and prioritize it so it kind of

352
00:12:41,910 --> 00:12:40,160
like creates this big long queue from

353
00:12:43,190 --> 00:12:41,920
top to bottom of what is the highest

354
00:12:44,550 --> 00:12:43,200
priority data make sure we send that

355
00:12:46,550 --> 00:12:44,560
back first and then kind of like work

356
00:12:47,829 --> 00:12:46,560
backwards through all that

357
00:12:50,870 --> 00:12:47,839
through all that data and send that back

358
00:12:54,629 --> 00:12:52,949
you probably had to work with a pretty

359
00:12:55,430 --> 00:12:54,639
enormous team of folks then i would

360
00:12:57,110 --> 00:12:55,440
guess

361
00:13:00,230 --> 00:12:57,120
uh what was that like how many people

362
00:13:02,949 --> 00:13:00,240
were you dealing with at the time

363
00:13:04,710 --> 00:13:02,959

yeah this was um this is probably one of

364
00:13:07,590 --> 00:13:04,720
the most rewarding parts of the project

365
00:13:09,030 --> 00:13:07,600
the team was very big so there's uh

366
00:13:10,710 --> 00:13:09,040
three or four dozen people that worked

367
00:13:13,750 --> 00:13:10,720
on the project

368
00:13:15,990 --> 00:13:13,760
everything from biologists to chemists

369
00:13:17,430 --> 00:13:16,000
to very talented instrument developers

370
00:13:18,829 --> 00:13:17,440
on both the biology and the chemistry

371
00:13:21,750 --> 00:13:18,839
side

372
00:13:23,030 --> 00:13:21,760
and as well as us on the autonomy team

373
00:13:24,389 --> 00:13:23,040
um and we also worked with the flight

374
00:13:25,350 --> 00:13:24,399
hardware and software teams so the

375
00:13:27,829 --> 00:13:25,360
people that are actually building the

376
00:13:29,750 --> 00:13:27,839
hardware that will uh that will run you

377
00:13:31,350 --> 00:13:29,760
know control these instruments and then

378
00:13:33,269 --> 00:13:31,360
allow us to from the ground to

379
00:13:34,389 --> 00:13:33,279
communicate and work with that uh work

380
00:13:36,710 --> 00:13:34,399
with the lander

381
00:13:38,389 --> 00:13:36,720
so it was a huge team and we got to we

382
00:13:39,910 --> 00:13:38,399
had to talk to everybody that was it was

383
00:13:41,990 --> 00:13:39,920
a great position to be in because we

384
00:13:43,750 --> 00:13:42,000
needed to kind of we needed to take

385
00:13:46,069 --> 00:13:43,760
input and

386
00:13:46,790 --> 00:13:46,079
and work with all those different groups

387
00:13:47,990 --> 00:13:46,800
so

388
00:13:49,829 --> 00:13:48,000

on the science side i think it's

389
00:13:52,069 --> 00:13:49,839
hopefully pretty obvious right like the

390
00:13:53,750 --> 00:13:52,079
scientists are going to define

391
00:13:55,430 --> 00:13:53,760
are are looking at this data so they're

392
00:13:57,030 --> 00:13:55,440
telling us what's the most important

393
00:13:58,230 --> 00:13:57,040
components of their data and we need to

394
00:13:59,990 --> 00:13:58,240
make sure that we're building software

395
00:14:02,470 --> 00:14:00,000
that can find and extract those you know

396
00:14:04,069 --> 00:14:02,480
those biosignatures those signs of life

397
00:14:05,750 --> 00:14:04,079
so that was you know weekly meetings

398
00:14:08,470 --> 00:14:05,760
right we're going back hey we uh we

399
00:14:09,829 --> 00:14:08,480
worked on adding this new algorithm here

400
00:14:11,750 --> 00:14:09,839
are some of the results in the data you

401
00:14:13,269 --> 00:14:11,760
have um what do you think like oh that's

402
00:14:14,710 --> 00:14:13,279
good but actually we got this new data

403
00:14:15,590 --> 00:14:14,720
set and last week that's very different

404
00:14:17,430 --> 00:14:15,600
so we're going to need you to go through

405
00:14:18,710 --> 00:14:17,440
this again and then okay we found out

406
00:14:19,990 --> 00:14:18,720
this doesn't work in this specific use

407
00:14:22,710 --> 00:14:20,000
case all right we'll get back to next

408
00:14:24,470 --> 00:14:22,720
week and just kind of repeatedly do that

409
00:14:25,509 --> 00:14:24,480
so that was a really important piece

410
00:14:26,790 --> 00:14:25,519
because that's

411
00:14:28,069 --> 00:14:26,800
you know we're building up that

412
00:14:29,350 --> 00:14:28,079
relationship and that trust with the

413
00:14:30,629 --> 00:14:29,360

science team

414
00:14:31,590 --> 00:14:30,639
to make sure that we can find and

415
00:14:33,110 --> 00:14:31,600
extract

416
00:14:34,949 --> 00:14:33,120
what they're most interested in uh

417
00:14:36,470 --> 00:14:34,959
interested in

418
00:14:38,389 --> 00:14:36,480
in a way that's also really scary

419
00:14:40,310 --> 00:14:38,399
because you're you're standing between

420
00:14:41,829 --> 00:14:40,320
the scientists and their data which is

421
00:14:43,829 --> 00:14:41,839
not something you usually have to deal

422
00:14:45,590 --> 00:14:43,839
with on earth right if i tell you it's a

423
00:14:46,870 --> 00:14:45,600
scientist you can only pick out point

424
00:14:48,389 --> 00:14:46,880
one to point zero one percent of your

425
00:14:50,870 --> 00:14:48,399
data and someone else's software is

426
00:14:52,150 --> 00:14:50,880
gonna do it that's going to uh that's

427
00:14:53,430 --> 00:14:52,160
gonna be really scary for a lot of

428
00:14:55,110 --> 00:14:53,440
people

429
00:14:57,829 --> 00:14:55,120
yeah um so yeah a lot of work with a

430
00:15:00,230 --> 00:14:57,839
scientist i'll go ahead yeah well you

431
00:15:02,710 --> 00:15:00,240
must develop quite a trusting bond bet

432
00:15:05,990 --> 00:15:02,720
with those teams right

433
00:15:06,949 --> 00:15:06,000
yeah i think that was absolutely vital

434
00:15:08,629 --> 00:15:06,959
and that was something that was really

435
00:15:10,230 --> 00:15:08,639
special about the project you know like

436
00:15:11,750 --> 00:15:10,240
a lot of times in our in these research

437
00:15:13,990 --> 00:15:11,760
projects you don't always get to spend

438
00:15:15,670 --> 00:15:14,000

years working with a science team from

439
00:15:17,189 --> 00:15:15,680
you know from us on like the autonomous

440
00:15:18,230 --> 00:15:17,199
software perspective

441
00:15:19,509 --> 00:15:18,240
so that was something that was very

442
00:15:24,389 --> 00:15:19,519
special that we got to build up that

443
00:15:26,949 --> 00:15:25,590
and then you know even working with the

444
00:15:28,389 --> 00:15:26,959
instrument developers as well like we

445
00:15:29,750 --> 00:15:28,399
need to understand a lot of the ins and

446
00:15:31,509 --> 00:15:29,760
outs about the raw data that's coming

447
00:15:33,110 --> 00:15:31,519
off those instruments

448
00:15:35,829 --> 00:15:33,120
i mentioned earlier that we have we've

449
00:15:37,910 --> 00:15:35,839
built up this battery of you know sanity

450
00:15:39,910 --> 00:15:37,920
checks for the data that actually

451
00:15:41,269 --> 00:15:39,920
becomes really helpful to sit next to

452
00:15:42,710 --> 00:15:41,279
the instrument developers and say like

453
00:15:44,389 --> 00:15:42,720
oh yeah you collected you know four

454
00:15:45,750 --> 00:15:44,399
hours of data yesterday i can run

455
00:15:47,430 --> 00:15:45,760
through and analyze that in you know

456
00:15:48,949 --> 00:15:47,440
maybe 20 minutes and i have all these

457
00:15:50,870 --> 00:15:48,959
checks that will run and flag things if

458
00:15:52,230 --> 00:15:50,880
there's any problems with the data so as

459
00:15:53,910 --> 00:15:52,240
they're developing the instrument adding

460
00:15:55,269 --> 00:15:53,920
new things that becomes kind of nice to

461
00:15:56,870 --> 00:15:55,279
be able to sit alongside them and help

462
00:15:57,910 --> 00:15:56,880
them in some ways

463
00:15:59,910 --> 00:15:57,920

i mean they didn't really need the help

464
00:16:02,629 --> 00:15:59,920
they're also very talented but it's a

465
00:16:03,509 --> 00:16:02,639
nice way to provide some value

466
00:16:05,509 --> 00:16:03,519
and then

467
00:16:07,189 --> 00:16:05,519
on the hardware side too

468
00:16:09,990 --> 00:16:07,199
i think that another one of the big

469
00:16:10,949 --> 00:16:10,000
challenges of doing this

470
00:16:12,310 --> 00:16:10,959
is that

471
00:16:14,230 --> 00:16:12,320
you

472
00:16:15,829 --> 00:16:14,240
have to make it run on a flight computer

473
00:16:17,110 --> 00:16:15,839
we don't have we don't have server racks

474
00:16:19,350 --> 00:16:17,120
you don't have cloud computing we don't

475
00:16:21,350 --> 00:16:19,360
have any like nice

476
00:16:22,710 --> 00:16:21,360
high performance computing software or a

477
00:16:24,069 --> 00:16:22,720
computer or anything like that we're

478
00:16:26,550 --> 00:16:24,079
running on something that's kind of like

479
00:16:28,389 --> 00:16:26,560
a modern smartphone that's as much as

480
00:16:30,069 --> 00:16:28,399
we've got so working with them to say

481
00:16:31,910 --> 00:16:30,079
okay we have to make sure that all the

482
00:16:33,350 --> 00:16:31,920
algorithms we develop also run in a

483
00:16:34,790 --> 00:16:33,360
reasonable amount of time they can't

484
00:16:35,749 --> 00:16:34,800
take you know two days to run when we

485
00:16:38,710 --> 00:16:35,759
can collect

486
00:16:40,150 --> 00:16:38,720
many samples a day

487
00:16:41,829 --> 00:16:40,160
so i know we've got a bunch of great

488
00:16:43,269 --> 00:16:41,839

slides so and i know most of them relate

489
00:16:47,030 --> 00:16:43,279
to this um

490
00:16:49,590 --> 00:16:47,040
how do you test this thing here on earth

491
00:16:50,870 --> 00:16:49,600
yeah so maybe we can pull up slide eight

492
00:16:52,629 --> 00:16:50,880
to start with

493
00:16:54,310 --> 00:16:52,639
just to show you guys what is what did

494
00:16:56,710 --> 00:16:54,320
it actually look like

495
00:16:58,629 --> 00:16:56,720
yeah so we took our instrument suite out

496
00:17:00,150 --> 00:16:58,639
to the field out to mono lake and we'll

497
00:17:02,710 --> 00:17:00,160
get to that in a second but this is this

498
00:17:05,270 --> 00:17:02,720
is actually the the owls um platform

499
00:17:08,309 --> 00:17:05,280
itself so three boxes on the left that's

500
00:17:09,909 --> 00:17:08,319
where all the the flight computers live

501
00:17:11,750 --> 00:17:09,919
in the middle is a bunch of the

502
00:17:13,909 --> 00:17:11,760
different chemistry instruments so

503
00:17:15,189 --> 00:17:13,919
there's a mass spec and several other uh

504
00:17:17,189 --> 00:17:15,199
several other chemistry focused

505
00:17:19,110 --> 00:17:17,199
instruments and then on the right side

506
00:17:20,390 --> 00:17:19,120
there we have the the microscopes live

507
00:17:23,110 --> 00:17:20,400
in that box

508
00:17:25,429 --> 00:17:23,120
so we took this out to monolake

509
00:17:27,669 --> 00:17:25,439
california um it's just a little east of

510
00:17:28,630 --> 00:17:27,679
yosemite uh kind of close to the nevada

511
00:17:31,990 --> 00:17:28,640
border

512
00:17:33,750 --> 00:17:32,000
and there mono lake um is actually in

513
00:17:34,870 --> 00:17:33,760

some ways a pretty good analog for what

514
00:17:36,710 --> 00:17:34,880
we would see

515
00:17:38,710 --> 00:17:36,720
on enceladus i mean it's not like frozen

516
00:17:42,230 --> 00:17:38,720
over anything we're in we're in desert

517
00:17:44,070 --> 00:17:42,240
california but the lake is hypersaline

518
00:17:45,190 --> 00:17:44,080
it kind of lies at the bottom of this

519
00:17:47,669 --> 00:17:45,200
old

520
00:17:49,510 --> 00:17:47,679
volcano caldera so all the water

521
00:17:52,390 --> 00:17:49,520
is always running down into the lake and

522
00:17:53,430 --> 00:17:52,400
it never leaves so it gets very salty

523
00:17:55,669 --> 00:17:53,440
and that's what we expect to see

524
00:17:57,029 --> 00:17:55,679
actually on enceladus

525
00:17:59,190 --> 00:17:57,039
so

526
00:18:00,870 --> 00:17:59,200
we maybe you can go through

527
00:18:02,870 --> 00:18:00,880
like slides

528
00:18:05,110 --> 00:18:02,880
9-13 just kind of like slowly flip

529
00:18:07,350 --> 00:18:05,120
through those and show you what

530
00:18:08,630 --> 00:18:07,360
uh what monolake looked like

531
00:18:10,470 --> 00:18:08,640
yeah so that's kind of like looking out

532
00:18:12,950 --> 00:18:10,480
from the parking lot into the lake

533
00:18:16,870 --> 00:18:15,190
so we went there to stress test this

534
00:18:17,669 --> 00:18:16,880
entire system

535
00:18:19,350 --> 00:18:17,679
we

536
00:18:21,110 --> 00:18:19,360
you know spent a lot of time developing

537
00:18:22,710 --> 00:18:21,120
it in the laboratory and working all

538
00:18:24,710 --> 00:18:22,720

these all these different components but

539
00:18:27,430 --> 00:18:24,720
at the end of the day we needed to go

540
00:18:30,630 --> 00:18:27,440
out to a field site show that we can

541
00:18:31,990 --> 00:18:30,640
take up samples of water

542
00:18:33,350 --> 00:18:32,000
introduce them to all the different

543
00:18:34,470 --> 00:18:33,360
instruments all those instruments are

544
00:18:35,669 --> 00:18:34,480
collecting data looking for those

545
00:18:37,350 --> 00:18:35,679
biosignatures all those different

546
00:18:40,150 --> 00:18:37,360
biocenters we talked about you know all

547
00:18:43,270 --> 00:18:40,160
those independent lines of evidence

548
00:18:45,110 --> 00:18:43,280
and uh once that data is collected then

549
00:18:47,990 --> 00:18:45,120
at the end of every day we would come in

550
00:18:50,150 --> 00:18:48,000
and run the autonomy software on that

551
00:18:51,430 --> 00:18:50,160
data and try to

552
00:18:53,110 --> 00:18:51,440
and confirm that we could extract the

553
00:18:57,510 --> 00:18:53,120
bio signatures and kind of give a report

554
00:18:59,190 --> 00:18:57,520
back to the team each morning so it was

555
00:19:00,950 --> 00:18:59,200
it's hard to describe how much fun it

556
00:19:03,029 --> 00:19:00,960
was to go there and work we were there

557
00:19:05,350 --> 00:19:03,039
for like six days it was basically like

558
00:19:08,630 --> 00:19:05,360
a huge hackathon where we're making sure

559
00:19:10,549 --> 00:19:08,640
we can you know go and end on the system

560
00:19:11,830 --> 00:19:10,559
debugging problems along the way but at

561
00:19:14,310 --> 00:19:11,840
the end of the day

562
00:19:16,549 --> 00:19:14,320
um with you know all the teams really

563
00:19:18,150 --> 00:19:16,559

hard work uh i think we had like about

564
00:19:19,909 --> 00:19:18,160
20 people that went

565
00:19:21,750 --> 00:19:19,919
with all the team's hard work we were

566
00:19:23,350 --> 00:19:21,760
able to show um

567
00:19:25,830 --> 00:19:23,360
we were able to show success on all the

568
00:19:27,590 --> 00:19:25,840
instruments and we found actually a

569
00:19:31,590 --> 00:19:27,600
couple of

570
00:19:32,870 --> 00:19:31,600
in the lake itself

571
00:19:34,710 --> 00:19:32,880
so a couple of cells are actually

572
00:19:35,909 --> 00:19:34,720
swimming around on their own

573
00:19:37,669 --> 00:19:35,919
which was really cool because we didn't

574
00:19:40,150 --> 00:19:37,679
know if we would find that

575
00:19:42,390 --> 00:19:40,160
there was a lot of algae and

576
00:19:44,789 --> 00:19:42,400
things there too so that you know that

577
00:19:48,710 --> 00:19:44,799
sign of life was very abundant

578
00:19:51,190 --> 00:19:48,720
maybe more than we'll find on enceladus

579
00:19:52,950 --> 00:19:51,200
but maybe i can show

580
00:19:54,310 --> 00:19:52,960
a couple examples of like what the

581
00:19:55,270 --> 00:19:54,320
instrument data we're actually looking

582
00:19:58,789 --> 00:19:55,280
at

583
00:20:00,390 --> 00:19:58,799
yeah

584
00:20:02,950 --> 00:20:00,400
i think on slide

585
00:20:04,150 --> 00:20:02,960
well so i'll just quickly describe two

586
00:20:07,029 --> 00:20:04,160
of the instruments then we can show some

587
00:20:09,510 --> 00:20:07,039
data from it from them

588
00:20:11,270 --> 00:20:09,520

the first one one of the

589
00:20:13,029 --> 00:20:11,280
one of the really cool microscopes on

590
00:20:15,750 --> 00:20:13,039
the project is called this digital

591
00:20:17,990 --> 00:20:15,760
holographic microscope or dhm

592
00:20:20,630 --> 00:20:18,000
and when i first saw this i was like

593
00:20:22,470 --> 00:20:20,640
holy cow this is way more interesting

594
00:20:24,549 --> 00:20:22,480
and sophisticated than like microscopes

595
00:20:26,470 --> 00:20:24,559
i dealt with in biology 101.

596
00:20:27,909 --> 00:20:26,480
all right instead of having like a slide

597
00:20:30,549 --> 00:20:27,919
like preparing a slide and looking at it

598
00:20:34,230 --> 00:20:30,559
through a microscope this microscope can

599
00:20:36,390 --> 00:20:34,240
image a 3d volume so we basically flow

600
00:20:38,070 --> 00:20:36,400
water a small like

601
00:20:40,710 --> 00:20:38,080
through a channel past the microscope's

602
00:20:42,870 --> 00:20:40,720
field of view and that microscope can

603
00:20:44,870 --> 00:20:42,880
image essentially what's like a a

604
00:20:46,070 --> 00:20:44,880
microscopic swimming pool so it's like a

605
00:20:47,909 --> 00:20:46,080
small

606
00:20:50,789 --> 00:20:47,919
about a millimeter by a millimeter i

607
00:20:52,310 --> 00:20:50,799
think by one half millimeter deep

608
00:20:54,710 --> 00:20:52,320
uh volume

609
00:20:56,070 --> 00:20:54,720
and what that means is you know this

610
00:20:58,230 --> 00:20:56,080
microscope the reason it's there at the

611
00:21:00,950 --> 00:20:58,240
biosignature we're looking for

612
00:21:02,630 --> 00:21:00,960
is motility so we have this essentially

613
00:21:04,870 --> 00:21:02,640

what's a microscopic swimming pool if

614
00:21:06,549 --> 00:21:04,880
there are any cells that can move on

615
00:21:09,029 --> 00:21:06,559
their own they can swim around and move

616
00:21:12,549 --> 00:21:09,039
around in that volume um and we can

617
00:21:14,710 --> 00:21:12,559
capture that on the microscope so

618
00:21:17,830 --> 00:21:14,720
maybe we can show slide three here that

619
00:21:18,950 --> 00:21:17,840
has some videos of the raw data

620
00:21:21,669 --> 00:21:18,960
yeah

621
00:21:23,590 --> 00:21:21,679
so what you're seeing here is you see a

622
00:21:25,510 --> 00:21:23,600
bunch of particles kind of drifting down

623
00:21:26,549 --> 00:21:25,520
from the top right to the bottom left

624
00:21:27,830 --> 00:21:26,559
and they're just kind of passively

625
00:21:29,430 --> 00:21:27,840
moving through those could be like dead

626
00:21:30,470 --> 00:21:29,440
cells or

627
00:21:32,630 --> 00:21:30,480
debris

628
00:21:34,070 --> 00:21:32,640
but you can also see some of these cells

629
00:21:35,669 --> 00:21:34,080
are kind of coarse screwing and swirling

630
00:21:37,830 --> 00:21:35,679
around on the screen

631
00:21:40,230 --> 00:21:37,840
so that those cells are swimming they're

632
00:21:42,149 --> 00:21:40,240
motile and this is one of the key bio

633
00:21:45,029 --> 00:21:42,159
signatures we're going to look for on

634
00:21:46,950 --> 00:21:45,039
places like enceladus because if a cell

635
00:21:49,750 --> 00:21:46,960
or something like a cell can move on its

636
00:21:52,789 --> 00:21:49,760
own that is really evolutionary

637
00:21:53,830 --> 00:21:52,799
evolutionarily advance advantageous

638
00:21:55,990 --> 00:21:53,840

because

639
00:21:58,230 --> 00:21:56,000
that means you can go swim and find food

640
00:22:00,470 --> 00:21:58,240
and also do a better job avoiding

641
00:22:02,470 --> 00:22:00,480
becoming somebody's food

642
00:22:03,750 --> 00:22:02,480
so on top of this what you're seeing is

643
00:22:04,950 --> 00:22:03,760
these tracks being drawn on those

644
00:22:06,549 --> 00:22:04,960
particles and that's actually the

645
00:22:08,149 --> 00:22:06,559
autonomy at work there

646
00:22:09,590 --> 00:22:08,159
so it is tracking some of the more

647
00:22:11,590 --> 00:22:09,600
salient some of those more visually

648
00:22:13,909 --> 00:22:11,600
salient particles

649
00:22:16,149 --> 00:22:13,919
and those those are what those lines are

650
00:22:16,950 --> 00:22:16,159
and then on top of those tracks then we

651
00:22:18,870 --> 00:22:16,960
have

652
00:22:20,310 --> 00:22:18,880
some machine learning algorithms that

653
00:22:21,350 --> 00:22:20,320
analyze those tracks and try to

654
00:22:23,110 --> 00:22:21,360
determine

655
00:22:25,029 --> 00:22:23,120
whether or not they're motile so it's

656
00:22:27,270 --> 00:22:25,039
taking in they're taking a various

657
00:22:28,789 --> 00:22:27,280
various track features like how fast was

658
00:22:30,710 --> 00:22:28,799
it moving how often did it turn things

659
00:22:32,549 --> 00:22:30,720
like this and making a prediction about

660
00:22:34,149 --> 00:22:32,559
whether or not they think those cells

661
00:22:36,149 --> 00:22:34,159
are alive and moving

662
00:22:37,909 --> 00:22:36,159
so that's one of the key

663
00:22:40,470 --> 00:22:37,919

the key bio signatures that our science

664
00:22:41,830 --> 00:22:40,480
autonomy is trying to extract

665
00:22:43,430 --> 00:22:41,840
so instead at the end of the day instead

666
00:22:45,190 --> 00:22:43,440
of having this like

667
00:22:46,070 --> 00:22:45,200
i think it's about five gigabytes per

668
00:22:49,190 --> 00:22:46,080
minute

669
00:22:52,070 --> 00:22:49,200
of raw data because this is this is

670
00:22:54,710 --> 00:22:52,080
3d data it comes in basically in 4k so

671
00:22:56,789 --> 00:22:54,720
it's generating a bunch of information

672
00:22:59,029 --> 00:22:56,799
the autonomy takes that extracts these

673
00:23:00,789 --> 00:22:59,039
tracks and extracts little

674
00:23:02,789 --> 00:23:00,799
almost like particle portraits little

675
00:23:04,149 --> 00:23:02,799
raw cutouts around any of the particles

676
00:23:05,430 --> 00:23:04,159
it sees

677
00:23:07,110 --> 00:23:05,440
as well as some other contextual

678
00:23:08,630 --> 00:23:07,120
information and that's what's

679
00:23:10,390 --> 00:23:08,640
transmitted back to the science team so

680
00:23:12,149 --> 00:23:10,400
you end up going from something like

681
00:23:13,830 --> 00:23:12,159
five gigabytes per minute um you can

682
00:23:15,270 --> 00:23:13,840
compress that down to maybe about five

683
00:23:17,430 --> 00:23:15,280
megabytes so that's how we get our

684
00:23:20,870 --> 00:23:17,440
compression here

685
00:23:24,149 --> 00:23:20,880
so this was on the biology side

686
00:23:26,549 --> 00:23:24,159
but we also worked with

687
00:23:27,350 --> 00:23:26,559
we also worked with the chemistry team

688
00:23:29,750 --> 00:23:27,360

so

689
00:23:31,110 --> 00:23:29,760
maybe if we well describe the instrument

690
00:23:33,990 --> 00:23:31,120
in a second then we can flip over to

691
00:23:35,750 --> 00:23:34,000
that that video

692
00:23:37,110 --> 00:23:35,760
on the chemistry side what we're looking

693
00:23:38,070 --> 00:23:37,120
for is very

694
00:23:41,029 --> 00:23:38,080
small

695
00:23:43,190 --> 00:23:41,039
molecules that may indicate life so

696
00:23:45,190 --> 00:23:43,200
things like think amino acids right

697
00:23:47,190 --> 00:23:45,200
building blocks building blocks for for

698
00:23:47,990 --> 00:23:47,200
proteins

699
00:23:49,510 --> 00:23:48,000
so

700
00:23:51,909 --> 00:23:49,520
on that side of the house basically what

701
00:23:53,669 --> 00:23:51,919
happens is we pull in our water sample

702
00:23:55,350 --> 00:23:53,679
it basically goes through like a mini

703
00:23:57,830 --> 00:23:55,360
pressure cooker

704
00:23:59,430 --> 00:23:57,840
so if there are any cells in in that

705
00:24:01,990 --> 00:23:59,440
specific sample they'll get cooked and

706
00:24:03,990 --> 00:24:02,000
kind of burst open and you end up with

707
00:24:06,070 --> 00:24:04,000
what's essentially almost like cell soup

708
00:24:08,710 --> 00:24:06,080
then you can feed to things like this

709
00:24:10,390 --> 00:24:08,720
mass spectrometer and that kind of

710
00:24:12,549 --> 00:24:10,400
exposes if there are things like amino

711
00:24:13,510 --> 00:24:12,559
acids they're now exposed in this fluid

712
00:24:17,269 --> 00:24:13,520
so

713
00:24:18,789 --> 00:24:17,279

maybe if we can go over to slide five

714
00:24:19,750 --> 00:24:18,799
that's going to show some of this data

715
00:24:21,990 --> 00:24:19,760
here

716
00:24:24,870 --> 00:24:22,000
yeah so we we get this mass spectrometer

717
00:24:26,549 --> 00:24:24,880
it's looking for peaks in the data

718
00:24:28,710 --> 00:24:26,559
so this would be

719
00:24:30,390 --> 00:24:28,720
when these things like amino acids are

720
00:24:32,630 --> 00:24:30,400
split up right as they get fed into the

721
00:24:35,269 --> 00:24:32,640
mass spectrometer they will show up as

722
00:24:36,710 --> 00:24:35,279
little peaks in this

723
00:24:38,789 --> 00:24:36,720
in this raw data and so what the

724
00:24:40,230 --> 00:24:38,799
autonomy doing is doing here is saying

725
00:24:42,310 --> 00:24:40,240
i'm going to go through and search and

726
00:24:44,630 --> 00:24:42,320
find where are all those peaks in this

727
00:24:46,149 --> 00:24:44,640
data identify them make these little

728
00:24:48,390 --> 00:24:46,159
cutouts again you can kind of see that

729
00:24:51,110 --> 00:24:48,400
pattern it's making these little cutouts

730
00:24:52,070 --> 00:24:51,120
of the the raw peaks and then

731
00:24:53,669 --> 00:24:52,080
pulling together some different

732
00:24:56,070 --> 00:24:53,679
statistics about how high they are how

733
00:24:57,830 --> 00:24:56,080
wide they were things like this

734
00:24:59,590 --> 00:24:57,840
with this information then the

735
00:25:01,830 --> 00:24:59,600
scientists can go through and use these

736
00:25:03,350 --> 00:25:01,840
peaks almost like like a chemical

737
00:25:04,549 --> 00:25:03,360
fingerprint

738
00:25:05,830 --> 00:25:04,559

so i actually

739
00:25:07,430 --> 00:25:05,840
saw them do this in the field it's

740
00:25:11,750 --> 00:25:07,440
really impressive you can say all right

741
00:25:12,630 --> 00:25:11,760
i saw a peak at 150 m over z at you know

742
00:25:14,950 --> 00:25:12,640
uh

743
00:25:16,549 --> 00:25:14,960
like 22 minutes and there's another one

744
00:25:18,070 --> 00:25:16,559
lined up at this mess and they'll be

745
00:25:19,430 --> 00:25:18,080
like okay that sounds like it could be

746
00:25:22,070 --> 00:25:19,440
guanine without even like looking at

747
00:25:23,990 --> 00:25:22,080
anything it's really impressive

748
00:25:25,990 --> 00:25:24,000
um so this is with this data here then

749
00:25:26,870 --> 00:25:26,000
they can go back and say okay are there

750
00:25:31,190 --> 00:25:26,880
any

751
00:25:33,190 --> 00:25:31,200
within the data that would indicate

752
00:25:36,230 --> 00:25:33,200
signs of life like amino acids or

753
00:25:38,149 --> 00:25:36,240
nucleic acids things like that

754
00:25:39,909 --> 00:25:38,159
um yeah hopefully that that makes some

755
00:25:41,830 --> 00:25:39,919
sense about how we're taking the raw

756
00:25:43,669 --> 00:25:41,840
data extracting these key signatures and

757
00:25:46,230 --> 00:25:43,679
transmitting just the most important

758
00:25:49,269 --> 00:25:46,240
pieces back to our science team

759
00:25:50,870 --> 00:25:49,279
that's pretty amazing it's got to take

760
00:25:52,549 --> 00:25:50,880
without that power you've got to deal

761
00:25:53,990 --> 00:25:52,559
with it's got to be so extremely

762
00:25:56,549 --> 00:25:54,000
challenging to narrow down the software

763
00:25:59,269 --> 00:25:56,559

to be able to do that so kudos to you

764
00:26:01,269 --> 00:25:59,279
and the team for sure um

765
00:26:03,029 --> 00:26:01,279
how long does it take to build something

766
00:26:04,870 --> 00:26:03,039
like this this instrument package that

767
00:26:07,029 --> 00:26:04,880
you've had out there at mono lake for

768
00:26:09,269 --> 00:26:07,039
example

769
00:26:11,190 --> 00:26:09,279
yeah it is uh

770
00:26:12,470 --> 00:26:11,200
so this is a long time in the making i

771
00:26:14,789 --> 00:26:12,480
think you know we

772
00:26:16,230 --> 00:26:14,799
the specific owls team came together and

773
00:26:17,110 --> 00:26:16,240
worked for

774
00:26:18,710 --> 00:26:17,120
um

775
00:26:20,390 --> 00:26:18,720
like three a little over three years on

776
00:26:21,990 --> 00:26:20,400
this on integrating all these different

777
00:26:23,669 --> 00:26:22,000
instruments but all the even the

778
00:26:25,110 --> 00:26:23,679
individual instruments right those same

779
00:26:27,190 --> 00:26:25,120
teams were working on those well before

780
00:26:28,710 --> 00:26:27,200
owls even started

781
00:26:30,230 --> 00:26:28,720
so it's

782
00:26:31,990 --> 00:26:30,240
it takes a long time it takes a lot of

783
00:26:33,990 --> 00:26:32,000
dedicated effort and it takes a lot of

784
00:26:36,149 --> 00:26:34,000
collaboration i think that's kind of the

785
00:26:39,029 --> 00:26:36,159
real key takeaway is having

786
00:26:40,630 --> 00:26:39,039
the team together working as one kind of

787
00:26:42,390 --> 00:26:40,640
like rowing all in the same direction on

788
00:26:44,390 --> 00:26:42,400

this really tough problem

789
00:26:46,230 --> 00:26:44,400
um that was what

790
00:26:47,669 --> 00:26:46,240
i think helped us be

791
00:26:49,350 --> 00:26:47,679
helped us be able to put together this

792
00:26:50,950 --> 00:26:49,360
entire integrated system

793
00:26:52,870 --> 00:26:50,960
and um

794
00:26:54,310 --> 00:26:52,880
and be successful in the field

795
00:26:56,789 --> 00:26:54,320
i think maybe

796
00:26:59,029 --> 00:26:56,799
it'd be good to show maybe like slide 14

797
00:27:01,669 --> 00:26:59,039
to 15 a couple more images from the from

798
00:27:03,430 --> 00:27:01,679
our field test

799
00:27:05,350 --> 00:27:03,440
yeah so here's um

800
00:27:06,630 --> 00:27:05,360
here's aaron mauro and nate they're

801
00:27:07,750 --> 00:27:06,640
putting together kind of setting up the

802
00:27:10,149 --> 00:27:07,760
system

803
00:27:11,590 --> 00:27:10,159
um underneath the tent we were about we

804
00:27:13,190 --> 00:27:11,600
were out basically in this parking lot

805
00:27:14,549 --> 00:27:13,200
outside the visitor center set up there

806
00:27:16,070 --> 00:27:14,559
for like six days

807
00:27:17,830 --> 00:27:16,080
um so they're just getting things set up

808
00:27:19,590 --> 00:27:17,840
now and and right after this i think

809
00:27:21,269 --> 00:27:19,600
they kind of set up the command kind of

810
00:27:22,070 --> 00:27:21,279
the command central where all where all

811
00:27:26,870 --> 00:27:22,080
the

812
00:27:29,909 --> 00:27:26,880
tables

813
00:27:31,350 --> 00:27:29,919

uh and on that i think on the next image

814
00:27:32,789 --> 00:27:31,360
yeah here's

815
00:27:35,590 --> 00:27:32,799
this is uh

816
00:27:37,350 --> 00:27:35,600
this is jess and seth and they were

817
00:27:38,870 --> 00:27:37,360
these these two were kind of in a way

818
00:27:40,470 --> 00:27:38,880
like heroes of the project especially

819
00:27:43,029 --> 00:27:40,480
one of the days they were getting up at

820
00:27:43,990 --> 00:27:43,039
like 5 00 a.m maybe even earlier each

821
00:27:46,870 --> 00:27:44,000
day

822
00:27:48,950 --> 00:27:46,880
going out on mono lake on a boat and

823
00:27:50,470 --> 00:27:48,960
pulling up water samples so that every

824
00:27:51,590 --> 00:27:50,480
single day we'd have a fresh sample to

825
00:27:53,190 --> 00:27:51,600
run through all the instruments and run

826
00:27:54,389 --> 00:27:53,200
all the autonomy on

827
00:27:56,230 --> 00:27:54,399
and

828
00:27:58,470 --> 00:27:56,240
i think it was maybe it was the last day

829
00:27:59,909 --> 00:27:58,480
they were collecting samples um actually

830
00:28:01,510 --> 00:27:59,919
the water it started getting really

831
00:28:02,710 --> 00:28:01,520
windy out and the reason they would go

832
00:28:04,389 --> 00:28:02,720
early in the morning is to avoid the

833
00:28:05,669 --> 00:28:04,399
wind and avoid getting any white caps on

834
00:28:07,669 --> 00:28:05,679
the water

835
00:28:09,830 --> 00:28:07,679
and one of the days it did pick up and

836
00:28:10,630 --> 00:28:09,840
so they had to ditch the boat

837
00:28:12,310 --> 00:28:10,640
and

838
00:28:15,190 --> 00:28:12,320

hike back i think it was like over two

839
00:28:16,789 --> 00:28:15,200
miles in the heat with the water samples

840
00:28:19,190 --> 00:28:16,799
and they were wearing like full body

841
00:28:21,269 --> 00:28:19,200
waders they had like all the way back to

842
00:28:22,630 --> 00:28:21,279
camp because it was too dangerous to be

843
00:28:24,630 --> 00:28:22,640
out on the water

844
00:28:26,549 --> 00:28:24,640
um so i think that just speaks to you

845
00:28:28,230 --> 00:28:26,559
know that the dedication of the team

846
00:28:30,950 --> 00:28:28,240
everyone was really was really working

847
00:28:32,789 --> 00:28:30,960
hard because we really believe in in

848
00:28:35,110 --> 00:28:32,799
what we're doing and it was

849
00:28:36,630 --> 00:28:35,120
again i can't capture the energy

850
00:28:38,149 --> 00:28:36,640
that was there in the field to work

851
00:28:39,909 --> 00:28:38,159
alongside all these all these great

852
00:28:41,269 --> 00:28:39,919
people

853
00:28:42,630 --> 00:28:41,279
you're doing a pretty good job it just

854
00:28:44,549 --> 00:28:42,640
kind of

855
00:28:46,070 --> 00:28:44,559
reviving it from you for sure had to be

856
00:28:47,590 --> 00:28:46,080
like the coolest science camping trip

857
00:28:49,510 --> 00:28:47,600
ever right

858
00:28:51,669 --> 00:28:49,520
yeah so i think we have i guess we have

859
00:28:53,269 --> 00:28:51,679
one team photo

860
00:28:54,789 --> 00:28:53,279
maybe go one more photo for it and we

861
00:28:56,310 --> 00:28:54,799
can show the whole

862
00:28:58,310 --> 00:28:56,320
um

863
00:29:00,149 --> 00:28:58,320

this is this is just the team that went

864
00:29:02,070 --> 00:29:00,159
out to the field unfortunately we didn't

865
00:29:03,590 --> 00:29:02,080
have the money to bring everyone out

866
00:29:05,830 --> 00:29:03,600
there because it was as you imagine like

867
00:29:07,990 --> 00:29:05,840
a week-long field campaign was pretty

868
00:29:09,350 --> 00:29:08,000
took a lot of resources um

869
00:29:10,789 --> 00:29:09,360
but yeah maybe flip forward back and

870
00:29:13,750 --> 00:29:10,799
forth between this photo and the next

871
00:29:15,590 --> 00:29:13,760
one

872
00:29:16,950 --> 00:29:15,600
yeah so it

873
00:29:19,269 --> 00:29:16,960
was a really really fun group to be

874
00:29:20,710 --> 00:29:19,279
working with very smart people but

875
00:29:22,389 --> 00:29:20,720
but

876
00:29:24,950 --> 00:29:22,399
just so much fun i i don't know if i've

877
00:29:27,350 --> 00:29:24,960
had a more rewarding like single week of

878
00:29:28,710 --> 00:29:27,360
work in my life it was it was so it was

879
00:29:32,710 --> 00:29:28,720
great

880
00:29:34,950 --> 00:29:32,720
me so smile

881
00:29:37,110 --> 00:29:34,960
so then what has to happen now before

882
00:29:38,870 --> 00:29:37,120
owls can become like a real-life flight

883
00:29:40,870 --> 00:29:38,880
project

884
00:29:42,070 --> 00:29:40,880
yeah so

885
00:29:50,870 --> 00:29:42,080
i

886
00:29:52,389 --> 00:29:50,880
so that's why we went out there that's

887
00:29:54,230 --> 00:29:52,399
why we stress test the system put it

888
00:29:57,590 --> 00:29:54,240

through it's all its paces tried to

889
00:29:58,950 --> 00:29:57,600
identify any places where we can improve

890
00:30:01,029 --> 00:29:58,960
but also

891
00:30:02,950 --> 00:30:01,039
showing that we could rely on some

892
00:30:04,789 --> 00:30:02,960
technology that's already out there so

893
00:30:07,750 --> 00:30:04,799
for example things like

894
00:30:09,990 --> 00:30:07,760
we used f prime which is a

895
00:30:11,750 --> 00:30:10,000
open source flight software package used

896
00:30:13,110 --> 00:30:11,760
to control

897
00:30:14,070 --> 00:30:13,120
like probes we've seen out in the solar

898
00:30:15,510 --> 00:30:14,080
system

899
00:30:18,950 --> 00:30:15,520
that's actually used right now to

900
00:30:20,870 --> 00:30:18,960
control mars helicopter ingenuity

901
00:30:23,909 --> 00:30:20,880
we also you know as i mentioned at the

902
00:30:25,830 --> 00:30:23,919
start we use this very uh light compute

903
00:30:27,510 --> 00:30:25,840
platform that's really similar to the

904
00:30:29,990 --> 00:30:27,520
snapdragon platform that runs in a lot

905
00:30:31,909 --> 00:30:30,000
of mobile phones that is also in use

906
00:30:33,269 --> 00:30:31,919
right now by ingenuity the mars

907
00:30:36,230 --> 00:30:33,279
helicopter

908
00:30:37,669 --> 00:30:36,240
and so the goal here was to try and show

909
00:30:39,590 --> 00:30:37,679
we can rely already on a lot of

910
00:30:41,510 --> 00:30:39,600
technology that's already proven and

911
00:30:43,510 --> 00:30:41,520
that makes the path towards getting

912
00:30:45,990 --> 00:30:43,520
things like owls on a real mission and

913
00:30:47,830 --> 00:30:46,000

actually gets sent out to enceladus

914
00:30:49,510 --> 00:30:47,840
that really shortens that path

915
00:30:51,190 --> 00:30:49,520
so at the end of the day what we're

916
00:30:53,190 --> 00:30:51,200
trying to do is really show

917
00:30:55,430 --> 00:30:53,200
there's no there's no miracles that need

918
00:30:56,310 --> 00:30:55,440
to happen for owls to get it ready for

919
00:30:57,909 --> 00:30:56,320
flight

920
00:31:00,070 --> 00:30:57,919
we try to push it as far as we can and

921
00:31:01,350 --> 00:31:00,080
understand the limits of the system and

922
00:31:02,789 --> 00:31:01,360
get to the point where we can start

923
00:31:04,549 --> 00:31:02,799
actually thinking about proposing this

924
00:31:06,149 --> 00:31:04,559
on some of the summer the future

925
00:31:07,510 --> 00:31:06,159
missions we want to send out to the to

926
00:31:09,269 --> 00:31:07,520
ocean worlds out in the outer solar

927
00:31:10,710 --> 00:31:09,279
system

928
00:31:12,870 --> 00:31:10,720
so yeah following that along that what

929
00:31:15,510 --> 00:31:12,880
kind of future missions do you see for

930
00:31:16,870 --> 00:31:15,520
this type of autonomy

931
00:31:18,870 --> 00:31:16,880
yeah

932
00:31:20,710 --> 00:31:18,880
uh it is a really

933
00:31:22,630 --> 00:31:20,720
interesting and fun area that's kind of

934
00:31:25,190 --> 00:31:22,640
it's it's kind of blowing up right now

935
00:31:26,549 --> 00:31:25,200
because data has become so cheap and

936
00:31:27,510 --> 00:31:26,559
easy to collect

937
00:31:30,389 --> 00:31:27,520
um

938
00:31:32,310 --> 00:31:30,399

you think about now that we get a

939
00:31:33,110 --> 00:31:32,320
global image of the entire earth every

940
00:31:34,149 --> 00:31:33,120
day

941
00:31:36,470 --> 00:31:34,159
we're

942
00:31:38,870 --> 00:31:36,480
nasa is working right now on the nysar

943
00:31:41,190 --> 00:31:38,880
uh the nysar orbiter

944
00:31:43,509 --> 00:31:41,200
which is going to it basically images

945
00:31:46,789 --> 00:31:43,519
and and kind of collects data about the

946
00:31:48,789 --> 00:31:46,799
3d surface of earth that when that gets

947
00:31:50,230 --> 00:31:48,799
launched that will produce

948
00:31:51,830 --> 00:31:50,240
i don't quote me on this but i think

949
00:31:53,669 --> 00:31:51,840
it's more

950
00:31:54,549 --> 00:31:53,679
data per year

951
00:31:56,230 --> 00:31:54,559
than

952
00:31:57,990 --> 00:31:56,240
nasa has ever collected on all of its

953
00:32:01,269 --> 00:31:58,000
missions over all time

954
00:32:02,710 --> 00:32:01,279
like it's crazy so the amount of data

955
00:32:04,470 --> 00:32:02,720
that we're going to have it just keeps

956
00:32:05,909 --> 00:32:04,480
exponentially rising and so having

957
00:32:07,509 --> 00:32:05,919
things like

958
00:32:09,190 --> 00:32:07,519
science autonomy to help us focus our

959
00:32:11,590 --> 00:32:09,200
attention and understand

960
00:32:13,590 --> 00:32:11,600
what is how do i understand where the

961
00:32:15,750 --> 00:32:13,600
interesting bits of my data are how do i

962
00:32:17,350 --> 00:32:15,760
how do i put those pieces of data in

963
00:32:19,190 --> 00:32:17,360

front of scientists and humans rather

964
00:32:20,710 --> 00:32:19,200
than having to hire you know armies of

965
00:32:22,230 --> 00:32:20,720
grad students and interns to manually

966
00:32:23,269 --> 00:32:22,240
flip through images or like look through

967
00:32:24,389 --> 00:32:23,279
data

968
00:32:25,669 --> 00:32:24,399
that's just not going to be tenable

969
00:32:27,669 --> 00:32:25,679
anymore

970
00:32:29,669 --> 00:32:27,679
so that's one piece of it we want to do

971
00:32:30,950 --> 00:32:29,679
we want to take all those same

972
00:32:33,909 --> 00:32:30,960
um

973
00:32:35,830 --> 00:32:33,919
we we can

974
00:32:37,430 --> 00:32:35,840
use right now here on earth

975
00:32:38,710 --> 00:32:37,440
uh because we're so close but it's able

976
00:32:40,230 --> 00:32:38,720
we're able to transmit the data pretty

977
00:32:42,630 --> 00:32:40,240
easily back down to the ground but if we

978
00:32:43,990 --> 00:32:42,640
could take all those same fantastic

979
00:32:45,830 --> 00:32:44,000
scientific instruments and send them out

980
00:32:48,230 --> 00:32:45,840
to mars or the asteroid belt or further

981
00:32:50,310 --> 00:32:48,240
out like we're trying to go to enceladus

982
00:32:52,389 --> 00:32:50,320
you're going to run into that problem

983
00:32:55,029 --> 00:32:52,399
that we we talked about at the start

984
00:32:56,230 --> 00:32:55,039
that physics just

985
00:32:57,990 --> 00:32:56,240
says that you are not going to be able

986
00:33:00,389 --> 00:32:58,000
to transmit very much data it is it's

987
00:33:02,549 --> 00:33:00,399
worse than dial up out there

988
00:33:04,389 --> 00:33:02,559

and you need something like this on

989
00:33:07,110 --> 00:33:04,399
board science autonomy to be able to

990
00:33:08,870 --> 00:33:07,120
extract out the best uh most

991
00:33:10,389 --> 00:33:08,880
scientifically interesting components of

992
00:33:12,789 --> 00:33:10,399
your data however the scientists define

993
00:33:14,470 --> 00:33:12,799
that and transmit that back to earth

994
00:33:15,430 --> 00:33:14,480
so that's

995
00:33:17,029 --> 00:33:15,440
that's

996
00:33:19,509 --> 00:33:17,039
what's it's very exciting like one of

997
00:33:22,070 --> 00:33:19,519
the very exciting ways this is going to

998
00:33:25,190 --> 00:33:22,080
help enable more science and as we

999
00:33:26,470 --> 00:33:25,200
explore the solar system but even here

1000
00:33:28,230 --> 00:33:26,480
on the ground

1001
00:33:29,669 --> 00:33:28,240
there are so many areas where we could

1002
00:33:31,830 --> 00:33:29,679
help

1003
00:33:33,990 --> 00:33:31,840
save scientists time by just pointing

1004
00:33:36,789 --> 00:33:34,000
them to the most interesting bits of the

1005
00:33:38,470 --> 00:33:36,799
data so think back to you know those

1006
00:33:39,669 --> 00:33:38,480
microscopy videos i was showing you

1007
00:33:41,029 --> 00:33:39,679
where we're just track we're trying to

1008
00:33:43,190 --> 00:33:41,039
find and track anything that seems to

1009
00:33:45,830 --> 00:33:43,200
swim under its own power

1010
00:33:47,990 --> 00:33:45,840
that can be useful in a medical setting

1011
00:33:50,070 --> 00:33:48,000
for example if you're looking at

1012
00:33:51,350 --> 00:33:50,080
blood from someone who may have sepsis

1013
00:33:52,310 --> 00:33:51,360

and you want to see there's any bacteria

1014
00:33:53,830 --> 00:33:52,320
swimming around in their blood and

1015
00:33:55,110 --> 00:33:53,840
there's all these red blood cells and

1016
00:33:57,029 --> 00:33:55,120
it's really hard to track just the one

1017
00:33:58,630 --> 00:33:57,039
or two bacteria you're looking for

1018
00:34:01,029 --> 00:33:58,640
rather than having a person manually

1019
00:34:02,310 --> 00:34:01,039
look in a microscope and kind of like be

1020
00:34:04,310 --> 00:34:02,320
turning the knob and focusing back and

1021
00:34:06,149 --> 00:34:04,320
forth seeing if they see anything

1022
00:34:08,230 --> 00:34:06,159
send like a larger blood sample through

1023
00:34:10,950 --> 00:34:08,240
something like that instrument with an

1024
00:34:12,869 --> 00:34:10,960
autonomy that can tell you hey at time

1025
00:34:14,149 --> 00:34:12,879
32 in this portion of the image it looks

1026
00:34:15,829 --> 00:34:14,159
like there's something swimming around

1027
00:34:17,829 --> 00:34:15,839
please check this out and see if this is

1028
00:34:20,069 --> 00:34:17,839
what you're looking for

1029
00:34:21,109 --> 00:34:20,079
same thing for like closing down beaches

1030
00:34:23,270 --> 00:34:21,119
right if you want to know if there's

1031
00:34:25,030 --> 00:34:23,280
harmful bacteria in the water someone

1032
00:34:26,550 --> 00:34:25,040
just goes out scoops up a little water

1033
00:34:28,310 --> 00:34:26,560
goes back to a lab and runs through a

1034
00:34:31,990 --> 00:34:28,320
few slides well what if we could do that

1035
00:34:34,389 --> 00:34:32,000
automatically like that would be huge

1036
00:34:36,230 --> 00:34:34,399
and just to close that out even the our

1037
00:34:38,069 --> 00:34:36,240
oceans here on earth

1038
00:34:40,230 --> 00:34:38,079

we don't

1039
00:34:42,310 --> 00:34:40,240
understand all the bacteria that are in

1040
00:34:43,909 --> 00:34:42,320
our own oceans i think again this is

1041
00:34:46,230 --> 00:34:43,919
another place don't quote me but i think

1042
00:34:48,710 --> 00:34:46,240
that it's i've heard over 90 of the

1043
00:34:51,270 --> 00:34:48,720
bacteria here on earth we don't fully

1044
00:34:53,510 --> 00:34:51,280
understand and so just putting maybe 10

1045
00:34:55,109 --> 00:34:53,520
of those on

1046
00:34:56,790 --> 00:34:55,119
like container ships and just having

1047
00:34:58,069 --> 00:34:56,800
them you know collect data for

1048
00:35:00,310 --> 00:34:58,079
two years

1049
00:35:01,750 --> 00:35:00,320
all right now you have i don't know

1050
00:35:03,829 --> 00:35:01,760
10 petabytes of data it's probably going

1051
00:35:06,790 --> 00:35:03,839
to be a lot more than that but here's

1052
00:35:08,950 --> 00:35:06,800
the 50 here's 50 uh

1053
00:35:10,310 --> 00:35:08,960
recordings we the autonomy is telling

1054
00:35:11,750 --> 00:35:10,320
you like you should look at these first

1055
00:35:13,430 --> 00:35:11,760
we've characterized them down into like

1056
00:35:15,030 --> 00:35:13,440
four types of motility that we tend to

1057
00:35:16,550 --> 00:35:15,040
see um here's where you should spend

1058
00:35:18,550 --> 00:35:16,560
your time looking first rather than

1059
00:35:19,829 --> 00:35:18,560
having to manually watch

1060
00:35:22,870 --> 00:35:19,839
you know all those videos which at some

1061
00:35:24,150 --> 00:35:22,880
point becomes uh impossible

1062
00:35:25,670 --> 00:35:24,160
so that's

1063
00:35:26,870 --> 00:35:25,680

that's kind of why i'm excited about

1064
00:35:28,790 --> 00:35:26,880
science autonomy i think there's a lot

1065
00:35:30,710 --> 00:35:28,800
of ways that we can help

1066
00:35:32,390 --> 00:35:30,720
empower scientists to spend more time

1067
00:35:34,069 --> 00:35:32,400
looking at interesting data and get good

1068
00:35:35,510 --> 00:35:34,079
data back to earth

1069
00:35:37,589 --> 00:35:35,520
rather than have them kind of manually

1070
00:35:39,190 --> 00:35:37,599
flipping through or you know

1071
00:35:41,589 --> 00:35:39,200
just reducing the tedium that they have

1072
00:35:42,390 --> 00:35:41,599
to have to deal with

1073
00:35:46,550 --> 00:35:42,400
right

1074
00:35:51,109 --> 00:35:49,430
that's amazing the applications are yeah

1075
00:35:52,710 --> 00:35:51,119
pretty endless i can see where this can

1076
00:35:54,230 --> 00:35:52,720
be used all over the place

1077
00:35:56,550 --> 00:35:54,240
um so given that i think it's a good

1078
00:35:58,230 --> 00:35:56,560
time actually to check in with our

1079
00:35:59,430 --> 00:35:58,240
with nikki to see what's going on out

1080
00:36:00,950 --> 00:35:59,440
there i'm sure we've got questions

1081
00:36:01,910 --> 00:36:00,960
coming in nikki how how's it going out

1082
00:36:03,829 --> 00:36:01,920
there

1083
00:36:05,829 --> 00:36:03,839
oh my goodness the chat has been so very

1084
00:36:07,589 --> 00:36:05,839
busy tons of questions free mark first

1085
00:36:09,270 --> 00:36:07,599
off tons of happy birthdays from the

1086
00:36:10,630 --> 00:36:09,280
chat so happy birthday from everyone in

1087
00:36:12,550 --> 00:36:10,640
the chat as well

1088
00:36:14,630 --> 00:36:12,560

um but one of the biggest things people

1089
00:36:16,870 --> 00:36:14,640
are kind of wondering about on all the

1090
00:36:18,310 --> 00:36:16,880
different channels is how do you get

1091
00:36:20,550 --> 00:36:18,320
into a field like this and what kind of

1092
00:36:23,109 --> 00:36:20,560
advice would you have for a college

1093
00:36:24,630 --> 00:36:23,119
student a grad student a high school

1094
00:36:27,030 --> 00:36:24,640
student who wants to do something like

1095
00:36:29,190 --> 00:36:27,040
this

1096
00:36:31,430 --> 00:36:29,200
yeah that's a great question

1097
00:36:34,069 --> 00:36:31,440
i think like hopefully from

1098
00:36:35,829 --> 00:36:34,079
these like this picture and talking

1099
00:36:37,990 --> 00:36:35,839
about the team i think one of the things

1100
00:36:39,990 --> 00:36:38,000
that's worth stressing is that

1101
00:36:42,150 --> 00:36:40,000
there are a lot of really tough problems

1102
00:36:44,150 --> 00:36:42,160
that we want to

1103
00:36:45,990 --> 00:36:44,160
solve or look at like trying to find

1104
00:36:48,230 --> 00:36:46,000
life and those take

1105
00:36:49,750 --> 00:36:48,240
it takes so many different people with

1106
00:36:51,910 --> 00:36:49,760
different backgrounds

1107
00:36:53,589 --> 00:36:51,920
different areas of expertise like

1108
00:36:56,230 --> 00:36:53,599
different ways of thinking

1109
00:36:57,829 --> 00:36:56,240
to be able to actually make progress on

1110
00:37:00,630 --> 00:36:57,839
those problems

1111
00:37:03,030 --> 00:37:00,640
in some ways like to me it almost feels

1112
00:37:03,670 --> 00:37:03,040
freeing in a way because

1113
00:37:06,790 --> 00:37:03,680

the

1114
00:37:08,470 --> 00:37:06,800
have a kind of like a single inventor

1115
00:37:10,390 --> 00:37:08,480
make huge strides and some really

1116
00:37:13,109 --> 00:37:10,400
important problem you need to have these

1117
00:37:15,750 --> 00:37:13,119
really big teams and so i think what's

1118
00:37:18,230 --> 00:37:15,760
nice about that is that means like

1119
00:37:19,349 --> 00:37:18,240
you can kind of think about and and try

1120
00:37:23,670 --> 00:37:19,359
to

1121
00:37:25,510 --> 00:37:23,680
like learning different types of skills

1122
00:37:27,510 --> 00:37:25,520
or learning different types of knowledge

1123
00:37:29,430 --> 00:37:27,520
or studying different things and those

1124
00:37:31,190 --> 00:37:29,440
can all be relevant to working on some

1125
00:37:33,270 --> 00:37:31,200
of these big problems

1126
00:37:35,510 --> 00:37:33,280
so i think my advice to especially to

1127
00:37:36,950 --> 00:37:35,520
the college students and high school

1128
00:37:39,670 --> 00:37:36,960
students you know try a lot of different

1129
00:37:41,910 --> 00:37:39,680
things do internships shadow people

1130
00:37:43,750 --> 00:37:41,920
um just do even in informational

1131
00:37:45,030 --> 00:37:43,760
interviews with people who you think

1132
00:37:46,630 --> 00:37:45,040
they have interesting work would like

1133
00:37:48,310 --> 00:37:46,640
what ask them how their how their

1134
00:37:49,750 --> 00:37:48,320
day-to-day looks

1135
00:37:50,870 --> 00:37:49,760
and then maybe try to understand okay

1136
00:37:52,630 --> 00:37:50,880
like what

1137
00:37:53,430 --> 00:37:52,640
what am i most passionate and excited

1138
00:37:55,510 --> 00:37:53,440

about

1139
00:37:57,190 --> 00:37:55,520
um day to day and how do i like what

1140
00:37:59,109 --> 00:37:57,200
type of really big problems do i care

1141
00:38:00,870 --> 00:37:59,119
about like how do i connect those two

1142
00:38:03,430 --> 00:38:00,880
those two aspects

1143
00:38:05,430 --> 00:38:03,440
um and i'll say spoiler alert like i'm

1144
00:38:07,109 --> 00:38:05,440
still figuring it out too right it's

1145
00:38:08,870 --> 00:38:07,119
probably what are you passionate about

1146
00:38:11,190 --> 00:38:08,880
is probably life's one of life's

1147
00:38:12,710 --> 00:38:11,200
toughest challenges to to try and answer

1148
00:38:15,030 --> 00:38:12,720
for yourself so

1149
00:38:16,630 --> 00:38:15,040
it's always a work in progress

1150
00:38:19,349 --> 00:38:16,640
yeah i mean i always say the toughest

1151
00:38:21,349 --> 00:38:19,359
things are the things most worth doing

1152
00:38:23,430 --> 00:38:21,359
but that's some great advice

1153
00:38:25,109 --> 00:38:23,440
you mentioned as well how difficult this

1154
00:38:26,470 --> 00:38:25,119
is this kind of observing and

1155
00:38:27,829 --> 00:38:26,480
understanding and potentially looking

1156
00:38:29,510 --> 00:38:27,839
for life and we've had quite a few

1157
00:38:31,670 --> 00:38:29,520
questions on that so i'm actually going

1158
00:38:33,349 --> 00:38:31,680
to put two together neil on facebook

1159
00:38:36,230 --> 00:38:33,359
wants to know what happens if you

1160
00:38:38,310 --> 00:38:36,240
actually find life with owls and bill on

1161
00:38:40,150 --> 00:38:38,320
youtube wants to know if life is found

1162
00:38:42,150 --> 00:38:40,160
on another place is there a way to

1163
00:38:46,310 --> 00:38:42,160

determine if it came from an asteroid or

1164
00:38:48,950 --> 00:38:46,320
a comet strike on the early earth

1165
00:38:51,190 --> 00:38:48,960
yeah so how do we first question how do

1166
00:38:52,550 --> 00:38:51,200
we determine if we found life

1167
00:38:55,270 --> 00:38:52,560
with owls

1168
00:38:57,030 --> 00:38:55,280
and at the end of the day

1169
00:38:58,470 --> 00:38:57,040
owls and the instruments and the

1170
00:39:00,230 --> 00:38:58,480
autonomy i've been talking about are not

1171
00:39:01,910 --> 00:39:00,240
going to replace the scientists i think

1172
00:39:04,150 --> 00:39:01,920
that is one of the most important bits

1173
00:39:06,150 --> 00:39:04,160
to understand we are just trying to send

1174
00:39:08,870 --> 00:39:06,160
back the best data that we can

1175
00:39:10,630 --> 00:39:08,880
the science team will make the final

1176
00:39:12,710 --> 00:39:10,640
conclusions that they can based on the

1177
00:39:13,990 --> 00:39:12,720
data and so they'll be working with

1178
00:39:15,270 --> 00:39:14,000
i mean honestly just the entire

1179
00:39:16,710 --> 00:39:15,280
scientific community probably at that

1180
00:39:17,910 --> 00:39:16,720
point because this is such a huge

1181
00:39:19,030 --> 00:39:17,920
problem

1182
00:39:21,190 --> 00:39:19,040
but they'll be putting together the

1183
00:39:22,630 --> 00:39:21,200
evidence and it is going to take an

1184
00:39:24,870 --> 00:39:22,640
extraordinary amount of evidence because

1185
00:39:26,390 --> 00:39:24,880
this would be an extraordinary claim if

1186
00:39:27,589 --> 00:39:26,400
we were to say we actually think we

1187
00:39:29,109 --> 00:39:27,599
found life

1188
00:39:31,510 --> 00:39:29,119

um but yeah at the end of the day that

1189
00:39:32,950 --> 00:39:31,520
decision will go to the scientists to to

1190
00:39:33,750 --> 00:39:32,960
defend

1191
00:39:36,630 --> 00:39:33,760
um

1192
00:39:38,710 --> 00:39:36,640
the other question yeah about where

1193
00:39:41,190 --> 00:39:38,720
where does life like how can we tell if

1194
00:39:43,030 --> 00:39:41,200
it came from somewhere uh

1195
00:39:44,630 --> 00:39:43,040
like if there was multiple places that

1196
00:39:46,310 --> 00:39:44,640
originated or did it originate in one

1197
00:39:48,390 --> 00:39:46,320
place and kind of spread

1198
00:39:50,710 --> 00:39:48,400
owls isn't gonna answer that per se but

1199
00:39:53,190 --> 00:39:50,720
i think there will be some interesting

1200
00:39:54,550 --> 00:39:53,200
like as the data came comes off owls and

1201
00:39:55,990 --> 00:39:54,560
maybe we did find something interesting

1202
00:39:58,710 --> 00:39:56,000
we'll be looking at some of those

1203
00:39:59,750 --> 00:39:58,720
questions so you could ask

1204
00:40:02,630 --> 00:39:59,760
you know one of the things we'll be

1205
00:40:04,230 --> 00:40:02,640
looking for is nucleic acids

1206
00:40:06,710 --> 00:40:04,240
so that would be really interesting if

1207
00:40:08,550 --> 00:40:06,720
we see that it seems like the cells or

1208
00:40:11,910 --> 00:40:08,560
you know whatever we found on the ocean

1209
00:40:13,030 --> 00:40:11,920
of enceladus for example also uses dna

1210
00:40:14,230 --> 00:40:13,040
that's going to be really interesting

1211
00:40:16,150 --> 00:40:14,240
because that's going to start prompting

1212
00:40:17,030 --> 00:40:16,160
questions okay well maybe there was some

1213
00:40:18,390 --> 00:40:17,040

kind of

1214
00:40:19,990 --> 00:40:18,400
cross-contamination if you will from

1215
00:40:20,870 --> 00:40:20,000
like a meteorite strike

1216
00:40:22,390 --> 00:40:20,880
and

1217
00:40:23,990 --> 00:40:22,400
those meteorites got transferred between

1218
00:40:25,829 --> 00:40:24,000
multiple places in the solar system

1219
00:40:27,829 --> 00:40:25,839
that's possible i think those

1220
00:40:29,829 --> 00:40:27,839
those theories are definitely out there

1221
00:40:31,670 --> 00:40:29,839
and very well thought about

1222
00:40:32,790 --> 00:40:31,680
but what if it doesn't contain dna what

1223
00:40:34,310 --> 00:40:32,800
if it's like something completely

1224
00:40:35,270 --> 00:40:34,320
different that would be really exciting

1225
00:40:36,310 --> 00:40:35,280
too

1226
00:40:38,230 --> 00:40:36,320
and i think

1227
00:40:40,550 --> 00:40:38,240
looking at those individual bio

1228
00:40:41,990 --> 00:40:40,560
signatures would probably help

1229
00:40:43,829 --> 00:40:42,000
you know start to direct our thinking

1230
00:40:45,430 --> 00:40:43,839
about which of those which those

1231
00:40:49,030 --> 00:40:45,440
hypotheses would be

1232
00:40:52,470 --> 00:40:50,710
yeah so i mean there's a lot of

1233
00:40:54,790 --> 00:40:52,480
different ways we have to think about

1234
00:40:56,390 --> 00:40:54,800
this but you're you're i mean

1235
00:40:58,150 --> 00:40:56,400
i love what you're sharing and more

1236
00:41:00,790 --> 00:40:58,160
people are asking more questions about

1237
00:41:02,950 --> 00:41:00,800
life and alexis on linkedin wants to

1238
00:41:04,870 --> 00:41:02,960

know would amino acids still be the

1239
00:41:09,430 --> 00:41:04,880
building blocks of life for something

1240
00:41:13,589 --> 00:41:11,190
yeah i

1241
00:41:15,190 --> 00:41:13,599
this is one of those it kind of comes

1242
00:41:17,589 --> 00:41:15,200
back to the fact that this is in some

1243
00:41:18,710 --> 00:41:17,599
ways like a paradoxical search like we

1244
00:41:21,910 --> 00:41:18,720
understand

1245
00:41:23,990 --> 00:41:21,920
our like life on earth reasonably well

1246
00:41:25,270 --> 00:41:24,000
and in some ways we don't like i

1247
00:41:27,109 --> 00:41:25,280
mentioned at the start we don't know

1248
00:41:28,470 --> 00:41:27,119
exactly what we'll find

1249
00:41:30,630 --> 00:41:28,480
somewhere else

1250
00:41:32,710 --> 00:41:30,640
and so it may not be carbon based there

1251
00:41:34,710 --> 00:41:32,720
may be a lot of there may be some key

1252
00:41:37,109 --> 00:41:34,720
differences for from

1253
00:41:39,190 --> 00:41:37,119
life that we understand on earth

1254
00:41:39,990 --> 00:41:39,200
and so i think that's what comes back to

1255
00:41:42,630 --> 00:41:40,000
that

1256
00:41:45,270 --> 00:41:42,640
the strategy of owls right we try to put

1257
00:41:46,230 --> 00:41:45,280
as many instruments as we can

1258
00:41:50,550 --> 00:41:46,240
on this

1259
00:41:51,910 --> 00:41:50,560
many as many independent ways as we can

1260
00:41:54,069 --> 00:41:51,920
so

1261
00:41:55,510 --> 00:41:54,079
even if we don't see for example we

1262
00:41:56,790 --> 00:41:55,520
didn't find any amino acids at all

1263
00:41:58,950 --> 00:41:56,800

there's a bunch of other molecules that

1264
00:42:00,710 --> 00:41:58,960
we don't fully understand but we took

1265
00:42:01,990 --> 00:42:00,720
these microscopy videos and indeed

1266
00:42:03,829 --> 00:42:02,000
there's something swimming around in

1267
00:42:05,589 --> 00:42:03,839
there that's really interesting because

1268
00:42:08,390 --> 00:42:05,599
we have ways to both look on the

1269
00:42:09,750 --> 00:42:08,400
chemistry side we also have ways to look

1270
00:42:11,670 --> 00:42:09,760
for signs of life that don't involve

1271
00:42:13,030 --> 00:42:11,680
chemistry at all

1272
00:42:14,870 --> 00:42:13,040
and so i think that

1273
00:42:16,870 --> 00:42:14,880
that is the that's the important bit

1274
00:42:19,430 --> 00:42:16,880
about the strategy is as you try to

1275
00:42:20,950 --> 00:42:19,440
carry out this search and you realize

1276
00:42:22,069 --> 00:42:20,960
how hard it is you have to be able to

1277
00:42:25,589 --> 00:42:22,079
try and count for as many of those

1278
00:42:28,710 --> 00:42:26,870
it's good that the scientists are

1279
00:42:30,950 --> 00:42:28,720
thinking of all of the things out there

1280
00:42:32,550 --> 00:42:30,960
so that uh we know that but it is weird

1281
00:42:35,270 --> 00:42:32,560
to think about life that could be

1282
00:42:36,630 --> 00:42:35,280
non-carbon based um so we've got some

1283
00:42:38,870 --> 00:42:36,640
other great questions i think we've got

1284
00:42:40,950 --> 00:42:38,880
time for maybe three quick answers so

1285
00:42:44,630 --> 00:42:40,960
rob on linkedin wants to know could owls

1286
00:42:46,550 --> 00:42:44,640
be used on mars at the ice caps and d on

1287
00:42:49,510 --> 00:42:46,560
linkedin also wants to know could we go

1288
00:42:51,190 --> 00:42:49,520

to water exoplanets so i know we talked

1289
00:42:52,790 --> 00:42:51,200
about enceladus and europa but where

1290
00:42:55,589 --> 00:42:52,800
else could these things be applicable

1291
00:42:56,470 --> 00:42:55,599
where else could we use owls

1292
00:42:58,710 --> 00:42:56,480
yeah

1293
00:43:00,630 --> 00:42:58,720
mars is definitely one that um people

1294
00:43:02,309 --> 00:43:00,640
are talking more about i think you know

1295
00:43:03,910 --> 00:43:02,319
we're still

1296
00:43:06,710 --> 00:43:03,920
searching and trying to understand more

1297
00:43:08,150 --> 00:43:06,720
about where water is within our solar

1298
00:43:09,990 --> 00:43:08,160
system and mars is one that's popping up

1299
00:43:12,470 --> 00:43:10,000
a lot more so

1300
00:43:13,990 --> 00:43:12,480
maybe at the polls but uh i i think i've

1301
00:43:15,990 --> 00:43:14,000
heard people talk a lot more about you

1302
00:43:17,829 --> 00:43:16,000
know lava tubes as well like old lava

1303
00:43:19,670 --> 00:43:17,839
tubes that could have liquid water

1304
00:43:21,349 --> 00:43:19,680
underneath that's the key is we want to

1305
00:43:22,870 --> 00:43:21,359
try to find places where there's liquid

1306
00:43:24,829 --> 00:43:22,880
water present

1307
00:43:27,349 --> 00:43:24,839
and those are those are going to

1308
00:43:30,550 --> 00:43:27,359
form some of those target locations that

1309
00:43:32,550 --> 00:43:30,560
we want to send the owl suite

1310
00:43:33,910 --> 00:43:32,560
and going yeah it would be really really

1311
00:43:36,390 --> 00:43:33,920
interesting to send it to some

1312
00:43:38,870 --> 00:43:36,400
exoplanets even further out i think

1313
00:43:40,390 --> 00:43:38,880

we'll have to we'll be especially

1314
00:43:42,309 --> 00:43:40,400
challenged then to make sure we can

1315
00:43:43,750 --> 00:43:42,319
transmit the data back home because the

1316
00:43:44,950 --> 00:43:43,760
distance is there you know when we start

1317
00:43:47,589 --> 00:43:44,960
talking about going between solar

1318
00:43:49,190 --> 00:43:47,599
systems or you know to other stars

1319
00:43:50,790 --> 00:43:49,200
in the galaxy

1320
00:43:52,550 --> 00:43:50,800
um we're going to be really pressed so

1321
00:43:54,309 --> 00:43:52,560
maybe that's a good way to

1322
00:43:55,670 --> 00:43:54,319
to confirm that that i'll have job

1323
00:43:58,470 --> 00:43:55,680
security is just try to send these

1324
00:44:00,790 --> 00:43:58,480
things even further out

1325
00:44:02,710 --> 00:44:00,800
job security is a great answer i love

1326
00:44:05,030 --> 00:44:02,720
that for you um i think we've got time

1327
00:44:07,430 --> 00:44:05,040
for one last question and you have

1328
00:44:09,349 --> 00:44:07,440
inspired some people but anaya on

1329
00:44:11,589 --> 00:44:09,359
youtube wants even more information so

1330
00:44:14,950 --> 00:44:11,599
mark how did you know that you wanted to

1331
00:44:21,270 --> 00:44:17,510
oh i it's so hard i don't know if i can

1332
00:44:23,030 --> 00:44:21,280
even explain what it is it's uh

1333
00:44:24,790 --> 00:44:23,040
i think just in general there are so

1334
00:44:28,550 --> 00:44:24,800
many

1335
00:44:31,670 --> 00:44:28,560
challenges and problems uh in the

1336
00:44:33,349 --> 00:44:31,680
scientific domain and i think for me

1337
00:44:35,510 --> 00:44:33,359
i don't know i felt a draw especially to

1338
00:44:37,190 --> 00:44:35,520

mars and to some of these big challenges

1339
00:44:38,870 --> 00:44:37,200
and being able to work with such a big

1340
00:44:39,829 --> 00:44:38,880
team i think that's what i enjoy most

1341
00:44:43,109 --> 00:44:39,839
about it

1342
00:44:45,510 --> 00:44:43,119
um it's a feeling i guess i i again i

1343
00:44:47,750 --> 00:44:45,520
don't know if i can like write down

1344
00:44:48,790 --> 00:44:47,760
what exactly got me to this point

1345
00:44:50,710 --> 00:44:48,800
but

1346
00:44:52,069 --> 00:44:50,720
yet i'll go back to what i said earlier

1347
00:44:53,349 --> 00:44:52,079
you know if you

1348
00:44:55,510 --> 00:44:53,359
if you're trying to figure out what

1349
00:44:57,990 --> 00:44:55,520
exactly are my passions try as many

1350
00:44:59,349 --> 00:44:58,000
things as you can you know you don't you

1351
00:45:01,109 --> 00:44:59,359
don't come out and know your favorite

1352
00:45:03,109 --> 00:45:01,119
ice cream offhand you need to you know

1353
00:45:04,470 --> 00:45:03,119
try like 20 or 30 or 40 varieties of

1354
00:45:05,990 --> 00:45:04,480
your lifetime to really hone in on what

1355
00:45:07,750 --> 00:45:06,000
your favorite ice cream is it's the same

1356
00:45:09,190 --> 00:45:07,760
thing for for doing work you got to try

1357
00:45:11,349 --> 00:45:09,200
a lot of different things and collect

1358
00:45:13,109 --> 00:45:11,359
your own data in a way to see what it is

1359
00:45:17,510 --> 00:45:13,119
that most inspires you and where you

1360
00:45:21,190 --> 00:45:19,750
oh that's fantastic uh those are great

1361
00:45:22,630 --> 00:45:21,200
words nikki those were fantastic

1362
00:45:24,710 --> 00:45:22,640
questions thank you all of you out there

1363
00:45:25,750 --> 00:45:24,720

on social media for your contributions

1364
00:45:27,190 --> 00:45:25,760
tonight

1365
00:45:29,750 --> 00:45:27,200
so that really is just about all the

1366
00:45:32,550 --> 00:45:29,760
time we have so again mark thank you

1367
00:45:34,309 --> 00:45:32,560
very much again happy birthday nikki

1368
00:45:36,309 --> 00:45:34,319
thank you as always for your great job

1369
00:45:37,670 --> 00:45:36,319
behind the scenes there doing this whole

1370
00:45:40,069 --> 00:45:37,680
social media question handling thing i

1371
00:45:41,829 --> 00:45:40,079
really appreciate that all of you team

1372
00:45:43,270 --> 00:45:41,839
behind the scenes directing this and

1373
00:45:44,870 --> 00:45:43,280
making all this happen all of you

1374
00:45:46,870 --> 00:45:44,880
handling the chats out there on the very

1375
00:45:47,670 --> 00:45:46,880
social media platforms thank you very

1376
00:45:49,589 --> 00:45:47,680
much

1377
00:45:51,030 --> 00:45:49,599
and of course all you viewers thank you

1378
00:45:52,230 --> 00:45:51,040
for tuning in

1379
00:45:53,349 --> 00:45:52,240
we couldn't do this without you we

1380
00:45:54,790 --> 00:45:53,359
wouldn't do this without you so we

1381
00:45:56,470 --> 00:45:54,800
really do appreciate your time and

1382
00:45:58,950 --> 00:45:56,480
effort just to tune in and see what's

1383
00:46:00,790 --> 00:45:58,960
going on with us so please join us next

1384
00:46:03,109 --> 00:46:00,800
month when we'll discuss what can be

1385
00:46:05,109 --> 00:46:03,119
learned by studying those occasionally

1386
00:46:07,109 --> 00:46:05,119
threatening near-earth objects that

1387
00:46:09,589 --> 00:46:07,119
should be a fun one until then my