1
00:00:31,080 --> 00:00:28,830
[Music]

2
00:00:36,950 --> 00:00:31,090
hmm

3
00:00:45,920 --> 00:00:39,800
[Applause]

4
00:00:56,830 --> 00:00:55,470
[Music]

5
00:01:04,770 --> 00:00:56,840
[Applause]

6
00:01:04,780 --> 00:01:10,830
[Music]

7
00:01:10,840 --> 00:01:16,860
bye

8
00:02:22,580 --> 00:01:24,010
[Music]

9
00:02:42,620 --> 00:02:22,590
that's

10
00:03:05,990 --> 00:02:55,500
[Music]

11
00:03:30,830 --> 00:03:06,000
[Applause]

12
00:03:33,540 --> 00:03:30,840
[Music]

13
00:04:16,789 --> 00:03:33,550

so

14
00:04:20,229 --> 00:04:18,629
nasa's jet propulsion laboratory

15
00:04:22,950 --> 00:04:20,239
presents

16
00:04:24,950 --> 00:04:22,960
the von carmen lecture a series of talks

17
00:04:25,670 --> 00:04:24,960
by scientists and engineers who are

18
00:04:29,110 --> 00:04:25,680
exploring

19
00:04:29,910 --> 00:04:29,120
our planet our solar system and all that

20
00:04:38,629 --> 00:04:29,920
lies beyond

21
00:04:40,390 --> 00:04:38,639
[Music]

22
00:04:42,469 --> 00:04:40,400
hello everyone and a very pleasant

23
00:04:44,629 --> 00:04:42,479
evening to you wherever you may be

24
00:04:46,390 --> 00:04:44,639
i am brian white from jpl's office of

25
00:04:48,950 --> 00:04:46,400
communications and education

26
00:04:50,710 --> 00:04:48,960
and welcome to our final remote edition

27
00:04:53,430 --> 00:04:50,720
of the 2020

28
00:04:56,870 --> 00:04:53,440
von carmen lecture series our series

29
00:04:59,030 --> 00:04:56,880
will return in january of 2021 but

30
00:05:00,070 --> 00:04:59,040
it's been quite a year and i wanted to

31
00:05:02,150 --> 00:05:00,080
take a moment to thank

32
00:05:03,749 --> 00:05:02,160
all of you joining us from all over the

33
00:05:05,990 --> 00:05:03,759
world for this series

34
00:05:07,590 --> 00:05:06,000
as we've gone from our public on lab

35
00:05:09,909 --> 00:05:07,600
lectures to these remote editions

36
00:05:11,670 --> 00:05:09,919
your patience and curiosity fueled us to

37
00:05:12,390 --> 00:05:11,680
find ways to continue to connect with

38
00:05:15,430 --> 00:05:12,400

you

39
00:05:17,990 --> 00:05:15,440
our audience as we say every single week

40
00:05:19,350 --> 00:05:18,000
every single month this is your space

41
00:05:20,790 --> 00:05:19,360
program

42
00:05:22,469 --> 00:05:20,800
over the past 11 months we've said

43
00:05:22,870 --> 00:05:22,479
farewell to spitzer we've looked to

44
00:05:24,870 --> 00:05:22,880
earth

45
00:05:25,909 --> 00:05:24,880
explored how to become an engineer and

46
00:05:29,110 --> 00:05:25,919
tonight

47
00:05:32,950 --> 00:05:29,120
we talk about the lessons of failure

48
00:05:35,990 --> 00:05:32,960
ever try ever fail try again

49
00:05:37,430 --> 00:05:36,000
fail again fail better

50
00:05:39,510 --> 00:05:37,440
i think we could all relate to samuel

51
00:05:41,590 --> 00:05:39,520
beckett after this year

52
00:05:44,550 --> 00:05:41,600
joining us as co-host this evening is my

53
00:05:46,629 --> 00:05:44,560
colleague nikki wyrick hiya nikki

54
00:05:48,469 --> 00:05:46,639
hi brian thanks for having me tonight i

55
00:05:50,070 --> 00:05:48,479
am very excited to be here and i am

56
00:05:51,430 --> 00:05:50,080
excited to take questions from all of

57
00:05:52,870 --> 00:05:51,440
you watching tonight

58
00:05:54,469 --> 00:05:52,880
we want to make sure that you stay

59
00:05:56,150 --> 00:05:54,479
involved with our conversation this

60
00:05:57,430 --> 00:05:56,160
evening so if you're watching on youtube

61
00:05:59,270 --> 00:05:57,440
or facebook live

62
00:06:01,830 --> 00:05:59,280
make sure you ask questions in the chat

63
00:06:03,990 --> 00:06:01,840

box and our diligent social media team

64
00:06:05,029 --> 00:06:04,000
will bring in as many as they can to our

65
00:06:06,550 --> 00:06:05,039
talk tonight

66
00:06:08,070 --> 00:06:06,560
if you don't see the chat box make sure

67
00:06:09,909 --> 00:06:08,080
you re-load

68
00:06:11,749 --> 00:06:09,919
and as always we want to remind you that

69
00:06:14,150 --> 00:06:11,759
this is your space program so thanks for

70
00:06:16,390 --> 00:06:14,160
being involved tonight

71
00:06:17,670 --> 00:06:16,400
thanks nikki thanks for joining us as

72
00:06:19,510 --> 00:06:17,680
always folks if we run into any

73
00:06:20,469 --> 00:06:19,520
technical difficulty or small little

74
00:06:22,150 --> 00:06:20,479
failures

75
00:06:23,510 --> 00:06:22,160
we ask your patients and stick with us

76
00:06:24,309 --> 00:06:23,520
we'll get them sorted out as soon as we

77
00:06:26,790 --> 00:06:24,319
can

78
00:06:27,749 --> 00:06:26,800
now our speaker tonight discussing this

79
00:06:30,070 --> 00:06:27,759
wonderful topic

80
00:06:31,510 --> 00:06:30,080
is chief engineer for nasa's jet

81
00:06:33,350 --> 00:06:31,520
propulsion laboratory

82
00:06:35,270 --> 00:06:33,360
as well as chief engineer for jpl's

83
00:06:37,029 --> 00:06:35,280
engineering and science directorate

84
00:06:38,550 --> 00:06:37,039
and i'm not going to go through all of

85
00:06:39,909 --> 00:06:38,560
the missions he's worked on because we'd

86
00:06:42,309 --> 00:06:39,919
be here all day and we will be

87
00:06:43,990 --> 00:06:42,319
discussing quite a few of them

88
00:06:46,469 --> 00:06:44,000

throughout the evening but as an

89
00:06:48,870 --> 00:06:46,479
engineering fellow he has been designing

90
00:06:50,790 --> 00:06:48,880
testing and operating robotics robotic

91
00:06:53,670 --> 00:06:50,800
spacecraft for nearly 40 years

92
00:06:55,350 --> 00:06:53,680
including galileo cassini magellan and

93
00:06:57,270 --> 00:06:55,360
many mars missions

94
00:06:58,629 --> 00:06:57,280
most recently rob helped create a team

95
00:07:00,870 --> 00:06:58,639
to design and build

96
00:07:03,189 --> 00:07:00,880
an emergency use ventilator specifically

97
00:07:05,189 --> 00:07:03,199
for the covet 19 pandemic

98
00:07:06,230 --> 00:07:05,199
of all of his accolades and there are

99
00:07:08,070 --> 00:07:06,240
many

100
00:07:09,749 --> 00:07:08,080
my favorite is that he has a minor

101
00:07:13,350 --> 00:07:09,759
planet named after him

102
00:07:16,070 --> 00:07:13,360
please welcome rob manning hi rob

103
00:07:16,629 --> 00:07:16,080
hey brian thank you what a great intro i

104
00:07:18,469 --> 00:07:16,639
always like

105
00:07:20,070 --> 00:07:18,479
who is that person you're talking about

106
00:07:21,749 --> 00:07:20,080
well thank you very much

107
00:07:23,270 --> 00:07:21,759
thank you brian and nikki it's so great

108
00:07:25,589 --> 00:07:23,280
to be here and it's so great to talk to

109
00:07:26,950 --> 00:07:25,599
everybody this is a real treat

110
00:07:29,990 --> 00:07:26,960
of course thank you for being with us

111
00:07:31,670 --> 00:07:30,000
tonight um particularly on this topic we

112
00:07:32,309 --> 00:07:31,680
just said your resume is exemplary

113
00:07:35,270 --> 00:07:32,319

you've

114
00:07:36,390 --> 00:07:35,280
gotten to work so many missions but i

115
00:07:37,990 --> 00:07:36,400
want to know particularly for our

116
00:07:39,189 --> 00:07:38,000
students watching tonight how did you

117
00:07:42,309 --> 00:07:39,199
originally get

118
00:07:44,230 --> 00:07:42,319
to jpl ah great question

119
00:07:45,749 --> 00:07:44,240
well i was very lucky i i was i always

120
00:07:47,589 --> 00:07:45,759
say you know i'm fact

121
00:07:49,589 --> 00:07:47,599
luck plays a role for all of our lives

122
00:07:51,749 --> 00:07:49,599
of course but but i was very lucky

123
00:07:53,749 --> 00:07:51,759
in that i was a student at caltech which

124
00:07:54,869 --> 00:07:53,759
is just a few miles down the street from

125
00:07:56,550 --> 00:07:54,879
uh from jbl

126
00:07:58,230 --> 00:07:56,560
and i was and they were looking in the

127
00:07:59,749 --> 00:07:58,240
early 80s they were looking

128
00:08:01,589 --> 00:07:59,759
not for engineers because they had

129
00:08:03,350 --> 00:08:01,599
plenty of them in that in those days

130
00:08:05,589 --> 00:08:03,360
they wanted some technicians and i said

131
00:08:07,110 --> 00:08:05,599
hey i'm willing to take anything just my

132
00:08:09,830 --> 00:08:07,120
just get my foot in the door

133
00:08:11,189 --> 00:08:09,840
so i found myself as really literally as

134
00:08:14,150 --> 00:08:11,199
a draftsman sitting on

135
00:08:15,029 --> 00:08:14,160
a drafting table with big classes

136
00:08:18,070 --> 00:08:15,039
plastic

137
00:08:18,390 --> 00:08:18,080
vellum uh sheets of schematics where i

138
00:08:20,629 --> 00:08:18,400

was

139
00:08:22,710 --> 00:08:20,639
drawing with a number two pencil and a

140
00:08:25,270 --> 00:08:22,720
nice wonderful electric spinning eraser

141
00:08:26,710 --> 00:08:25,280
and drawing and erasing my mistakes on

142
00:08:29,189 --> 00:08:26,720
the in these in these electronic

143
00:08:30,629 --> 00:08:29,199
circuits that were going to be

144
00:08:32,709 --> 00:08:30,639
electronics that were going to

145
00:08:33,909 --> 00:08:32,719
ultimately fly on a mission called

146
00:08:37,990 --> 00:08:33,919
galileo

147
00:08:40,230 --> 00:08:38,000
to to jupiter in a few years

148
00:08:41,750 --> 00:08:40,240
uh well i want to bring up image number

149
00:08:42,469 --> 00:08:41,760
one because we've got a great shot of

150
00:08:45,350 --> 00:08:42,479
jpl

151
00:08:47,110 --> 00:08:45,360
and also you uh and you're you're

152
00:08:48,470 --> 00:08:47,120
letting somebody sit on a model of a

153
00:08:51,030 --> 00:08:48,480
rover who is that

154
00:08:52,630 --> 00:08:51,040
ah i know that that well with that it's

155
00:08:53,269 --> 00:08:52,640
actually a little robot that we put

156
00:08:55,110 --> 00:08:53,279
inside

157
00:08:56,630 --> 00:08:55,120
our smaller robots this is where we get

158
00:08:57,350 --> 00:08:56,640
our taunt i mean we put small people

159
00:08:59,750 --> 00:08:57,360
inside

160
00:09:00,710 --> 00:08:59,760
small rovers you probably thought

161
00:09:02,150 --> 00:09:00,720
probably knew that

162
00:09:04,230 --> 00:09:02,160
this is the trick behind all of our

163
00:09:05,990 --> 00:09:04,240

autonomous systems but no this is my

164
00:09:08,070 --> 00:09:06,000
daughter colleen manning and she's

165
00:09:09,750 --> 00:09:08,080
she when she was very young i took her

166
00:09:12,230 --> 00:09:09,760
into our sandbox

167
00:09:13,430 --> 00:09:12,240
uh where we had been testing the

168
00:09:15,670 --> 00:09:13,440
curiosity rover

169
00:09:17,829 --> 00:09:15,680
and uh little sojourner rover the very

170
00:09:18,949 --> 00:09:17,839
first mars rover to explore the surface

171
00:09:21,670 --> 00:09:18,959
of another planet

172
00:09:22,949 --> 00:09:21,680
uh and uh and i couldn't resist putting

173
00:09:24,949 --> 00:09:22,959
her this is just a model

174
00:09:26,710 --> 00:09:24,959
uh of the rover but i couldn't resist

175
00:09:27,430 --> 00:09:26,720
sitting here there she was so light and

176
00:09:31,030 --> 00:09:27,440
uh

177
00:09:33,190 --> 00:09:31,040
was a lot of fun i mean it was

178
00:09:34,630 --> 00:09:33,200
we had such an amazing experience very

179
00:09:36,630 --> 00:09:34,640
much like the ventilator experience

180
00:09:38,389 --> 00:09:36,640
where a small team people did amazing

181
00:09:40,470 --> 00:09:38,399
things to make something happen

182
00:09:42,150 --> 00:09:40,480
uh where we really tried to dare mighty

183
00:09:44,790 --> 00:09:42,160
things on mars pathfinder

184
00:09:46,470 --> 00:09:44,800
it was quite an experience well we'll be

185
00:09:49,190 --> 00:09:46,480
bringing that phrase up again

186
00:09:49,509 --> 00:09:49,200
and before we get into these examples

187
00:09:51,590 --> 00:09:49,519
why

188
00:09:53,350 --> 00:09:51,600

is this i mean this topic is important

189
00:09:55,190 --> 00:09:53,360
for me i know a lot of people it is why

190
00:09:56,790 --> 00:09:55,200
do you think this is important for not

191
00:09:59,110 --> 00:09:56,800
only our audience but

192
00:10:01,269 --> 00:09:59,120
anybody walking down the street well

193
00:10:03,190 --> 00:10:01,279
this is a great question

194
00:10:04,949 --> 00:10:03,200
brian i think one of my one of the

195
00:10:06,710 --> 00:10:04,959
things well first of all this is a talk

196
00:10:09,750 --> 00:10:06,720
that this is derived from a talk

197
00:10:12,150 --> 00:10:09,760
i give to my to engineers and not just

198
00:10:15,190 --> 00:10:12,160
engineers but all of our staff at jpl

199
00:10:17,350 --> 00:10:15,200
uh to try to remind them that that that

200
00:10:19,190 --> 00:10:17,360
this is a very humanistic effort that we

201
00:10:20,949 --> 00:10:19,200
do we try to do very hard things

202
00:10:22,069 --> 00:10:20,959
i said earlier trying to dare mining

203
00:10:23,910 --> 00:10:22,079
things this is one of our modules this

204
00:10:26,230 --> 00:10:23,920
is not just jbl it's all of nasa

205
00:10:27,430 --> 00:10:26,240
we try to we try to we we're we're

206
00:10:29,269 --> 00:10:27,440
working at the behest

207
00:10:30,550 --> 00:10:29,279
of all of you taxpayers out there thank

208
00:10:32,470 --> 00:10:30,560
you very much but

209
00:10:34,069 --> 00:10:32,480
our goal is to try to be to try to go

210
00:10:35,509 --> 00:10:34,079
out there and try to not just do

211
00:10:37,430 --> 00:10:35,519
something new and for the first time

212
00:10:39,350 --> 00:10:37,440
for its own sake but try to do something

213
00:10:42,150 --> 00:10:39,360

for for great reasons

214
00:10:44,389 --> 00:10:42,160
so that we can push both the human and

215
00:10:47,190 --> 00:10:44,399
scientific understanding of our world

216
00:10:48,310 --> 00:10:47,200
and our universe um but you know in the

217
00:10:50,389 --> 00:10:48,320
process though

218
00:10:51,990 --> 00:10:50,399
i see a lot of people including

219
00:10:52,949 --> 00:10:52,000
ourselves our own engineers and

220
00:10:55,430 --> 00:10:52,959
scientists

221
00:10:56,949 --> 00:10:55,440
um being really hard on ourselves it's

222
00:10:59,190 --> 00:10:56,959
it's interesting um

223
00:10:59,990 --> 00:10:59,200
in fact this this seems to be our whole

224
00:11:02,710 --> 00:11:00,000
culture right now

225
00:11:03,670 --> 00:11:02,720
i'm sure all of you uh can comment on it

226
00:11:06,230 --> 00:11:03,680
uh well

227
00:11:06,870 --> 00:11:06,240
is that is one of a lot of criticism and

228
00:11:10,389 --> 00:11:06,880
a lot of

229
00:11:12,949 --> 00:11:10,399
ourselves and i and i really

230
00:11:13,430 --> 00:11:12,959
i see that that our expectations for all

231
00:11:15,110 --> 00:11:13,440
of us

232
00:11:16,550 --> 00:11:15,120
seem to be so high and yet we're always

233
00:11:18,389 --> 00:11:16,560
disappointed and

234
00:11:19,590 --> 00:11:18,399
people seem to be so disappointed when

235
00:11:21,750 --> 00:11:19,600
we turn out to be just

236
00:11:23,190 --> 00:11:21,760
normal mortals all of us and it's not

237
00:11:23,590 --> 00:11:23,200
talking about engineers and scientists

238
00:11:26,550 --> 00:11:23,600

but

239
00:11:27,030 --> 00:11:26,560
everybody we put the bar very very high

240
00:11:28,949 --> 00:11:27,040
which is

241
00:11:30,470 --> 00:11:28,959
you know it's just good but we have to

242
00:11:33,030 --> 00:11:30,480
understand our own

243
00:11:34,310 --> 00:11:33,040
humility and humanity that we are not

244
00:11:36,870 --> 00:11:34,320
perfect human beings

245
00:11:37,430 --> 00:11:36,880
and that we as human beings need to

246
00:11:39,269 --> 00:11:37,440
learn

247
00:11:41,190 --> 00:11:39,279
and one of the wonderful things about

248
00:11:44,550 --> 00:11:41,200
engineering it's built

249
00:11:45,030 --> 00:11:44,560
on the idea of trial and error that you

250
00:11:47,190 --> 00:11:45,040
can

251
00:11:49,590 --> 00:11:47,200
make mistakes try something and build it

252
00:11:52,389 --> 00:11:49,600
again see if you can get it because

253
00:11:53,990 --> 00:11:52,399
no one is perfect no matter how smart

254
00:11:54,870 --> 00:11:54,000
you think you are or how smart you would

255
00:11:57,990 --> 00:11:54,880
love to be

256
00:12:00,230 --> 00:11:58,000
you have to understand that we do

257
00:12:01,430 --> 00:12:00,240
make mistakes and we have to create

258
00:12:04,790 --> 00:12:01,440
environments where

259
00:12:08,710 --> 00:12:04,800
mistakes can be made before

260
00:12:13,190 --> 00:12:11,190
well that's that's kind of good to bring

261
00:12:15,509 --> 00:12:13,200
us up to our first um

262
00:12:17,110 --> 00:12:15,519
talking point today uh there was a time

263
00:12:20,310 --> 00:12:17,120

before people walked on the moon

264
00:12:22,470 --> 00:12:20,320
and jpl had a big part of of that

265
00:12:24,230 --> 00:12:22,480
um those proof of concept early on

266
00:12:24,790 --> 00:12:24,240
missions and we'll discuss the ranger

267
00:12:26,310 --> 00:12:24,800
missions

268
00:12:27,750 --> 00:12:26,320
now these proof of concept robotic

269
00:12:29,670 --> 00:12:27,760
missions what were some of the first

270
00:12:31,110 --> 00:12:29,680
lessons that we learned from those

271
00:12:33,190 --> 00:12:31,120
and we'll bring up our next image on

272
00:12:35,030 --> 00:12:33,200
that too okay

273
00:12:36,550 --> 00:12:35,040
well so so the ranges were really cool

274
00:12:37,030 --> 00:12:36,560
and it's funny i like talking about

275
00:12:40,230 --> 00:12:37,040
because

276
00:12:42,389 --> 00:12:40,240
actually for sorry

277
00:12:43,509 --> 00:12:42,399
forgotten with what actually happened

278
00:12:45,509 --> 00:12:43,519
and that so

279
00:12:47,430 --> 00:12:45,519
so jbl was very lucky to be in the right

280
00:12:48,310 --> 00:12:47,440
place at the right time and and was able

281
00:12:51,430 --> 00:12:48,320
to build

282
00:12:53,110 --> 00:12:51,440
uh the very first american satellite

283
00:12:54,870 --> 00:12:53,120
that was put into outer space as part of

284
00:12:57,350 --> 00:12:54,880
explorer program that was

285
00:12:57,910 --> 00:12:57,360
that was in the very late 50s but but

286
00:13:00,230 --> 00:12:57,920
but

287
00:13:01,750 --> 00:13:00,240
uh fortunately our the director of jpl

288
00:13:03,430 --> 00:13:01,760

said we wanted to we don't

289
00:13:05,110 --> 00:13:03,440
you know we'd love to get you all the

290
00:13:06,629 --> 00:13:05,120
rest of you nasa you can work on

291
00:13:08,230 --> 00:13:06,639
you can work on getting people all we

292
00:13:09,030 --> 00:13:08,240
want to do is sort of make robots and

293
00:13:10,949 --> 00:13:09,040
explore

294
00:13:12,230 --> 00:13:10,959
the scientific element and we you can

295
00:13:13,590 --> 00:13:12,240
while you're doing humans we will send

296
00:13:15,590 --> 00:13:13,600
these little robots out there

297
00:13:16,790 --> 00:13:15,600
and and so nasa's okay fine fine fine

298
00:13:19,509 --> 00:13:16,800
you can do that so

299
00:13:20,150 --> 00:13:19,519
so we started making these relatively

300
00:13:22,069 --> 00:13:20,160
ina

301
00:13:23,750 --> 00:13:22,079
by today's standards very inexpensive

302
00:13:25,110 --> 00:13:23,760
missions and the and the ranger program

303
00:13:27,670 --> 00:13:25,120
was the first in a series so

304
00:13:28,870 --> 00:13:27,680
now but nasa said listen you guys before

305
00:13:30,629 --> 00:13:28,880
you go down the place what we need to do

306
00:13:32,710 --> 00:13:30,639
we're going to the moon we want to send

307
00:13:34,389 --> 00:13:32,720
astronauts to land on the moon by the

308
00:13:37,430 --> 00:13:34,399
end but before the decade is out

309
00:13:40,710 --> 00:13:37,440
so early in 1960s jpl

310
00:13:41,829 --> 00:13:40,720
set out to build um a series of missions

311
00:13:43,829 --> 00:13:41,839
called the ranger

312
00:13:45,750 --> 00:13:43,839
what they were these ranger spacecraft

313
00:13:48,150 --> 00:13:45,760

were intended to aim for the moon

314
00:13:49,350 --> 00:13:48,160
no one had been to the moon and or even

315
00:13:51,189 --> 00:13:49,360
taking close-up pictures

316
00:13:52,389 --> 00:13:51,199
so idea was this spacecraft would be

317
00:13:54,550 --> 00:13:52,399
aimed like a bullet

318
00:13:55,829 --> 00:13:54,560
to the moon directly and have a camera

319
00:13:57,269 --> 00:13:55,839
that was pointed down go click click

320
00:13:58,550 --> 00:13:57,279
click click click click taking pictures

321
00:14:00,550 --> 00:13:58,560
really quick click click click click

322
00:14:01,670 --> 00:14:00,560
and send them back as fast as they can

323
00:14:03,990 --> 00:14:01,680
up to the point where

324
00:14:06,550 --> 00:14:04,000
just before impact the resolution on the

325
00:14:08,710 --> 00:14:06,560
images would expect to be very very good

326
00:14:10,470 --> 00:14:08,720
but it all but that was a tall order

327
00:14:12,310 --> 00:14:10,480
because in those days we didn't have

328
00:14:13,829 --> 00:14:12,320
digital cameras there are video cameras

329
00:14:15,590 --> 00:14:13,839
they're called vidicon tubes

330
00:14:17,110 --> 00:14:15,600
um they were it was it was really a

331
00:14:17,590 --> 00:14:17,120
television set very much like the old

332
00:14:19,509 --> 00:14:17,600
days

333
00:14:21,350 --> 00:14:19,519
in the 1960s and 50s of the big

334
00:14:22,230 --> 00:14:21,360
television screens but made much much

335
00:14:24,150 --> 00:14:22,240
smaller

336
00:14:25,829 --> 00:14:24,160
and and all that had to be put together

337
00:14:28,389 --> 00:14:25,839
and work properly and so

338
00:14:30,470 --> 00:14:28,399

jpl had never navigated something that

339
00:14:31,990 --> 00:14:30,480
all that far across the solar system

340
00:14:32,710 --> 00:14:32,000
they just really had thrown things out

341
00:14:34,629 --> 00:14:32,720
there before

342
00:14:36,150 --> 00:14:34,639
and hope they weren't trying to aim but

343
00:14:36,629 --> 00:14:36,160
now we were learning how to aim we were

344
00:14:38,389 --> 00:14:36,639
trying to

345
00:14:39,990 --> 00:14:38,399
learn how to control something from

346
00:14:41,350 --> 00:14:40,000
earth and we didn't we really

347
00:14:43,269 --> 00:14:41,360
didn't have a lot of control over the

348
00:14:45,269 --> 00:14:43,279
joysticking of earth from earth

349
00:14:46,870 --> 00:14:45,279
um it was because even though it was it

350
00:14:47,269 --> 00:14:46,880
was only three seconds away by speed of

351
00:14:49,350 --> 00:14:47,279
light

352
00:14:50,310 --> 00:14:49,360
it still required a lot of autonomy on

353
00:14:51,430 --> 00:14:50,320
board the vehicle

354
00:14:53,030 --> 00:14:51,440
to be able to click through those

355
00:14:54,389 --> 00:14:53,040
actions very quickly as it approached

356
00:14:57,990 --> 00:14:54,399
the moon

357
00:14:58,629 --> 00:14:58,000
so what happened well they build a whole

358
00:15:02,150 --> 00:14:58,639
bunch of these

359
00:15:04,870 --> 00:15:02,160
first

360
00:15:05,910 --> 00:15:04,880
five over the course of about a little

361
00:15:09,350 --> 00:15:05,920
over a year from

362
00:15:11,269 --> 00:15:09,360
from late 1961 to late to 62

363
00:15:12,949 --> 00:15:11,279

they set five of these missions up one

364
00:15:14,710 --> 00:15:12,959
at a time every few months

365
00:15:16,230 --> 00:15:14,720
and every single one of them failed in

366
00:15:18,150 --> 00:15:16,240
fact the first one was

367
00:15:19,430 --> 00:15:18,160
very you know it would be by today's

368
00:15:21,750 --> 00:15:19,440
standards very embarrassing

369
00:15:22,870 --> 00:15:21,760
while it was sitting there uh inside the

370
00:15:25,350 --> 00:15:22,880
nose cone on this

371
00:15:25,990 --> 00:15:25,360
on the rocket pad the solar panels which

372
00:15:27,910 --> 00:15:26,000
are both

373
00:15:29,670 --> 00:15:27,920
buttoned up like this um they

374
00:15:31,269 --> 00:15:29,680
inadvertently send a command or

375
00:15:33,749 --> 00:15:31,279
caused a command to happen where the

376
00:15:35,910 --> 00:15:33,759
solar panels went boom and hit the wall

377
00:15:37,110 --> 00:15:35,920
of the nose cone so it's like a almost

378
00:15:38,949 --> 00:15:37,120
like a cartoon

379
00:15:40,470 --> 00:15:38,959
um fortunately they were able to open

380
00:15:41,030 --> 00:15:40,480
take the nose kill off climb up on the

381
00:15:43,189 --> 00:15:41,040
rocket

382
00:15:45,110 --> 00:15:43,199
restow the solar panels screw them back

383
00:15:46,550 --> 00:15:45,120
in and then launch it well fortunately

384
00:15:47,910 --> 00:15:46,560
that was the good news but the bad news

385
00:15:49,430 --> 00:15:47,920
as soon as it went up there it had all

386
00:15:50,069 --> 00:15:49,440
sorts of problems and it didn't make it

387
00:15:52,310 --> 00:15:50,079
to the moon

388
00:15:53,430 --> 00:15:52,320

that was number one this other problems

389
00:15:55,350 --> 00:15:53,440
happen on number two

390
00:15:57,030 --> 00:15:55,360
other problems happen number three other

391
00:15:58,629 --> 00:15:57,040
problems number four

392
00:16:00,230 --> 00:15:58,639
another set of problems that number five

393
00:16:01,350 --> 00:16:00,240
and the last one just kind of they keep

394
00:16:02,629 --> 00:16:01,360
missing the moon

395
00:16:03,670 --> 00:16:02,639
in some cases they hit the moon went

396
00:16:04,629 --> 00:16:03,680
around the back and bumped into the

397
00:16:05,910 --> 00:16:04,639
wrong part of the moon of course the

398
00:16:06,470 --> 00:16:05,920
backside of the moon you can't send back

399
00:16:09,910 --> 00:16:06,480
to earth

400
00:16:12,550 --> 00:16:09,920
so it was a series of of really um

401
00:16:13,990 --> 00:16:12,560
horrible disasters and and after you

402
00:16:16,629 --> 00:16:14,000
know you can imagine

403
00:16:18,069 --> 00:16:16,639
that the lab director um who who came

404
00:16:21,189 --> 00:16:18,079
along who's he would he

405
00:16:22,949 --> 00:16:21,199
every every few months he would stand up

406
00:16:26,230 --> 00:16:22,959
in front of a wall of tv

407
00:16:27,350 --> 00:16:26,240
cameras and reporters and come up to the

408
00:16:30,710 --> 00:16:27,360
microphone and say

409
00:16:32,710 --> 00:16:30,720
well it didn't work again and

410
00:16:34,870 --> 00:16:32,720
up can you imagine wow at an

411
00:16:37,030 --> 00:16:34,880
institutional man those engineers and

412
00:16:39,430 --> 00:16:37,040
people who are developing how they felt

413
00:16:40,870 --> 00:16:39,440

it was absolutely heartbreaking

414
00:16:41,749 --> 00:16:40,880
and frustrating because one of the

415
00:16:43,590 --> 00:16:41,759
problems is they didn't really

416
00:16:46,230 --> 00:16:43,600
understand why it was failing

417
00:16:47,829 --> 00:16:46,240
so after five attempts nasa says stop

418
00:16:50,150 --> 00:16:47,839
stop stop you're just

419
00:16:50,870 --> 00:16:50,160
wasting taxpayers money what are you

420
00:16:54,150 --> 00:16:50,880
doing

421
00:16:56,790 --> 00:16:54,160
here

422
00:16:58,150 --> 00:16:56,800
and so jpl regrouped and rethought this

423
00:16:59,509 --> 00:16:58,160
through and said okay what would it take

424
00:17:00,069 --> 00:16:59,519
to be what are the things we're doing

425
00:17:03,110 --> 00:17:00,079
wrong

426
00:17:03,350 --> 00:17:03,120
so jpl said to us towards the engineers

427
00:17:06,470 --> 00:17:03,360
and

428
00:17:07,510 --> 00:17:06,480
to themselves well what could we do

429
00:17:09,110 --> 00:17:07,520
differently

430
00:17:10,549 --> 00:17:09,120
and they realize there's a lot of

431
00:17:12,870 --> 00:17:10,559
lessons we can take even though we don't

432
00:17:14,549 --> 00:17:12,880
exactly know why all these things failed

433
00:17:16,390 --> 00:17:14,559
we can take we can take this much more

434
00:17:17,990 --> 00:17:16,400
seriously than we have so jpl

435
00:17:20,150 --> 00:17:18,000
reorganized itself

436
00:17:21,270 --> 00:17:20,160
and added things like quality assurance

437
00:17:24,309 --> 00:17:21,280
and mission assurance

438
00:17:26,949 --> 00:17:24,319

and all sorts of uh patterns for

439
00:17:27,429 --> 00:17:26,959
ownership of design among individuals

440
00:17:28,789 --> 00:17:27,439
because

441
00:17:30,870 --> 00:17:28,799
up to that it's just a bunch of people

442
00:17:33,990 --> 00:17:30,880
working together as as

443
00:17:34,310 --> 00:17:34,000
as my uh as my mentor john cassani told

444
00:17:35,750 --> 00:17:34,320
me

445
00:17:37,029 --> 00:17:35,760
you know people were falling over each

446
00:17:37,909 --> 00:17:37,039
other working on the spacecraft at the

447
00:17:39,270 --> 00:17:37,919
same time it just

448
00:17:41,029 --> 00:17:39,280
no one was no one knew what they were

449
00:17:43,110 --> 00:17:41,039
doing now so

450
00:17:44,549 --> 00:17:43,120
jbl reorganized itself re-thought it

451
00:17:47,909 --> 00:17:44,559
through and and

452
00:17:50,470 --> 00:17:47,919
uh and try to make uh uh

453
00:17:52,390 --> 00:17:50,480
rethink the design in fact that's

454
00:17:52,950 --> 00:17:52,400
exactly what they did they stood down

455
00:17:54,310 --> 00:17:52,960
for

456
00:17:56,549 --> 00:17:54,320
a good fraction of a year and

457
00:17:57,669 --> 00:17:56,559
reorganized itself um one of the things

458
00:17:59,590 --> 00:17:57,679
they did is i know

459
00:18:00,789 --> 00:17:59,600
you can see in that picture there is a

460
00:18:04,549 --> 00:18:00,799
there is a

461
00:18:06,070 --> 00:18:04,559
a uh a round ball on top jpl

462
00:18:07,990 --> 00:18:06,080
it was very audacious they were going to

463
00:18:08,710 --> 00:18:08,000

make a land or a balsa wood lander with

464
00:18:11,190 --> 00:18:08,720
a rocket

465
00:18:11,830 --> 00:18:11,200
that stopped in midair allowed it to

466
00:18:13,430 --> 00:18:11,840
crash on the

467
00:18:15,110 --> 00:18:13,440
on the surface of mars and be able to

468
00:18:16,710 --> 00:18:15,120
make some seismic measurements on the

469
00:18:18,150 --> 00:18:16,720
surface of the moon they got rid of that

470
00:18:19,669 --> 00:18:18,160
they simplified listen we don't need

471
00:18:20,230 --> 00:18:19,679
that anymore we can just make it keep it

472
00:18:23,350 --> 00:18:20,240
simple

473
00:18:25,990 --> 00:18:23,360
did and they finally

474
00:18:27,590 --> 00:18:26,000
finally after a year of redesigning the

475
00:18:27,990 --> 00:18:27,600
laboratory redesigning how we're doing

476
00:18:30,630 --> 00:18:28,000
everything

477
00:18:31,750 --> 00:18:30,640
from scratch they finally got it to work

478
00:18:33,430 --> 00:18:31,760
uh it turns out

479
00:18:34,870 --> 00:18:33,440
the first attempt they tried after start

480
00:18:35,350 --> 00:18:34,880
after the start down actually didn't

481
00:18:39,110 --> 00:18:35,360
work

482
00:18:39,750 --> 00:18:39,120
accident the uh while the vehicle

483
00:18:42,150 --> 00:18:39,760
launched

484
00:18:43,909 --> 00:18:42,160
the camera took all its pictures early

485
00:18:44,630 --> 00:18:43,919
due to a little bit of a spark in one of

486
00:18:46,950 --> 00:18:44,640
the connectors

487
00:18:48,230 --> 00:18:46,960
and so so another disaster but

488
00:18:50,470 --> 00:18:48,240

fortunately there are three more

489
00:18:52,630 --> 00:18:50,480
successes in a row that that followed

490
00:18:54,310 --> 00:18:52,640
and you know what the jpl breathed this

491
00:18:56,870 --> 00:18:54,320
huge sign of relief can you imagine

492
00:18:58,150 --> 00:18:56,880
so there are imagine the report the

493
00:18:58,950 --> 00:18:58,160
reporters and others are saying you know

494
00:19:00,390 --> 00:18:58,960
what you know

495
00:19:01,750 --> 00:19:00,400
who are these idiots you know what are

496
00:19:02,950 --> 00:19:01,760
they doing you know what they do with

497
00:19:04,150 --> 00:19:02,960
our taxpayers money

498
00:19:06,710 --> 00:19:04,160
why do they think they know what they're

499
00:19:09,510 --> 00:19:06,720
doing um and you know what

500
00:19:10,789 --> 00:19:09,520
because we didn't we had never done this

501
00:19:12,310 --> 00:19:10,799
before we were asking

502
00:19:14,630 --> 00:19:12,320
we were being asked and we were

503
00:19:15,909 --> 00:19:14,640
audacious enough as an institution to

504
00:19:18,549 --> 00:19:15,919
say yes we can

505
00:19:19,590 --> 00:19:18,559
can we can we yes we sure we'll do it

506
00:19:21,029 --> 00:19:19,600
we'll learn

507
00:19:22,710 --> 00:19:21,039
well the trouble with this is we

508
00:19:23,990 --> 00:19:22,720
couldn't learn we didn't know why they

509
00:19:26,789 --> 00:19:24,000
failed so we worked hard

510
00:19:27,350 --> 00:19:26,799
to figure this out and and and made it

511
00:19:29,110 --> 00:19:27,360
make sure

512
00:19:31,190 --> 00:19:29,120
we understood what was going on and try

513
00:19:32,150 --> 00:19:31,200

to understand why it worked and why it

514
00:19:34,470 --> 00:19:32,160
wouldn't work

515
00:19:35,909 --> 00:19:34,480
and and we took this to heart and we and

516
00:19:37,990 --> 00:19:35,919
we we were we've

517
00:19:39,029 --> 00:19:38,000
started the process of saying listen if

518
00:19:41,029 --> 00:19:39,039
we're going to fail

519
00:19:42,710 --> 00:19:41,039
let's understand why we feel and not be

520
00:19:44,950 --> 00:19:42,720
afraid to stare

521
00:19:47,270 --> 00:19:44,960
failure directly in the face and learn

522
00:19:50,150 --> 00:19:47,280
and learn from these mistakes

523
00:19:52,070 --> 00:19:50,160
so ranger really was the first step in

524
00:19:54,630 --> 00:19:52,080
establishing a culture of

525
00:19:55,909 --> 00:19:54,640
learning from these moments but

526
00:19:56,470 --> 00:19:55,919
something else that you said was talking

527
00:20:00,230 --> 00:19:56,480
about taking

528
00:20:00,630 --> 00:20:00,240
ownership yeah and that's something i

529
00:20:01,909 --> 00:20:00,640
think

530
00:20:02,789 --> 00:20:01,919
we're going to talk about throughout all

531
00:20:04,470 --> 00:20:02,799
these different missions that we're

532
00:20:05,750 --> 00:20:04,480
going to talk about but taking ownership

533
00:20:09,029 --> 00:20:05,760
of

534
00:20:10,870 --> 00:20:09,039
just saying

535
00:20:12,230 --> 00:20:10,880
do it this way this way in this way

536
00:20:14,470 --> 00:20:12,240
you've talked to me about

537
00:20:16,470 --> 00:20:14,480
the differences between that well you

538
00:20:19,909 --> 00:20:16,480

know we you know as you know i i

539
00:20:20,390 --> 00:20:19,919
i'm a parent and so uh one of the things

540
00:20:24,549 --> 00:20:20,400
that

541
00:20:26,390 --> 00:20:24,559
in fact not just parents all of us

542
00:20:28,789 --> 00:20:26,400
it's we're just wired to do it is to

543
00:20:30,870 --> 00:20:28,799
tell people how to do their job

544
00:20:32,310 --> 00:20:30,880
you tell them do this okay no now move

545
00:20:34,549 --> 00:20:32,320
your move your mouse more to the right

546
00:20:37,430 --> 00:20:34,559
then click no no not now click again

547
00:20:40,390 --> 00:20:37,440
and so so people people we're really

548
00:20:43,190 --> 00:20:40,400
really tempted to want to give people

549
00:20:45,430 --> 00:20:43,200
you know do the fishing for them rather

550
00:20:47,750 --> 00:20:45,440
than teaching them how to fish and

551
00:20:48,470 --> 00:20:47,760
take ownership to become a fisher person

552
00:20:51,909 --> 00:20:48,480
and so

553
00:20:54,070 --> 00:20:51,919
so so so the idea of ownership is to

554
00:20:57,029 --> 00:20:54,080
give people the objective

555
00:20:58,470 --> 00:20:57,039
sure show them how you do it so show

556
00:20:59,669 --> 00:20:58,480
them how it's done they can watch it

557
00:21:01,990 --> 00:20:59,679
they can practice it

558
00:21:03,669 --> 00:21:02,000
but then give them the space to figure

559
00:21:04,950 --> 00:21:03,679
out really how to get it done for the

560
00:21:07,350 --> 00:21:04,960
situation that they are

561
00:21:08,549 --> 00:21:07,360
in and that's called for us has called

562
00:21:12,230 --> 00:21:08,559
ownership and

563
00:21:14,549 --> 00:21:12,240

aligning a group of people along a

564
00:21:16,149 --> 00:21:14,559
mission objective and you could do that

565
00:21:17,510 --> 00:21:16,159
not just at the top level in terms of

566
00:21:18,149 --> 00:21:17,520
where yes we're going to send a mission

567
00:21:20,149 --> 00:21:18,159
to mars

568
00:21:22,070 --> 00:21:20,159
it's going to drive around another

569
00:21:23,909 --> 00:21:22,080
another planet but each piece

570
00:21:25,430 --> 00:21:23,919
can be done the same way you can take

571
00:21:26,950 --> 00:21:25,440
each piece and say listen what is your

572
00:21:29,510 --> 00:21:26,960
mission well my mission

573
00:21:30,149 --> 00:21:29,520
is to make a mobility system that can

574
00:21:33,510 --> 00:21:30,159
walk

575
00:21:35,590 --> 00:21:33,520
drive over these complicated rocking

576
00:21:37,510 --> 00:21:35,600
slopes in the surface of another planet

577
00:21:39,510 --> 00:21:37,520
and so you take that as a mission as

578
00:21:42,789 --> 00:21:39,520
opposed to a series of tasks

579
00:21:43,990 --> 00:21:42,799
now you're more likely to take ownership

580
00:21:47,110 --> 00:21:44,000
with the outcome

581
00:21:48,390 --> 00:21:47,120
and be an and own the fact that yes my

582
00:21:50,950 --> 00:21:48,400
job is to make that happen

583
00:21:52,950 --> 00:21:50,960
yes my job is actually see it through

584
00:21:55,270 --> 00:21:52,960
and so that's that is something that um

585
00:21:56,870 --> 00:21:55,280
many of us in fact there's a it's a very

586
00:21:57,669 --> 00:21:56,880
common belief that we have a jpl that

587
00:21:59,830 --> 00:21:57,679
ownership is a

588
00:22:01,669 --> 00:21:59,840

key function of how you get something

589
00:22:03,909 --> 00:22:01,679
accomplished

590
00:22:04,710 --> 00:22:03,919
so nasa jpl we're starting to take

591
00:22:06,549 --> 00:22:04,720
ownership

592
00:22:08,950 --> 00:22:06,559
we're learning from these early lessons

593
00:22:11,110 --> 00:22:08,960
we have we have some successes

594
00:22:13,990 --> 00:22:11,120
and we're able to start daring mightier

595
00:22:16,070 --> 00:22:14,000
and mightier things and the more we dare

596
00:22:17,430 --> 00:22:16,080
the higher the risk of failure and i

597
00:22:20,310 --> 00:22:17,440
want to go to our next image

598
00:22:21,350 --> 00:22:20,320
and let's talk about the mars climate

599
00:22:24,470 --> 00:22:21,360
orbiter

600
00:22:27,190 --> 00:22:24,480
yes um well that's a great

601
00:22:28,549 --> 00:22:27,200
vision um i i i mean it was it's a great

602
00:22:29,590 --> 00:22:28,559
example i mean to be honest with you

603
00:22:31,110 --> 00:22:29,600
it's actually part

604
00:22:33,190 --> 00:22:31,120
as part of two missions there are two

605
00:22:34,549 --> 00:22:33,200
missions i you know um i had mentioned

606
00:22:36,230 --> 00:22:34,559
mars pathfinder earlier

607
00:22:37,909 --> 00:22:36,240
but mass mars pathfinder was one of the

608
00:22:38,630 --> 00:22:37,919
first of a series that was called at the

609
00:22:40,870 --> 00:22:38,640
time

610
00:22:42,789 --> 00:22:40,880
faster better cheaper missions where the

611
00:22:43,510 --> 00:22:42,799
idea is to reduce the cost reduce the

612
00:22:45,909 --> 00:22:43,520
overhead

613
00:22:47,430 --> 00:22:45,919

try to be lean and mean and try to do as

614
00:22:49,669 --> 00:22:47,440
much as you can with the smallest team

615
00:22:52,310 --> 00:22:49,679
you possibly can

616
00:22:53,669 --> 00:22:52,320
well here a wonderful team of very

617
00:22:55,990 --> 00:22:53,679
talented people mind you

618
00:22:56,789 --> 00:22:56,000
were designing two missions an orbiter

619
00:22:59,350 --> 00:22:56,799
and a lander

620
00:23:01,350 --> 00:22:59,360
at the same time and they were trying to

621
00:23:03,510 --> 00:23:01,360
capitalize on the simulators and those

622
00:23:05,909 --> 00:23:03,520
designs and put them together

623
00:23:07,510 --> 00:23:05,919
in the process this the they were both

624
00:23:09,510 --> 00:23:07,520
launched in the same launch window

625
00:23:12,070 --> 00:23:09,520
remember you can only go to mars

626
00:23:12,549 --> 00:23:12,080
every 26 months because you have to wait

627
00:23:13,990 --> 00:23:12,559
for

628
00:23:16,149 --> 00:23:14,000
the line you can actually you can leave

629
00:23:17,029 --> 00:23:16,159
earth orbit anytime you want to get to

630
00:23:19,430 --> 00:23:17,039
mars orbit

631
00:23:21,110 --> 00:23:19,440
but if you do it if you leave it anytime

632
00:23:21,990 --> 00:23:21,120
you want chances are bars won't be there

633
00:23:23,669 --> 00:23:22,000
when you get there

634
00:23:25,110 --> 00:23:23,679
so you have to time your departure so

635
00:23:25,669 --> 00:23:25,120
that mars will be there when you get

636
00:23:27,510 --> 00:23:25,679
there

637
00:23:29,190 --> 00:23:27,520
and so that means every 26 months you

638
00:23:30,390 --> 00:23:29,200

can go and that's the launch window is

639
00:23:32,470 --> 00:23:30,400
only a few weeks long

640
00:23:33,590 --> 00:23:32,480
these two vehicles are on the way this

641
00:23:35,830 --> 00:23:33,600
one was was

642
00:23:37,190 --> 00:23:35,840
a head of the lander and this is mars

643
00:23:38,789 --> 00:23:37,200
climate orbiting it was a wonderful

644
00:23:42,149 --> 00:23:38,799
mission it was actually itself

645
00:23:42,710 --> 00:23:42,159
um uh a a mission to kind of help make

646
00:23:45,430 --> 00:23:42,720
up for

647
00:23:46,070 --> 00:23:45,440
uh some some missions another failure

648
00:23:48,870 --> 00:23:46,080
that it happened

649
00:23:49,669 --> 00:23:48,880
happened even earlier but so so this is

650
00:23:51,110 --> 00:23:49,679
what's interesting

651
00:23:52,789 --> 00:23:51,120
this is what i love about this is when i

652
00:23:55,110 --> 00:23:52,799
talk to young people

653
00:23:56,630 --> 00:23:55,120
i said i said listen you know you don't

654
00:23:57,669 --> 00:23:56,640
have to be a rocket scientist to be a

655
00:23:59,269 --> 00:23:57,679
rocket scientist

656
00:24:00,950 --> 00:23:59,279
you can just look at this you can look

657
00:24:03,110 --> 00:24:00,960
at this picture and says what's about

658
00:24:04,549 --> 00:24:03,120
this so imagine you're flying this thing

659
00:24:07,269 --> 00:24:04,559
from earth

660
00:24:08,549 --> 00:24:07,279
to mars and you're and those those are

661
00:24:11,350 --> 00:24:08,559
solar panels you see

662
00:24:11,909 --> 00:24:11,360
um sticking on the left there it's on my

663
00:24:14,870 --> 00:24:11,919

right hand

664
00:24:15,750 --> 00:24:14,880
actually yeah there we go um i think we

665
00:24:17,190 --> 00:24:15,760
have

666
00:24:18,470 --> 00:24:17,200
you see it there okay so look at that

667
00:24:19,990 --> 00:24:18,480
picture so what do you see it's

668
00:24:22,789 --> 00:24:20,000
asymmetric isn't it

669
00:24:23,029 --> 00:24:22,799
so what what do you see you see uh that

670
00:24:26,070 --> 00:24:23,039
is

671
00:24:28,549 --> 00:24:26,080
a big

672
00:24:29,350 --> 00:24:28,559
antenna that's that's that circular

673
00:24:32,470 --> 00:24:29,360
thing up on a

674
00:24:34,470 --> 00:24:32,480
boom points back to earth um it's

675
00:24:35,990 --> 00:24:34,480
it's a very uh it's a nice compact

676
00:24:37,510 --> 00:24:36,000
design it's very elegant

677
00:24:39,029 --> 00:24:37,520
um but this asymmetric so what does that

678
00:24:39,430 --> 00:24:39,039
mean it means that if you're facing the

679
00:24:42,789 --> 00:24:39,440
sun

680
00:24:45,110 --> 00:24:42,799
light and

681
00:24:46,390 --> 00:24:45,120
shines on your vehicle well light is

682
00:24:48,630 --> 00:24:46,400
like like any other

683
00:24:50,070 --> 00:24:48,640
photons of light have have momentum when

684
00:24:52,470 --> 00:24:50,080
they hit the solar panels

685
00:24:53,990 --> 00:24:52,480
they cause the solar panels to to be a

686
00:24:56,630 --> 00:24:54,000
very tiny little force

687
00:24:58,070 --> 00:24:56,640
that force just ever so slightly pushes

688
00:25:00,070 --> 00:24:58,080

the spacecraft to one side so

689
00:25:02,230 --> 00:25:00,080
no problem you just have to round it

690
00:25:03,029 --> 00:25:02,240
back again right fire your thrusters on

691
00:25:05,830 --> 00:25:03,039
the vehicle

692
00:25:06,390 --> 00:25:05,840
or or speed up a reaction wheel or one

693
00:25:08,230 --> 00:25:06,400
of the two

694
00:25:09,669 --> 00:25:08,240
to get the vehicle to straighten out but

695
00:25:10,870 --> 00:25:09,679
eventually you have to keep firing these

696
00:25:13,110 --> 00:25:10,880
thrusters to keep them

697
00:25:14,710 --> 00:25:13,120
keep the vehicle pointed the right way

698
00:25:16,070 --> 00:25:14,720
well no problem

699
00:25:17,909 --> 00:25:16,080
they were playing this was planned for

700
00:25:19,510 --> 00:25:17,919
this was expected there's nothing

701
00:25:21,269 --> 00:25:19,520
surprising about that but these

702
00:25:22,549 --> 00:25:21,279
thrusters in the process of doing what

703
00:25:25,110 --> 00:25:22,559
they were doing

704
00:25:25,830 --> 00:25:25,120
not only rotate the vehicle but ever so

705
00:25:28,630 --> 00:25:25,840
slightly

706
00:25:29,909 --> 00:25:28,640
gave the vehicle the tiniest little push

707
00:25:31,830 --> 00:25:29,919
to the left

708
00:25:33,590 --> 00:25:31,840
you just move move move move just to the

709
00:25:35,909 --> 00:25:33,600
left and and so

710
00:25:37,590 --> 00:25:35,919
but it's a very tiny amount and and this

711
00:25:40,710 --> 00:25:37,600
would happen every few days

712
00:25:43,909 --> 00:25:40,720
over time it's the equivalent of force

713
00:25:45,590 --> 00:25:43,919

of of literally imagine a toilet paper

714
00:25:48,149 --> 00:25:45,600
square on your hand

715
00:25:49,990 --> 00:25:48,159
pushing you pushing you to the left ever

716
00:25:52,390 --> 00:25:50,000
so slightly every day every

717
00:25:54,549 --> 00:25:52,400
all the time just slightly pushing you

718
00:25:56,870 --> 00:25:54,559
where over the course of months it turns

719
00:25:59,110 --> 00:25:56,880
out that small amount of force

720
00:26:01,190 --> 00:25:59,120
will push your beagle to the left well

721
00:26:02,390 --> 00:26:01,200
we're not stupid we know those kinds of

722
00:26:04,149 --> 00:26:02,400
things could happen so

723
00:26:06,470 --> 00:26:04,159
we just have to estimate how much that

724
00:26:07,510 --> 00:26:06,480
force is so what we did we had the

725
00:26:10,310 --> 00:26:07,520
software on board

726
00:26:11,830 --> 00:26:10,320
the vehicle tell software on the ground

727
00:26:13,110 --> 00:26:11,840
how much those thrusters were firing and

728
00:26:14,390 --> 00:26:13,120
how much it was pushing it

729
00:26:16,310 --> 00:26:14,400
and we would then transfer that

730
00:26:18,149 --> 00:26:16,320
information to the navigation team

731
00:26:19,590 --> 00:26:18,159
that which would then figure out how

732
00:26:20,870 --> 00:26:19,600
much the vehicles moved

733
00:26:22,070 --> 00:26:20,880
well why do they need that why don't

734
00:26:23,510 --> 00:26:22,080
they just look at it well this is

735
00:26:23,990 --> 00:26:23,520
another little detail this is something

736
00:26:25,750 --> 00:26:24,000
that

737
00:26:28,230 --> 00:26:25,760
um i try to encourage all of my friends

738
00:26:29,909 --> 00:26:28,240

at jbl especially the new people at jbl

739
00:26:31,990 --> 00:26:29,919
they all should know how do you know

740
00:26:32,870 --> 00:26:32,000
what your spacecraft spacecraft are in

741
00:26:34,630 --> 00:26:32,880
outer space

742
00:26:36,070 --> 00:26:34,640
this is a great question you know how do

743
00:26:37,190 --> 00:26:36,080
you know i mean it goes way out there

744
00:26:38,950 --> 00:26:37,200
you can't see it

745
00:26:40,789 --> 00:26:38,960
you know telescopes you look out there

746
00:26:42,630 --> 00:26:40,799
just can't it's not a little dot right

747
00:26:44,070 --> 00:26:42,640
it's just you can't even see it no dot

748
00:26:45,909 --> 00:26:44,080
it's too small to be a dot

749
00:26:47,350 --> 00:26:45,919
um and so do it because we can ask what

750
00:26:48,870 --> 00:26:47,360
the vehicle knows well how does the

751
00:26:50,070 --> 00:26:48,880
vehicle know it looks back on earth it

752
00:26:51,269 --> 00:26:50,080
sees another little dot

753
00:26:52,549 --> 00:26:51,279
maybe a little mars maybe you can kind

754
00:26:53,750 --> 00:26:52,559
of figure it out but it doesn't have

755
00:26:55,190 --> 00:26:53,760
these vehicles

756
00:26:57,029 --> 00:26:55,200
this one didn't couldn't have cameras to

757
00:26:58,950 --> 00:26:57,039
see where it is no with the trick that

758
00:27:01,110 --> 00:26:58,960
we've used we've used the radio

759
00:27:02,549 --> 00:27:01,120
so what we do we have a we get

760
00:27:02,950 --> 00:27:02,559
transmitters on earth and we send a

761
00:27:06,149 --> 00:27:02,960
little

762
00:27:09,269 --> 00:27:06,159
goes across

763
00:27:11,269 --> 00:27:09,279

space bounces off the radio and antenna

764
00:27:12,549 --> 00:27:11,279
and the radio inside and bounces back to

765
00:27:13,750 --> 00:27:12,559
earth and we time it

766
00:27:15,190 --> 00:27:13,760
and you know the speed of light because

767
00:27:16,549 --> 00:27:15,200
radio waves move with the speed of light

768
00:27:19,350 --> 00:27:16,559
right everyone knows that

769
00:27:20,950 --> 00:27:19,360
click okay now we know the speed now we

770
00:27:23,830 --> 00:27:20,960
know how far away it is

771
00:27:24,950 --> 00:27:23,840
yes oh and by the way i can also send a

772
00:27:26,389 --> 00:27:24,960
tone

773
00:27:28,149 --> 00:27:26,399
to the spacecraft and it can bounce the

774
00:27:29,510 --> 00:27:28,159
tone back if the tone is

775
00:27:31,110 --> 00:27:29,520
getting is higher when it comes back it

776
00:27:32,630 --> 00:27:31,120
means it's coming toward you if it's

777
00:27:33,350 --> 00:27:32,640
lower it's going away you can tell how

778
00:27:35,430 --> 00:27:33,360
fast it is

779
00:27:36,549 --> 00:27:35,440
so those two pieces of information

780
00:27:37,830 --> 00:27:36,559
should really help you

781
00:27:40,070 --> 00:27:37,840
figure out where your spacecraft is

782
00:27:43,430 --> 00:27:40,080
right except for

783
00:27:46,389 --> 00:27:43,440
one detail right thanks yeah

784
00:27:48,149 --> 00:27:46,399
it's it except except that you you know

785
00:27:50,789 --> 00:27:48,159
how far it is but you don't know if it's

786
00:27:52,070 --> 00:27:50,799
over there or over there or over there

787
00:27:53,029 --> 00:27:52,080
because the radio beams we're sending

788
00:27:55,350 --> 00:27:53,039

back are really big

789
00:27:56,389 --> 00:27:55,360
and so it's like huh i want but that's

790
00:27:57,750 --> 00:27:56,399
okay we can figure out where it is

791
00:27:59,029 --> 00:27:57,760
because we've been counting how much has

792
00:28:00,470 --> 00:27:59,039
been moving to the left because we've

793
00:28:03,190 --> 00:28:00,480
been getting this data

794
00:28:04,070 --> 00:28:03,200
well um what happened as the vehicle

795
00:28:06,389 --> 00:28:04,080
approached mars

796
00:28:07,590 --> 00:28:06,399
we discovered and i said i think there's

797
00:28:09,669 --> 00:28:07,600
another picture

798
00:28:10,630 --> 00:28:09,679
um yeah coming up image five here

799
00:28:13,909 --> 00:28:10,640
actually

800
00:28:15,510 --> 00:28:13,919
yeah um so as as we're approaching mars

801
00:28:18,549 --> 00:28:15,520
this vehicle is approaching mars

802
00:28:21,350 --> 00:28:18,559
unbeknownst to us we had mis

803
00:28:22,950 --> 00:28:21,360
underestimated the amount the space

804
00:28:24,470 --> 00:28:22,960
school had moved to the left

805
00:28:26,230 --> 00:28:24,480
and in the wrong direction the left and

806
00:28:27,830 --> 00:28:26,240
this to mention this

807
00:28:29,269 --> 00:28:27,840
you're coming in from the lower right of

808
00:28:31,190 --> 00:28:29,279
your picture there and

809
00:28:33,350 --> 00:28:31,200
as the vehicle's coming in it's being

810
00:28:35,830 --> 00:28:33,360
pushed to the left closer toward mars

811
00:28:37,669 --> 00:28:35,840
but you can't see it from earth right

812
00:28:39,190 --> 00:28:37,679
what's happened and what happened was as

813
00:28:41,669 --> 00:28:39,200

as the vehicle came around

814
00:28:43,110 --> 00:28:41,679
got to the planet uh by planet mars it

815
00:28:44,630 --> 00:28:43,120
fired its engines just before it got

816
00:28:47,110 --> 00:28:44,640
there we could see the engines fire

817
00:28:48,310 --> 00:28:47,120
and then it disappeared behind mars

818
00:28:51,669 --> 00:28:48,320
early

819
00:28:53,750 --> 00:28:51,679
moved mars

820
00:28:55,269 --> 00:28:53,760
mars wasn't supposed to be there mars

821
00:28:57,190 --> 00:28:55,279
we're supposed to have plenty of time

822
00:28:58,470 --> 00:28:57,200
we know our spacecraft has marcy what's

823
00:29:00,310 --> 00:28:58,480
what's going what's going on

824
00:29:01,510 --> 00:29:00,320
and so we're like very nervous about

825
00:29:03,909 --> 00:29:01,520
that um so

826
00:29:05,350 --> 00:29:03,919
but unfortunately some minutes later

827
00:29:06,310 --> 00:29:05,360
we're expecting to come around the back

828
00:29:07,990 --> 00:29:06,320
and this nice little

829
00:29:10,230 --> 00:29:08,000
nice little loop you see here put itself

830
00:29:11,669 --> 00:29:10,240
in nice elliptical shaped orbit

831
00:29:12,789 --> 00:29:11,679
um because the engines put yourself

832
00:29:14,070 --> 00:29:12,799
there or by the way they're just gone

833
00:29:17,750 --> 00:29:14,080
straight

834
00:29:20,070 --> 00:29:17,760
so we we were turns out we

835
00:29:20,789 --> 00:29:20,080
we we actually hit the top of atmosphere

836
00:29:23,669 --> 00:29:20,799
this at this

837
00:29:24,470 --> 00:29:23,679
lander and this orbiter became a lander

838
00:29:25,830 --> 00:29:24,480

by mistake

839
00:29:27,669 --> 00:29:25,840
it hit the top of the atmosphere and

840
00:29:29,750 --> 00:29:27,679
broke up what happened

841
00:29:31,350 --> 00:29:29,760
well within a day we found within a day

842
00:29:35,110 --> 00:29:31,360
or two we figured out

843
00:29:36,230 --> 00:29:35,120
that that that the the the forces we

844
00:29:39,029 --> 00:29:36,240
were in estimating from this

845
00:29:40,230 --> 00:29:39,039
from the spacecraft were in the units of

846
00:29:43,350 --> 00:29:40,240
pounds

847
00:29:45,350 --> 00:29:43,360
common for propulsion people

848
00:29:46,549 --> 00:29:45,360
because because they use uh english

849
00:29:48,710 --> 00:29:46,559
units for

850
00:29:50,470 --> 00:29:48,720
for plumbing you know you get a one inch

851
00:29:51,269 --> 00:29:50,480
pipe right quarter inch pipe one pound

852
00:29:54,389 --> 00:29:51,279
thruster

853
00:29:55,350 --> 00:29:54,399
um so so but but we but our navigators

854
00:29:58,310 --> 00:29:55,360
do everything in

855
00:29:59,990 --> 00:29:58,320
in metric and so we expected that this

856
00:30:01,750 --> 00:30:00,000
this team expected to be a metric and so

857
00:30:02,389 --> 00:30:01,760
did everyone else because but of a very

858
00:30:04,549 --> 00:30:02,399
tiny

859
00:30:06,389 --> 00:30:04,559
little mistake that they it wasn't

860
00:30:07,830 --> 00:30:06,399
corrected properly and and

861
00:30:10,070 --> 00:30:07,840
and we were off by the difference

862
00:30:11,350 --> 00:30:10,080
between pounds and the metric version

863
00:30:14,789 --> 00:30:11,360

which is newton's

864
00:30:17,269 --> 00:30:14,799
a factor of four and a half that's

865
00:30:18,549 --> 00:30:17,279
that's huge we underestimated the force

866
00:30:21,590 --> 00:30:18,559
we were 100

867
00:30:22,470 --> 00:30:21,600
kilometers off course and in the wrong

868
00:30:24,630 --> 00:30:22,480
direction

869
00:30:26,950 --> 00:30:24,640
and this this again this orbiter became

870
00:30:29,590 --> 00:30:26,960
a lander it was very embarrassing

871
00:30:30,950 --> 00:30:29,600
it was very big news um we were shocked

872
00:30:32,789 --> 00:30:30,960
all of us that we

873
00:30:34,230 --> 00:30:32,799
how could we make something so stupid i

874
00:30:34,710 --> 00:30:34,240
mean it seems like a stupid mistake

875
00:30:36,230 --> 00:30:34,720
right

876
00:30:38,149 --> 00:30:36,240
but then you start thinking about you

877
00:30:38,630 --> 00:30:38,159
know sir what is what's for this mistake

878
00:30:40,230 --> 00:30:38,640
what

879
00:30:42,470 --> 00:30:40,240
how do we make mistakes like this well

880
00:30:44,230 --> 00:30:42,480
it wasn't turns out that's it

881
00:30:46,549 --> 00:30:44,240
we make those kind of mistakes all the

882
00:30:47,669 --> 00:30:46,559
time it's a miscommunication those kinds

883
00:30:49,510 --> 00:30:47,679
of things

884
00:30:50,789 --> 00:30:49,520
it's not that we made the mistake that

885
00:30:53,909 --> 00:30:50,799
was wrong

886
00:30:55,909 --> 00:30:53,919
it was that we didn't catch it because

887
00:30:57,909 --> 00:30:55,919
all of us make thousands and thousands

888
00:31:01,190 --> 00:30:57,919

of mistakes all human beings

889
00:31:02,870 --> 00:31:01,200
that's what humans do including

890
00:31:04,230 --> 00:31:02,880
the best engineers and scientists of the

891
00:31:07,830 --> 00:31:04,240
world we

892
00:31:10,310 --> 00:31:07,840
we're all human we're all fallible

893
00:31:11,909 --> 00:31:10,320
and so the trick is how do you do

894
00:31:13,350 --> 00:31:11,919
something how do you make something a

895
00:31:15,430 --> 00:31:13,360
billion dollar mission

896
00:31:17,269 --> 00:31:15,440
say land or big billion dollar rover on

897
00:31:19,590 --> 00:31:17,279
surface of mars where thousands of

898
00:31:20,950 --> 00:31:19,600
things have to work right

899
00:31:23,590 --> 00:31:20,960
how is that possible you just hire a

900
00:31:27,430 --> 00:31:23,600
bunch of great people

901
00:31:29,509 --> 00:31:27,440
no no you don't just hire great people

902
00:31:30,789 --> 00:31:29,519
you hire good people the best you can

903
00:31:34,310 --> 00:31:30,799
but you can't expect

904
00:31:35,190 --> 00:31:34,320
being good to be good enough and so what

905
00:31:38,870 --> 00:31:35,200
you need to do

906
00:31:42,389 --> 00:31:38,880
is test test test check find out

907
00:31:43,830 --> 00:31:42,399
before it's too late ask the questions

908
00:31:45,750 --> 00:31:43,840
how do we really know that this is

909
00:31:48,470 --> 00:31:45,760
working what if it doesn't work

910
00:31:50,230 --> 00:31:48,480
do we do we care we really didn't ask

911
00:31:52,230 --> 00:31:50,240
those kinds of questions and i felt

912
00:31:53,590 --> 00:31:52,240
you know i people like me really were

913
00:31:57,909 --> 00:31:53,600

very naive about this

914
00:31:59,430 --> 00:31:57,919
and so um i remember those days terribly

915
00:32:00,710 --> 00:31:59,440
we were very hard by the way talk about

916
00:32:01,909 --> 00:32:00,720
being hard at each other we were very

917
00:32:03,430 --> 00:32:01,919
hard on each other

918
00:32:04,710 --> 00:32:03,440
um we were you know at first people like

919
00:32:05,350 --> 00:32:04,720
because can you imagine the emotional

920
00:32:06,710 --> 00:32:05,360
attachment

921
00:32:08,630 --> 00:32:06,720
of spending years trying to get these

922
00:32:11,750 --> 00:32:08,640
things to work but

923
00:32:15,110 --> 00:32:11,760
you know we learned and guess what

924
00:32:17,350 --> 00:32:15,120
we figured out how to do this better and

925
00:32:18,470 --> 00:32:17,360
ever since we have come up with new

926
00:32:21,990 --> 00:32:18,480
tricks

927
00:32:25,750 --> 00:32:22,000
used and we'll be using again

928
00:32:28,470 --> 00:32:25,760
coming up here in january when mars 2020

929
00:32:29,669 --> 00:32:28,480
the perseverance rover arrives at mars

930
00:32:31,269 --> 00:32:29,679
we're going to use new tricks and the

931
00:32:32,070 --> 00:32:31,279
new tricks allow us to see where their

932
00:32:33,669 --> 00:32:32,080
vehicle is

933
00:32:35,269 --> 00:32:33,679
in the plane of the sky rather than

934
00:32:35,909 --> 00:32:35,279
rather than just guessing where it is

935
00:32:39,269 --> 00:32:35,919
over there

936
00:32:40,549 --> 00:32:39,279
we can now see where it is exactly

937
00:32:42,710 --> 00:32:40,559
because we're going to measure with our

938
00:32:44,950 --> 00:32:42,720

radio the angles between that

939
00:32:46,310 --> 00:32:44,960
and nearby quasars that have been

940
00:32:48,470 --> 00:32:46,320
tracked in the sky

941
00:32:49,430 --> 00:32:48,480
so so that's how we do it and it's a new

942
00:32:50,950 --> 00:32:49,440
trick and we've been

943
00:32:52,710 --> 00:32:50,960
it's been it's it's and it's something

944
00:32:54,470 --> 00:32:52,720
we've used ever since

945
00:32:56,149 --> 00:32:54,480
it was it had been invented before this

946
00:32:56,630 --> 00:32:56,159
mission but we hadn't really put it to

947
00:32:58,470 --> 00:32:56,640
use

948
00:33:00,389 --> 00:32:58,480
in all of our missions and it was just a

949
00:33:02,789 --> 00:33:00,399
wonderful wonderful uh

950
00:33:04,789 --> 00:33:02,799
addition and now it's become uh just

951
00:33:05,750 --> 00:33:04,799
part of our new lessons and we take this

952
00:33:07,909 --> 00:33:05,760
forward and

953
00:33:09,110 --> 00:33:07,919
that's how we get ahead we learn from

954
00:33:10,789 --> 00:33:09,120
our mistakes

955
00:33:13,190 --> 00:33:10,799
get ourselves back up on the horse and

956
00:33:15,909 --> 00:33:13,200
start again

957
00:33:16,710 --> 00:33:15,919
well something you've talked about um

958
00:33:19,350 --> 00:33:16,720
when we've been

959
00:33:21,029 --> 00:33:19,360
preparing for this show was talk i've

960
00:33:23,509 --> 00:33:21,039
always appreciated the the grace and

961
00:33:25,430 --> 00:33:23,519
humility which you've talked about

962
00:33:26,950 --> 00:33:25,440
you mentioned that jay leno made a joke

963
00:33:29,509 --> 00:33:26,960

about your i mean that's

964
00:33:31,430 --> 00:33:29,519
that that can't be easy to deal with um

965
00:33:33,669 --> 00:33:31,440
but there's also this idea between and

966
00:33:35,190 --> 00:33:33,679
something you brought up is

967
00:33:37,590 --> 00:33:35,200
even with moments like this there needs

968
00:33:40,710 --> 00:33:37,600
to be authentic confidence there

969
00:33:42,789 --> 00:33:40,720
needs to be humility versus hubris yeah

970
00:33:44,070 --> 00:33:42,799
um yeah that's that's that's a tough

971
00:33:44,789 --> 00:33:44,080
thing because think about it we're

972
00:33:46,149 --> 00:33:44,799
hiring

973
00:33:48,149 --> 00:33:46,159
so who are the people we're putting on

974
00:33:48,710 --> 00:33:48,159
these jobs first of all you have to say

975
00:33:50,549 --> 00:33:48,720
whether

976
00:33:51,990 --> 00:33:50,559
they're they're uh they were in their

977
00:33:54,950 --> 00:33:52,000
elementary school they were a

978
00:33:55,430 --> 00:33:54,960
students a lot of my a students you know

979
00:33:58,789 --> 00:33:55,440
you

980
00:34:00,549 --> 00:33:58,799
they um their parents uh

981
00:34:01,830 --> 00:34:00,559
thought they were they were pretty smart

982
00:34:04,549 --> 00:34:01,840
and their siblings

983
00:34:05,830 --> 00:34:04,559
always would say uh i don't know when

984
00:34:06,230 --> 00:34:05,840
it's when a parent would ask a question

985
00:34:08,550 --> 00:34:06,240
and

986
00:34:11,270 --> 00:34:08,560
the other siblings would say i don't

987
00:34:14,310 --> 00:34:11,280
know ask susie she knows all the answers

988
00:34:16,149 --> 00:34:14,320

and and then you go um

989
00:34:17,589 --> 00:34:16,159
so susie so like on the spot like oh i

990
00:34:19,669 --> 00:34:17,599
gotta get over these answers

991
00:34:21,510 --> 00:34:19,679
all of us are in the same boat we all

992
00:34:23,990 --> 00:34:21,520
try to we all try to know

993
00:34:24,550 --> 00:34:24,000
but uh and it's important by the way you

994
00:34:27,589 --> 00:34:24,560
can't be

995
00:34:28,230 --> 00:34:27,599
of your shadow you've got to be able to

996
00:34:30,230 --> 00:34:28,240
willing to

997
00:34:31,589 --> 00:34:30,240
to get up in the morning which is

998
00:34:32,869 --> 00:34:31,599
probably the hardest part of anybody's

999
00:34:34,470 --> 00:34:32,879
day where it's just waking up and

1000
00:34:35,190 --> 00:34:34,480
getting out of bed right but then once

1001
00:34:37,349 --> 00:34:35,200
you get going

1002
00:34:39,030 --> 00:34:37,359
get yours get the energy going see if

1003
00:34:39,589 --> 00:34:39,040
you can make something happen but don't

1004
00:34:42,629 --> 00:34:39,599
be

1005
00:34:46,389 --> 00:34:42,639
don't let that confidence

1006
00:34:49,909 --> 00:34:46,399
that that that uh become that that

1007
00:34:53,829 --> 00:34:49,919
that wonderful excitement of being

1008
00:34:56,550 --> 00:34:53,839
successful turn into hubris

1009
00:34:57,829 --> 00:34:56,560
and overconfidence and that's that's the

1010
00:35:00,069 --> 00:34:57,839
balancing act that we do

1011
00:35:01,270 --> 00:35:00,079
and and and and it's important i mean so

1012
00:35:02,310 --> 00:35:01,280
i have this is one of the reasons i have

1013
00:35:04,470 --> 00:35:02,320

to talk at jbl

1014
00:35:06,069 --> 00:35:04,480
because because because we see it but

1015
00:35:07,910 --> 00:35:06,079
but but even though even though these

1016
00:35:08,950 --> 00:35:07,920
people they're it's so easy for us to be

1017
00:35:10,550 --> 00:35:08,960
hard on each other

1018
00:35:12,710 --> 00:35:10,560
and not just and i don't mean at jpl at

1019
00:35:15,270 --> 00:35:12,720
nasa and together but just in general

1020
00:35:15,990 --> 00:35:15,280
um we all have to give people space you

1021
00:35:17,349 --> 00:35:16,000
know for kids

1022
00:35:19,190 --> 00:35:17,359
especially for kids growing up today

1023
00:35:23,030 --> 00:35:19,200
think about this you know think about

1024
00:35:26,069 --> 00:35:23,040
one mistake on a on a social networking

1025
00:35:27,190 --> 00:35:26,079
uh is on there permanently you know and

1026
00:35:30,150 --> 00:35:27,200
they so that so

1027
00:35:30,470 --> 00:35:30,160
they they they it's like it's like it's

1028
00:35:33,670 --> 00:35:30,480
like

1029
00:35:34,710 --> 00:35:33,680
uh um bob marley's chains you know and

1030
00:35:38,310 --> 00:35:34,720
around your neck

1031
00:35:39,750 --> 00:35:38,320
on on uh on the uh uh

1032
00:35:41,510 --> 00:35:39,760
what's that christmas show um you'll

1033
00:35:49,420 --> 00:35:41,520
remember i'm talking about uh

1034
00:35:53,750 --> 00:35:50,950
[Laughter]

1035
00:35:54,390 --> 00:35:53,760
not the jamaican one no so no it's it's

1036
00:36:00,870 --> 00:35:54,400
it

1037
00:36:02,870 --> 00:36:00,880
these these issues we have that

1038
00:36:04,150 --> 00:36:02,880

in the old days people will forget the

1039
00:36:05,670 --> 00:36:04,160
mistakes you made now

1040
00:36:07,190 --> 00:36:05,680
these mistakes feel like they have to

1041
00:36:08,310 --> 00:36:07,200
wear them on their sleeves and they

1042
00:36:09,190 --> 00:36:08,320
don't want to and it's something they're

1043
00:36:10,790 --> 00:36:09,200
afraid of

1044
00:36:13,109 --> 00:36:10,800
uh and and that's and it's true for all

1045
00:36:13,670 --> 00:36:13,119
of us we've got to stop being so hard on

1046
00:36:17,510 --> 00:36:13,680
each other

1047
00:36:19,349 --> 00:36:17,520
and give ourselves a chance to to

1048
00:36:20,710 --> 00:36:19,359
make a mistake create an environment

1049
00:36:23,510 --> 00:36:20,720
where mistakes can be

1050
00:36:24,950 --> 00:36:23,520
caught um if possible and and don't be

1051
00:36:25,670 --> 00:36:24,960
hard on people just because they make a

1052
00:36:27,190 --> 00:36:25,680
mistake listen

1053
00:36:28,630 --> 00:36:27,200
we don't want incompetence either we

1054
00:36:30,310 --> 00:36:28,640
don't everyone making mistakes and just

1055
00:36:32,550 --> 00:36:30,320
know being

1056
00:36:34,470 --> 00:36:32,560
going crazy but but we definitely need

1057
00:36:37,670 --> 00:36:34,480
uh to to allow people

1058
00:36:39,510 --> 00:36:37,680
the space to to to fail and be human

1059
00:36:41,030 --> 00:36:39,520
and learn from those mistakes and try to

1060
00:36:44,069 --> 00:36:41,040
be better as people

1061
00:36:45,109 --> 00:36:44,079
because we are not perfect people none

1062
00:36:47,990 --> 00:36:45,119
of us are

1063
00:36:49,190 --> 00:36:48,000

no one is we're just people and so uh

1064
00:36:50,950 --> 00:36:49,200
anyway so that's

1065
00:36:52,310 --> 00:36:50,960
that's where that comes out and i think

1066
00:36:54,390 --> 00:36:52,320
the comment you made earlier about

1067
00:36:56,470 --> 00:36:54,400
you know it was actually after the next

1068
00:36:58,950 --> 00:36:56,480
this other failure mars polder lander

1069
00:36:59,670 --> 00:36:58,960
uh i believe is when uh jay leno who is

1070
00:37:02,790 --> 00:36:59,680
some of you

1071
00:37:06,710 --> 00:37:02,800
may know as was remember was a as a uh a

1072
00:37:08,550 --> 00:37:06,720
nighttime uh uh i had the tonight show

1073
00:37:09,990 --> 00:37:08,560
and he and he you know and i watched him

1074
00:37:11,270 --> 00:37:10,000
one night and i was and

1075
00:37:13,190 --> 00:37:11,280
trying to trying to get away from my

1076
00:37:15,109 --> 00:37:13,200
brain away from the stress of work

1077
00:37:16,710 --> 00:37:15,119
and he said you know well just goes to

1078
00:37:19,270 --> 00:37:16,720
show you you don't have to be a rocket

1079
00:37:21,349 --> 00:37:19,280
scientist to be a rocket scientist

1080
00:37:22,470 --> 00:37:21,359
after after embarrassing failures and i

1081
00:37:24,870 --> 00:37:22,480
and i just like this like

1082
00:37:25,990 --> 00:37:24,880
diary that he's right first of all he's

1083
00:37:27,589 --> 00:37:26,000
right you don't have to be rocket

1084
00:37:28,710 --> 00:37:27,599
science but more importantly at that

1085
00:37:30,870 --> 00:37:28,720
point is is that

1086
00:37:31,829 --> 00:37:30,880
yeah he's actually making it sounds it's

1087
00:37:35,030 --> 00:37:31,839
funny but it is

1088
00:37:36,230 --> 00:37:35,040

we are human as anybody and that's okay

1089
00:37:38,870 --> 00:37:36,240
and there's nothing wrong with being a

1090
00:37:40,470 --> 00:37:38,880
human and and so and i think that's

1091
00:37:41,990 --> 00:37:40,480
you know all of us have to do it and

1092
00:37:43,270 --> 00:37:42,000
whether you're a student where you're

1093
00:37:45,270 --> 00:37:43,280
trying to learn and you're getting

1094
00:37:46,710 --> 00:37:45,280
and you and you get a bad report card or

1095
00:37:48,870 --> 00:37:46,720
a bad grade on something and

1096
00:37:50,790 --> 00:37:48,880
you know it's not the end of the world

1097
00:37:53,190 --> 00:37:50,800
and now you know what mistakes are part

1098
00:37:56,870 --> 00:37:53,200
of our very being i can tell you i have

1099
00:37:58,710 --> 00:37:56,880
personally personally damaged

1100
00:37:59,990 --> 00:37:58,720
i you know i'm not proud of this but

1101
00:38:03,270 --> 00:38:00,000
i've damaged

1102
00:38:04,550 --> 00:38:03,280
no less than three mars spacecraft

1103
00:38:06,550 --> 00:38:04,560
before they launched

1104
00:38:08,390 --> 00:38:06,560
that where they had to be repaired

1105
00:38:11,270 --> 00:38:08,400
because of me

1106
00:38:12,630 --> 00:38:11,280
because i messed up i screwed up you

1107
00:38:14,630 --> 00:38:12,640
know i told this to our

1108
00:38:15,990 --> 00:38:14,640
hr department and they were like well

1109
00:38:16,870 --> 00:38:16,000
maybe we should have fired you yeah you

1110
00:38:24,630 --> 00:38:16,880
know

1111
00:38:26,870 --> 00:38:24,640
it's hard to get me right and and

1112
00:38:28,630 --> 00:38:26,880
and and almost all these mistakes are

1113
00:38:29,910 --> 00:38:28,640

are things mistakes that i wanted that i

1114
00:38:33,270 --> 00:38:29,920
share with other people

1115
00:38:35,510 --> 00:38:33,280
that i that i'm not i'm not i'm not a

1116
00:38:36,470 --> 00:38:35,520
i'm not happy that i made those mistakes

1117
00:38:38,310 --> 00:38:36,480
but but

1118
00:38:39,750 --> 00:38:38,320
but i'm willing to share them because it

1119
00:38:42,390 --> 00:38:39,760
just tells the people that

1120
00:38:44,150 --> 00:38:42,400
it can happen to any one of us you know

1121
00:38:44,790 --> 00:38:44,160
even if the chief engineer of jpl can

1122
00:38:46,870 --> 00:38:44,800
make him a

1123
00:38:48,069 --> 00:38:46,880
dumb mistake then maybe i can't hear but

1124
00:38:49,910 --> 00:38:48,079
the other hand

1125
00:38:51,589 --> 00:38:49,920
we've got to learn from these mistakes

1126
00:38:53,030 --> 00:38:51,599
and try to make mistakes before

1127
00:38:55,190 --> 00:38:53,040
i don't recommend breaking flight harbor

1128
00:38:57,190 --> 00:38:55,200
by the way it's very expensive

1129
00:38:59,030 --> 00:38:57,200
and very time consuming and so i was

1130
00:39:01,670 --> 00:38:59,040
very embarrassed and very

1131
00:39:02,310 --> 00:39:01,680
you know it was what didn't wasn't great

1132
00:39:04,230 --> 00:39:02,320
but but

1133
00:39:05,589 --> 00:39:04,240
but i do tell people you know why not

1134
00:39:07,030 --> 00:39:05,599
you know you're uh

1135
00:39:09,190 --> 00:39:07,040
you know are you afraid of making

1136
00:39:12,390 --> 00:39:09,200
mistakes are you afraid of being wrong

1137
00:39:15,430 --> 00:39:12,400
you can't be afraid of being wrong

1138
00:39:17,109 --> 00:39:15,440

that's i think that's that's a great uh

1139
00:39:18,470 --> 00:39:17,119
segue to our f we're the last mission

1140
00:39:19,910 --> 00:39:18,480
we're going to talk about tonight

1141
00:39:21,190 --> 00:39:19,920
because there are lots of questions out

1142
00:39:21,670 --> 00:39:21,200
there and we want to make sure that

1143
00:39:23,190 --> 00:39:21,680
everybody

1144
00:39:24,870 --> 00:39:23,200
as many of you can get as many of those

1145
00:39:27,030 --> 00:39:24,880
in as possible um

1146
00:39:29,030 --> 00:39:27,040
i want to go to image seven and it's a

1147
00:39:31,990 --> 00:39:29,040
it's a successful mission

1148
00:39:33,030 --> 00:39:32,000
um but curiosity and we want to talk

1149
00:39:35,190 --> 00:39:33,040
about the wheels but

1150
00:39:37,109 --> 00:39:35,200
really what what you were talking about

1151
00:39:38,069 --> 00:39:37,119
what is the difference between a lesson

1152
00:39:42,790 --> 00:39:38,079
and a failure

1153
00:39:45,589 --> 00:39:42,800
and what is a failure of the imagination

1154
00:39:46,710 --> 00:39:45,599
yeah so i mean certainly um you can by

1155
00:39:49,430 --> 00:39:46,720
the way lessons can be

1156
00:39:49,829 --> 00:39:49,440
positive as well as negative but but but

1157
00:39:51,349 --> 00:39:49,839
you know

1158
00:39:53,030 --> 00:39:51,359
one of the things and this is something

1159
00:39:55,270 --> 00:39:53,040
that

1160
00:39:56,230 --> 00:39:55,280
you know almost always if we make a

1161
00:39:57,910 --> 00:39:56,240
mistake or something

1162
00:39:59,349 --> 00:39:57,920
it's because there's something we didn't

1163
00:40:02,069 --> 00:39:59,359

know and

1164
00:40:03,750 --> 00:40:02,079
uh one one of the things that i you know

1165
00:40:06,550 --> 00:40:03,760
i try to remind people is

1166
00:40:07,910 --> 00:40:06,560
is to is to keep that humility running

1167
00:40:10,790 --> 00:40:07,920
keep that

1168
00:40:12,309 --> 00:40:10,800
new humility knob as high as you can go

1169
00:40:13,670 --> 00:40:12,319
even when you're being challenged to do

1170
00:40:15,750 --> 00:40:13,680
something that other people aren't being

1171
00:40:18,230 --> 00:40:15,760
challenged to do

1172
00:40:19,910 --> 00:40:18,240
and remember by the way is to to listen

1173
00:40:21,589 --> 00:40:19,920
to the quiet voices and make sure that

1174
00:40:24,710 --> 00:40:21,599
the people who don't have

1175
00:40:27,109 --> 00:40:24,720
who aren't as verbose as people like me

1176
00:40:29,190 --> 00:40:27,119
uh to the they can bring their voices to

1177
00:40:31,589 --> 00:40:29,200
this to the table and remind us

1178
00:40:33,030 --> 00:40:31,599
what the right things are to do and uh

1179
00:40:34,230 --> 00:40:33,040
because everybody knows something you

1180
00:40:36,550 --> 00:40:34,240
don't know

1181
00:40:38,870 --> 00:40:36,560
in this case we've this is a picture of

1182
00:40:41,670 --> 00:40:38,880
curiosity rovers wheels

1183
00:40:43,510 --> 00:40:41,680
now i am a i'm a bit partial to

1184
00:40:45,990 --> 00:40:43,520
curiosity i was the chief engineer

1185
00:40:47,750 --> 00:40:46,000
i loved is a great team and it was a

1186
00:40:49,670 --> 00:40:47,760
huge challenge for project

1187
00:40:51,270 --> 00:40:49,680
um we had we did make a lot of mistakes

1188
00:40:53,270 --> 00:40:51,280

but we fixed them and

1189
00:40:55,109 --> 00:40:53,280
learn from them but one in particular

1190
00:40:55,589 --> 00:40:55,119
one that i feel personally responsible

1191
00:40:57,910 --> 00:40:55,599
for

1192
00:40:59,270 --> 00:40:57,920
um is right there in this picture if you

1193
00:40:59,670 --> 00:40:59,280
look carefully in that picture i know if

1194
00:41:02,790 --> 00:40:59,680
you can

1195
00:41:04,069 --> 00:41:02,800
folks can see it um there's there's the

1196
00:41:06,309 --> 00:41:04,079
wheel on the right

1197
00:41:07,990 --> 00:41:06,319
um this image was taken by a camera at

1198
00:41:09,510 --> 00:41:08,000
the end of a robotic arm

1199
00:41:10,710 --> 00:41:09,520
and so it was able to look underneath

1200
00:41:11,109 --> 00:41:10,720
the belly and take a picture and we

1201
00:41:12,550 --> 00:41:11,119
don't

1202
00:41:14,230 --> 00:41:12,560
do that very often but when we did we

1203
00:41:17,430 --> 00:41:14,240
looked and said oh my goodness

1204
00:41:19,510 --> 00:41:17,440
what is going on here those holes

1205
00:41:20,790 --> 00:41:19,520
in that wheel not that not the kind of

1206
00:41:22,710 --> 00:41:20,800
the rounded holes

1207
00:41:24,069 --> 00:41:22,720
but the one the holes on the right

1208
00:41:26,390 --> 00:41:24,079
should not be there

1209
00:41:27,750 --> 00:41:26,400
what's going on it's like somebody poked

1210
00:41:31,349 --> 00:41:27,760
poke a hole

1211
00:41:33,430 --> 00:41:31,359
poked holes in the wheels and you know

1212
00:41:34,870 --> 00:41:33,440
people like me instantly knew what was

1213
00:41:37,829 --> 00:41:34,880

going on and because i

1214
00:41:39,670 --> 00:41:37,839
seen similar things going wrong in

1215
00:41:40,870 --> 00:41:39,680
testing we had done before we launched

1216
00:41:44,150 --> 00:41:40,880
it years before

1217
00:41:45,829 --> 00:41:44,160
but in fact at least a couple of years

1218
00:41:47,349 --> 00:41:45,839
and and and in time

1219
00:41:49,510 --> 00:41:47,359
at a time when we i could have done

1220
00:41:52,630 --> 00:41:49,520
something about it and fixed it

1221
00:41:54,790 --> 00:41:52,640
but what happened was we didn't use our

1222
00:41:55,829 --> 00:41:54,800
imagination we didn't this is a case

1223
00:41:58,309 --> 00:41:55,839
where you know

1224
00:41:59,270 --> 00:41:58,319
it's hard to be it's hard to be smart

1225
00:42:00,950 --> 00:41:59,280
and hard to know

1226
00:42:03,670 --> 00:42:00,960
how to predict the future hardest you

1227
00:42:05,109 --> 00:42:03,680
know yeah you know

1228
00:42:06,710 --> 00:42:05,119
predicting the future is very difficult

1229
00:42:08,230 --> 00:42:06,720
i forget what uh yogi berra said

1230
00:42:10,710 --> 00:42:08,240
a version of that but it's it is it is

1231
00:42:13,349 --> 00:42:10,720
very uh it's very hard um

1232
00:42:13,910 --> 00:42:13,359
uh and but but even so we should have

1233
00:42:15,829 --> 00:42:13,920
put the

1234
00:42:17,190 --> 00:42:15,839
all the two and two together so what had

1235
00:42:19,430 --> 00:42:17,200
happened was we had seen

1236
00:42:20,790 --> 00:42:19,440
that the wheels in our test bed the

1237
00:42:22,470 --> 00:42:20,800
wheels had been damaged

1238
00:42:24,309 --> 00:42:22,480

and so we talked ourselves into thinking

1239
00:42:26,630 --> 00:42:24,319
well well listen our test program for

1240
00:42:28,230 --> 00:42:26,640
these wheels was pretty darn good we had

1241
00:42:29,670 --> 00:42:28,240
we had a wheel that was went over these

1242
00:42:30,470 --> 00:42:29,680
very sharp rocks i don't know if you

1243
00:42:32,950 --> 00:42:30,480
know this so so

1244
00:42:35,349 --> 00:42:32,960
where curiosity landed in a lake bed um

1245
00:42:36,309 --> 00:42:35,359
it's it has it's clays everywhere and

1246
00:42:38,309 --> 00:42:36,319
they're rocks

1247
00:42:39,589 --> 00:42:38,319
sitting in the clay clay bed and those

1248
00:42:41,990 --> 00:42:39,599
rocks are sitting there

1249
00:42:43,510 --> 00:42:42,000
they're bound hard into this lake bed

1250
00:42:45,270 --> 00:42:43,520
and oh and turns out

1251
00:42:47,109 --> 00:42:45,280
if even though there's air is only one

1252
00:42:47,750 --> 00:42:47,119
percent the density of earth's very very

1253
00:42:50,470 --> 00:42:47,760
thin

1254
00:42:52,150 --> 00:42:50,480
there's wind on mars it's not huge and

1255
00:42:54,309 --> 00:42:52,160
it's kind you can barely feel but it's

1256
00:42:55,109 --> 00:42:54,319
enough to get little tiny particles of

1257
00:42:56,950 --> 00:42:55,119
dust

1258
00:42:58,790 --> 00:42:56,960
to bounce along the surface it's called

1259
00:43:00,950 --> 00:42:58,800
saltation it bounces over the surface

1260
00:43:02,230 --> 00:43:00,960
and it can wear these rocks into these

1261
00:43:05,190 --> 00:43:02,240
incredibly sharp

1262
00:43:06,470 --> 00:43:05,200
fine edges almost like knife edges

1263
00:43:08,550 --> 00:43:06,480

they're called ventifacts

1264
00:43:10,309 --> 00:43:08,560
that this happens on earth too but these

1265
00:43:13,430 --> 00:43:10,319
rocks are basalts

1266
00:43:14,069 --> 00:43:13,440
lava rocks they're really hard and so so

1267
00:43:16,309 --> 00:43:14,079
uh

1268
00:43:17,829 --> 00:43:16,319
to but you know we knew that that

1269
00:43:19,030 --> 00:43:17,839
happened because we could we saw that

1270
00:43:21,190 --> 00:43:19,040
same thing happen

1271
00:43:22,710 --> 00:43:21,200
some years back with spirit when it

1272
00:43:24,230 --> 00:43:22,720
landed on mars we were driving i was

1273
00:43:26,069 --> 00:43:24,240
like well look at those sharp rocks

1274
00:43:27,349 --> 00:43:26,079
those are airbag eaters i sold myself

1275
00:43:29,349 --> 00:43:27,359
told myself and the team

1276
00:43:30,790 --> 00:43:29,359
and so so we were designing this wheel

1277
00:43:32,150 --> 00:43:30,800
we wanted to be sharp handy

1278
00:43:33,750 --> 00:43:32,160
we worked fine with these rocks well we

1279
00:43:34,150 --> 00:43:33,760
tested these things on rocks but guess

1280
00:43:35,910 --> 00:43:34,160
what

1281
00:43:37,190 --> 00:43:35,920
in our test bed we put the rocks down we

1282
00:43:40,790 --> 00:43:37,200
didn't glue them down

1283
00:43:42,069 --> 00:43:40,800
there's another thing we did we did

1284
00:43:43,030 --> 00:43:42,079
that's one thing we did wrong the other

1285
00:43:44,470 --> 00:43:43,040
thing we did wrong

1286
00:43:46,309 --> 00:43:44,480
i might just grab since i have it here

1287
00:43:49,670 --> 00:43:46,319
handy i happen to have uh

1288
00:43:52,870 --> 00:43:49,680

curiosity rover uh a model right here

1289
00:43:55,030 --> 00:43:52,880
that just happened to have it um yeah

1290
00:43:55,990 --> 00:43:55,040
um i ca i i sleep with it at night it's

1291
00:43:58,870 --> 00:43:56,000
kind of nice

1292
00:44:00,309 --> 00:43:58,880
so so it's it's it is it's got these we

1293
00:44:01,270 --> 00:44:00,319
got these wheels here and so what

1294
00:44:02,710 --> 00:44:01,280
happens so look at this

1295
00:44:04,630 --> 00:44:02,720
so these wheels look at how they move

1296
00:44:06,630 --> 00:44:04,640
around this mobility system these

1297
00:44:08,309 --> 00:44:06,640
this wheel these wheels go up and down

1298
00:44:09,030 --> 00:44:08,319
um they move over rocks the whole thing

1299
00:44:11,109 --> 00:44:09,040
moves

1300
00:44:12,710 --> 00:44:11,119
but we designed all three wheels to move

1301
00:44:14,390 --> 00:44:12,720
at the same speed

1302
00:44:16,470 --> 00:44:14,400
all three thinking that was the right

1303
00:44:18,470 --> 00:44:16,480
thing to do and that works fine for

1304
00:44:19,990 --> 00:44:18,480
small rovers but when we scaled up this

1305
00:44:20,630 --> 00:44:20,000
bigger rover we weren't really thinking

1306
00:44:22,550 --> 00:44:20,640
were we

1307
00:44:24,069 --> 00:44:22,560
it turns out it turns out if you're

1308
00:44:24,630 --> 00:44:24,079
trying to draw what this wheel is trying

1309
00:44:26,950 --> 00:44:24,640
to drive

1310
00:44:29,430 --> 00:44:26,960
over a bigger rock and these wheels are

1311
00:44:30,710 --> 00:44:29,440
these back wheels are going at at a

1312
00:44:32,470 --> 00:44:30,720
fixed constant speed

1313
00:44:34,309 --> 00:44:32,480

but this wheel isn't isn't is going the

1314
00:44:36,069 --> 00:44:34,319
same speed this wheel needs to go faster

1315
00:44:38,069 --> 00:44:36,079
to go over the rock

1316
00:44:39,430 --> 00:44:38,079
well it but it wasn't it was going the

1317
00:44:41,109 --> 00:44:39,440
same speed so basically these back

1318
00:44:43,510 --> 00:44:41,119
wheels are pushing these wheels

1319
00:44:44,950 --> 00:44:43,520
the front wheel and the side wheels are

1320
00:44:46,390 --> 00:44:44,960
faster than they can keep up

1321
00:44:48,309 --> 00:44:46,400
and now if you get these rocks that are

1322
00:44:51,589 --> 00:44:48,319
buried in clay with sharp

1323
00:44:53,430 --> 00:44:51,599
edges and sharp like a like a bear claw

1324
00:44:54,710 --> 00:44:53,440
you're just going to rip these these

1325
00:44:58,069 --> 00:44:54,720
these aluminum

1326
00:44:59,990 --> 00:44:58,079
wheels like like a like a coca-cola can

1327
00:45:01,670 --> 00:45:00,000
and that's that's basically what

1328
00:45:04,710 --> 00:45:01,680
happened uh with us

1329
00:45:05,109 --> 00:45:04,720
uh and and to to in my dismay and i i

1330
00:45:09,510 --> 00:45:05,119
was

1331
00:45:11,270 --> 00:45:09,520
those two pieces together that we really

1332
00:45:13,349 --> 00:45:11,280
we weren't thinking about we were going

1333
00:45:14,069 --> 00:45:13,359
to a clay clay we're going to place with

1334
00:45:15,670 --> 00:45:14,079
water right

1335
00:45:17,349 --> 00:45:15,680
and that means it's going to be clay's

1336
00:45:19,430 --> 00:45:17,359
what's clay's do clay's block

1337
00:45:20,550 --> 00:45:19,440
lock rocks down what do rock locked

1338
00:45:22,230 --> 00:45:20,560

rocks do they

1339
00:45:23,430 --> 00:45:22,240
should make sharp points they just don't

1340
00:45:24,390 --> 00:45:23,440
lie they're in the ground because we

1341
00:45:25,910 --> 00:45:24,400
drunk we were testing

1342
00:45:27,589 --> 00:45:25,920
just in the wheels over sharp rocks

1343
00:45:29,510 --> 00:45:27,599
these rocks would bend over as the

1344
00:45:31,190 --> 00:45:29,520
wheels turned over the rocks

1345
00:45:32,710 --> 00:45:31,200
the points would move with it and they

1346
00:45:35,109 --> 00:45:32,720
weren't damaging the rocks

1347
00:45:36,950 --> 00:45:35,119
and so we miss we underestimated just

1348
00:45:39,349 --> 00:45:36,960
how bad mars really could be

1349
00:45:40,470 --> 00:45:39,359
so we did our imaginations were not

1350
00:45:41,990 --> 00:45:40,480
sufficient we didn't put

1351
00:45:43,990 --> 00:45:42,000
all the pieces together to allow

1352
00:45:47,109 --> 00:45:44,000
ourselves to appreciate

1353
00:45:49,829 --> 00:45:47,119
what this what uh what could actually

1354
00:45:51,030 --> 00:45:49,839
uh arise when we get to mars and yet all

1355
00:45:51,750 --> 00:45:51,040
the ingredients for figuring that out

1356
00:45:54,309 --> 00:45:51,760
were there

1357
00:45:55,670 --> 00:45:54,319
two years before we launched so i so i i

1358
00:45:57,349 --> 00:45:55,680
kicked myself for not

1359
00:45:59,510 --> 00:45:57,359
put thinking that through or making a

1360
00:46:01,910 --> 00:45:59,520
bigger issue out of it

1361
00:46:03,990 --> 00:46:01,920
i always appreciate your accountability

1362
00:46:05,109 --> 00:46:04,000
and your acceptance into these um and i

1363
00:46:07,829 --> 00:46:05,119

think that's a that's a

1364
00:46:09,109 --> 00:46:07,839
big part of of what you have to do but

1365
00:46:10,309 --> 00:46:09,119
also in everyday life

1366
00:46:11,829 --> 00:46:10,319
um we're going to open it up to the

1367
00:46:13,430 --> 00:46:11,839
audience they've got a lot of questions

1368
00:46:16,150 --> 00:46:13,440
so i'm going to send it over to

1369
00:46:18,630 --> 00:46:16,160
nikki how's it looking out there nikki

1370
00:46:20,870 --> 00:46:18,640
we've got a ton of interest online rob

1371
00:46:23,190 --> 00:46:20,880
especially with our students i know

1372
00:46:24,630 --> 00:46:23,200
that's a big passion project of yours

1373
00:46:27,510 --> 00:46:24,640
we've got quite a few people who are

1374
00:46:29,750 --> 00:46:27,520
asking for advice how to get jobs at jpl

1375
00:46:31,430 --> 00:46:29,760
for instance kevin on youtube has asked

1376
00:46:33,349 --> 00:46:31,440
what are your suggestions for early

1377
00:46:34,870 --> 00:46:33,359
career scientists and engineers

1378
00:46:37,190 --> 00:46:34,880
wanting to pivot towards getting

1379
00:46:39,829 --> 00:46:37,200
involved in future space related

1380
00:46:45,829 --> 00:46:42,950
oh well a little luck doesn't hurt

1381
00:46:46,309 --> 00:46:45,839
okay but i tell you i think i think i

1382
00:46:49,109 --> 00:46:46,319
think

1383
00:46:49,750 --> 00:46:49,119
there is something about people in this

1384
00:46:52,309 --> 00:46:49,760
line of work

1385
00:46:53,030 --> 00:46:52,319
that is important first of all uh you

1386
00:46:54,870 --> 00:46:53,040
you're

1387
00:46:56,550 --> 00:46:54,880
unlikely unless you start your own

1388
00:47:00,630 --> 00:46:56,560

company to get rich

1389
00:47:03,349 --> 00:47:00,640
doing this work um but you will be

1390
00:47:05,109 --> 00:47:03,359
greatly enriched with with with the

1391
00:47:07,270 --> 00:47:05,119
magic of exploration

1392
00:47:09,109 --> 00:47:07,280
the magic of trying hard things and

1393
00:47:10,230 --> 00:47:09,119
being at least attempting to be

1394
00:47:12,550 --> 00:47:10,240
successful

1395
00:47:13,990 --> 00:47:12,560
um i think the biggest thing i would

1396
00:47:14,550 --> 00:47:14,000
recommend for anybody and they all seem

1397
00:47:16,630 --> 00:47:14,560
to have this

1398
00:47:18,230 --> 00:47:16,640
all the people who come to this whether

1399
00:47:19,030 --> 00:47:18,240
it's jpl or nasa they all share

1400
00:47:21,670 --> 00:47:19,040
something

1401
00:47:22,710 --> 00:47:21,680
they share a deep passion and interest

1402
00:47:24,790 --> 00:47:22,720
in curiosity

1403
00:47:26,390 --> 00:47:24,800
and how things work they want to be part

1404
00:47:29,030 --> 00:47:26,400
of it they they're they're

1405
00:47:29,670 --> 00:47:29,040
patient they're willing to learn they're

1406
00:47:32,710 --> 00:47:29,680
they're not

1407
00:47:35,750 --> 00:47:32,720
afraid of of not knowing

1408
00:47:36,230 --> 00:47:35,760
uh at least at least at first uh and i

1409
00:47:39,990 --> 00:47:36,240
think i

1410
00:47:42,470 --> 00:47:40,000
i think that uh a a a a

1411
00:47:43,829 --> 00:47:42,480
a a career that starts off where i mean

1412
00:47:45,670 --> 00:47:43,839
obviously it's the kind of work we do

1413
00:47:46,950 --> 00:47:45,680

it's really hard to get a take a class

1414
00:47:48,309 --> 00:47:46,960
on how to build these things and how to

1415
00:47:52,150 --> 00:47:48,319
do these kinds of missions

1416
00:47:53,910 --> 00:47:52,160
however there is plenty of room to to

1417
00:47:56,309 --> 00:47:53,920
really you can learn that on the job the

1418
00:47:59,750 --> 00:47:56,319
hard part is learning the fundamentals

1419
00:48:01,990 --> 00:47:59,760
knowing the math physics understanding

1420
00:48:03,510 --> 00:48:02,000
uh communications theory understanding

1421
00:48:07,190 --> 00:48:03,520
uh thermal dynamics

1422
00:48:10,069 --> 00:48:07,200
understanding the basics of how how

1423
00:48:11,670 --> 00:48:10,079
physics works uh and and the lowest

1424
00:48:14,230 --> 00:48:11,680
level of engineering works

1425
00:48:15,430 --> 00:48:14,240
uh how electronics works how computers

1426
00:48:17,430 --> 00:48:15,440
work fundamentally

1427
00:48:18,950 --> 00:48:17,440
uh not just not just that how the apps

1428
00:48:20,630 --> 00:48:18,960
work but what's going on inside these

1429
00:48:22,150 --> 00:48:20,640
complicated machines that we build

1430
00:48:23,430 --> 00:48:22,160
and try to understand those and get

1431
00:48:24,630 --> 00:48:23,440
trying to get an authentic understanding

1432
00:48:26,630 --> 00:48:24,640
of that lower level

1433
00:48:28,710 --> 00:48:26,640
because because it will take a lifetime

1434
00:48:29,829 --> 00:48:28,720
to really learn about all these details

1435
00:48:31,910 --> 00:48:29,839
about these things

1436
00:48:33,190 --> 00:48:31,920
that's okay you'll learn that on the job

1437
00:48:35,510 --> 00:48:33,200
they'll pay you to

1438
00:48:36,230 --> 00:48:35,520

figure that out we'll our we'll pay you

1439
00:48:38,630 --> 00:48:36,240
to do that

1440
00:48:39,270 --> 00:48:38,640
but but we but we really need you to be

1441
00:48:43,030 --> 00:48:39,280
a person

1442
00:48:45,030 --> 00:48:43,040
of curiosity and passion and interest

1443
00:48:48,630 --> 00:48:45,040
with a spark and a willingness to learn

1444
00:48:50,630 --> 00:48:48,640
and ask questions

1445
00:48:52,470 --> 00:48:50,640
that's really great to hear and you know

1446
00:48:54,150 --> 00:48:52,480
some people online have also been asking

1447
00:48:54,630 --> 00:48:54,160
a little bit more specific questions for

1448
00:48:57,109 --> 00:48:54,640
instance

1449
00:48:58,309 --> 00:48:57,119
jeremiah was asking about what type of

1450
00:49:00,309 --> 00:48:58,319
programs we use

1451
00:49:02,549 --> 00:49:00,319
and how jeremiah can learn more about

1452
00:49:04,390 --> 00:49:02,559
those launch programs or other types of

1453
00:49:05,990 --> 00:49:04,400
projects how do we do those calculations

1454
00:49:07,670 --> 00:49:06,000
and those simulations for those type of

1455
00:49:10,870 --> 00:49:07,680
things

1456
00:49:12,950 --> 00:49:10,880
how how do we yeah good question

1457
00:49:13,990 --> 00:49:12,960
i actually i've wondered that for years

1458
00:49:15,990 --> 00:49:14,000
um

1459
00:49:17,750 --> 00:49:16,000
but it's the wonderful thing about

1460
00:49:19,270 --> 00:49:17,760
understanding how things work

1461
00:49:21,190 --> 00:49:19,280
is that once you understand you can

1462
00:49:22,069 --> 00:49:21,200
create models of these worlds you know

1463
00:49:24,710 --> 00:49:22,079

for example

1464
00:49:26,630 --> 00:49:24,720
the whole the incredibly exciting

1465
00:49:28,790 --> 00:49:26,640
sequence of steps that requ

1466
00:49:30,470 --> 00:49:28,800
that require that you that you that the

1467
00:49:33,030 --> 00:49:30,480
vehicle needs to transform in

1468
00:49:35,190 --> 00:49:33,040
automatically all by itself on landing

1469
00:49:36,309 --> 00:49:35,200
day to land these big expensive missions

1470
00:49:39,589 --> 00:49:36,319
on another planet

1471
00:49:40,390 --> 00:49:39,599
um is is almost impossible to test here

1472
00:49:42,470 --> 00:49:40,400
on this planet

1473
00:49:46,069 --> 00:49:42,480
it really is you can test pieces i can

1474
00:49:49,190 --> 00:49:46,079
take i can go up to 130 000 feet

1475
00:49:51,589 --> 00:49:49,200
or higher and and inflate a

1476
00:49:52,309 --> 00:49:51,599
a full-scale parachute in front of a

1477
00:49:54,950 --> 00:49:52,319
rocket

1478
00:49:55,750 --> 00:49:54,960
and test out the parachute that way um i

1479
00:49:58,710 --> 00:49:55,760
could i could

1480
00:50:00,230 --> 00:49:58,720
uh i can take these wheels and drive

1481
00:50:02,630 --> 00:50:00,240
them on an environment

1482
00:50:03,349 --> 00:50:02,640
that that looks a lot like mars and do

1483
00:50:06,950 --> 00:50:03,359
it right

1484
00:50:09,190 --> 00:50:06,960
testing properly

1485
00:50:11,510 --> 00:50:09,200
um we can we can do almost all these

1486
00:50:14,470 --> 00:50:11,520
things in bits and pieces but we can't

1487
00:50:16,309 --> 00:50:14,480
really test all these things as a system

1488
00:50:19,030 --> 00:50:16,319

you can't do entry descent landing

1489
00:50:19,750 --> 00:50:19,040
on a mars entry set landing on this

1490
00:50:21,990 --> 00:50:19,760
planet

1491
00:50:23,910 --> 00:50:22,000
why because it's not just the gravity

1492
00:50:25,750 --> 00:50:23,920
but the atmosphere is so much thicker

1493
00:50:28,390 --> 00:50:25,760
it's a very different system

1494
00:50:29,349 --> 00:50:28,400
on mars the atmos is equivalent to try

1495
00:50:32,630 --> 00:50:29,359
to land

1496
00:50:34,069 --> 00:50:32,640
on a mountain that's really 130 feet

1497
00:50:35,750 --> 00:50:34,079
high above the surface there are no

1498
00:50:36,950 --> 00:50:35,760
mountains that high that's many times

1499
00:50:38,710 --> 00:50:36,960
higher than mount everest

1500
00:50:40,470 --> 00:50:38,720
and so there's no real way to do it so

1501
00:50:42,790 --> 00:50:40,480
instead we have to build

1502
00:50:46,470 --> 00:50:42,800
computer simulations and we have to use

1503
00:50:50,230 --> 00:50:47,990
interacting with models of the

1504
00:50:53,510 --> 00:50:50,240
atmosphere of the surface

1505
00:50:55,910 --> 00:50:53,520
of how understanding how how radar

1506
00:50:56,790 --> 00:50:55,920
signals come out of a radar radios come

1507
00:50:58,870 --> 00:50:56,800
out of a radar

1508
00:50:59,829 --> 00:50:58,880
and how it bounces off of rocks and

1509
00:51:01,910 --> 00:50:59,839
slopes

1510
00:51:02,950 --> 00:51:01,920
and back into the radar and simulate all

1511
00:51:04,710 --> 00:51:02,960
those pieces

1512
00:51:06,150 --> 00:51:04,720
to try to really get yourself a good

1513
00:51:07,270 --> 00:51:06,160

understanding of

1514
00:51:09,589 --> 00:51:07,280
whether or not you think this thing's

1515
00:51:10,069 --> 00:51:09,599
going to work or not it's very dangerous

1516
00:51:13,510 --> 00:51:10,079
because

1517
00:51:14,069 --> 00:51:13,520
this imagine the first time you flew an

1518
00:51:15,270 --> 00:51:14,079
airplane

1519
00:51:17,430 --> 00:51:15,280
is when you floated up with all the

1520
00:51:20,790 --> 00:51:17,440
passengers now don't do that

1521
00:51:22,230 --> 00:51:20,800
um but we have no choice so so we have

1522
00:51:23,349 --> 00:51:22,240
to have models we have to have

1523
00:51:24,790 --> 00:51:23,359
computer simulations we have to

1524
00:51:25,670 --> 00:51:24,800
understand the mass properties of a

1525
00:51:27,829 --> 00:51:25,680
spacecraft

1526
00:51:29,990 --> 00:51:27,839
in space it's momentum how much its

1527
00:51:30,950 --> 00:51:30,000
angular angular momentum it has in space

1528
00:51:33,030 --> 00:51:30,960
so we can fire

1529
00:51:34,870 --> 00:51:33,040
simulated rockets that push it this way

1530
00:51:37,349 --> 00:51:34,880
and push it that way so it can aim

1531
00:51:37,990 --> 00:51:37,359
its it's it's solar panels properly at

1532
00:51:39,510 --> 00:51:38,000
the sun

1533
00:51:41,109 --> 00:51:39,520
and you can do those kinds of things but

1534
00:51:42,710 --> 00:51:41,119
it is it does take

1535
00:51:44,230 --> 00:51:42,720
it's very tedious work i'm telling you

1536
00:51:45,829 --> 00:51:44,240
this stuff is tedious work

1537
00:51:47,349 --> 00:51:45,839
all the almost all the engineers that

1538
00:51:48,790 --> 00:51:47,359

come here very excited first thing we do

1539
00:51:49,750 --> 00:51:48,800
is to give them something massively

1540
00:51:52,549 --> 00:51:49,760
tedious to do

1541
00:51:53,750 --> 00:51:52,559
because this because because it's so

1542
00:51:55,109 --> 00:51:53,760
easy to get it wrong

1543
00:51:57,270 --> 00:51:55,119
they have to they have to go through

1544
00:51:58,950 --> 00:51:57,280
this this this this detail

1545
00:52:00,309 --> 00:51:58,960
to figure out and have the perseverance

1546
00:52:03,510 --> 00:52:00,319
which is a key attribute

1547
00:52:04,150 --> 00:52:03,520
of success in in this business to go

1548
00:52:05,910 --> 00:52:04,160
through and

1549
00:52:09,349 --> 00:52:05,920
struggle through it and struggle through

1550
00:52:12,390 --> 00:52:11,829
you know with so many opportunities and

1551
00:52:15,030 --> 00:52:12,400
points

1552
00:52:17,510 --> 00:52:15,040
of failure possibility it's astounding

1553
00:52:18,150 --> 00:52:17,520
how much success that you and jpl have

1554
00:52:20,230 --> 00:52:18,160
had

1555
00:52:22,150 --> 00:52:20,240
and canon on youtube wants to know how

1556
00:52:23,829 --> 00:52:22,160
does it feel to have a mission

1557
00:52:25,109 --> 00:52:23,839
in which thousands of things can go

1558
00:52:26,309 --> 00:52:25,119
wrong and have it turn out to be a

1559
00:52:28,710 --> 00:52:26,319
complete success

1560
00:52:31,030 --> 00:52:28,720
how does that feel well it's usually a

1561
00:52:32,710 --> 00:52:31,040
big surprise

1562
00:52:34,230 --> 00:52:32,720
every so i'm tell you i tell you so i i

1563
00:52:34,630 --> 00:52:34,240

like to tell people all this all the

1564
00:52:36,309 --> 00:52:34,640
time

1565
00:52:37,990 --> 00:52:36,319
and so you know you've seen us you know

1566
00:52:41,109 --> 00:52:38,000
uh there in our in our

1567
00:52:43,190 --> 00:52:41,119
in our in our uh polo shirts you know

1568
00:52:44,230 --> 00:52:43,200
our case of curiosity elena was these

1569
00:52:45,589 --> 00:52:44,240
light blue shirts

1570
00:52:47,510 --> 00:52:45,599
we're all like going screaming up and

1571
00:52:49,430 --> 00:52:47,520
down your faces are turning red

1572
00:52:50,710 --> 00:52:49,440
people are crying is it are they

1573
00:52:52,230 --> 00:52:50,720
relieved no i mean

1574
00:52:53,910 --> 00:52:52,240
are they happy no they're not happy

1575
00:52:56,309 --> 00:52:53,920
they're relieved they're they're they

1576
00:52:57,910 --> 00:52:56,319
it's just like because because even up

1577
00:52:59,589 --> 00:52:57,920
into that very moment in fact for me

1578
00:53:01,349 --> 00:52:59,599
sometimes for days after

1579
00:53:02,790 --> 00:53:01,359
um you you are constantly what did i

1580
00:53:04,069 --> 00:53:02,800
forget what did i miss

1581
00:53:06,390 --> 00:53:04,079
what are the what's the piece of the

1582
00:53:08,390 --> 00:53:06,400
puzzle that i that i didn't think of

1583
00:53:09,829 --> 00:53:08,400
and so so but that's what we want people

1584
00:53:10,470 --> 00:53:09,839
to do we want them to be constantly

1585
00:53:12,870 --> 00:53:10,480
think about

1586
00:53:14,710 --> 00:53:12,880
what did we miss what did i not do right

1587
00:53:17,829 --> 00:53:14,720
what mistake did i make

1588
00:53:18,950 --> 00:53:17,839

and so so so when you put all these

1589
00:53:21,430 --> 00:53:18,960
pieces together

1590
00:53:22,630 --> 00:53:21,440
um in fact it's really even hard to know

1591
00:53:23,190 --> 00:53:22,640
as you're getting closer and closer you

1592
00:53:25,829 --> 00:53:23,200
think

1593
00:53:27,109 --> 00:53:25,839
am i done well you never really done

1594
00:53:28,790 --> 00:53:27,119
until the thing lands

1595
00:53:31,190 --> 00:53:28,800
you're constantly thinking about those

1596
00:53:33,349 --> 00:53:31,200
things and um and that's a good thing

1597
00:53:34,950 --> 00:53:33,359
it's it's a good thing you sort of know

1598
00:53:36,470 --> 00:53:34,960
i have to admit people i people ask me

1599
00:53:38,150 --> 00:53:36,480
so rob how do i know when we're actually

1600
00:53:39,270 --> 00:53:38,160
done we seem to be testing and testing

1601
00:53:41,430 --> 00:53:39,280
testing how are we getting done

1602
00:53:43,430 --> 00:53:41,440
he says well here's a question are we

1603
00:53:45,190 --> 00:53:43,440
learning anything new

1604
00:53:47,030 --> 00:53:45,200
if if we're still testing and we're not

1605
00:53:48,230 --> 00:53:47,040
learning anything new and it seems to be

1606
00:53:50,230 --> 00:53:48,240
doing what we wanted to do

1607
00:53:51,510 --> 00:53:50,240
we might very well be on the plateau

1608
00:53:52,870 --> 00:53:51,520
it's very much like you mentioned you're

1609
00:53:54,069 --> 00:53:52,880
climbing mount everest right

1610
00:53:55,589 --> 00:53:54,079
you're climbing the mountain going up

1611
00:53:56,950 --> 00:53:55,599
higher and higher and higher and but

1612
00:53:58,549 --> 00:53:56,960
it's but you can't see what the

1613
00:53:59,990 --> 00:53:58,559

summit is it's it's all murky and

1614
00:54:01,750 --> 00:54:00,000
there's clouds everywhere

1615
00:54:03,349 --> 00:54:01,760
but but but but the slope is sort of

1616
00:54:04,790 --> 00:54:03,359
leveling off you're getting up this

1617
00:54:06,150 --> 00:54:04,800
it's getting it was still very steep but

1618
00:54:06,630 --> 00:54:06,160
eventually gets flatter and flatter and

1619
00:54:08,390 --> 00:54:06,640
flatter

1620
00:54:10,150 --> 00:54:08,400
and you go like which you really can't

1621
00:54:13,270 --> 00:54:10,160
see if there's another peak ahead of you

1622
00:54:15,510 --> 00:54:13,280
but you just say you know what i think

1623
00:54:17,510 --> 00:54:15,520
i might be there it's we're at the flat

1624
00:54:18,069 --> 00:54:17,520
spot we maybe we're at the sweet spot

1625
00:54:24,790 --> 00:54:18,079
maybe we

1626
00:54:26,069 --> 00:54:24,800
for sure

1627
00:54:27,589 --> 00:54:26,079
you know it's great that we can have

1628
00:54:29,190 --> 00:54:27,599
these conversations about all this

1629
00:54:30,950 --> 00:54:29,200
knowledge that you're passing on

1630
00:54:33,270 --> 00:54:30,960
and all the information that you're

1631
00:54:35,670 --> 00:54:33,280
learning from your own experience at jpl

1632
00:54:37,510 --> 00:54:35,680
and teo on youtube wants to know how

1633
00:54:39,589 --> 00:54:37,520
does jpl and nasa work

1634
00:54:41,349 --> 00:54:39,599
to pass on generational knowledge and

1635
00:54:44,069 --> 00:54:41,359
make sure new employees don't make the

1636
00:54:46,950 --> 00:54:44,079
same mistakes as their predecessors

1637
00:54:48,710 --> 00:54:46,960
oh what a great question i we have a

1638
00:54:51,589 --> 00:54:48,720

chief knowledge officer who works

1639
00:54:52,710 --> 00:54:51,599
works with me and and she is uh she's

1640
00:54:54,630 --> 00:54:52,720
chartered with

1641
00:54:55,829 --> 00:54:54,640
figuring out how we do that i tell you

1642
00:54:57,670 --> 00:54:55,839
it's really hard

1643
00:54:59,349 --> 00:54:57,680
because it's a lot of it is story

1644
00:55:01,910 --> 00:54:59,359
storytelling i mean a lot

1645
00:55:02,470 --> 00:55:01,920
and a lot of things we do for example we

1646
00:55:04,309 --> 00:55:02,480
we do

1647
00:55:06,230 --> 00:55:04,319
because we're engineers right okay well

1648
00:55:08,230 --> 00:55:06,240
we learned this lesson so um

1649
00:55:09,670 --> 00:55:08,240
we write down new rules right new rules

1650
00:55:10,150 --> 00:55:09,680
a whole little rule book that goes

1651
00:55:13,430 --> 00:55:10,160
longer

1652
00:55:15,190 --> 00:55:13,440
all the of all the

1653
00:55:16,789 --> 00:55:15,200
other things will you know remember you

1654
00:55:17,910 --> 00:55:16,799
can't do this you got to do this

1655
00:55:19,510 --> 00:55:17,920
you can't do this you have to do this

1656
00:55:21,030 --> 00:55:19,520
and but there was trouble with that

1657
00:55:21,750 --> 00:55:21,040
style and we d and that's something we

1658
00:55:25,030 --> 00:55:21,760
do a lot

1659
00:55:27,670 --> 00:55:25,040
is that it misses the story

1660
00:55:28,069 --> 00:55:27,680
the narrative that that and and in some

1661
00:55:30,150 --> 00:55:28,079
sense

1662
00:55:31,670 --> 00:55:30,160
the way that we really learn is by

1663
00:55:33,190 --> 00:55:31,680

living vicariously through the

1664
00:55:35,190 --> 00:55:33,200
experiences of others

1665
00:55:37,750 --> 00:55:35,200
previous generations standing on

1666
00:55:39,750 --> 00:55:37,760
shoulders of giants of people who tried

1667
00:55:40,870 --> 00:55:39,760
and succeeded and those who tried and

1668
00:55:42,870 --> 00:55:40,880
failed and that's

1669
00:55:44,789 --> 00:55:42,880
and it's really hard to do because guess

1670
00:55:46,230 --> 00:55:44,799
what we also have real jobs to do

1671
00:55:48,069 --> 00:55:46,240
and we don't have a lot of time and it's

1672
00:55:48,870 --> 00:55:48,079
really now in this time in the time of

1673
00:55:51,750 --> 00:55:48,880
zoom and

1674
00:55:53,030 --> 00:55:51,760
and webex and other and uh teams it's

1675
00:55:56,470 --> 00:55:53,040
very difficult

1676
00:55:59,030 --> 00:55:56,480
to to to have those those uh those uh

1677
00:56:01,270 --> 00:55:59,040
casual uh water cooler conversations

1678
00:56:02,549 --> 00:56:01,280
that allow people to tell the stories so

1679
00:56:04,549 --> 00:56:02,559
this is a really difficult time and so

1680
00:56:06,470 --> 00:56:04,559
it's really hard i'm honest with you

1681
00:56:07,750 --> 00:56:06,480
i'm not sure we know how to answer how

1682
00:56:11,270 --> 00:56:07,760
to answer that question we're still

1683
00:56:14,069 --> 00:56:12,870
well i love that your attitude is that

1684
00:56:16,309 --> 00:56:14,079
we're still figuring it out we still get

1685
00:56:19,750 --> 00:56:16,319
to work together on these things and

1686
00:56:22,470 --> 00:56:19,760
make improvements and learn together um

1687
00:56:24,069 --> 00:56:22,480
ryukachu on youtube asks us what's a

1688
00:56:26,230 --> 00:56:24,079

project that's on the horizon that

1689
00:56:27,990 --> 00:56:26,240
you're incredibly excited about either

1690
00:56:29,510 --> 00:56:28,000
something right now or something that's

1691
00:56:30,549 --> 00:56:29,520
not built yet that's coming in the

1692
00:56:32,230 --> 00:56:30,559
future

1693
00:56:33,670 --> 00:56:32,240
oh we have a bunch of them it's really

1694
00:56:34,950 --> 00:56:33,680
exciting the great thing about being the

1695
00:56:36,069 --> 00:56:34,960
lab chief engineer i can see all the

1696
00:56:38,069 --> 00:56:36,079
things that are going on

1697
00:56:39,510 --> 00:56:38,079
one there's there's there's a there's a

1698
00:56:40,549 --> 00:56:39,520
there's one mission we're building which

1699
00:56:44,470 --> 00:56:40,559
is going to go

1700
00:56:45,430 --> 00:56:44,480
visit a uh a an asteroid on the asteroid

1701
00:56:48,069 --> 00:56:45,440
belt

1702
00:56:48,710 --> 00:56:48,079
called psyche and this is a this is a

1703
00:56:51,990 --> 00:56:48,720
rock

1704
00:56:52,950 --> 00:56:52,000
in outer space that we think was once a

1705
00:56:55,270 --> 00:56:52,960
planet testimony

1706
00:56:57,349 --> 00:56:55,280
a small planet and something you know if

1707
00:56:57,750 --> 00:56:57,359
you know most planets have an iron core

1708
00:56:59,670 --> 00:56:57,760
right

1709
00:57:00,789 --> 00:56:59,680
with something we think we can tell from

1710
00:57:03,510 --> 00:57:00,799
our telescopes on earth

1711
00:57:05,349 --> 00:57:03,520
we think that that's that something

1712
00:57:08,710 --> 00:57:05,359
wiped away all the rock

1713
00:57:11,190 --> 00:57:08,720

and left this big iron ball this massive

1714
00:57:12,150 --> 00:57:11,200
iron ball in the middle of space and we

1715
00:57:13,750 --> 00:57:12,160
think that's what it is

1716
00:57:16,069 --> 00:57:13,760
we're going to send a spaceship out

1717
00:57:18,069 --> 00:57:16,079
there to go visit and confirm that's

1718
00:57:19,750 --> 00:57:18,079
exactly what that is that if that's the

1719
00:57:21,829 --> 00:57:19,760
case that's the largest

1720
00:57:23,510 --> 00:57:21,839
chunk of available iron you would find

1721
00:57:24,630 --> 00:57:23,520
anywhere in our in our solar system it's

1722
00:57:25,990 --> 00:57:24,640
amazing

1723
00:57:28,870 --> 00:57:26,000
we have another mission that's going to

1724
00:57:31,910 --> 00:57:28,880
go to in orbit around

1725
00:57:33,910 --> 00:57:31,920
around jupiter jupiter a very scary

1726
00:57:35,430 --> 00:57:33,920
place to fly around it turns out because

1727
00:57:39,670 --> 00:57:35,440
it's got radiation

1728
00:57:41,990 --> 00:57:39,680
from from this jupiter has this amazing

1729
00:57:43,270 --> 00:57:42,000
magnetic field which is beautiful and

1730
00:57:45,510 --> 00:57:43,280
that and powerful

1731
00:57:48,150 --> 00:57:45,520
but this also got moons that squirt up

1732
00:57:50,549 --> 00:57:48,160
atoms from volcanoes io in particular

1733
00:57:51,990 --> 00:57:50,559
and that those those those particles get

1734
00:57:53,750 --> 00:57:52,000
accelerated because they're charged up

1735
00:57:56,150 --> 00:57:53,760
and they got start racing around

1736
00:57:56,789 --> 00:57:56,160
around from pole to pole on in around

1737
00:57:58,789 --> 00:57:56,799
jupiter

1738
00:58:00,950 --> 00:57:58,799

making this a very dangerous place to

1739
00:58:02,470 --> 00:58:00,960
fly it's very dangerous for people

1740
00:58:03,829 --> 00:58:02,480
it's even more dangerous for people but

1741
00:58:05,430 --> 00:58:03,839
you can if you're lucky you can make

1742
00:58:08,549 --> 00:58:05,440
electronics and put them inside

1743
00:58:10,309 --> 00:58:08,559
vaults of lead and send them to jupiter

1744
00:58:11,910 --> 00:58:10,319
but we're going to do is go to go to

1745
00:58:12,470 --> 00:58:11,920
orbit and zone jupiter but not to see

1746
00:58:15,190 --> 00:58:12,480
jupiter

1747
00:58:15,750 --> 00:58:15,200
we're we're we want to go visit and fly

1748
00:58:19,349 --> 00:58:15,760
by

1749
00:58:21,190 --> 00:58:19,359
europa europa is this moon it's a very

1750
00:58:23,510 --> 00:58:21,200
large moon it's smaller than our moon

1751
00:58:23,990 --> 00:58:23,520
but it's a it's it's unlike any other

1752
00:58:26,150 --> 00:58:24,000
place

1753
00:58:27,750 --> 00:58:26,160
with a possible exception enceladus it

1754
00:58:30,789 --> 00:58:27,760
it's it's it's a big

1755
00:58:32,870 --> 00:58:30,799
iceberg a giant ball of ice

1756
00:58:34,230 --> 00:58:32,880
that but underneath kilometers many

1757
00:58:36,549 --> 00:58:34,240
kilometers of ice

1758
00:58:37,430 --> 00:58:36,559
are these massive oceans and below the

1759
00:58:39,990 --> 00:58:37,440
oceans is

1760
00:58:41,670 --> 00:58:40,000
a rocky center so it's like it's almost

1761
00:58:43,829 --> 00:58:41,680
like like antarctica

1762
00:58:46,549 --> 00:58:43,839
except it's the whole moon in fact

1763
00:58:49,109 --> 00:58:46,559

there's more liquid water

1764
00:58:50,069 --> 00:58:49,119
on that little moon than all of earth in

1765
00:58:53,109 --> 00:58:50,079
fact maybe

1766
00:58:53,589 --> 00:58:53,119
three times or more water on that little

1767
00:58:55,670 --> 00:58:53,599
moon

1768
00:58:57,430 --> 00:58:55,680
than earth in fact that water could be a

1769
00:58:59,270 --> 00:58:57,440
very habitable place

1770
00:59:01,030 --> 00:58:59,280
could very well be a habitable place for

1771
00:59:02,549 --> 00:59:01,040
life as we might

1772
00:59:04,069 --> 00:59:02,559
know it on this planet where the

1773
00:59:06,309 --> 00:59:04,079
inside's nice and warm

1774
00:59:07,829 --> 00:59:06,319
heated from the tidal forces of jupiter

1775
00:59:08,950 --> 00:59:07,839
and the outside is very cold but

1776
00:59:12,390 --> 00:59:08,960
protects the life

1777
00:59:14,230 --> 00:59:12,400
that horrible radiation environment

1778
00:59:15,750 --> 00:59:14,240
so that's a very exciting mission of

1779
00:59:17,990 --> 00:59:15,760
course we get another one get a mission

1780
00:59:20,150 --> 00:59:18,000
on its way to mars right this second

1781
00:59:21,829 --> 00:59:20,160
um mars 2020 perseverance rover i

1782
00:59:25,030 --> 00:59:21,839
mentioned this before is on its way june

1783
00:59:27,670 --> 00:59:25,040
uh uh february 18th i believe right

1784
00:59:28,150 --> 00:59:27,680
um is landing on mars in the in the

1785
00:59:33,589 --> 00:59:28,160
around

1786
00:59:34,870 --> 00:59:33,599
and and i'm gonna be watching uh and i

1787
00:59:36,230 --> 00:59:34,880
hope all of you will too

1788
00:59:39,270 --> 00:59:36,240

it's a rover look very much like

1789
00:59:42,390 --> 00:59:39,280
curiosity but unlike curiosity

1790
00:59:44,150 --> 00:59:42,400
this vehicle is going to collect samples

1791
00:59:45,750 --> 00:59:44,160
pristine samples and put them very

1792
00:59:46,630 --> 00:59:45,760
carefully in these very specially

1793
00:59:49,589 --> 00:59:46,640
designed

1794
00:59:50,230 --> 00:59:49,599
tubes to hold them seal them tight and

1795
00:59:53,270 --> 00:59:50,240
and and

1796
00:59:56,549 --> 00:59:53,280
with with very with no

1797
00:59:59,030 --> 00:59:56,559
trace of human contamination

1798
01:00:00,470 --> 00:59:59,040
or biological or chemical contamination

1799
01:00:02,390 --> 01:00:00,480
because of how we're doing it

1800
01:00:04,150 --> 01:00:02,400
very surgically on the surface of mars

1801
01:00:06,470 --> 01:00:04,160
once those tubes are collected another

1802
01:00:08,549 --> 01:00:06,480
emissions which is just starting now

1803
01:00:09,910 --> 01:00:08,559
uh called mars sample return is going to

1804
01:00:11,510 --> 01:00:09,920
land another vehicle

1805
01:00:14,069 --> 01:00:11,520
it's going to it's going to go collect

1806
01:00:16,230 --> 01:00:14,079
go send a a rover built by europe

1807
01:00:17,910 --> 01:00:16,240
to go collect those sample tubes bring

1808
01:00:19,510 --> 01:00:17,920
them back to a rocket

1809
01:00:21,109 --> 01:00:19,520
made by nasa's marshal space flight

1810
01:00:23,750 --> 01:00:21,119
center and launch it into

1811
01:00:25,190 --> 01:00:23,760
space and will be then picked up by

1812
01:00:28,549 --> 01:00:25,200
another system built by

1813
01:00:29,910 --> 01:00:28,559

nasa's goddard and and is attached to a

1814
01:00:32,309 --> 01:00:29,920
big european

1815
01:00:34,870 --> 01:00:32,319
space biggest spacecraft ever sent to

1816
01:00:35,510 --> 01:00:34,880
mars uh that will then fly back to earth

1817
01:00:38,870 --> 01:00:35,520
and drop

1818
01:00:40,470 --> 01:00:38,880
off a space capsule that nasa langley

1819
01:00:41,030 --> 01:00:40,480
and nasa ames research center have put

1820
01:00:43,349 --> 01:00:41,040
together

1821
01:00:44,150 --> 01:00:43,359
and drop these samples back to uh back

1822
01:00:46,309 --> 01:00:44,160
to earth

1823
01:00:47,190 --> 01:00:46,319
this is the later part of this decade um

1824
01:00:50,309 --> 01:00:47,200
in the early

1825
01:00:50,789 --> 01:00:50,319
20th around 2030 but that's our hope and

1826
01:00:52,789 --> 01:00:50,799
uh

1827
01:00:54,549 --> 01:00:52,799
this is what's going on so incredible

1828
01:00:55,030 --> 01:00:54,559
excitement lots of amazing things it's

1829
01:00:58,069 --> 01:00:55,040
just

1830
01:01:00,309 --> 01:00:58,079
well

1831
01:01:01,190 --> 01:01:00,319
looks like we've got time for one last

1832
01:01:08,069 --> 01:01:01,200
question

1833
01:01:10,470 --> 01:01:08,079
asks loved your book rob are you

1834
01:01:13,990 --> 01:01:10,480
planning a sequel about perseverance

1835
01:01:14,630 --> 01:01:14,000
oh oh thank you very much i'm glad you

1836
01:01:16,230 --> 01:01:14,640
liked my book

1837
01:01:18,630 --> 01:01:16,240
but i'm not allowed to advertise it but

1838
01:01:20,950 --> 01:01:18,640

i tell you it was it was a uh

1839
01:01:21,910 --> 01:01:20,960
uh it was it's a joy to capture these

1840
01:01:23,430 --> 01:01:21,920
stories and i

1841
01:01:24,549 --> 01:01:23,440
i'm i don't know if i'm to write i'm not

1842
01:01:25,430 --> 01:01:24,559
going to rhyme for perseverance i'm

1843
01:01:28,390 --> 01:01:25,440
going to leave that to

1844
01:01:30,230 --> 01:01:28,400
uh the t the perseverance team uh to to

1845
01:01:33,750 --> 01:01:30,240
tell their stories and uh

1846
01:01:34,950 --> 01:01:33,760
uh but it's but you know capturing these

1847
01:01:38,069 --> 01:01:34,960
stories is just so

1848
01:01:38,710 --> 01:01:38,079
essential um for not not just for the

1849
01:01:40,549 --> 01:01:38,720
public

1850
01:01:42,069 --> 01:01:40,559
to see what really goes on behind the

1851
01:01:45,030 --> 01:01:42,079
scenes but also

1852
01:01:46,710 --> 01:01:45,040
to to share with our own staff and the

1853
01:01:50,829 --> 01:01:46,720
next generation of future

1854
01:01:52,230 --> 01:01:50,839
space explorers that many of you are i

1855
01:01:53,510 --> 01:01:52,240
presume

1856
01:01:55,670 --> 01:01:53,520
thank you for sharing your stories with

1857
01:01:57,589 --> 01:01:55,680
us tonight rob sure that is all the time

1858
01:01:59,430 --> 01:01:57,599
we have for questions i want to thank

1859
01:02:01,109 --> 01:01:59,440
rob for joining us and discussing this

1860
01:02:03,109 --> 01:02:01,119
often neglected topic

1861
01:02:05,109 --> 01:02:03,119
um as a reminder to our audience we do

1862
01:02:07,750 --> 01:02:05,119
not have a lecture in december

1863
01:02:08,789 --> 01:02:07,760

but we will see you again in january

1864
01:02:11,670 --> 01:02:08,799
when we discuss

1865
01:02:12,230 --> 01:02:11,680
spacecraft origami i'd like to give a

1866
01:02:15,910 --> 01:02:12,240
huge

1867
01:02:18,309 --> 01:02:15,920
thank you to everyone on our crew

1868
01:02:20,230 --> 01:02:18,319
every single person who is involved in

1869
01:02:22,069 --> 01:02:20,240
these talks for their ingenuity

1870
01:02:25,109 --> 01:02:22,079
and their drive and keeping these

1871
01:02:27,029 --> 01:02:25,119
monthly talks going this past year

1872
01:02:29,670 --> 01:02:27,039
my final thank you does go out to you

1873
01:02:31,990 --> 01:02:29,680
the audience from all over the world

1874
01:02:33,750 --> 01:02:32,000
this is your lecture series we're happy

1875
01:02:35,190 --> 01:02:33,760
to bring it to you every month

1876
01:02:36,630 --> 01:02:35,200
thank you for the time for joy thank you

1877
01:02:37,990 --> 01:02:36,640
for taking the time to join us and if

1878
01:02:40,470 --> 01:02:38,000
you missed one of our talks

1879
01:02:41,270 --> 01:02:40,480
uh you can revisit our von carmen talks

1880
01:02:43,910 --> 01:02:41,280
from the past

1881
01:02:44,870 --> 01:02:43,920
five years they're all on our available

1882
01:02:46,390 --> 01:02:44,880
on jpl's

1883
01:02:48,150 --> 01:02:46,400
youtube page there's a whole playlist

1884
01:02:50,710 --> 01:02:48,160
for them so you can go find them

1885
01:02:52,950 --> 01:02:50,720
before we go i'd like to pass it over to

1886
01:02:54,630 --> 01:02:52,960
rob one last time to

1887
01:02:57,109 --> 01:02:54,640
give us a reminder of why we shouldn't

1888
01:02:59,910 --> 01:02:57,119

be so hard on ourselves

1889
01:03:01,430 --> 01:02:59,920
well brian this is great nikki brian

1890
01:03:01,910 --> 01:03:01,440
this is fabulous thank you for inviting

1891
01:03:04,470 --> 01:03:01,920
me

1892
01:03:05,109 --> 01:03:04,480
i i have to say i i learned one thing

1893
01:03:08,549 --> 01:03:05,119
from uh

1894
01:03:10,789 --> 01:03:08,559
uh my my uh mentor john cassani

1895
01:03:12,549 --> 01:03:10,799
who told a story about one of jpl's or

1896
01:03:13,349 --> 01:03:12,559
the early nasa pioneers named homer

1897
01:03:15,270 --> 01:03:13,359
stewart

1898
01:03:17,109 --> 01:03:15,280
um who said he said there you know

1899
01:03:17,829 --> 01:03:17,119
remember there's 10 most important words

1900
01:03:22,390 --> 01:03:17,839
that they retire

1901
01:03:30,470 --> 01:03:26,710
uh i don't know i'm sorry we can fix it

1902
01:03:32,549 --> 01:03:30,480
and so it it it's i i think

1903
01:03:34,230 --> 01:03:32,559
i think those kinds of those kinds of uh

1904
01:03:36,230 --> 01:03:34,240
uh expressions are very important i

1905
01:03:37,990 --> 01:03:36,240
think you need to

1906
01:03:39,349 --> 01:03:38,000
know that we don't know and and by the

1907
01:03:41,270 --> 01:03:39,359
way it's not just

1908
01:03:42,950 --> 01:03:41,280
individuals that we should be unafraid

1909
01:03:43,589 --> 01:03:42,960
to be to be honest about our own

1910
01:03:45,990 --> 01:03:43,599
mistakes

1911
01:03:46,630 --> 01:03:46,000
but we but our bosses have to also

1912
01:03:49,829 --> 01:03:46,640
remember

1913
01:03:51,990 --> 01:03:49,839

to let the people who work for them

1914
01:03:53,829 --> 01:03:52,000
uh give we need to give them the space

1915
01:03:54,150 --> 01:03:53,839
to succeed and all of us need to give us

1916
01:03:56,230 --> 01:03:54,160
this

1917
01:03:57,349 --> 01:03:56,240
place to succeed by learning testing

1918
01:04:00,390 --> 01:03:57,359
trying things out

1919
01:04:02,390 --> 01:04:00,400
and before make the mistakes before

1920
01:04:05,029 --> 01:04:02,400
it's live in front of millions of people

1921
01:04:07,510 --> 01:04:05,039
on national television

1922
01:04:08,069 --> 01:04:07,520
thank you again for joining us rob and

1923
01:04:12,309 --> 01:04:08,079
thank

1924
01:04:29,010 --> 01:04:12,319
you folks stay safe stay kind