
Dr. Ian Clark
Principal Investigator, NASA Jet Propulsion Laboratory

1
00:00:06,230 --> 00:00:03,909
welcome to the smithsonian's national

2
00:00:08,310 --> 00:00:06,240
air and space museum my name is margaret

3
00:00:10,230 --> 00:00:08,320
weidekamp i'm a curator here in our

4
00:00:12,390 --> 00:00:10,240
space history department and i'm

5
00:00:15,110 --> 00:00:12,400
delighted to welcome you to our moving

6
00:00:16,470 --> 00:00:15,120
beyond earth gallery this is our gallery

7
00:00:18,950 --> 00:00:16,480
which is dedicated

8
00:00:21,510 --> 00:00:18,960
to the space shuttle program the

9
00:00:23,109 --> 00:00:21,520
international space station and future

10
00:00:25,189 --> 00:00:23,119
human space flight

11
00:00:28,470 --> 00:00:25,199
and it's a particularly

12
00:00:31,029 --> 00:00:28,480
good setting for our speaker today as a

13
00:00:34,150 --> 00:00:31,039

part of our what's new and aerospace

14
00:00:36,870 --> 00:00:34,160
series and this is a series of lectures

15
00:00:39,910 --> 00:00:36,880
and public outreach that we're doing in

16
00:00:41,990 --> 00:00:39,920
partnership here at the museum with nasa

17
00:00:44,069 --> 00:00:42,000
and i'm delighted to be able to welcome

18
00:00:50,229 --> 00:00:44,079
and thank mike green who helped to make

19
00:00:56,790 --> 00:00:53,590
and our speaker today is dr ian clark

20
00:00:59,750 --> 00:00:56,800
who has a ba masters and phd from

21
00:01:01,670 --> 00:00:59,760
georgia tech and works at nasa's jet

22
00:01:03,670 --> 00:01:01,680
propulsion laboratory

23
00:01:05,590 --> 00:01:03,680
he is the principal investigator which

24
00:01:08,310 --> 00:01:05,600
means he is the lead scientist and

25
00:01:11,590 --> 00:01:08,320
engineer on a project that is called the

26
00:01:14,630 --> 00:01:11,600
low density supersonic decelerator which

27
00:01:16,469 --> 00:01:14,640
is a way of landing on mars and so he's

28
00:01:18,710 --> 00:01:16,479
going to talk to us a little bit today

29
00:01:21,910 --> 00:01:18,720
about some of the history of landing on

30
00:01:24,550 --> 00:01:21,920
mars and some of his ideas for what is

31
00:01:32,149 --> 00:01:24,560
going to come next so i'm delighted to

32
00:01:35,590 --> 00:01:34,230
thank you thank you thank you very much

33
00:01:37,670 --> 00:01:35,600
and thank you very much to the air and

34
00:01:39,429 --> 00:01:37,680
space museum for hosting me and allowing

35
00:01:41,749 --> 00:01:39,439
me to give this talk at what is really

36
00:01:43,510 --> 00:01:41,759
an amazing setting uh so i've got a lot

37
00:01:45,190 --> 00:01:43,520
of exciting things to talk about today

38
00:01:47,830 --> 00:01:45,200

if we can go ahead and get the the

39
00:01:48,870 --> 00:01:47,840
presentation up on the screen there

40
00:01:51,270 --> 00:01:48,880
so i'm going to be giving you an

41
00:01:53,109 --> 00:01:51,280
overview of how we land on mars

42
00:01:54,310 --> 00:01:53,119
and then talking about the future of how

43
00:01:55,990 --> 00:01:54,320
we're going to be landing on mars in

44
00:01:58,709 --> 00:01:56,000
particular some of the technologies that

45
00:02:00,069 --> 00:01:58,719
developing today for the future mars

46
00:02:02,069 --> 00:02:00,079
missions

47
00:02:04,550 --> 00:02:02,079
we call it nasa's flying saucer learning

48
00:02:06,789 --> 00:02:04,560
to land on mars it's uh

49
00:02:08,710 --> 00:02:06,799
there's a lot more there

50
00:02:09,990 --> 00:02:08,720
and i am uh the principal investigator

51
00:02:11,990 --> 00:02:10,000
on the project she mentioned i'm one of

52
00:02:14,229 --> 00:02:12,000
the the scientists i'm really one of

53
00:02:16,229 --> 00:02:14,239
many mad scientists on this uh project

54
00:02:17,750 --> 00:02:16,239
to help come up with some of these ideas

55
00:02:19,990 --> 00:02:17,760
and in particular the way to test these

56
00:02:21,670 --> 00:02:20,000
technologies so let's go to the next

57
00:02:23,350 --> 00:02:21,680
slide

58
00:02:25,190 --> 00:02:23,360
a few of you hopefully remember that a

59
00:02:27,350 --> 00:02:25,200
few years ago we landed the curiosity

60
00:02:30,070 --> 00:02:27,360
rover on the surface of mars this is a

61
00:02:32,790 --> 00:02:30,080
one-ton nuclear powered laser equipped

62
00:02:35,110 --> 00:02:32,800
rover that's the size of a small suv it

63
00:02:36,869 --> 00:02:35,120

is the largest most massive thing we've

64
00:02:39,190 --> 00:02:36,879
ever landed on another planet and

65
00:02:41,589 --> 00:02:39,200
putting it safely on the surface of mars

66
00:02:43,430 --> 00:02:41,599
was a tremendous undertaking of just

67
00:02:45,430 --> 00:02:43,440
immense engineering skill talent and

68
00:02:47,589 --> 00:02:45,440
capability to do that and one of the

69
00:02:49,430 --> 00:02:47,599
reasons why is because of the mars

70
00:02:51,350 --> 00:02:49,440
environment the mars atmosphere itself

71
00:02:52,710 --> 00:02:51,360
mars of all the planets in the solar

72
00:02:54,869 --> 00:02:52,720
system is probably one of the very

73
00:02:57,110 --> 00:02:54,879
toughest to land on the atmosphere is

74
00:02:59,589 --> 00:02:57,120
extremely thin which means that the

75
00:03:01,110 --> 00:02:59,599
ability to generate drag to slow our

76
00:03:03,350 --> 00:03:01,120
vehicle down as it's entering the

77
00:03:04,790 --> 00:03:03,360
atmosphere is mitigated there's just not

78
00:03:06,630 --> 00:03:04,800
much atmosphere to fight against the

79
00:03:09,110 --> 00:03:06,640
vehicle to help slow us down so

80
00:03:11,350 --> 00:03:09,120
typically we need very large structures

81
00:03:13,270 --> 00:03:11,360
so the question is how do we land today

82
00:03:14,949 --> 00:03:13,280
but maybe before we do one of the neat

83
00:03:17,509 --> 00:03:14,959
things about this rover if we go back

84
00:03:20,149 --> 00:03:17,519
one slide it is on mars and in fact this

85
00:03:22,390 --> 00:03:20,159
image that i have on my title slide is

86
00:03:24,550 --> 00:03:22,400
from an orbiter around mars and the

87
00:03:28,229 --> 00:03:24,560
curiosity rover is right here at the

88
00:03:31,509 --> 00:03:28,239

base of mount sharp in this image

89
00:03:33,110 --> 00:03:31,519
let's go two slides forward please

90
00:03:34,710 --> 00:03:33,120
so how did we get curiosity on the

91
00:03:35,830 --> 00:03:34,720
surface of mars let's go ahead and play

92
00:03:37,430 --> 00:03:35,840
the video

93
00:03:39,270 --> 00:03:37,440
we start at the top of the atmosphere

94
00:03:41,190 --> 00:03:39,280
and we're going about 10 000 miles an

95
00:03:43,430 --> 00:03:41,200
hour and we have an enormous aeroshell

96
00:03:45,110 --> 00:03:43,440
it's 15 feet in diameter that we use to

97
00:03:47,350 --> 00:03:45,120
react against the atmosphere to help

98
00:03:49,589 --> 00:03:47,360
slow us down that takes us from the top

99
00:03:51,509 --> 00:03:49,599
of the atmosphere down to an altitude

100
00:03:53,350 --> 00:03:51,519
about six miles from the surface and it

101
00:03:55,190 --> 00:03:53,360
gets us from ten thousand miles an hour

102
00:03:56,869 --> 00:03:55,200
to a thousand miles an hour but that's

103
00:03:59,270 --> 00:03:56,879
not enough we have to hit the emergency

104
00:04:01,509 --> 00:03:59,280
brake so we deploy an enormous 60-foot

105
00:04:03,350 --> 00:04:01,519
parachute at twice the speed of sound

106
00:04:05,589 --> 00:04:03,360
and that parachute helps us get from a

107
00:04:07,670 --> 00:04:05,599
thousand miles an hour to 200 miles an

108
00:04:09,030 --> 00:04:07,680
hour but that's still not slow enough

109
00:04:11,110 --> 00:04:09,040
once we're on the parachute we're going

110
00:04:13,350 --> 00:04:11,120
200 miles an hour we deploy the sky

111
00:04:15,350 --> 00:04:13,360
crane the sky crane turns on its rockets

112
00:04:17,509 --> 00:04:15,360
and helps slow us from 200 miles an hour

113
00:04:19,590 --> 00:04:17,519

down to just a few miles an hour and get

114
00:04:22,710 --> 00:04:19,600
us right above the surface going very

115
00:04:25,350 --> 00:04:22,720
very slowly we then lower this enormous

116
00:04:27,590 --> 00:04:25,360
rover down towards the ground it deploys

117
00:04:28,550 --> 00:04:27,600
its wheels we put it safely on the

118
00:04:30,629 --> 00:04:28,560
surface

119
00:04:32,550 --> 00:04:30,639
we cut the cables and the sky crane

120
00:04:34,390 --> 00:04:32,560
system flies away and goes off in the

121
00:04:36,230 --> 00:04:34,400
distance

122
00:04:38,390 --> 00:04:36,240
and it leaves curiosity safely on the

123
00:04:39,909 --> 00:04:38,400
surface where it is today doing amazing

124
00:04:41,990 --> 00:04:39,919
science for us

125
00:04:45,030 --> 00:04:42,000
that was how we landed curiosity let's

126
00:04:49,189 --> 00:04:46,629
if we look at the technologies that we

127
00:04:51,110 --> 00:04:49,199
use to land curiosity the big aeroshells

128
00:04:53,270 --> 00:04:51,120
the big supersonic parachutes and the

129
00:04:54,790 --> 00:04:53,280
sky crane system we can trace a lot of

130
00:04:55,990 --> 00:04:54,800
that heritage back to the very first

131
00:04:58,310 --> 00:04:56,000
time that we landed something on the

132
00:05:01,029 --> 00:04:58,320
surface of mars the twin viking landers

133
00:05:02,950 --> 00:05:01,039
in the mid-1970s the technologies that

134
00:05:04,710 --> 00:05:02,960
viking used are largely the same ones

135
00:05:06,790 --> 00:05:04,720
that we use today there are a couple

136
00:05:08,710 --> 00:05:06,800
differences the aeroshells changed a

137
00:05:10,629 --> 00:05:08,720
little bit not the shape of the air show

138
00:05:12,070 --> 00:05:10,639

but how we use the aeroshell

139
00:05:13,830 --> 00:05:12,080
we've learned that we can fly it

140
00:05:16,230 --> 00:05:13,840
differently and steer it through the

141
00:05:17,749 --> 00:05:16,240
atmosphere to help fly it and steer it

142
00:05:19,909 --> 00:05:17,759
to get closer to where we actually want

143
00:05:22,070 --> 00:05:19,919
to land we've gone from uncertainties of

144
00:05:24,310 --> 00:05:22,080
150 miles of where we're going to land

145
00:05:26,390 --> 00:05:24,320
on the surface of mars down to five or

146
00:05:27,510 --> 00:05:26,400
six miles by flying out this in this

147
00:05:30,950 --> 00:05:27,520
aeroshell

148
00:05:33,029 --> 00:05:30,960
that allow us to see much much higher

149
00:05:34,469 --> 00:05:33,039
heating and enter heavier vehicles

150
00:05:35,990 --> 00:05:34,479
because of that

151
00:05:38,070 --> 00:05:36,000
on the landing side

152
00:05:40,390 --> 00:05:38,080
viking used rockets directly attached to

153
00:05:42,230 --> 00:05:40,400
the lander to help slowly safely slow it

154
00:05:44,629 --> 00:05:42,240
down and put it on the surface we've

155
00:05:46,070 --> 00:05:44,639
developed airbags that we use to inflate

156
00:05:48,150 --> 00:05:46,080
and then we bounce our rovers on the

157
00:05:49,590 --> 00:05:48,160
surface and we bring them to a slow stop

158
00:05:51,670 --> 00:05:49,600
and of course we've developed the sky

159
00:05:53,670 --> 00:05:51,680
crane system which gently lowers very

160
00:05:55,270 --> 00:05:53,680
large rovers towards the surface so

161
00:05:57,270 --> 00:05:55,280
we've made some improvements on the

162
00:05:59,110 --> 00:05:57,280
entry side and on the landing side but

163
00:06:01,110 --> 00:05:59,120

we haven't really made any improvements

164
00:06:02,870 --> 00:06:01,120
in 40 years of exploring mars on the

165
00:06:04,710 --> 00:06:02,880
descent side that is the supersonic

166
00:06:06,550 --> 00:06:04,720
parachute that was used by viking it's

167
00:06:08,230 --> 00:06:06,560
still largely the same exact parachute

168
00:06:11,029 --> 00:06:08,240
that we use today just a little bit

169
00:06:12,629 --> 00:06:11,039
bigger as was the case with msl

170
00:06:13,830 --> 00:06:12,639
so it's an obvious area that as we look

171
00:06:15,749 --> 00:06:13,840
to the future and we want to be able to

172
00:06:17,350 --> 00:06:15,759
land bigger things on mars things that

173
00:06:19,029 --> 00:06:17,360
we'd like to be able to improve are on

174
00:06:21,189 --> 00:06:19,039
the the parachute our ability to slow

175
00:06:23,029 --> 00:06:21,199
down at mach number several times the

176
00:06:25,110 --> 00:06:23,039
speed of sound so let's go to the next

177
00:06:26,550 --> 00:06:25,120
slide

178
00:06:29,350 --> 00:06:26,560
why do we want to do this and what makes

179
00:06:31,029 --> 00:06:29,360
it difficult well if we go back to our

180
00:06:33,990 --> 00:06:31,039
history of landing rovers on the surface

181
00:06:35,510 --> 00:06:34,000
of mars we've got a very small sojourner

182
00:06:38,469 --> 00:06:35,520
rover that was part of the pathfinder

183
00:06:40,070 --> 00:06:38,479
mission back in the mid late 1990s then

184
00:06:42,070 --> 00:06:40,080
we grew up from the sojourner rover

185
00:06:43,749 --> 00:06:42,080
which is about this big to the mars

186
00:06:45,670 --> 00:06:43,759
exploration rovers the twin rovers

187
00:06:47,749 --> 00:06:45,680
spirit and opportunity we went from a

188
00:06:49,990 --> 00:06:47,759

few kilograms to several hundred

189
00:06:52,550 --> 00:06:50,000
kilograms for the curios excuse me for

190
00:06:54,390 --> 00:06:52,560
the mars exploration rovers uh then we

191
00:06:56,469 --> 00:06:54,400
landed phoenix and most recently we

192
00:06:58,870 --> 00:06:56,479
landed curiosity which was nearly a

193
00:07:00,469 --> 00:06:58,880
thousand kilograms one metric ton an

194
00:07:02,870 --> 00:07:00,479
enormous rover

195
00:07:04,710 --> 00:07:02,880
as our payloads get bigger and bigger

196
00:07:06,870 --> 00:07:04,720
our vehicles get bigger but there's a

197
00:07:08,710 --> 00:07:06,880
challenge as the vehicles get bigger our

198
00:07:10,550 --> 00:07:08,720
ability to slow them down is really

199
00:07:12,629 --> 00:07:10,560
based on the area how big is the thing

200
00:07:14,230 --> 00:07:12,639
what's the what's the surface area look

201
00:07:16,390 --> 00:07:14,240
like that's only going up with the

202
00:07:18,469 --> 00:07:16,400
square of the diameter but the volume of

203
00:07:20,150 --> 00:07:18,479
that capsule that's using it is going up

204
00:07:22,390 --> 00:07:20,160
with a cube diameter in other words as

205
00:07:24,390 --> 00:07:22,400
we get bigger we're getting more volume

206
00:07:26,469 --> 00:07:24,400
quicker than we're getting surface area

207
00:07:28,150 --> 00:07:26,479
that means we're carrying more mass

208
00:07:30,469 --> 00:07:28,160
relative to our ability to slow that

209
00:07:32,870 --> 00:07:30,479
mass down we have

210
00:07:34,629 --> 00:07:32,880
more mass less area that makes it harder

211
00:07:36,309 --> 00:07:34,639
to slow down it makes it harder as these

212
00:07:37,990 --> 00:07:36,319
payloads get bigger and bigger and they

213
00:07:39,749 --> 00:07:38,000

do want to get bigger you know the image

214
00:07:41,990 --> 00:07:39,759
i have here on the right

215
00:07:43,589 --> 00:07:42,000
is you know a hypothetical payload of

216
00:07:45,110 --> 00:07:43,599
what it would take to put humans on the

217
00:07:48,230 --> 00:07:45,120
surface of mars

218
00:07:50,869 --> 00:07:49,589
and so if we look at the future of

219
00:07:53,189 --> 00:07:50,879
missions that we want to put on the

220
00:07:54,710 --> 00:07:53,199
surface of mars we see things like

221
00:07:57,270 --> 00:07:54,720
rockets maybe that we want to use to

222
00:07:59,430 --> 00:07:57,280
return samples from the surface of mars

223
00:08:01,029 --> 00:07:59,440
we think about maybe putting greenhouses

224
00:08:03,189 --> 00:08:01,039
down to see if we could put

225
00:08:04,309 --> 00:08:03,199
and grow plants on the surface of mars

226
00:08:06,950 --> 00:08:04,319
things that would be necessary to

227
00:08:08,390 --> 00:08:06,960
survive uh maybe we want to put

228
00:08:10,070 --> 00:08:08,400
payloads down that see if we can take

229
00:08:11,270 --> 00:08:10,080
the carbon dioxide atmosphere and create

230
00:08:13,510 --> 00:08:11,280
rocket fuel

231
00:08:15,189 --> 00:08:13,520
from it and eventually as we cast our

232
00:08:17,110 --> 00:08:15,199
eyes to the horizon we want to be able

233
00:08:19,029 --> 00:08:17,120
to put humans safely on the surface of

234
00:08:21,430 --> 00:08:19,039
mars and that means all of the stuff

235
00:08:23,670 --> 00:08:21,440
that has to accommodate humans all of

236
00:08:26,390 --> 00:08:23,680
the tools all of the food water

237
00:08:28,550 --> 00:08:26,400
resources all of the ipads iphones

238
00:08:30,950 --> 00:08:28,560

whatever the astronauts need to survive

239
00:08:33,190 --> 00:08:30,960
on the surface of mars for days weeks or

240
00:08:35,029 --> 00:08:33,200
months at a time it's an enormous amount

241
00:08:37,029 --> 00:08:35,039
of stuff that has to get put down and

242
00:08:38,469 --> 00:08:37,039
it's several several times larger than

243
00:08:41,190 --> 00:08:38,479
anything we've ever been able to safely

244
00:08:44,550 --> 00:08:41,200
land on the surface of mars to date

245
00:08:46,230 --> 00:08:44,560
let's go the next slide please

246
00:08:47,590 --> 00:08:46,240
so we are at the national air and space

247
00:08:48,790 --> 00:08:47,600
museum which is the best museum in the

248
00:08:50,949 --> 00:08:48,800
world which means i have to talk a

249
00:08:52,949 --> 00:08:50,959
little bit about history this problem of

250
00:08:55,110 --> 00:08:52,959
landing large things on mars isn't new

251
00:08:58,070 --> 00:08:55,120
in fact it's one very similar that we

252
00:09:00,310 --> 00:08:58,080
had a about the early 1960s one of the

253
00:09:02,070 --> 00:09:00,320
very first concepts for a mars mission

254
00:09:03,750 --> 00:09:02,080
was called the mars voyager project it's

255
00:09:04,949 --> 00:09:03,760
not the voyager that we later would send

256
00:09:07,350 --> 00:09:04,959
to the outer planets this was a

257
00:09:09,190 --> 00:09:07,360
predecessor and the idea was that we

258
00:09:11,110 --> 00:09:09,200
wanted to use the saturn v the rocket

259
00:09:13,190 --> 00:09:11,120
that we used to send humans to the moon

260
00:09:15,269 --> 00:09:13,200
we wanted to take that enormous rocket

261
00:09:17,350 --> 00:09:15,279
and all of the capability it had to send

262
00:09:19,430 --> 00:09:17,360
payloads into space and use it to send a

263
00:09:21,509 --> 00:09:19,440

payload to mars this was in the early

264
00:09:23,190 --> 00:09:21,519
1960s we actually knew very little about

265
00:09:24,710 --> 00:09:23,200
the martian atmosphere at the time we

266
00:09:26,630 --> 00:09:24,720
had a couple of spacecraft that had done

267
00:09:28,230 --> 00:09:26,640
flybys and got into some soundings of

268
00:09:30,389 --> 00:09:28,240
the atmosphere but we really didn't have

269
00:09:31,430 --> 00:09:30,399
a great idea initially we did know that

270
00:09:32,630 --> 00:09:31,440
it was thinner than the earth's

271
00:09:34,230 --> 00:09:32,640
atmosphere that it was going to be

272
00:09:36,150 --> 00:09:34,240
challenging but we didn't know how much

273
00:09:37,590 --> 00:09:36,160
thinner we thought you know it might

274
00:09:39,509 --> 00:09:37,600
have been ten percent the thickness of

275
00:09:40,790 --> 00:09:39,519
the earth's atmosphere and then later on

276
00:09:42,310 --> 00:09:40,800
we started getting better data and we

277
00:09:44,710 --> 00:09:42,320
realized it's not ten percent it's not

278
00:09:47,030 --> 00:09:44,720
eight percent it's not six five four uh

279
00:09:48,550 --> 00:09:47,040
eventually by the mid and late 1960s we

280
00:09:50,230 --> 00:09:48,560
realized that the thickness of the

281
00:09:51,750 --> 00:09:50,240
martian atmosphere was less than one

282
00:09:53,350 --> 00:09:51,760
percent the thickness of earth's

283
00:09:55,030 --> 00:09:53,360
atmosphere that means it's going to be

284
00:09:57,030 --> 00:09:55,040
very very difficult to slow down the

285
00:09:58,949 --> 00:09:57,040
payload big enough to fit into this

286
00:10:00,949 --> 00:09:58,959
large saturn v rocket

287
00:10:03,350 --> 00:10:00,959
and so in that that problem that

288
00:10:04,949 --> 00:10:03,360

quandary we started developing new ideas

289
00:10:08,310 --> 00:10:04,959
of slowing our rockets and our entry

290
00:10:09,750 --> 00:10:08,320
vehicles down let's go to the next slide

291
00:10:11,670 --> 00:10:09,760
for the first time and you can go ahead

292
00:10:12,949 --> 00:10:11,680
and play the video on the top right for

293
00:10:14,790 --> 00:10:12,959
the first time we started taking

294
00:10:17,030 --> 00:10:14,800
parachutes things that we've used at low

295
00:10:18,470 --> 00:10:17,040
altitudes and relatively low speeds and

296
00:10:19,750 --> 00:10:18,480
trying to deploy them at several times

297
00:10:22,069 --> 00:10:19,760
the speed of sound to see how they

298
00:10:23,509 --> 00:10:22,079
behave will they successfully inflate

299
00:10:25,509 --> 00:10:23,519
what do they look like when they inflate

300
00:10:27,190 --> 00:10:25,519
how much drag do you get out of them

301
00:10:28,790 --> 00:10:27,200
does the material survive can you make

302
00:10:30,630 --> 00:10:28,800
them light enough to be used on a mars

303
00:10:32,630 --> 00:10:30,640
mission we also tried a number of other

304
00:10:34,790 --> 00:10:32,640
devices more innovative devices we

305
00:10:37,030 --> 00:10:34,800
thought about taking uh inflatable

306
00:10:38,630 --> 00:10:37,040
structures and attaching them directly

307
00:10:40,790 --> 00:10:38,640
to the aeroshell the entry vehicle

308
00:10:42,790 --> 00:10:40,800
itself and then we would inflate these

309
00:10:44,870 --> 00:10:42,800
as we're entering the martian atmosphere

310
00:10:47,030 --> 00:10:44,880
grow the size of the aeroshell create

311
00:10:48,470 --> 00:10:47,040
more drag that way and allow us to slow

312
00:10:50,310 --> 00:10:48,480
down easier

313
00:10:52,630 --> 00:10:50,320

there was lots of testing that went on

314
00:10:54,550 --> 00:10:52,640
to support these ideas lots of parachute

315
00:10:56,150 --> 00:10:54,560
testing at high altitudes and very very

316
00:10:57,030 --> 00:10:56,160
fast speeds several times the speed of

317
00:10:59,269 --> 00:10:57,040
sound

318
00:11:00,870 --> 00:10:59,279
lots of wind tunnel testing of devices

319
00:11:03,269 --> 00:11:00,880
like you see there in the middle that's

320
00:11:04,710 --> 00:11:03,279
a several stills from a deployment video

321
00:11:06,790 --> 00:11:04,720
at several times the speed of sound

322
00:11:09,590 --> 00:11:06,800
about 4.4 times the speed of sound of an

323
00:11:11,430 --> 00:11:09,600
article about five feet high or so uh we

324
00:11:13,350 --> 00:11:11,440
even developed articles that were in the

325
00:11:14,710 --> 00:11:13,360
20 to 30 foot size and we had drop them

326
00:11:16,710 --> 00:11:14,720
from a helicopter and see how they

327
00:11:18,389 --> 00:11:16,720
inflate and see how they perform and

328
00:11:20,230 --> 00:11:18,399
then we would continue to test them

329
00:11:21,750 --> 00:11:20,240
using large aeroshells that looked very

330
00:11:23,829 --> 00:11:21,760
similar to the aeroshells that we would

331
00:11:25,590 --> 00:11:23,839
use to land the viking landers on the

332
00:11:27,350 --> 00:11:25,600
surface of mars

333
00:11:29,030 --> 00:11:27,360
eventually the mars voyager program

334
00:11:31,350 --> 00:11:29,040
would go away it was a little too

335
00:11:32,949 --> 00:11:31,360
ambitious for the time and it would be

336
00:11:34,949 --> 00:11:32,959
down selected in favor of the mars

337
00:11:37,190 --> 00:11:34,959
viking project the mars viking project

338
00:11:38,630 --> 00:11:37,200

was a smaller payload we understood the

339
00:11:40,550 --> 00:11:38,640
martian atmosphere a little bit better

340
00:11:42,389 --> 00:11:40,560
at that time and eventually the work in

341
00:11:44,790 --> 00:11:42,399
these attached decelerators or what we

342
00:11:46,389 --> 00:11:44,800
refer to as uh supersonic inflatable

343
00:11:49,269 --> 00:11:46,399
aerodynamic decelerators we love our

344
00:11:51,350 --> 00:11:49,279
acronyms so we call them cyads

345
00:11:52,710 --> 00:11:51,360
would go away in favor of a parachute

346
00:11:55,030 --> 00:11:52,720
viking would only really need a

347
00:11:59,030 --> 00:11:55,040
supersonic parachute to proceed

348
00:12:03,190 --> 00:12:00,870
so here we are today facing the same

349
00:12:05,829 --> 00:12:03,200
problem that the mars voyager program

350
00:12:08,069 --> 00:12:05,839
faced and looking at the same solutions

351
00:12:09,750 --> 00:12:08,079
that they were considering namely large

352
00:12:11,590 --> 00:12:09,760
inflatable structures that we can deploy

353
00:12:12,949 --> 00:12:11,600
at several times the speed of sound to

354
00:12:14,790 --> 00:12:12,959
help us slow down these enormous

355
00:12:17,590 --> 00:12:14,800
payloads as they enter the very very

356
00:12:19,670 --> 00:12:17,600
thin very tenuous martian atmosphere we

357
00:12:21,430 --> 00:12:19,680
have inflatable structures and that look

358
00:12:23,509 --> 00:12:21,440
like giant inflatable donuts that we can

359
00:12:26,230 --> 00:12:23,519
inflate at four times the speed of sound

360
00:12:28,230 --> 00:12:26,240
and go from 15 feet to 20 feet or 22

361
00:12:30,230 --> 00:12:28,240
feet in diameter we have another device

362
00:12:32,389 --> 00:12:30,240
they'll talk about that goes even larger

363
00:12:34,069 --> 00:12:32,399

almost 30 feet in diameter and we have a

364
00:12:36,150 --> 00:12:34,079
new supersonic parachute that we're

365
00:12:37,910 --> 00:12:36,160
developing something much much bigger

366
00:12:39,750 --> 00:12:37,920
than any parachute we've ever tested

367
00:12:41,509 --> 00:12:39,760
before at these speeds

368
00:12:43,509 --> 00:12:41,519
it's about 100 feet in diameter the size

369
00:12:45,030 --> 00:12:43,519
of a small warehouse when it's inflated

370
00:12:47,350 --> 00:12:45,040
and we're going to be testing it at over

371
00:12:49,750 --> 00:12:47,360
two and a half times the speed of sound

372
00:12:51,670 --> 00:12:49,760
so let's go to the next slide

373
00:12:53,190 --> 00:12:51,680
a little bit of detail there's a lot of

374
00:12:55,190 --> 00:12:53,200
words with a lot of syllables on here

375
00:12:56,870 --> 00:12:55,200
the real basic idea with this first one

376
00:12:59,509 --> 00:12:56,880
we call this the six meter taurus it's a

377
00:13:01,350 --> 00:12:59,519
giant inflated donut and again we use it

378
00:13:03,430 --> 00:13:01,360
we inflate it very quickly and we grow

379
00:13:04,949 --> 00:13:03,440
the size of the vehicle to create bigger

380
00:13:06,710 --> 00:13:04,959
surface area to react against the

381
00:13:09,190 --> 00:13:06,720
atmosphere create more drag and help us

382
00:13:10,949 --> 00:13:09,200
slow down uh it's designed to be

383
00:13:12,949 --> 00:13:10,959
pressurized using not a lot of pressure

384
00:13:15,269 --> 00:13:12,959
a few pounds per square inch but

385
00:13:17,670 --> 00:13:15,279
otherwise create a rigid structure and

386
00:13:19,350 --> 00:13:17,680
why do we like rigid structures well

387
00:13:21,590 --> 00:13:19,360
aerodynamicists have a few tricks up

388
00:13:23,030 --> 00:13:21,600

their sleeves and one of our favorite is

389
00:13:26,069 --> 00:13:23,040
that we like to be able to test very

390
00:13:27,829 --> 00:13:26,079
small things in wind tunnels or in with

391
00:13:29,509 --> 00:13:27,839
ballistic ranges we take very small

392
00:13:30,949 --> 00:13:29,519
models and we shoot them out of a cannon

393
00:13:33,509 --> 00:13:30,959
and we watch how they behave how they

394
00:13:35,350 --> 00:13:33,519
fly how they move and we're able to back

395
00:13:37,110 --> 00:13:35,360
out the aerodynamics of the vehicle that

396
00:13:38,949 --> 00:13:37,120
way and we feel comfortable that testing

397
00:13:40,949 --> 00:13:38,959
these very small articles that we can

398
00:13:42,790 --> 00:13:40,959
grow those results to very very large

399
00:13:44,949 --> 00:13:42,800
articles so when we test six-inch

400
00:13:46,710 --> 00:13:44,959
diameter wind tunnel models that we the

401
00:13:48,629 --> 00:13:46,720
results that we see of the aerodynamics

402
00:13:50,870 --> 00:13:48,639
are scalable to these 15-foot diameter

403
00:13:52,230 --> 00:13:50,880
vehicles

404
00:13:54,069 --> 00:13:52,240
it also means that we understand the

405
00:13:56,150 --> 00:13:54,079
geometry when we inflate it we know what

406
00:13:57,670 --> 00:13:56,160
the shape of the device looks like so

407
00:13:59,670 --> 00:13:57,680
when we first started developing these

408
00:14:01,030 --> 00:13:59,680
inflatable devices we want something we

409
00:14:02,790 --> 00:14:01,040
wanted something that we could make

410
00:14:04,870 --> 00:14:02,800
rigid that we'd have that determinism

411
00:14:06,310 --> 00:14:04,880
and that would help simplify what the

412
00:14:07,670 --> 00:14:06,320
testing was going to look like to

413
00:14:09,670 --> 00:14:07,680

convince ourselves this would work at

414
00:14:12,949 --> 00:14:09,680
mars

415
00:14:16,230 --> 00:14:14,790
but we can't do that forever we really

416
00:14:18,550 --> 00:14:16,240
wanted to have a rigid device but at

417
00:14:20,550 --> 00:14:18,560
some point these devices grow so large

418
00:14:21,990 --> 00:14:20,560
you just cannot make them rigid anymore

419
00:14:23,990 --> 00:14:22,000
and they will have some flexibility

420
00:14:25,509 --> 00:14:24,000
associated with it and so we realized

421
00:14:27,110 --> 00:14:25,519
that and we realized that now is the

422
00:14:29,030 --> 00:14:27,120
time to start testing and understand

423
00:14:30,310 --> 00:14:29,040
what that flexibility means so we

424
00:14:31,750 --> 00:14:30,320
developed another device that we're

425
00:14:33,670 --> 00:14:31,760
going to be testing it's even larger

426
00:14:35,430 --> 00:14:33,680
than the inflated torus it's called an

427
00:14:37,030 --> 00:14:35,440
attached isotension and it looks very

428
00:14:39,189 --> 00:14:37,040
similar to devices that were tested in

429
00:14:40,790 --> 00:14:39,199
the 1960s we've taken a lot of that

430
00:14:42,230 --> 00:14:40,800
knowledge a lot of that experience and

431
00:14:43,990 --> 00:14:42,240
now we're growing these devices and

432
00:14:45,590 --> 00:14:44,000
we're going to be testing them at scales

433
00:14:47,829 --> 00:14:45,600
more relevant to what they would be need

434
00:14:49,509 --> 00:14:47,839
to be to be used at mars so we've got a

435
00:14:51,750 --> 00:14:49,519
device that rather than we inflate to

436
00:14:53,430 --> 00:14:51,760
several psi it's predominantly ram air

437
00:14:55,430 --> 00:14:53,440
inflated that is we have scoops on the

438
00:14:57,590 --> 00:14:55,440

side of it that helps swallow and ingest

439
00:14:58,710 --> 00:14:57,600
the oncoming air and pressurize it that

440
00:15:01,030 --> 00:14:58,720
way

441
00:15:02,870 --> 00:15:01,040
it's a enormous device but it also has a

442
00:15:05,110 --> 00:15:02,880
lot of flexibility associated with it so

443
00:15:07,110 --> 00:15:05,120
we'll get to see okay if this device

444
00:15:08,629 --> 00:15:07,120
isn't rigid and it is flexible what does

445
00:15:10,150 --> 00:15:08,639
that flexibility mean how does it

446
00:15:12,310 --> 00:15:10,160
interact with the rigid vehicle in front

447
00:15:14,230 --> 00:15:12,320
of it can we inflate it in the right way

448
00:15:16,710 --> 00:15:14,240
does it inflate symmetrically does it

449
00:15:18,949 --> 00:15:16,720
flat in a controlled way and does it uh

450
00:15:21,350 --> 00:15:18,959
once it's inflated does it attain

451
00:15:24,870 --> 00:15:21,360
achieve a nice good geometry that helps

452
00:15:26,710 --> 00:15:24,880
produce lots of drag for us to slow down

453
00:15:28,550 --> 00:15:26,720
let's go to the next slide

454
00:15:30,710 --> 00:15:28,560
so the third device is the large

455
00:15:33,110 --> 00:15:30,720
supersonic parachute and i say large it

456
00:15:34,629 --> 00:15:33,120
is 100 feet in diameter it's more than

457
00:15:36,470 --> 00:15:34,639
two and a half times the area of any

458
00:15:38,069 --> 00:15:36,480
parachute we've ever used in the past at

459
00:15:39,749 --> 00:15:38,079
supersonic speeds

460
00:15:41,110 --> 00:15:39,759
and it's very similar the parachute

461
00:15:42,870 --> 00:15:41,120
we're using is very similar to a

462
00:15:44,710 --> 00:15:42,880
parachute we've got experience with it's

463
00:15:46,710 --> 00:15:44,720

a ring sail parachute it's the same kind

464
00:15:48,629 --> 00:15:46,720
of basic parachute used by the apollo

465
00:15:51,749 --> 00:15:48,639
gemini mercury programs and more

466
00:15:53,829 --> 00:15:51,759
recently by the orion programs

467
00:15:55,910 --> 00:15:53,839
so you see a little bit of the scale

468
00:15:57,350 --> 00:15:55,920
this is the phoenix lander that we

469
00:16:00,389 --> 00:15:57,360
landed on mars a few years ago the

470
00:16:02,069 --> 00:16:00,399
viking lander parachute from the 1970s

471
00:16:04,150 --> 00:16:02,079
the msl parachute and here we see the

472
00:16:05,749 --> 00:16:04,160
parachute that the low density

473
00:16:08,550 --> 00:16:05,759
supersonic decelerator project is

474
00:16:13,670 --> 00:16:08,560
developing or ldsd parachute and it's

475
00:16:13,680 --> 00:16:16,790
let's go to the next slide

476
00:16:20,629 --> 00:16:18,710
so we've got these devices

477
00:16:23,110 --> 00:16:20,639
but in order to make sure that they work

478
00:16:24,550 --> 00:16:23,120
and we need to test them here at earth

479
00:16:27,030 --> 00:16:24,560
make sure that we understand how they

480
00:16:29,030 --> 00:16:27,040
perform how they behave we want to test

481
00:16:31,509 --> 00:16:29,040
them here before they have to work at

482
00:16:33,749 --> 00:16:31,519
mars and one of the hardest things about

483
00:16:35,350 --> 00:16:33,759
the ldsd project is figuring out how to

484
00:16:37,030 --> 00:16:35,360
test these devices

485
00:16:39,670 --> 00:16:37,040
and the reason is

486
00:16:41,590 --> 00:16:39,680
we came up with a test method a way of

487
00:16:43,509 --> 00:16:41,600
decomposing all the different aspects of

488
00:16:45,269 --> 00:16:43,519

these devices and we started looking

489
00:16:47,590 --> 00:16:45,279
around the world for where we could test

490
00:16:49,430 --> 00:16:47,600
to achieve the knowledge necessary for

491
00:16:51,509 --> 00:16:49,440
each of these different phases

492
00:16:53,189 --> 00:16:51,519
we looked at wind tunnels we looked at

493
00:16:54,790 --> 00:16:53,199
all these different test

494
00:16:56,069 --> 00:16:54,800
architectures that existed and we

495
00:16:57,749 --> 00:16:56,079
realized that for the size of the

496
00:16:59,189 --> 00:16:57,759
devices that we're developing and the

497
00:17:01,670 --> 00:16:59,199
conditions that we needed to test them

498
00:17:04,549 --> 00:17:01,680
in there were no places in the world

499
00:17:05,669 --> 00:17:04,559
able to test them and that's a

500
00:17:07,590 --> 00:17:05,679
you know you kind of have to pause for a

501
00:17:10,150 --> 00:17:07,600
moment and think about what that means

502
00:17:12,309 --> 00:17:10,160
we've been exploring space for 60 years

503
00:17:13,669 --> 00:17:12,319
we've built monuments to our endeavors

504
00:17:15,590 --> 00:17:13,679
right we've got wind tunnels that are

505
00:17:17,270 --> 00:17:15,600
the size of entire city blocks and that

506
00:17:19,270 --> 00:17:17,280
use more power than three nuclear

507
00:17:21,669 --> 00:17:19,280
aircraft carriers we've got vacuum

508
00:17:23,750 --> 00:17:21,679
chambers that are just as large we've

509
00:17:25,590 --> 00:17:23,760
got test stands thrust structures that

510
00:17:27,350 --> 00:17:25,600
are as big as buildings and we built

511
00:17:29,190 --> 00:17:27,360
buildings that at the time were the

512
00:17:30,870 --> 00:17:29,200
largest in the world

513
00:17:33,669 --> 00:17:30,880

all of that infrastructure that we've

514
00:17:35,510 --> 00:17:33,679
used for decades of space exploration we

515
00:17:37,350 --> 00:17:35,520
are now beginning to outgrow

516
00:17:39,590 --> 00:17:37,360
and we when it comes to devices like

517
00:17:41,270 --> 00:17:39,600
this that have to be the scale that they

518
00:17:42,950 --> 00:17:41,280
are and get tested at the conditions

519
00:17:44,390 --> 00:17:42,960
that we need to test them there was

520
00:17:46,310 --> 00:17:44,400
nowhere in the world that we could do it

521
00:17:47,909 --> 00:17:46,320
so we had to develop new ways of testing

522
00:17:50,789 --> 00:17:47,919
them

523
00:17:52,789 --> 00:17:50,799
so let's go to the next

524
00:17:54,710 --> 00:17:52,799
the first of those for that attached

525
00:17:57,029 --> 00:17:54,720
torus that inflatable drag device the

526
00:17:59,110 --> 00:17:57,039
device that we refer to as the side

527
00:18:00,470 --> 00:17:59,120
we want to expose it to aerodynamic

528
00:18:02,470 --> 00:18:00,480
loading similar to what i would see at

529
00:18:03,669 --> 00:18:02,480
mars we want to put it exposed to wind

530
00:18:05,590 --> 00:18:03,679
and make sure that it's structurally

531
00:18:07,430 --> 00:18:05,600
strong enough to survive the aerodynamic

532
00:18:09,909 --> 00:18:07,440
loads that it's going to see at mars so

533
00:18:11,909 --> 00:18:09,919
we went out to the desert we went to

534
00:18:13,270 --> 00:18:11,919
the china lake naval air weapon station

535
00:18:14,950 --> 00:18:13,280
where they have a standard gauge

536
00:18:17,590 --> 00:18:14,960
railroad track that's about five miles

537
00:18:19,909 --> 00:18:17,600
long we built a 20 foot tall 40 ton

538
00:18:22,390 --> 00:18:19,919

welded steel siege tower that we put on

539
00:18:24,870 --> 00:18:22,400
this standard gauge railway track we put

540
00:18:27,029 --> 00:18:24,880
a aeroshell simulator and then we pack

541
00:18:29,110 --> 00:18:27,039
the side around the periphery

542
00:18:30,950 --> 00:18:29,120
on the back end of this are six solid

543
00:18:32,630 --> 00:18:30,960
rocket motors these are nike solid

544
00:18:34,950 --> 00:18:32,640
rocket motors that were originally cast

545
00:18:37,110 --> 00:18:34,960
and built in the 1950s and would have

546
00:18:38,789 --> 00:18:37,120
been sent around cities like los angeles

547
00:18:40,310 --> 00:18:38,799
to protect us from soviet bombers but

548
00:18:42,390 --> 00:18:40,320
we've got a lot of these surplus rockets

549
00:18:45,110 --> 00:18:42,400
left over so we took six of them and we

550
00:18:48,710 --> 00:18:45,120
put them on another sled a pusher sled

551
00:18:52,070 --> 00:18:50,390
and go ahead

552
00:18:53,909 --> 00:18:52,080
we light those rockets

553
00:18:57,110 --> 00:18:53,919
the six rockets ignite and they take the

554
00:19:07,830 --> 00:18:57,120
sled this 40 ton stud from zero to 300

555
00:19:12,070 --> 00:19:09,350
once we get going at several hundred

556
00:19:15,669 --> 00:19:12,080
miles an hour we now have aerodynamic

557
00:19:17,990 --> 00:19:15,679
loads that we can test the sciad

558
00:19:19,750 --> 00:19:18,000
so we inflate the syad we deploy it from

559
00:19:22,789 --> 00:19:19,760
this mock aeroshell we see how it

560
00:19:24,549 --> 00:19:22,799
inflates we put the the air into it we

561
00:19:26,950 --> 00:19:24,559
see how it emerges from a very stowed

562
00:19:28,070 --> 00:19:26,960
configuration here you have a high speed

563
00:19:32,470 --> 00:19:28,080

video

564
00:19:35,909 --> 00:19:34,390
and once it's inflated we see is it

565
00:19:38,390 --> 00:19:35,919
strong enough does it survive does it

566
00:19:40,390 --> 00:19:38,400
develop holes does the fabric hold

567
00:19:42,310 --> 00:19:40,400
does the shape hold is the shape what we

568
00:19:44,470 --> 00:19:42,320
expected it to be when it's exposed to

569
00:19:46,230 --> 00:19:44,480
these very high loads now we're going

570
00:19:47,909 --> 00:19:46,240
very fast several hundred miles an hour

571
00:19:49,830 --> 00:19:47,919
but it's actually significantly slower

572
00:19:50,870 --> 00:19:49,840
than we would be going at mars and

573
00:19:52,150 --> 00:19:50,880
that's because one of the

574
00:19:54,070 --> 00:19:52,160
characteristics that you want to test

575
00:19:56,310 --> 00:19:54,080
out is the dynamic pressure it's the

576
00:19:58,470 --> 00:19:56,320
product of the density and the square

577
00:19:59,909 --> 00:19:58,480
velocity so the density here at the

578
00:20:01,350 --> 00:19:59,919
surface of earth is much much higher

579
00:20:03,190 --> 00:20:01,360
than it is at mars we don't have to be

580
00:20:04,669 --> 00:20:03,200
going as fast to achieve the same

581
00:20:07,190 --> 00:20:04,679
aerodynamic

582
00:20:09,110 --> 00:20:07,200
loads so we do these tests we see that

583
00:20:10,630 --> 00:20:09,120
the devices survive and they survive the

584
00:20:11,909 --> 00:20:10,640
structural loads necessary to work at

585
00:20:14,149 --> 00:20:11,919
mars

586
00:20:16,070 --> 00:20:14,159
next slide please

587
00:20:17,830 --> 00:20:16,080
we also want to test the parachute and

588
00:20:19,669 --> 00:20:17,840

even before we selected the parachute we

589
00:20:21,029 --> 00:20:19,679
wanted to develop keeping in mind that

590
00:20:22,630 --> 00:20:21,039
the parachute we were testing that we

591
00:20:24,230 --> 00:20:22,640
are developing could be the parachute

592
00:20:26,230 --> 00:20:24,240
that's used for next several decades of

593
00:20:28,230 --> 00:20:26,240
mars exploration we wanted to figure out

594
00:20:29,830 --> 00:20:28,240
what that parachute should look like so

595
00:20:32,149 --> 00:20:29,840
we went into it the world's biggest wind

596
00:20:34,789 --> 00:20:32,159
tunnel the 80 by 120 at nasa ames

597
00:20:36,789 --> 00:20:34,799
outside san francisco and we tested over

598
00:20:38,630 --> 00:20:36,799
50 different parachutes and the way that

599
00:20:40,630 --> 00:20:38,640
we tested them is we started with one

600
00:20:41,990 --> 00:20:40,640
parachute we flew it we saw how it

601
00:20:43,830 --> 00:20:42,000
behaved we saw how much drag it

602
00:20:46,230 --> 00:20:43,840
generated we tried measuring some of the

603
00:20:47,669 --> 00:20:46,240
aerodynamics we put little uh smoke

604
00:20:49,110 --> 00:20:47,679
bombs up at the front and we'd see the

605
00:20:50,630 --> 00:20:49,120
smoke and see how the smoke flowed

606
00:20:52,390 --> 00:20:50,640
around the parachute

607
00:20:53,990 --> 00:20:52,400
we do little streams of smoke and see

608
00:20:56,470 --> 00:20:54,000
what the flow field the aerodynamics

609
00:20:58,230 --> 00:20:56,480
looked like around the the parachute

610
00:20:59,990 --> 00:20:58,240
and then once we got some data we turn

611
00:21:01,510 --> 00:21:00,000
off the wind and we go and we cut some

612
00:21:03,190 --> 00:21:01,520
holes in it and we'd say all right let's

613
00:21:04,630 --> 00:21:03,200

try some holes over here and fly the

614
00:21:06,310 --> 00:21:04,640
parachute now let's try some holes over

615
00:21:08,470 --> 00:21:06,320
here and fly the parachute and we did

616
00:21:09,510 --> 00:21:08,480
that to help optimize the drag of the

617
00:21:11,350 --> 00:21:09,520
parachute but also another

618
00:21:13,029 --> 00:21:11,360
characteristic of parachute stability

619
00:21:14,789 --> 00:21:13,039
there's usually a race condition the two

620
00:21:16,310 --> 00:21:14,799
things are competing the more drag it

621
00:21:18,070 --> 00:21:16,320
generates the less stable the more the

622
00:21:20,149 --> 00:21:18,080
parachute wants to move around and fly

623
00:21:21,669 --> 00:21:20,159
all over the place uh but you can put

624
00:21:23,510 --> 00:21:21,679
holes in it decrease the amount of drag

625
00:21:25,350 --> 00:21:23,520
it generates and create a more stable

626
00:21:26,710 --> 00:21:25,360
parachute so you wanted to try to find

627
00:21:28,470 --> 00:21:26,720
what the best mix of those two

628
00:21:30,070 --> 00:21:28,480
parameters were so we went to this giant

629
00:21:32,390 --> 00:21:30,080
wind tunnel to do that that's what

630
00:21:34,310 --> 00:21:32,400
helped us pick a parachute configuration

631
00:21:35,590 --> 00:21:34,320
next slide but we also needed to test

632
00:21:37,190 --> 00:21:35,600
the strength of the parachute to make

633
00:21:38,710 --> 00:21:37,200
sure it was strong enough for that we

634
00:21:40,630 --> 00:21:38,720
came up with another idea based on

635
00:21:42,710 --> 00:21:40,640
rocket sled we went out to that same

636
00:21:44,390 --> 00:21:42,720
desert railroad track

637
00:21:47,110 --> 00:21:44,400
and we built an enormous structure

638
00:21:49,430 --> 00:21:47,120

this is a giant tripod that's in the the

639
00:21:50,710 --> 00:21:49,440
desert above the railroad track and here

640
00:21:52,710 --> 00:21:50,720
you can't really see but there's a few

641
00:21:54,710 --> 00:21:52,720
people down in the lower to give you a

642
00:21:55,909 --> 00:21:54,720
sense of scale you also see that there's

643
00:21:58,390 --> 00:21:55,919
this long

644
00:21:59,510 --> 00:21:58,400
sled here and some much larger rocket

645
00:22:00,950 --> 00:21:59,520
motors

646
00:22:01,990 --> 00:22:00,960
so let's go to the next slide and play

647
00:22:04,310 --> 00:22:02,000
the video

648
00:22:06,149 --> 00:22:04,320
and i'll talk you through how this works

649
00:22:08,789 --> 00:22:06,159
we start with a helicopter navy seahawk

650
00:22:10,950 --> 00:22:08,799
or a blackhawk helicopter the helicopter

651
00:22:12,870 --> 00:22:10,960
flies down picks up our parachute our

652
00:22:16,470 --> 00:22:12,880
tightly packed parachute and carries it

653
00:22:17,990 --> 00:22:16,480
to an altitude of about 4000 feet

654
00:22:18,950 --> 00:22:18,000
from that altitude the parachute is

655
00:22:23,270 --> 00:22:18,960
released

656
00:22:27,510 --> 00:22:24,549
and attached to the bottom of this

657
00:22:29,029 --> 00:22:27,520
parachute is a rope a 4 000 foot long

658
00:22:31,270 --> 00:22:29,039
rope that goes all the way down to the

659
00:22:32,710 --> 00:22:31,280
ground wraps itself around the pulley

660
00:22:35,669 --> 00:22:32,720
and then we tie it off to the back of a

661
00:22:40,870 --> 00:22:38,070
as that rope comes down it latches up to

662
00:22:43,350 --> 00:22:40,880
the rocket sled we light the rockets

663
00:22:45,190 --> 00:22:43,360

the rockets take off horizontally

664
00:22:46,950 --> 00:22:45,200
and they pull on that rope and they pull

665
00:22:49,110 --> 00:22:46,960
on the parachute and they generate over

666
00:22:50,789 --> 00:22:49,120
a hundred thousand pounds of force it's

667
00:22:51,990 --> 00:22:50,799
an enormous amount of force but it's the

668
00:22:53,270 --> 00:22:52,000
amount of force that again these

669
00:22:54,950 --> 00:22:53,280
parachutes are going to have to be able

670
00:22:56,230 --> 00:22:54,960
to survive if they're going to be used

671
00:22:57,270 --> 00:22:56,240
at mars and if they're going to work at

672
00:22:59,430 --> 00:22:57,280
mars

673
00:23:01,510 --> 00:22:59,440
so the test is over the parachute gently

674
00:23:03,830 --> 00:23:01,520
descends to the desert floor we see that

675
00:23:05,110 --> 00:23:03,840
the parachute had a failure we go and we

676
00:23:06,630 --> 00:23:05,120
picked the parachute off the desert

677
00:23:08,310 --> 00:23:06,640
floor we brushed the sagebrush out

678
00:23:10,470 --> 00:23:08,320
pulled the sand out and then we

679
00:23:12,149 --> 00:23:10,480
celebrate

680
00:23:14,390 --> 00:23:12,159
and we well we try to high five a little

681
00:23:20,230 --> 00:23:16,710
you know engineers calculus rockets good

682
00:23:22,230 --> 00:23:20,240
high fiving not not so good at

683
00:23:23,590 --> 00:23:22,240
so those were just structural tests that

684
00:23:25,669 --> 00:23:23,600
was just to make sure that things are

685
00:23:27,669 --> 00:23:25,679
survived the loads necessary we also

686
00:23:29,750 --> 00:23:27,679
need to see how these devices fly how

687
00:23:31,350 --> 00:23:29,760
they deploy how they inflate and we need

688
00:23:33,270 --> 00:23:31,360

to do that in conditions similar to what

689
00:23:35,350 --> 00:23:33,280
they'd see at mars that means going

690
00:23:37,669 --> 00:23:35,360
several times the speed of sound and

691
00:23:39,190 --> 00:23:37,679
doing it in a very very thin atmosphere

692
00:23:41,510 --> 00:23:39,200
and there is a place here on earth to do

693
00:23:43,590 --> 00:23:41,520
that you just have to go very very high

694
00:23:45,669 --> 00:23:43,600
in the sky to do that almost halfway to

695
00:23:48,230 --> 00:23:45,679
the edge of space in fact so let's go to

696
00:23:50,549 --> 00:23:48,240
the next slide

697
00:23:52,789 --> 00:23:50,559
so we built a test vehicle

698
00:23:54,470 --> 00:23:52,799
we took a 15-foot diameter air shell

699
00:23:56,470 --> 00:23:54,480
very similar looking to the one that we

700
00:23:58,230 --> 00:23:56,480
use to land curiosity on surface of mars

701
00:23:59,269 --> 00:23:58,240
and we put our technologies on it and we

702
00:24:00,950 --> 00:23:59,279
loaded it with all kinds of

703
00:24:02,950 --> 00:24:00,960
instrumentation load cells pressure

704
00:24:04,549 --> 00:24:02,960
transducers thermocouples

705
00:24:06,710 --> 00:24:04,559
all sorts of cameras high speed high

706
00:24:07,830 --> 00:24:06,720
definition high resolution all that kind

707
00:24:09,669 --> 00:24:07,840
of stuff

708
00:24:11,590 --> 00:24:09,679
and then we shipped it out to hawaii to

709
00:24:14,230 --> 00:24:11,600
the west coast of kauai let's go to the

710
00:24:20,310 --> 00:24:18,470
yeah i'll talk through this next slide

711
00:24:21,269 --> 00:24:20,320
and we attached it to a balloon a giant

712
00:24:22,789 --> 00:24:21,279
balloon

713
00:24:24,310 --> 00:24:22,799

there's a tether here that goes up

714
00:24:26,149 --> 00:24:24,320
around this launch tower and then

715
00:24:28,230 --> 00:24:26,159
there's more tethers and then a balloon

716
00:24:30,549 --> 00:24:28,240
that's laid out many many hundreds of

717
00:24:32,230 --> 00:24:30,559
feet back behind here

718
00:24:34,390 --> 00:24:32,240
so we use this balloon let's go to the

719
00:24:37,110 --> 00:24:34,400
next slide

720
00:24:38,549 --> 00:24:37,120
and play the video please

721
00:24:41,110 --> 00:24:38,559
we start very early in the morning

722
00:24:42,630 --> 00:24:41,120
actually about 11 p.m the night before

723
00:24:44,870 --> 00:24:42,640
to attach our test vehicle to this

724
00:24:46,710 --> 00:24:44,880
balloon we hoist it up on the tower and

725
00:24:48,710 --> 00:24:46,720
then we begin inflating this balloon and

726
00:24:51,190 --> 00:24:48,720
i say it's an enormous balloon it's 34

727
00:24:54,149 --> 00:24:51,200
million cubic feet in volume that's

728
00:24:56,230 --> 00:24:54,159
maybe hard to fathom but think about

729
00:24:58,710 --> 00:24:56,240
a large football stadium where we

730
00:25:00,149 --> 00:24:58,720
washington so the redskins game next

731
00:25:01,590 --> 00:25:00,159
time you're at a redskins game sitting

732
00:25:03,510 --> 00:25:01,600
in that stadium think about a balloon

733
00:25:05,269 --> 00:25:03,520
that at altitude is as large as that

734
00:25:07,269 --> 00:25:05,279
entire stadium and that's the balloon

735
00:25:08,630 --> 00:25:07,279
that we used several thousand pounds of

736
00:25:09,990 --> 00:25:08,640
helium and the balloon itself weighed

737
00:25:11,990 --> 00:25:10,000
several thousand pounds even though it's

738
00:25:14,390 --> 00:25:12,000

made from a very thin material like a

739
00:25:15,909 --> 00:25:14,400
saran wrap or a very thin garbage bag

740
00:25:17,510 --> 00:25:15,919
and we needed a balloon that big to

741
00:25:19,669 --> 00:25:17,520
hoist our test vehicle because our test

742
00:25:21,269 --> 00:25:19,679
vehicle weighs 7 000 pounds and we want

743
00:25:23,350 --> 00:25:21,279
to get it very very high in the sky so

744
00:25:24,870 --> 00:25:23,360
here it is at altitude

745
00:25:26,630 --> 00:25:24,880
in fact the test vehicle is a few little

746
00:25:28,230 --> 00:25:26,640
pixels down at the bottom of that image

747
00:25:30,390 --> 00:25:28,240
attention all stations and then we got

748
00:25:33,190 --> 00:25:30,400
ready to task

749
00:25:34,149 --> 00:25:33,200
i repeat test vehicle is go for drop

750
00:25:35,269 --> 00:25:34,159
four

751
00:25:36,230 --> 00:25:35,279
three

752
00:25:38,070 --> 00:25:36,240
two

753
00:25:39,590 --> 00:25:38,080
one

754
00:25:41,750 --> 00:25:39,600
so the balloon carries us to an altitude

755
00:25:43,909 --> 00:25:41,760
of 120 000 feet then we released our

756
00:25:46,070 --> 00:25:43,919
test vehicle from the balloon we spin it

757
00:25:48,310 --> 00:25:46,080
up for stability and then we light a

758
00:25:49,909 --> 00:25:48,320
giant solid rocket motor a solid rocket

759
00:25:51,830 --> 00:25:49,919
motor that's more typically used as the

760
00:25:53,830 --> 00:25:51,840
third stage of a launch vehicle or to

761
00:25:56,390 --> 00:25:53,840
send spacecraft from earth orbit all the

762
00:25:59,029 --> 00:25:56,400
way to mars but this giant rocket motor

763
00:26:01,510 --> 00:25:59,039

takes our enormous 15-foot test vehicle

764
00:26:03,909 --> 00:26:01,520
from an altitude of 120 000 feet to an

765
00:26:06,390 --> 00:26:03,919
altitude of 180 000 feet and it gets

766
00:26:08,149 --> 00:26:06,400
moving very very fast in fact over four

767
00:26:09,750 --> 00:26:08,159
times the speed of sound

768
00:26:11,510 --> 00:26:09,760
you see the balloon in the background

769
00:26:13,430 --> 00:26:11,520
balloon got very high we put a tear in

770
00:26:15,110 --> 00:26:13,440
it it begins coming back it crashes into

771
00:26:16,710 --> 00:26:15,120
the pacific ocean we go and we collect

772
00:26:17,590 --> 00:26:16,720
the balloon and all the the debris we

773
00:26:19,269 --> 00:26:17,600
want to be good stewards of the

774
00:26:21,350 --> 00:26:19,279
environment you know please don't litter

775
00:26:25,990 --> 00:26:21,360
uh but meanwhile the spacecraft is

776
00:26:30,950 --> 00:26:28,149
when that motor burns out after about 70

777
00:26:33,590 --> 00:26:30,960
seconds we're going almost 3000 miles an

778
00:26:35,430 --> 00:26:33,600
hour and we're now at an altitude and

779
00:26:37,029 --> 00:26:35,440
earth's atmosphere that's very similar

780
00:26:38,549 --> 00:26:37,039
to the atmosphere density that we would

781
00:26:41,110 --> 00:26:38,559
see if we were to use these devices at

782
00:26:42,630 --> 00:26:41,120
mars so we de-spin the vehicle we deploy

783
00:26:44,950 --> 00:26:42,640
camera lens covers that are protecting

784
00:26:47,350 --> 00:26:44,960
our cameras

785
00:26:49,190 --> 00:26:47,360
and then we inflate our device

786
00:26:50,470 --> 00:26:49,200
in a fraction of a second we go from a

787
00:26:52,470 --> 00:26:50,480
tightly packed tightly stowed

788
00:26:55,269 --> 00:26:52,480

configuration to something that's now 20

789
00:26:57,990 --> 00:26:55,279
feet in diameter and again going 3000

790
00:27:00,070 --> 00:26:58,000
miles an hour

791
00:27:02,549 --> 00:27:00,080
we see how the device behaves we see how

792
00:27:04,630 --> 00:27:02,559
rigid it is we see the shape it takes we

793
00:27:05,990 --> 00:27:04,640
see that it performs and survives all

794
00:27:08,070 --> 00:27:06,000
the aerodynamic loads and then we get

795
00:27:10,149 --> 00:27:08,080
ready to test our parachute at 2 000

796
00:27:11,830 --> 00:27:10,159
miles an hour we shoot a 40 pound pack

797
00:27:13,909 --> 00:27:11,840
off the back of the vehicle 200 feet per

798
00:27:15,909 --> 00:27:13,919
second which inflates another drag

799
00:27:17,990 --> 00:27:15,919
device a balut a balloon parachute looks

800
00:27:19,830 --> 00:27:18,000
like a giant supersonic acorn you know

801
00:27:22,310 --> 00:27:19,840
something that scrap would chase after

802
00:27:23,750 --> 00:27:22,320
in the ice age movies this inflates and

803
00:27:25,750 --> 00:27:23,760
it begins pulling our parachute off the

804
00:27:28,470 --> 00:27:25,760
back of the vehicle and we try to

805
00:27:30,630 --> 00:27:28,480
inflate 200 pounds of nylon and kevlar

806
00:27:33,510 --> 00:27:30,640
in a 2 000 mile an hour wind and see

807
00:27:35,510 --> 00:27:33,520
what happens and we learn from that

808
00:27:36,950 --> 00:27:35,520
meanwhile the vehicle decelerates that

809
00:27:38,950 --> 00:27:36,960
little bit of pressure that we put into

810
00:27:40,310 --> 00:27:38,960
our inflated device is not enough as the

811
00:27:41,750 --> 00:27:40,320
device gets lower and lower in the

812
00:27:42,950 --> 00:27:41,760
earth's altitude the atmospheric

813
00:27:44,870 --> 00:27:42,960

pressure begins building up and

814
00:27:46,310 --> 00:27:44,880
collapsing it so it begins deflating and

815
00:27:48,389 --> 00:27:46,320
flopping around a little bit but that's

816
00:27:50,149 --> 00:27:48,399
all expected and then all of this lands

817
00:27:51,669 --> 00:27:50,159
in the pacific ocean you see an image of

818
00:27:55,110 --> 00:27:51,679
the parachute that's just underneath the

819
00:28:02,389 --> 00:27:56,950
and another image of it looks like a

820
00:28:06,710 --> 00:28:04,630
and we had some help the navy explosive

821
00:28:07,990 --> 00:28:06,720
ordnance disposal team uh went to help

822
00:28:10,070 --> 00:28:08,000
them recover this test vehicle in fact

823
00:28:11,430 --> 00:28:10,080
these are two gentlemen sitting on it uh

824
00:28:13,190 --> 00:28:11,440
on our test vehicle as they're waiting

825
00:28:14,630 --> 00:28:13,200
for the recovery boat to come and

826
00:28:15,590 --> 00:28:14,640
they're wearing cameras at one point the

827
00:28:17,510 --> 00:28:15,600
gentleman

828
00:28:18,870 --> 00:28:17,520
turns the other and says bro there's

829
00:28:20,310 --> 00:28:18,880
nobody else in the world i'd rather be

830
00:28:22,070 --> 00:28:20,320
sitting on a sinking spaceship in the

831
00:28:23,750 --> 00:28:22,080
middle of the pacific ocean with than

832
00:28:24,870 --> 00:28:23,760
you and they do a fist bump and they

833
00:28:26,149 --> 00:28:24,880
high-five

834
00:28:28,950 --> 00:28:26,159
and then they help us pull the vehicle

835
00:28:31,909 --> 00:28:30,310
and they help us pull the parachute out

836
00:28:33,350 --> 00:28:31,919
of the water

837
00:28:34,789 --> 00:28:33,360
and we take this vehicle we take the

838
00:28:36,389 --> 00:28:34,799

technologies we take the inflatable

839
00:28:38,389 --> 00:28:36,399
device the parachute we take all the

840
00:28:39,830 --> 00:28:38,399
cameras all the data we get and we start

841
00:28:41,510 --> 00:28:39,840
to understand what happened in that

842
00:28:44,549 --> 00:28:41,520
flight

843
00:28:45,990 --> 00:28:44,559
so let's go to the next slide

844
00:28:48,950 --> 00:28:46,000
and we had a number of tremendous

845
00:28:50,549 --> 00:28:48,960
accomplishments for this test really

846
00:28:52,070 --> 00:28:50,559
this test that we conducted last june

847
00:28:54,070 --> 00:28:52,080
was really just a shakeout test nobody

848
00:28:56,310 --> 00:28:54,080
had done anything like this in over 40

849
00:28:58,070 --> 00:28:56,320
years we developed a new vehicle a new

850
00:28:59,830 --> 00:28:58,080
balloon capability a new and entirely

851
00:29:01,990 --> 00:28:59,840
new test architecture and we just wanted

852
00:29:04,070 --> 00:29:02,000
to see does it work will it help us get

853
00:29:06,070 --> 00:29:04,080
to the conditions necessary to test the

854
00:29:07,830 --> 00:29:06,080
technologies that we're developing uh we

855
00:29:09,510 --> 00:29:07,840
got lucky because the technologies were

856
00:29:10,710 --> 00:29:09,520
actually ready a year ahead of schedule

857
00:29:12,149 --> 00:29:10,720
and we got to put them on this vehicle

858
00:29:13,830 --> 00:29:12,159
and see how they performed a year ahead

859
00:29:15,510 --> 00:29:13,840
of schedule and we had some tremendous

860
00:29:17,430 --> 00:29:15,520
accomplishments we inflated the largest

861
00:29:19,830 --> 00:29:17,440
inflatable device ever deployed at

862
00:29:21,669 --> 00:29:19,840
supersonic conditions uh we deployed the

863
00:29:23,750 --> 00:29:21,679

largest balut that giant supersonic

864
00:29:24,470 --> 00:29:23,760
acorn that's in the lower right corner

865
00:29:26,230 --> 00:29:24,480
there

866
00:29:28,230 --> 00:29:26,240
largest balloon ever inflated it several

867
00:29:30,070 --> 00:29:28,240
times the speed of sound we performed

868
00:29:31,909 --> 00:29:30,080
the first ever pilot deployment that is

869
00:29:33,750 --> 00:29:31,919
using one device to help deploy the

870
00:29:36,549 --> 00:29:33,760
other uh pilot deployment of a

871
00:29:38,549 --> 00:29:36,559
supersonic parachute uh we deployed the

872
00:29:40,950 --> 00:29:38,559
largest supersonic parachute ever we got

873
00:29:42,310 --> 00:29:40,960
to see how it began to inflate what it

874
00:29:43,830 --> 00:29:42,320
looked like when it began to inflate and

875
00:29:44,789 --> 00:29:43,840
how it behaved during the inflation

876
00:29:46,630 --> 00:29:44,799
process

877
00:29:48,870 --> 00:29:46,640
and the quantity in the quality of the

878
00:29:50,310 --> 00:29:48,880
data that we got was orders of magnitude

879
00:29:52,310 --> 00:29:50,320
above and beyond anything that we've

880
00:29:54,710 --> 00:29:52,320
ever had before in four decades of

881
00:29:57,029 --> 00:29:54,720
exploring mars

882
00:29:58,789 --> 00:29:57,039
so let's go to the next slide

883
00:30:00,470 --> 00:29:58,799
but that was just a start

884
00:30:02,789 --> 00:30:00,480
we've got two more tests coming up in

885
00:30:04,710 --> 00:30:02,799
2015 and we're presently building two

886
00:30:06,230 --> 00:30:04,720
more test vehicles this is in the high

887
00:30:08,149 --> 00:30:06,240
bay at jpl

888
00:30:10,149 --> 00:30:08,159

and it's the data from those tests it's

889
00:30:12,230 --> 00:30:10,159
the technologies that we're testing that

890
00:30:15,029 --> 00:30:12,240
are going to be used to explore and

891
00:30:17,830 --> 00:30:15,039
develop and design and land safely the

892
00:30:20,870 --> 00:30:17,840
future explorers of mars that means the

893
00:30:22,230 --> 00:30:20,880
payloads the more capable more exciting

894
00:30:23,990 --> 00:30:22,240
more massive rovers that we're going to

895
00:30:26,070 --> 00:30:24,000
put on the surface of mars

896
00:30:27,990 --> 00:30:26,080
in the payloads that will precede humans

897
00:30:30,149 --> 00:30:28,000
and eventually hopefully one day to be

898
00:30:31,830 --> 00:30:30,159
used to land humans on the surface of

899
00:30:34,149 --> 00:30:31,840
mars

900
00:30:36,149 --> 00:30:34,159
so i've got one more slide

901
00:30:37,590 --> 00:30:36,159
and it's a quote uh it's actually a

902
00:30:39,350 --> 00:30:37,600
quote from teddy roosevelt that i think

903
00:30:41,190 --> 00:30:39,360
is very applicable particularly when it

904
00:30:42,870 --> 00:30:41,200
comes to technology development but also

905
00:30:45,350 --> 00:30:42,880
more broadly applicable to space

906
00:30:47,669 --> 00:30:45,360
exploration in general and the quote is

907
00:30:49,830 --> 00:30:47,679
it is far better it is to dare mighty

908
00:30:51,990 --> 00:30:49,840
things to win glorious triumphs even

909
00:30:53,750 --> 00:30:52,000
though checkered by failure than to rank

910
00:30:56,149 --> 00:30:53,760
with those timid spirits who neither

911
00:30:57,830 --> 00:30:56,159
enjoy nor suffer much because they live

912
00:30:59,830 --> 00:30:57,840
in the gray twilight that knows neither

913
00:31:02,389 --> 00:30:59,840

victory nor defeat

914
00:31:04,149 --> 00:31:02,399
we got to see a lot of success and we

915
00:31:05,830 --> 00:31:04,159
also got to see a parachute not work the

916
00:31:07,590 --> 00:31:05,840
way that we wanted to but it's lessons

917
00:31:09,509 --> 00:31:07,600
learned it's data that we can then go

918
00:31:10,950 --> 00:31:09,519
and use to design the next generation of

919
00:31:13,750 --> 00:31:10,960
parachute that we're getting ready to

920
00:31:15,590 --> 00:31:13,760
test again in 2015.

921
00:31:17,750 --> 00:31:15,600
so with that i'm done and i'll take any

922
00:31:25,110 --> 00:31:17,760
questions if you guys want to play a

923
00:31:29,669 --> 00:31:27,750
dr clark thank you very much

924
00:31:31,590 --> 00:31:29,679
we are very excited to have the chance

925
00:31:34,070 --> 00:31:31,600
to ask you some questions about the

926
00:31:36,549 --> 00:31:34,080
presentation i know i learned a ton and

927
00:31:39,269 --> 00:31:36,559
i'm really interested in this if anyone

928
00:31:41,029 --> 00:31:39,279
would like to ask a question of dr ian

929
00:31:42,630 --> 00:31:41,039
clark you can come over to me and we're

930
00:31:44,470 --> 00:31:42,640
going to ask you to

931
00:31:51,110 --> 00:31:44,480
tell us your first name and where you're

932
00:31:54,950 --> 00:31:53,269
hi my name is brianna and i'm from

933
00:31:57,430 --> 00:31:54,960
washington d.c

934
00:31:59,909 --> 00:31:57,440
my school is blow pierced i have a

935
00:32:01,110 --> 00:31:59,919
question about the human about landing

936
00:32:04,470 --> 00:32:01,120
on mars

937
00:32:06,789 --> 00:32:04,480
so when you said you were planting food

938
00:32:09,830 --> 00:32:06,799

and materials that we need do you want

939
00:32:11,029 --> 00:32:09,840
to apply trees because trees are the

940
00:32:13,350 --> 00:32:11,039
actual

941
00:32:14,950 --> 00:32:13,360
oxygen on earth so you're going to plant

942
00:32:16,149 --> 00:32:14,960
trees on mars

943
00:32:18,630 --> 00:32:16,159
that's certainly one of the the

944
00:32:20,389 --> 00:32:18,640
possibilities you know really uh the

945
00:32:21,750 --> 00:32:20,399
things i work on and what how do you

946
00:32:23,509 --> 00:32:21,760
land those payloads safely on the

947
00:32:25,350 --> 00:32:23,519
surface of mars other folks are working

948
00:32:27,269 --> 00:32:25,360
on what those payloads will need to be

949
00:32:29,430 --> 00:32:27,279
uh for humans to live on surface of mars

950
00:32:31,110 --> 00:32:29,440
so you know do we bring our own plants

951
00:32:33,110 --> 00:32:31,120
do we bring what kind of plants do they

952
00:32:34,149 --> 00:32:33,120
need you know to survive to generate the

953
00:32:36,230 --> 00:32:34,159
food

954
00:32:46,630 --> 00:32:36,240
and maybe they they do use trees it's

955
00:32:51,590 --> 00:32:49,350
hello my name is deshayla bailey and i'm

956
00:32:54,870 --> 00:32:51,600
from washington dc and my school is

957
00:32:57,909 --> 00:32:54,880
blowpins and i want to ask you was it

958
00:32:59,909 --> 00:32:57,919
hard making the inflatable balloon

959
00:33:01,029 --> 00:32:59,919
was it hard making the balloon

960
00:33:03,269 --> 00:33:01,039
uh

961
00:33:04,870 --> 00:33:03,279
i didn't make the balloon myself

962
00:33:07,909 --> 00:33:04,880
but i suspect it was i mean the balloon

963
00:33:09,190 --> 00:33:07,919

is it's enormous it's so much material

964
00:33:10,389 --> 00:33:09,200
that they've got to work with and you

965
00:33:12,149 --> 00:33:10,399
have to

966
00:33:14,230 --> 00:33:12,159
very very thin material just a little

967
00:33:15,909 --> 00:33:14,240
bit of tear in this very thin material

968
00:33:17,430 --> 00:33:15,919
and the balloon won't inflate and it

969
00:33:19,190 --> 00:33:17,440
will deflate and you won't be able to do

970
00:33:20,950 --> 00:33:19,200
your mission and then it has to survive

971
00:33:23,430 --> 00:33:20,960
it has to carry this enormously heavy

972
00:33:24,950 --> 00:33:23,440
vehicle up to extremely high altitudes

973
00:33:26,470 --> 00:33:24,960
so though i don't know for sure i

974
00:33:30,789 --> 00:33:26,480
suspect it was very difficult to build

975
00:33:35,110 --> 00:33:32,789
thank you very much

976
00:33:36,149 --> 00:33:35,120
do i have our next question ready

977
00:33:37,669 --> 00:33:36,159
okay

978
00:33:39,830 --> 00:33:37,679
come on up

979
00:33:44,230 --> 00:33:39,840
can you tell us your name and then where

980
00:33:50,549 --> 00:33:47,269
my name is julia rodriguez and i'm from

981
00:33:53,110 --> 00:33:50,559
washington d.c and my school is

982
00:33:55,830 --> 00:33:53,120
blow pierce and

983
00:33:59,190 --> 00:33:55,840
my question is

984
00:34:03,509 --> 00:34:02,470
about nasa thinking of

985
00:34:07,750 --> 00:34:03,519
making

986
00:34:08,950 --> 00:34:07,760
possible for humans to live on mars

987
00:34:11,349 --> 00:34:08,960
and

988
00:34:13,270 --> 00:34:11,359

i was asking

989
00:34:16,149 --> 00:34:13,280
if do you know

990
00:34:19,510 --> 00:34:16,159
how to bring the

991
00:34:21,430 --> 00:34:19,520
soil that you need to plant plants

992
00:34:23,510 --> 00:34:21,440
on mars how do we bring the soil that we

993
00:34:26,470 --> 00:34:23,520
need to plant plants on mars uh that's

994
00:34:28,470 --> 00:34:26,480
an excellent question i

995
00:34:29,990 --> 00:34:28,480
so i was joking mostly when i said stump

996
00:34:33,349 --> 00:34:30,000
the pi

997
00:34:38,149 --> 00:34:36,230
uh anybody want star wars trivia or

998
00:34:40,069 --> 00:34:38,159
no um

999
00:34:41,109 --> 00:34:40,079
how do you bring the soil well

1000
00:34:43,669 --> 00:34:41,119
you know first you have to figure out

1001
00:34:45,030 --> 00:34:43,679
what that soil looks like maybe you know

1002
00:34:46,470 --> 00:34:45,040
we know what the soil here at earth

1003
00:34:48,069 --> 00:34:46,480
looks like and we know how well plants

1004
00:34:48,790 --> 00:34:48,079
grow in that but maybe a good question

1005
00:34:50,869 --> 00:34:48,800
is

1006
00:34:53,349 --> 00:34:50,879
can we use the the material the dirt

1007
00:34:54,629 --> 00:34:53,359
that is there on mars now to grow plants

1008
00:34:56,389 --> 00:34:54,639
i don't know the answer to that and i'm

1009
00:34:58,069 --> 00:34:56,399
not sure if if others know the answer to

1010
00:35:00,069 --> 00:34:58,079
that but that may that might be

1011
00:35:01,670 --> 00:35:00,079
something that we want to look at

1012
00:35:03,750 --> 00:35:01,680
there might be plants that work very

1013
00:35:05,589 --> 00:35:03,760

well here on earth that also work at

1014
00:35:07,349 --> 00:35:05,599
mars in a controlled environment that is

1015
00:35:09,589 --> 00:35:07,359
you know maybe we build a capsule around

1016
00:35:12,150 --> 00:35:09,599
them and we put a different environment

1017
00:35:13,430 --> 00:35:12,160
not using just the carbon dioxide uh of

1018
00:35:14,950 --> 00:35:13,440
the martian atmosphere but maybe we

1019
00:35:16,310 --> 00:35:14,960
bring some of our own gases to put in

1020
00:35:18,390 --> 00:35:16,320
there to help the plants grow but

1021
00:35:20,550 --> 00:35:18,400
otherwise using the martian soil there's

1022
00:35:21,829 --> 00:35:20,560
lots of ideas out there and i think

1023
00:35:23,030 --> 00:35:21,839
people are you know that's one of the

1024
00:35:25,109 --> 00:35:23,040
questions that people are trying to

1025
00:35:26,630 --> 00:35:25,119
answer today as we prepare for

1026
00:35:30,950 --> 00:35:26,640
eventually putting humans on the surface

1027
00:35:37,349 --> 00:35:32,950
thank you can you move right up please

1028
00:35:41,190 --> 00:35:39,270
my name is taylor and i'm from

1029
00:35:43,589 --> 00:35:41,200
washington dc and my school is blue

1030
00:35:46,470 --> 00:35:43,599
pierce i wanted to know how you're going

1031
00:35:49,349 --> 00:35:46,480
to build the parachute for 2015.

1032
00:35:51,589 --> 00:35:49,359
how did we build the parachute for 2015

1033
00:35:52,550 --> 00:35:51,599
oh how are we going to build a parachute

1034
00:35:54,710 --> 00:35:52,560
uh

1035
00:35:57,430 --> 00:35:54,720
much stronger

1036
00:35:59,349 --> 00:35:57,440
than the one that we previously built um

1037
00:36:01,030 --> 00:35:59,359
you know a parachute is really made from

1038
00:36:02,950 --> 00:36:01,040

lightweight materials i see lightweight

1039
00:36:05,349 --> 00:36:02,960
you know it's nylon like what your

1040
00:36:07,349 --> 00:36:05,359
camping tint might be made out of uh

1041
00:36:09,829 --> 00:36:07,359
it's predominantly nylon but we add much

1042
00:36:12,550 --> 00:36:09,839
stronger materials like kevlar which is

1043
00:36:14,630 --> 00:36:12,560
what's used for bulletproof vests and

1044
00:36:16,550 --> 00:36:14,640
what we can do is change where we use

1045
00:36:18,790 --> 00:36:16,560
the kevlar relative to where we use the

1046
00:36:20,950 --> 00:36:18,800
nylon and help the parachute carry loads

1047
00:36:22,870 --> 00:36:20,960
better carry stresses better in that

1048
00:36:24,470 --> 00:36:22,880
geometry so that's one of the key things

1049
00:36:27,190 --> 00:36:24,480
that we're doing we're changing the the

1050
00:36:29,349 --> 00:36:27,200
basic configuration to add more skeletal

1051
00:36:31,349 --> 00:36:29,359
kevlar more structure uh that can help

1052
00:36:33,349 --> 00:36:31,359
carry some of the higher loads that it

1053
00:36:35,589 --> 00:36:33,359
sees during inflation

1054
00:36:37,829 --> 00:36:35,599
great question

1055
00:36:39,430 --> 00:36:37,839
i knew the answer i'm going to interject

1056
00:36:41,030 --> 00:36:39,440
one question i was struck as i was

1057
00:36:42,470 --> 00:36:41,040
watching this that it's a tremendous

1058
00:36:44,069 --> 00:36:42,480
amount of engineering and scientific

1059
00:36:46,710 --> 00:36:44,079
knowledge but also looks like an awful

1060
00:36:48,790 --> 00:36:46,720
lot of fun giant rocket sleds

1061
00:36:51,589 --> 00:36:48,800
um how did you get interested in this as

1062
00:36:53,190 --> 00:36:51,599
a kid uh or is was this an interest that

1063
00:36:54,630 --> 00:36:53,200

you had as a child oh absolutely you

1064
00:36:56,069 --> 00:36:54,640
know i'd always been interested in space

1065
00:36:57,990 --> 00:36:56,079
as a kid uh

1066
00:36:59,270 --> 00:36:58,000
and i think one of the earliest things

1067
00:37:00,710 --> 00:36:59,280
was just legos you know playing around

1068
00:37:02,470 --> 00:37:00,720
with legos and building things that way

1069
00:37:03,589 --> 00:37:02,480
in fact i didn't even it wasn't until my

1070
00:37:04,630 --> 00:37:03,599
senior year in high school that i

1071
00:37:06,230 --> 00:37:04,640
understood that there was such a thing

1072
00:37:07,910 --> 00:37:06,240
as aerospace engineering i thought i was

1073
00:37:09,829 --> 00:37:07,920
going to go into astronomy to you know

1074
00:37:11,109 --> 00:37:09,839
study planets and that's the path and

1075
00:37:12,710 --> 00:37:11,119
then a friend of mine who was applying

1076
00:37:13,990 --> 00:37:12,720
to to schools

1077
00:37:15,270 --> 00:37:14,000
said he was applying in aerospace

1078
00:37:17,190 --> 00:37:15,280
engineering

1079
00:37:19,990 --> 00:37:17,200
what there's engineer i can build things

1080
00:37:21,829 --> 00:37:20,000
and it can be an aerospace

1081
00:37:24,310 --> 00:37:21,839
so that's what i ended up getting into

1082
00:37:25,990 --> 00:37:24,320
uh eventually found my path you know

1083
00:37:27,670 --> 00:37:26,000
towards doing stuff like this which as

1084
00:37:29,430 --> 00:37:27,680
you point out is a tremendous amount of

1085
00:37:31,270 --> 00:37:29,440
fun

1086
00:37:34,069 --> 00:37:31,280
can you step up so tell us your name

1087
00:37:34,950 --> 00:37:34,079
where are you from and your question

1088
00:37:37,589 --> 00:37:34,960

okay

1089
00:37:40,550 --> 00:37:37,599
my name is sequon faulkner

1090
00:37:41,349 --> 00:37:40,560
i'm from washington dc my school is blow

1091
00:37:43,750 --> 00:37:41,359
pierce

1092
00:37:45,910 --> 00:37:43,760
my question is will you ever do tests on

1093
00:37:47,510 --> 00:37:45,920
different planets will we ever test on

1094
00:37:48,470 --> 00:37:47,520
other planets yes

1095
00:37:50,230 --> 00:37:48,480
uh

1096
00:37:51,750 --> 00:37:50,240
you know we like to test here on earth

1097
00:37:53,589 --> 00:37:51,760
because generally we can control those

1098
00:37:55,750 --> 00:37:53,599
tasks a little bit better it's a little

1099
00:37:57,349 --> 00:37:55,760
easier to test here on earth

1100
00:37:58,870 --> 00:37:57,359
and as much as we can replicate the

1101
00:38:01,589 --> 00:37:58,880
environments and the conditions that are

1102
00:38:03,190 --> 00:38:01,599
necessary to survive going to other

1103
00:38:04,870 --> 00:38:03,200
planets we'll continue to test here on

1104
00:38:06,710 --> 00:38:04,880
earth that doesn't mean we won't there

1105
00:38:08,069 --> 00:38:06,720
might be things that you know what we

1106
00:38:09,670 --> 00:38:08,079
just can't convince ourselves that we

1107
00:38:10,790 --> 00:38:09,680
can do a test well enough here on earth

1108
00:38:12,390 --> 00:38:10,800
we are going to have to send it to

1109
00:38:13,430 --> 00:38:12,400
another planet we haven't had to do that

1110
00:38:22,790 --> 00:38:13,440
yet

1111
00:38:27,109 --> 00:38:25,430
hello my name is michaela wooten and uh

1112
00:38:30,470 --> 00:38:27,119
i'm from dc

1113
00:38:32,310 --> 00:38:30,480

and uh i'm my school is blow peers

1114
00:38:33,589 --> 00:38:32,320
and my question is about how much would

1115
00:38:36,150 --> 00:38:33,599
it cost

1116
00:38:38,870 --> 00:38:36,160
for all those test flights and launches

1117
00:38:40,630 --> 00:38:38,880
how much does it cost uh the entire cost

1118
00:38:42,630 --> 00:38:40,640
from the beginning to the end of the low

1119
00:38:44,230 --> 00:38:42,640
density supersonic decelerator project

1120
00:38:47,990 --> 00:38:44,240
is a little less than 200 million

1121
00:38:48,000 --> 00:38:53,190
it's a lot

1122
00:38:56,470 --> 00:38:54,790
very good value for the money oh it's

1123
00:38:58,950 --> 00:38:56,480
absolutely good value the emissions that

1124
00:39:01,430 --> 00:38:58,960
we use you know the curiosity mission uh

1125
00:39:02,790 --> 00:39:01,440
was more than a billion dollars right so

1126
00:39:04,710 --> 00:39:02,800
we're developing the technologies that

1127
00:39:06,390 --> 00:39:04,720
will allow these very large very capable

1128
00:39:08,069 --> 00:39:06,400
very exciting science missions to safely

1129
00:39:09,750 --> 00:39:08,079
land on the surface and we're doing it

1130
00:39:12,829 --> 00:39:09,760
at much a very small fraction of the

1131
00:39:16,230 --> 00:39:12,839
overall cost of those

1132
00:39:17,990 --> 00:39:16,240
missions i am uh daniel davey i'm uh

1133
00:39:20,150 --> 00:39:18,000
from austin texas but i'm currently

1134
00:39:23,670 --> 00:39:20,160
pursuing a phd in physics at william and

1135
00:39:25,589 --> 00:39:23,680
mary um so actually uh our projects are

1136
00:39:27,270 --> 00:39:25,599
a little bit more expensive

1137
00:39:29,750 --> 00:39:27,280
the you know

1138
00:39:31,750 --> 00:39:29,760

lhc was like 12 billion

1139
00:39:34,710 --> 00:39:31,760
but uh i was wondering

1140
00:39:37,910 --> 00:39:34,720
what exactly uh caused the failure in

1141
00:39:40,390 --> 00:39:37,920
the parachute uh what what happened

1142
00:39:42,390 --> 00:39:40,400
with that i mean we saw it but

1143
00:39:46,550 --> 00:39:42,400
you didn't uh i was wondering

1144
00:39:49,510 --> 00:39:46,560
what were the details there okay uh

1145
00:39:51,349 --> 00:39:49,520
basically the the parachute shape itself

1146
00:39:53,109 --> 00:39:51,359
was something that we had

1147
00:39:54,630 --> 00:39:53,119
come up with out of the earlier wind

1148
00:39:56,150 --> 00:39:54,640
tunneling testing and the way that we

1149
00:39:58,230 --> 00:39:56,160
test is we generally have them fully

1150
00:40:00,150 --> 00:39:58,240
inflated and we watch how they fly what

1151
00:40:02,310 --> 00:40:00,160
we saw was that when the parachute began

1152
00:40:04,150 --> 00:40:02,320
inflating that shape that we had was

1153
00:40:05,430 --> 00:40:04,160
just not a very good shape for surviving

1154
00:40:07,829 --> 00:40:05,440
the stresses and the loads that it

1155
00:40:10,309 --> 00:40:07,839
seized during the inflation process

1156
00:40:11,670 --> 00:40:10,319
parachutes typically are very curved or

1157
00:40:13,910 --> 00:40:11,680
certainly they have a lot of curvature

1158
00:40:15,910 --> 00:40:13,920
when you know they're inflated what we

1159
00:40:17,190 --> 00:40:15,920
started with was a combination of a

1160
00:40:19,109 --> 00:40:17,200
geometry

1161
00:40:20,710 --> 00:40:19,119
that starts very curved but otherwise is

1162
00:40:23,190 --> 00:40:20,720
a very flat top

1163
00:40:24,950 --> 00:40:23,200

a pressure vessel excuse me a parachute

1164
00:40:26,150 --> 00:40:24,960
at its core is a pressure vessel it

1165
00:40:27,670 --> 00:40:26,160
holds a lot of pressure and helps

1166
00:40:29,430 --> 00:40:27,680
generate drag

1167
00:40:31,430 --> 00:40:29,440
the stresses in a pressure vessel

1168
00:40:33,349 --> 00:40:31,440
pressure vessel are a function of how

1169
00:40:35,270 --> 00:40:33,359
much pressure is inside of it and the

1170
00:40:37,270 --> 00:40:35,280
curvature the local radius of curvature

1171
00:40:38,230 --> 00:40:37,280
of the parachute and what we saw was

1172
00:40:40,309 --> 00:40:38,240
even though there wasn't a lot of

1173
00:40:42,790 --> 00:40:40,319
pressure and that with that very flat

1174
00:40:45,349 --> 00:40:42,800
top uh you could develop very very high

1175
00:40:46,870 --> 00:40:45,359
stresses very early on and it's a shape

1176
00:40:48,550 --> 00:40:46,880
that you don't have and when it's fully

1177
00:40:50,390 --> 00:40:48,560
inflated but that you can get when it's

1178
00:40:52,870 --> 00:40:50,400
inflating and that's what damage the

1179
00:40:56,069 --> 00:40:52,880
parachute

1180
00:40:58,309 --> 00:40:56,079
sorry so uh what are you uh

1181
00:41:00,230 --> 00:40:58,319
do you guys have a solution to fix it or

1182
00:41:02,470 --> 00:41:00,240
what's the put more curvature back in

1183
00:41:04,550 --> 00:41:02,480
for one oh yeah so we're going to remove

1184
00:41:06,230 --> 00:41:04,560
the flat top make it more hemispherical

1185
00:41:07,670 --> 00:41:06,240
or at least a you know what's called a

1186
00:41:09,670 --> 00:41:07,680
quarter sphere

1187
00:41:11,589 --> 00:41:09,680
and add more kevlar more skeletal

1188
00:41:13,349 --> 00:41:11,599

structure that can help take and reduce

1189
00:41:15,030 --> 00:41:13,359
some of the stresses on the fabric in

1190
00:41:16,790 --> 00:41:15,040
that region you know

1191
00:41:18,230 --> 00:41:16,800
the design that we're going to if you

1192
00:41:19,750 --> 00:41:18,240
have a little bit of tear in the fabric

1193
00:41:21,349 --> 00:41:19,760
it ends up being very localized the

1194
00:41:22,630 --> 00:41:21,359
kevlar will stop that tear from

1195
00:41:23,990 --> 00:41:22,640
propagating

1196
00:41:25,829 --> 00:41:24,000
to the rest of the parachute or at least

1197
00:41:27,910 --> 00:41:25,839
that's the idea and that's what we have

1198
00:41:32,550 --> 00:41:27,920
to go and test and hopefully find out is

1199
00:41:36,870 --> 00:41:34,230
i'm david kinniproth from portland

1200
00:41:38,950 --> 00:41:36,880
oregon i was wondering um

1201
00:41:40,710 --> 00:41:38,960
besides mars are there any locations

1202
00:41:41,829 --> 00:41:40,720
that there are plans to deliver a

1203
00:41:43,829 --> 00:41:41,839
payload to

1204
00:41:46,390 --> 00:41:43,839
and if not what would you think would be

1205
00:41:48,870 --> 00:41:46,400
the most interesting place besides mars

1206
00:41:50,790 --> 00:41:48,880
to deliver a payload uh

1207
00:41:52,630 --> 00:41:50,800
besides mars yeah i mean

1208
00:41:55,349 --> 00:41:52,640
you know we've got spacecraft that are

1209
00:41:57,430 --> 00:41:55,359
going all over the solar system and

1210
00:41:59,910 --> 00:41:57,440
my personal you know where i would like

1211
00:42:02,150 --> 00:41:59,920
to see a payload next i mean there's a

1212
00:42:03,910 --> 00:42:02,160
lot of exciting moons of jupiter and of

1213
00:42:06,309 --> 00:42:03,920

saturn that i think would be you know

1214
00:42:09,030 --> 00:42:06,319
just fascinating places to explore

1215
00:42:11,510 --> 00:42:09,040
maybe of all of them europa having a

1216
00:42:13,589 --> 00:42:11,520
payload land on the surface of europa

1217
00:42:15,270 --> 00:42:13,599
where they have a very thick layer of

1218
00:42:17,109 --> 00:42:15,280
ice on it and maybe even dive into the

1219
00:42:19,109 --> 00:42:17,119
ice a little bit where people

1220
00:42:21,510 --> 00:42:19,119
scientists hypothesize that there's a

1221
00:42:22,630 --> 00:42:21,520
subsurface ocean underneath

1222
00:42:27,589 --> 00:42:22,640
i think that would be something very

1223
00:42:30,950 --> 00:42:29,190
so i understand that you've been doing

1224
00:42:33,109 --> 00:42:30,960
this test that

1225
00:42:35,349 --> 00:42:33,119
i'm testing the structure and will the

1226
00:42:38,710 --> 00:42:35,359
structure where can it stand up under

1227
00:42:41,349 --> 00:42:38,720
the supersonic forces

1228
00:42:43,510 --> 00:42:41,359
the question of does it work is you know

1229
00:42:45,670 --> 00:42:43,520
can you maintain the integrity of the

1230
00:42:47,670 --> 00:42:45,680
structure will the parachute work the

1231
00:42:49,750 --> 00:42:47,680
other question that strikes me is does

1232
00:42:51,670 --> 00:42:49,760
it work does it decelerate if you

1233
00:42:54,150 --> 00:42:51,680
inflate this thing at supersonic speeds

1234
00:42:55,750 --> 00:42:54,160
does it get slower well so does it work

1235
00:42:57,990 --> 00:42:55,760
can you inflate it will it survive the

1236
00:42:59,750 --> 00:42:58,000
inflation and then once it's inflated

1237
00:43:01,510 --> 00:42:59,760
does it do the job that it needs to does

1238
00:43:03,190 --> 00:43:01,520

it it will decelerate but does it

1239
00:43:05,190 --> 00:43:03,200
decelerate enough does it generate all

1240
00:43:06,230 --> 00:43:05,200
of the drag that you need right does it

1241
00:43:07,750 --> 00:43:06,240
generate

1242
00:43:10,069 --> 00:43:07,760
you know enough force to help slow you

1243
00:43:12,230 --> 00:43:10,079
down in time right because the a mars

1244
00:43:14,470 --> 00:43:12,240
entry is a very very fast process we

1245
00:43:16,230 --> 00:43:14,480
refer to the curiosity landing as seven

1246
00:43:17,430 --> 00:43:16,240
minutes of terror because it takes seven

1247
00:43:19,750 --> 00:43:17,440
minutes to go from the top of the

1248
00:43:21,589 --> 00:43:19,760
atmosphere down to the surface and the

1249
00:43:23,829 --> 00:43:21,599
first two or three of that is taking us

1250
00:43:26,230 --> 00:43:23,839
from uh almost 70 miles above the

1251
00:43:28,309 --> 00:43:26,240
surface down to the final six minutes or

1252
00:43:30,150 --> 00:43:28,319
so maybe six miles above the surface we

1253
00:43:31,829 --> 00:43:30,160
do that part very quickly then we hit

1254
00:43:33,430 --> 00:43:31,839
the emergency brake deploy the parachute

1255
00:43:34,710 --> 00:43:33,440
and we spend the other several minutes

1256
00:43:37,030 --> 00:43:34,720
uh helping slow us down and get us

1257
00:43:38,069 --> 00:43:37,040
safely on the surface so

1258
00:43:39,430 --> 00:43:38,079
that's one of the things that we're

1259
00:43:41,430 --> 00:43:39,440
testing to find out and that's why we

1260
00:43:43,109 --> 00:43:41,440
have to do tests like the high altitude

1261
00:43:44,630 --> 00:43:43,119
test because that performance is

1262
00:43:45,829 --> 00:43:44,640
something that's very much a function of

1263
00:43:48,150 --> 00:43:45,839

the environment in which you're using

1264
00:43:50,069 --> 00:43:48,160
these devices i say environment the

1265
00:43:51,510 --> 00:43:50,079
density of the atmosphere and the speed

1266
00:43:53,270 --> 00:43:51,520
at which it's going

1267
00:43:54,710 --> 00:43:53,280
in particular

1268
00:43:55,750 --> 00:43:54,720
so those are all things that we tasked

1269
00:43:59,589 --> 00:43:55,760
yep

1270
00:44:02,950 --> 00:44:01,109
my name is mark bremmer i'm from

1271
00:44:05,430 --> 00:44:02,960
columbia south carolina

1272
00:44:06,309 --> 00:44:05,440
um yeah actually one question

1273
00:44:09,589 --> 00:44:06,319
when

1274
00:44:11,589 --> 00:44:09,599
like a non

1275
00:44:12,710 --> 00:44:11,599
sort of non-linear trajectory can you

1276
00:44:14,150 --> 00:44:12,720
actually we're going to actually be

1277
00:44:16,150 --> 00:44:14,160
thinking about steering the vehicle to

1278
00:44:18,390 --> 00:44:16,160
do a series of s turns

1279
00:44:20,950 --> 00:44:18,400
so when you come in

1280
00:44:23,109 --> 00:44:20,960
it gives you a lot longer a lot more

1281
00:44:24,309 --> 00:44:23,119
atmosphere so like the show right the

1282
00:44:25,750 --> 00:44:24,319
shuttle does when it comes out i

1283
00:44:27,829 --> 00:44:25,760
actually saw

1284
00:44:29,990 --> 00:44:27,839
a simulation of

1285
00:44:31,349 --> 00:44:30,000
in a thin atmosphere

1286
00:44:33,030 --> 00:44:31,359
so

1287
00:44:35,270 --> 00:44:33,040
lots of good questions in there a little

1288
00:44:36,630 --> 00:44:35,280

bit long of an answer first uh

1289
00:44:38,470 --> 00:44:36,640
hail to colombia i actually went to high

1290
00:44:40,069 --> 00:44:38,480
school at irmo uh which is right outside

1291
00:44:42,230 --> 00:44:40,079
columbia

1292
00:44:43,990 --> 00:44:42,240
um

1293
00:44:45,589 --> 00:44:44,000
do you do we steer the the vehicle well

1294
00:44:48,150 --> 00:44:45,599
for this test flight no we didn't steer

1295
00:44:49,589 --> 00:44:48,160
the vehicle it was a you know passive

1296
00:44:50,870 --> 00:44:49,599
vehicle that we just wanted to get up to

1297
00:44:52,710 --> 00:44:50,880
the conditions that we would be using

1298
00:44:54,470 --> 00:44:52,720
the the inflatable devices in the

1299
00:44:55,910 --> 00:44:54,480
parachute uh

1300
00:44:57,829 --> 00:44:55,920
we did steer the vehicle for the

1301
00:44:59,430 --> 00:44:57,839
curiosity lander one of the nice tricks

1302
00:45:00,950 --> 00:44:59,440
that you can play with a vehicle and

1303
00:45:02,870 --> 00:45:00,960
that we learned even going back to

1304
00:45:05,670 --> 00:45:02,880
viking is that even though it's a very

1305
00:45:06,790 --> 00:45:05,680
blunt shape geometry uh with the drag

1306
00:45:08,950 --> 00:45:06,800
characteristics and stability

1307
00:45:11,510 --> 00:45:08,960
characteristics of a barn door you can

1308
00:45:12,790 --> 00:45:11,520
fly it at an angle and in doing so it

1309
00:45:14,550 --> 00:45:12,800
actually generates a little bit of lift

1310
00:45:16,069 --> 00:45:14,560
not as much lift to say an airplane and

1311
00:45:17,750 --> 00:45:16,079
nothing close to that but even a little

1312
00:45:19,510 --> 00:45:17,760
bit of lift helps a lot when you're

1313
00:45:21,190 --> 00:45:19,520

entering in the martian atmosphere we

1314
00:45:23,430 --> 00:45:21,200
can use that lift to fly higher in the

1315
00:45:25,349 --> 00:45:23,440
martian atmosphere and spin longer

1316
00:45:27,030 --> 00:45:25,359
flying higher we don't come straight in

1317
00:45:28,470 --> 00:45:27,040
we come flying and we try to coast a

1318
00:45:30,390 --> 00:45:28,480
little bit

1319
00:45:31,190 --> 00:45:30,400
we also steer it we do bank it a little

1320
00:45:33,190 --> 00:45:31,200
bit

1321
00:45:34,550 --> 00:45:33,200
to try to give more time decelerating

1322
00:45:35,430 --> 00:45:34,560
but you know

1323
00:45:36,710 --> 00:45:35,440
that's

1324
00:45:38,630 --> 00:45:36,720
you don't have a whole lot of atmosphere

1325
00:45:40,790 --> 00:45:38,640
to do that in and particularly at higher

1326
00:45:41,829 --> 00:45:40,800
altitudes at mars the atmosphere is very

1327
00:45:43,589 --> 00:45:41,839
thin so

1328
00:45:45,030 --> 00:45:43,599
we do it a little bit lower

1329
00:45:49,030 --> 00:45:45,040
but it is one of the the tricks that we

1330
00:45:53,109 --> 00:45:51,430
well thank you very much dr ian clark it

1331
00:45:55,510 --> 00:45:53,119
has been really a pleasure to hear from

1332
00:45:58,630 --> 00:45:55,520
you this afternoon i want to make our

1333
00:46:01,670 --> 00:45:58,640
visitors here and on nasa tv aware in

1334
00:46:04,069 --> 00:46:01,680
2012 dr clark was awarded an uh

1335
00:46:06,150 --> 00:46:04,079
presidential early career in science and

1336
00:46:08,069 --> 00:46:06,160
engineering award and we can see from

1337
00:46:09,670 --> 00:46:08,079
his presentation today

1338
00:46:11,190 --> 00:46:09,680

why the president himself would have

1339
00:46:13,910 --> 00:46:11,200
given him one of the highest science and

1340
00:46:15,589 --> 00:46:13,920
engineering awards in this country we're

1341
00:46:17,990 --> 00:46:15,599
delighted to have had you here as a part

1342
00:46:19,430 --> 00:46:18,000
of the what's new in aerospace program

1343
00:46:21,430 --> 00:46:19,440
here at the national air and space

1344
00:46:24,309 --> 00:46:21,440
museum we're doing this in partnership

1345
00:46:25,670 --> 00:46:24,319
with nasa and thanks to some funding

1346
00:46:27,990 --> 00:46:25,680
from boeing

1347
00:46:29,910 --> 00:46:28,000
and we look forward next year to both

1348
00:46:31,829 --> 00:46:29,920
your successful tests and we will be

1349
00:46:33,190 --> 00:46:31,839
developing the new boeing milestones of

1350
00:46:35,270 --> 00:46:33,200
flight gallery

1351
00:46:36,950 --> 00:46:35,280
so you'll be able to see that here back

1352
00:46:38,390 --> 00:46:36,960
at the museum so thank you for your

1353
00:46:40,390 --> 00:46:38,400
presence here thank you to the school

1354
00:46:42,069 --> 00:46:40,400
children who joined us and thank you to