
IRVE3

1
00:00:08,720 --> 00:00:16,300
[Music]

2
00:00:21,710 --> 00:00:19,130
for those of us who are excited by the

3
00:00:23,090 --> 00:00:21,720
idea of space travel we recently got

4
00:00:26,030 --> 00:00:23,100
some good news

5
00:00:29,110 --> 00:00:26,040
NASA is looking into the idea of sending

6
00:00:40,720 --> 00:00:29,120
humans to Mars as early as the late

7
00:00:46,360 --> 00:00:43,690
that means ideas and hardware designed

8
00:00:49,630 --> 00:00:46,370
to get us to Mars is now being ramped up

9
00:00:51,760 --> 00:00:49,640
to meet this challenge but if you ask

10
00:00:53,760 --> 00:00:51,770
anyone who has ever been involved with

11
00:00:56,890 --> 00:00:53,770
the Mars mission they will tell you that

12
00:01:00,100 --> 00:00:56,900
successfully landing on or orbiting Mars

13
00:01:02,410 --> 00:01:00,110

is incredibly difficult in fact of the

14
00:01:05,079 --> 00:01:02,420
more than 40 missions that humans have

15
00:01:15,120 --> 00:01:05,089
previously sent to Mars less than half

16
00:01:20,680 --> 00:01:17,950
one of the major challenges that face

17
00:01:23,500 --> 00:01:20,690
NASA researchers is how to deliver heavy

18
00:01:26,590 --> 00:01:23,510
equipment and people safely to the

19
00:01:28,600 --> 00:01:26,600
surface of Mars popular movies and

20
00:01:31,360 --> 00:01:28,610
science fiction articles make landing on

21
00:01:32,860 --> 00:01:31,370
a planet look easy but in fact that is

22
00:01:35,469 --> 00:01:32,870
where the hardest elements to achieve

23
00:01:37,600 --> 00:01:35,479
there are a host of aerodynamic and

24
00:01:40,350 --> 00:01:37,610
physics issues that engineers need to

25
00:01:43,300 --> 00:01:40,360
overcome first and foremost is

26
00:01:45,760 --> 00:01:43,310
decelerating a spacecraft traveling many

27
00:01:48,460 --> 00:01:45,770
times faster than a bullet and allow it

28
00:01:50,859 --> 00:01:48,470
to gently land with precision onto

29
00:01:53,950 --> 00:01:50,869
another planetary surface hundreds of

30
00:01:56,230 --> 00:01:53,960
millions of miles away to date the

31
00:01:58,900 --> 00:01:56,240
maximum weight we have landed on Mars is

32
00:02:02,350 --> 00:01:58,910
about one time but when humans arrive

33
00:02:05,410 --> 00:02:02,360
we'll need to land 15 to 20 tons onto

34
00:02:08,229 --> 00:02:05,420
the surface the only way to accomplish

35
00:02:11,110 --> 00:02:08,239
this feat is to innovate and come up

36
00:02:13,860 --> 00:02:11,120
with a new strategy a small group of

37
00:02:16,900 --> 00:02:13,870
dedicated NASA engineers researchers

38
00:02:19,270 --> 00:02:16,910

designers and craftspeople are currently

39
00:02:22,180 --> 00:02:19,280
working on making a safe entry into the

40
00:02:24,910 --> 00:02:22,190
Mars atmosphere possible the technology

41
00:02:27,699 --> 00:02:24,920
is called kayak for hypersonic

42
00:02:30,580 --> 00:02:27,709
inflatable aerodynamic decelerator and

43
00:02:32,770 --> 00:02:30,590
it promises to redefine how we deliver

44
00:02:36,340 --> 00:02:32,780
spacecraft to Mars and other planets

45
00:02:39,940 --> 00:02:36,350
with atmospheres coming up on this

46
00:02:42,550 --> 00:02:39,950
episode of NASA X we will take a look at

47
00:02:44,920 --> 00:02:42,560
the difficulties associated with landing

48
00:02:47,770 --> 00:02:44,930
on a planet like Mars and see how the

49
00:02:49,930 --> 00:02:47,780
nasa hyatt team plans to overcome the

50
00:02:52,690 --> 00:02:49,940
tremendous challenges faced with landing

51
00:02:54,610 --> 00:02:52,700
there we will also visit the labs and

52
00:02:57,400 --> 00:02:54,620
partner companies who are helping to

53
00:03:07,120 --> 00:02:57,410
build high ad and see firsthand what

54
00:03:07,130 --> 00:03:21,640
[Music]

55
00:03:27,680 --> 00:03:25,790
entry descent and landing or EDL is one

56
00:03:28,640 --> 00:03:27,690
of the most challenging aspects of any

57
00:03:31,520 --> 00:03:28,650
Lander mission

58
00:03:33,160 --> 00:03:31,530
that's because landing the spacecraft is

59
00:03:35,630 --> 00:03:33,170
hard

60
00:03:37,080 --> 00:03:35,640
whether you are landing it back here on

61
00:03:41,070 --> 00:03:37,090
earth

62
00:03:43,740 --> 00:03:41,080
or on another planet like Mars although

63
00:03:46,410 --> 00:03:43,750

it's not easy on either planet Earth's

64
00:03:48,720 --> 00:03:46,420
atmosphere does offer more help to slow

65
00:03:51,240 --> 00:03:48,730
down a speeding spacecraft this is

66
00:03:54,360 --> 00:03:51,250
because our atmosphere is dense compared

67
00:03:57,059 --> 00:03:54,370
to Mars when a spacecraft flies through

68
00:03:59,790 --> 00:03:57,069
an atmosphere aerodynamic forces act

69
00:04:01,920 --> 00:03:59,800
upon it to help slow it down the drag

70
00:04:03,809 --> 00:04:01,930
that is created on the craft allows it

71
00:04:06,420 --> 00:04:03,819
to decelerate to the point where

72
00:04:08,250 --> 00:04:06,430
subsonic parachutes can be deployed or

73
00:04:12,270 --> 00:04:08,260
in the case of the shuttle where a

74
00:04:14,670 --> 00:04:12,280
guided landing could occur the same

75
00:04:17,280 --> 00:04:14,680
can't be said for a Mars landing the

76
00:04:18,330 --> 00:04:17,290
Martian atmosphere is very thin and much

77
00:04:20,969 --> 00:04:18,340
different than Earth's

78
00:04:23,460 --> 00:04:20,979
in fact the densest portion of the

79
00:04:26,100 --> 00:04:23,470
Martian atmosphere is only about as

80
00:04:29,520 --> 00:04:26,110
thick as our atmosphere is at a hundred

81
00:04:30,920 --> 00:04:29,530
thousand feet as a result a spacecraft

82
00:04:34,440 --> 00:04:30,930
flying through the Martian atmosphere

83
00:04:36,420 --> 00:04:34,450
does not generate as much drag so it

84
00:04:39,150 --> 00:04:36,430
cannot be slowed down as quickly as it

85
00:04:41,909 --> 00:04:39,160
could back on earth for most laypeople

86
00:04:45,300 --> 00:04:41,919
to immediate thoughts may come to mind

87
00:04:49,100 --> 00:04:45,310
about how to slow a craft at Mars the

88
00:04:51,990 --> 00:04:49,110

first is to use rocket propulsion in

89
00:04:53,850 --> 00:04:52,000
theory this is a good plan but in

90
00:04:57,300 --> 00:04:53,860
actuality the amount of fuel needed

91
00:05:00,150 --> 00:04:57,310
would be enormous one NASA study

92
00:05:03,630 --> 00:05:00,160
determined that landing 40 tons on the

93
00:05:06,420 --> 00:05:03,640
surface of Mars would require over 60

94
00:05:08,279 --> 00:05:06,430
tons of rocket fuel the other thought is

95
00:05:11,040 --> 00:05:08,289
to use giant parachutes

96
00:05:12,570 --> 00:05:11,050
however this much mass would require a

97
00:05:15,270 --> 00:05:12,580
cluster of parachutes

98
00:05:17,340 --> 00:05:15,280
each the size of a football field to be

99
00:05:20,460 --> 00:05:17,350
deployed while traveling more than 2

100
00:05:22,650 --> 00:05:20,470
times the speed of sound so to the high

101
00:05:25,800 --> 00:05:22,660
ad team working on this problem the

102
00:05:28,370 --> 00:05:25,810
solution is clear use a larger vehicle

103
00:05:31,060 --> 00:05:28,380
so that the Martian atmosphere slow

104
00:05:33,140 --> 00:05:31,070
astound higher up in the atmosphere

105
00:05:35,660 --> 00:05:33,150
previous missions have used the

106
00:05:38,780 --> 00:05:35,670
atmosphere to successfully slow a craft

107
00:05:40,970 --> 00:05:38,790
but the mass and entry speed of the

108
00:05:43,640 --> 00:05:40,980
spacecraft coupled with the thin

109
00:05:46,520 --> 00:05:43,650
atmosphere limited landing areas to only

110
00:05:50,300 --> 00:05:46,530
the lowest elevations on the planet

111
00:05:52,280 --> 00:05:50,310
in fact currently only 40% of the

112
00:05:55,640 --> 00:05:52,290
Martian surface is accessible for

113
00:05:57,500 --> 00:05:55,650

one-time payloads clearly these are

114
00:06:00,320 --> 00:05:57,510
major issues that must be overcome

115
00:06:03,620 --> 00:06:00,330
before we can send larger payloads and

116
00:06:06,800 --> 00:06:03,630
eventually humans to Mars so how do we

117
00:06:08,930 --> 00:06:06,810
overcome all these obstacles here at

118
00:06:11,240 --> 00:06:08,940
NASA a group of engineers and

119
00:06:12,890 --> 00:06:11,250
researchers are working on that exact

120
00:06:15,140 --> 00:06:12,900
problem and they have come up with a

121
00:06:16,790 --> 00:06:15,150
solution that looks like the most viable

122
00:06:19,730 --> 00:06:16,800
option available to us

123
00:06:22,970 --> 00:06:19,740
they call it hi add or hypersonic

124
00:06:26,360 --> 00:06:22,980
inflatable aerodynamic decelerator here

125
00:06:29,390 --> 00:06:26,370
is dr. Neil Cheatwood to explain if you

126
00:06:31,970 --> 00:06:29,400
look at how we get to Mars now we're

127
00:06:34,070 --> 00:06:31,980
using the technologies that we developed

128
00:06:35,690 --> 00:06:34,080
back in the 60s and 70s for project

129
00:06:37,700 --> 00:06:35,700
vacuuming and that was the first time we

130
00:06:39,920 --> 00:06:37,710
successfully landed on Mars way back

131
00:06:42,320 --> 00:06:39,930
when in the 60s and 70s project Viking

132
00:06:44,720 --> 00:06:42,330
had a technology development effort and

133
00:06:46,190 --> 00:06:44,730
that's where they developed a thermal

134
00:06:49,120 --> 00:06:46,200
protection system and it's known as

135
00:06:52,490 --> 00:06:49,130
Bob's SLA superlight weight of blade ur

136
00:06:54,290 --> 00:06:52,500
561 V for Viking and we've been using

137
00:06:56,620 --> 00:06:54,300
that for every successful mission to

138
00:07:00,140 --> 00:06:56,630

Mars up until our most recent adventure

139
00:07:02,330 --> 00:07:00,150
the Curiosity rover so we had that TPS

140
00:07:04,160 --> 00:07:02,340
that was heritage from way back when the

141
00:07:05,780 --> 00:07:04,170
disc cap BAM parachute the supersonic

142
00:07:08,510 --> 00:07:05,790
parachute was developed under the Viking

143
00:07:10,340 --> 00:07:08,520
program and we're still using all these

144
00:07:12,950 --> 00:07:10,350
things we're still flying the same air

145
00:07:15,770 --> 00:07:12,960
shell for body shape that we had from

146
00:07:19,010 --> 00:07:15,780
project Viking so we've been living off

147
00:07:21,110 --> 00:07:19,020
of that heritage out for that legacy but

148
00:07:24,050 --> 00:07:21,120
with the Curiosity rover we basically

149
00:07:26,660 --> 00:07:24,060
landed as much mass as we possibly can

150
00:07:28,100 --> 00:07:26,670
at Mars at least at that altitude if we

151
00:07:31,310 --> 00:07:28,110
tried to land more we would end up

152
00:07:34,250 --> 00:07:31,320
hitting the surface before we achieved

153
00:07:36,270 --> 00:07:34,260
all the the sequence of events that we

154
00:07:38,280 --> 00:07:36,280
had to achieve in a timeline

155
00:07:41,280 --> 00:07:38,290
if we wanted to land that same Rover at

156
00:07:42,930 --> 00:07:41,290
a higher altitude also we would run out

157
00:07:44,790 --> 00:07:42,940
of time we'd hit the ground before we

158
00:07:47,820 --> 00:07:44,800
finished everything we needed to do and

159
00:07:50,880 --> 00:07:47,830
so that really that motive was our

160
00:07:53,550 --> 00:07:50,890
motivation when we we started looking at

161
00:07:56,250 --> 00:07:53,560
Kirby the first earthly mission and so

162
00:07:59,640 --> 00:07:56,260
what we what we had done one of the guys

163
00:08:02,730 --> 00:07:59,650

that was involved in this had had you

164
00:08:03,960 --> 00:08:02,740
know done some research and seen a

165
00:08:06,210 --> 00:08:03,970
concept that the Russians were

166
00:08:07,860 --> 00:08:06,220
developing and they tried flying this

167
00:08:10,080 --> 00:08:07,870
inflatable aeroshell sometimes where you

168
00:08:12,360 --> 00:08:10,090
could deploy something bigger and a

169
00:08:15,210 --> 00:08:12,370
larger drag device lets you slow down

170
00:08:17,220 --> 00:08:15,220
faster so you can either land that same

171
00:08:19,560 --> 00:08:17,230
mass at a higher altitude adjustment

172
00:08:21,270 --> 00:08:19,570
falls out of the equations or you could

173
00:08:23,159 --> 00:08:21,280
bring in more mass and land it at the

174
00:08:25,230 --> 00:08:23,169
same location so we were looking at

175
00:08:28,380 --> 00:08:25,240
deployable devices the Russians were

176
00:08:29,970 --> 00:08:28,390
looking at this inflatable aeroshell but

177
00:08:32,969 --> 00:08:29,980
they covered theirs with an ablative

178
00:08:36,149 --> 00:08:32,979
thermal protection system and we were

179
00:08:38,730 --> 00:08:36,159
concerned that maybe that wasn't the way

180
00:08:40,110 --> 00:08:38,740
to go and so we started looking at a one

181
00:08:42,800 --> 00:08:40,120
that poor we could just make it bigger

182
00:08:45,450 --> 00:08:42,810
so he keeps the heat rate down lower and

183
00:08:48,090 --> 00:08:45,460
not using a blade but with the human

184
00:08:50,340 --> 00:08:48,100
scale now you won't land 40 metric tons

185
00:08:52,200 --> 00:08:50,350
or certainly at least 20 metric tons it

186
00:08:54,150 --> 00:08:52,210
is like holy cow how you gonna do that

187
00:08:56,070 --> 00:08:54,160
let's talk some numbers with the

188
00:08:58,770 --> 00:08:56,080

Curiosity rover that mission the Mars

189
00:09:01,980 --> 00:08:58,780
Science Laboratory is the largest

190
00:09:03,329 --> 00:09:01,990
aeroshell we've ever built so the air

191
00:09:05,160 --> 00:09:03,339
shell is what protects us when we go

192
00:09:08,190 --> 00:09:05,170
through the atmosphere and say it's a

193
00:09:10,829 --> 00:09:08,200
cocoon for our payload for our science

194
00:09:12,240 --> 00:09:10,839
so that that structure that protects

195
00:09:13,500 --> 00:09:12,250
that and to protect the structure we

196
00:09:17,160 --> 00:09:13,510
have to have that heat shield that

197
00:09:20,370 --> 00:09:17,170
protects us that era shell for her MSL

198
00:09:21,570 --> 00:09:20,380
is Mars Science Laboratory is a little

199
00:09:23,130 --> 00:09:21,580
over four and a half meters in diameter

200
00:09:24,810 --> 00:09:23,140
biggest one we've ever built

201
00:09:27,840 --> 00:09:24,820
it's bigger than Apollo bigger than

202
00:09:31,620 --> 00:09:27,850
anything it's it's a big area even with

203
00:09:33,180 --> 00:09:31,630
that large era shell what it contains

204
00:09:36,210 --> 00:09:33,190
within that Rover and all the

205
00:09:39,390 --> 00:09:36,220
experiments are so heavy that we can't

206
00:09:41,160 --> 00:09:39,400
decelerate fast enough to reach the

207
00:09:43,439 --> 00:09:41,170
higher altitudes of Mars

208
00:09:45,809 --> 00:09:43,449
in fact the best we can do with that

209
00:09:48,900 --> 00:09:45,819
system we can't even get to what was the

210
00:09:52,169 --> 00:09:48,910
Mars sea level so we're landing below

211
00:09:55,349 --> 00:09:52,179
what was Martian sea level where it

212
00:09:57,869 --> 00:09:55,359
ultimately landed is about minus one

213
00:10:00,389 --> 00:09:57,879

kilometer so a kilometer below that sea

214
00:10:05,099 --> 00:10:00,399
level location because it's just so

215
00:10:06,539 --> 00:10:05,109
heavy if we had a larger era shell then

216
00:10:10,099 --> 00:10:06,549
we could decelerate that mass sooner

217
00:10:12,659 --> 00:10:10,109
that larger aeroshell could be a high ad

218
00:10:14,879 --> 00:10:12,669
because the launch vehicle can only

219
00:10:17,359 --> 00:10:14,889
physically accommodate a certain size

220
00:10:19,889 --> 00:10:17,369
payload to fit inside the fairing

221
00:10:22,530 --> 00:10:19,899
Engineers believe that an inflatable

222
00:10:25,109 --> 00:10:22,540
aeroshell is the best answer to get

223
00:10:28,229 --> 00:10:25,119
larger mass items onto other planetary

224
00:10:30,539 --> 00:10:28,239
surfaces with atmospheres the basic

225
00:10:32,999 --> 00:10:30,549
concept of a high ad is pretty simple

226
00:10:36,269 --> 00:10:33,009
the payload is placed in the center

227
00:10:38,609 --> 00:10:36,279
surrounded by a group of rings or tor I

228
00:10:41,340 --> 00:10:38,619
that look very similar to large inner

229
00:10:43,559 --> 00:10:41,350
tubes the tour I are stacked in such a

230
00:10:45,539 --> 00:10:43,569
way that different diameters will be

231
00:10:48,629 --> 00:10:45,549
stacked one on top of each other and

232
00:10:50,909 --> 00:10:48,639
strapped together then a flexible

233
00:10:53,400 --> 00:10:50,919
thermal protection system is placed

234
00:10:56,489 --> 00:10:53,410
around them to create a more smooth and

235
00:10:59,400 --> 00:10:56,499
heat resistant surface the materials

236
00:11:02,220 --> 00:10:59,410
used are incredibly strong fabrics like

237
00:11:05,639 --> 00:11:02,230
Xylon and Kevlar but can also easily

238
00:11:08,159 --> 00:11:05,649

fold into the rocket shroud once

239
00:11:10,379 --> 00:11:08,169
inflated these crafts can become

240
00:11:13,019 --> 00:11:10,389
stronger than steel and handle

241
00:11:16,280 --> 00:11:13,029
tremendous loads well one thing that

242
00:11:21,079 --> 00:11:16,290
maybe can give people an idea of how

243
00:11:24,479 --> 00:11:21,089
structurally strong and durable these

244
00:11:27,359 --> 00:11:24,489
inflatables are is that a 15-meter

245
00:11:29,309 --> 00:11:27,369
design of a Flavel Aero shell is

246
00:11:32,129 --> 00:11:29,319
designed to take a load of about 300

247
00:11:33,900 --> 00:11:32,139
thousand pounds during entry so 300

248
00:11:35,759 --> 00:11:33,910
thousand pounds is approximately a

249
00:11:38,720 --> 00:11:35,769
hundred cars so if you think of hundred

250
00:11:41,729 --> 00:11:38,730
stacking 100 vehicles on top of this

251
00:11:44,309 --> 00:11:41,739
fabric structure is very impressive that

252
00:11:45,250 --> 00:11:44,319
structured this made out of cloth and

253
00:11:47,500 --> 00:11:45,260
and

254
00:11:50,860 --> 00:11:47,510
woven materials can take that kind of

255
00:11:53,590 --> 00:11:50,870
load once the craft arrives at its

256
00:11:56,790 --> 00:11:53,600
destination the Hyatt will inflate to

257
00:11:58,810 --> 00:11:56,800
enter the atmosphere all of these strong

258
00:12:01,360 --> 00:11:58,820
heat-resistant materials will act

259
00:12:03,550 --> 00:12:01,370
together to keep the payload safe from

260
00:12:06,010 --> 00:12:03,560
heating while slowing the craft down

261
00:12:08,530 --> 00:12:06,020
long enough to land at virtually any

262
00:12:10,540 --> 00:12:08,540
location this device has already

263
00:12:12,850 --> 00:12:10,550

undergone spaceflight tests and has

264
00:12:14,980 --> 00:12:12,860
proven to be incredibly successful it

265
00:12:19,390 --> 00:12:14,990
has been flight tested twice most

266
00:12:22,630 --> 00:12:19,400
recently on a test called ERV III ERV

267
00:12:24,850 --> 00:12:22,640
III launched in 2012 from the NASA

268
00:12:26,710 --> 00:12:24,860
Wallops Flight Facility on Virginia's

269
00:12:29,380 --> 00:12:26,720
Eastern Shore although it was a

270
00:12:31,930 --> 00:12:29,390
relatively small test the data that it

271
00:12:34,270 --> 00:12:31,940
produced gave the team the confidence

272
00:12:35,050 --> 00:12:34,280
they needed to continue exploring this

273
00:12:37,870 --> 00:12:35,060
concept

274
00:12:41,010 --> 00:12:37,880
ERV III entered Earth's atmosphere at

275
00:12:43,150 --> 00:12:41,020
Mach 10 10 times the speed of sound and

276
00:12:45,250 --> 00:12:43,160
successfully survived the heat and

277
00:12:47,530 --> 00:12:45,260
forces of the journey temperature

278
00:12:49,960 --> 00:12:47,540
readings recorded on this suborbital

279
00:12:52,360 --> 00:12:49,970
test were as much as 1,000 degrees

280
00:12:56,020 --> 00:12:52,370
Fahrenheit and the device experienced

281
00:12:58,150 --> 00:12:56,030
forces up to 20 G's this test opened the

282
00:13:00,490 --> 00:12:58,160
doors to larger missions and the

283
00:13:04,030 --> 00:13:00,500
opportunity to construct larger high

284
00:13:06,970 --> 00:13:04,040
adds up next we'll see how a new Hyatt

285
00:13:09,620 --> 00:13:06,980
article is custom made by hand in a

286
00:13:14,730 --> 00:13:09,630
unique facility in California

287
00:13:14,740 --> 00:13:26,889
[Music]

288
00:13:33,139 --> 00:13:30,350

when you think about building a craft to

289
00:13:35,240 --> 00:13:33,149
travel to other planets you may think

290
00:13:37,579 --> 00:13:35,250
about men and women and pristine

291
00:13:40,429 --> 00:13:37,589
buildings coming up with designs and

292
00:13:43,249 --> 00:13:40,439
concepts on the computer then high-tech

293
00:13:45,769 --> 00:13:43,259
machines and tools used to help put them

294
00:13:47,869 --> 00:13:45,779
together in truth that is how many

295
00:13:50,389 --> 00:13:47,879
crafts are built but in these early

296
00:13:51,949 --> 00:13:50,399
stages of high ad testing the places

297
00:13:54,259 --> 00:13:51,959
where these devices are being

298
00:13:56,660 --> 00:13:54,269
constructed look more like workshops

299
00:13:58,790 --> 00:13:56,670
than pristine clean rooms and although

300
00:14:01,280 --> 00:13:58,800
the men and women working on this

301
00:14:03,410 --> 00:14:01,290
concept are using computers to aid in

302
00:14:05,329 --> 00:14:03,420
their development there are also skilled

303
00:14:08,240 --> 00:14:05,339
craftspeople that are putting together

304
00:14:10,879 --> 00:14:08,250
these devices just like a fine tailor

305
00:14:13,340 --> 00:14:10,889
may put together a suit here in this

306
00:14:15,980 --> 00:14:13,350
nondescript building in California

307
00:14:18,199 --> 00:14:15,990
you can see how these fabric pieces are

308
00:14:19,699 --> 00:14:18,209
put together they're tailored it's it's

309
00:14:21,470 --> 00:14:19,709
an art form I mean you can't just plug

310
00:14:24,490 --> 00:14:21,480
it into a computer and spit it out and

311
00:14:26,660 --> 00:14:24,500
make this there's there's a hands-on

312
00:14:28,939 --> 00:14:26,670
huge hands-on influence and that's

313
00:14:30,710 --> 00:14:28,949

mostly where my site comes in

314
00:14:33,110 --> 00:14:30,720
communication with how to build these

315
00:14:34,699 --> 00:14:33,120
things figure out how to get the in

316
00:14:35,929 --> 00:14:34,709
finished product we want from materials

317
00:14:37,879 --> 00:14:35,939
we've never worked with before in our

318
00:14:40,040 --> 00:14:37,889
lives there's the major components to a

319
00:14:42,499 --> 00:14:40,050
torus we have the braid which is outer

320
00:14:44,509 --> 00:14:42,509
material you see with the criss cross we

321
00:14:46,970 --> 00:14:44,519
have the liner which is inside of that

322
00:14:49,550 --> 00:14:46,980
which is the seal it basically keeps the

323
00:14:51,829 --> 00:14:49,560
air from leaking out and then we have a

324
00:14:55,189 --> 00:14:51,839
adhesive we use for coating and for

325
00:14:57,439 --> 00:14:55,199
bonding all the pieces together on the

326
00:14:59,600 --> 00:14:57,449
table everything's laid out flat so we

327
00:15:01,040 --> 00:14:59,610
it's it's not in this curved shape when

328
00:15:01,970 --> 00:15:01,050
we're building it it's straight in the

329
00:15:04,670 --> 00:15:01,980
tube

330
00:15:07,329 --> 00:15:04,680
we take our measurements straight we use

331
00:15:10,519 --> 00:15:07,339
squares and basic tape measures rulers

332
00:15:13,249 --> 00:15:10,529
marked with a permanent marker and make

333
00:15:14,809 --> 00:15:13,259
a cut with the ends it's like a end of a

334
00:15:16,970 --> 00:15:14,819
t-shirt if you could cut it and it'll

335
00:15:18,829 --> 00:15:16,980
fray we have to kind of doctor the ends

336
00:15:20,650 --> 00:15:18,839
up to make sure that

337
00:15:23,360 --> 00:15:20,660
they don't fray unravel so we can

338
00:15:25,550 --> 00:15:23,370

consistently have our lengths we wanted

339
00:15:27,199 --> 00:15:25,560
these liners can be 200 feet long and

340
00:15:28,850 --> 00:15:27,209
there's a line that I've drawn that I

341
00:15:32,060 --> 00:15:28,860
have to keep and I'm just walking along

342
00:15:33,949 --> 00:15:32,070
and cut this line but because there's no

343
00:15:35,780 --> 00:15:33,959
machine that's out there to make it cut

344
00:15:36,889 --> 00:15:35,790
that long so we're and at this stage

345
00:15:39,440 --> 00:15:36,899
where it's all handwork

346
00:15:41,150 --> 00:15:39,450
so we basically pieced it together and

347
00:15:44,449 --> 00:15:41,160
if the piece isn't wide enough like the

348
00:15:45,860 --> 00:15:44,459
the liner inside the the Taurus consists

349
00:15:47,630 --> 00:15:45,870
of three different pieces it's got

350
00:15:49,819 --> 00:15:47,640
because the materials not wide enough to

351
00:15:52,699 --> 00:15:49,829
go around we have to put seams together

352
00:15:54,710 --> 00:15:52,709
to figure the size we want so I have to

353
00:15:57,170 --> 00:15:54,720
know I cut the panels and line them up

354
00:15:59,690 --> 00:15:57,180
then I have to bottom up and then glue

355
00:16:02,180 --> 00:15:59,700
the panels together with an RVT adhesive

356
00:16:05,720 --> 00:16:02,190
we use the yellow and red one are both

357
00:16:08,210 --> 00:16:05,730
the same construction the yellow one

358
00:16:10,910 --> 00:16:08,220
hasn't been coated yet so it is it's

359
00:16:12,490 --> 00:16:10,920
built to the right shape but they all

360
00:16:14,990 --> 00:16:12,500
the pieces haven't been tied together

361
00:16:16,699 --> 00:16:15,000
when the braids finished like this this

362
00:16:18,710 --> 00:16:16,709
is uncoated so if you take the pressure

363
00:16:21,139 --> 00:16:18,720

out of this article right now the braid

364
00:16:23,269 --> 00:16:21,149
will get completely disorganized and the

365
00:16:24,920 --> 00:16:23,279
gasper inside the braid would actually

366
00:16:26,449 --> 00:16:24,930
become disassociated with the outer

367
00:16:28,880 --> 00:16:26,459
layer so when you want to inflate it

368
00:16:32,360 --> 00:16:28,890
again the barrier would probably wrinkle

369
00:16:34,009 --> 00:16:32,370
up inside and you have localized

370
00:16:35,900 --> 00:16:34,019
elongation though they see the

371
00:16:37,610 --> 00:16:35,910
capabilities the material and probably

372
00:16:39,500 --> 00:16:37,620
the spring leaks in it and also the

373
00:16:42,410 --> 00:16:39,510
braid itself would would tend to open up

374
00:16:43,970 --> 00:16:42,420
the gaps so before we can deflate it we

375
00:16:47,900 --> 00:16:43,980
have to coat it and we use this high

376
00:16:50,360 --> 00:16:47,910
temperature silicone coating it's a RTV

377
00:16:52,699 --> 00:16:50,370
that we put on it it helps organize the

378
00:16:56,120 --> 00:16:52,709
braid and it also we we push it through

379
00:16:58,160 --> 00:16:56,130
the material so that it adheres to the

380
00:17:00,710 --> 00:16:58,170
gas barrier on the inside so those stay

381
00:17:03,890 --> 00:17:00,720
locked together in the matrix

382
00:17:07,100 --> 00:17:03,900
after putting together these tour I the

383
00:17:09,740 --> 00:17:07,110
next step is to begin testing up next

384
00:17:11,929 --> 00:17:09,750
the article is placed inside a hydro rig

385
00:17:17,950 --> 00:17:11,939
while engineers test the high adds

386
00:17:17,960 --> 00:17:32,620
[Music]

387
00:17:39,110 --> 00:17:36,500
guess they were performing a a test to

388
00:17:41,029 --> 00:17:39,120

prove that the the article could take a

389
00:17:42,799 --> 00:17:41,039
certain amount of pressure inside of it

390
00:17:46,730 --> 00:17:42,809
I have to work around this thing if the

391
00:17:48,650 --> 00:17:46,740
pressure gets increased in them the with

392
00:17:50,060 --> 00:17:48,660
air inside of it if it pops like a

393
00:17:51,350 --> 00:17:50,070
balloon you pop a balloon and even

394
00:17:52,580 --> 00:17:51,360
though it's got very much don't how much

395
00:17:54,169 --> 00:17:52,590
pressure and you pop it makes a loud

396
00:17:55,970 --> 00:17:54,179
noise there's this energy going

397
00:17:57,919 --> 00:17:55,980
somewhere if you take a water balloon

398
00:17:58,940 --> 00:17:57,929
and put it under water and pop it

399
00:18:00,260 --> 00:17:58,950
the only thing you're going to see is

400
00:18:01,640 --> 00:18:00,270
you're gonna see the outside the balloon

401
00:18:03,620 --> 00:18:01,650
just kind of disappear you're not going

402
00:18:05,779 --> 00:18:03,630
to have any of this effect or or or

403
00:18:07,190 --> 00:18:05,789
movement so what we were doing is we're

404
00:18:09,890 --> 00:18:07,200
testing the article to a high pressure

405
00:18:11,630 --> 00:18:09,900
that we calculated would be good too but

406
00:18:13,580 --> 00:18:11,640
we we don't want to test it with air

407
00:18:16,549 --> 00:18:13,590
because if it did pop or rupture have a

408
00:18:19,520 --> 00:18:16,559
failure then it would be like a balloon

409
00:18:21,110 --> 00:18:19,530
on steroids so by by putting underwater

410
00:18:22,870 --> 00:18:21,120
filling it with water taking it to a

411
00:18:25,430 --> 00:18:22,880
pressure which is higher than we'd ever

412
00:18:27,470 --> 00:18:25,440
operate it out we have that cushion in

413
00:18:29,630 --> 00:18:27,480

that a comfort level I can stand next to

414
00:18:32,720 --> 00:18:29,640
it and know that it's been it's safe to

415
00:18:35,049 --> 00:18:32,730
operate and be around so as lead for the

416
00:18:37,789 --> 00:18:35,059
inflatable structures development I'm

417
00:18:39,770 --> 00:18:37,799
working with a group of engineers we're

418
00:18:42,049 --> 00:18:39,780
doing analysis work to structurally

419
00:18:43,549 --> 00:18:42,059
analyze to be at the design to make sure

420
00:18:46,279 --> 00:18:43,559
I can take the the loads that are being

421
00:18:48,770 --> 00:18:46,289
applied we have to also look at the

422
00:18:50,299 --> 00:18:48,780
thermal properties of the material so it

423
00:18:52,039 --> 00:18:50,309
can withstand the heat in environment

424
00:18:55,220 --> 00:18:52,049
and we're also doing a lot of material

425
00:18:57,140 --> 00:18:55,230
testing so everything from testing from

426
00:18:59,210 --> 00:18:57,150
the strength of materials to of being

427
00:19:01,430 --> 00:18:59,220
able to withstand the temperatures the

428
00:19:04,250 --> 00:19:01,440
team has good data about these smaller

429
00:19:07,310 --> 00:19:04,260
tor i but if we are to use this concept

430
00:19:10,399 --> 00:19:07,320
to eventually land humans on Mars we

431
00:19:11,899 --> 00:19:10,409
must get these sizes much larger one

432
00:19:13,390 --> 00:19:11,909
thing about soft goods is they're hard

433
00:19:15,160 --> 00:19:13,400
to characterize

434
00:19:18,040 --> 00:19:15,170
you know we have a lot of analytical

435
00:19:19,270 --> 00:19:18,050
models that we have pretty good faith in

436
00:19:22,210 --> 00:19:19,280
now that we've developed over the course

437
00:19:23,830 --> 00:19:22,220
of the hai project but still as we make

438
00:19:25,330 --> 00:19:23,840

these large jumps you know there's not a

439
00:19:27,250 --> 00:19:25,340
lot of faith in them and so the only

440
00:19:29,740 --> 00:19:27,260
real way to get data is to build these

441
00:19:31,870 --> 00:19:29,750
things and test them the tour I stack

442
00:19:35,020 --> 00:19:31,880
that is being manufactured here in

443
00:19:37,330 --> 00:19:35,030
California is the structure the interior

444
00:19:39,880 --> 00:19:37,340
piece of the high ad but the flexible

445
00:19:42,490 --> 00:19:39,890
heat shield the external piece is being

446
00:19:45,130 --> 00:19:42,500
designed and built across the country in

447
00:19:47,650 --> 00:19:45,140
Dover New Hampshire at this facility a

448
00:19:50,170 --> 00:19:47,660
small team is developing the process

449
00:19:52,840 --> 00:19:50,180
that will be used to sew together the

450
00:19:55,080 --> 00:19:52,850
cutting edge materials used on the

451
00:19:57,910 --> 00:19:55,090
exterior of the high ad structure

452
00:20:00,430 --> 00:19:57,920
because the external shielding will see

453
00:20:02,830 --> 00:20:00,440
the highest temperatures it must be made

454
00:20:05,200 --> 00:20:02,840
from materials that can withstand the

455
00:20:07,300 --> 00:20:05,210
massive heating environment the high app

456
00:20:10,300 --> 00:20:07,310
will encounter flexible thermal

457
00:20:12,250 --> 00:20:10,310
protection systems part of a re-entry

458
00:20:14,580 --> 00:20:12,260
system that could be used to bring

459
00:20:17,230 --> 00:20:14,590
things back from the space station or

460
00:20:19,660 --> 00:20:17,240
ultimately go out and provide larger

461
00:20:21,340 --> 00:20:19,670
payloads out to Mars it incorporates a

462
00:20:24,670 --> 00:20:21,350
thermal protection system outer layer

463
00:20:27,370 --> 00:20:24,680

with an inflatable interior portion

464
00:20:30,340 --> 00:20:27,380
which provides the shape and stability

465
00:20:32,950 --> 00:20:30,350
the fabric is silicon carbide which

466
00:20:35,440 --> 00:20:32,960
allows it to take the high heat loads

467
00:20:38,810 --> 00:20:35,450
unlike other materials that we've tried

468
00:20:44,310 --> 00:20:41,580
the insulating layers are carbon felts

469
00:20:47,760 --> 00:20:44,320
and an aerogel material they're backed

470
00:20:50,100 --> 00:20:47,770
up by a gas barrier which prevents any

471
00:20:52,440 --> 00:20:50,110
gas is flowing through the entire system

472
00:20:55,370 --> 00:20:52,450
so the highest temperature rated

473
00:20:57,840 --> 00:20:55,380
materials on the outside and any

474
00:21:00,330 --> 00:20:57,850
insulators to prevent the gas barrier

475
00:21:03,030 --> 00:21:00,340
from over tamping although this material

476
00:21:05,130 --> 00:21:03,040
is incredibly resistant to heating it is

477
00:21:07,860 --> 00:21:05,140
somewhat challenging to manipulate in

478
00:21:10,380 --> 00:21:07,870
the construction process that difficulty

479
00:21:12,720 --> 00:21:10,390
has forced this team to come up with

480
00:21:15,120 --> 00:21:12,730
innovative proprietary sewing and

481
00:21:18,180 --> 00:21:15,130
manufacturing procedures to outfit the

482
00:21:20,070 --> 00:21:18,190
high ad once the outer shell is married

483
00:21:23,070 --> 00:21:20,080
with the internal structure you have a

484
00:21:25,560 --> 00:21:23,080
very strong heat resistant cover that

485
00:21:27,930 --> 00:21:25,570
can be folded and packed to fit within a

486
00:21:30,240 --> 00:21:27,940
rocket shroud and the combination of all

487
00:21:32,240 --> 00:21:30,250
the parts together now make flying to

488
00:21:36,330 --> 00:21:32,250

Mars and other planets with atmospheres

489
00:21:38,340 --> 00:21:36,340
much more viable this technology is not

490
00:21:41,100 --> 00:21:38,350
just an incremental advancement in our

491
00:21:44,220 --> 00:21:41,110
entry capabilities for NASA this is

492
00:21:45,990 --> 00:21:44,230
actually a leap we're actually making a

493
00:21:48,630 --> 00:21:46,000
big change in what our capabilities are

494
00:21:50,900 --> 00:21:48,640
it's a new way of doing business

495
00:21:53,820 --> 00:21:50,910
actually being able to have very large

496
00:21:55,290 --> 00:21:53,830
entry vehicles changes the way that

497
00:21:58,020 --> 00:21:55,300
these payloads come into the atmosphere

498
00:21:59,850 --> 00:21:58,030
we're looking at actually using high ads

499
00:22:02,310 --> 00:21:59,860
the inflatable decelerator technology to

500
00:22:05,290 --> 00:22:02,320
recover launch assets both first stage

501
00:22:06,580 --> 00:22:05,300
recovery as well as second stage

502
00:22:08,680 --> 00:22:06,590
so that we're not really talking about

503
00:22:10,540 --> 00:22:08,690
these vehicles being the same shape that

504
00:22:12,310 --> 00:22:10,550
you would have coming into an atmosphere

505
00:22:13,540 --> 00:22:12,320
you were delivering a payload but

506
00:22:15,730 --> 00:22:13,550
actually maybe something a little bit

507
00:22:17,590 --> 00:22:15,740
elongated that conforms wall to the

508
00:22:19,990 --> 00:22:17,600
launch asset that you want to recover

509
00:22:23,130 --> 00:22:20,000
that gives it more of a gliding reentry

510
00:22:25,990 --> 00:22:23,140
or a gliding capability back to earth

511
00:22:28,270 --> 00:22:26,000
whether it's a fair expectation or not

512
00:22:31,060 --> 00:22:28,280
those of us in the public have come to

513
00:22:33,130 --> 00:22:31,070

expect NASA and its partners to always

514
00:22:36,280 --> 00:22:33,140
come through with solutions to overcome

515
00:22:40,360 --> 00:22:36,290
challenges the brilliant team working on

516
00:22:42,490 --> 00:22:40,370
high ad has done just that the ideas and

517
00:22:44,620 --> 00:22:42,500
processes they have developed have

518
00:22:47,020 --> 00:22:44,630
pushed through some big barriers and

519
00:22:50,020 --> 00:22:47,030
will almost certainly help us land on

520
00:22:52,510 --> 00:22:50,030
far-off places like Mars while also

521
00:22:54,970 --> 00:22:52,520
being used back here in our own

522
00:22:58,150 --> 00:22:54,980
atmosphere on earth it just goes to show

523
00:23:00,820 --> 00:22:58,160
that virtually any technological issue

524
00:23:03,340 --> 00:23:00,830
can be overcome when you put the right

525
00:23:11,410 --> 00:23:03,350
team of people on the problem and this