1
00:00:01,501 --> 00:00:04,771
>> Narrator: NASA's Jet
Propulsion Laboratory presents

2
00:00:04,771 --> 00:00:08,608
the von Karman Lecture, a
series of talks by scientists

3
00:00:08,608 --> 00:00:11,711
and engineers who are
exploring our planet,

4
00:00:11,711 --> 00:00:14,848
our solar system, and
all that lies beyond.

5
00:00:16,416 --> 00:00:20,086
[gentle instrumental music]

6
00:00:23,790 --> 00:00:24,924
>> Hello and welcome.

7
00:00:27,360 --> 00:00:28,895
Good evening.

8
00:00:28,895 --> 00:00:30,630
[laughs]

9
00:00:30,630 --> 00:00:33,066
[applause]

10
00:00:33,066 --> 00:00:34,567
Thanks.

11
00:00:34,567 --> 00:00:36,970
Well welcome to NASA's
Jet Propulsion Laboratory

12

00:00:36,970 --> 00:00:39,839
here in Pasadena, California,
I'm Preston Dyches.

13
00:00:39,839 --> 00:00:42,675
Welcome to our monthly
lecture and discussion series

14
00:00:42,675 --> 00:00:44,444
that we call the
von Karman Lecture.

15
00:00:45,645 --> 00:00:47,747
Our show this month
is a Mars roundup.

16
00:00:47,747 --> 00:00:50,483
Our two speakers will tell
you about the activities

17
00:00:50,483 --> 00:00:52,619
of our Mars rovers
on the Red Planet,

18
00:00:52,619 --> 00:00:55,889
including the next rover
plan to launch in 2020.

19
00:00:55,889 --> 00:00:57,791
And the latest arrival
on the Red Planet,

20
00:00:57,791 --> 00:00:59,559
NASA's InSight lander.

21
00:01:00,760 --> 00:01:02,862
Our first speaker is
Dr. Abigail Fraeman.

22
00:01:02,862 --> 00:01:05,231

She's a research scientist
working here at JPL,

23
00:01:05,231 --> 00:01:08,501
and her work focuses
on understanding

24
00:01:08,501 --> 00:01:11,704
the evolution of rocky
bodies in the solar system.

25
00:01:11,704 --> 00:01:15,075
She is the Deputy
Project Scientist on
the Opportunity Rover

26
00:01:15,075 --> 00:01:18,912
and was the campaign lead
during the Curiosity Rover's

27
00:01:18,912 --> 00:01:22,048
exploration of Vera
Rubin Ridge, recently.

28
00:01:22,048 --> 00:01:25,985
Dr. Fraeman received her PhD
in earth and planetary sciences

29
00:01:25,985 --> 00:01:30,323
at Washington
University in St. Louis,

30
00:01:30,323 --> 00:01:32,992
and completed a
post-doc at Cal Tech

31
00:01:32,992 --> 00:01:35,361
before coming to JPL in 2016.

32
00:01:35,361 --> 00:01:37,931

So please welcome Dr. Fraeman.

33
00:01:37,931 --> 00:01:40,166
[applause]

34
00:01:46,106 --> 00:01:48,575
>> Awesome, thank you so
much and I'm so excited

35
00:01:48,575 --> 00:01:51,744
to see you guys all here
today, what a good crowd.

36
00:01:51,744 --> 00:01:52,979
Awesome.

37
00:01:52,979 --> 00:01:54,981
So, all right,
let's get into it.

38
00:01:54,981 --> 00:01:56,883
I'll be doing the
first half of this talk

39
00:01:56,883 --> 00:01:59,085
about our Red Planet
rovers and InSights,

40
00:01:59,085 --> 00:02:00,887
and I will be
focusing on the rovers

41
00:02:00,887 --> 00:02:02,822
that we have currently
exploring the planet,

42
00:02:02,822 --> 00:02:05,825
and the rovers that we
have headed to the planet.

43
00:02:06,926 --> 00:02:09,062
To start, I'm gonna
take you back.

44
00:02:09,062 --> 00:02:13,032
About six months ago from
today, it was a Monday morning,

45
00:02:13,032 --> 00:02:15,802
and for the Opportunity Rover
we came in in the morning,

46
00:02:15,802 --> 00:02:18,171
and we were starting our
regular tactical planning,

47
00:02:18,171 --> 00:02:20,740
as we do every morning
for both rovers

48
00:02:20,740 --> 00:02:22,275
that are operating on Mars.

49
00:02:23,576 --> 00:02:26,146
We were parked at this
interesting outcrop at La Joya,

50
00:02:26,146 --> 00:02:27,680
that's an informal
name for this rock,

51
00:02:27,680 --> 00:02:30,650
and we were investigating
it with our instruments

52
00:02:30,650 --> 00:02:32,352
on the end of the rover arm.

53
00:02:32,352 --> 00:02:35,355

And if you take a look at
the Documentarian Report,

54
00:02:35,355 --> 00:02:38,024
this is a report we have that
we've done every single day

55
00:02:38,024 --> 00:02:41,027
we've planned this mission,
you can see it reads that

56
00:02:41,027 --> 00:02:43,863
Opportunity is at the tan
bedrock target La Joya

57
00:02:43,863 --> 00:02:46,633
in Perseverance
Valley, and the APXS,

58
00:02:46,633 --> 00:02:49,335
that's one of our
instruments, is down.

59
00:02:49,335 --> 00:02:52,338
However, a dust storm
is our next challenge.

60
00:02:52,338 --> 00:02:54,607
A measure of dust
level that we call tau

61
00:02:54,607 --> 00:02:58,511
has jumped from .6 to 1.5.

62
00:02:59,679 --> 00:03:01,948
Why did we report this,
why do we care about

63
00:03:01,948 --> 00:03:04,350
what the dust level

in the atmosphere is?

64
00:03:04,350 --> 00:03:06,286
Well, here's a picture
of the Opportunity Rover,

65
00:03:06,286 --> 00:03:09,222
and as I'm sure most of
you in the audience know,

66
00:03:09,222 --> 00:03:12,025
the vehicle is powered
by solar energy.

67
00:03:12,025 --> 00:03:14,260
We have solar panels
on top of the rover

68
00:03:14,260 --> 00:03:16,062
that give us our power
to charge our battery

69
00:03:16,062 --> 00:03:17,597
and do our science.

70
00:03:17,597 --> 00:03:19,065
When you have dust
in the atmosphere

71
00:03:19,065 --> 00:03:20,700
you can block out
some of the sunlight,

72
00:03:20,700 --> 00:03:23,269
and so it makes it harder to
get power onto these panels

73
00:03:23,269 --> 00:03:25,505
and harder to get
power to do science.

74
00:03:25,505 --> 00:03:28,841
That Monday when we had
a dust level of one,

75
00:03:28,841 --> 00:03:32,679
a tau of one, the sun
looked something like this.

76
00:03:32,679 --> 00:03:35,715
So we were interested, the sun
was dimmer than it usually is

77
00:03:35,715 --> 00:03:38,451
but we were approaching
summer in the time of year

78
00:03:38,451 --> 00:03:40,920
where Opportunity
was investigating,

79
00:03:40,920 --> 00:03:43,623
and sometimes we get dust
storms in the summer.

80
00:03:43,623 --> 00:03:45,525
And sometimes they're kinda big,

81
00:03:45,525 --> 00:03:47,527
sometimes we get regional
level dust storms,

82
00:03:47,527 --> 00:03:48,695
and so we thought,

83
00:03:48,695 --> 00:03:50,230
maybe this is a regional
level dust storm,

84

00:03:50,230 --> 00:03:52,031
we're gonna have a
little bit less power

85
00:03:52,031 --> 00:03:53,233
for the next few weeks,

86
00:03:53,233 --> 00:03:55,268
but we're gonna manage
our power smartly,

87
00:03:55,268 --> 00:03:57,136
we've survived
dust storms before.

88
00:03:57,136 --> 00:03:59,372
And so this is
something to be wary of,

89
00:03:59,372 --> 00:04:00,873
but not necessarily something

90
00:04:00,873 --> 00:04:02,642
that we think is super horrible.

91
00:04:04,077 --> 00:04:07,080
The next day, on Tuesday,
when we got the reading

92
00:04:07,080 --> 00:04:08,481
of what the dust
measurement off,

93
00:04:08,481 --> 00:04:11,017
it had jumped even further,
the storm had grown.

94
00:04:11,017 --> 00:04:13,553
The dust level was down
to about three now,

95
00:04:13,553 --> 00:04:16,889
or up to about three, and
the sun was slightly fainter.

96
00:04:16,889 --> 00:04:18,358
By Friday,

97
00:04:18,358 --> 00:04:20,593
we'd realized that this
was a pretty massive storm,

98
00:04:20,593 --> 00:04:23,396
and it was probably
going to be pretty bad

99
00:04:23,396 --> 00:04:25,865
and probably one of the
worst we've ever seen.

100
00:04:25,865 --> 00:04:29,002
We got data, we couldn't even
tell how dark the sky was,

101
00:04:29,002 --> 00:04:30,837
'cause when we tried to
take a picture of the sun,

102
00:04:30,837 --> 00:04:33,206
we couldn't see it
through our solar filter.

103
00:04:33,206 --> 00:04:35,942
But we think the tau value,
the dust level value,

104
00:04:35,942 --> 00:04:37,577
was something around six.

105

00:04:37,577 --> 00:04:39,879
So this is a simulation of
what the sun would look like

106
00:04:39,879 --> 00:04:43,149
when it was about five,
so this is now Friday.

107
00:04:43,149 --> 00:04:45,351
At this point we know this
is a very serious event,

108
00:04:45,351 --> 00:04:47,320
we could see from the orbital
data that the dust storm

109
00:04:47,320 --> 00:04:49,689
was expanding, it was
continuing to grow,

110
00:04:49,689 --> 00:04:51,691
we knew it was likely
to become global.

111
00:04:51,691 --> 00:04:53,426
And so all we could
do was hunker down,

112
00:04:53,426 --> 00:04:56,529
do our best to manage power
over the weekend, and wait.

113
00:04:56,529 --> 00:04:58,731
So that's what we did,
we were very careful,

114
00:04:58,731 --> 00:05:00,233
we canceled some
of the down links

115

00:05:00,233 --> 00:05:02,835
we thought we were gonna have
in an attempt to save power,

116
00:05:02,835 --> 00:05:04,304
and we sat, and we waited.

117
00:05:05,471 --> 00:05:07,674
So we're awaiting the
down link on Sunday,

118
00:05:07,674 --> 00:05:09,375
that's when it was
supposed to come in.

119
00:05:09,375 --> 00:05:13,146
This is what a sun would look
like if a tau level was seven.

120
00:05:13,146 --> 00:05:16,182
This is what it would look
like if a tau level was nine.

121
00:05:17,884 --> 00:05:21,020
This is what we saw when we
got the down link on Sunday.

122
00:05:21,020 --> 00:05:24,490
We had a tau level
that was above 10.5.

123
00:05:24,490 --> 00:05:26,359
So the sun probably looked

124
00:05:26,359 --> 00:05:28,494
something like this
to the vehicle.

125
00:05:28,494 --> 00:05:30,563
This is the highest

we've ever measured

126
00:05:30,563 --> 00:05:33,733
on the surface of Mars
for how dark the sky got.

127
00:05:33,733 --> 00:05:36,402
We honestly were amazed that
we heard from the vehicle

128
00:05:36,402 --> 00:05:38,905
at all, but we knew at this
point we were probably going to

129
00:05:38,905 --> 00:05:41,774
lose contact with the vehicle,
it was probably gonna slip

130
00:05:41,774 --> 00:05:44,310
into what we call a
low power mode fault,

131
00:05:44,310 --> 00:05:46,646
and the only thing we
could do was to sit,

132
00:05:46,646 --> 00:05:49,682
hunker down, and wait it
out and see what happened.

133
00:05:49,682 --> 00:05:52,719
But let's go back a little
bit and let's talk about

134
00:05:52,719 --> 00:05:55,588
what Opportunity was doing
before this all happened,

135
00:05:55,588 --> 00:05:58,858
and the really interesting

science that we were doing.

136
00:05:58,858 --> 00:06:01,861
Why was our arm down on
that particular rock?

137
00:06:01,861 --> 00:06:04,897
Well, Opportunity is our
robot field geologist

138
00:06:04,897 --> 00:06:06,399
on the surface of Mars.

139
00:06:06,399 --> 00:06:09,335
The payload of the rover are
instruments that are designed

140
00:06:09,335 --> 00:06:11,871
to act like a geologist
in the field would do.

141
00:06:11,871 --> 00:06:14,507
We have a tool that we can
use to grind into rocks

142
00:06:14,507 --> 00:06:16,109
that's a lot like a rock hammer,

143
00:06:16,109 --> 00:06:18,945
we have a microscope that acts
like a geologist hand lens,

144
00:06:18,945 --> 00:06:21,381
we can look up really
close to the rock.

145
00:06:21,381 --> 00:06:23,249
And we have other
instruments that we can use

146
00:06:23,249 --> 00:06:24,817
to measure the
chemistry of the rocks,

147
00:06:24,817 --> 00:06:27,086
and get really fine-scale
pictures of them.

148
00:06:27,086 --> 00:06:30,056
So integrated, we can
use all of these tools

149
00:06:30,056 --> 00:06:32,458
to tell us about the
geology of the environment,

150
00:06:32,458 --> 00:06:35,495
and to understand the past
and the past processes

151
00:06:35,495 --> 00:06:38,464
that formed these rocks
and shaped these rocks.

152
00:06:38,464 --> 00:06:42,101
Throughout its traverse,
opportunity has started up here

153
00:06:42,101 --> 00:06:44,837
at Endurance Crater,
and we've crater-hopped

154
00:06:44,837 --> 00:06:47,840
through the plains of an
area called Meridiani Planum.

155
00:06:47,840 --> 00:06:50,743
We started in Endurance, we
traveled to Eagle Crater,

156
00:06:50,743 --> 00:06:53,012
then we traveled down to
a slightly bigger crater

157
00:06:53,012 --> 00:06:56,315
called Victoria Crater,
and in about 2010,

158
00:06:56,315 --> 00:06:58,317
we got to the rim of
this giant crater,

159
00:06:58,317 --> 00:07:00,486
it's about 22
kilometers in diameter,

160
00:07:00,486 --> 00:07:01,988
called Endeavor Crater.

161
00:07:01,988 --> 00:07:05,191
And this crater is a really
exciting place for us to study

162
00:07:05,191 --> 00:07:07,660
because we know that the
rocks exposed in the rim

163
00:07:07,660 --> 00:07:10,563
of this really large
crater are a lot older

164
00:07:10,563 --> 00:07:13,166
than the plains rocks that
we'd been driving across.

165
00:07:13,166 --> 00:07:14,967
So they represent
a period of time

166

00:07:14,967 --> 00:07:18,504
in Mars' history that
was a lot longer ago

167
00:07:18,504 --> 00:07:20,139
than the rocks we'd
been looking before.

168
00:07:20,139 --> 00:07:22,442
So we got to see
different environments,

169
00:07:22,442 --> 00:07:24,610
different kinds of
geologic processes,

170
00:07:24,610 --> 00:07:26,179
all of their signatures
were in these rocks.

171
00:07:26,179 --> 00:07:28,448
The mission basically
started over again

172
00:07:28,448 --> 00:07:31,150
when we got to the rim
of Endeavor Crater.

173
00:07:31,150 --> 00:07:33,786
This is also the first time
we've been able to investigate

174
00:07:33,786 --> 00:07:37,323
the rim of such a large
crater on any planet anywhere,

175
00:07:37,323 --> 00:07:40,693
and that's really important,
because impact processes,

176

00:07:40,693 --> 00:07:43,296
the formation of crater,
is a universal process

177
00:07:43,296 --> 00:07:45,364
across planets in
the solar system.

178
00:07:45,364 --> 00:07:48,534
So the opportunity
to investigate one
on another planet,

179
00:07:48,534 --> 00:07:51,003
to get really good
data, is important,

180
00:07:51,003 --> 00:07:52,972
not only for understanding
Mars and its history,

181
00:07:52,972 --> 00:07:55,107
but also, how does
this process operate

182
00:07:55,107 --> 00:07:56,976
across the entire solar system?

183
00:07:58,377 --> 00:08:00,813
For the past year we've
been exploring this feature

184
00:08:00,813 --> 00:08:02,048
called Perseverance Valley,

185
00:08:02,048 --> 00:08:04,650
which is about the size
of a football field,

186
00:08:04,650 --> 00:08:06,686

and this is an area on
the rim of the crater,

187
00:08:06,686 --> 00:08:09,322
you'll note here the north
arrow is pointed to the side.

188
00:08:09,322 --> 00:08:10,957
This is just to kind of
show what it looks like.

189
00:08:10,957 --> 00:08:14,694
We're driving down the valley
into the inside of the crater,

190
00:08:14,694 --> 00:08:16,696
and what's really
neat is from orbit,

191
00:08:16,696 --> 00:08:18,865
this valley looks
quite interesting.

192
00:08:18,865 --> 00:08:21,400
We kinda see these
bifurcated channels,

193
00:08:21,400 --> 00:08:22,969
almost these flow features,

194
00:08:22,969 --> 00:08:25,738
so the question we were really
interested in answering is,

195
00:08:25,738 --> 00:08:29,375
what were the processes that
formed this particular valley?

196
00:08:29,375 --> 00:08:31,844
Now we had three kind of

ideas that we'd thought of

197
00:08:31,844 --> 00:08:33,579
before we went into the valley.

198
00:08:33,579 --> 00:08:35,915
The first was that it
formed by a dry avalanche,

199
00:08:35,915 --> 00:08:37,350
so you just had a bunch of rocks

200
00:08:37,350 --> 00:08:39,252
that rolled down the
hill and carved this out.

201
00:08:39,252 --> 00:08:40,586
We didn't think that was likely,

202
00:08:40,586 --> 00:08:42,755
'cause it was a
little too shallow.

203
00:08:42,755 --> 00:08:45,091
The second idea
was a debris flow,

204
00:08:45,091 --> 00:08:47,193
which you can have in
slightly shallower slopes,

205
00:08:47,193 --> 00:08:48,427
and in this case it would be

206
00:08:48,427 --> 00:08:50,663
kind of a slurry
of mud and rocks.

207
00:08:50,663 --> 00:08:53,099

Or the third option, maybe this
is an ancient river channel,

208
00:08:53,099 --> 00:08:55,601
this is kind of a gully
that was a lot of water.

209
00:08:55,601 --> 00:08:57,637
So we went down there and
we used our instruments

210
00:08:57,637 --> 00:09:00,373
to check this out, see if
we could figure it out.

211
00:09:00,373 --> 00:09:02,041
This is what the
valley looks like

212
00:09:02,041 --> 00:09:03,676
kind of at the top looking down,

213
00:09:03,676 --> 00:09:05,177
and you guys might
look at that and say

214
00:09:05,177 --> 00:09:07,246
where is it, I don't see it.

215
00:09:07,246 --> 00:09:10,383
And it turns out, the
morphology, it's really subtle,

216
00:09:10,383 --> 00:09:11,817
this is a really subtle feature

217
00:09:11,817 --> 00:09:14,720
that gets really well emphasized
when we see it from orbit.

218
00:09:14,720 --> 00:09:16,556
But this is a beautiful
view, we're looking down,

219
00:09:16,556 --> 00:09:19,959
you can kind of see a shadow,
that's our mast right there.

220
00:09:22,662 --> 00:09:23,863
But when we got in the valley

221
00:09:23,863 --> 00:09:25,731
we did notice something
really interesting,

222
00:09:25,731 --> 00:09:28,367
and we started looking at the
rocks that were exposed there.

223
00:09:28,367 --> 00:09:29,835
And what we found was evidence

224
00:09:29,835 --> 00:09:31,637
that there's these linear faults

225
00:09:31,637 --> 00:09:33,472
that were kind of running
up and down the valley,

226
00:09:33,472 --> 00:09:34,974
you can see there's
two kinds of rocks

227
00:09:34,974 --> 00:09:36,609
on either side of this fault.

228
00:09:36,609 --> 00:09:39,278
So there's a process here
that's shaping the faulting,

229
00:09:39,278 --> 00:09:42,648
these linear, radial faultings
along the crater rim.

230
00:09:42,648 --> 00:09:44,984
And then when we took a closer
look at some of the rocks

231
00:09:44,984 --> 00:09:47,453
on them, we could see that
they were sculpted in a really

232
00:09:47,453 --> 00:09:50,389
interesting way, and if you
take a really close look,

233
00:09:50,389 --> 00:09:52,024
you can see in this rock
there's kind of these

234
00:09:52,024 --> 00:09:54,293
more resistant little
pebbles sticking up,

235
00:09:54,293 --> 00:09:56,095
and then coming off
of these pebbles

236
00:09:56,095 --> 00:09:57,997
are these sort of flow lines.

237
00:09:57,997 --> 00:09:59,799
So you go hmm, flow lines,

238
00:09:59,799 --> 00:10:02,301
maybe this is evidence,
here's our river.

239

00:10:02,301 --> 00:10:03,903
But when you look
carefully at the direction,

240
00:10:03,903 --> 00:10:05,471
they're pointed uphill.

241
00:10:05,471 --> 00:10:08,341
And water doesn't flow uphill.

242
00:10:08,341 --> 00:10:10,643
So this isn't water
that's shaping these,

243
00:10:10,643 --> 00:10:13,479
at least modern day
surfaces, this is wind.

244
00:10:13,479 --> 00:10:15,214
This is the result
of wind erosion

245
00:10:15,214 --> 00:10:17,516
in the modern day
surface of Mars.

246
00:10:17,516 --> 00:10:20,286
So integrating all of
these things that we found,

247
00:10:20,286 --> 00:10:23,255
we came up with a new
hypothesis to consider.

248
00:10:23,255 --> 00:10:26,025
Maybe parts of this valley
are carved by wind erosion.

249
00:10:26,025 --> 00:10:28,628
We have these faults that

we see cutting through them,

250
00:10:28,628 --> 00:10:31,397
maybe wind is taking advantage
of these preexisting faults

251
00:10:31,397 --> 00:10:33,232
and sorta carving it out.

252
00:10:33,232 --> 00:10:36,669
But you know, if they were
partially a debris flow

253
00:10:36,669 --> 00:10:39,138
or a river, we might expect
to find all of these deposits

254
00:10:39,138 --> 00:10:40,806
that would be carried
by these events,

255
00:10:40,806 --> 00:10:43,242
that would kinda be the
signature for these events,

256
00:10:43,242 --> 00:10:45,111
they'd be at the
bottom of the valley.

257
00:10:45,111 --> 00:10:47,546
So we have to wait 'til we get
to the bottom of the valley

258
00:10:47,546 --> 00:10:49,882
before we can think we
can really say for sure,

259
00:10:49,882 --> 00:10:52,251
are these deposits here
or aren't they here?

260
00:10:52,251 --> 00:10:53,653
So we're still exploring.

261
00:10:54,854 --> 00:10:57,423
Another awesome thing
that Perseverance Valley

262
00:10:57,423 --> 00:10:59,225
exposed that was
totally unexpected

263
00:10:59,225 --> 00:11:01,694
were some really
interesting rocks.

264
00:11:01,694 --> 00:11:03,229
And the rocks that it turned up

265
00:11:03,229 --> 00:11:05,598
are unlike any of the rocks
that we've seen before

266
00:11:05,598 --> 00:11:08,034
in the entire 14
years of the mission,

267
00:11:08,034 --> 00:11:09,935
it was something completely new.

268
00:11:09,935 --> 00:11:11,404
Here's a picture of
some of these rocks

269
00:11:11,404 --> 00:11:13,372
that this big valley
was sort of digging up.

270
00:11:13,372 --> 00:11:14,707

And you can see their textures,

271
00:11:14,707 --> 00:11:16,475
they have kind of pits in them,

272
00:11:16,475 --> 00:11:18,177
so we're wondering,
is this a weathering,

273
00:11:18,177 --> 00:11:20,513
you can weather rocks and
get pits that look like this.

274
00:11:20,513 --> 00:11:23,149
They could be from trapped
gases that were in the rocks

275
00:11:23,149 --> 00:11:25,284
that are coming
out, we're not sure.

276
00:11:25,284 --> 00:11:27,486
And so we were
investigating the chemistry,

277
00:11:27,486 --> 00:11:29,955
the textures of these
rocks, and that outcrop

278
00:11:29,955 --> 00:11:32,658
that we were on when the
dust hit, dust storm hit,

279
00:11:32,658 --> 00:11:34,660
the La Joya outcrop,
that was one of the rocks

280
00:11:34,660 --> 00:11:36,228
that was nearby to these rocks.

281
00:11:36,228 --> 00:11:37,963
And what we were trying
to do is figure out,

282
00:11:37,963 --> 00:11:39,899
how does the composition
of these rocks differ

283
00:11:39,899 --> 00:11:41,567
from the rocks that
are surrounding it?

284
00:11:41,567 --> 00:11:43,035
Is there some sort
of relationship

285
00:11:43,035 --> 00:11:46,038
in terms of one melted
from another or not.

286
00:11:46,038 --> 00:11:48,708
So we were trying to piece
together this whole story,

287
00:11:48,708 --> 00:11:50,476
and that's why we
were at La Joya,

288
00:11:50,476 --> 00:11:53,746
and that's what we were doing
when this day in June happened

289
00:11:53,746 --> 00:11:56,382
and we lost contact
with the vehicle.

290
00:11:56,382 --> 00:11:59,518
We did something else really
fun in Perseverance Valley,

291
00:11:59,518 --> 00:12:02,888
and that was we hit Sol
5,000 of the mission.

292
00:12:04,056 --> 00:12:05,825
That's a pretty big
number, Sol 5,000,

293
00:12:05,825 --> 00:12:07,593
and we wanted to celebrate it,

294
00:12:07,593 --> 00:12:09,895
and so we did a
first time activity

295
00:12:09,895 --> 00:12:11,897
that we had never
done for 14 years,

296
00:12:11,897 --> 00:12:13,466
and that was take a selfie.

297
00:12:13,466 --> 00:12:16,602
Now you've probably seen
the selfies from Curiosity,

298
00:12:16,602 --> 00:12:18,838
and Curiosity takes those
by taking the camera

299
00:12:18,838 --> 00:12:21,373
on the end of its arm
and they look really good

300
00:12:21,373 --> 00:12:23,275
and we were kinda jealous,
and we said you know what,

301
00:12:23,275 --> 00:12:24,744

we have a camera at
the end of our arm,

302
00:12:24,744 --> 00:12:27,179
and yeah, the focus
is not quite the same,

303
00:12:27,179 --> 00:12:29,582
so if we take a selfie
it'll be a little blurry,

304
00:12:29,582 --> 00:12:32,485
but we can do it, and
some very smart people

305
00:12:32,485 --> 00:12:34,453
put their heads together,
they planned this mosaic,

306
00:12:34,453 --> 00:12:35,888
and I think it came
out beautifully.

307
00:12:35,888 --> 00:12:38,657
And so this was awesome
because this is the first time

308
00:12:38,657 --> 00:12:41,994
human eyes had seen
this side of Opportunity

309
00:12:41,994 --> 00:12:44,730
since it's left Earth in 2003.

310
00:12:44,730 --> 00:12:46,866
So I'm so glad we
got this observation,

311
00:12:46,866 --> 00:12:49,602
and it's really special

to commemorate Sol 5,000,

312
00:12:49,602 --> 00:12:52,238
and I'm gonna put that
into context to you,

313
00:12:52,238 --> 00:12:54,774
how long is 5,000 sols.

314
00:12:54,774 --> 00:12:57,009
So here's my personal career

315
00:12:57,009 --> 00:12:59,879
plotted along
Opportunity's traverse.

316
00:13:01,247 --> 00:13:03,883
And Opportunity is a
very special rover to me,

317
00:13:03,883 --> 00:13:06,118
because when I was
in high school,

318
00:13:06,118 --> 00:13:07,987
I actually got to
come out to JPL

319
00:13:07,987 --> 00:13:10,923
as an outreach program sponsored
by the Planetary Society,

320
00:13:10,923 --> 00:13:13,993
and be here the night
that Opportunity landed.

321
00:13:13,993 --> 00:13:16,428
I got to be in this room for
the landing press conference,

322
00:13:16,428 --> 00:13:17,930
I got to be with
the science team,

323
00:13:17,930 --> 00:13:20,332
and that totally blew my mind,

324
00:13:20,332 --> 00:13:23,002
it inspired me to pursue
space exploration.

325
00:13:23,002 --> 00:13:25,604
And so I took that night
and I said, this is great,

326
00:13:25,604 --> 00:13:27,606
this mission will last
three months, maybe six,

327
00:13:27,606 --> 00:13:29,675
and there'll hopefully
be more stuff going on.

328
00:13:29,675 --> 00:13:32,044
But since that time
I've managed to graduate

329
00:13:32,044 --> 00:13:34,780
from high school, I
went to undergrad,

330
00:13:34,780 --> 00:13:37,516
graduated from undergrad,
I started grad school.

331
00:13:37,516 --> 00:13:41,453
My graduate advisor is on
the Opportunity science team,

332

00:13:41,453 --> 00:13:44,423
so as a graduate student I
started doing tactical shifts.

333
00:13:44,423 --> 00:13:47,092
I was a documentarian, so I
got to write those reports

334
00:13:47,092 --> 00:13:49,361
that I read you at the
beginning of the talk.

335
00:13:49,361 --> 00:13:50,896
Finished grad school.

336
00:13:50,896 --> 00:13:52,698
Went on, started a post-doc.

337
00:13:52,698 --> 00:13:54,333
Finished my post-doc, came here.

338
00:13:54,333 --> 00:13:56,769
And now I'm the deputy project
scientist of the mission.

339
00:13:56,769 --> 00:14:01,340
So this mission has been going
a really really long time.

340
00:14:03,509 --> 00:14:04,877
[chuckling]

341
00:14:04,877 --> 00:14:07,112
[applause]

342
00:14:10,082 --> 00:14:12,985
We do know, we haven't
heard from Opportunity,

343

00:14:12,985 --> 00:14:15,855
it's been exactly
six months to today.

344
00:14:15,855 --> 00:14:17,957
'Cause June 10th was the
last time we heard from it

345
00:14:17,957 --> 00:14:19,491
and it's now January 10th,

346
00:14:19,491 --> 00:14:22,261
so six months today was the
last time we heard from it.

347
00:14:22,261 --> 00:14:23,596
We do know it's still there.

348
00:14:23,596 --> 00:14:25,631
This was a picture we
captured from orbit

349
00:14:25,631 --> 00:14:29,034
after the dust settled and we
could still see the surface.

350
00:14:29,034 --> 00:14:31,270
Can you see the rover
in Perseverance Valley?

351
00:14:32,504 --> 00:14:33,405
There she is.

352
00:14:34,573 --> 00:14:37,209
So we can see from orbit
she hasn't blown away.

353
00:14:37,209 --> 00:14:39,311
And so what we're
doing now at JPL is,

354
00:14:39,311 --> 00:14:42,147
we're trying to do
these recovery efforts
for the vehicle.

355
00:14:42,147 --> 00:14:45,050
So we think the temperatures
haven't gotten cold enough

356
00:14:45,050 --> 00:14:47,119
that anything would break,
we're in summertime,

357
00:14:47,119 --> 00:14:48,320
so that's helpful.

358
00:14:48,320 --> 00:14:51,657
And so what we're trying
to do is two things.

359
00:14:51,657 --> 00:14:53,659
First, we're gonna always be
listening for the vehicle.

360
00:14:53,659 --> 00:14:56,795
So if Opportunity, if everything
kind of, if she wakes up,

361
00:14:56,795 --> 00:14:59,365
if whatever dust has
settled on her solar panels

362
00:14:59,365 --> 00:15:02,268
that is causing her to
have low power blows away,

363
00:15:02,268 --> 00:15:04,536
we'll hear from
her no matter up.

364
00:15:04,536 --> 00:15:06,105
If there's just enough dust

365
00:15:06,105 --> 00:15:07,640
to blow away that
she can wake up,

366
00:15:07,640 --> 00:15:09,975
but she doesn't have quite
enough power to call home,

367
00:15:09,975 --> 00:15:11,143
what we're doing is a campaign

368
00:15:11,143 --> 00:15:12,778
of what we're calling
sweep and beeps.

369
00:15:12,778 --> 00:15:14,613
Where we're sweeping
the frequency ranges

370
00:15:14,613 --> 00:15:17,082
that we know that
she's listening, and
we're telling her,

371
00:15:17,082 --> 00:15:18,751
beep if you hear us,
beep if you hear us.

372
00:15:18,751 --> 00:15:21,520
And so we've been doing that
campaign for a few months now,

373
00:15:21,520 --> 00:15:23,522
and we're just waiting,
and we're hoping

374
00:15:23,522 --> 00:15:24,957
that there'll be a
beautiful gust of wind

375
00:15:24,957 --> 00:15:27,593
that'll clean the panels
off, and we'll hear from her.

376
00:15:29,261 --> 00:15:32,598
This is what the dust storm
looked like from orbit.

377
00:15:32,598 --> 00:15:35,301
You can see it started
right around Opportunity,

378
00:15:35,301 --> 00:15:37,703
but you'll notice there's
another guy on the planet.

379
00:15:37,703 --> 00:15:39,872
Curiosity, that's
our other rover.

380
00:15:39,872 --> 00:15:43,609
And this event was so big
it encircled the planet,

381
00:15:43,609 --> 00:15:45,210
and Curiosity saw it as well.

382
00:15:45,210 --> 00:15:48,314
This is June 11th, that's
what the storm looked like.

383
00:15:48,314 --> 00:15:50,416
Here's one of those
selfies that we took

384

00:15:50,416 --> 00:15:53,052
with Curiosity on June 15th.

385
00:15:53,052 --> 00:15:55,621
This was right after,
it was a great week

386
00:15:55,621 --> 00:15:58,090
for Curiosity that we week,
we used our drill again,

387
00:15:58,090 --> 00:16:00,826
we collected a drill sample
after a very long time.

388
00:16:00,826 --> 00:16:02,962
We hadn't been drilling,
but we got our drill up,

389
00:16:02,962 --> 00:16:05,030
we got this Duluth drill sample.

390
00:16:05,030 --> 00:16:06,966
But you can see in the selfie,

391
00:16:06,966 --> 00:16:10,069
there's sort of this ominous
dust cloud on the horizon

392
00:16:10,069 --> 00:16:12,738
as this global dust
storm is approaching.

393
00:16:12,738 --> 00:16:16,675
And this is a series of
images we took of the wall,

394
00:16:16,675 --> 00:16:18,610
we've landed in a big
crater with Curiosity

395
00:16:18,610 --> 00:16:20,913
and we can watch as the
mountains on the wall

396
00:16:20,913 --> 00:16:23,716
on the crater get harder
and harder to see,

397
00:16:23,716 --> 00:16:27,286
it's kinda like a smoggy day
in L.A. when the smog comes in

398
00:16:27,286 --> 00:16:28,587
and you can't see the
mountains anymore.

399
00:16:28,587 --> 00:16:30,956
That's what we're seeing here.

400
00:16:30,956 --> 00:16:33,926
So the dust storm was
really bad for Opportunity,

401
00:16:33,926 --> 00:16:36,495
but it's a great
chance for Curiosity,

402
00:16:36,495 --> 00:16:39,231
for the first time
since Viking in the 70s,

403
00:16:39,231 --> 00:16:41,734
we were able to make
observations on the ground

404
00:16:41,734 --> 00:16:44,069
of a dust storm and the
effects it has on Mars.

405
00:16:44,069 --> 00:16:47,106
And this is really important
because it helps us understand

406
00:16:47,106 --> 00:16:50,409
more about how these processes
start, how they operate,

407
00:16:50,409 --> 00:16:52,678
and the effects that
they have on the surface.

408
00:16:52,678 --> 00:16:54,913
Curiosity is
fortunately equipped

409
00:16:54,913 --> 00:16:56,949
not only with the
cameras that you can see,

410
00:16:56,949 --> 00:16:59,051
but we also have a weather
station on Curiosity.

411
00:16:59,051 --> 00:17:01,320
So we can make near
continuous measurements

412
00:17:01,320 --> 00:17:03,355
of how the dust storm
affected the temperature,

413
00:17:03,355 --> 00:17:04,890
how it affected the pressure,

414
00:17:04,890 --> 00:17:06,492
how it affected
relative humidity,

415

00:17:06,492 --> 00:17:09,061
the UV radiation
reaching the surface,

416
00:17:09,061 --> 00:17:10,629
all of these wonderful
things that we can now

417
00:17:10,629 --> 00:17:12,364
put into our
meteorological models

418
00:17:12,364 --> 00:17:16,068
and better understand how
these events happen and evolve.

419
00:17:16,068 --> 00:17:17,503
This is one of my
favorite pictures,

420
00:17:17,503 --> 00:17:19,238
this is that Duluth drill hole.

421
00:17:19,238 --> 00:17:21,840
This is what it looks like
kind of on a normal day.

422
00:17:21,840 --> 00:17:24,810
You can see here's the rock,
here's some sand nearby.

423
00:17:24,810 --> 00:17:27,679
This is what it looked like at
the height of the dust storm.

424
00:17:27,679 --> 00:17:30,149
Every picture we took in
the height of the dust storm

425
00:17:30,149 --> 00:17:34,086

has this, like, unearthly,
really reddish hue.

426
00:17:34,086 --> 00:17:36,989
The exposure for this
picture is also a lot longer,

427
00:17:36,989 --> 00:17:39,024
so you can think of
it's really really dark.

428
00:17:39,024 --> 00:17:40,893
Turns out we had to
expose the photos

429
00:17:40,893 --> 00:17:42,428
a lot longer for Curiosity,

430
00:17:42,428 --> 00:17:44,830
and we had to build that into
our margins for our planning,

431
00:17:44,830 --> 00:17:46,298
that the photos were
gonna take longer

432
00:17:46,298 --> 00:17:47,900
when this dust
storm was happening.

433
00:17:47,900 --> 00:17:50,202
But everything kinda
looked this really cool,

434
00:17:50,202 --> 00:17:51,937
weird red color.

435
00:17:51,937 --> 00:17:53,906
But we got a lot of
really good observations

436
00:17:53,906 --> 00:17:57,176
about the environment
and what was happening.

437
00:17:57,176 --> 00:17:59,745
In September, after
the dust storm settled,

438
00:17:59,745 --> 00:18:01,613
these storms can
take weeks to kind of

439
00:18:01,613 --> 00:18:03,715
settle out of the atmosphere.

440
00:18:03,715 --> 00:18:05,084
It turned out there
was a lot of dust

441
00:18:05,084 --> 00:18:06,585
that settled on the vehicle.

442
00:18:06,585 --> 00:18:09,154
So this is a picture of one
of our calibration targets

443
00:18:09,154 --> 00:18:11,190
for a microscope, and
it's kind of a play on

444
00:18:11,190 --> 00:18:13,492
the geologist's penny for scale.

445
00:18:13,492 --> 00:18:15,427
So we have a scale on the rover,

446
00:18:15,427 --> 00:18:17,229
and that's what the

penny looked like.

447
00:18:17,229 --> 00:18:19,498
And this is in September,
so right when the dust storm

448
00:18:19,498 --> 00:18:22,534
had finished, all the dust
settled out onto the rover,

449
00:18:22,534 --> 00:18:24,503
and Curiosity was pretty dusty.

450
00:18:24,503 --> 00:18:27,272
But turns out Gale Crater
is a pretty windy place,

451
00:18:27,272 --> 00:18:29,675
and by December when we
imaged that exact same spot,

452
00:18:29,675 --> 00:18:30,976
it's totally clean.

453
00:18:32,077 --> 00:18:33,979
So just the regular
seasonal winds

454
00:18:33,979 --> 00:18:36,014
have cleaned off Curiosity.

455
00:18:36,014 --> 00:18:37,549
What does this mean
for Opportunity?

456
00:18:37,549 --> 00:18:40,385
Well, it's hard to say,
it's like trying to predict

457

00:18:40,385 --> 00:18:42,588
the weather in London if
you're in New Zealand,

458
00:18:42,588 --> 00:18:45,257
you know, we're opposite
sides of the planet,

459
00:18:45,257 --> 00:18:47,559
but it's a pretty cool
effect of just how mobile

460
00:18:47,559 --> 00:18:50,662
this dust is in this modern
day martian environment.

461
00:18:51,864 --> 00:18:54,333
So here's what
Curiosity looks like.

462
00:18:54,333 --> 00:18:57,703
And if Opportunity is
our mobile geologist,

463
00:18:57,703 --> 00:18:59,872
well, Curiosity is
a mobile chemist.

464
00:18:59,872 --> 00:19:02,141
And part of the reason
that Curiosity's

465
00:19:02,141 --> 00:19:04,143
such an exciting
mission is because

466
00:19:04,143 --> 00:19:06,912
it has two very special
instruments inside the rover

467

00:19:06,912 --> 00:19:09,648
that can make kind of really
advanced measurements.

468
00:19:09,648 --> 00:19:11,150
And to make those measurements

469
00:19:11,150 --> 00:19:12,584
we need to get samples of rocks

470
00:19:12,584 --> 00:19:15,454
that we've drilled
inside the rover.

471
00:19:15,454 --> 00:19:18,223
We've spent the last
about year or so

472
00:19:18,223 --> 00:19:20,959
exploring this ridge that's
part of this mountain

473
00:19:20,959 --> 00:19:22,861
that we're climbing,
this Mount Sharp.

474
00:19:22,861 --> 00:19:24,530
Here's a picture of the ridge,

475
00:19:24,530 --> 00:19:26,198
we can see a kind
of climbing up,

476
00:19:26,198 --> 00:19:28,867
we're on the side of the picture
so it's tilted a little bit

477
00:19:28,867 --> 00:19:30,969
but you can see it's this ridge.

478
00:19:30,969 --> 00:19:34,873
And this feature we've
named Vera Rubin Ridge.

479
00:19:34,873 --> 00:19:38,343
And we've named this after
the astronomer Vera Rubin.

480
00:19:38,343 --> 00:19:43,182
She's a remarkable woman, and
her most well-known discovery

481
00:19:43,182 --> 00:19:45,918
was that she was the one
who made the observations

482
00:19:45,918 --> 00:19:48,754
that led to the discovery, and
she discovered, dark matter.

483
00:19:48,754 --> 00:19:52,491
So this mysterious force
that is in everything,

484
00:19:52,491 --> 00:19:54,159
and we don't know what it is,

485
00:19:54,159 --> 00:19:56,061
and she was the one who
was the one who made

486
00:19:56,061 --> 00:19:59,464
the very precise rotational
curve measurements of galaxies.

487
00:20:00,866 --> 00:20:04,469
On this mission, we name major
features after scientists.

488

00:20:04,469 --> 00:20:06,738
We have Murray Buttes
after Bruce Murray,

489
00:20:06,738 --> 00:20:10,175
we have the Bagnold Dunes
after Ralph Bagnold.

490
00:20:10,175 --> 00:20:12,744
And to me personally
it was very exciting

491
00:20:12,744 --> 00:20:15,380
to be able to choose
a really prominent

492
00:20:15,380 --> 00:20:17,416
female scientist
to name this after.

493
00:20:18,884 --> 00:20:21,153
And I'm really happy that
we're on Vera Rubin Ridge

494
00:20:21,153 --> 00:20:23,255
and I'm really happy
with this name.

495
00:20:23,255 --> 00:20:26,491
Another little fun fact,
she has several children

496
00:20:26,491 --> 00:20:29,194
who are all scientists as
well, and one of her sons,

497
00:20:29,194 --> 00:20:30,662
David Rubin, is
actually a member

498

00:20:30,662 --> 00:20:32,731
of the Curiosity science team.

499
00:20:32,731 --> 00:20:35,033
So that's, it was easy
to find the family

500
00:20:35,033 --> 00:20:36,568
to contact to get
their permission,

501
00:20:36,568 --> 00:20:39,304
'cause one of their family
members was on our team.

502
00:20:41,273 --> 00:20:44,109
This is what Vera Rubin
Ridge looks like from orbit,

503
00:20:44,109 --> 00:20:45,410
so you can think of the ridge,

504
00:20:45,410 --> 00:20:47,713
it's kind of this
tanner looking feature

505
00:20:47,713 --> 00:20:48,981
that's kinda wavy like this.

506
00:20:48,981 --> 00:20:51,617
This white line is
Curiosity's traverse.

507
00:20:51,617 --> 00:20:53,285
And you can see kinda
the biggest thing

508
00:20:53,285 --> 00:20:54,953
is just in this picture,

509
00:20:54,953 --> 00:20:57,189
the ridge looks pretty
different from the rocks below.

510
00:20:57,189 --> 00:20:59,424
So before we got here,
we were really curious.

511
00:20:59,424 --> 00:21:02,160
We knew these rocks
were lake bed deposits,

512
00:21:02,160 --> 00:21:03,795
what were the
rocks in the ridge?

513
00:21:03,795 --> 00:21:07,733
And then also, from orbit,
we've mapped this mineral

514
00:21:07,733 --> 00:21:10,836
called hematite, which is a
mineral that forms in water.

515
00:21:10,836 --> 00:21:13,138
And what's really
exciting is the reaction

516
00:21:13,138 --> 00:21:16,341
that forms hematite can
be favorable to life.

517
00:21:16,341 --> 00:21:17,776
And we saw this from orbit,

518
00:21:17,776 --> 00:21:19,811
and we saw it just light
up along the ridge.

519

00:21:19,811 --> 00:21:22,180
And so we were really interested
in what was causing this.

520
00:21:22,180 --> 00:21:24,716
And I'll say on a personal note,

521
00:21:24,716 --> 00:21:28,020
one of the chapters in my
PhD thesis was the discovery

522
00:21:28,020 --> 00:21:30,656
and mapping of this mineral
with the orbital data,

523
00:21:30,656 --> 00:21:33,458
so I'm super excited to be
able to get to this ridge,

524
00:21:33,458 --> 00:21:35,160
to drill, to see what we find,

525
00:21:35,160 --> 00:21:36,895
and then it's also
a little bit scary

526
00:21:36,895 --> 00:21:39,731
because it's one of the few
times in planetary science

527
00:21:39,731 --> 00:21:42,034
where what you predict,
you see from orbital data,

528
00:21:42,034 --> 00:21:43,602
can actually be tested

529
00:21:43,602 --> 00:21:45,704
by kind of the definitive
on the ground instruments.

530
00:21:45,704 --> 00:21:48,573
So I had my fingers crossed
that we'd find this mineral

531
00:21:48,573 --> 00:21:51,743
that I said we'd find, and
hopefully figure it out.

532
00:21:51,743 --> 00:21:55,080
So we get there, we
drive around, we drive
right to the spot

533
00:21:55,080 --> 00:21:56,882
where we have the
strongest signature,

534
00:21:56,882 --> 00:21:58,750
and this was, I said,
we have to go here,

535
00:21:58,750 --> 00:22:01,119
this is what we see from orbit,
this is where we need to go.

536
00:22:01,119 --> 00:22:04,122
And crossed my fingers,
we got our drill sample,

537
00:22:04,122 --> 00:22:06,792
I wanted to see what was
in it, we picked the rock.

538
00:22:06,792 --> 00:22:10,495
Oh excuse me, this is what the
rocks in the ridge look like.

539
00:22:10,495 --> 00:22:11,997
We found,

540
00:22:11,997 --> 00:22:13,732
first of all we found that
they were layered rocks.

541
00:22:13,732 --> 00:22:17,135
They're these beautiful,
beautiful layered rocks.

542
00:22:17,135 --> 00:22:19,104
And we decided that these rocks

543
00:22:19,104 --> 00:22:21,139
are very similar
to the rocks below,

544
00:22:21,139 --> 00:22:23,075
and these were
probably also formed

545
00:22:23,075 --> 00:22:25,110
in a lake similar
to the rocks below.

546
00:22:25,110 --> 00:22:27,212
But getting back to
the story of the drill,

547
00:22:27,212 --> 00:22:29,414
'cause I'm really excited,
'cause I really wanted to know,

548
00:22:29,414 --> 00:22:31,550
I'd been waiting for five
years since I graduated

549
00:22:31,550 --> 00:22:34,920
from grad school to know if
this mineral was really there.

550
00:22:34,920 --> 00:22:37,823
We went to drill, and
that's what happened.

551
00:22:37,823 --> 00:22:41,626
And what happened was
the rock was too hard,

552
00:22:41,626 --> 00:22:43,628
and the vehicle
sensed that the rate

553
00:22:43,628 --> 00:22:47,733
that the drill was making
progress was basically zero,

554
00:22:47,733 --> 00:22:48,967
and we stopped drilling,

555
00:22:48,967 --> 00:22:51,203
'cause we couldn't
get through the rocks.

556
00:22:51,203 --> 00:22:53,772
I guess this makes sense,
we're sitting on this ridge,

557
00:22:53,772 --> 00:22:56,375
it's a ridge because it's
harder than the rocks around it,

558
00:22:56,375 --> 00:22:58,777
and the rocks are really hard.

559
00:22:58,777 --> 00:23:00,946
So it was a little
disappointing, but you know,

560
00:23:00,946 --> 00:23:03,882

we're engineers, we're
scientists, let's try again,

561
00:23:03,882 --> 00:23:06,084
let's pick another
rock, and so we did,

562
00:23:06,084 --> 00:23:08,153
and this rock was too hard.

563
00:23:08,153 --> 00:23:13,158
And it turns out a lot of the
rocks here were just so hard.

564
00:23:14,025 --> 00:23:16,361
So Mars threw a challenge at us,

565
00:23:16,361 --> 00:23:17,829
and it was really disappointing,

566
00:23:17,829 --> 00:23:20,799
because in particular
this was the drill sample,

567
00:23:20,799 --> 00:23:22,401
of all the drill
samples in the mission,

568
00:23:22,401 --> 00:23:24,970
I really wanted to see what
was in this drill sample.

569
00:23:24,970 --> 00:23:27,672
So, it's a challenge.

570
00:23:27,672 --> 00:23:28,807
We put on our engineering hats,

571
00:23:28,807 --> 00:23:30,142

we put on our geologist hats,

572
00:23:30,142 --> 00:23:31,343
and this was actually I think

573
00:23:31,343 --> 00:23:32,577
a really cool part
of the mission

574
00:23:32,577 --> 00:23:34,012
where the science team
and the engineering team

575
00:23:34,012 --> 00:23:36,882
really really worked together
to solve this problem.

576
00:23:36,882 --> 00:23:39,284
So the engineers went
and they looked at,

577
00:23:39,284 --> 00:23:42,187
what can we do to make the
drill slightly more powerful,

578
00:23:42,187 --> 00:23:44,322
slightly more able to
penetrate these rocks.

579
00:23:44,322 --> 00:23:47,692
And then on geology side,
we said okay, what can we do

580
00:23:47,692 --> 00:23:50,862
to try and find a rock that
might be a little bit softer

581
00:23:50,862 --> 00:23:53,331
and might be more able to drill?

582
00:23:53,331 --> 00:23:55,300
And so you look at
a rock like this,

583
00:23:55,300 --> 00:23:57,169
how do you know if this
is gonna be drillable

584
00:23:57,169 --> 00:23:58,637
versus those other rocks?

585
00:23:58,637 --> 00:24:00,539
And we came up with
three things to look for.

586
00:24:00,539 --> 00:24:01,940
First we came up with, you know,

587
00:24:01,940 --> 00:24:04,209
let's just look for the
broad scale topography,

588
00:24:04,209 --> 00:24:05,610
if the rock is slightly lower,

589
00:24:05,610 --> 00:24:08,447
maybe it's a little
softer, more easily eroded.

590
00:24:08,447 --> 00:24:11,082
We looked at the way
the rock was weathering

591
00:24:11,082 --> 00:24:13,819
with respect to these white
veins that are cutting through.

592
00:24:13,819 --> 00:24:15,854
If the veins were

standing up with respect

593
00:24:15,854 --> 00:24:17,989
to the rest of the rock,
maybe the rock was soft.

594
00:24:17,989 --> 00:24:19,991
If the veins were
recessed into the rock,

595
00:24:19,991 --> 00:24:21,960
maybe the rock was hard.

596
00:24:21,960 --> 00:24:25,130
And then also we have a brush
that we have on Curiosity,

597
00:24:25,130 --> 00:24:27,065
and it turns out if
you look real closely

598
00:24:27,065 --> 00:24:29,734
at where you can brush,
sometimes you can see scratches

599
00:24:29,734 --> 00:24:31,670
in the rocks, and
sometimes you can't.

600
00:24:31,670 --> 00:24:33,438
But the rocks we
see scratches on,

601
00:24:33,438 --> 00:24:36,942
we see that they're maybe a
little bit more easier to drill.

602
00:24:36,942 --> 00:24:39,110
So we kinda put on
our geology hats,

603
00:24:39,110 --> 00:24:41,446
we looked at a lot of pictures
that we'd taken of the rocks,

604
00:24:41,446 --> 00:24:43,081
we picked this rock.

605
00:24:43,081 --> 00:24:45,484
We said, we feel pretty
good about this one,

606
00:24:45,484 --> 00:24:46,718
and if it's not this one,

607
00:24:46,718 --> 00:24:48,186
we don't know what we're
gonna be able to find.

608
00:24:48,186 --> 00:24:50,956
And we crossed our fingers,
we waited for the data,

609
00:24:50,956 --> 00:24:54,493
and then we got a
full drill hole, so.

610
00:24:54,493 --> 00:24:56,661
This is my favorite drill,

611
00:24:56,661 --> 00:24:58,763
we have 19 drill holes
with Curiosity right now,

612
00:24:58,763 --> 00:25:00,665
this one is my
favorite, hands down.

613
00:25:00,665 --> 00:25:01,900

[chuckling]

614
00:25:01,900 --> 00:25:03,001
Because I didn't know
if we were gonna get it

615
00:25:03,001 --> 00:25:05,337
and I was so excited to get it.

616
00:25:05,337 --> 00:25:07,672
And we got it, we analyzed
it, it turned out yes,

617
00:25:07,672 --> 00:25:10,075
the mineral
hematite, it's there,

618
00:25:10,075 --> 00:25:11,977
it's the most that we've
seen in any drill hole,

619
00:25:11,977 --> 00:25:13,912
although not a huge amount.

620
00:25:13,912 --> 00:25:16,548
But the orbital
detection is correct,

621
00:25:16,548 --> 00:25:18,984
and we're kinda looking
at now the bigger picture

622
00:25:18,984 --> 00:25:20,385
to understand okay,
what does this mean

623
00:25:20,385 --> 00:25:22,587
about the past habitability
of Gale crater?

624
00:25:23,989 --> 00:25:25,891
We've gotten two more holes
on the ridge since then.

625
00:25:25,891 --> 00:25:27,959
We've gotten this really
interesting gray one,

626
00:25:27,959 --> 00:25:31,296
and then this, this one we
got right before Christmas,

627
00:25:31,296 --> 00:25:32,898
and this is what
we're doing right now,

628
00:25:32,898 --> 00:25:34,866
we're sitting in front of
this high field drill sample

629
00:25:34,866 --> 00:25:36,868
and we're analyzing it to
figure out what it's made of,

630
00:25:36,868 --> 00:25:39,604
we've found some
cool stuff, and yeah.

631
00:25:39,604 --> 00:25:41,706
So we have three drill
holes now from the ridge,

632
00:25:41,706 --> 00:25:43,975
and one very happy
person on the team.

633
00:25:43,975 --> 00:25:45,644
Many very happy
people on the team,

634
00:25:45,644 --> 00:25:47,512
but for myself, I'm very happy,

635
00:25:47,512 --> 00:25:50,148
and it's been a great campaign.

636
00:25:50,148 --> 00:25:51,883
But what's next?

637
00:25:51,883 --> 00:25:54,853
So next we're gonna keep
climbing this mountain,

638
00:25:54,853 --> 00:25:56,588
and we're gonna head
into these rocks

639
00:25:56,588 --> 00:25:58,156
further up the mountain,

640
00:25:58,156 --> 00:26:00,559
which are just beautiful
to look at, I can't wait.

641
00:26:00,559 --> 00:26:02,260
I love the ridge, but
I'm ready to get off it

642
00:26:02,260 --> 00:26:04,963
and go to new, really
exciting places.

643
00:26:04,963 --> 00:26:08,733
So in particular, these
kinda purple-y looking rocks,

644
00:26:08,733 --> 00:26:10,101
these rocks we see from orbit

645
00:26:10,101 --> 00:26:12,070
have a signature
of clay minerals,

646
00:26:12,070 --> 00:26:13,405
and those are really interesting

647
00:26:13,405 --> 00:26:14,673
because they have the potential

648
00:26:14,673 --> 00:26:17,142
to really well preserve
organic molecules.

649
00:26:17,142 --> 00:26:19,978
And then beyond that we see
all these color changes,

650
00:26:19,978 --> 00:26:21,846
different rocks,
different environments

651
00:26:21,846 --> 00:26:23,582
that we're gonna get to explore

652
00:26:23,582 --> 00:26:26,985
as we drive up through
time up this mountain.

653
00:26:26,985 --> 00:26:29,821
I'll leave you talking
about the last rover,

654
00:26:29,821 --> 00:26:32,090
which is this rover that
we're launching in 2020,

655
00:26:32,090 --> 00:26:35,760
which is creatively named Mars

2020, it will get a new name.

656
00:26:35,760 --> 00:26:38,663
But if Opportunity's
our geologist,

657
00:26:38,663 --> 00:26:41,032
if Curiosity is our chemist,

658
00:26:42,133 --> 00:26:45,470
Mars 2020 is our little
collection rover.

659
00:26:45,470 --> 00:26:49,641
And really, the big science
that this rover's gonna do

660
00:26:49,641 --> 00:26:51,643
is it's gonna drive around
and it's gonna collect little

661
00:26:51,643 --> 00:26:55,313
rock samples, and it's gonna
collect these rock cores.

662
00:26:55,313 --> 00:26:57,582
These little kind of
chalk-sized cores,

663
00:26:57,582 --> 00:26:59,818
and bring them back to
Earth so we can analyze them

664
00:26:59,818 --> 00:27:02,587
in our laboratory, and this
is really gonna revolutionize,

665
00:27:02,587 --> 00:27:05,123
I am sure, our
understanding of Mars.

666
00:27:05,123 --> 00:27:07,892
We just announced we
picked a landing site.

667
00:27:07,892 --> 00:27:09,861
Mars has a lot of
really exciting places,

668
00:27:09,861 --> 00:27:11,630
but we're looking
forward to landing

669
00:27:11,630 --> 00:27:13,598
in this place called
Jezero Crater.

670
00:27:13,598 --> 00:27:15,834
We're gonna lands somewhere
in this yellow circle,

671
00:27:15,834 --> 00:27:17,335
this ellipse.

672
00:27:17,335 --> 00:27:19,070
And Jezero Crater, this
is the rim of the crater,

673
00:27:19,070 --> 00:27:22,407
it's exciting, because leading
into it we see this feature

674
00:27:22,407 --> 00:27:25,043
which is actually
an ancient Delta.

675
00:27:25,043 --> 00:27:27,679
So we know that there was a
river coming into this crater,

676
00:27:27,679 --> 00:27:29,581
this crater was
filled with a lake,

677
00:27:29,581 --> 00:27:31,650
and there was a delta
that was feeding into

678
00:27:31,650 --> 00:27:33,985
these really calm waters
forming this shape.

679
00:27:33,985 --> 00:27:37,222
We can also see the
minerals in this delta

680
00:27:37,222 --> 00:27:38,957
are what you would
expect to have formed

681
00:27:38,957 --> 00:27:41,126
in this really kind of
quiescent environment,

682
00:27:41,126 --> 00:27:43,094
and a really
exciting environment

683
00:27:43,094 --> 00:27:44,763
if you're looking for a place

684
00:27:44,763 --> 00:27:46,798
that may have preserved
signs of past life.

685
00:27:46,798 --> 00:27:49,968
So stay tuned for
more from Jezero.

686

00:27:49,968 --> 00:27:53,672
And I'll leave you with really
the latest and greatest,

687
00:27:53,672 --> 00:27:56,041
these are pictures that
we took just at a building

688
00:27:56,041 --> 00:28:00,011
down the road here, JPL, of
the current state of build

689
00:28:00,011 --> 00:28:03,381
for this rover, these were
taken a week or two ago.

690
00:28:03,381 --> 00:28:04,849
This is what the
clean room looks like,

691
00:28:04,849 --> 00:28:06,317
we build everything
in a clean room

692
00:28:06,317 --> 00:28:07,986
to make sure we
don't get little gunk

693
00:28:07,986 --> 00:28:10,321
and particles to
clog the electronics.

694
00:28:10,321 --> 00:28:13,758
But if you look closely,
you'll see these guys.

695
00:28:13,758 --> 00:28:15,794
These are gonna turn
into the back shell

696

00:28:15,794 --> 00:28:17,629
and the cruise stage.

697
00:28:19,197 --> 00:28:21,066
This guy back there
in the corner,

698
00:28:22,233 --> 00:28:24,869
blown up there, that's
gonna be the sky crane.

699
00:28:24,869 --> 00:28:26,137
Those are gonna be the thrusters

700
00:28:26,137 --> 00:28:28,306
that's gonna help
the vehicle land.

701
00:28:28,306 --> 00:28:30,975
And then I think most excitingly

702
00:28:30,975 --> 00:28:32,711
that little kind
of innocuous box

703
00:28:32,711 --> 00:28:34,579
that's all wrapped
up back there,

704
00:28:34,579 --> 00:28:36,681
well that's actually the
chasse for the vehicle.

705
00:28:36,681 --> 00:28:39,017
So we're starting
construction on this,

706
00:28:39,017 --> 00:28:41,519
and really looking
forward to launching

707
00:28:41,519 --> 00:28:44,823
and getting our samples
and bringing back to Earth.

708
00:28:44,823 --> 00:28:47,792
So that's all I have for you
guys talking about rovers,

709
00:28:47,792 --> 00:28:49,461
and I think our next
speaker will talk to you

710
00:28:49,461 --> 00:28:53,198
all about our most recent
neighbor and lander.

711
00:28:53,198 --> 00:28:55,467
[applause]

712
00:29:01,606 --> 00:29:04,242
>> Pretty cool stuff,
thank you so much Abby.

713
00:29:04,242 --> 00:29:05,543
All right, well
it's time for some

714
00:29:05,543 --> 00:29:07,879
insight from our next speaker.

715
00:29:07,879 --> 00:29:11,416
Elizabeth Barrett is a science
systems engineer at the JPL

716
00:29:11,416 --> 00:29:13,551
working on the Mars
InSight mission.

717

00:29:13,551 --> 00:29:15,553
In this role she
coordinates with the science

718
00:29:15,553 --> 00:29:17,155
and instrument operations team

719
00:29:17,155 --> 00:29:19,891
to accomplish the
mission's goals.

720
00:29:19,891 --> 00:29:22,560
Dr. Barrett received a
masters of engineering

721
00:29:22,560 --> 00:29:26,431
from Cornell University, taught
English in postwar Bosnia

722
00:29:26,431 --> 00:29:30,468
for 18 months, and then returned
to school to receive a PhD

723
00:29:30,468 --> 00:29:32,637
in astronomy from the
University of Hawaii.

724
00:29:33,738 --> 00:29:36,574
After that, she
worked for eight years

725
00:29:36,574 --> 00:29:40,011
as a flight controller for the
International Space Station

726
00:29:40,011 --> 00:29:43,481
before joining JPL and the
InSight mission in 2015.

727
00:29:43,481 --> 00:29:45,383

Please welcome Dr. Barrett.

728
00:29:45,383 --> 00:29:47,619
[applause]

729
00:29:53,057 --> 00:29:54,759
>> All right, thank
you guys for coming.

730
00:29:54,759 --> 00:29:56,961
So as Abigail mentioned,

731
00:29:56,961 --> 00:29:59,364
Insight is our newest
addition to Mars,

732
00:29:59,364 --> 00:30:02,000
and the biggest difference
you can see, no wheels.

733
00:30:02,000 --> 00:30:04,969
So we're a lander,
we stay in one place.

734
00:30:04,969 --> 00:30:07,839
InSight is very different
from the other missions,

735
00:30:07,839 --> 00:30:10,475
the other missions are
investigating a surface of Mars.

736
00:30:10,475 --> 00:30:13,511
They're doing a great job
analyzing the surface of Mars,

737
00:30:13,511 --> 00:30:15,880
InSight's looking at
the interior of Mars.

738
00:30:15,880 --> 00:30:18,016
So InSight's a
geophysical station,

739
00:30:18,016 --> 00:30:20,885
and we're gonna use
seismology, heat flow,

740
00:30:20,885 --> 00:30:24,823
and actually measuring the
wobble of Mars as it rotates

741
00:30:24,823 --> 00:30:27,959
to determine the interior
structure of Mars.

742
00:30:27,959 --> 00:30:30,094
What does the core look
like, what does the crust,

743
00:30:30,094 --> 00:30:31,563
what does the mantle look like.

744
00:30:31,563 --> 00:30:33,598
We've been able to do
that for Earth, of course,

745
00:30:33,598 --> 00:30:35,934
and we've also been able
to do that for the moon.

746
00:30:35,934 --> 00:30:36,901
But we've never
been able to do it

747
00:30:36,901 --> 00:30:38,403
for the other rocky planets,

748
00:30:38,403 --> 00:30:40,004

so we're very much
looking forward to Mars

749
00:30:40,004 --> 00:30:42,774
as an intermediary between
the size of the earth

750
00:30:42,774 --> 00:30:43,942
and the size of the moon,

751
00:30:43,942 --> 00:30:45,276
to show us the different types

752
00:30:45,276 --> 00:30:47,011
of terrestrial planet evolution.

753
00:30:48,546 --> 00:30:50,648
Where did InSight begin.

754
00:30:50,648 --> 00:30:52,584
So it launched on Cinco de Mayo

755
00:30:52,584 --> 00:30:55,286
from Vandenberg Air Force
Base here on the west coast.

756
00:30:55,286 --> 00:30:57,455
First interplanetary
launch from the west coast.

757
00:30:57,455 --> 00:31:02,327
It launched about 4:05 AM and
it was a beautiful launch,

758
00:31:02,327 --> 00:31:04,696
as long as you were not at
the public viewing site.

759
00:31:04,696 --> 00:31:07,932

If you were there, you saw
something kinda like that.

760
00:31:07,932 --> 00:31:08,766
[laughter]

761
00:31:08,766 --> 00:31:10,134
It was very dense fog.

762
00:31:10,134 --> 00:31:11,436
A lot of people has described it

763
00:31:11,436 --> 00:31:13,671
as the best launch
they ever heard.

764
00:31:13,671 --> 00:31:14,873
[laughter]

765
00:31:14,873 --> 00:31:16,441
But at least we launched.

766
00:31:16,441 --> 00:31:19,477
After that we began a six
month journey to Mars,

767
00:31:19,477 --> 00:31:21,012
so it took us six
months to get there

768
00:31:21,012 --> 00:31:23,414
with about six little
trajectory correction maneuvers

769
00:31:23,414 --> 00:31:25,083
along the way to
make sure we landed

770
00:31:25,083 --> 00:31:27,118

at the exact right spot on Mars.

771
00:31:27,118 --> 00:31:30,922
And then on Cyber Monday,
that's the 26th of November,

772
00:31:30,922 --> 00:31:32,056
right after Thanksgiving,

773
00:31:32,056 --> 00:31:33,958
we got a great
Thanksgiving present,

774
00:31:33,958 --> 00:31:37,795
and just before noon, InSight
successfully landed on Mars.

775
00:31:37,795 --> 00:31:39,697
And so we were all very excited,

776
00:31:39,697 --> 00:31:41,933
you can see even the
engineers in the control room,

777
00:31:41,933 --> 00:31:44,535
our project managers
and PIs celebrating.

778
00:31:44,535 --> 00:31:47,038
I was lucky enough to be
able to spend that time

779
00:31:47,038 --> 00:31:49,974
with the scientists and
the instrument engineers,

780
00:31:49,974 --> 00:31:53,511
and as soon as that first
picture came down from Mars,

781
00:31:53,511 --> 00:31:55,513
they immediately crowded
around and were looking at

782
00:31:55,513 --> 00:31:57,849
where they could put the
instruments on the surface,

783
00:31:57,849 --> 00:32:00,318
and trying to analyze how
many rocks they could see,

784
00:32:00,318 --> 00:32:01,853
immediately getting to work,

785
00:32:01,853 --> 00:32:04,956
even in the room where we're
still watching the landing.

786
00:32:04,956 --> 00:32:06,758
All right, and then of course,

787
00:32:06,758 --> 00:32:09,460
no story of InSight's
landing on Mars is complete

788
00:32:09,460 --> 00:32:11,663
without thanking our
MarCO companions.

789
00:32:11,663 --> 00:32:15,800
We had two little
cube satellites that
went to Mars with us,

790
00:32:15,800 --> 00:32:17,769
it was a technology
demonstration

791

00:32:17,769 --> 00:32:20,805
and have the first
CubeSats go interplanetary.

792
00:32:20,805 --> 00:32:23,574
They were able to provide relay
data for us during landing

793
00:32:23,574 --> 00:32:25,576
so that we did not all
have to hold our breath

794
00:32:25,576 --> 00:32:28,079
during landing, and wait
to see if we got a beat

795
00:32:28,079 --> 00:32:29,580
from the surface of Mars.

796
00:32:29,580 --> 00:32:32,717
Instead, with they relaying
the telemetry to Earth for us,

797
00:32:32,717 --> 00:32:35,853
we got to watch a near
continuous stream of telemetry,

798
00:32:35,853 --> 00:32:37,822
and hear updates along
the way for landing,

799
00:32:37,822 --> 00:32:39,524
so we could breathe
a little bit better.

800
00:32:39,524 --> 00:32:42,727
So MarCO is now continuing
on its way around the sun,

801
00:32:42,727 --> 00:32:46,497

and they were very helpful
in getting us to Mars.

802
00:32:46,497 --> 00:32:48,800
So, okay, where did we land?

803
00:32:48,800 --> 00:32:51,402
Well, we landed on
Mars, good start.

804
00:32:51,402 --> 00:32:54,205
You land on the wrong
planet, it looks really bad.

805
00:32:54,205 --> 00:32:57,742
We're about 375 miles
or about 600 kilometers

806
00:32:57,742 --> 00:33:00,278
north of Curiosity,
that's the big rover

807
00:33:00,278 --> 00:33:02,113
that Abigail was
able to talk about.

808
00:33:02,113 --> 00:33:04,215
So we're sharing that
same general area

809
00:33:04,215 --> 00:33:06,017
but we're in a slightly
different location.

810
00:33:06,017 --> 00:33:08,820
If we zoom in a little
bit on that landing site,

811
00:33:08,820 --> 00:33:12,023
this is our landing ellipse

where we intended to land,

812
00:33:12,023 --> 00:33:14,625
and those navigators
and landing team people

813
00:33:14,625 --> 00:33:17,528
can do their job pretty well,
'cause we landed right there

814
00:33:17,528 --> 00:33:18,696
in the ellipse.

815
00:33:18,696 --> 00:33:21,065
You zoom in a little bit closer,

816
00:33:21,065 --> 00:33:22,834
and Mars Reconnaissance Orbiter,

817
00:33:22,834 --> 00:33:24,102
one of the orbiters around Mars,

818
00:33:24,102 --> 00:33:25,670
used their high rise instrument

819
00:33:25,670 --> 00:33:28,773
to get detailed images of
where InSight has landed.

820
00:33:28,773 --> 00:33:31,309
So the big image is
actually a pre-landing image

821
00:33:31,309 --> 00:33:33,011
just showing you the
relative location

822
00:33:33,011 --> 00:33:34,679
of the different items.

823
00:33:34,679 --> 00:33:38,049
The heat shield landed up
north by that big crater.

824
00:33:38,049 --> 00:33:41,252
The parachute and back
shell landed down south,

825
00:33:41,252 --> 00:33:43,788
and if you actually look
closely at the parachute image,

826
00:33:43,788 --> 00:33:45,423
you can see the
deflated parachute

827
00:33:45,423 --> 00:33:47,191
lying on the surface of Mars.

828
00:33:47,191 --> 00:33:50,228
And then the lander was
right there in the center,

829
00:33:50,228 --> 00:33:52,497
and you can see that we even
created a little blast zone

830
00:33:52,497 --> 00:33:54,732
around us as our thrusters
came down for landing,

831
00:33:54,732 --> 00:33:57,468
blowing off that
loose, dusty material

832
00:33:57,468 --> 00:33:58,736
from the surface of Mars.

833

00:34:00,805 --> 00:34:02,473
Well, what did we
do after landing?

834
00:34:02,473 --> 00:34:04,575
Well, actually 30
minutes after landing,

835
00:34:04,575 --> 00:34:06,044
we had to deploy our solar array

836
00:34:06,044 --> 00:34:08,880
so we could generate power
to continue with the mission.

837
00:34:08,880 --> 00:34:11,115
We did that about 30
minutes after landing,

838
00:34:11,115 --> 00:34:13,851
but unfortunately due to
the way the missions work,

839
00:34:13,851 --> 00:34:16,788
we couldn't get confirmation
of that deployment

840
00:34:16,788 --> 00:34:19,090
'til about five
hours after landing.

841
00:34:19,090 --> 00:34:20,992
So that first landing day
was a little bit tense

842
00:34:20,992 --> 00:34:22,326
until we heard that
those solar arrays

843
00:34:22,326 --> 00:34:23,561

were successfully deployed,

844
00:34:23,561 --> 00:34:24,862
and then we could
all go to happy hour

845
00:34:24,862 --> 00:34:26,831
and celebrate a little bit.

846
00:34:26,831 --> 00:34:28,699
So we have great
solar ray panels,

847
00:34:28,699 --> 00:34:30,968
I think they look a little
bit like Mickey Mouse ears.

848
00:34:32,403 --> 00:34:34,605
After that we checked
out the instruments.

849
00:34:34,605 --> 00:34:37,442
First thing, they're still
attached, that was a good start.

850
00:34:37,442 --> 00:34:39,677
We powered them all on
for about 15 minutes

851
00:34:39,677 --> 00:34:41,112
to make sure that they
were working okay,

852
00:34:41,112 --> 00:34:43,281
and you've never seen
happier scientists

853
00:34:43,281 --> 00:34:46,217
than the first 15 minutes
of data that they got.

854
00:34:46,217 --> 00:34:49,520
They analyzed that for days,
just those 15 minutes of data.

855
00:34:50,922 --> 00:34:53,591
All right, after that we
then did a lot of surveying

856
00:34:53,591 --> 00:34:55,827
of our workspace
out in front of us.

857
00:34:55,827 --> 00:34:58,362
So if you see the public images
coming down from InSight,

858
00:34:58,362 --> 00:34:59,931
there's a long stretch of
time where you're like,

859
00:34:59,931 --> 00:35:02,166
wow, they really like
taking pictures of dirt.

860
00:35:02,166 --> 00:35:04,035
We were taking pictures
of our workspace here

861
00:35:04,035 --> 00:35:05,970
to get a very
detailed stereo image

862
00:35:05,970 --> 00:35:08,106
of what it looked like
in front of our lander,

863
00:35:08,106 --> 00:35:10,808
and the amazing thing
is, very few rocks,

864
00:35:10,808 --> 00:35:12,410
we couldn't have been happier.

865
00:35:12,410 --> 00:35:15,279
We had to decide then where
to deploy our instruments,

866
00:35:15,279 --> 00:35:18,316
and this little purple,
bluish outline shows

867
00:35:18,316 --> 00:35:19,851
where we can put
the instruments,

868
00:35:19,851 --> 00:35:23,754
the reach of the arm trying to
deploy those instruments out.

869
00:35:23,754 --> 00:35:27,191
And even more fun, this
little area right here,

870
00:35:27,191 --> 00:35:30,461
you zoom in, and there's
a little bitty rock there

871
00:35:30,461 --> 00:35:31,829
that as we came
down for landing,

872
00:35:31,829 --> 00:35:33,431
you can see the divots
along the ground,

873
00:35:33,431 --> 00:35:35,133
and it seems to have
rolled along the ground

874
00:35:35,133 --> 00:35:36,701
with those thrusters pushing it.

875
00:35:36,701 --> 00:35:39,437
So of course the scientists
called it the Rolling Rock,

876
00:35:39,437 --> 00:35:41,572
because Rolling Stone is taken.

877
00:35:41,572 --> 00:35:43,841
[chuckling]

878
00:35:43,841 --> 00:35:46,210
So what are these instruments
that we're gonna deploy.

879
00:35:46,210 --> 00:35:49,413
Well, one of them is our
seismometer that we call SEIS,

880
00:35:49,413 --> 00:35:51,816
it's going to listen
to the seismic waves

881
00:35:51,816 --> 00:35:54,218
to investigate the
interior of Mars.

882
00:35:54,218 --> 00:35:55,887
How are those seismic
waves generated,

883
00:35:55,887 --> 00:35:58,923
they could be generated by
marsquakes, not earthquakes.

884
00:35:58,923 --> 00:36:02,226
They could be generated by

meteorites striking the surface,

885
00:36:02,226 --> 00:36:05,530
and it's so sensitive that if
you convert the acceleration

886
00:36:05,530 --> 00:36:08,933
that it can detect into actually
a deflection, a distance,

887
00:36:08,933 --> 00:36:10,234
it can actually
measure movements

888
00:36:10,234 --> 00:36:12,703
smaller than the radius
of a hydrogen atom.

889
00:36:12,703 --> 00:36:15,473
So it is a very
sensitive instrument.

890
00:36:15,473 --> 00:36:18,676
WTS is our wind
and thermal shield.

891
00:36:18,676 --> 00:36:22,013
That goes on top of SEIS to
protect it from the environment.

892
00:36:22,013 --> 00:36:24,015
To protect it from the
thermal variations,

893
00:36:24,015 --> 00:36:25,383
to protect it from the wind,

894
00:36:25,383 --> 00:36:26,884
because the seismometer
is so sensitive,

895
00:36:26,884 --> 00:36:29,287
you don't want it to detect
just the wind rattling it,

896
00:36:29,287 --> 00:36:32,089
you actually wanna
protect it from that.

897
00:36:32,089 --> 00:36:35,126
Another instrument we
have is called HP cubed,

898
00:36:35,126 --> 00:36:37,762
it's our heat flow
measurement probe.

899
00:36:37,762 --> 00:36:41,432
It has a self-penetrating
mole, looks like a little nail,

900
00:36:41,432 --> 00:36:43,968
that buries itself
under the ground

901
00:36:43,968 --> 00:36:46,971
up to five meters, or
about 16 feet deep.

902
00:36:46,971 --> 00:36:51,342
The tether it drives behind it
contains temperature sensors

903
00:36:51,342 --> 00:36:54,478
that can measure the heat
flow coming out of Mars.

904
00:36:54,478 --> 00:36:57,215
It also has a radiometer
that's attached

905
00:36:57,215 --> 00:36:59,317
to the back of
InSight on the deck,

906
00:36:59,317 --> 00:37:01,786
and can be used to measure
the temperature of the ground

907
00:37:01,786 --> 00:37:03,254
using the radiometer.

908
00:37:03,254 --> 00:37:06,023
So this one's gonna detect
heat coming out of the planet.

909
00:37:07,191 --> 00:37:10,027
We also have another
set of instruments

910
00:37:10,027 --> 00:37:12,763
that were designed particularly
to help our seismometer

911
00:37:12,763 --> 00:37:15,166
to understand the
noise that it's seeing,

912
00:37:15,166 --> 00:37:17,969
but also can be used
to do stealth science.

913
00:37:17,969 --> 00:37:20,371
So we have an
environmental sensor suite,

914
00:37:20,371 --> 00:37:22,607
we call it the auxiliary
payload sensor suite,

915
00:37:22,607 --> 00:37:24,742
or APSS, for short.

916
00:37:24,742 --> 00:37:26,544
One of them is the
pressure sensor,

917
00:37:26,544 --> 00:37:28,045
and you can see the little inlet

918
00:37:28,045 --> 00:37:29,480
for the pressure sensor
here on the deck,

919
00:37:29,480 --> 00:37:32,316
the sensor's buried in
the depth of the lander.

920
00:37:32,316 --> 00:37:34,919
We have TWINS which
measure wind speed,

921
00:37:34,919 --> 00:37:36,520
direction, and temperature,

922
00:37:36,520 --> 00:37:37,722
they look like little fingers

923
00:37:37,722 --> 00:37:39,991
sticking out in the
wind either way.

924
00:37:39,991 --> 00:37:41,592
Then you have IFG,

925
00:37:41,592 --> 00:37:44,095
which is our magnetometer
measuring the magnetic field,

926
00:37:44,095 --> 00:37:46,697
in particular to make
sure that we understand

927
00:37:46,697 --> 00:37:48,799
magnetic fields that's
generated by the lander

928
00:37:48,799 --> 00:37:50,601
and how it could
affect the seismometer,

929
00:37:50,601 --> 00:37:53,537
but it can also measure
the local magnetic field,

930
00:37:53,537 --> 00:37:56,674
of which Mars has very little,
but we're gonna measure it.

931
00:37:56,674 --> 00:37:58,943
And then we have another
experiment that we can do

932
00:37:58,943 --> 00:38:00,278
but doesn't take
its own instrument,

933
00:38:00,278 --> 00:38:03,114
'cause it's gonna use
the medium gain antenna

934
00:38:03,114 --> 00:38:04,715
that we already have
to talk to Earth,

935
00:38:04,715 --> 00:38:06,517
these two little
cones on either side.

936
00:38:06,517 --> 00:38:09,220
And by measuring the change
in the little signals

937
00:38:09,220 --> 00:38:12,556
as Mars is rotating around, we
can actually track accurately

938
00:38:12,556 --> 00:38:15,826
up to 10 centimeters
the location of Insight,

939
00:38:15,826 --> 00:38:17,328
and how it's wobbling around,

940
00:38:17,328 --> 00:38:20,031
and that's how Mars is
wobbling as it rotates.

941
00:38:20,031 --> 00:38:21,832
And just like you spin an egg,

942
00:38:21,832 --> 00:38:23,401
and a hard boiled
egg spins different

943
00:38:23,401 --> 00:38:25,236
than a non-hard boiled egg,

944
00:38:25,236 --> 00:38:26,737
that's what RISE is
gonna help us measure

945
00:38:26,737 --> 00:38:28,506
to determine what's
inside of Mars.

946
00:38:29,707 --> 00:38:31,909
We also have something

called LaRRI,

947
00:38:31,909 --> 00:38:34,545
which is on the back
side of the deck.

948
00:38:34,545 --> 00:38:36,514
It's near our
calibration target,

949
00:38:36,514 --> 00:38:38,249
and it's a laser retroreflector.

950
00:38:38,249 --> 00:38:39,984
So you can shoot a laser at it

951
00:38:39,984 --> 00:38:42,420
from a satellite
orbiting in orbit,

952
00:38:42,420 --> 00:38:43,888
and it can get the
reflection back

953
00:38:43,888 --> 00:38:47,491
to help accurately determine
the location of InSight.

954
00:38:47,491 --> 00:38:49,994
That's an Italian Space
Agency contribution.

955
00:38:49,994 --> 00:38:52,163
And then of course for everybody
who submitted their names

956
00:38:52,163 --> 00:38:55,166
to go to Mars, we've got the
chips with all your names on it

957
00:38:55,166 --> 00:38:57,001
also on the deck of the lander.

958
00:38:58,135 --> 00:39:00,571
So, that's great, where
are our instruments,

959
00:39:00,571 --> 00:39:03,174
they're on the deck, TWINS
you can see on either side,

960
00:39:03,174 --> 00:39:05,676
they're bolted to the
deck, they stay there.

961
00:39:05,676 --> 00:39:08,746
The other instruments
here located on the deck.

962
00:39:08,746 --> 00:39:12,350
But surface deployment
is the key for InSight.

963
00:39:12,350 --> 00:39:14,752
The quality of a seismic station

964
00:39:14,752 --> 00:39:17,455
is directly related to the
quality of installation.

965
00:39:17,455 --> 00:39:18,756
What does that mean?

966
00:39:18,756 --> 00:39:20,958
Well, in Viking I in 1976,

967
00:39:20,958 --> 00:39:23,894
we actually had a
seismometer on the mission.

968
00:39:23,894 --> 00:39:27,932
You can see it there on the
deck and not on the ground.

969
00:39:27,932 --> 00:39:31,469
So on the deck, above
legs that were dampened,

970
00:39:31,469 --> 00:39:34,038
and in a vehicle that
could shake in the wind.

971
00:39:34,038 --> 00:39:38,843
So as a seismometer, it wasn't
measuring the best data.

972
00:39:38,843 --> 00:39:42,513
Instead the principal
investigator for
this mission says

973
00:39:42,513 --> 00:39:44,682
one of his big contributions
was saying, well,

974
00:39:44,682 --> 00:39:47,084
I have an idea, put the
seismometer on the ground,

975
00:39:47,084 --> 00:39:49,053
and then maybe we
can get better data.

976
00:39:49,053 --> 00:39:51,222
So that's what
InSight wants to do.

977
00:39:51,222 --> 00:39:54,091
Additionally, HP cubed is

on the deck when we land,

978
00:39:54,091 --> 00:39:57,027
where it's supposed to be,
but you don't want it there

979
00:39:57,027 --> 00:39:59,196
when you start hammering,
'cause the engineers assure us

980
00:39:59,196 --> 00:40:01,132
that's not gonna be a good idea.

981
00:40:01,132 --> 00:40:03,401
So you wanna put that
on the ground as well.

982
00:40:03,401 --> 00:40:06,170
But after we've traveled
all the way to Mars,

983
00:40:06,170 --> 00:40:07,705
the instruments are
still about a meter

984
00:40:07,705 --> 00:40:10,975
away from the ground, we need
to get them on the ground.

985
00:40:10,975 --> 00:40:14,812
So how do we do that, well,
we wanna get SEIS and WTS

986
00:40:14,812 --> 00:40:17,348
on the ground, and we wanna
get HP cubed on the ground.

987
00:40:17,348 --> 00:40:21,318
We use our robotic arm, or
instrument deployment arm,

988
00:40:21,318 --> 00:40:24,221
to do that, and it has a little
grapple hanging off of it

989
00:40:24,221 --> 00:40:28,125
that we use, so basically,
we're playing an interplanetary

990
00:40:28,125 --> 00:40:31,228
claw game, those little
carnival claw games you can do.

991
00:40:31,228 --> 00:40:33,597
And in this case,
unfortunately, if you mess up

992
00:40:33,597 --> 00:40:35,833
or you miss it, you can't
put in a few more quarters

993
00:40:35,833 --> 00:40:37,902
and try again, so you've
gotta go nice and slow

994
00:40:37,902 --> 00:40:39,537
to get it right the first time.

995
00:40:39,537 --> 00:40:43,040
To make it a little easier,
we do provide a camera here

996
00:40:43,040 --> 00:40:44,675
called the deployment
camera on the arm

997
00:40:44,675 --> 00:40:47,611
to look down the
arm, and another one
underneath the lander

998
00:40:47,611 --> 00:40:50,681
that looks out in front of the
lander, the context camera.

999
00:40:50,681 --> 00:40:53,050
So it's not completely blind.

1000
00:40:53,050 --> 00:40:55,453
Well here, what
have we done lately?

1001
00:40:55,453 --> 00:40:58,722
At the end of the
year, in December,

1002
00:40:58,722 --> 00:41:02,159
we actually deployed SEIS
to the surface of Mars.

1003
00:41:02,159 --> 00:41:04,028
So it's now on the
surf, that was so cool,

1004
00:41:04,028 --> 00:41:05,362
we've gotta watch it again.

1005
00:41:06,464 --> 00:41:08,499
There it goes, flying
through the air,

1006
00:41:08,499 --> 00:41:11,635
and it's safely on
the surface of Mars.

1007
00:41:11,635 --> 00:41:14,472
You'll notice the tether is
still attached to the vehicle,

1008

00:41:14,472 --> 00:41:16,273
and it kinda flutters in
the wind a little bit,

1009
00:41:16,273 --> 00:41:18,943
that's gonna mess up our
measurements of the seismometer.

1010
00:41:18,943 --> 00:41:22,446
So the next thing we do is we
drop the tether to the ground.

1011
00:41:22,446 --> 00:41:23,948
If you missed it, one more time,

1012
00:41:23,948 --> 00:41:27,117
we let the tether go and
it falls to the ground.

1013
00:41:27,117 --> 00:41:29,286
So that lets the
tether's slack out,

1014
00:41:29,286 --> 00:41:31,822
and then we do a few more
weeks of commissioning

1015
00:41:31,822 --> 00:41:33,390
before we're gonna move on.

1016
00:41:33,390 --> 00:41:35,493
So what does the rest
of deployment look like?

1017
00:41:35,493 --> 00:41:38,629
Well this is a simulation
that was created

1018
00:41:38,629 --> 00:41:40,164
before InSight landed.

1019
00:41:40,164 --> 00:41:43,901
It's very accurate except we
have fewer rocks in our area

1020
00:41:43,901 --> 00:41:44,869
that we're deploying
the instruments,

1021
00:41:44,869 --> 00:41:46,504
so we're even better off.

1022
00:41:46,504 --> 00:41:48,405
So here you can see
we're deploying SEIS

1023
00:41:48,405 --> 00:41:52,510
to the surface of MARS, just
like we did in December.

1024
00:41:52,510 --> 00:41:54,612
Once SEIS is on the
ground, as I said,

1025
00:41:54,612 --> 00:41:55,880
we have several
weeks of checkouts.

1026
00:41:55,880 --> 00:41:57,348
We wanna make sure
that it's level,

1027
00:41:57,348 --> 00:41:59,250
that the instruments
are performing correct,

1028
00:41:59,250 --> 00:42:00,751
that we get as low as possible,

1029

00:42:00,751 --> 00:42:02,386
that we've isolated
the seismometer

1030
00:42:02,386 --> 00:42:04,054
as completely as
possible from the landing

1031
00:42:04,054 --> 00:42:05,689
before we move on.

1032
00:42:05,689 --> 00:42:08,826
After that, we go back
to collect the WTS,

1033
00:42:08,826 --> 00:42:11,295
that's the wind and
thermal shield again,

1034
00:42:11,295 --> 00:42:14,164
and we're gonna put
that directly on top
of the seismometer.

1035
00:42:14,164 --> 00:42:15,933
So once we deploy WTS,

1036
00:42:15,933 --> 00:42:18,802
we cannot physically interact
with the seismometer anymore,

1037
00:42:18,802 --> 00:42:21,605
that's why we take our time
before going to this next step.

1038
00:42:21,605 --> 00:42:24,408
WTS deployment is
expected in mid-January,

1039
00:42:24,408 --> 00:42:25,943

so it's coming up soon.

1040
00:42:25,943 --> 00:42:28,078
You can see when we pick it
up it drops a little skirt,

1041
00:42:28,078 --> 00:42:30,247
that allows it to have better
contact with the ground

1042
00:42:30,247 --> 00:42:31,749
when we put it over SEIS,

1043
00:42:31,749 --> 00:42:34,785
to protect SEIS better
from the environment.

1044
00:42:34,785 --> 00:42:36,987
Once WTS is on the
ground and we confirm

1045
00:42:36,987 --> 00:42:39,423
that there's no problems
with SEIS underneath,

1046
00:42:39,423 --> 00:42:42,359
then we're gonna move on
and get back to HP cubed

1047
00:42:42,359 --> 00:42:44,228
and deploy it to the surface.

1048
00:42:44,228 --> 00:42:46,764
This simulation actually
shows the instruments

1049
00:42:46,764 --> 00:42:48,499
pretty closely to where
we're deploying them

1050
00:42:48,499 --> 00:42:49,967
on the surface of Mars.

1051
00:42:49,967 --> 00:42:51,835
SEIS will go a little
bit off to one side,

1052
00:42:51,835 --> 00:42:53,470
HP cubed to the other.

1053
00:42:53,470 --> 00:42:56,840
They wanna be approximately
a meter apart at the grapples

1054
00:42:56,840 --> 00:42:59,043
so that they don't
interfere with one another

1055
00:42:59,043 --> 00:43:00,344
in a negative way.

1056
00:43:00,344 --> 00:43:03,547
That way the WTS shadow
does not interfere

1057
00:43:03,547 --> 00:43:06,584
with HP cubed's measurement,
and HP cubed hammering

1058
00:43:06,584 --> 00:43:08,719
does not inadvertently
trouble SEIS,

1059
00:43:08,719 --> 00:43:12,222
even though we will use it
for some cool measurements

1060
00:43:12,222 --> 00:43:14,825
because we're generating

a seismic signal.

1061
00:43:14,825 --> 00:43:16,961
So once HP cubed is
safely on the ground,

1062
00:43:16,961 --> 00:43:18,862
then we make sure it's
in a good location

1063
00:43:18,862 --> 00:43:20,698
and release the
mole to the surface

1064
00:43:20,698 --> 00:43:23,033
so it can begin its
penetration phase.

1065
00:43:23,033 --> 00:43:24,635
So what does that look like?

1066
00:43:24,635 --> 00:43:28,372
The mole hammering mechanism,
it's like a long nail

1067
00:43:28,372 --> 00:43:31,375
with a hammer inside
of it, just saves time.

1068
00:43:31,375 --> 00:43:32,977
So there's a motor
here that's gonna

1069
00:43:32,977 --> 00:43:35,279
spin a weight and lift it up.

1070
00:43:35,279 --> 00:43:38,749
As it lifts the weight, it's
actually compressing a spring

1071
00:43:38,749 --> 00:43:42,486
above it, and then the spring
pushes that weight down

1072
00:43:42,486 --> 00:43:44,888
really rapidly,
and hits the tip,

1073
00:43:44,888 --> 00:43:47,458
and moves it slightly into
the ground with every stroke.

1074
00:43:47,458 --> 00:43:49,059
So it slowly hammers its way in,

1075
00:43:49,059 --> 00:43:50,928
and there's actually
a spring at the top

1076
00:43:50,928 --> 00:43:52,196
that absorbs some of the recoil,

1077
00:43:52,196 --> 00:43:54,732
so it doesn't just
bounce in place.

1078
00:43:54,732 --> 00:43:56,000
As we go down,

1079
00:43:56,000 --> 00:43:57,901
we're gonna go about 50
centimeters at a time,

1080
00:43:57,901 --> 00:44:00,904
and then pause, let the soil
cool off for a few days,

1081
00:44:00,904 --> 00:44:03,107
and then do a thermal

conductivity measurement,

1082
00:44:03,107 --> 00:44:05,976
and then move on, because
once we've left one depth,

1083
00:44:05,976 --> 00:44:08,579
we cannot come back to it,
it stays in the surface.

1084
00:44:08,579 --> 00:44:11,248
Then we go all the way down
for three to five meters,

1085
00:44:11,248 --> 00:44:13,584
up to 16 feet
beneath the ground,

1086
00:44:13,584 --> 00:44:15,519
taking measurements as we go.

1087
00:44:15,519 --> 00:44:17,021
Once we're there,

1088
00:44:17,021 --> 00:44:19,189
we stay in that configuration
for the rest of the mission.

1089
00:44:19,189 --> 00:44:21,592
That's for one Mars
year or two Earth years,

1090
00:44:21,592 --> 00:44:24,595
and measure the heat flow
coming out of the planet

1091
00:44:24,595 --> 00:44:26,063
using the temperature sensors

1092

00:44:26,063 --> 00:44:28,232
scattered along
the science tether

1093
00:44:28,232 --> 00:44:29,667
that we've dragged
behind the mole

1094
00:44:29,667 --> 00:44:31,502
for the rest of the mission,

1095
00:44:31,502 --> 00:44:33,437
figuring out the heat
coming out of Mars

1096
00:44:33,437 --> 00:44:37,241
and therefore providing
a constraint on
the various models.

1097
00:44:37,241 --> 00:44:39,510
This is where
InSight is right now,

1098
00:44:39,510 --> 00:44:42,746
we're looking forward very
much to seeing WTS deployment

1099
00:44:42,746 --> 00:44:44,515
coming up soon,
middle of the month.

1100
00:44:44,515 --> 00:44:47,017
We expect HP cubed
deployment end of January,

1101
00:44:47,017 --> 00:44:48,886
early February if
everything goes smoothly,

1102

00:44:48,886 --> 00:44:50,888
and then moving on to
the hammering phase.

1103
00:44:50,888 --> 00:44:52,189
And we're looking
forward very much

1104
00:44:52,189 --> 00:44:53,691
to the exciting science to come,

1105
00:44:53,691 --> 00:44:55,993
so please follow
Insight as you can,

1106
00:44:55,993 --> 00:44:57,161
as we go forward on Mars.

1107
00:44:57,161 --> 00:44:58,262
Thank you.

1108
00:44:58,262 --> 00:45:00,464
[applause]

1109
00:45:05,903 --> 00:45:07,171
>> Okay.

1110
00:45:07,171 --> 00:45:08,772
Thanks so much, Liz.

1111
00:45:08,772 --> 00:45:11,875
We're gonna get set to
take your questions now.

1112
00:45:11,875 --> 00:45:15,179
If you'll come down to the
microphone in the center aisle

1113
00:45:15,179 --> 00:45:17,214

for your questions, and
while we're getting set up,

1114
00:45:17,214 --> 00:45:19,683
I'd like to show you
a cool new online tool

1115
00:45:19,683 --> 00:45:22,553
for getting to know more
about the InSight mission.

1116
00:45:22,553 --> 00:45:24,421
It's called Experience InSight,

1117
00:45:24,421 --> 00:45:27,858
and it's a 3D interactive
model of the InSight lander.

1118
00:45:27,858 --> 00:45:31,061
You can rotate it in 3D, you
can deploy the solar arrays

1119
00:45:31,061 --> 00:45:32,629
and the instruments yourself,

1120
00:45:32,629 --> 00:45:34,665
you can take control
of the robotic arm

1121
00:45:34,665 --> 00:45:36,567
to get a feel for how it works,

1122
00:45:36,567 --> 00:45:38,535
and you can click
around on the different

1123
00:45:38,535 --> 00:45:42,473
spacecraft components to
learn more about what they do.

1124
00:45:42,473 --> 00:45:44,341
Experience InSight
works on your computer

1125
00:45:44,341 --> 00:45:46,243
as well as on your
mobile devices.

1126
00:45:46,243 --> 00:45:50,647
So check it out at
eyes.nasa.gov/insight.

1127
00:45:50,647 --> 00:45:53,684
Okay, and so if Abby and Liz
will join me back up here,

1128
00:45:53,684 --> 00:45:55,285
we'll get set for
your questions.

1129
00:46:03,060 --> 00:46:05,262
And it looks like
we do have one.

1130
00:46:05,262 --> 00:46:06,430
>> Okay.

1131
00:46:06,430 --> 00:46:07,264
Testing?

1132
00:46:07,264 --> 00:46:08,499
All right, great.

1133
00:46:08,499 --> 00:46:11,235
I had a question about
the Mars 2020 Rover.

1134
00:46:11,235 --> 00:46:13,504
You mentioned that one of

the exciting things about it

1135
00:46:13,504 --> 00:46:15,806
is that it's going to
be taking rock samples

1136
00:46:15,806 --> 00:46:18,041
and bringing them back to Earth.

1137
00:46:18,041 --> 00:46:21,211
How is the return
process going to happen?

1138
00:46:21,211 --> 00:46:22,479
>> Yes, that's a great question,

1139
00:46:22,479 --> 00:46:25,215
and we're still kind of
talking through details.

1140
00:46:25,215 --> 00:46:28,051
We have a lot of options
for possible ways to do it.

1141
00:46:28,051 --> 00:46:30,287
Broadly the architecture
is probably gonna look

1142
00:46:30,287 --> 00:46:32,856
something like, we're
gonna send another rover,

1143
00:46:32,856 --> 00:46:36,026
a fetch rover, that's
gonna collect the samples,

1144
00:46:36,026 --> 00:46:38,395
we're gonna launch them,
send a Mars Assent Vehicle,

1145
00:46:38,395 --> 00:46:41,165
or a MAV, to launch
them back into orbit.

1146
00:46:41,165 --> 00:46:42,900
And then, some details
about how either

1147
00:46:42,900 --> 00:46:44,968
it's gonna orbit Mars and
then we'll pick it up,

1148
00:46:44,968 --> 00:46:46,837
or we'll just send it
directly back to Earth.

1149
00:46:46,837 --> 00:46:49,139
But it'll be a
multi-step process.

1150
00:46:49,139 --> 00:46:50,240
>> Man: Okay, thank you.

1151
00:46:50,240 --> 00:46:51,074
>> Sure.

1152
00:46:52,242 --> 00:46:54,678
>> A couple of questions.

1153
00:46:54,678 --> 00:46:58,148
First of all, for the drilling
problems you were having,

1154
00:46:58,148 --> 00:47:00,751
is there a percussive element
with the rotational element?

1155
00:47:00,751 --> 00:47:03,220
I know there is like

a hammer drill effect

1156
00:47:03,220 --> 00:47:05,189
that you've used, and
has that worked out,

1157
00:47:05,189 --> 00:47:07,291
or what's the status with that?

1158
00:47:07,291 --> 00:47:08,492
>> Yeah.

1159
00:47:08,492 --> 00:47:10,460
So the question is about
the Curiosity drill.

1160
00:47:10,460 --> 00:47:13,564
And so the Curiosity drill,
yes, it's a percussive drill,

1161
00:47:13,564 --> 00:47:16,300
a rotary percussive drill,
so that means it spins

1162
00:47:16,300 --> 00:47:19,770
and it percusses, both.

1163
00:47:19,770 --> 00:47:23,106
We attempted to do a couple
drills that I didn't show

1164
00:47:23,106 --> 00:47:26,109
using rotary only, and
didn't get very far.

1165
00:47:26,109 --> 00:47:28,312
But those drills
that we tried with,

1166

00:47:28,312 --> 00:47:31,415
the rock was still too hard,
that was rotary and percussive

1167
00:47:31,415 --> 00:47:34,051
kind of at our maximum
percussion level.

1168
00:47:34,051 --> 00:47:35,986
The drill has several
percussion levels

1169
00:47:35,986 --> 00:47:37,554
and it has a smart sensor on it

1170
00:47:37,554 --> 00:47:39,423
that it can figure out
when it needs to kind of

1171
00:47:39,423 --> 00:47:41,325
up the rotation or
up the percussion.

1172
00:47:41,325 --> 00:47:44,494
And so we kind of maxed
it out at our level five,

1173
00:47:44,494 --> 00:47:46,997
and we still found we
weren't making any progress.

1174
00:47:46,997 --> 00:47:50,400
>> Is there a way to use
the actuators in the arm

1175
00:47:50,400 --> 00:47:53,403
to assist in the
percussion element?

1176
00:47:53,403 --> 00:47:57,841

So you could have
the arm pushing at
alternating frequencies

1177
00:47:57,841 --> 00:48:01,211
to aid the effectiveness
of the percussion effect?

1178
00:48:01,211 --> 00:48:02,746
>> So yeah, I'm not sure.

1179
00:48:02,746 --> 00:48:04,248
The arm itself,

1180
00:48:04,248 --> 00:48:07,651
so how the drill used to work
is it had these kinda prongs

1181
00:48:07,651 --> 00:48:09,386
that we'd put down
on the surface,

1182
00:48:09,386 --> 00:48:11,455
and then we had a feed mechanism
that would actually extend

1183
00:48:11,455 --> 00:48:14,291
and so the arm would be
completely stationary.

1184
00:48:14,291 --> 00:48:16,894
The feed mechanism is
no longer operating,

1185
00:48:16,894 --> 00:48:19,496
so the engineers actually
did some really amazing work

1186
00:48:19,496 --> 00:48:20,864
figuring out how to

operate the drill

1187
00:48:20,864 --> 00:48:23,200
without the feed mechanism,
so fully extended.

1188
00:48:23,200 --> 00:48:25,402
So think of it kind
of like using a drill,

1189
00:48:25,402 --> 00:48:26,837
how you would use it anyway,

1190
00:48:26,837 --> 00:48:28,005
just kind of pushing
straight down.

1191
00:48:28,005 --> 00:48:29,573
So we have the weight of the arm

1192
00:48:29,573 --> 00:48:31,708
that's kind of being
the gravity vector,

1193
00:48:31,708 --> 00:48:33,644
I don't think we'd be
able to percuss the arm

1194
00:48:33,644 --> 00:48:35,212
as fast as we percuss the drill.

1195
00:48:35,212 --> 00:48:37,781
I don't know, as an engineer.

1196
00:48:37,781 --> 00:48:40,217
>> Seems like I
wouldn't recommend it.

1197
00:48:40,217 --> 00:48:41,718

>> Yeah, yeah.

1198
00:48:41,718 --> 00:48:43,453
Thought there might be some
hazards associated with that.

1199
00:48:43,453 --> 00:48:45,856
And I'm sure this one
is something that's
occurred to you,

1200
00:48:45,856 --> 00:48:47,424
but I'm gonna bring
it up just to find out

1201
00:48:47,424 --> 00:48:48,859
why it wasn't done.

1202
00:48:48,859 --> 00:48:51,461
With the solar panels, I mean,

1203
00:48:51,461 --> 00:48:55,132
everybody's thought of some
sort of like a windshield wiper

1204
00:48:55,132 --> 00:48:58,268
type effect, I've even
heard of artificial muscles

1205
00:48:58,268 --> 00:49:01,305
that could be used
to have the action

1206
00:49:01,305 --> 00:49:03,674
with very little
energy requirement.

1207
00:49:03,674 --> 00:49:05,909
Or you could turn
them on an angle

1208
00:49:05,909 --> 00:49:08,011
and shake them, or use air jets.

1209
00:49:08,011 --> 00:49:10,948
Surely you must've come
close to trying something.

1210
00:49:10,948 --> 00:49:13,350
What did you think of,
and why didn't you do it?

1211
00:49:14,785 --> 00:49:17,087
>> Well, I know when I came I
actually asked that question

1212
00:49:17,087 --> 00:49:19,222
of somebody I was like, why
don't we have a windshield wiper

1213
00:49:19,222 --> 00:49:21,158
that can just
occasionally go across,

1214
00:49:21,158 --> 00:49:23,360
and the answer is, as
an engineering thing,

1215
00:49:23,360 --> 00:49:25,462
that's another motor
you have to heat,

1216
00:49:25,462 --> 00:49:27,230
you've got to make
sure it can work.

1217
00:49:27,230 --> 00:49:29,166
There's a lot of items
there where we know

1218
00:49:29,166 --> 00:49:31,001
if you size those solar
arrays big enough,

1219
00:49:31,001 --> 00:49:33,570
and if you get these occasional
dust cleaning events,

1220
00:49:33,570 --> 00:49:35,772
that we tend to be
okay as we are now,

1221
00:49:35,772 --> 00:49:37,674
so it just hasn't been a
requirement at this point.

1222
00:49:37,674 --> 00:49:39,176
>> And just a reminder,

1223
00:49:39,176 --> 00:49:43,246
the requirement for the Spirit
and Opportunity was 90 sols.

1224
00:49:43,246 --> 00:49:46,383
And it was easier to
build bigger solar panels

1225
00:49:46,383 --> 00:49:49,119
that would get you to 90
sols than it would be to try

1226
00:49:49,119 --> 00:49:51,888
and find one of these devices
that would add complexity.

1227
00:49:51,888 --> 00:49:54,591
And it's just been a gift
that they've lasted so long,

1228

00:49:54,591 --> 00:49:57,561
and it's been a gift that we've
had these cleaning events.

1229
00:49:57,561 --> 00:49:59,029
>> Well with 20/20 hindsight,

1230
00:49:59,029 --> 00:50:01,031
which of course is very suspect,

1231
00:50:01,031 --> 00:50:02,866
would you say after six months

1232
00:50:02,866 --> 00:50:04,634
that maybe it might've
been a good idea

1233
00:50:04,634 --> 00:50:06,970
to try one of those mechanisms?

1234
00:50:06,970 --> 00:50:08,505
>> Absolutely not.

1235
00:50:08,505 --> 00:50:11,074
I think that the way they
are designed was perfect,

1236
00:50:11,074 --> 00:50:14,277
and beautiful, and I think
that they've far exceeded

1237
00:50:14,277 --> 00:50:16,346
what they were designed to do.

1238
00:50:16,346 --> 00:50:17,614
>> Man: Okay.

1239
00:50:17,614 --> 00:50:18,415
>> Preston: Thanks

for your question.

1240
00:50:20,550 --> 00:50:21,918
>> Hi.

1241
00:50:21,918 --> 00:50:23,653
Thanks for the presentation.

1242
00:50:23,653 --> 00:50:26,790
Could you explain in
a little more detail

1243
00:50:26,790 --> 00:50:30,060
the mechanism
behind the HP3 mole?

1244
00:50:30,060 --> 00:50:32,929
Specifically, you've
got a nail there that's,

1245
00:50:32,929 --> 00:50:34,931
I don't know what that
is, eight, 10, 12 inches,

1246
00:50:34,931 --> 00:50:36,133
something like that?

1247
00:50:36,133 --> 00:50:37,968
>> Liz: It's about
maybe 30 inches or so.

1248
00:50:37,968 --> 00:50:39,436
>> Oh 30, okay.

1249
00:50:39,436 --> 00:50:40,737
>> No I'm sorry, 12
inches, about a foot long.

1250
00:50:40,737 --> 00:50:42,839

>> Oh, okay, so, like I said.

1251
00:50:42,839 --> 00:50:47,144
And whatever material is
attaching it to the instrument

1252
00:50:47,144 --> 00:50:51,415
on the surface must be a
softer, malleable material,

1253
00:50:51,415 --> 00:50:54,017
because it presumably
is coiled up

1254
00:50:54,017 --> 00:50:55,652
somehow inside the instrument?

1255
00:50:55,652 --> 00:50:56,720
>> It doesn't actually
rotate at all,

1256
00:50:56,720 --> 00:50:58,755
it just percusses it's way down.

1257
00:50:58,755 --> 00:51:00,991
So it won't actually rotate,
it just pulls out the tether,

1258
00:51:00,991 --> 00:51:04,795
and the tether's stored in
the portion on the surface,

1259
00:51:04,795 --> 00:51:06,963
and it gets pulled
out as it goes deeper.

1260
00:51:06,963 --> 00:51:08,098
>> Man: Right, that's what
I'm saying, so you've got

1261
00:51:08,098 --> 00:51:09,266
a tether that's --
>> Yep.

1262
00:51:09,266 --> 00:51:10,233
>> Man: That's
some kind of softer

1263
00:51:10,233 --> 00:51:11,368
material --
>> It is.

1264
00:51:11,368 --> 00:51:11,902
>> Man: That's
attached to the nail.

1265
00:51:11,902 --> 00:51:12,836
>> Yep.

1266
00:51:12,836 --> 00:51:14,438
>> And so how are you able to,

1267
00:51:14,438 --> 00:51:17,007
how is it able to
transmit the force

1268
00:51:17,007 --> 00:51:20,911
as you get deeper and
deeper into the ground

1269
00:51:20,911 --> 00:51:22,712
through that softer material?

1270
00:51:22,712 --> 00:51:25,749
That device that you,
it's able to do that?

1271
00:51:25,749 --> 00:51:28,051
>> The device is actually

in the nail itself.

1272
00:51:28,051 --> 00:51:30,620
So it actually
hammers itself deeper

1273
00:51:30,620 --> 00:51:32,089
and just pulls the
tether behind it.

1274
00:51:32,089 --> 00:51:33,623
>> Oh, I understand.

1275
00:51:33,623 --> 00:51:35,025
>> So it doesn't actually
need to transfer anything

1276
00:51:35,025 --> 00:51:36,560
through the tether, the
tether's very flexible and thin,

1277
00:51:36,560 --> 00:51:38,462
it couldn't actually transmit
any force through it.

1278
00:51:38,462 --> 00:51:40,230
>> Male: Okay, okay that
makes sense, thank you.

1279
00:51:40,230 --> 00:51:43,033
>> We'd all like to be able
to get self-drilling nails for

1280
00:51:43,033 --> 00:51:47,270
home improvement projects.
[laughter]

1281
00:51:47,270 --> 00:51:49,005
>> Hello, is there
ever a situation

1282
00:51:49,005 --> 00:51:50,607
where a rover would be planned

1283
00:51:50,607 --> 00:51:52,776
that would assist
a previous rover?

1284
00:51:52,776 --> 00:51:54,711
Is there anything that
you could think of

1285
00:51:54,711 --> 00:51:58,482
that would make that
an opportunity that
you would go for?

1286
00:51:58,482 --> 00:52:00,117
>> Yeah, I think
it'd be totally cool

1287
00:52:00,117 --> 00:52:03,053
if we could go send a rover
in and nudge another one.

1288
00:52:03,053 --> 00:52:05,322
Right now where the
rovers are landed,

1289
00:52:05,322 --> 00:52:07,791
they're thousands
of kilometers apart.

1290
00:52:07,791 --> 00:52:12,262
So our current rovers, to
get from one to another,

1291
00:52:12,262 --> 00:52:16,032
would take a Mars
record, world record,

1292
00:52:16,032 --> 00:52:18,401
amounts of driving
in order to do it.

1293
00:52:18,401 --> 00:52:20,170
But you know, in the future
we are thinking about,

1294
00:52:20,170 --> 00:52:22,906
are there ways we might
wanna design groups of rovers

1295
00:52:22,906 --> 00:52:24,074
that might go to a single site,

1296
00:52:24,074 --> 00:52:25,609
how might that
enable exploration,

1297
00:52:25,609 --> 00:52:27,144
what would be the ideal number.

1298
00:52:27,144 --> 00:52:28,745
And so these are all
things we think about

1299
00:52:28,745 --> 00:52:30,914
for future exploration.

1300
00:52:30,914 --> 00:52:32,115
>> Thank you.

1301
00:52:32,115 --> 00:52:33,617
>> And Abby, let me
follow that question up,

1302
00:52:33,617 --> 00:52:36,219
'cause you helped to select

the landing site for 2020,

1303
00:52:36,219 --> 00:52:37,454
right, or you
worked, you worked --

1304
00:52:37,454 --> 00:52:39,322
>> I was part of the
science community

1305
00:52:39,322 --> 00:52:41,091
who provided input,
yeah, yeah yeah.

1306
00:52:41,091 --> 00:52:44,995
>> So, one of the sites
that was being considered

1307
00:52:44,995 --> 00:52:46,530
was Gale Crater, right?

1308
00:52:46,530 --> 00:52:48,465
>> Yeah, so one of the sites,
it was actually Gusev Crater.

1309
00:52:48,465 --> 00:52:52,502
So one of the areas we thought
about landing the 2020 Rover

1310
00:52:52,502 --> 00:52:55,605
was in Gusev Crater, which is
where the Spirit rover landed,

1311
00:52:55,605 --> 00:52:57,541
and that's because
Spirit discovered

1312
00:52:57,541 --> 00:52:59,509
some kind of
interesting features

1313
00:52:59,509 --> 00:53:02,078
that we thought maybe
was a sign of past life.

1314
00:53:02,078 --> 00:53:04,681
But maybe they weren't
a sign of past life,

1315
00:53:04,681 --> 00:53:07,551
and Mars is a big planet
with lots to explore.

1316
00:53:07,551 --> 00:53:10,320
So in the end, we decided
the science rationale

1317
00:53:10,320 --> 00:53:13,590
was just so much more
compelling to go to Jezero.

1318
00:53:13,590 --> 00:53:17,194
But there's interesting stuff
at these site we've been to,

1319
00:53:17,194 --> 00:53:19,563
so don't rule out a mission in
the future to go back there,

1320
00:53:19,563 --> 00:53:20,697
I think that would
be pretty cool.

1321
00:53:20,697 --> 00:53:21,698
>> Woman: Thank you.

1322
00:53:23,466 --> 00:53:25,035
>> The last one.

1323

00:53:25,035 --> 00:53:30,040
How hard of rock does the HP3
hammer been able to dig down,

1324
00:53:31,408 --> 00:53:35,478
have you been able to sort
through something like granite?

1325
00:53:35,478 --> 00:53:38,148
>> No, it actually can't
go through rock at all.

1326
00:53:38,148 --> 00:53:40,584
So if we hit a rock dead on,

1327
00:53:40,584 --> 00:53:43,286
then we will be stopped by the
rock, it can't go through it.

1328
00:53:43,286 --> 00:53:45,622
However, if we hit a rock
a little bit edge on,

1329
00:53:45,622 --> 00:53:48,592
it can actually kinda start
going a little bit sideways,

1330
00:53:48,592 --> 00:53:51,561
and we can actually measure
the tilt of the HP cubed,

1331
00:53:51,561 --> 00:53:52,829
so we can see how deep it is

1332
00:53:52,829 --> 00:53:54,798
even if it's going a
little bit sideways.

1333
00:53:54,798 --> 00:53:56,967
So it might be able to slip

around a rock completely

1334
00:53:56,967 --> 00:53:59,369
or go off a little bit
sideways and keep going.

1335
00:53:59,369 --> 00:54:01,338
If we hit a flat rock
essentially dead on,

1336
00:54:01,338 --> 00:54:03,673
then unfortunately we
couldn't get through that.

1337
00:54:03,673 --> 00:54:04,507
>> Thank you.

1338
00:54:06,509 --> 00:54:11,514
>> I want to ask about the
solar energy versus nuclear.

1339
00:54:12,849 --> 00:54:17,554
We started the first
landing on Mars with solar.

1340
00:54:17,554 --> 00:54:22,092
And then we went into nuclear
and went back to solar.

1341
00:54:22,092 --> 00:54:23,460
There was some nuke, okay.

1342
00:54:24,828 --> 00:54:28,365
Now, if solar had the problem
that you have to clean,

1343
00:54:28,365 --> 00:54:30,767
why didn't you use nuclear?

1344

00:54:30,767 --> 00:54:32,769
And I see Bill here,

1345
00:54:32,769 --> 00:54:36,539
who is the one who can
answer that question, too.

1346
00:54:36,539 --> 00:54:39,409
>> Well I'll say for InSight,
we didn't need nuclear,

1347
00:54:39,409 --> 00:54:41,645
solar was gonna work just fine.

1348
00:54:41,645 --> 00:54:44,047
We landed within four
degrees of the equator,

1349
00:54:44,047 --> 00:54:45,882
so we're very close
to the equator,

1350
00:54:45,882 --> 00:54:48,318
and luckily we just happened
to be slightly tilted south,

1351
00:54:48,318 --> 00:54:50,186
which is the
perfect tilt for us.

1352
00:54:50,186 --> 00:54:52,455
We oversized our solar
arrays so we could make sure

1353
00:54:52,455 --> 00:54:54,257
we could survive one
full martian year,

1354
00:54:54,257 --> 00:54:57,394
including through the winter,

and the good thing is,

1355
00:54:57,394 --> 00:54:59,362
if you can survive
one martian year,

1356
00:54:59,362 --> 00:55:00,563
there's nothing that says

1357
00:55:00,563 --> 00:55:02,799
you can't survive the
next martian year,

1358
00:55:02,799 --> 00:55:05,669
so there's always
opportunities for the future.

1359
00:55:05,669 --> 00:55:08,905
But we didn't need to go to
nuclear to make the mission work

1360
00:55:08,905 --> 00:55:10,073
so we were able to
do it with solar.

1361
00:55:10,073 --> 00:55:12,375
>> Yeah but what about the dust?

1362
00:55:12,375 --> 00:55:14,444
>> There's the dust that we
will always keep an eye on,

1363
00:55:14,444 --> 00:55:16,946
if there's a dust event, then
we know that we'll get dust

1364
00:55:16,946 --> 00:55:18,415
in the arrays, but
we oversized them

1365
00:55:18,415 --> 00:55:20,283
knowing that that
was likely to happen,

1366
00:55:20,283 --> 00:55:21,985
and then that we'd get
some dust cleaning events.

1367
00:55:21,985 --> 00:55:24,287
>> Are you going to
go again with nuclear?

1368
00:55:24,287 --> 00:55:26,156
>> Yeah, so again,
this all goes back to,

1369
00:55:26,156 --> 00:55:28,224
what's the requirement
of the mission?

1370
00:55:28,224 --> 00:55:29,759
What science do we need to?

1371
00:55:29,759 --> 00:55:31,961
And that, it drives how
long does it need to last

1372
00:55:31,961 --> 00:55:33,630
and how much power do we need?

1373
00:55:33,630 --> 00:55:35,699
So nuclear's gonna be
a lot more expensive,

1374
00:55:35,699 --> 00:55:37,300
more complicated,

1375
00:55:37,300 --> 00:55:39,436
and it'll get you

more power, though.

1376
00:55:39,436 --> 00:55:43,073
So for Spirit and Opportunity
we used solar panels

1377
00:55:43,073 --> 00:55:45,175
because in terms of the
power and how long we thought

1378
00:55:45,175 --> 00:55:48,278
we needed to do the science
to do, that was sufficient.

1379
00:55:48,278 --> 00:55:51,548
For Curiosity and for Mars
2020 we're using nuclear

1380
00:55:51,548 --> 00:55:54,317
because those vehicles just
require so much more power,

1381
00:55:54,317 --> 00:55:55,952
it would be impossible
to size a solar array

1382
00:55:55,952 --> 00:55:57,220
that would be big enough.

1383
00:55:57,220 --> 00:55:59,122
So what's the mission
that you wanna do,

1384
00:55:59,122 --> 00:56:01,591
how much power do you need,
how long does it need to last,

1385
00:56:01,591 --> 00:56:04,227
that's gonna tell you what
power source you wanna use.

1386
00:56:04,227 --> 00:56:05,562
And remember it's all trade offs

1387
00:56:05,562 --> 00:56:07,864
in terms of cost complexity.

1388
00:56:07,864 --> 00:56:08,832
>> Male: Okay.

1389
00:56:08,832 --> 00:56:09,666
Thank you.

1390
00:56:10,800 --> 00:56:12,535
>> I'll give folks
another chance

1391
00:56:12,535 --> 00:56:14,104
if anybody else has a question.

1392
00:56:14,104 --> 00:56:17,040
I'll ask you guys if you
wanna get a little science-y

1393
00:56:17,040 --> 00:56:19,209
about that heat
probe measurement.

1394
00:56:20,577 --> 00:56:24,147
What do you learn from taking
the temperature of Mars

1395
00:56:24,147 --> 00:56:25,615
at these different levels?

1396
00:56:25,615 --> 00:56:28,918
Why do you want to know the
temperature at multiple levels,

1397
00:56:28,918 --> 00:56:30,520
what does it tell
you about Mars?

1398
00:56:30,520 --> 00:56:32,756
>> So one of the things we
wanna measure is actually,

1399
00:56:32,756 --> 00:56:36,459
as the seasons come about
on Mars it heats the ground,

1400
00:56:36,459 --> 00:56:38,962
and it actually has a heat
pulse that goes into the ground.

1401
00:56:38,962 --> 00:56:41,364
You wanna see how deep
that heat pulse can go,

1402
00:56:41,364 --> 00:56:42,699
and also you need to
be able to remove that

1403
00:56:42,699 --> 00:56:44,834
through the total
calculations of how much heat

1404
00:56:44,834 --> 00:56:46,169
is flowing out of Mars.

1405
00:56:46,169 --> 00:56:47,737
So you actually want
the measurements

1406
00:56:47,737 --> 00:56:49,639
at lots of different points.

1407
00:56:49,639 --> 00:56:52,809

Also, we don't know how
deep we'll actually make it

1408
00:56:52,809 --> 00:56:54,277
into the surface of Mars,

1409
00:56:54,277 --> 00:56:56,413
so we'd hate to have
the heat probe sensor

1410
00:56:56,413 --> 00:56:57,814
be at the very
end of the tether,

1411
00:56:57,814 --> 00:56:59,816
and that be the one
sensor sticking out

1412
00:56:59,816 --> 00:57:01,084
at the top of the surface,

1413
00:57:01,084 --> 00:57:02,419
and the rest of the
probe be underneath.

1414
00:57:02,419 --> 00:57:03,853
That would just be terrible.

1415
00:57:03,853 --> 00:57:05,555
So you want sensors along
the way to make sure

1416
00:57:05,555 --> 00:57:08,958
as you go down you get some
sensors into the ground.

1417
00:57:08,958 --> 00:57:10,527
>> Yeah and I can just add,

1418

00:57:10,527 --> 00:57:12,262
kinda from a
geophysics perspective,

1419
00:57:12,262 --> 00:57:14,164
when all rocky planets form,

1420
00:57:14,164 --> 00:57:16,299
they have some residual
heat on their core,

1421
00:57:16,299 --> 00:57:17,967
and that heat is
from just the energy

1422
00:57:17,967 --> 00:57:19,536
from the planet
forming and accreting,

1423
00:57:19,536 --> 00:57:22,238
and also any
radioactive elements

1424
00:57:22,238 --> 00:57:23,473
that may be trapped down there

1425
00:57:23,473 --> 00:57:24,941
are gonna decay and
they're gonna warm up.

1426
00:57:24,941 --> 00:57:28,645
And that heat on Earth, that's
what drive the convection,

1427
00:57:28,645 --> 00:57:30,113
that's what drives
plate tectonics.

1428
00:57:30,113 --> 00:57:32,282
That's why we have

earthquakes and volcanoes.

1429
00:57:32,282 --> 00:57:34,584
So the question is, a
planet as small as Mars,

1430
00:57:34,584 --> 00:57:36,586
how much heat did
it initially have?

1431
00:57:36,586 --> 00:57:38,154
How did the heat cool over time?

1432
00:57:38,154 --> 00:57:39,656
How much heat is
it producing now?

1433
00:57:39,656 --> 00:57:42,258
And you need that number in
order to make these models

1434
00:57:42,258 --> 00:57:43,993
to kind of backtrack
through time.

1435
00:57:43,993 --> 00:57:47,397
>> And we could do models for
lots of different variations,

1436
00:57:47,397 --> 00:57:49,666
but this measurement will help
nail down the models and say,

1437
00:57:49,666 --> 00:57:51,701
you've gotta at least
match this point

1438
00:57:51,701 --> 00:57:54,270
to be considered
at least feasible.

1439
00:57:54,270 --> 00:57:55,805
>> Great.

1440
00:57:55,805 --> 00:57:57,507
I know in December of last year

1441
00:57:57,507 --> 00:57:59,142
there was a beautiful
picture released

1442
00:57:59,142 --> 00:58:02,479
of this ice crater on
Mars that was discovered,

1443
00:58:02,479 --> 00:58:05,215
I'm not sure if that
was by JPL or not.

1444
00:58:05,215 --> 00:58:09,385
But what are the scientific
implications of that discovery,

1445
00:58:09,385 --> 00:58:11,554
according to you guys?

1446
00:58:11,554 --> 00:58:14,491
>> I actually missed that
story when it went by, so.

1447
00:58:14,491 --> 00:58:15,725
>> I don't know a ton about it,

1448
00:58:15,725 --> 00:58:17,193
I saw a little bit
of a news story.

1449
00:58:17,193 --> 00:58:18,728
>> Preston: A Mars Express

image I think, right?

1450
00:58:18,728 --> 00:58:20,163
>> Yeah, I think so.

1451
00:58:20,163 --> 00:58:22,665
And I mean, we know
there's water on Mars,

1452
00:58:22,665 --> 00:58:24,601
there's water at
the poles of Mars,

1453
00:58:24,601 --> 00:58:27,837
so it actually has ice
caps that are permanent,

1454
00:58:27,837 --> 00:58:30,273
and also that freeze
the atmosphere,

1455
00:58:30,273 --> 00:58:31,708
actually, onto the ice caps.

1456
00:58:31,708 --> 00:58:33,476
Think in Earth in the
wintertime if our atmosphere

1457
00:58:33,476 --> 00:58:35,812
actually froze to
ice at the poles,

1458
00:58:35,812 --> 00:58:38,181
which would be really unique,
that actually happens on Mars.

1459
00:58:38,181 --> 00:58:41,584
So we know there's water
ice and CO2 ice on Mars.

1460
00:58:41,584 --> 00:58:43,119
The fact that in a crater

1461
00:58:43,119 --> 00:58:44,988
that perhaps is shadowed
a lot of the year,

1462
00:58:44,988 --> 00:58:47,657
you could still have some
sort of ice permanently there,

1463
00:58:47,657 --> 00:58:49,692
or at least for some
point of the year there,

1464
00:58:49,692 --> 00:58:51,261
doesn't surprise me.

1465
00:58:51,261 --> 00:58:53,029
I don't know where on
Mars that crater was,

1466
00:58:53,029 --> 00:58:55,965
so I don't know exactly
how surprised to be.

1467
00:58:55,965 --> 00:58:56,833
>> Man: Gotcha.

1468
00:58:56,833 --> 00:58:57,867
All right, thank you.

1469
00:58:59,869 --> 00:59:00,637
>> Hi there.

1470
00:59:01,638 --> 00:59:03,439
So you said with Curiosity,

1471

00:59:03,439 --> 00:59:07,043
the rocks that you kept trying
to drill into were too hard.

1472
00:59:07,043 --> 00:59:09,012
Isn't finding a
softer rock change

1473
00:59:09,012 --> 00:59:11,414
what you're gonna find
once you drill into it?

1474
00:59:12,649 --> 00:59:13,483
>> Maybe?

1475
00:59:13,483 --> 00:59:14,317
>> Man: Okay.

1476
00:59:14,317 --> 00:59:15,518
[laughter]

1477
00:59:15,518 --> 00:59:17,887
>> Yeah, but getting
any rock sample

1478
00:59:17,887 --> 00:59:19,389
is better than getting none.

1479
00:59:19,389 --> 00:59:21,624
And we can do things, we
can measure the chemistry,

1480
00:59:21,624 --> 00:59:23,860
and kinda the
properties, and can see,

1481
00:59:23,860 --> 00:59:25,528
the chemistry is
kind of in family

1482
00:59:25,528 --> 00:59:27,030
with what we've been looking at.

1483
00:59:27,030 --> 00:59:28,932
Does that mean that the
minerals are the same,

1484
00:59:28,932 --> 00:59:32,068
does it mean that the little
bits in it are the same?

1485
00:59:32,068 --> 00:59:33,469
We'll never know.

1486
00:59:34,904 --> 00:59:37,907
But getting one sample is
better than no samples.

1487
00:59:37,907 --> 00:59:38,775
>> Thanks.

1488
00:59:41,578 --> 00:59:44,147
>> Hi, can you go a little
bit more into the details

1489
00:59:44,147 --> 00:59:47,550
about what we can expect to
learn from the wobble of Mars?

1490
00:59:47,550 --> 00:59:49,152
So are we are looking
at different densities

1491
00:59:49,152 --> 00:59:50,620
and trying to figure out
like a density gradient

1492
00:59:50,620 --> 00:59:53,122
through the planet, or what

exactly is it we're looking at?

1493
00:59:53,122 --> 00:59:54,390
>> Particularly the
size of the core.

1494
00:59:54,390 --> 00:59:56,693
So just like the hard
boiled egg example,

1495
00:59:56,693 --> 00:59:59,295
if you spin the hard boiled egg
versus one that hasn't been,

1496
00:59:59,295 --> 01:00:01,230
it's gonna wobble
slightly differently.

1497
01:00:01,230 --> 01:00:04,267
We're looking for how
Mars wobbles over time,

1498
01:00:04,267 --> 01:00:06,202
and with the sensitivity
that we're gonna get

1499
01:00:06,202 --> 01:00:09,272
from this experiment, we can
see not only the big wobbles

1500
01:00:09,272 --> 01:00:12,008
it's gonna do, but the tiny
little wobbles on top of that.

1501
01:00:12,008 --> 01:00:16,045
So we have measurements of the
big wobble from 20 years ago

1502
01:00:16,045 --> 01:00:17,981
from previous missions, and

even 20 years before that

1503
01:00:17,981 --> 01:00:20,183
when we go all the way
back to things like Viking.

1504
01:00:20,183 --> 01:00:22,752
You can go back far enough
that we have a few data points.

1505
01:00:22,752 --> 01:00:24,554
InSight will give us
another data point,

1506
01:00:24,554 --> 01:00:26,055
and then in particular,

1507
01:00:26,055 --> 01:00:28,858
high resolution of these itty
bitty wobbles on top of it.

1508
01:00:28,858 --> 01:00:32,362
From that you can
constrain the models

1509
01:00:32,362 --> 01:00:34,664
that say how much
Mars should wobble

1510
01:00:34,664 --> 01:00:36,366
depending on how
big its core is,

1511
01:00:36,366 --> 01:00:39,202
and a little bit what it's
made out of on this inside.

1512
01:00:39,202 --> 01:00:41,070
>> Are you hoping to see
any kind of evolution

1513
01:00:41,070 --> 01:00:43,206
in all the measurements we've
taken in the last 20 years,

1514
01:00:43,206 --> 01:00:45,775
or is that just too small of
a geological time scale to?

1515
01:00:45,775 --> 01:00:47,844
>> Well, to be able to see
the difference in the big,

1516
01:00:47,844 --> 01:00:51,280
procession, essentially,
of Mars' spin axis.

1517
01:00:51,280 --> 01:00:53,416
But in terms of
the little things,

1518
01:00:53,416 --> 01:00:55,351
InSight's the only one
that'll have the fidelity

1519
01:00:55,351 --> 01:00:56,686
to see that, so we
wouldn't be able to

1520
01:00:56,686 --> 01:00:58,187
compare that with
previous missions.

1521
01:00:58,187 --> 01:01:01,457
But the big position of
where is Mars' axis tilted,

1522
01:01:01,457 --> 01:01:03,693
this longer time span
of about 40 years

1523
01:01:03,693 --> 01:01:06,496
gives us actually enough time
to look at a small change.

1524
01:01:06,496 --> 01:01:07,497
>> Woman: Thank you.

1525
01:01:12,101 --> 01:01:17,106
>> With Insight, are you going
to be able to compare Mars

1526
01:01:18,574 --> 01:01:21,144
to Earth in terms of whether
or not it has a molten core,

1527
01:01:21,144 --> 01:01:25,682
or how large it is, and what
other features of comparison

1528
01:01:25,682 --> 01:01:29,686
like the magnetic poles
and things like that?

1529
01:01:29,686 --> 01:01:32,021
>> Yeah, that's actually the
goal of the InSight is to

1530
01:01:32,021 --> 01:01:34,957
understand better
this terrestrial
evolution of planets.

1531
01:01:34,957 --> 01:01:36,426
We've got the data for Earth,

1532
01:01:36,426 --> 01:01:37,593
we've got the data for the moon,

1533

01:01:37,593 --> 01:01:39,162
which was formed a
little bit differently,

1534
01:01:39,162 --> 01:01:41,164
and it's small enough
that it didn't have

1535
01:01:41,164 --> 01:01:42,699
the exact same processes.

1536
01:01:42,699 --> 01:01:44,634
We really wanna see
this data for Mars

1537
01:01:44,634 --> 01:01:46,469
to see the intermediate
mix of a planet

1538
01:01:46,469 --> 01:01:48,304
that never had plate tectonics.

1539
01:01:48,304 --> 01:01:51,007
So actually we think
its current structure

1540
01:01:51,007 --> 01:01:54,544
locks in what it looked like
when it finished forming,

1541
01:01:54,544 --> 01:01:57,246
four billion years ago.

1542
01:01:57,246 --> 01:02:00,283
We want to understand, does
it have a solid core or not,

1543
01:02:00,283 --> 01:02:01,484
how big is that core?

1544
01:02:01,484 --> 01:02:04,287
We have about, a
big variation in it,

1545
01:02:04,287 --> 01:02:07,290
we wanna get it down about
a factor of four better

1546
01:02:07,290 --> 01:02:10,326
than we know right now, how
big is that core exactly.

1547
01:02:10,326 --> 01:02:12,795
How thick is the crust,
how does that vary,

1548
01:02:12,795 --> 01:02:14,731
all those answers are what
InSight's trying to look at

1549
01:02:14,731 --> 01:02:16,699
is that interior structure

1550
01:02:16,699 --> 01:02:18,768
that we can't see
from the surface.

1551
01:02:18,768 --> 01:02:22,271
>> Man: Do we already know
that it has a molten core?

1552
01:02:22,271 --> 01:02:26,242
>> We think it does, but
it's still uncertain.

1553
01:02:26,242 --> 01:02:28,311
So that's what InSight's
actually trying to look at.

1554

01:02:28,311 --> 01:02:29,479
>> Okay.

1555
01:02:29,479 --> 01:02:34,050
And, given some
theories that the moon

1556
01:02:34,050 --> 01:02:36,686
was actually crashed
into the Earth

1557
01:02:36,686 --> 01:02:40,823
and then separated
into two bodies,

1558
01:02:40,823 --> 01:02:43,926
do we think anything like
that ever happened at Mars?

1559
01:02:43,926 --> 01:02:45,862
>> We know Mars has had
some really big impacts,

1560
01:02:45,862 --> 01:02:49,065
of course we can see the
craters on the surface of Mars.

1561
01:02:49,065 --> 01:02:51,134
Mars' moons we
don't think formed

1562
01:02:51,134 --> 01:02:53,002
in the same way as Earth's
moon, they're much smaller,

1563
01:02:53,002 --> 01:02:56,272
they look like kinda captured
asteroid type things.

1564
01:02:56,272 --> 01:02:58,775

But Mars of course
has had impacts

1565
01:02:58,775 --> 01:03:01,077
over the life of its formation.

1566
01:03:01,077 --> 01:03:03,212
Whether it had a big one
early in its formation,

1567
01:03:03,212 --> 01:03:04,714
that's a little
bit harder to tell.

1568
01:03:04,714 --> 01:03:07,984
>> So yeah, I love Mars' moons,
'cause they're super weird,

1569
01:03:07,984 --> 01:03:10,486
and we super don't
know how they're there.

1570
01:03:10,486 --> 01:03:12,722
And there's really, there's
two schools of thought.

1571
01:03:12,722 --> 01:03:15,057
The asteroids, they really,

1572
01:03:15,057 --> 01:03:17,693
from a distance they
look just like asteroids.

1573
01:03:17,693 --> 01:03:19,095
But then it turns
out dynamically

1574
01:03:19,095 --> 01:03:21,297
it's hard to get asteroids
and capture them,

1575
01:03:21,297 --> 01:03:24,000
and get them into the orbit
that we see Mars' moons in.

1576
01:03:24,000 --> 01:03:27,503
And it's a lot easier to form
them if you have a big impact.

1577
01:03:27,503 --> 01:03:31,107
And we're actually sending,
Jaxa is sending a mission

1578
01:03:31,107 --> 01:03:33,743
to Phobos, which is one
of the moons of Mars,

1579
01:03:33,743 --> 01:03:35,444
and there's going to be
a US instrument on there

1580
01:03:35,444 --> 01:03:37,947
that's gonna land, pick up
a sample, and bring it back,

1581
01:03:37,947 --> 01:03:40,316
and hopefully those
analyses will tell us,

1582
01:03:40,316 --> 01:03:43,019
is it chunk o' Mars, it
might be an impact from Mars,

1583
01:03:43,019 --> 01:03:45,822
is it, like the meteorites we
see, it might be an asteroid.

1584
01:03:45,822 --> 01:03:48,124
So we're gonna kinda solve
one of these big solar system

1585
01:03:48,124 --> 01:03:51,627
questions about what's
the deal with Mars' moons?

1586
01:03:51,627 --> 01:03:52,829
>> Man: Okay, thank you.

1587
01:03:54,897 --> 01:03:56,098
>> Hi.

1588
01:03:56,098 --> 01:03:58,534
For the InSight craft,

1589
01:03:58,534 --> 01:04:03,439
we talked about the
seismometer and the mole.

1590
01:04:04,707 --> 01:04:05,975
There are other instruments
on that vehicle,

1591
01:04:05,975 --> 01:04:07,476
could you talk about
some of the science

1592
01:04:07,476 --> 01:04:10,279
that you're planning for
some of those instruments?

1593
01:04:10,279 --> 01:04:11,347
>> Yeah so --
>> Or are they just support?

1594
01:04:11,347 --> 01:04:12,548
>> Yeah.

1595
01:04:12,548 --> 01:04:14,016
It's a combination,

they both are supportive

1596
01:04:14,016 --> 01:04:15,418
and they could do
their own science,

1597
01:04:15,418 --> 01:04:17,520
we call it stealth science.

1598
01:04:17,520 --> 01:04:18,988
So we have the pressure sensor

1599
01:04:18,988 --> 01:04:21,324
that can measure the pressure,
the atmospheric pressure.

1600
01:04:21,324 --> 01:04:23,359
We've got TWINS, which
measures the wind

1601
01:04:23,359 --> 01:04:25,228
and the temperature
of the atmosphere.

1602
01:04:25,228 --> 01:04:27,563
So between those we're
looking at things like

1603
01:04:27,563 --> 01:04:28,998
how does the atmosphere behave,

1604
01:04:28,998 --> 01:04:30,700
we could do very high
precision measurements

1605
01:04:30,700 --> 01:04:35,037
of the atmosphere, what it's
little local eddies look like.

1606

01:04:35,037 --> 01:04:36,639
Is there dust devils
coming through,

1607
01:04:36,639 --> 01:04:38,341
how often do they happen.

1608
01:04:38,341 --> 01:04:40,042
We've got the
magnetometer looking at

1609
01:04:40,042 --> 01:04:42,612
what's the inherent
magnetic field at Mars,

1610
01:04:42,612 --> 01:04:45,915
which is very very weak, but
we're trying to look for that.

1611
01:04:45,915 --> 01:04:47,416
So we've got those
three instruments

1612
01:04:47,416 --> 01:04:51,087
supporting the seismometer
and the heat probe as well,

1613
01:04:51,087 --> 01:04:52,855
as well as our RISE instrument

1614
01:04:52,855 --> 01:04:55,191
looking at the
rotational procession.

1615
01:04:55,191 --> 01:04:56,726
>> Thank you.

1616
01:04:56,726 --> 01:04:57,727
And are there any cameras
that you're gonna be using

1617
01:04:57,727 --> 01:04:59,695
for science, or just support?

1618
01:04:59,695 --> 01:05:01,197
>> We do use some of
the cameras for science.

1619
01:05:01,197 --> 01:05:03,366
So we had to do a lot
of the camera work

1620
01:05:03,366 --> 01:05:04,734
for our workspace imaging,

1621
01:05:04,734 --> 01:05:07,003
but the geologists love
looking at the dirt

1622
01:05:07,003 --> 01:05:08,471
and the rocks really close up.

1623
01:05:08,471 --> 01:05:10,606
And of course we're gonna
do some more panoramas

1624
01:05:10,606 --> 01:05:14,277
looking around the lander
to see more of the geology

1625
01:05:14,277 --> 01:05:16,712
in the area, watching,
actually one of the things

1626
01:05:16,712 --> 01:05:18,814
we're trying to do is
watch a little pile of dirt

1627
01:05:18,814 --> 01:05:21,017

that happened when we dropped
the tether to the ground,

1628
01:05:21,017 --> 01:05:22,752
and there's a little pile
of dirt that happened.

1629
01:05:22,752 --> 01:05:24,153
We wanna see, are
the little grains

1630
01:05:24,153 --> 01:05:26,555
of that pile of dirt
moving, and how fast,

1631
01:05:26,555 --> 01:05:28,891
based on the wind that's
blowing in the area.

1632
01:05:28,891 --> 01:05:29,725
>> Man: Thank you.

1633
01:05:29,725 --> 01:05:30,559
>> Mm-hmm.

1634
01:05:35,765 --> 01:05:36,933
>> Hi.

1635
01:05:36,933 --> 01:05:38,200
Just a couple
questions, actually.

1636
01:05:38,200 --> 01:05:39,702
It seemed as though
in one of the slides

1637
01:05:39,702 --> 01:05:42,638
for the upcoming
mission in 2020 that

1638
01:05:42,638 --> 01:05:45,107
in lowering the lander
there seemed to be

1639
01:05:45,107 --> 01:05:47,276
another craft, if you
will, with boosters,

1640
01:05:47,276 --> 01:05:50,780
to help it land softly.

1641
01:05:50,780 --> 01:05:54,784
What is the objective with
that other craft, if you will,

1642
01:05:54,784 --> 01:05:58,654
whether to fly away, or is
there hope, if possible,

1643
01:05:58,654 --> 01:06:00,990
to utilize that craft later on?

1644
01:06:00,990 --> 01:06:04,193
>> Yeah, so that craft
is called the Sky Crane.

1645
01:06:04,193 --> 01:06:06,896
And that is actually
the same landing system

1646
01:06:06,896 --> 01:06:08,331
that we used for Curiosity.

1647
01:06:08,331 --> 01:06:10,333
So how it's gonna
work is it's gonna be

1648
01:06:10,333 --> 01:06:11,534
coming through the atmosphere,

1649
01:06:11,534 --> 01:06:13,002
we'll do the parachute,
we'll slow it down,

1650
01:06:13,002 --> 01:06:15,404
we'll deploy the back
shell and we'll lower it,

1651
01:06:15,404 --> 01:06:17,773
and lower it on the
bridle from the Sky Crane.

1652
01:06:17,773 --> 01:06:19,375
And what happens
is the thrusters

1653
01:06:19,375 --> 01:06:20,876
on the Sky Crane will
slow it down enough

1654
01:06:20,876 --> 01:06:23,179
that we can touch very
gently on the ground.

1655
01:06:23,179 --> 01:06:26,082
You can't put thrusters on a
rover because you need wheels,

1656
01:06:26,082 --> 01:06:27,483
where are you gonna
put the thrusters.

1657
01:06:27,483 --> 01:06:28,985
So we'll deploy
it, but then yeah,

1658
01:06:28,985 --> 01:06:30,453
after that we're
gonna cut the tether

1659
01:06:30,453 --> 01:06:33,956
and then send the Sky Crane
as far away as possible

1660
01:06:33,956 --> 01:06:36,158
because you don't want it
to land on the vehicle.

1661
01:06:36,158 --> 01:06:39,395
And in fact, a fun story
from Curiosity's landing

1662
01:06:39,395 --> 01:06:41,530
is one of the first
pictures we took,

1663
01:06:41,530 --> 01:06:44,200
there's like a little
smudge off in the distance,

1664
01:06:44,200 --> 01:06:45,735
and it could be
dirt on the lens,

1665
01:06:45,735 --> 01:06:48,337
but it's kinda pointed in the
direction the Sky Crane went,

1666
01:06:48,337 --> 01:06:50,539
and we know there was a
lot of extra hydrazine

1667
01:06:50,539 --> 01:06:53,976
on the Sky Crane, so it might
be a bit of an explosion

1668
01:06:53,976 --> 01:06:54,910
from when it landed.

1669
01:06:54,910 --> 01:06:57,113
But we wanna get it as far away

1670
01:06:57,113 --> 01:06:59,015
as fast as possible
from the vehicle,

1671
01:06:59,015 --> 01:07:02,084
'cause the vehicle's the
main important thing.

1672
01:07:02,084 --> 01:07:03,319
>> I guess I was just wondering

1673
01:07:03,319 --> 01:07:05,621
if you guys wanted to
utilize it later on

1674
01:07:05,621 --> 01:07:07,623
to maybe collect
those rock samples,

1675
01:07:07,623 --> 01:07:10,159
if possible, to
get another thing.

1676
01:07:11,027 --> 01:07:12,962
But the second question is,

1677
01:07:12,962 --> 01:07:16,565
what makes a team
decide to land a rover

1678
01:07:17,967 --> 01:07:21,437
in an area that seems to
might have water in the past

1679
01:07:21,437 --> 01:07:23,639
versus going somewhere

closer to where

1680
01:07:23,639 --> 01:07:25,674
you feel is the water,
like the ice caps,

1681
01:07:25,674 --> 01:07:28,377
or somewhere close to the
ice caps, things like that.

1682
01:07:28,377 --> 01:07:29,845
>> Yeah, that's a
really good question,

1683
01:07:29,845 --> 01:07:32,214
and it's a bit of a
complicated answer,

1684
01:07:32,214 --> 01:07:34,383
but there's kind of
two main drivers.

1685
01:07:35,551 --> 01:07:38,554
The first thing is, even
though the 2020 Rover

1686
01:07:38,554 --> 01:07:40,890
will be nuclear powered,
there still are restrictions

1687
01:07:40,890 --> 01:07:42,558
on how far north or
south you can go.

1688
01:07:42,558 --> 01:07:44,760
Because as you go
closer to the poles,

1689
01:07:44,760 --> 01:07:46,996
the temperature variations

become very great

1690
01:07:46,996 --> 01:07:48,898
and you need to spend
just so much energy

1691
01:07:48,898 --> 01:07:51,400
heating the rover
that it makes it hard.

1692
01:07:51,400 --> 01:07:53,469
So you restrict it
to a latitude range.

1693
01:07:53,469 --> 01:07:56,005
And then you also start to
get into interesting questions

1694
01:07:56,005 --> 01:07:59,442
about planetary protection,
which is a phrase we use a lot,

1695
01:07:59,442 --> 01:08:01,744
and it means both kind
of protecting our planet

1696
01:08:01,744 --> 01:08:04,680
from samples we bring back in
case there's any killer bugs,

1697
01:08:04,680 --> 01:08:06,849
but also protecting
the planet we land on

1698
01:08:06,849 --> 01:08:08,417
from any forward contamination.

1699
01:08:08,417 --> 01:08:10,853
And it turns out
requirements near areas

1700
01:08:10,853 --> 01:08:13,389
where you might have liquid
water are really really strict.

1701
01:08:13,389 --> 01:08:15,825
So it makes it
difficult to land there,

1702
01:08:15,825 --> 01:08:18,327
you wanna make sure your
mission's really really clean.

1703
01:08:18,327 --> 01:08:20,663
And we think there's a lot
of really good science to do

1704
01:08:20,663 --> 01:08:23,065
in the sites that we
picked, and the idea is,

1705
01:08:23,065 --> 01:08:26,068
if Mars had life in the
past, maybe the old rocks

1706
01:08:26,068 --> 01:08:28,304
would be a great place to look.

1707
01:08:28,304 --> 01:08:29,338
>> Thank you.

1708
01:08:34,143 --> 01:08:36,612
>> I have a chemistry
question for you.

1709
01:08:36,612 --> 01:08:39,882
So you mentioned that
Curiosity is the chemist

1710

01:08:39,882 --> 01:08:43,586
that analyzes for certain
organic compounds in the soil.

1711
01:08:43,586 --> 01:08:45,121
I'm just wondering,

1712
01:08:45,121 --> 01:08:47,389
how does it determine the
structure of these compounds?

1713
01:08:47,389 --> 01:08:50,626
Does it use mass spectroscopy
or NMR or something similar?

1714
01:08:50,626 --> 01:08:52,761
>> Yeah, so it has an
instrument called SAM,

1715
01:08:52,761 --> 01:08:54,730
which stands for sample
analysis at Mars,

1716
01:08:54,730 --> 01:08:56,599
we like our three
letter acronyms.

1717
01:08:56,599 --> 01:08:59,635
And SAM is a gas chromatograph
and a mass spectrometer

1718
01:08:59,635 --> 01:09:01,637
on it, it's a quadruple
mass spectrometer.

1719
01:09:01,637 --> 01:09:03,439
And so what we do is
we take the sample

1720
01:09:03,439 --> 01:09:04,940

and we actually
bake it in an oven,

1721
01:09:04,940 --> 01:09:06,876
which is part of the reason
it's so energy intensive

1722
01:09:06,876 --> 01:09:08,210
is 'cause we heat the sample up

1723
01:09:08,210 --> 01:09:09,678
to hundred of
degrees centigrade,

1724
01:09:09,678 --> 01:09:12,815
and then we can measure the
masses of the gases coming off.

1725
01:09:12,815 --> 01:09:13,716
>> Man: Thank you.

1726
01:09:17,686 --> 01:09:20,022
>> I have a pretty simple
question about the dust storm,

1727
01:09:20,022 --> 01:09:22,625
but the question
about the Sky Crane

1728
01:09:22,625 --> 01:09:26,595
prompted me to want to share
just a personal observation.

1729
01:09:26,595 --> 01:09:30,432
Watching that landing
and having read about it

1730
01:09:30,432 --> 01:09:33,202
in the lead up to it
and then watching it,

1731
01:09:33,202 --> 01:09:36,005
watching you all
in the control room

1732
01:09:36,005 --> 01:09:37,773
and your reaction
and everything,

1733
01:09:37,773 --> 01:09:39,475
was so exciting.

1734
01:09:39,475 --> 01:09:42,511
I mean, to the point where,

1735
01:09:42,511 --> 01:09:45,915
in the career that I
was in, I was a lawyer,

1736
01:09:45,915 --> 01:09:49,051
and I watched this and
thought, first of all,

1737
01:09:49,051 --> 01:09:53,956
the whole Rube Goldberg,
whoever came up with the idea

1738
01:09:53,956 --> 01:09:57,660
to pull off that
landing, blew my mind.

1739
01:09:57,660 --> 01:10:00,596
But then to do it successfully

1740
01:10:00,596 --> 01:10:02,598
and to see the joy
and the satisfaction

1741
01:10:02,598 --> 01:10:05,100

and the accomplishment
in the room,

1742
01:10:05,100 --> 01:10:06,569
I looked at it and I said,

1743
01:10:06,569 --> 01:10:08,404
there was nothing that was ever
going to happen in my career

1744
01:10:08,404 --> 01:10:11,407
that would ever give me that
kind of satisfaction and joy,

1745
01:10:11,407 --> 01:10:13,042
and I left that career.

1746
01:10:13,042 --> 01:10:14,410
[laughter and applause]

1747
01:10:14,410 --> 01:10:15,744
And I'm much happier.

1748
01:10:17,513 --> 01:10:19,381
So thank you.

1749
01:10:19,381 --> 01:10:24,153
The question is, what causes a
dust storm of that magnitude,

1750
01:10:24,153 --> 01:10:26,388
a planet-wide dust
storm on Mars,

1751
01:10:26,388 --> 01:10:29,858
where the atmosphere
is relatively thin
compared to earth.

1752

01:10:31,160 --> 01:10:33,128
And what would precipitate
it specifically

1753
01:10:33,128 --> 01:10:34,396
to happen at that time?

1754
01:10:34,396 --> 01:10:37,132
Is this something that's
connected to solar wind,

1755
01:10:37,132 --> 01:10:41,136
or just the atmosphere on
Mars itself, other processes.

1756
01:10:42,271 --> 01:10:43,539
Do we know?

1757
01:10:43,539 --> 01:10:45,674
>> If you know,
just let us know.

1758
01:10:45,674 --> 01:10:48,477
>> So no, so yeah, so
there are meteoriticists

1759
01:10:48,477 --> 01:10:50,613
who study this sort
of process on Mars,

1760
01:10:50,613 --> 01:10:52,114
and what we do know about
these global dust storms

1761
01:10:52,114 --> 01:10:55,017
is that they start in summertime

1762
01:10:55,017 --> 01:10:56,518
when you have kind
of warmer ground,

1763
01:10:56,518 --> 01:10:58,654
and you start to have
kind of these differences

1764
01:10:58,654 --> 01:11:00,556
in the temperatures,
and you have these,

1765
01:11:00,556 --> 01:11:03,325
what start to become active
lifting centers of dust.

1766
01:11:03,325 --> 01:11:05,060
So it's not one big
giant dust storm,

1767
01:11:05,060 --> 01:11:06,528
what it turns out
is you actually have

1768
01:11:06,528 --> 01:11:09,031
a couple of these active lifting
centers that start to lift.

1769
01:11:09,031 --> 01:11:12,101
And so for this most recent
one, we saw them pop up,

1770
01:11:12,101 --> 01:11:13,969
kind of around
Acidalia Planitia,

1771
01:11:13,969 --> 01:11:16,105
and part of the reason it
was so bad for Opportunity

1772
01:11:16,105 --> 01:11:17,473
is there was one of
these active centers

1773
01:11:17,473 --> 01:11:19,508
that was like right
nextdoor to Opportunity,

1774
01:11:19,508 --> 01:11:22,211
rather than partway
around the planet.

1775
01:11:22,211 --> 01:11:24,813
And you have them start to lift,

1776
01:11:24,813 --> 01:11:26,949
and if you have enough of them
and they become big enough,

1777
01:11:26,949 --> 01:11:29,318
they kind of interact with
stuff in the southern hemisphere

1778
01:11:29,318 --> 01:11:32,655
and that's when it starts to
get bad and really mix up.

1779
01:11:32,655 --> 01:11:34,490
And there's a whole bunch of
dust that's kind of sitting

1780
01:11:34,490 --> 01:11:36,492
in this big basin
called Hellas Basin,

1781
01:11:36,492 --> 01:11:38,093
which is one of
these giant impacts.

1782
01:11:38,093 --> 01:11:41,130
And when you start to get that
interacting with each other

1783
01:11:41,130 --> 01:11:43,365
and picking up the dust
that's sitting down there,

1784
01:11:43,365 --> 01:11:46,001
that's when things just
kind of cycle in on itself

1785
01:11:46,001 --> 01:11:48,971
and it becomes this huge
planetary and circling event.

1786
01:11:48,971 --> 01:11:50,272
And this is a known phenomenon,

1787
01:11:50,272 --> 01:11:52,608
we know dust storms
have been going on,

1788
01:11:52,608 --> 01:11:56,145
every couple of Mars years
we get global dust storms,

1789
01:11:56,145 --> 01:11:57,346
it's not a surprise,

1790
01:11:57,346 --> 01:11:59,148
but it's a really
interesting phenomenon.

1791
01:11:59,148 --> 01:12:01,450
And some of the measurements
that Curiosity made

1792
01:12:01,450 --> 01:12:03,519
were really cool, looking
at how the temperature

1793
01:12:03,519 --> 01:12:05,487

changes during the dust storm.

1794
01:12:05,487 --> 01:12:08,357
We found that the seasonal
differences dropped

1795
01:12:08,357 --> 01:12:10,526
by many 10s of degrees, sorry,
the diurnal differences,

1796
01:12:10,526 --> 01:12:14,296
so that the nights were warmer
and the days were cooler.

1797
01:12:14,296 --> 01:12:15,464
We can measure how it actually

1798
01:12:15,464 --> 01:12:17,599
affected the relative humidity.

1799
01:12:17,599 --> 01:12:20,469
We can look at how it
affects the pressure.

1800
01:12:20,469 --> 01:12:21,704
When you have
different temperatures

1801
01:12:21,704 --> 01:12:23,038
your pressure's gonna change.

1802
01:12:23,038 --> 01:12:24,373
so there's all these really neat

1803
01:12:24,373 --> 01:12:27,109
kind of interlocking
systems that happen

1804
01:12:27,109 --> 01:12:28,644

that we were able to kind of get

1805
01:12:28,644 --> 01:12:30,779
a good measurement
on from the ground.

1806
01:12:30,779 --> 01:12:32,581
>> Both being able to
predict year to year,

1807
01:12:32,581 --> 01:12:34,149
we know when dust
storm season is.

1808
01:12:34,149 --> 01:12:36,485
Being able to say if a
dust storm's gonna happen,

1809
01:12:36,485 --> 01:12:38,087
that's where we're
not quite at yet.

1810
01:12:38,087 --> 01:12:40,589
>> That's one of the
mysteries of Mars.

1811
01:12:40,589 --> 01:12:42,758
>> All right, any other
questions tonight?

1812
01:12:43,959 --> 01:12:46,161
If not, I guess
we'll stop there.

1813
01:12:46,161 --> 01:12:47,930
Thanks to all of our speakers.

1814
01:12:47,930 --> 01:12:50,199
[applause]

1815
01:12:54,436 --> 01:12:57,039
And thank you very
much to all of you

1816
01:12:57,039 --> 01:12:58,874
for being here and
for watching us.

1817
01:12:58,874 --> 01:13:01,243
Join us for next month's
show when we'll focus on

1818
01:13:01,243 --> 01:13:04,279
the world of
scientific ballooning.

1819
01:13:04,279 --> 01:13:05,981
So we'll see you
then, good night.

1820
01:13:07,483 --> 01:13:09,752
[applause]