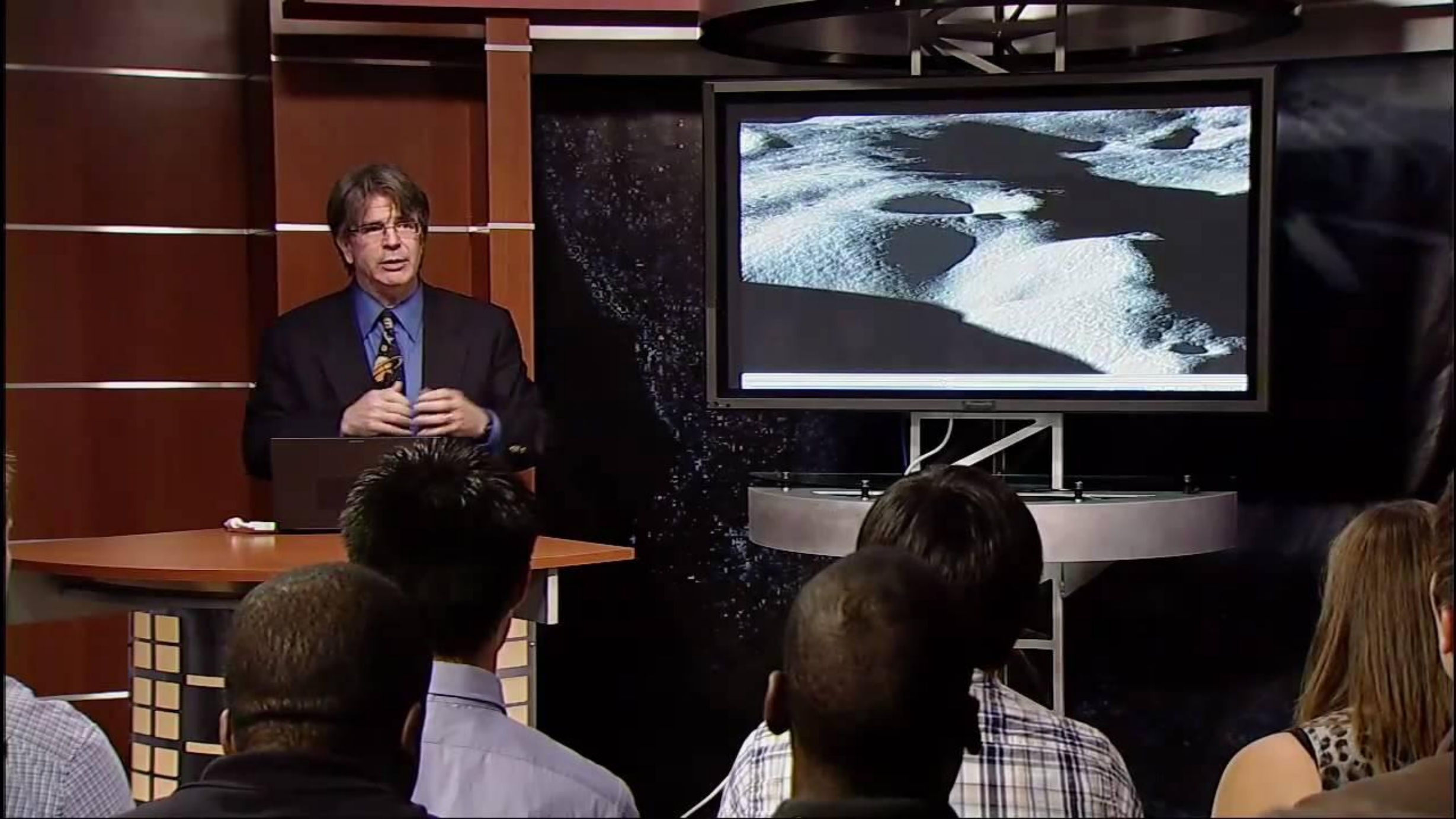

1
00:00:04,230 --> 00:00:02,070
so the moon now is a new place it's a

2
00:00:06,389 --> 00:00:04,240
new place because of an armada of robots

3
00:00:08,470 --> 00:00:06,399
that have gone to the moon um in the

4
00:00:10,150 --> 00:00:08,480
basically the last five years it started

5
00:00:12,390 --> 00:00:10,160
with the japanese a brilliant mission

6
00:00:14,390 --> 00:00:12,400
known as kaguya also called cellini

7
00:00:16,150 --> 00:00:14,400
selene has been at the moon it ended its

8
00:00:17,510 --> 00:00:16,160
mission last summer but it produced

9
00:00:19,910 --> 00:00:17,520
beautiful

10
00:00:20,950 --> 00:00:19,920
hdtv quality fly around so places on the

11
00:00:22,710 --> 00:00:20,960
moon these are some of the biggest

12
00:00:24,790 --> 00:00:22,720
mountains on the moon these are four

13
00:00:27,029 --> 00:00:24,800

kilometer high central peaks of the

14
00:00:29,109 --> 00:00:27,039
crater tycho the crater tycho we think

15
00:00:31,589 --> 00:00:29,119
was formed about 95 million years ago

16
00:00:33,910 --> 00:00:31,599
when dinosaurs roamed the earth so this

17
00:00:35,270 --> 00:00:33,920
is a real mountaineering peak john

18
00:00:37,350 --> 00:00:35,280
grunsfeld the astronaut of service to

19
00:00:39,430 --> 00:00:37,360
humble he'd like to go climb the mount

20
00:00:41,350 --> 00:00:39,440
tycho or whatever we call it but this

21
00:00:43,590 --> 00:00:41,360
data was collected by the japanese

22
00:00:45,510 --> 00:00:43,600
mission that started ushering ourselves

23
00:00:47,110 --> 00:00:45,520
back to the moon so why why go back to

24
00:00:49,350 --> 00:00:47,120
the moon everything on the moon happened

25
00:00:50,790 --> 00:00:49,360
a long time ago the reason is the moon

26
00:00:52,069 --> 00:00:50,800
is a history book

27
00:00:53,910 --> 00:00:52,079
on earth we're we're seeing what

28
00:00:55,830 --> 00:00:53,920
happened in the last since the dinosaurs

29
00:00:57,590 --> 00:00:55,840
since we've owned roamed the planet but

30
00:00:59,670 --> 00:00:57,600
on the moon we're interested in other

31
00:01:02,150 --> 00:00:59,680
things for example before the mission

32
00:01:03,590 --> 00:01:02,160
known as lro that nasa goddard launched

33
00:01:05,109 --> 00:01:03,600
this was the best topography of the moon

34
00:01:06,710 --> 00:01:05,119
if you wanted to land there your

35
00:01:09,270 --> 00:01:06,720
accuracy of that landing site was good

36
00:01:11,270 --> 00:01:09,280
to a thousand feet so imagine coming in

37
00:01:13,350 --> 00:01:11,280
to land in washington saying we hope the

38
00:01:15,270 --> 00:01:13,360

airfield's within a thousand feet

39
00:01:17,190 --> 00:01:15,280
wouldn't be the safest landing now we

40
00:01:18,950 --> 00:01:17,200
have new maps that not only look better

41
00:01:20,230 --> 00:01:18,960
from an instrument built here at nasa

42
00:01:22,550 --> 00:01:20,240
goddard on the lunar reconnaissance

43
00:01:24,070 --> 00:01:22,560
orbiter but the quality vertically is

44
00:01:27,270 --> 00:01:24,080
good to about a foot

45
00:01:29,190 --> 00:01:27,280
so we can now plan landings more safely

46
00:01:30,469 --> 00:01:29,200
we can go to the interesting places and

47
00:01:32,710 --> 00:01:30,479
land so one of the things we're doing

48
00:01:34,870 --> 00:01:32,720
now with nasa's return to the moon with

49
00:01:37,350 --> 00:01:34,880
robots is mapping the planet at the

50
00:01:39,429 --> 00:01:37,360
scale that you guys can choose to use if

51
00:01:41,990 --> 00:01:39,439
you want to go back to that planet we

52
00:01:43,590 --> 00:01:42,000
didn't do that with apollo we went with

53
00:01:45,590 --> 00:01:43,600
elegant engineering and brute force to

54
00:01:46,950 --> 00:01:45,600
the safest places we can get to

55
00:01:48,550 --> 00:01:46,960
turns out the moon's also interesting

56
00:01:50,469 --> 00:01:48,560
for another reason probably something

57
00:01:51,910 --> 00:01:50,479
you've seen on jeopardy there are places

58
00:01:53,990 --> 00:01:51,920
on the moon

59
00:01:56,469 --> 00:01:54,000
you see their names floating around here

60
00:01:58,230 --> 00:01:56,479
that um actually are permanently

61
00:02:00,870 --> 00:01:58,240
shadowed from sunlight

62
00:02:02,230 --> 00:02:00,880
that means they are the darkest coldest

63
00:02:03,910 --> 00:02:02,240

places

64
00:02:06,230 --> 00:02:03,920
the inside some of these craters at the

65
00:02:08,550 --> 00:02:06,240
south pole named for famous explorers

66
00:02:10,630 --> 00:02:08,560
that we ever ever understood in fact

67
00:02:12,710 --> 00:02:10,640
inside those shadowed areas it's colder

68
00:02:14,550 --> 00:02:12,720
than the planet pluto or i should say

69
00:02:16,150 --> 00:02:14,560
the dwarf object formerly known as a

70
00:02:18,150 --> 00:02:16,160
planet pluto

71
00:02:21,110 --> 00:02:18,160
so here's the moon inside those cold

72
00:02:22,550 --> 00:02:21,120
places you could actually entrap frozen

73
00:02:25,190 --> 00:02:22,560
stuff like

74
00:02:27,190 --> 00:02:25,200
water hence ice and the ices that are

75
00:02:29,110 --> 00:02:27,200
trapped could record a couple of billion

76
00:02:32,070 --> 00:02:29,120
years of the collisions of the moon with

77
00:02:33,670 --> 00:02:32,080
comets now do we care about comets yes

78
00:02:36,150 --> 00:02:33,680
because some colleagues scientists

79
00:02:37,509 --> 00:02:36,160
believe that comets help seed our oceans

80
00:02:39,350 --> 00:02:37,519
with some of the chemical building

81
00:02:41,030 --> 00:02:39,360
blocks that led to life

82
00:02:43,030 --> 00:02:41,040
so here's the

83
00:02:44,710 --> 00:02:43,040
the telescopic view of the moon we now

84
00:02:46,309 --> 00:02:44,720
see the moon in 3d

85
00:02:48,390 --> 00:02:46,319
at the scale where you could drive a car

86
00:02:50,070 --> 00:02:48,400
across it and plant landing strips we've

87
00:02:51,830 --> 00:02:50,080
gone from the era of looking at the moon

88
00:02:53,509 --> 00:02:51,840

through telescopes to being there in

89
00:02:55,910 --> 00:02:53,519
person our lunar reconnaissance orbiter

90
00:02:56,949 --> 00:02:55,920
is there now about 45 kilometers above

91
00:02:58,630 --> 00:02:56,959
the surface

92
00:03:00,470 --> 00:02:58,640
mapping the moon at scales where there's

93
00:03:02,470 --> 00:03:00,480
that crater tycho where you could plant

94
00:03:04,790 --> 00:03:02,480
a landing site on the peak of a mountain

95
00:03:06,229 --> 00:03:04,800
if you wanted to go there um one of the

96
00:03:07,670 --> 00:03:06,239
revolutions about the moon we learned

97
00:03:10,790 --> 00:03:07,680
from the apollo missions that we can now

98
00:03:12,949 --> 00:03:10,800
show you in depth from these new maps is

99
00:03:15,110 --> 00:03:12,959
the fact that it has all these these

100
00:03:16,390 --> 00:03:15,120
craters these circular depressions is

101
00:03:17,750 --> 00:03:16,400
actually important now why should you

102
00:03:19,750 --> 00:03:17,760
care about craters

103
00:03:21,509 --> 00:03:19,760
i happen to study them i'm sorry it's a

104
00:03:23,830 --> 00:03:21,519
boring thing but you know my wife says

105
00:03:26,789 --> 00:03:23,840
someone has to do it so i'm doing it

106
00:03:28,470 --> 00:03:26,799
this here is the topographic expression

107
00:03:29,750 --> 00:03:28,480
of uh

108
00:03:32,949 --> 00:03:29,760
a one

109
00:03:35,030 --> 00:03:32,959
trillion megaton explosion that shocked

110
00:03:36,390 --> 00:03:35,040
the moon four and four point two billion

111
00:03:38,229 --> 00:03:36,400
years ago that formed what's called the

112
00:03:40,229 --> 00:03:38,239
south pole lake in basin the impact

113
00:03:42,229 --> 00:03:40,239

collision air was so intense it probably

114
00:03:43,830 --> 00:03:42,239
excavated the lunar mantle

115
00:03:45,509 --> 00:03:43,840
through the crust brought up stuff that

116
00:03:46,949 --> 00:03:45,519
we would never get to

117
00:03:48,390 --> 00:03:46,959
we want to sample this basement we

118
00:03:50,869 --> 00:03:48,400
didn't even know it existed until these

119
00:03:53,429 --> 00:03:50,879
measurements we see these big cosmic

120
00:03:54,869 --> 00:03:53,439
collision scars on mars on the moon

121
00:03:55,750 --> 00:03:54,879
we're looking from venus haven't found

122
00:03:57,509 --> 00:03:55,760
them

123
00:03:59,270 --> 00:03:57,519
and they're actually great windows into

124
00:04:00,710 --> 00:03:59,280
the history of planets so now we see

125
00:04:02,630 --> 00:04:00,720
them we know where they are we can

126
00:04:04,470 --> 00:04:02,640
figure out how to sample them so all the

127
00:04:06,229 --> 00:04:04,480
data you see here was collected in the

128
00:04:08,390 --> 00:04:06,239
last year the lunar reconnaissance

129
00:04:10,789 --> 00:04:08,400
orbiter has collected data

130
00:04:13,429 --> 00:04:10,799
for the last year on the order of 78

131
00:04:14,789 --> 00:04:13,439
terabytes of data that's more data for

132
00:04:17,189 --> 00:04:14,799
any object in the history of solar

133
00:04:19,030 --> 00:04:17,199
system exploration in one mission in one

134
00:04:21,030 --> 00:04:19,040
year it does pay to have your own ground

135
00:04:22,469 --> 00:04:21,040
receiving station if you moderate to

136
00:04:23,909 --> 00:04:22,479
know that so one of the things we're

137
00:04:25,590 --> 00:04:23,919
really interested in is if you were to

138
00:04:27,590 --> 00:04:25,600

go back to the moon with people where

139
00:04:29,909 --> 00:04:27,600
would you go this is what the sun would

140
00:04:31,909 --> 00:04:29,919
do in the sky rotating around one of the

141
00:04:34,150 --> 00:04:31,919
sites right here on the rim of the

142
00:04:35,830 --> 00:04:34,160
shackleton crater where some engineers

143
00:04:37,670 --> 00:04:35,840
think we could set up

144
00:04:40,310 --> 00:04:37,680
stations for people to live

145
00:04:42,550 --> 00:04:40,320
and have sunlight basically all but 60

146
00:04:43,830 --> 00:04:42,560
hours every year and this shows the

147
00:04:46,230 --> 00:04:43,840
shadowed areas which have not seen

148
00:04:47,990 --> 00:04:46,240
sunlight in 2 billion years so we look

149
00:04:49,350 --> 00:04:48,000
at these places and wonder

150
00:04:51,189 --> 00:04:49,360
now the other thing we've done which is

151
00:04:53,510 --> 00:04:51,199
kind of history in the making is we've

152
00:04:55,189 --> 00:04:53,520
actually taken photographs of the places

153
00:04:56,950 --> 00:04:55,199
where we've been on the moon and these

154
00:04:58,950 --> 00:04:56,960
photographs are basically about three

155
00:05:00,710 --> 00:04:58,960
foot resolution you can see the blast

156
00:05:02,390 --> 00:05:00,720
spot these are where they actually

157
00:05:03,510 --> 00:05:02,400
walked on the moon you can see the

158
00:05:06,870 --> 00:05:03,520
trails

159
00:05:10,390 --> 00:05:06,880
now remember this all happened in 1969

160
00:05:11,749 --> 00:05:10,400
so in the 41 years since all this

161
00:05:13,270 --> 00:05:11,759
happened

162
00:05:14,790 --> 00:05:13,280
nothing's changed

163
00:05:17,749 --> 00:05:14,800

this is a planet where things work

164
00:05:19,270 --> 00:05:17,759
slowly you can see the stations the all

165
00:05:21,510 --> 00:05:19,280
the features there's the weird crater

166
00:05:24,310 --> 00:05:21,520
this is the traverse they made on apollo

167
00:05:27,189 --> 00:05:24,320
14 the longest walk made by people the

168
00:05:29,270 --> 00:05:27,199
apollo seismic network um here's another

169
00:05:30,710 --> 00:05:29,280
one from apollo 15 all the drive paths

170
00:05:32,550 --> 00:05:30,720
you see the two wheels

171
00:05:34,710 --> 00:05:32,560
we can now see what we've done to other

172
00:05:36,390 --> 00:05:34,720
planets i mean this is something you'd

173
00:05:37,590 --> 00:05:36,400
expect in the smithsonian we haven't

174
00:05:39,350 --> 00:05:37,600
brought back these pieces here's the

175
00:05:40,790 --> 00:05:39,360
challenger descent stage that's what

176
00:05:43,110 --> 00:05:40,800
brought us to the moon and then blasted

177
00:05:44,870 --> 00:05:43,120
us off there's our flag a little shadow

178
00:05:46,390 --> 00:05:44,880
um so now we look we found the

179
00:05:48,950 --> 00:05:46,400
collisions of the first russian probes

180
00:05:50,629 --> 00:05:48,960
on the moon um we could if you were

181
00:05:52,790 --> 00:05:50,639
there we could probably see you waving

182
00:05:54,469 --> 00:05:52,800
but we're not there so couldn't do that

183
00:05:56,390 --> 00:05:54,479
we've of course counted a lot of rocks i

184
00:05:57,909 --> 00:05:56,400
won't bore you with those and move on

185
00:05:59,990 --> 00:05:57,919
but i just want to point out that we've

186
00:06:02,230 --> 00:06:00,000
done a lot at timon and it's kind of a

187
00:06:03,430 --> 00:06:02,240
cool place um one of the other things

188
00:06:04,950 --> 00:06:03,440

we've observed on the moon and i'll

189
00:06:06,390 --> 00:06:04,960
quickly cut to this

190
00:06:08,390 --> 00:06:06,400
as we go

191
00:06:10,950 --> 00:06:08,400
is in fact there are places on the moon

192
00:06:12,870 --> 00:06:10,960
that are so cold they're off the charts

193
00:06:14,550 --> 00:06:12,880
some of these shadowed areas are 25

194
00:06:17,270 --> 00:06:14,560
degrees kelvin

195
00:06:18,469 --> 00:06:17,280
that's cold folks colder than liquid

196
00:06:19,990 --> 00:06:18,479
nitrogen

197
00:06:21,270 --> 00:06:20,000
we didn't know that we've measured again

198
00:06:23,029 --> 00:06:21,280
the topography

199
00:06:24,390 --> 00:06:23,039
and just a little summary of what we've

200
00:06:26,469 --> 00:06:24,400
already done with this mission known as

201
00:06:27,909 --> 00:06:26,479
lro starting in september the lunar

202
00:06:29,189 --> 00:06:27,919
reconnaissance orbiter built right here

203
00:06:31,110 --> 00:06:29,199
some of you may be working on it this

204
00:06:32,870 --> 00:06:31,120
summer will transition into a science

205
00:06:34,950 --> 00:06:32,880
mode now this is a view of the place

206
00:06:37,110 --> 00:06:34,960
right in that shadow where the l cross

207
00:06:39,749 --> 00:06:37,120
collision occurred last october 9th

208
00:06:40,950 --> 00:06:39,759
we smashed a leftover piece of a rocket

209
00:06:42,870 --> 00:06:40,960
and watched what happened when we

210
00:06:44,070 --> 00:06:42,880
collided with the moon and guess what

211
00:06:46,070 --> 00:06:44,080
it kicked up

212
00:06:48,950 --> 00:06:46,080
kind of stuff that can be vaporized like

213
00:06:50,550 --> 00:06:48,960

we think water hydrogen and even mercury

214
00:06:51,990 --> 00:06:50,560
the kind of mercury in your thermometer

215
00:06:53,510 --> 00:06:52,000
so these are views of the moon as if you

216
00:06:56,390 --> 00:06:53,520
were flying in a helicopter across the

217
00:06:57,510 --> 00:06:56,400
surface at about in this case about 50

218
00:06:59,270 --> 00:06:57,520
000 feet

219
00:07:01,510 --> 00:06:59,280
pretty cool this is the l cross

220
00:07:03,510 --> 00:07:01,520
experiment it was co-launched with lro

221
00:07:05,749 --> 00:07:03,520
it took its time getting around to the

222
00:07:07,189 --> 00:07:05,759
moon this is the flight dynamics that is

223
00:07:10,230 --> 00:07:07,199
something that's pretty amazing that we

224
00:07:12,230 --> 00:07:10,240
can do um we threaded the needle of the

225
00:07:14,950 --> 00:07:12,240
of the rings of saturn we went to the

226
00:07:16,710 --> 00:07:14,960
moon um with it and uh in fact you can

227
00:07:18,469 --> 00:07:16,720
see what we did to get there so there's

228
00:07:20,790 --> 00:07:18,479
lro went straight this thing looped

229
00:07:22,870 --> 00:07:20,800
around for a while actually for almost a

230
00:07:25,430 --> 00:07:22,880
year and then collided with the mode and

231
00:07:27,110 --> 00:07:25,440
the experiment was incredibly successful

232
00:07:28,950 --> 00:07:27,120
research papers are coming out um in

233
00:07:30,309 --> 00:07:28,960
science magazine in the next month so

234
00:07:32,790 --> 00:07:30,319
we're very excited about that but l

235
00:07:35,110 --> 00:07:32,800
cross was an example of women and men

236
00:07:37,350 --> 00:07:35,120
using ingenuity they had something we

237
00:07:39,350 --> 00:07:37,360
used lro to target where to go

238
00:07:41,029 --> 00:07:39,360

um which we did and then we collided the

239
00:07:42,950 --> 00:07:41,039
spent upper rocket stage with a small

240
00:07:45,670 --> 00:07:42,960
shepherding satellite with the moon

241
00:07:48,629 --> 00:07:45,680
making a crater exposing dirt

242
00:07:49,749 --> 00:07:48,639
vaporizing we think ice and measuring

243
00:07:51,350 --> 00:07:49,759
its signature

244
00:07:52,550 --> 00:07:51,360
so you might say well were we allowed to

245
00:07:54,469 --> 00:07:52,560
do that

246
00:07:56,150 --> 00:07:54,479
we were as a planet that we do not think

247
00:07:58,469 --> 00:07:56,160
is a life-bearing planet this kind of

248
00:07:59,749 --> 00:07:58,479
experiment is allowed this kind of

249
00:08:02,230 --> 00:07:59,759
experiment would not be allowed on the

250
00:08:05,110 --> 00:08:02,240
planet mars because we think mars may or

251
00:08:06,710 --> 00:08:05,120
may well possibly had life so anyway the

252
00:08:08,390 --> 00:08:06,720
moon has come alive as a new world we

253
00:08:10,230 --> 00:08:08,400
have another couple of years of mapping

254
00:08:11,670 --> 00:08:10,240
with the lunar reconnaissance orbiter we

255
00:08:13,350 --> 00:08:11,680
hope to send landers to the moan this

256
00:08:16,469 --> 00:08:13,360
just shows an animation of what happened

257
00:08:18,469 --> 00:08:16,479
last october um and in fact we actually

258
00:08:20,230 --> 00:08:18,479
impacted the place in shadow produced a

259
00:08:22,710 --> 00:08:20,240
plume that was received and measured by

260
00:08:25,430 --> 00:08:22,720
lro on orbit with its fire ultraviolet

261
00:08:27,350 --> 00:08:25,440
spectrometer so pretty cool stuff

262
00:08:28,710 --> 00:08:27,360
mission was a total success and i'm

263
00:08:30,710 --> 00:08:28,720

really proud of the team that did that

264
00:08:32,070 --> 00:08:30,720
um you can just see that again now

265
00:08:33,509 --> 00:08:32,080
another thing we've done in our

266
00:08:36,469 --> 00:08:33,519
exploration of the solar system is

267
00:08:38,709 --> 00:08:36,479
visited near earth objects and in 1999

268
00:08:40,630 --> 00:08:38,719
through 2001 a little tiny satellite

269
00:08:43,670 --> 00:08:40,640
about as big as this

270
00:08:45,750 --> 00:08:43,680
called near shoemaker visited one of the

271
00:08:47,829 --> 00:08:45,760
biggest uh near-earth asteroids known as

272
00:08:49,670 --> 00:08:47,839
eros it mapped the surface of this

273
00:08:51,670 --> 00:08:49,680
rubble pile of

274
00:08:52,870 --> 00:08:51,680
silica based rock and then it docked

275
00:08:54,870 --> 00:08:52,880
with the surface

276
00:08:56,949 --> 00:08:54,880
and one of the dreams we have for people

277
00:08:58,550 --> 00:08:56,959
going into space is instead of leaping

278
00:09:00,150 --> 00:08:58,560
straight to mars

279
00:09:02,230 --> 00:09:00,160
actually going to visit near-earth

280
00:09:03,910 --> 00:09:02,240
objects first why because they actually

281
00:09:05,269 --> 00:09:03,920
collide with earth and are relevant to

282
00:09:07,990 --> 00:09:05,279
the history of life

283
00:09:10,470 --> 00:09:08,000
two there are hundreds of thousands of

284
00:09:12,470 --> 00:09:10,480
them of which 90 are uncatalogued

285
00:09:15,190 --> 00:09:12,480
they're everywhere there will be a close

286
00:09:16,790 --> 00:09:15,200
encounter with one in the year 2036.

287
00:09:18,870 --> 00:09:16,800
it'll come within the orbit of the

288
00:09:22,150 --> 00:09:18,880

earth's moon to earth

289
00:09:23,990 --> 00:09:22,160
called apophis so we care one of the

290
00:09:25,750 --> 00:09:24,000
theories now uh one of the

291
00:09:28,630 --> 00:09:25,760
studies that we're doing in the agency

292
00:09:30,550 --> 00:09:28,640
is what would it take to send you all to

293
00:09:32,550 --> 00:09:30,560
a near-earth object where the

294
00:09:33,750 --> 00:09:32,560
surface uh gravitational acceleration is

295
00:09:35,110 --> 00:09:33,760
such that if you took a step you'd

296
00:09:37,030 --> 00:09:35,120
escape

297
00:09:39,750 --> 00:09:37,040
be a great weight loss clinic you know

298
00:09:42,389 --> 00:09:39,760
you go from weighing 100 pounds or 150

299
00:09:43,590 --> 00:09:42,399
pounds and you weigh 5 ounces on one of