
SILICON
VALLEY
LIVE
NASA
SILICON
VALLEY
AMES RESEARCH CENTER

1
00:00:00,030 --> 00:00:08,420
seven six five four three two

2
00:00:28,890 --> 00:00:25,520
[Music]

3
00:00:31,140 --> 00:00:28,900
hey everybody welcome to this episode of

4
00:00:34,140 --> 00:00:31,150
NASA and Silicon Valley live for October

5
00:00:36,120 --> 00:00:34,150
11th 2018 I'm your host Abbey Taber

6
00:00:38,760 --> 00:00:36,130
and today we're going to be talking all

7
00:00:40,050 --> 00:00:38,770
about robotic exploration of the moon

8
00:00:42,420 --> 00:00:40,060
and we have some really fascinating

9
00:00:44,820 --> 00:00:42,430
guests with us but first let me

10
00:00:47,610 --> 00:00:44,830
introduce my co-host Cassandra Bell Hey

11
00:00:49,950 --> 00:00:47,620
hi so this is NASA and Silicon Valley

12
00:00:51,750 --> 00:00:49,960
live a conversational talk show out of

13
00:00:53,610 --> 00:00:51,760

NASA Ames Research Center with the

14
00:00:55,650 --> 00:00:53,620
various scientists engineers and

15
00:00:58,049 --> 00:00:55,660
researchers and all-around cool people

16
00:01:00,509 --> 00:00:58,059
at NASA to talk about all the nerdy NASA

17
00:01:02,729 --> 00:01:00,519
news you need to know about if you like

18
00:01:07,290 --> 00:01:02,739
that we're simultaneously live on twitch

19
00:01:10,290 --> 00:01:07,300
that is twitch.tv slash NASA and we're

20
00:01:12,149 --> 00:01:10,300
also on Facebook and YouTube and if you

21
00:01:14,280 --> 00:01:12,159
want to participate live in our chat you

22
00:01:16,380 --> 00:01:14,290
gotta catch us on Twitch but if you want

23
00:01:20,190 --> 00:01:16,390
to if you miss the live show we will be

24
00:01:23,580 --> 00:01:20,200
on demand after the fact on NASA TV and

25
00:01:25,770 --> 00:01:23,590
we can also have the pop podcasts for an

26
00:01:28,710 --> 00:01:25,780
audio version if you like that better so

27
00:01:31,110 --> 00:01:28,720
today we have with us our guest Tony

28
00:01:32,550 --> 00:01:31,120
Kola preach and Kimberly anak o Smith

29
00:01:34,200 --> 00:01:32,560
thank you both for being here

30
00:01:38,100 --> 00:01:34,210
and can you tell us a little bit about

31
00:01:39,960 --> 00:01:38,110
what you both do yeah hi thanks I'm a

32
00:01:42,180 --> 00:01:39,970
planetary scientist here at NASA Ames

33
00:01:44,880 --> 00:01:42,190
have been here about 15 years almost

34
00:01:46,320 --> 00:01:44,890
exactly 15 years and as a planetary

35
00:01:50,130 --> 00:01:46,330
scientist and mostly study planetary

36
00:01:53,010 --> 00:01:50,140
atmospheres and surfaces really focusing

37
00:01:56,010 --> 00:01:53,020
on Isis and and other volatiles that

38
00:01:57,900 --> 00:01:56,020

freeze out I also design and build

39
00:02:00,180 --> 00:01:57,910
instruments that go to different worlds

40
00:02:05,010 --> 00:02:00,190
and make measurements of the atmospheres

41
00:02:07,470 --> 00:02:05,020
and surfaces and things like that you

42
00:02:09,779 --> 00:02:07,480
can really well thanks for having me I'm

43
00:02:11,640 --> 00:02:09,789
a research astrophysicists here at NASA

44
00:02:15,270 --> 00:02:11,650
Ames and I've been here a little bit

45
00:02:19,470 --> 00:02:15,280
longer than Tony I study the universe

46
00:02:22,020 --> 00:02:19,480
and I also build payloads or instruments

47
00:02:24,630 --> 00:02:22,030
cameras spectrometers that help us

48
00:02:26,699 --> 00:02:24,640
understand the universe around us both

49
00:02:29,509 --> 00:02:26,709
near and far so I have dabbled a little

50
00:02:33,479 --> 00:02:29,519
bit in some of Tony's planets as well

51
00:02:36,810 --> 00:02:33,489
very cool well speaking of nerdy NASA

52
00:02:37,160 --> 00:02:36,820
news NASA just turned 60

53
00:02:40,530 --> 00:02:37,170
[Music]

54
00:02:52,540 --> 00:02:47,620
Singh Oh last week we had cake I had a

55
00:02:55,210 --> 00:02:52,550
we I had a lunchtime meeting okay well

56
00:02:57,240 --> 00:02:55,220
NASA turned one on October 1st and that

57
00:03:00,040 --> 00:02:57,250
would 60 years would be October 1st in

58
00:03:02,140 --> 00:03:00,050
1958 you guys know what actually

59
00:03:03,520 --> 00:03:02,150
happened at that point because like you

60
00:03:05,170 --> 00:03:03,530
know you picture the the President

61
00:03:11,860 --> 00:03:05,180
signed a thing and then NASA suddenly

62
00:03:14,530 --> 00:03:11,870
existed or certificate built on earlier

63
00:03:16,840 --> 00:03:14,540

research labs that existed yeah yeah and

64
00:03:19,750 --> 00:03:16,850
at the time it was aeronautics was the

65
00:03:21,610 --> 00:03:19,760
focus of of what the laboratories did

66
00:03:23,250 --> 00:03:21,620
they weren't doing space research yet

67
00:03:25,930 --> 00:03:23,260
but they were very heavily into

68
00:03:28,210 --> 00:03:25,940
understanding aerodynamics aerospace

69
00:03:31,000 --> 00:03:28,220
engineering and whatnot to help really

70
00:03:33,490 --> 00:03:31,010
the fledgling airline industry and

71
00:03:35,920 --> 00:03:33,500
aviation industry you know doing the

72
00:03:37,570 --> 00:03:35,930
things that they couldn't do helping

73
00:03:39,430 --> 00:03:37,580
them do the research they couldn't do

74
00:03:41,230 --> 00:03:39,440
and pushing the envelope you know you

75
00:03:43,120 --> 00:03:41,240
know see what else you could do you know

76
00:03:49,720 --> 00:03:43,130
buy different designs oh yeah and that

77
00:03:51,970 --> 00:03:49,730
was the NACA right okay don't call it

78
00:03:53,830 --> 00:03:51,980
that no the National Advisory Committee

79
00:03:55,660 --> 00:03:53,840
for Aeronautics is what preceded NASA

80
00:03:59,890 --> 00:03:55,670
right and I've been scolded for calling

81
00:04:03,990 --> 00:03:59,900
it NACA we are now is anaise yeah that's

82
00:04:07,060 --> 00:04:04,000
right again there are three centers yeah

83
00:04:09,390 --> 00:04:07,070
right it was a one out of Langley

84
00:04:15,699 --> 00:04:09,400
Virginia on the East Coast in these guys

85
00:04:17,909 --> 00:04:15,709
that's Langley Laboratory to the Langley

86
00:04:21,729 --> 00:04:17,919
Research Center that's right one in Ohio

87
00:04:28,450 --> 00:04:21,739
which was no I always forget this one it

88
00:04:29,860 --> 00:04:28,460

was a Vincent now what was it now of

89
00:04:32,470 --> 00:04:29,870
course the Glenn Research Center I know

90
00:04:34,360 --> 00:04:32,480
that yeah and then our favorite very

91
00:04:37,060 --> 00:04:34,370
favorite not bias I can't remember the

92
00:04:40,120 --> 00:04:37,070
third that's out here in California Oh

93
00:04:44,920 --> 00:04:40,130
Ames you might have have been there the

94
00:04:47,080 --> 00:04:44,930
Ames now knows Ames Research Center

95
00:04:50,020 --> 00:04:47,090
where we are right now yeah of course

96
00:04:50,710 --> 00:04:50,030
yeah and now that we have ten field

97
00:04:52,960 --> 00:04:50,720
centers

98
00:04:54,760 --> 00:04:52,970
doing all kinds of amazing work so to

99
00:04:59,200 --> 00:04:54,770
learn about the last 60 years of

100
00:05:02,020 --> 00:04:59,210
innovation go to nasa.gov slash 60 yeah

101
00:05:04,540 --> 00:05:02,030
so in this episode though we're going to

102
00:05:06,730 --> 00:05:04,550
focus on the moon research the lunar

103
00:05:09,160 --> 00:05:06,740
research that Ames has worked on over

104
00:05:11,200 --> 00:05:09,170
those years since NASA was founded and

105
00:05:12,670 --> 00:05:11,210
if you have questions be sure to leave

106
00:05:13,900 --> 00:05:12,680
them in the chat and I'll be checking

107
00:05:14,650 --> 00:05:13,910
for those and trying to throw some of

108
00:05:16,960 --> 00:05:14,660
those in later

109
00:05:19,540 --> 00:05:16,970
for example already we have questions

110
00:05:21,280 --> 00:05:19,550
from Zazi lavender is asking what things

111
00:05:22,960 --> 00:05:21,290
will you be exploring on the moon we're

112
00:05:25,630 --> 00:05:22,970
gonna come to that that's the heart of

113
00:05:27,400 --> 00:05:25,640

today's episode so to kick things off

114
00:05:37,240 --> 00:05:27,410
we're gonna go to our first segment

115
00:05:39,220 --> 00:05:37,250
let's play let's roll that all right

116
00:05:42,270 --> 00:05:39,230
it's time for let's play this may

117
00:05:44,470 --> 00:05:42,280
include game controllers 12 sided dice

118
00:05:46,390 --> 00:05:44,480
but basically it's all an excuse to play

119
00:05:48,909 --> 00:05:46,400
games and talk about science and so

120
00:05:57,820 --> 00:05:48,919
today what we have is the lunar firsts

121
00:06:07,300 --> 00:05:57,830
pop quiz surprise chat and we'll see how

122
00:06:11,440 --> 00:06:07,310
you fare so we'll see how you do okay

123
00:06:13,420 --> 00:06:11,450
question one here on March 3rd 1959 the

124
00:06:15,070 --> 00:06:13,430
United States sent this spacecraft to

125
00:06:19,600 --> 00:06:15,080
the moon successfully making the first

126
00:06:25,990 --> 00:06:19,610
u.s. lunar flyby with whips the uragan

127
00:06:28,150 --> 00:06:26,000
sixth part of the Mariner series well

128
00:06:29,200 --> 00:06:28,160
the Mariners yeah they went to Venus and

129
00:06:32,320 --> 00:06:29,210
they went to Mars

130
00:06:35,830 --> 00:06:32,330
they did a flyby okay okay it's not this

131
00:06:40,330 --> 00:06:35,840
guy this is another maybe a first first

132
00:06:43,230 --> 00:06:40,340
person a trailblazing Pony Express

133
00:06:45,870 --> 00:06:43,240
oh maybe like a pioneer yeah

134
00:06:47,760 --> 00:06:45,880
I know about the Pioneers that went to

135
00:06:49,830 --> 00:06:47,770
the outer solar system we went to the

136
00:06:53,460 --> 00:06:49,840
moon as well I'm good to the flyby so

137
00:06:55,920 --> 00:06:53,470
yep yep earlier ones it's the you know

138
00:06:58,050 --> 00:06:55,930

the number two well for full credit

139
00:07:05,249 --> 00:06:58,060
Oh credit but for partial you got

140
00:07:10,439 --> 00:07:05,259
pioneer so this is PI all right moving

141
00:07:12,089 --> 00:07:10,449
on number two on October 27th 1961 NASA

142
00:07:13,980 --> 00:07:12,099
accomplished the first successful test

143
00:07:15,629 --> 00:07:13,990
of this rocket which shares its name

144
00:07:18,839 --> 00:07:15,639
with the family of rockets that would

145
00:07:22,110 --> 00:07:18,849
eventually take humans to the moon wow

146
00:07:25,050 --> 00:07:22,120
this one's easier yeah yeah well the up

147
00:07:27,719 --> 00:07:25,060
go or five or 75 took us to the moons Oh

148
00:07:32,279 --> 00:07:27,729
must be the Saturn series it is ya know

149
00:07:35,640 --> 00:07:32,289
stage Saturn one good very good Saturn

150
00:07:40,529 --> 00:07:35,650
one all right question three let's see

151
00:07:42,240 --> 00:07:40,539
what that looks like on June 2nd 1966

152
00:07:44,730 --> 00:07:42,250
this spacecraft became the first

153
00:07:56,330 --> 00:07:44,740
American spacecraft to soft land on the

154
00:08:01,379 --> 00:07:59,700
excellent and I have a fun fact here

155
00:08:03,779 --> 00:08:01,389
that surveyor one transmitted more than

156
00:08:07,950 --> 00:08:03,789
10,000 high quality photographs of the

157
00:08:10,290 --> 00:08:07,960
surface of the Moon my survey series of

158
00:08:13,409 --> 00:08:10,300
these Landers this is before we had

159
00:08:16,020 --> 00:08:13,419
digital cameras you know yeah those are

160
00:08:17,820 --> 00:08:16,030
video cameras and film talk about how

161
00:08:26,430 --> 00:08:17,830
many put ten thousand ten thousand

162
00:08:29,879 --> 00:08:26,440
photos that's a lot of film alright one

163
00:08:33,089 --> 00:08:29,889

more question number four on July 20th

164
00:08:37,199 --> 00:08:33,099
1969 this Apollo 11 astronaut became the

165
00:08:42,269 --> 00:08:37,209
first person to walk on the moon that's

166
00:08:45,990 --> 00:08:42,279
the people that would be Neil Armstrong

167
00:08:47,250 --> 00:08:46,000
that is Neil Armstrong exactly very good

168
00:08:54,290 --> 00:08:47,260
so well done

169
00:08:58,040 --> 00:08:55,879
so if you're just joining us we're

170
00:09:01,790 --> 00:08:58,050
talking about robotic exploration of the

171
00:09:04,369 --> 00:09:01,800
moon today and before humans got there

172
00:09:05,780 --> 00:09:04,379
before Neil there were robots so

173
00:09:08,629 --> 00:09:05,790
Cassandra I think he's gonna walk us

174
00:09:11,090 --> 00:09:08,639
through some of that history yes so it

175
00:09:12,769 --> 00:09:11,100
all it all started with robots actually

176
00:09:14,869 --> 00:09:12,779
I think Tony's more the and Kimberly are

177
00:09:18,670 --> 00:09:14,879
experts on how this robotic exploration

178
00:09:22,790 --> 00:09:18,680
started yeah it started back in the late

179
00:09:24,410 --> 00:09:22,800
1950s when a little orbiter named

180
00:09:36,590 --> 00:09:24,420
Sputnik went overhead and ushered us

181
00:09:39,470 --> 00:09:36,600
into the Space Age and with it

182
00:09:43,069 --> 00:09:39,480
the exploration of the earth from orbit

183
00:09:47,240 --> 00:09:43,079
but also beyond the earth and as part of

184
00:09:49,309 --> 00:09:47,250
the space race to the moon the effort

185
00:09:51,139 --> 00:09:49,319
between the United States and the Soviet

186
00:09:53,569 --> 00:09:51,149
Union to get to the humans to the moon

187
00:09:56,179 --> 00:09:53,579
first there was a range of robotic

188
00:09:58,999 --> 00:09:56,189

missions that took the steps necessary

189
00:10:01,129 --> 00:09:59,009
to eventually bring humans to the moon

190
00:10:03,920 --> 00:10:01,139
and return them safely and talking about

191
00:10:07,040 --> 00:10:03,930
steps you have to leave the earth safely

192
00:10:09,170 --> 00:10:07,050
you then have to get to the moon so you

193
00:10:11,240 --> 00:10:09,180
have to be able to reach the moon and

194
00:10:13,220 --> 00:10:11,250
then if you want to go in orbit around

195
00:10:15,019 --> 00:10:13,230
the moon you have to be able to go and

196
00:10:16,579 --> 00:10:15,029
get captured by the there's a lot of

197
00:10:19,120 --> 00:10:16,589
different steps to when you're starting

198
00:10:22,100 --> 00:10:19,130
to explore so you can use these robotic

199
00:10:33,439 --> 00:10:22,110
you know messengers to work out all the

200
00:10:35,900 --> 00:10:33,449
kinks and always nice well so the first

201
00:10:38,090 --> 00:10:35,910
series with respect to the moon as was

202
00:10:39,949 --> 00:10:38,100
the Ranger series and that was as Kim

203
00:10:46,549 --> 00:10:39,959
described really just learning how to

204
00:10:49,939 --> 00:10:46,559
get off the moon and that that was a

205
00:10:52,340 --> 00:10:49,949
challenging period the first six Ranger

206
00:10:55,369 --> 00:10:52,350
missions had failures or problems to

207
00:10:57,350 --> 00:10:55,379
make him not fully successful really one

208
00:10:58,910 --> 00:10:57,360
of them missed the moon but that was

209
00:10:59,990 --> 00:10:58,920
there but that was just you know the

210
00:11:01,150 --> 00:11:00,000
rocket fired at a slightly different

211
00:11:02,439 --> 00:11:01,160
time and

212
00:11:04,660 --> 00:11:02,449
you know the moon and the earth are

213
00:11:06,730 --> 00:11:04,670

moving with respect to the Sun video

214
00:11:08,920 --> 00:11:06,740
yeah we do

215
00:11:11,619 --> 00:11:08,930
Ranger seven luncheon this was the first

216
00:11:14,769 --> 00:11:11,629
fully successful Ranger mission Ranger

217
00:11:16,990 --> 00:11:14,779
six hit the moon intentionally but it's

218
00:11:19,210 --> 00:11:17,000
camera failed the first two failed on

219
00:11:20,439 --> 00:11:19,220
lodge others the fairings didn't work

220
00:11:23,740 --> 00:11:20,449
that's the part that holds the

221
00:11:25,410 --> 00:11:23,750
spacecraft this one was first fully

222
00:11:28,629 --> 00:11:25,420
successful and it did everything from

223
00:11:30,490 --> 00:11:28,639
teach us how to navigate to the moon but

224
00:11:32,499 --> 00:11:30,500
also transmit data so these are images

225
00:11:34,360 --> 00:11:32,509
of the moon as we go into crash it's a

226
00:11:37,569 --> 00:11:34,370
controlled landing controlled hard

227
00:11:41,530 --> 00:11:37,579
landing and it's beaming live television

228
00:11:43,360 --> 00:11:41,540
live from the moon images so there's a

229
00:11:45,670 --> 00:11:43,370
really important series and it was key

230
00:11:47,139 --> 00:11:45,680
because without doing that being able to

231
00:11:54,490 --> 00:11:47,149
go to the moon you can't do the next

232
00:11:56,499 --> 00:11:54,500
step which is going around the moon then

233
00:11:57,790 --> 00:11:56,509
you can you've shown that you can slow

234
00:11:59,379 --> 00:11:57,800
down your spacecraft that you've

235
00:12:02,079 --> 00:11:59,389
launched from the earth and it's

236
00:12:05,350 --> 00:12:02,089
traveling really fast and then control

237
00:12:07,240 --> 00:12:05,360
it to go and then even look at the moon

238
00:12:09,879 --> 00:12:07,250

and take pictures or perhaps you can

239
00:12:11,710 --> 00:12:09,889
look at something else yeah speaking of

240
00:12:16,629 --> 00:12:11,720
that I know one of your favorite images

241
00:12:21,309 --> 00:12:16,639
right is lunar orbiter a spacecraft from

242
00:12:24,069 --> 00:12:21,319
that was if we got our first image of

243
00:12:25,329 --> 00:12:24,079
our homeworld of Earth from lunar orbit

244
00:12:27,249 --> 00:12:25,339
and that was from lunar orbiter one

245
00:12:31,269 --> 00:12:27,259
you're seeing it right now took place in

246
00:12:33,220 --> 00:12:31,279
August of 1966 and phenomenal I mean

247
00:12:35,079 --> 00:12:33,230
it's a perspective changing photograph

248
00:12:36,730 --> 00:12:35,089
because this is us looking back at home

249
00:12:40,210 --> 00:12:36,740
from our nearest neighbor of the moon

250
00:12:42,460 --> 00:12:40,220
and you can see the it's again a video

251
00:12:45,429 --> 00:12:42,470
camera and they processed the film

252
00:12:47,620 --> 00:12:45,439
onboard the spacecraft and sent it back

253
00:12:49,749 --> 00:12:47,630
and that's also technology that had to

254
00:12:52,449 --> 00:12:49,759
be developed if they had felt film on

255
00:12:54,400 --> 00:12:52,459
the moon well it's on the spacecraft and

256
00:12:56,019 --> 00:12:54,410
from lunar orbit and then sending it

257
00:12:58,749 --> 00:12:56,029
back so then we got these amazing

258
00:13:00,040 --> 00:12:58,759
pictures of both the surface of the Moon

259
00:13:03,400 --> 00:13:00,050
but also looking back at the earth

260
00:13:05,920 --> 00:13:03,410
mm-hmm so that one had stripy bands

261
00:13:10,329 --> 00:13:05,930
throughout it yeah film so they share

262
00:13:12,429 --> 00:13:10,339
the TV camera go across an image take TV

263
00:13:14,240 --> 00:13:12,439

motion picture of the film and that's

264
00:13:16,010 --> 00:13:14,250
what was being back to earth that's what

265
00:13:17,330 --> 00:13:16,020
look striped that way I see but then you

266
00:13:19,100 --> 00:13:17,340
were telling me that this was

267
00:13:21,590 --> 00:13:19,110
reprocessed more recently here at Ames

268
00:13:23,750 --> 00:13:21,600
yeah there's a group of citizen

269
00:13:25,160 --> 00:13:23,760
scientists who take an interest in the

270
00:13:26,330 --> 00:13:25,170
history of NASA and look at this

271
00:13:26,750 --> 00:13:26,340
beautiful picture you're seeing right

272
00:13:28,820 --> 00:13:26,760
now

273
00:13:32,270 --> 00:13:28,830
digitally reprocess and so that's that

274
00:13:33,620 --> 00:13:32,280
same image from lunar orbiter and you

275
00:13:35,510 --> 00:13:33,630
know with the today's computer

276
00:13:39,620 --> 00:13:35,520
techniques and looking at images you can

277
00:13:43,670 --> 00:13:39,630
remove artifacts and maintain the yeah

278
00:13:45,200 --> 00:13:43,680
the the image yeah yeah and some of our

279
00:13:45,860 --> 00:13:45,210
best images of the moon come from that

280
00:13:48,470 --> 00:13:45,870
period

281
00:13:50,660 --> 00:13:48,480
I mean you capture a lot on film really

282
00:13:52,550 --> 00:13:50,670
high-quality yes I mean down to the

283
00:13:55,450 --> 00:13:52,560
smallest of scales to the dynamic range

284
00:13:58,010 --> 00:13:55,460
so we orbited the moon yeah and then

285
00:14:00,230 --> 00:13:58,020
next next up there's another step after

286
00:14:02,300 --> 00:14:00,240
that get to the surface if again the

287
00:14:03,680 --> 00:14:02,310
ultimate goal at this period was to land

288
00:14:06,230 --> 00:14:03,690

on the moon land humans on the moon

289
00:14:08,570 --> 00:14:06,240
getting back we had to get to the moon

290
00:14:10,600 --> 00:14:08,580
and get to the surface and not in the

291
00:14:19,579 --> 00:14:10,610
way Ranger did that was a hard landing

292
00:14:22,610 --> 00:14:19,589
sometimes a crash ok but intentional so

293
00:14:24,980 --> 00:14:22,620
the next set of missions surveyor

294
00:14:27,380 --> 00:14:24,990
missions really were intended to

295
00:14:31,250 --> 00:14:27,390
understand how to land on the moon

296
00:14:33,590 --> 00:14:31,260
softly and in in controlled way and they

297
00:14:35,390 --> 00:14:33,600
taught us not just how to land but how

298
00:14:37,430 --> 00:14:35,400
to land where you want to land because

299
00:14:39,590 --> 00:14:37,440
you know that's another skill exactly

300
00:14:41,900 --> 00:14:39,600
you know we're on the moon to a pinpoint

301
00:14:44,060 --> 00:14:41,910
yeah we had these images from orbit we

302
00:14:45,770 --> 00:14:44,070
knew we wanted to go to this place how

303
00:14:47,690 --> 00:14:45,780
do I get a spacecraft to go to that

304
00:14:53,720 --> 00:14:47,700
place it's it's easy now with GPS right

305
00:14:55,579 --> 00:14:53,730
you pull up your map according to it so

306
00:14:57,920 --> 00:14:55,589
there was all those techniques

307
00:15:00,440 --> 00:14:57,930
technologies that they had to learn how

308
00:15:02,570 --> 00:15:00,450
to have the Rockets not only slow you

309
00:15:04,400 --> 00:15:02,580
into orbit and now slow you down so you

310
00:15:08,120 --> 00:15:04,410
fall out of orbit and do a controlled

311
00:15:09,170 --> 00:15:08,130
landing that was to learn about they

312
00:15:11,240 --> 00:15:09,180
were trying to learn about the surface

313
00:15:15,020 --> 00:15:11,250

yeah so one of the biggest questions at

314
00:15:16,790 --> 00:15:15,030
the time was how deep was the lunar dust

315
00:15:19,100 --> 00:15:16,800
we knew there was a dust that covered

316
00:15:23,090 --> 00:15:19,110
the moon from generated from meteor

317
00:15:25,190 --> 00:15:23,100
impacts churning up the surface there

318
00:15:27,890 --> 00:15:25,200
was all kinds of theories about it being

319
00:15:31,250 --> 00:15:27,900
very very thick and very very

320
00:15:33,950 --> 00:15:31,260
porous or fluffy like a deep powdered

321
00:15:35,750 --> 00:15:33,960
snow if you will and so there was a real

322
00:15:38,900 --> 00:15:35,760
concern that if you landed something on

323
00:15:40,700 --> 00:15:38,910
the moon you could sink ah like trying

324
00:15:41,870 --> 00:15:40,710
to walk in deep snow or just walking and

325
00:15:43,730 --> 00:15:41,880
we don't really get very far yeah yeah

326
00:15:44,990 --> 00:15:43,740
yeah and and if you're landing a

327
00:15:46,910 --> 00:15:45,000
spacecraft maybe the feet just go

328
00:15:48,110 --> 00:15:46,920
straight down and you just fall over the

329
00:15:50,780 --> 00:15:48,120
spacecraft and falls on his side

330
00:15:54,080 --> 00:15:50,790
whatever so sending the robots the

331
00:15:56,540 --> 00:15:54,090
robotic before the humans came answered

332
00:15:58,370 --> 00:15:56,550
a lot of those questions yeah and we

333
00:16:01,010 --> 00:15:58,380
made us realise that yeah you you can't

334
00:16:03,590 --> 00:16:01,020
induce us all any and in these places of

335
00:16:06,380 --> 00:16:03,600
the Moon you you can land safely Wow

336
00:16:08,780 --> 00:16:06,390
yeah a quick question from the chat this

337
00:16:11,270 --> 00:16:08,790
is a fundamental moon question from Abu

338
00:16:23,840 --> 00:16:11,280

Bakar how old is the moon as old as

339
00:16:24,890 --> 00:16:23,850
Earth that's it's yes I mean the origin

340
00:16:26,900 --> 00:16:24,900
of the moon is something that we're

341
00:16:28,600 --> 00:16:26,910
still trying to address I mean there are

342
00:16:31,220 --> 00:16:28,610
theories out there and theories are only

343
00:16:33,440 --> 00:16:31,230
tested by an observational evidence and

344
00:16:35,330 --> 00:16:33,450
we don't have that time machine you know

345
00:16:38,930 --> 00:16:35,340
a TARDIS to go back in time to find the

346
00:16:40,430 --> 00:16:38,940
birth of the moon but the leading theory

347
00:16:43,130 --> 00:16:40,440
is that at some point during the early

348
00:16:45,440 --> 00:16:43,140
parts of our solar system mars-sized

349
00:16:47,920 --> 00:16:45,450
object hit the early Earth's and spun

350
00:16:50,090 --> 00:16:47,930
off what now has become our Moon and

351
00:16:51,530 --> 00:16:50,100
that's got a lot of observational

352
00:16:53,510 --> 00:16:51,540
evidence so we can support that but we

353
00:16:56,570 --> 00:16:53,520
weren't there to watch it happen happen

354
00:16:58,160 --> 00:16:56,580
so it is quite old it could be then if

355
00:17:02,360 --> 00:16:58,170
that theory is right it's just a little

356
00:17:05,390 --> 00:17:02,370
bit younger but made largely or in large

357
00:17:07,699 --> 00:17:05,400
part of Earth material so in a way it is

358
00:17:09,050 --> 00:17:07,709
as old as the moon and this is one of

359
00:17:10,490 --> 00:17:09,060
reasons why we want to study the moon

360
00:17:12,350 --> 00:17:10,500
because it also tells us about our own

361
00:17:13,730 --> 00:17:12,360
origins exactly very much at a

362
00:17:15,530 --> 00:17:13,740
fundamental level and you talked about

363
00:17:17,600 --> 00:17:15,540

that surveyor mission trying to figure

364
00:17:19,670 --> 00:17:17,610
out how how fluffy or not fluffy the

365
00:17:22,579 --> 00:17:19,680
moon isn't Kimberly you said one of your

366
00:17:25,340 --> 00:17:22,589
favorite pictures is has surveyor in it

367
00:17:27,530 --> 00:17:25,350
oh yeah there's a bring this one up this

368
00:17:32,120 --> 00:17:27,540
is from Apollo 12 what you're seeing is

369
00:17:36,410 --> 00:17:32,130
astronaut Pete Conrad walking up to

370
00:17:39,170 --> 00:17:36,420
surveyor 3 they the in the background is

371
00:17:41,690 --> 00:17:39,180
the lunar excursion module from Apollo

372
00:17:44,710 --> 00:17:41,700
12 they pinpointed

373
00:17:46,580 --> 00:17:44,720
exact landing to about 600 feet of

374
00:17:48,590 --> 00:17:46,590
surveyor 3 and they did that

375
00:17:50,570 --> 00:17:48,600
deliberately for course testing where he

376
00:17:52,280 --> 00:17:50,580
can land vertically if they could do it

377
00:17:54,350 --> 00:17:52,290
but now they're going up and saying

378
00:17:56,690 --> 00:17:54,360
hello to the robot that came two years

379
00:17:58,120 --> 00:17:56,700
earlier and looking at the experiments

380
00:18:01,010 --> 00:17:58,130
that were on board and brought back

381
00:18:03,680 --> 00:18:01,020
equipment from the the surveyor but

382
00:18:06,020 --> 00:18:03,690
there was a surveyor that set the scale

383
00:18:07,310 --> 00:18:06,030
for you know the landscape and and then

384
00:18:10,040 --> 00:18:07,320
we followed it with the humans and I

385
00:18:11,570 --> 00:18:10,050
just think it's it's both logical and

386
00:18:14,750 --> 00:18:11,580
poetic when I look at this picture

387
00:18:19,430 --> 00:18:14,760
because it shows that the robots helped

388
00:18:20,780 --> 00:18:19,440

with the human exploration and also you

389
00:18:24,470 --> 00:18:20,790
know it's just beautiful

390
00:18:26,660 --> 00:18:24,480
it's one of my favorite images so after

391
00:18:29,360 --> 00:18:26,670
these Apollo missions got to walk on the

392
00:18:32,510 --> 00:18:29,370
moon we know we wouldn't think what

393
00:18:35,270 --> 00:18:32,520
happened after Apollo Apollo 17 was the

394
00:18:39,280 --> 00:18:35,280
last mission that we flew and one of the

395
00:18:41,930 --> 00:18:39,290
best and it was 1972 and then after that

396
00:18:44,960 --> 00:18:41,940
nothing happened I think nothing it's

397
00:18:45,970 --> 00:18:44,970
the dark ages of lunar exploration went

398
00:18:52,250 --> 00:18:45,980
into a dark period

399
00:18:54,470 --> 00:18:52,260
or NASA it wasn't until 1994 that one of

400
00:18:55,370 --> 00:18:54,480
the United States returned 22 years you

401
00:18:57,350 --> 00:18:55,380
say two years

402
00:19:00,110 --> 00:18:57,360
I mean two years after the final Apollo

403
00:19:02,060 --> 00:19:00,120
mission okay and that was a Clementine

404
00:19:09,140 --> 00:19:02,070
mission which was the department of

405
00:19:11,690 --> 00:19:09,150
defense not the fruit spacecraft and it

406
00:19:14,990 --> 00:19:11,700
had some NASA instrument so it was a DoD

407
00:19:17,870 --> 00:19:15,000
spacecraft but it had a NASA instruments

408
00:19:18,290 --> 00:19:17,880
on it and but it's a really important

409
00:19:21,470 --> 00:19:18,300
mission

410
00:19:24,860 --> 00:19:21,480
because it tested a theory that had been

411
00:19:28,220 --> 00:19:24,870
outstanding or been put forward back in

412
00:19:30,410 --> 00:19:28,230
the late 1950s by Yuri and others that

413
00:19:33,860 --> 00:19:30,420

water could exist at the poles of the

414
00:19:36,640 --> 00:19:33,870
moon because the moon has a very slight

415
00:19:39,740 --> 00:19:36,650
tilt in its axis much smaller the nurse

416
00:19:41,990 --> 00:19:39,750
craters at the poles have floors that

417
00:19:43,400 --> 00:19:42,000
are permanently shadowed so it goes back

418
00:19:46,070 --> 00:19:43,410
to the question of when is the moon for

419
00:19:48,260 --> 00:19:46,080
and it goes back for these shadows have

420
00:19:50,270 --> 00:19:48,270
been at the bottom of these craters for

421
00:19:53,090 --> 00:19:50,280
as long as the Earth's been his petition

422
00:19:55,680 --> 00:19:53,100
it's current obliquity and it never seen

423
00:19:57,970 --> 00:19:55,690
sunlight for two billion years

424
00:19:59,530 --> 00:19:57,980
and because they haven't seen sunlight

425
00:20:00,880 --> 00:19:59,540
and there's no atmosphere mm-hmm

426
00:20:05,710 --> 00:20:00,890
appreciable atmosphere in the minute

427
00:20:08,500 --> 00:20:05,720
they are a cold - 250 degrees below zero

428
00:20:10,030 --> 00:20:08,510
centigrade which I looked up you told me

429
00:20:13,750 --> 00:20:10,040
that before and it's like - 400

430
00:20:17,289 --> 00:20:13,760
Fahrenheit I think yeah it's really cold

431
00:20:26,950 --> 00:20:17,299
and it's cold enough to trap all kinds

432
00:20:28,990 --> 00:20:26,960
of things including water very sweet

433
00:20:31,090 --> 00:20:29,000
talking about the pole yeah we were

434
00:20:34,080 --> 00:20:31,100
talking about the poles the Norse and

435
00:20:36,940 --> 00:20:34,090
the South and all our a lot of our

436
00:20:39,700 --> 00:20:36,950
earlier explorers had looked more around

437
00:20:44,530 --> 00:20:39,710
the equator hmm the tropics you could

438
00:20:47,080 --> 00:20:44,540

say fascinating with Clementine and

439
00:20:49,299 --> 00:20:47,090
we've learned that the poles are special

440
00:20:51,789 --> 00:20:49,309
places because of the the moon is

441
00:20:53,740 --> 00:20:51,799
slightly tilted so it's what's specially

442
00:20:55,630 --> 00:20:53,750
Mikey water he said yeah so there might

443
00:20:57,039 --> 00:20:55,640
be water trapped in these these craters

444
00:20:59,230 --> 00:20:57,049
and that was speculated back in the late

445
00:21:01,320 --> 00:20:59,240
1950s so the Clementine mission did an

446
00:21:03,970 --> 00:21:01,330
experiment to test this using radar and

447
00:21:05,470 --> 00:21:03,980
they saw a result for a particular

448
00:21:09,310 --> 00:21:05,480
crater at the South Pole called

449
00:21:11,650 --> 00:21:09,320
Shackleton and it suggested that there

450
00:21:14,049 --> 00:21:11,660
could be bulk water ice really problem

451
00:21:15,340 --> 00:21:14,059
is what's inconclusive inconclusive the

452
00:21:18,190 --> 00:21:15,350
results could have been explained by

453
00:21:19,630 --> 00:21:18,200
large rocks oh and you know couldn't

454
00:21:22,630 --> 00:21:19,640
tell the difference between the data so

455
00:21:24,490 --> 00:21:22,640
what do you do yes you have to yeah and

456
00:21:25,930 --> 00:21:24,500
then there was one other you have to go

457
00:21:29,260 --> 00:21:25,940
you have to return yet to look like you

458
00:21:32,230 --> 00:21:29,270
said you'll learn from me previous to it

459
00:21:36,190 --> 00:21:32,240
so so that was tantalizing not

460
00:21:38,560 --> 00:21:36,200
conclusive but it inspired on the next

461
00:21:41,560 --> 00:21:38,570
mission which happened four years later

462
00:21:44,770 --> 00:21:41,570
in 1998 and this was a NASA led mission

463
00:21:47,140 --> 00:21:44,780

actually led by NASA Ames yeah yeah and

464
00:21:50,380 --> 00:21:47,150
it was called lunar prospector I think

465
00:21:55,799 --> 00:21:50,390
we have a model yeah we do and but be

466
00:21:59,980 --> 00:21:55,809
careful it's as old as no spacecraft and

467
00:22:03,460 --> 00:21:59,990
so so yeah lunar prospector did exactly

468
00:22:06,250 --> 00:22:03,470
like its name suggests it prospect it

469
00:22:08,380 --> 00:22:06,260
looked for certain compositions and

470
00:22:09,820 --> 00:22:08,390
really elements what it did it

471
00:22:12,100 --> 00:22:09,830
out on these booms here these see these

472
00:22:15,690 --> 00:22:12,110
long arms or instruments that measure

473
00:22:17,740 --> 00:22:15,700
the surface composition and one of the

474
00:22:19,270 --> 00:22:17,750
things that was looking for one of the

475
00:22:23,650 --> 00:22:19,280
elements that was looking for was

476
00:22:26,110 --> 00:22:23,660
hydrogen now why hydrogen well there's

477
00:22:31,690 --> 00:22:26,120
two hydrogen's and any water molecule

478
00:22:33,700 --> 00:22:31,700
you might so if there is indeed water at

479
00:22:35,860 --> 00:22:33,710
the poles of the moon it might be able

480
00:22:39,670 --> 00:22:35,870
to see it in the form of a increase in

481
00:22:42,670 --> 00:22:39,680
hydrogen and lo and behold at the poles

482
00:22:44,440 --> 00:22:42,680
of the moon it saw increases in hydrogen

483
00:22:45,850 --> 00:22:44,450
and it didn't see it around the equator

484
00:22:48,880 --> 00:22:45,860
which really did suggest there was

485
00:22:50,200 --> 00:22:48,890
something inherent about the qualities

486
00:22:52,300 --> 00:22:50,210
or conditions at the poles of the moon

487
00:22:55,390 --> 00:22:52,310
that was allowing this hydrogen to

488
00:22:57,730 --> 00:22:55,400

accumulate we had a way to the 1990s

489
00:23:01,150 --> 00:22:57,740
right to actually get our first glimpse

490
00:23:03,520 --> 00:23:01,160
of a global chemistry of the Moon yeah I

491
00:23:05,170 --> 00:23:03,530
mean it and it raised more questions so

492
00:23:07,360 --> 00:23:05,180
lunar prospector did all of that but

493
00:23:08,590 --> 00:23:07,370
this is can you tell us more about how

494
00:23:10,540 --> 00:23:08,600
that what they were looking at here this

495
00:23:12,370 --> 00:23:10,550
is a model of it yeah yeah it's a model

496
00:23:13,660 --> 00:23:12,380
it's a very simple spacecraft is about I

497
00:23:18,370 --> 00:23:13,670
think we have a picture it's about the

498
00:23:20,740 --> 00:23:18,380
size of a human on top of the booster

499
00:23:22,540 --> 00:23:20,750
that helps put it into lunar orbit so

500
00:23:24,490 --> 00:23:22,550
just the blue the shiny blue part on the

501
00:23:26,800 --> 00:23:24,500
top is the spacecraft those are solar

502
00:23:28,660 --> 00:23:26,810
panels the white spike is the radio

503
00:23:31,330 --> 00:23:28,670
antenna for beaming back information to

504
00:23:33,150 --> 00:23:31,340
earth and you see the booms are stacked

505
00:23:37,540 --> 00:23:33,160
along the sides they're packaged for

506
00:23:39,790 --> 00:23:37,550
launch and and it had some three

507
00:23:41,680 --> 00:23:39,800
relatively simple instruments or Suites

508
00:23:43,180 --> 00:23:41,690
of instruments that measured the

509
00:23:45,640 --> 00:23:43,190
magnetic fields around the moon in the

510
00:23:48,160 --> 00:23:45,650
composition it was so simple this

511
00:23:49,660 --> 00:23:48,170
spacecraft that you could say it didn't

512
00:23:52,390 --> 00:23:49,670
even really have a computer on the

513
00:23:53,950 --> 00:23:52,400

computer no no it didn't run software

514
00:23:56,290 --> 00:23:53,960
like we think it run software it had

515
00:23:58,870 --> 00:23:56,300
processes and electronic processes were

516
00:24:01,000 --> 00:23:58,880
that were event-driven and command a

517
00:24:04,240 --> 00:24:01,010
ball but otherwise is pretty much just

518
00:24:06,280 --> 00:24:04,250
turn on and go and it just spun in orbit

519
00:24:07,600 --> 00:24:06,290
and I think we have an animation if you

520
00:24:10,450 --> 00:24:07,610
want to look at that just spends in

521
00:24:12,760 --> 00:24:10,460
orbit and and and there you go it just

522
00:24:14,830 --> 00:24:12,770
goes around it's a very efficient way of

523
00:24:17,830 --> 00:24:14,840
taking I'll keep in control the

524
00:24:19,780 --> 00:24:17,840
spacecraft is spinning okay keeps you

525
00:24:21,440 --> 00:24:19,790
stable these instruments didn't have a

526
00:24:23,149 --> 00:24:21,450
lot of pointing needs

527
00:24:25,399 --> 00:24:23,159
you know point them at the targets it

528
00:24:27,769 --> 00:24:25,409
just went around the moon's candid and a

529
00:24:29,899 --> 00:24:27,779
relatively low orbit and made these

530
00:24:33,740 --> 00:24:29,909
measurements and at the very end like

531
00:24:38,269 --> 00:24:33,750
all things that are up it had to come

532
00:24:41,419 --> 00:24:38,279
down and crashed right after about a

533
00:24:43,460 --> 00:24:41,429
hard landing it was a hard landing it

534
00:24:46,190 --> 00:24:43,470
was it was going to crash it was running

535
00:24:48,200 --> 00:24:46,200
out of fuel but it was directed into a

536
00:24:49,700 --> 00:24:48,210
place where there was this excess

537
00:24:51,950 --> 00:24:49,710
hydrogen and the reason they did that

538
00:24:53,450 --> 00:24:51,960

was they knew it was hydrogen but they

539
00:24:55,940 --> 00:24:53,460
didn't know the form of the hydrogen

540
00:24:58,970 --> 00:24:55,950
they didn't know if it was the agent h2o

541
00:25:02,539 --> 00:24:58,980
it could have been the H and O H or the

542
00:25:04,340 --> 00:25:02,549
H stuck onto a mineral or just protons

543
00:25:06,620 --> 00:25:04,350
from the Sun the sun's constantly

544
00:25:08,060 --> 00:25:06,630
sending protons and hit a soil and like

545
00:25:09,560 --> 00:25:08,070
good scientists and engineers they

546
00:25:11,960 --> 00:25:09,570
wanted to get something more out of this

547
00:25:15,830 --> 00:25:11,970
amazing mission and they did an

548
00:25:18,830 --> 00:25:15,840
experiment they did the controlled crash

549
00:25:20,930 --> 00:25:18,840
of this spacecraft into one of these

550
00:25:24,320 --> 00:25:20,940
craters yeah and to get back into shaker

551
00:25:26,509 --> 00:25:24,330
crater yeah in South Pole okay and it

552
00:25:28,909 --> 00:25:26,519
had this elevated hydrogen and the idea

553
00:25:31,700 --> 00:25:28,919
there was we'll crash this spacecraft

554
00:25:34,250 --> 00:25:31,710
into it and and as it hits the dirt

555
00:25:36,049 --> 00:25:34,260
it'll splash the dirt up and that dirt

556
00:25:37,909 --> 00:25:36,059
will come into sunlight remember the

557
00:25:40,879 --> 00:25:37,919
dirt that where it's impacting hasn't

558
00:25:43,730 --> 00:25:40,889
seen lightened up 2 billion years so to

559
00:25:45,259 --> 00:25:43,740
see it it lifts it up into sunlight and

560
00:25:48,529 --> 00:25:45,269
then they were going to observe it with

561
00:25:51,230 --> 00:25:48,539
the Hubble Space Telescope how about the

562
00:25:54,649 --> 00:25:51,240
moon and this precise time exactly yeah

563
00:26:04,250 --> 00:25:54,659

and the it all went to plan it impacted

564
00:26:06,980 --> 00:26:04,260
and Hubble saw yeah it's not an it's

565
00:26:09,259 --> 00:26:06,990
it's difficult at the time it was very

566
00:26:11,029 --> 00:26:09,269
difficult to predict what they were

567
00:26:13,519 --> 00:26:11,039
gonna see it was the first time they'd

568
00:26:14,930 --> 00:26:13,529
ever tried something like this so just

569
00:26:17,750 --> 00:26:14,940
like in the Ranger series where the

570
00:26:19,070 --> 00:26:17,760
first few launches weren't so good this

571
00:26:21,139 --> 00:26:19,080
is the first time they tried an

572
00:26:23,090 --> 00:26:21,149
experiment like this and why do they

573
00:26:26,480 --> 00:26:23,100
think how both didn't see anything is

574
00:26:28,519 --> 00:26:26,490
what about this didn't work yeah so we

575
00:26:29,990 --> 00:26:28,529
looked at that and we looked at it at

576
00:26:31,909 --> 00:26:30,000
that because we were planning a

577
00:26:34,159 --> 00:26:31,919
follow-on mission to get at that

578
00:26:35,090 --> 00:26:34,169
question what is the hydrogen again

579
00:26:38,360 --> 00:26:35,100
learning from

580
00:26:41,450 --> 00:26:38,370
what came before you know and that was a

581
00:26:46,940 --> 00:26:41,460
mission that came later about ten years

582
00:26:50,150 --> 00:26:46,950
later called L cross and and what we did

583
00:26:52,930 --> 00:26:50,160
was we learned a lot about but not to do

584
00:26:56,450 --> 00:26:52,940
what this did lunar prospector came in

585
00:26:59,480 --> 00:26:56,460
very shallow a great it's in orbit

586
00:27:01,100 --> 00:26:59,490
around the moon and so when it's gonna

587
00:27:03,980 --> 00:27:01,110
re-enter it's gonna come in in the shell

588
00:27:06,620 --> 00:27:03,990

shallow angle and it's not shallow

589
00:27:11,000 --> 00:27:06,630
shallow just kind of grazes it's almost

590
00:27:12,350 --> 00:27:11,010
skipping a rock and it's a small

591
00:27:16,370 --> 00:27:12,360
spacecraft as you saw it's only about

592
00:27:18,380 --> 00:27:16,380
130 kilograms 300 pounds and so again if

593
00:27:20,149 --> 00:27:18,390
you want to make a splash you throw a

594
00:27:23,029 --> 00:27:20,159
bigger rock right there the rock had

595
00:27:26,450 --> 00:27:23,039
better and and it was going relatively

596
00:27:28,909 --> 00:27:26,460
slow because it was an orbit it's top

597
00:27:38,210 --> 00:27:28,919
speed was only about one point eight

598
00:27:40,130 --> 00:27:38,220
kilometers per second which is slow so

599
00:27:43,010 --> 00:27:40,140
all those things led to probably a very

600
00:27:47,539 --> 00:27:43,020
small splash so not a lot of material

601
00:27:49,250 --> 00:27:47,549
got up if hardly any it didn't just have

602
00:27:52,490 --> 00:27:49,260
to splash dirt it had to splash it

603
00:27:54,169 --> 00:27:52,500
enough of it to get into sunlight so

604
00:27:57,370 --> 00:27:54,179
that the Hubble Space Telescope could

605
00:28:00,970 --> 00:27:57,380
see it because it can see in the dark so

606
00:28:03,770 --> 00:28:00,980
that's where again the next NASA

607
00:28:07,220 --> 00:28:03,780
impactor mission and the next NASA Ames

608
00:28:08,990 --> 00:28:07,230
mission to the moon comes in three out

609
00:28:11,360 --> 00:28:09,000
of the five lunar missions were manager

610
00:28:13,370 --> 00:28:11,370
at Ames and this is yeah this was the

611
00:28:15,080 --> 00:28:13,380
first one manage today yeah Ames is

612
00:28:17,840 --> 00:28:15,090
actually quite a leader in lunar

613
00:28:19,669 --> 00:28:17,850

research I just want to mention that my

614
00:28:21,169 --> 00:28:19,679
questions are not loading at the moment

615
00:28:23,270 --> 00:28:21,179
so I don't have any questions from the

616
00:28:24,380 --> 00:28:23,280
chat for you just yet but hopefully

617
00:28:26,419 --> 00:28:24,390
we'll get those up and running before

618
00:28:33,140 --> 00:28:26,429
the end so we can throw you a lot of

619
00:28:35,750 --> 00:28:33,150
questions Thanks so we can now L cross

620
00:28:38,510 --> 00:28:35,760
you just mentioned is a special mission

621
00:28:40,010 --> 00:28:38,520
for the two of you right yes I was how

622
00:28:42,830 --> 00:28:40,020
you were I was Tony's one of Tony's

623
00:28:47,150 --> 00:28:42,840
ideas and I hope held it

624
00:28:48,590 --> 00:28:47,160
a crazy idea and I'm told came about and

625
00:28:55,520 --> 00:28:48,600
she said yeah that's crazy enough it

626
00:28:58,130 --> 00:28:55,530
could work lunar crater observation and

627
00:29:06,800 --> 00:28:58,140
sensing satellite yeah Thank You Ike

628
00:29:13,550 --> 00:29:06,810
Evans part of the quiz not the sport and

629
00:29:16,190 --> 00:29:13,560
this was a very special unique and so as

630
00:29:19,700 --> 00:29:16,200
you recall what I said was bigger Rock

631
00:29:22,010 --> 00:29:19,710
makes bigger splashes and so it's part

632
00:29:25,430 --> 00:29:22,020
Rock this this is part of the bigger

633
00:29:27,320 --> 00:29:25,440
rock yeah it takes a lot of it's very

634
00:29:32,570 --> 00:29:27,330
expensive to launch large things in the

635
00:29:38,930 --> 00:29:32,580
space so we didn't want to just launch

636
00:29:42,380 --> 00:29:38,940
or spend a lot of money if you will we

637
00:29:44,570 --> 00:29:42,390
used the this is the upper stage to the

638
00:29:46,970 --> 00:29:44,580

Atlas 5 that launched us to the moment

639
00:29:48,950 --> 00:29:46,980
so it's part of the rocket they're gonna

640
00:29:50,930 --> 00:29:48,960
be there anyway yeah okay it's the one

641
00:29:53,000 --> 00:29:50,940
that got us you know to leave the earth

642
00:29:54,530 --> 00:29:53,010
system to go to the moon and it would

643
00:29:57,650 --> 00:29:54,540
have eventually fallen back to earth

644
00:29:58,850 --> 00:29:57,660
it's space junk but we recycled space

645
00:30:08,200 --> 00:29:58,860
junk and turn it into a scientific

646
00:30:11,540 --> 00:30:08,210
experiment that's right a hundred and

647
00:30:14,650 --> 00:30:11,550
forty kilogram impact

648
00:30:27,290 --> 00:30:14,660
yeah spacecraft this is 2,500 kilograms

649
00:30:29,720 --> 00:30:27,300
2500 about 5,000 pounds yeah we had some

650
00:30:32,450 --> 00:30:29,730
smarts on board and and and also it came

651
00:30:33,980 --> 00:30:32,460
in a very steep angle it came in at 89

652
00:30:36,110 --> 00:30:33,990
degrees so it went skipping a rock

653
00:30:38,810 --> 00:30:36,120
because we came from Earth orbit and we

654
00:30:44,780 --> 00:30:38,820
actually crashed into the moon not to

655
00:30:46,310 --> 00:30:44,790
scale almost 90 degree angle okay not so

656
00:30:48,230 --> 00:30:46,320
therefore we don't have the grazing

657
00:30:50,630 --> 00:30:48,240
incidence we're gonna so your rocket

658
00:30:52,970 --> 00:30:50,640
hits the moon and then this little guy

659
00:30:54,950 --> 00:30:52,980
and the best part we call this the

660
00:30:56,710 --> 00:30:54,960
shepherding spacecraft because it tucked

661
00:31:00,140 --> 00:30:56,720
us around for

662
00:31:02,180 --> 00:31:00,150
yeah two months two months yeah we had

663
00:31:04,789 --> 00:31:02,190

to do that because the upper stage of

664
00:31:06,980 --> 00:31:04,799
the rocket contained hydrogen and oxygen

665
00:31:09,169 --> 00:31:06,990
the fuel of rockets and we're trying to

666
00:31:11,270 --> 00:31:09,179
find hydrogen and oxygen water on the

667
00:31:14,780 --> 00:31:11,280
moon so we were just drying it out for

668
00:31:16,850 --> 00:31:14,790
to open up the Mensa the the operators

669
00:31:18,020 --> 00:31:16,860
of our shepherding spacecraft when they

670
00:31:19,490 --> 00:31:18,030
talk to the you know we had this massive

671
00:31:21,230 --> 00:31:19,500
weight on the back course and it's

672
00:31:23,150 --> 00:31:21,240
basically it's weightless but it does

673
00:31:26,060 --> 00:31:23,160
affect how much your propellant was when

674
00:31:33,680 --> 00:31:26,070
we separated that was a really gotten

675
00:31:35,510 --> 00:31:33,690
written overload talking about the

676
00:31:37,039 --> 00:31:35,520
separation that's whether the best parts

677
00:31:39,140 --> 00:31:37,049
actually - so we had the big rock coming

678
00:31:42,650 --> 00:31:39,150
in steep angle but a lot of energy came

679
00:31:43,850 --> 00:31:42,660
in - also almost twice as fast we had

680
00:31:46,789 --> 00:31:43,860
this shepherding spacecraft it wasn't

681
00:31:48,380 --> 00:31:46,799
just a tugboat but it had instruments on

682
00:31:51,560 --> 00:31:48,390
it and that's what Kim was mentioning

683
00:31:53,330 --> 00:31:51,570
she was the lead for like a camera okay

684
00:32:03,190 --> 00:31:53,340
where's spectrometers I have cameras

685
00:32:08,030 --> 00:32:05,270
doing this yeah there we are with a

686
00:32:09,590 --> 00:32:08,040
separation and you can see the Centaurs

687
00:32:10,610 --> 00:32:09,600
on its way to the moon from the effect

688
00:32:12,380 --> 00:32:10,620

the moon got in its way

689
00:32:14,030 --> 00:32:12,390
and we're turning the shepherding

690
00:32:16,730 --> 00:32:14,040
spacecraft around and we're following

691
00:32:19,880 --> 00:32:16,740
behind and as the moon got in the way

692
00:32:24,260 --> 00:32:19,890
the impact happened and we are taking

693
00:32:27,500 --> 00:32:24,270
data live stream back to earth and four

694
00:32:31,610 --> 00:32:27,510
minutes behind so as we flew through the

695
00:32:37,700 --> 00:32:31,620
ejecta from this impact experiment we

696
00:32:39,650 --> 00:32:37,710
ourselves as a spacecraft we come is

697
00:32:42,890 --> 00:32:39,660
live from the moon being streamed back

698
00:32:47,200 --> 00:32:42,900
to earth and we were commanding all 10

699
00:32:52,340 --> 00:32:50,960
well I made four minutes of data in the

700
00:32:54,380 --> 00:32:52,350
fact you couldn't store and you know

701
00:32:58,430 --> 00:32:54,390
look at it later it was all coming down

702
00:33:00,919 --> 00:32:58,440
in livestream and the we are changing

703
00:33:03,020 --> 00:33:00,929
the exposure times of the cameras in

704
00:33:04,159 --> 00:33:03,030
real-time three or four minutes during

705
00:33:06,139 --> 00:33:04,169
our four minutes

706
00:33:07,489 --> 00:33:06,149
and this was also happening at 4:00 in

707
00:33:12,349 --> 00:33:07,499
the morning because you know when you're

708
00:33:14,389 --> 00:33:12,359
gonna do something like this so we had

709
00:33:16,220 --> 00:33:14,399
separated from the the center about an

710
00:33:18,729 --> 00:33:16,230
hour prior and we were taking data and

711
00:33:20,720 --> 00:33:18,739
as the moon was coming closer to us the

712
00:33:22,789 --> 00:33:20,730
complexity of the scene was starting to

713
00:33:25,549 --> 00:33:22,799

have our instruments start getting a

714
00:33:28,070 --> 00:33:25,559
little bit overloading so we're actually

715
00:33:30,409 --> 00:33:28,080
adjusting the gain and exposure times of

716
00:33:33,529 --> 00:33:30,419
our camera in real time oh my gosh four

717
00:33:35,690 --> 00:33:33,539
minutes four minutes to get this again

718
00:33:38,359 --> 00:33:35,700
one of my favorite memories from that

719
00:33:40,970 --> 00:33:38,369
was yeah the exposure to she knows what

720
00:33:42,739 --> 00:33:40,980
I'm talking about there are craters

721
00:33:44,659 --> 00:33:42,749
there you can't see in them but we had

722
00:33:45,889 --> 00:33:44,669
some cameras we have thermal cameras we

723
00:33:47,599 --> 00:33:45,899
also had one that looks into the

724
00:33:51,489 --> 00:33:47,609
near-infrared it's just past the visible

725
00:33:54,379 --> 00:33:51,499
wavelengths of light that we see and the

726
00:33:56,180 --> 00:33:54,389
soils in the area where we impacted on

727
00:33:59,810 --> 00:33:56,190
the moon aren't actually brighter in

728
00:34:02,299 --> 00:33:59,820
these later infrared wavelengths so some

729
00:34:04,279 --> 00:34:02,309
light scaring off a rim tops goes into

730
00:34:06,019 --> 00:34:04,289
the dark craters and we thought we might

731
00:34:07,940 --> 00:34:06,029
be able to image them with their crater

732
00:34:11,389 --> 00:34:07,950
with our cameras and for the first time

733
00:34:13,129 --> 00:34:11,399
get an image of the floor and this was a

734
00:34:14,599 --> 00:34:13,139
risky thing we did we wanted first and

735
00:34:16,639 --> 00:34:14,609
foremost just to get good images of

736
00:34:16,940 --> 00:34:16,649
where we were impact in the plume and so

737
00:34:20,659 --> 00:34:16,950
on

738
00:34:22,569 --> 00:34:20,669

but about three minutes in or so Kim and

739
00:34:29,450 --> 00:34:22,579
I decided let's change the exposure

740
00:34:31,460 --> 00:34:29,460
three minutes into form and we didn't

741
00:34:34,369 --> 00:34:31,470
control it we had to call in the request

742
00:34:36,230 --> 00:34:34,379
to command who then had to get approval

743
00:34:39,289 --> 00:34:36,240
from flight so you know this process

744
00:34:41,210 --> 00:34:39,299
right and of course we had lots of

745
00:34:44,869 --> 00:34:41,220
cameras r5 these are the near infrared

746
00:34:47,510 --> 00:34:44,879
cameras we wanted to change and IR we

747
00:34:51,530 --> 00:34:47,520
also had mid infrared cameras an IR

748
00:34:56,260 --> 00:34:51,540
camera camera Kim calls and changed near

749
00:35:10,460 --> 00:34:56,270
IR one exposure to three command copy

750
00:35:22,920 --> 00:35:13,050
it goes on a couple more times finally

751
00:35:26,310 --> 00:35:22,930
Kim screams November November Oh NIR

752
00:35:29,970 --> 00:35:26,320
ones and then the change and in time in

753
00:35:33,510 --> 00:35:29,980
time and video here that shows those

754
00:35:35,400 --> 00:35:33,520
images those are still the only images

755
00:35:36,870 --> 00:35:35,410
of the impact site that we've we've

756
00:35:38,700 --> 00:35:36,880
gotten from it and they're beautiful

757
00:35:40,260 --> 00:35:38,710
because it actually showed the crater we

758
00:35:42,050 --> 00:35:40,270
made and you could see it and we

759
00:35:44,790 --> 00:35:42,060
measured it there's thirty meters across

760
00:35:46,230 --> 00:35:44,800
and we're looking in these permanently

761
00:35:47,610 --> 00:35:46,240
shadowed regions the regions they don't

762
00:35:48,780 --> 00:35:47,620
have any sunlight and we're looking at

763
00:35:50,190 --> 00:35:48,790

it in the infrared because we can get

764
00:35:51,360 --> 00:35:50,200
the scattered light off the crater walls

765
00:35:54,360 --> 00:35:51,370
but then we also were able to measure

766
00:35:56,370 --> 00:35:54,370
the thermal signature the heat from the

767
00:35:59,430 --> 00:35:56,380
impact and we're gonna find the crater

768
00:36:02,520 --> 00:35:59,440
we made oh my god experiment it was a

769
00:36:04,290 --> 00:36:02,530
really fun project I have a question

770
00:36:06,030 --> 00:36:04,300
here from the chat could setting up a

771
00:36:10,970 --> 00:36:06,040
telescope in a dark crater on the moon

772
00:36:16,110 --> 00:36:14,160
absolutely actually I'm having a

773
00:36:18,540 --> 00:36:16,120
telescope on the moon in general would

774
00:36:21,000 --> 00:36:18,550
be wonderful because you don't have the

775
00:36:22,800 --> 00:36:21,010
atmosphere in the way and the atmosphere

776
00:36:24,900 --> 00:36:22,810
prevents us from seeing a lot of what

777
00:36:26,790 --> 00:36:24,910
light in fact telescopes on the ground

778
00:36:28,140 --> 00:36:26,800
are really restricted to two wavelengths

779
00:36:30,810 --> 00:36:28,150
the visible what our eyes can see and

780
00:36:32,340 --> 00:36:30,820
also the radio that can transmit through

781
00:36:34,080 --> 00:36:32,350
our atmosphere and having a telescope

782
00:36:36,450 --> 00:36:34,090
anywhere on the moon would allow us to

783
00:36:38,900 --> 00:36:36,460
see a whole range of light now if you

784
00:36:40,830 --> 00:36:38,910
were in the permanently shadowed part

785
00:36:42,030 --> 00:36:40,840
you'd have to you know deal with

786
00:36:43,350 --> 00:36:42,040
technicalities of how you keep

787
00:36:47,520 --> 00:36:43,360
everything warm because it's also very

788
00:36:49,170 --> 00:36:47,530

cold there and from using a telescope to

789
00:36:51,090 --> 00:36:49,180
look at things in the universe you just

790
00:36:52,380 --> 00:36:51,100
have to stay away from having when the

791
00:36:53,850 --> 00:36:52,390
moon comes into your sorry when the

792
00:36:55,560 --> 00:36:53,860
earth comes into your field of view it's

793
00:36:56,970 --> 00:36:55,570
a nice bright reflected ball because of

794
00:36:58,440 --> 00:36:56,980
the sunlight reflecting off the earth

795
00:37:00,240 --> 00:36:58,450
the course you'll want to look at the

796
00:37:01,730 --> 00:37:00,250
Sun but you can look at the universe

797
00:37:05,760 --> 00:37:01,740
from there or anywhere on the moon a

798
00:37:07,710 --> 00:37:05,770
thesis so I don't know if you had a

799
00:37:09,330 --> 00:37:07,720
question but I want to know what this

800
00:37:12,240 --> 00:37:09,340
thing is all about okay yeah the Sun

801
00:37:14,760 --> 00:37:12,250
curious getting back to El cross which

802
00:37:15,359 --> 00:37:14,770
you crashed into the crater yes see what

803
00:37:17,759 --> 00:37:15,369
was in

804
00:37:19,289 --> 00:37:17,769
debris okay I know that a month after

805
00:37:34,339 --> 00:37:19,299
that there was a press conference right

806
00:37:40,920 --> 00:37:38,640
what's going on so yeah we the

807
00:37:43,470 --> 00:37:40,930
unfortunate thing about a impact mission

808
00:37:46,559 --> 00:37:43,480
is it comes to an end very dramatically

809
00:37:48,720 --> 00:37:46,569
and and and everyone everybody wants to

810
00:37:50,999 --> 00:37:48,730
know what what you see what you see this

811
00:37:54,420 --> 00:37:51,009
is actually our second press conference

812
00:37:56,670 --> 00:37:54,430
Kim and I had to prepare for a press

813
00:38:03,239 --> 00:37:56,680

conference one hour after the impact

814
00:38:06,120 --> 00:38:03,249
so at 5:00 a.m. later after working

815
00:38:09,480 --> 00:38:06,130
basically the entire team working 24/7

816
00:38:11,039 --> 00:38:09,490
we came to a unanimous decision go

817
00:38:14,339 --> 00:38:11,049
forward with the results which was we

818
00:38:16,200 --> 00:38:14,349
found water and it was not a small

819
00:38:18,509 --> 00:38:16,210
amount of water it was a significant

820
00:38:20,880 --> 00:38:18,519
amount and I was talking with my wife

821
00:38:22,349 --> 00:38:20,890
actually about how to convey this

822
00:38:24,599 --> 00:38:22,359
because I could talk with five percent

823
00:38:27,120 --> 00:38:24,609
by weight or it was you know thirteen

824
00:38:30,720 --> 00:38:27,130
hundred and forty two kilograms and a

825
00:38:33,089 --> 00:38:30,730
30-meter yeah five percent by weight

826
00:38:35,069 --> 00:38:33,099
whereas water in the sahara desert on

827
00:38:38,160 --> 00:38:35,079
earth or three percent by weight so we

828
00:38:49,430 --> 00:38:38,170
did sort of a relatively dry but still

829
00:38:54,269 --> 00:38:52,349
well how many buckets is that nice

830
00:38:57,630 --> 00:38:54,279
buckets like why don't you just get a

831
00:39:00,029 --> 00:38:57,640
bucket and say i got this much water in

832
00:39:01,680 --> 00:39:00,039
the moon okay i could do that so we got

833
00:39:03,479 --> 00:39:01,690
a two gallon bucket and that press

834
00:39:05,069 --> 00:39:03,489
briefing we said we found not a small

835
00:39:07,259 --> 00:39:05,079
amount we found a significant amount and

836
00:39:10,289 --> 00:39:07,269
actually and the little hole we made

837
00:39:13,559 --> 00:39:10,299
teeny little hole we made we had 150 of

838
00:39:15,960 --> 00:39:13,569

these two gallon buckets so that's

839
00:39:18,150 --> 00:39:15,970
origin of the bucket and i think it made

840
00:39:19,650 --> 00:39:18,160
a good point and that's actually really

841
00:39:23,339 --> 00:39:19,660
keen the other thing that i like about

842
00:39:24,299 --> 00:39:23,349
using the bucket was el cross was not a

843
00:39:26,309 --> 00:39:24,309
science mission

844
00:39:28,800 --> 00:39:26,319
it didn't fantastic science but it was

845
00:39:31,080 --> 00:39:28,810
not a science mission its purpose

846
00:39:33,900 --> 00:39:31,090
was actually supported funded through

847
00:39:36,030 --> 00:39:33,910
the human exploration office in NASA not

848
00:39:38,760 --> 00:39:36,040
the science mission his purpose was to

849
00:39:41,580 --> 00:39:38,770
understand that hydrogen as it related

850
00:39:44,670 --> 00:39:41,590
to a potential resource could we use a

851
00:39:49,080 --> 00:39:44,680
hydrogen on the moon for making water

852
00:39:50,910 --> 00:39:49,090
for making rocket fuel and that's the

853
00:39:52,740 --> 00:39:50,920
most important one it takes a lot of

854
00:39:55,080 --> 00:39:52,750
energy to lift anything out of the

855
00:39:57,000 --> 00:39:55,090
gravity well of the earth resources

856
00:39:58,860 --> 00:39:57,010
right there right on the making it here

857
00:40:00,450 --> 00:39:58,870
bring it up it's not efficient that's

858
00:40:04,050 --> 00:40:00,460
not efficient if you can make it there

859
00:40:07,380 --> 00:40:04,060
you can you're saving a 90% of your fuel

860
00:40:09,990 --> 00:40:07,390
I need because you spend 90% or so of

861
00:40:12,450 --> 00:40:10,000
the fuel just to get off the earth and

862
00:40:14,310 --> 00:40:12,460
I'll cross the sample one tiny place and

863
00:40:18,300 --> 00:40:14,320

had buckets of water and all those

864
00:40:20,370 --> 00:40:18,310
images from the the predecessor on

865
00:40:22,230 --> 00:40:20,380
orbiters that showed hydrogen signatures

866
00:40:25,020 --> 00:40:22,240
and many many craters on both poles

867
00:40:27,240 --> 00:40:25,030
there's a lot of resources there so the

868
00:40:36,630 --> 00:40:27,250
anniversary of that was what was Tuesday

869
00:40:41,040 --> 00:40:36,640
yes four minutes that all the data could

870
00:40:42,540 --> 00:40:41,050
fit onto a circa 2009 thumb drive oh and

871
00:40:44,310 --> 00:40:42,550
then have plenty of room left over yeah

872
00:40:45,960 --> 00:40:44,320
it's also changed the way we were

873
00:40:48,570 --> 00:40:45,970
looking at the moon now completely it

874
00:40:49,890 --> 00:40:48,580
really has you know changed the way yeah

875
00:40:51,360 --> 00:40:49,900
that's actually a really good point the

876
00:40:53,670 --> 00:40:51,370
last thing I'll say about the the

877
00:40:55,530 --> 00:40:53,680
results well so there are significant

878
00:40:58,350 --> 00:40:55,540
results out of El cross that we reported

879
00:41:00,480 --> 00:40:58,360
and that mean was there we knew the form

880
00:41:03,480 --> 00:41:00,490
of the water or the hydrogen in indeed

881
00:41:06,390 --> 00:41:03,490
was it at least yeah was water and we

882
00:41:09,480 --> 00:41:06,400
know now is water ice we knew there was

883
00:41:11,250 --> 00:41:09,490
enough to be a to be a potential

884
00:41:13,500 --> 00:41:11,260
resource for in situ resource

885
00:41:15,120 --> 00:41:13,510
utilization and those were the two big

886
00:41:17,760 --> 00:41:15,130
questions and the third thing was

887
00:41:19,890 --> 00:41:17,770
unexpected we saw lots of other things

888
00:41:21,720 --> 00:41:19,900

besides water yeah it's almost like

889
00:41:24,450 --> 00:41:21,730
these permanently shadowed craters are

890
00:41:28,910 --> 00:41:24,460
garbage heaps of the solar system

891
00:41:37,620 --> 00:41:35,190
heavy cycling - so here are ways you can

892
00:41:39,380 --> 00:41:37,630
reuse things that are been kind and

893
00:41:44,490 --> 00:41:39,390
other things were like carbon dioxide

894
00:41:45,569 --> 00:41:44,500
hydrogen sulfide mercury some of these

895
00:41:47,819 --> 00:41:45,579
things you can use some of these things

896
00:41:49,650 --> 00:41:47,829
you want to avoid like if you mind the

897
00:41:53,609 --> 00:41:49,660
water for drinking you better get rid of

898
00:41:55,620 --> 00:41:53,619
the mercury and and so but it's very

899
00:41:56,819 --> 00:41:55,630
interesting from a science standpoint so

900
00:41:57,870 --> 00:41:56,829
from a resource standpoint yes

901
00:41:59,970 --> 00:41:57,880
interesting but from a scientific

902
00:42:02,670 --> 00:41:59,980
standpoint from this says something

903
00:42:04,620 --> 00:42:02,680
about the origin of the water and then

904
00:42:06,569 --> 00:42:04,630
therefore says something about the

905
00:42:10,170 --> 00:42:06,579
history of the moment yeah and the earth

906
00:42:13,230 --> 00:42:10,180
and all the inner and it's inner solar

907
00:42:15,329 --> 00:42:13,240
system planets and so it's really was an

908
00:42:17,789 --> 00:42:15,339
amazing finding from male cross I mean

909
00:42:20,520 --> 00:42:17,799
the moon is a laboratory and it's a time

910
00:42:22,079 --> 00:42:20,530
machine back you know what had happened

911
00:42:24,029 --> 00:42:22,089
back then what's been happening since

912
00:42:25,319 --> 00:42:24,039
that's that water and those other

913
00:42:27,809 --> 00:42:25,329

speeches have been there for at least

914
00:42:30,059 --> 00:42:27,819
two billion years so we found water yeah

915
00:42:31,170 --> 00:42:30,069
and now we did we followed up there's

916
00:42:35,849 --> 00:42:31,180
another mission we said there was three

917
00:42:38,779 --> 00:42:35,859
at a last five what was warn you I've

918
00:42:41,160 --> 00:42:38,789
got a bunch of awesome questions so

919
00:42:43,079 --> 00:42:41,170
question oh we get the model yeah okay

920
00:42:44,700 --> 00:42:43,089
Tony was talking about how we found all

921
00:42:47,609 --> 00:42:44,710
these other things in the basin of this

922
00:42:49,349 --> 00:42:47,619
crater there's one place um and you you

923
00:42:51,420 --> 00:42:49,359
know you'll naturally ask more questions

924
00:42:52,589 --> 00:42:51,430
that's the beauty of these missions you

925
00:42:53,940 --> 00:42:52,599
find a discovery but you're like where

926
00:42:56,160 --> 00:42:53,950
did it come from did it come from within

927
00:42:57,690 --> 00:42:56,170
the moon did it come from things hitting

928
00:43:01,710 --> 00:42:57,700
the moon bringing it like comets or

929
00:43:03,930 --> 00:43:01,720
asteroids um or you know is it from the

930
00:43:06,809 --> 00:43:03,940
atmosphere around the moon you know so

931
00:43:09,720 --> 00:43:06,819
that led to the next mission its mission

932
00:43:18,870 --> 00:43:09,730
ladee which stands for lunar atmosphere

933
00:43:24,180 --> 00:43:18,880
and dust environment Explorer yes yes

934
00:43:26,609 --> 00:43:24,190
and managed by a spacecraft built by

935
00:43:29,490 --> 00:43:26,619
Ames one the instruments I led built

936
00:43:31,200 --> 00:43:29,500
here at Ames instrument from the L cross

937
00:43:32,490 --> 00:43:31,210
made exactly I'd like to build upon our

938
00:43:34,289 --> 00:43:32,500

knowledge of what we've learned before

939
00:43:36,599 --> 00:43:34,299
exactly that that's key is really

940
00:43:38,609 --> 00:43:36,609
important the ladee was looking at it

941
00:43:41,190 --> 00:43:38,619
was looking at the the atmosphere of the

942
00:43:41,819 --> 00:43:41,200
moon it's we call it an exosphere and so

943
00:43:43,709 --> 00:43:41,829
an exosphere

944
00:43:45,569 --> 00:43:43,719
atmosphere to where the molecules in the

945
00:43:48,569 --> 00:43:45,579
atmosphere never come in contact with

946
00:43:53,309 --> 00:43:48,579
each other they're very lonely they just

947
00:43:55,469 --> 00:43:53,319
bounce around and they never but it's

948
00:43:57,930 --> 00:43:55,479
important because as Ken was saying it

949
00:43:59,099 --> 00:43:57,940
says something about how the surface of

950
00:44:01,799 --> 00:43:59,109
the Moon interacts with its environment

951
00:44:04,469 --> 00:44:01,809
the space environment and there are

952
00:44:08,069 --> 00:44:04,479
numerous other bodies like mercury the

953
00:44:10,709 --> 00:44:08,079
moons of Mars other moons of Jupiter

954
00:44:13,859 --> 00:44:10,719
Saturn icy moons that have these what

955
00:44:15,599 --> 00:44:13,869
are called surface EXO EXO sphere

956
00:44:18,809 --> 00:44:15,609
boundary conditions where they are

957
00:44:21,269 --> 00:44:18,819
interacting with space and how they

958
00:44:25,380 --> 00:44:21,279
interact with micrometeorites charged

959
00:44:28,289 --> 00:44:25,390
particles etc says a lot of governs a

960
00:44:30,239 --> 00:44:28,299
lot of how they have evolved over time

961
00:44:33,239 --> 00:44:30,249
so this mission is you know is designed

962
00:44:34,880 --> 00:44:33,249
to basically sniff the atmosphere the

963
00:44:37,859 --> 00:44:34,890

excellent excellent sphere of the

964
00:44:40,469 --> 00:44:37,869
technical we have an animation of how it

965
00:44:45,479 --> 00:44:40,479
kind of went about sniffing yeah yeah it

966
00:44:47,670 --> 00:44:45,489
also now it shows it spinning here and

967
00:44:51,779 --> 00:44:47,680
it's got panels and all side like like

968
00:44:54,209 --> 00:44:51,789
lunar prospector did but it actually had

969
00:44:55,979 --> 00:44:54,219
very fine pointing capabilities it had a

970
00:44:57,779 --> 00:44:55,989
point it's instruments in all different

971
00:45:03,959 --> 00:44:57,789
directions mostly my instrument I was

972
00:45:06,630 --> 00:45:03,969
the real paint in the questions that

973
00:45:09,479 --> 00:45:06,640
ladee address comes from Apollo actually

974
00:45:11,640 --> 00:45:09,489
in surveyor the Apollo astronauts

975
00:45:13,920 --> 00:45:11,650
thought they saw something that looked

976
00:45:16,380 --> 00:45:13,930
like scattered light from dust being

977
00:45:18,749 --> 00:45:16,390
elevated off the surface of the moon up

978
00:45:20,400 --> 00:45:18,759
to tens of kilometers above the surface

979
00:45:23,400 --> 00:45:20,410
and there's these images from the

980
00:45:25,559 --> 00:45:23,410
surveyor landers that show dust near the

981
00:45:27,539 --> 00:45:25,569
horizon at sunrise and sunset so there's

982
00:45:29,459 --> 00:45:27,549
this question is there elevated dust

983
00:45:31,949 --> 00:45:29,469
around the moon near the terminators

984
00:45:34,410 --> 00:45:31,959
where you go from light to dark ladee

985
00:45:36,630 --> 00:45:34,420
had a dust detector and flew very low

986
00:45:39,630 --> 00:45:36,640
just under 40 kilometers above the

987
00:45:41,640 --> 00:45:39,640
surface at the Terminator trying to

988
00:45:44,759 --> 00:45:41,650

sniff out that dust and and other

989
00:45:48,269 --> 00:45:44,769
species and when the really important

990
00:45:50,729 --> 00:45:48,279
findings is it didn't see it or not saw

991
00:45:53,140 --> 00:45:50,739
it but ladee didn't gladly do now yeah

992
00:45:56,789 --> 00:45:53,150
and robots are never wrong

993
00:46:01,690 --> 00:45:56,799
I would never say that to an astronaut

994
00:46:03,220 --> 00:46:01,700
no it could be the Dalek alight that

995
00:46:04,690 --> 00:46:03,230
it's the undoubtely sauce scattered

996
00:46:06,970 --> 00:46:04,700
light it's the questions where did it

997
00:46:08,559 --> 00:46:06,980
come from yeah the light is a light from

998
00:46:09,910 --> 00:46:08,569
our Sun scattering off the dust in the

999
00:46:11,980 --> 00:46:09,920
plane of our own solar system the

1000
00:46:17,289 --> 00:46:11,990
remnants of our okay so not coming it

1001
00:46:19,539 --> 00:46:17,299
was - just wasn't from the moon still be

1002
00:46:21,640 --> 00:46:19,549
dust down low we didn't get that low you

1003
00:46:24,309 --> 00:46:21,650
know the surveyor dust could be just

1004
00:46:25,680 --> 00:46:24,319
meters above the surface to this day

1005
00:46:29,559 --> 00:46:25,690
though Jack Schmitt one of the

1006
00:46:30,789 --> 00:46:29,569
astronauts on +17 really does contend

1007
00:46:33,039 --> 00:46:30,799
that well there was dust

1008
00:46:35,769 --> 00:46:33,049
it wasn't on rock so he's really of the

1009
00:46:38,920 --> 00:46:35,779
opinion that this elevated dust is not

1010
00:46:40,930 --> 00:46:38,930
there okay well so we still have more

1011
00:46:43,029 --> 00:46:40,940
questions we need to go back you work

1012
00:46:44,950 --> 00:46:43,039
right because we have tantalizing

1013
00:46:47,079 --> 00:46:44,960

evidence or not evidence of things you

1014
00:46:51,069 --> 00:46:47,089
know yeah I also have questions

1015
00:46:54,339 --> 00:46:51,079
I suggest we forge ahead into our next

1016
00:46:56,010 --> 00:46:54,349
segment which is rapid-fire questions so

1017
00:47:02,450 --> 00:46:56,020
let's roll the segment

1018
00:47:06,540 --> 00:47:04,770
alright you asked for it so here we go

1019
00:47:08,340 --> 00:47:06,550
again it's time for rapid-fire questions

1020
00:47:11,550 --> 00:47:08,350
where we cover as many from the chat as

1021
00:47:14,760 --> 00:47:11,560
we can so quick answers lots of

1022
00:47:17,490 --> 00:47:14,770
questions we're gonna get to bed quick

1023
00:47:18,600 --> 00:47:17,500
the future after some questions so there

1024
00:47:20,670 --> 00:47:18,610
are a number of questions about

1025
00:47:22,730 --> 00:47:20,680
exploring caves on the moon are there

1026
00:47:24,810 --> 00:47:22,740
plans to do this people have heard about

1027
00:47:26,790 --> 00:47:24,820
suggestions of building colonies in

1028
00:47:33,090 --> 00:47:26,800
those caves to avoid solar radiation any

1029
00:47:40,500 --> 00:47:33,100
plans to explore caves NASA potentially

1030
00:47:42,870 --> 00:47:40,510
so absolutely very interesting places

1031
00:47:44,790 --> 00:47:42,880
there are some commercial companies that

1032
00:47:48,090 --> 00:47:44,800
are very interested in these locations

1033
00:47:52,490 --> 00:47:48,100
as well and NASA is now working very

1034
00:47:54,570 --> 00:47:52,500
closely with commercial private sector

1035
00:47:56,940 --> 00:47:54,580
companies who are going to provide lunar

1036
00:47:58,590 --> 00:47:56,950
services to the moon and eventually yeah

1037
00:48:00,740 --> 00:47:58,600
we're going to definitely be exploring

1038
00:48:03,480 --> 00:48:00,750

those caves there's a number of projects

1039
00:48:04,860 --> 00:48:03,490
working on the technologies methods and

1040
00:48:07,260 --> 00:48:04,870
whatnot for exploring those gates and

1041
00:48:09,150 --> 00:48:07,270
the questioner was right about going

1042
00:48:10,740 --> 00:48:09,160
going beneath the surface to get away

1043
00:48:12,960 --> 00:48:10,750
from the radiation we're protected here

1044
00:48:15,090 --> 00:48:12,970
with our magnetosphere that protects us

1045
00:48:17,700 --> 00:48:15,100
from space radiation that's coming

1046
00:48:19,080 --> 00:48:17,710
mainly from the Sun out in the moon you

1047
00:48:21,750 --> 00:48:19,090
don't have that exposure but you can use

1048
00:48:25,140 --> 00:48:21,760
the rock or water as a shield oh yeah

1049
00:48:27,090 --> 00:48:25,150
so yeah cave is a lovely potential okay

1050
00:48:28,470 --> 00:48:27,100
here's a cool one what do your guests

1051
00:48:32,550 --> 00:48:28,480
personally think is the most interesting

1052
00:48:37,290 --> 00:48:32,560
mystery about the Moon what would you

1053
00:48:39,450 --> 00:48:37,300
love to solve you first oh well we had

1054
00:48:43,170 --> 00:48:39,460
this NASA this mission called Grail that

1055
00:48:47,910 --> 00:48:43,180
had had two satellites Evan flow and

1056
00:48:48,960 --> 00:48:47,920
they and they were to measure the they

1057
00:48:51,510 --> 00:48:48,970
wouldn't look at the interior of the

1058
00:48:54,000 --> 00:48:51,520
moon because we are wondering why you

1059
00:48:56,070 --> 00:48:54,010
know it's a little bit lopsided in terms

1060
00:48:58,770 --> 00:48:56,080
of its surface and where its gravity is

1061
00:49:00,450 --> 00:48:58,780
so it gave us the first map of the

1062
00:49:02,340 --> 00:49:00,460
gravity of the moon and it's still kind

1063
00:49:03,720 --> 00:49:02,350

of asymmetric and so I think that's one

1064
00:49:05,130 --> 00:49:03,730
of them interesting mysteries of the

1065
00:49:07,140 --> 00:49:05,140
moon it comes down to its origin again

1066
00:49:08,970 --> 00:49:07,150
we don't know how the moon formed but we

1067
00:49:11,070 --> 00:49:08,980
could see it signatures 4.6 billion

1068
00:49:13,020 --> 00:49:11,080
years later yeah and try to work out be

1069
00:49:14,350 --> 00:49:13,030
that detective yeah the things you can

1070
00:49:17,110 --> 00:49:14,360
work out I think

1071
00:49:21,820 --> 00:49:17,120
the gravity field of the moon is is

1072
00:49:24,400 --> 00:49:21,830
intriguing cool for me it's the water we

1073
00:49:27,100 --> 00:49:24,410
know there's water but we don't

1074
00:49:29,320 --> 00:49:27,110
understand why we see it where we see it

1075
00:49:32,080 --> 00:49:29,330
and why we don't see it where we think

1076
00:49:34,600 --> 00:49:32,090
we ought to see it mercury also has

1077
00:49:37,530 --> 00:49:34,610
water it's pulse and it is where you

1078
00:49:40,300 --> 00:49:37,540
expect to find it it is and where where

1079
00:49:41,920 --> 00:49:40,310
the models say it has these permanent

1080
00:49:45,340 --> 00:49:41,930
shadowed craters to because it has no

1081
00:49:47,110 --> 00:49:45,350
tilt to taxes very little to and it

1082
00:49:49,930 --> 00:49:47,120
behaves I always like to say mercury is

1083
00:49:54,760 --> 00:49:49,940
behaving itself the moon it's a plant

1084
00:49:57,220 --> 00:49:54,770
that craters plenty cold but the crater

1085
00:49:59,830 --> 00:49:57,230
right next to it is cold it does have

1086
00:50:03,040 --> 00:49:59,840
water so that is an ongoing mystery

1087
00:50:05,440 --> 00:50:03,050
right now is the history of the water on

1088
00:50:08,590 --> 00:50:05,450

the moon where did it come from and this

1089
00:50:11,440 --> 00:50:08,600
is very relevant for utilizing it

1090
00:50:15,250 --> 00:50:11,450
because you need to understand where it

1091
00:50:17,950 --> 00:50:15,260
is to be able to access it at the scales

1092
00:50:21,400 --> 00:50:17,960
we need to access it ok a quick question

1093
00:50:23,320 --> 00:50:21,410
can you build houses with moon dust

1094
00:50:26,470 --> 00:50:23,330
I think we could use that as a resource

1095
00:50:27,910 --> 00:50:26,480
yes yeah they can Center there's a lot

1096
00:50:29,380 --> 00:50:27,920
of projects going on right now where

1097
00:50:32,560 --> 00:50:29,390
they are developing the techniques to

1098
00:50:35,400 --> 00:50:32,570
Center basically heat it up and form it

1099
00:50:39,970 --> 00:50:35,410
into bricks yeah or like ceramics

1100
00:50:42,340 --> 00:50:39,980
ceramics you open up a shop and we have

1101
00:50:44,560 --> 00:50:42,350
like five minutes left and we also want

1102
00:50:47,170 --> 00:50:44,570
to talk about future missions which is

1103
00:50:49,330 --> 00:50:47,180
one of the questions do we have any

1104
00:50:51,790 --> 00:50:49,340
named missions gearing up to land on the

1105
00:50:53,650 --> 00:50:51,800
moon I know Ames has some instruments

1106
00:50:55,660 --> 00:50:53,660
that were building to study the moon but

1107
00:51:01,690 --> 00:50:55,670
but how would you guys talk about the

1108
00:51:04,420 --> 00:51:01,700
future so right the the there is space

1109
00:51:07,180 --> 00:51:04,430
directive one which yeah from the

1110
00:51:09,970 --> 00:51:07,190
President and and he established a space

1111
00:51:14,070 --> 00:51:09,980
Council to see it enacted and and what

1112
00:51:16,720 --> 00:51:14,080
it does is it gives direction to NASA to

1113
00:51:19,570 --> 00:51:16,730

re-establish a presence on the moon in a

1114
00:51:21,400 --> 00:51:19,580
sustained way so it's not just as our

1115
00:51:23,980 --> 00:51:21,410
administrator says it's not about flags

1116
00:51:26,030 --> 00:51:23,990
and and footsteps it's about a sustained

1117
00:51:29,240 --> 00:51:26,040
permanent presence on the moon

1118
00:51:32,090 --> 00:51:29,250
so right now NASA is building that plan

1119
00:51:35,030 --> 00:51:32,100
to do that and it's coming together

1120
00:51:37,580 --> 00:51:35,040
right now and formulating right now one

1121
00:51:39,110 --> 00:51:37,590
of the big differences between what

1122
00:51:40,910 --> 00:51:39,120
we're doing now and what we've done in

1123
00:51:42,970 --> 00:51:40,920
the past is an involvement of the

1124
00:51:48,320 --> 00:51:42,980
private sector and commercial companies

1125
00:51:50,600 --> 00:51:48,330
we routinely use private rockets to

1126
00:51:53,810 --> 00:51:50,610
launch our hardware now we're talking

1127
00:51:57,200 --> 00:51:53,820
about using private landed services to

1128
00:51:59,000 --> 00:51:57,210
bring payloads to the moon for NASA it's

1129
00:52:01,010 --> 00:51:59,010
a whole new paradigm and we shouldn't

1130
00:52:03,050 --> 00:52:01,020
ignore that the space between the Earth

1131
00:52:05,450 --> 00:52:03,060
and the moon is also very special

1132
00:52:08,230 --> 00:52:05,460
because there's designs in place where

1133
00:52:10,940 --> 00:52:08,240
what they call it the cislunar highway

1134
00:52:13,040 --> 00:52:10,950
this lunar gateway I feel like I'm

1135
00:52:15,050 --> 00:52:13,050
battling fiving or something but it's

1136
00:52:16,220 --> 00:52:15,060
like a gateway that it's a place where

1137
00:52:17,570 --> 00:52:16,230
you have to train the man we were

1138
00:52:19,100 --> 00:52:17,580

talking earlier about getting to the

1139
00:52:20,750 --> 00:52:19,110
moon as one parts of that evolution of

1140
00:52:22,790 --> 00:52:20,760
believing the earth and getting to the

1141
00:52:27,740 --> 00:52:22,800
moon but if there's ways to be efficient

1142
00:52:30,230 --> 00:52:27,750
- you know refill your your modules you

1143
00:52:44,270 --> 00:52:30,240
know that will help me add to the

1144
00:52:45,620 --> 00:52:44,280
sustainability we're actually two things

1145
00:52:48,860 --> 00:52:45,630
we're working on are two instruments

1146
00:52:50,270 --> 00:52:48,870
they're going forward are prospecting

1147
00:52:53,720 --> 00:52:50,280
instruments they're instruments that are

1148
00:52:55,730 --> 00:52:53,730
used to look for water on a rover at the

1149
00:52:57,890 --> 00:52:55,740
scales what I call the human scales the

1150
00:53:00,140 --> 00:52:57,900
scales at which we would utilize it

1151
00:53:01,820 --> 00:53:00,150
one's a neutron spectrometer and one's a

1152
00:53:04,850 --> 00:53:01,830
near infrared spectrometer and these are

1153
00:53:07,490 --> 00:53:04,860
the bloodhounds that would go on a rover

1154
00:53:10,550 --> 00:53:07,500
and characterize an area for the water

1155
00:53:12,290 --> 00:53:10,560
form and concentrations and

1156
00:53:15,650 --> 00:53:12,300
distributions the things you need to

1157
00:53:17,780 --> 00:53:15,660
know to establish whether or not how you

1158
00:53:19,550 --> 00:53:17,790
can utilize it yeah that's something

1159
00:53:24,800 --> 00:53:19,560
you've tested here in California right

1160
00:53:27,620 --> 00:53:24,810
yes so we've yeah this is on the K Rex

1161
00:53:29,540 --> 00:53:27,630
Rover here at Ames and on it are the two

1162
00:53:31,280 --> 00:53:29,550
instruments that black skirt their we

1163
00:53:33,020 --> 00:53:31,290

called it the skirt keeps the sunlight

1164
00:53:34,160 --> 00:53:33,030
out we don't like the Sun because it's

1165
00:53:35,450 --> 00:53:34,170
looking through the atmosphere it's

1166
00:53:37,670 --> 00:53:35,460
built for the moon these instruments are

1167
00:53:39,259 --> 00:53:37,680
built for the moon the Sun carries other

1168
00:53:41,479 --> 00:53:39,269
signatures on

1169
00:53:43,279 --> 00:53:41,489
neutron spectrometer is like a Grand

1170
00:53:45,799 --> 00:53:43,289
order instrument from lunar prospector

1171
00:53:48,499 --> 00:53:45,809
yeah and the infrared spectrometer is a

1172
00:53:56,059 --> 00:53:48,509
Grand order instrument from from El

1173
00:53:58,309 --> 00:53:56,069
Chrono Cross and this is in the Mojave

1174
00:53:59,889 --> 00:53:58,319
Desert so that's why it's again water

1175
00:54:02,359 --> 00:53:59,899
concentrations there are not too far

1176
00:54:04,699 --> 00:54:02,369
different from what we saw in the desert

1177
00:54:06,380 --> 00:54:04,709
pretty dry exactly and and we are

1178
00:54:08,089 --> 00:54:06,390
learning there in this and this that's

1179
00:54:09,469 --> 00:54:08,099
called an analogue field test where

1180
00:54:11,089 --> 00:54:09,479
you're trying to test something that's

1181
00:54:13,219 --> 00:54:11,099
analogous to how you do it on the moon

1182
00:54:16,130 --> 00:54:13,229
and there we're learning how to use the

1183
00:54:19,309 --> 00:54:16,140
data real time to make decisions about

1184
00:54:21,949 --> 00:54:19,319
where to make additional measurements

1185
00:54:23,389 --> 00:54:21,959
where to prospect to best characterize

1186
00:54:25,639 --> 00:54:23,399
the distribution of water we see

1187
00:54:33,259 --> 00:54:25,649
prospecting like we like the golden

1188
00:54:34,939 --> 00:54:33,269

brush they were they were pan you know

1189
00:54:36,499 --> 00:54:34,949
trying to find anything they don't find

1190
00:54:38,059 --> 00:54:36,509
anything to go to another place and they

1191
00:54:40,189 --> 00:54:38,069
try again and they go to another place

1192
00:54:41,899 --> 00:54:40,199
AHA found the gold and that's where

1193
00:54:46,159 --> 00:54:41,909
we'll set up shop for the button cynical

1194
00:54:49,099 --> 00:54:46,169
it's Rovers are gonna go first and scoop

1195
00:54:53,089 --> 00:54:49,109
it out for us exactly as you saw earlier

1196
00:54:53,899 --> 00:54:53,099
with the surveyor imagery with Apollo in

1197
00:54:56,689 --> 00:54:53,909
the background

1198
00:54:59,509 --> 00:54:56,699
yeah the robotic precursors are called

1199
00:55:00,979 --> 00:54:59,519
go there to survey it to understand it

1200
00:55:03,739 --> 00:55:00,989
and then you bring in the more valuable

1201
00:55:07,299 --> 00:55:03,749
assets following the robotic surveys a

1202
00:55:10,549 --> 00:55:07,309
little animation showing what a oh yeah

1203
00:55:14,299 --> 00:55:10,559
there's a lot here at Ames we built

1204
00:55:17,659 --> 00:55:14,309
synthetic lunar terrains and when Rock

1205
00:55:19,129 --> 00:55:17,669
yard tests so over the past really four

1206
00:55:21,229 --> 00:55:19,139
years we've been studying this heavily

1207
00:55:22,549 --> 00:55:21,239
along with in collaborating with a load

1208
00:55:26,019 --> 00:55:22,559
partnering with a lot of other NASA

1209
00:55:29,870 --> 00:55:26,029
centers and this just shows what a

1210
00:55:31,429 --> 00:55:29,880
prospecting rover would look like as it

1211
00:55:33,739 --> 00:55:31,439
drove up to a permanently shadowed

1212
00:55:35,120 --> 00:55:33,749
crater it'll have that light they all

1213
00:55:37,039 --> 00:55:35,130

have a light we've got a look in there

1214
00:55:39,169 --> 00:55:37,049
someone this particular design uses

1215
00:55:41,269 --> 00:55:39,179
cameras for navigation so you need to

1216
00:55:44,120 --> 00:55:41,279
bring light there's other variant that

1217
00:55:46,249 --> 00:55:44,130
could use lighter lasers that you

1218
00:55:48,259 --> 00:55:46,259
wouldn't need the light and Rovers are

1219
00:55:49,999 --> 00:55:48,269
all part of this evolution of exploring

1220
00:55:52,880 --> 00:55:50,009
new worlds you start with your flyby

1221
00:55:54,620 --> 00:55:52,890
then you have your orbiter then you land

1222
00:55:56,450 --> 00:55:54,630
like the surveyors right and then you

1223
00:55:58,220 --> 00:55:56,460
bring the rover you get the mobility get

1224
00:55:58,910 --> 00:55:58,230
mobility that's can you get to explore

1225
00:56:06,110 --> 00:55:58,920
yeah

1226
00:56:08,360 --> 00:56:06,120
that's just about all the time we have

1227
00:56:10,910 --> 00:56:08,370
sadly but this has been awesome thank

1228
00:56:12,170 --> 00:56:10,920
you for your stories and expertise well

1229
00:56:13,970 --> 00:56:12,180
the future is very bright for lunar

1230
00:56:15,230 --> 00:56:13,980
exploration we still don't know much

1231
00:56:17,330 --> 00:56:15,240
about the moon even though we've been

1232
00:56:20,720 --> 00:56:17,340
studying it and we're always surprised

1233
00:56:22,460 --> 00:56:20,730
by what we find and we're seeing asking

1234
00:56:25,400 --> 00:56:22,470
a lot more questions than we asked

1235
00:56:26,600 --> 00:56:25,410
before yeah as it should be that's a

1236
00:56:30,020 --> 00:56:26,610
beauty of science and exploration

1237
00:56:33,110 --> 00:56:30,030
there's always more and and you know the

1238
00:56:35,330 --> 00:56:33,120

amazing thing is is if you look at what

1239
00:56:37,700 --> 00:56:35,340
we how we think about the moon now with

1240
00:56:41,980 --> 00:56:37,710
the water cycle we talked about a water

1241
00:56:48,980 --> 00:56:45,590
your grandparents my father's moon you

1242
00:56:50,450 --> 00:56:48,990
know this is and I know in another 10

1243
00:56:53,780 --> 00:56:50,460
years we're gonna be looking back and

1244
00:56:56,240 --> 00:56:53,790
going wow we didn't know that so much

1245
00:56:58,100 --> 00:56:56,250
more well thank you for joining us both

1246
00:56:59,270 --> 00:56:58,110
it's been great having you here thanks

1247
00:57:00,890 --> 00:56:59,280
for having us

1248
00:57:03,740 --> 00:57:00,900
so this has been NASA in Silicon Valley

1249
00:57:05,480 --> 00:57:03,750
live conversational talk show out of

1250
00:57:07,040 --> 00:57:05,490
NASA Ames Research Center with the

1251
00:57:09,290 --> 00:57:07,050
various scientist engineers and

1252
00:57:11,360 --> 00:57:09,300
researchers and all-around cool people

1253
00:57:14,330 --> 00:57:11,370
at NASA where we talk about the nerdy

1254
00:57:15,650 --> 00:57:14,340
NASA news you need to know about if you

1255
00:57:18,230 --> 00:57:15,660
like that you can find us on twitch

1256
00:57:20,630 --> 00:57:18,240
YouTube and Facebook and we're also on

1257
00:57:23,180 --> 00:57:20,640
NASA TV and if you didn't catch us live

1258
00:57:25,400 --> 00:57:23,190
a we'll be on video on demand after the

1259
00:57:27,920 --> 00:57:25,410
show is over you can also catch the

1260
00:57:30,470 --> 00:57:27,930
audio version on podcast services so a

1261
00:57:33,170 --> 00:57:30,480
huge thanks again to our guest Tony and

1262
00:57:35,000 --> 00:57:33,180
Kimberly we'll be back on October 25th

1263
00:57:37,550 --> 00:57:35,010

when we talk about eight own we have a

1264
00:57:41,690 --> 00:57:37,560
NASA theme Halloween costume contest and