



Strategic Knowledge Gaps

New Technologies

Human Health and Performance



1
00:00:03,669 --> 00:00:01,829
well good morning

2
00:00:05,269 --> 00:00:03,679
my name is duane brown with nasa's

3
00:00:07,829 --> 00:00:05,279
office of communications i want to

4
00:00:09,750 --> 00:00:07,839
welcome you and i will welcome the folks

5
00:00:11,669 --> 00:00:09,760
watching us from all over the country on

6
00:00:13,910 --> 00:00:11,679
nasa television

7
00:00:15,430 --> 00:00:13,920
today you will hear about mars

8
00:00:17,269 --> 00:00:15,440
exploration

9
00:00:19,750 --> 00:00:17,279
and the future

10
00:00:21,670 --> 00:00:19,760
the future that holds a human mission to

11
00:00:23,990 --> 00:00:21,680
mars

12
00:00:25,910 --> 00:00:24,000
today's event is coming from the most

13
00:00:27,589 --> 00:00:25,920

visited museum

14

00:00:30,390 --> 00:00:27,599

in the united states and you're going to

15

00:00:32,630 --> 00:00:30,400

hear more about that shortly for our

16

00:00:35,110 --> 00:00:32,640

official welcome

17

00:00:37,510 --> 00:00:35,120

as always you can learn more about

18

00:00:41,430 --> 00:00:37,520

nasa's mars exploration program on the

19

00:00:47,270 --> 00:00:42,869

mars

20

00:00:48,389 --> 00:00:47,280

the social media is abuzz

21

00:00:51,189 --> 00:00:48,399

with

22

00:00:53,430 --> 00:00:51,199

communication in the conversation join

23

00:00:55,510 --> 00:00:53,440

the conversation and normally we have

24

00:00:58,549 --> 00:00:55,520

one hashtag but when it comes to mars

25

00:01:02,150 --> 00:00:58,559

and excitement we have two

26

00:01:04,549 --> 00:01:02,160

hashtag mer10 or mura10

27

00:01:07,270 --> 00:01:04,559

and hashtag 10 years

28

00:01:10,950 --> 00:01:09,270

sit back

29

00:01:12,390 --> 00:01:10,960

put your seat belts on and let's go to

30

00:01:14,070 --> 00:01:12,400

mars ladies and gentlemen for our

31

00:01:15,190 --> 00:01:14,080

official welcome

32

00:01:22,070 --> 00:01:15,200

please

33

00:01:26,950 --> 00:01:24,710

thank you duane

34

00:01:28,950 --> 00:01:26,960

well apropos to the occasion

35

00:01:31,510 --> 00:01:28,960

the temperature in washington dc is

36

00:01:34,069 --> 00:01:31,520

about the same as you can find in some

37

00:01:36,069 --> 00:01:34,079

locations on mars

38

00:01:38,469 --> 00:01:36,079

it's my pleasure to welcome you to the

39

00:01:40,710 --> 00:01:38,479

national air and space museum i'm senior

40

00:01:43,910 --> 00:01:40,720

scientist and chair of the museum center

41

00:01:46,630 --> 00:01:43,920

for earth and planetary studies

42

00:01:48,870 --> 00:01:46,640

the museum is very pleased to host

43

00:01:50,149 --> 00:01:48,880

this program celebrating the remarkable

44

00:01:52,630 --> 00:01:50,159

achievements

45

00:01:55,270 --> 00:01:52,640

of the mars exploration rovers

46

00:01:57,510 --> 00:01:55,280

this 10th anniversary of the murr rovers

47

00:02:00,789 --> 00:01:57,520

marks what i consider to be a true

48

00:02:02,789 --> 00:02:00,799

milestone in the exploration of mars

49

00:02:04,630 --> 00:02:02,799

the national air and space museum has a

50

00:02:07,590 --> 00:02:04,640

long tradition

51
00:02:09,589 --> 00:02:07,600
in celebrating mars exploration it

52
00:02:12,229 --> 00:02:09,599
actually started with the opening of

53
00:02:14,710 --> 00:02:12,239
this museum and the viking landers in

54
00:02:17,589 --> 00:02:14,720
1976

55
00:02:19,110 --> 00:02:17,599
we continue this tradition today

56
00:02:21,510 --> 00:02:19,120
with this program

57
00:02:24,070 --> 00:02:21,520
and the opening of a new exhibit

58
00:02:25,510 --> 00:02:24,080
spirit and opportunity ten years roving

59
00:02:27,990 --> 00:02:25,520
across mars

60
00:02:30,070 --> 00:02:28,000
i invite you all to come visit this

61
00:02:32,630 --> 00:02:30,080
exhibit and see the stunning and i mean

62
00:02:36,390 --> 00:02:32,640
stunning images that have been returned

63
00:02:39,430 --> 00:02:36,400

by the rove of the the murreh rovers

64

00:02:40,550 --> 00:02:39,440

the myrrh rovers the curiosity rover now

65

00:02:43,430 --> 00:02:40,560

operating

66

00:02:44,710 --> 00:02:43,440

as well as the one remaining were myrrh

67

00:02:46,630 --> 00:02:44,720

rover

68

00:02:48,309 --> 00:02:46,640

and the fleet of spacecraft in orbit

69

00:02:51,270 --> 00:02:48,319

around mars

70

00:02:52,309 --> 00:02:51,280

and those to come promise an exciting

71

00:02:55,270 --> 00:02:52,319

future

72

00:02:57,030 --> 00:02:55,280

for mars exploration

73

00:02:59,350 --> 00:02:57,040

with that

74

00:03:01,030 --> 00:02:59,360

i'd like to introduce

75

00:03:03,350 --> 00:03:01,040

the moderator

76

00:03:07,750 --> 00:03:03,360

for the first panel today

77

00:03:10,390 --> 00:03:07,760

and that is dr pamela or pan conrad

78

00:03:12,710 --> 00:03:10,400

she is mars senior scientist at nasa's

79

00:03:14,869 --> 00:03:12,720

goddard space flight center

80

00:03:17,990 --> 00:03:14,879

pam

81

00:03:20,149 --> 00:03:18,000

thank you

82

00:03:22,470 --> 00:03:20,159

you all for coming here today this is

83

00:03:24,070 --> 00:03:22,480

about the coolest place you can go to in

84

00:03:26,550 --> 00:03:24,080

washington

85

00:03:29,750 --> 00:03:26,560

and this is a really special occasion

86

00:03:31,830 --> 00:03:29,760

anybody ever buy something and about a

87

00:03:33,430 --> 00:03:31,840

week after the warranty expires it

88

00:03:35,750 --> 00:03:33,440

breaks

89

00:03:38,309 --> 00:03:35,760

yes can you relate to that

90

00:03:40,390 --> 00:03:38,319

so who wouldn't fall in love with two

91

00:03:42,390 --> 00:03:40,400

awesome robots who lasted about a

92

00:03:43,750 --> 00:03:42,400

bazillion times longer than they were

93

00:03:45,110 --> 00:03:43,760

supposed to

94

00:03:48,070 --> 00:03:45,120

so that's why we're here today to

95

00:03:50,149 --> 00:03:48,080

celebrate those and with me to do that

96

00:03:52,789 --> 00:03:50,159

we have the principal investigator of

97

00:03:55,190 --> 00:03:52,799

the mars exploration rovers which is

98

00:03:57,350 --> 00:03:55,200

steve squires on the end there

99

00:03:58,789 --> 00:03:57,360

who's also an awesome guy a friend of

100

00:04:01,030 --> 00:03:58,799

mine

101
00:04:02,710 --> 00:04:01,040
dave lavery from nasa headquarters who's

102
00:04:04,390 --> 00:04:02,720
the program executive for the mars

103
00:04:06,869 --> 00:04:04,400
exploration program

104
00:04:09,030 --> 00:04:06,879
who has had much to do with making the

105
00:04:11,830 --> 00:04:09,040
technology that has enabled us to do

106
00:04:12,630 --> 00:04:11,840
this in the center there another awesome

107
00:04:16,949 --> 00:04:12,640
guy

108
00:04:19,430 --> 00:04:16,959
my right is john grant from the

109
00:04:22,310 --> 00:04:19,440
smithsonian institution awesome

110
00:04:23,189 --> 00:04:22,320
scientist awesome guy and my colleague

111
00:04:27,990 --> 00:04:23,199
on

112
00:04:29,830 --> 00:04:28,000
curiosity didn't know you were our dad

113
00:04:31,590 --> 00:04:29,840

did you

114

00:04:33,430 --> 00:04:31,600

and john's gonna start by telling us

115

00:04:34,950 --> 00:04:33,440

just a little bit about the background

116

00:04:36,550 --> 00:04:34,960

of the mission and we'll plunge right in

117

00:04:38,790 --> 00:04:36,560

so you can hear from these three guys

118

00:04:40,950 --> 00:04:38,800

who are really the experts so john take

119

00:04:45,670 --> 00:04:40,960

it away okay thank you pam if i could

120

00:04:49,590 --> 00:04:47,510

uh what i'd like to say is first of all

121

00:04:51,189 --> 00:04:49,600

when we go from a parent that's a golf

122

00:04:53,350 --> 00:04:51,199

cart sized object to something that's

123

00:04:55,270 --> 00:04:53,360

the size of a mini cooper i'm curious if

124

00:04:56,790 --> 00:04:55,280

we really know who the parents might be

125

00:04:58,469 --> 00:04:56,800

there

126

00:05:00,390 --> 00:04:58,479

what i'd like to start off with is just

127

00:05:02,230 --> 00:05:00,400

sort of a brief summary to remind you

128

00:05:04,230 --> 00:05:02,240

all about what the mars exploration

129

00:05:07,029 --> 00:05:04,240

rover's mission is about and if i could

130

00:05:09,110 --> 00:05:07,039

get the first graphic up i would do that

131

00:05:10,950 --> 00:05:09,120

here we go so as i mentioned they're

132

00:05:12,950 --> 00:05:10,960

about the size of a golf cart they've

133

00:05:14,950 --> 00:05:12,960

got quite a payload that you can see

134

00:05:17,590 --> 00:05:14,960

labeled around there there's cameras up

135

00:05:18,950 --> 00:05:17,600

on the the mast assembly at the top out

136

00:05:21,110 --> 00:05:18,960

on the arm there's a couple of

137

00:05:23,110 --> 00:05:21,120

spectrometers that tell us information

138

00:05:25,189 --> 00:05:23,120

about the compositional and elemental

139

00:05:26,550 --> 00:05:25,199

abundance of the materials that we probe

140

00:05:29,110 --> 00:05:26,560

there's something called a rat that i

141

00:05:30,790 --> 00:05:29,120

can't quite say with the same uh

142

00:05:32,230 --> 00:05:30,800

tone that that steve does but i'm sure

143

00:05:33,189 --> 00:05:32,240

he'll say it later it's great to hear

144

00:05:34,710 --> 00:05:33,199

him do it

145

00:05:36,950 --> 00:05:34,720

and there's also

146

00:05:38,710 --> 00:05:36,960

a microscopic imager which is sort of

147

00:05:40,950 --> 00:05:38,720

like a geologist hand lens that we can

148

00:05:43,350 --> 00:05:40,960

see the fine detailed textures

149

00:05:45,110 --> 00:05:43,360

and by way of putting all that together

150

00:05:47,189 --> 00:05:45,120

what we essentially get

151
00:05:49,029 --> 00:05:47,199
is a field geologist on mars something

152
00:05:51,909 --> 00:05:49,039
that can move around on the surface

153
00:05:53,590 --> 00:05:51,919
interrogate the rocks tell us something

154
00:05:55,670 --> 00:05:53,600
about the geologic setting the

155
00:05:57,350 --> 00:05:55,680
environments that were there in the past

156
00:05:59,270 --> 00:05:57,360
but more specifically

157
00:06:01,110 --> 00:05:59,280
what the role of water was in shaping

158
00:06:03,270 --> 00:06:01,120
those environments if i could go to the

159
00:06:05,270 --> 00:06:03,280
next graphic please

160
00:06:07,270 --> 00:06:05,280
well the new rover smell wore off after

161
00:06:09,350 --> 00:06:07,280
about 90 saws and they kept going and

162
00:06:11,350 --> 00:06:09,360
going and going and just to give you a

163
00:06:12,870 --> 00:06:11,360

hint they get dirty after a while and

164

00:06:14,309 --> 00:06:12,880

that's kind of what you see here this is

165

00:06:15,909 --> 00:06:14,319

an image from the gallery that just

166

00:06:18,230 --> 00:06:15,919

opened up upstairs

167

00:06:19,510 --> 00:06:18,240

but everything's still working in one

168

00:06:20,710 --> 00:06:19,520

form another there's a couple of

169

00:06:21,749 --> 00:06:20,720

instruments

170

00:06:23,990 --> 00:06:21,759

that have

171

00:06:26,710 --> 00:06:24,000

have stopped operating in the the way

172

00:06:28,309 --> 00:06:26,720

they were designed to but these rovers

173

00:06:30,790 --> 00:06:28,319

especially in this case opportunity

174

00:06:33,270 --> 00:06:30,800

which is continuing uh just are doing a

175

00:06:35,430 --> 00:06:33,280

fantastic job in making discoveries and

176

00:06:36,550 --> 00:06:35,440

exploring the surface of mars next slide

177

00:06:38,070 --> 00:06:36,560

please

178

00:06:40,070 --> 00:06:38,080

well where are they just to give you a

179

00:06:42,309 --> 00:06:40,080

reminder of where things have landed on

180

00:06:44,070 --> 00:06:42,319

mars in the past we're on opposite sides

181

00:06:45,909 --> 00:06:44,080

of the planet this was really tricky

182

00:06:48,150 --> 00:06:45,919

during the initial operations because

183

00:06:49,990 --> 00:06:48,160

things were literally 12 hours apart you

184

00:06:51,990 --> 00:06:50,000

could go from one floor in jpl to the

185

00:06:53,430 --> 00:06:52,000

other and it was like going from india

186

00:06:55,430 --> 00:06:53,440

back to the east coast of the united

187

00:06:57,430 --> 00:06:55,440

states everybody was either just waking

188

00:06:59,029 --> 00:06:57,440

up or going to sleep

189

00:07:01,830 --> 00:06:59,039

opportunity landed in a place called

190

00:07:03,589 --> 00:07:01,840

meridiani planum flat plains that had a

191

00:07:06,629 --> 00:07:03,599

hematite signature that was observed

192

00:07:08,629 --> 00:07:06,639

from space uh hematite often is in place

193

00:07:09,510 --> 00:07:08,639

in the presence of water so that was our

194

00:07:11,909 --> 00:07:09,520

sort of

195

00:07:13,909 --> 00:07:11,919

tempting attraction there for for uh for

196

00:07:15,909 --> 00:07:13,919

the rover

197

00:07:17,430 --> 00:07:15,919

spirit landed over in gusev crater i

198

00:07:19,029 --> 00:07:17,440

almost said gale crater because i was

199

00:07:21,029 --> 00:07:19,039

confusing it with curiosity there for a

200

00:07:23,189 --> 00:07:21,039

second and what we had hoped to find

201
00:07:24,550 --> 00:07:23,199
there were deposits laid down in a lake

202
00:07:25,749 --> 00:07:24,560
from a valley that drained into the

203
00:07:27,749 --> 00:07:25,759
crater

204
00:07:29,670 --> 00:07:27,759
we did find a number of very intriguing

205
00:07:31,909 --> 00:07:29,680
features related to a past history of

206
00:07:33,749 --> 00:07:31,919
water on mars i'll let steve talk a

207
00:07:35,830 --> 00:07:33,759
little bit about those in just a second

208
00:07:38,710 --> 00:07:35,840
next slide please

209
00:07:41,029 --> 00:07:38,720
both rovers far far exceeded the the

210
00:07:42,070 --> 00:07:41,039
shelf life as pan pointed out

211
00:07:43,510 --> 00:07:42,080
spirit

212
00:07:45,189 --> 00:07:43,520
after landing

213
00:07:47,029 --> 00:07:45,199

uh over here to the

214

00:07:48,950 --> 00:07:47,039

glare here over here to the west of

215

00:07:50,629 --> 00:07:48,960

bonneville crater went up to the rim of

216

00:07:52,869 --> 00:07:50,639

bonneville and then made a beeline down

217

00:07:54,550 --> 00:07:52,879

towards the columbia hills across some

218

00:07:56,550 --> 00:07:54,560

volcanic plains and then reaching these

219

00:07:58,550 --> 00:07:56,560

ancient rocks that had been shaped by a

220

00:08:00,070 --> 00:07:58,560

number of processes some of which

221

00:08:02,070 --> 00:08:00,080

included water and we'll hear more about

222

00:08:03,430 --> 00:08:02,080

that in a bit if we go to the next slide

223

00:08:05,749 --> 00:08:03,440

this shows the traverse made by

224

00:08:07,510 --> 00:08:05,759

opportunity it's been going a lot longer

225

00:08:10,309 --> 00:08:07,520

it's been going a lot farther we've

226

00:08:12,550 --> 00:08:10,319

basically run more than a marathon now

227

00:08:14,390 --> 00:08:12,560

with opportunity starting off an eagle

228

00:08:16,710 --> 00:08:14,400

crater up there at the top and now all

229

00:08:18,390 --> 00:08:16,720

the way down around the rim of endeavour

230

00:08:21,350 --> 00:08:18,400

crater this large

231

00:08:23,589 --> 00:08:21,360

uh mostly buried crater that allows us

232

00:08:25,670 --> 00:08:23,599

to interrogate rocks from beneath the

233

00:08:28,150 --> 00:08:25,680

plains that tell us something about the

234

00:08:30,790 --> 00:08:28,160

very ancient history of mars so with

235

00:08:32,709 --> 00:08:30,800

that i think i can move on to questions

236

00:08:35,190 --> 00:08:32,719

or other things related to the missions

237

00:08:37,350 --> 00:08:35,200

pam oh just a couple of questions listen

238

00:08:39,589 --> 00:08:37,360

you know you've got a lot of work in on

239

00:08:42,149 --> 00:08:39,599

these two rovers and you've done some

240

00:08:44,470 --> 00:08:42,159

work subsequently on the next rover what

241

00:08:46,470 --> 00:08:44,480

did these rovers teach you about how to

242

00:08:48,470 --> 00:08:46,480

explore mars well

243

00:08:50,230 --> 00:08:48,480

i have to say that the mars exploration

244

00:08:52,310 --> 00:08:50,240

rovers they're my they're my first

245

00:08:54,389 --> 00:08:52,320

mission so i really didn't know what to

246

00:08:56,630 --> 00:08:54,399

expect and steve

247

00:08:59,110 --> 00:08:56,640

to his credit i would say and much to my

248

00:09:00,710 --> 00:08:59,120

surprise early on approached me and said

249

00:09:02,310 --> 00:09:00,720

i'd like you to be a science operation

250

00:09:04,870 --> 00:09:02,320

working group chair

251
00:09:06,630 --> 00:09:04,880
that gave me an opportunity that i will

252
00:09:09,030 --> 00:09:06,640
never forget and thank him for many

253
00:09:10,470 --> 00:09:09,040
times to actually get involved in the

254
00:09:11,990 --> 00:09:10,480
day-to-day planning

255
00:09:14,070 --> 00:09:12,000
and you really have a different

256
00:09:16,630 --> 00:09:14,080
perspective when you understand what

257
00:09:18,790 --> 00:09:16,640
goes into getting the commands up to the

258
00:09:20,630 --> 00:09:18,800
spacecraft getting the data back and

259
00:09:22,870 --> 00:09:20,640
then repeating that process over and

260
00:09:25,190 --> 00:09:22,880
over again the efficiency that's

261
00:09:26,949 --> 00:09:25,200
required the teamwork that's required

262
00:09:29,030 --> 00:09:26,959
everything really has to come together

263
00:09:31,430 --> 00:09:29,040

between the scientists and the engineers

264

00:09:34,070 --> 00:09:31,440

to make it happen on a day-to-day basis

265

00:09:35,350 --> 00:09:34,080

and so that process of sort of

266

00:09:37,030 --> 00:09:35,360

honing

267

00:09:39,350 --> 00:09:37,040

what we do with our skills with the

268

00:09:41,430 --> 00:09:39,360

rovers to maximize the science we get

269

00:09:43,350 --> 00:09:41,440

back is something that i really came to

270

00:09:45,269 --> 00:09:43,360

appreciate over the mission

271

00:09:48,550 --> 00:09:45,279

you also did a lot of work in helping

272

00:09:51,590 --> 00:09:48,560

select the landing site where curiosity

273

00:09:53,750 --> 00:09:51,600

is and i wonder what did you learn from

274

00:09:55,829 --> 00:09:53,760

the mars exploration rovers that helped

275

00:09:58,070 --> 00:09:55,839

you with that process of selecting where

276
00:10:00,310 --> 00:09:58,080
to go on mars with the mars exploration

277
00:10:02,150 --> 00:10:00,320
rovers the landing ellipse as we call it

278
00:10:03,509 --> 00:10:02,160
the area that we targeted to land was

279
00:10:05,269 --> 00:10:03,519
quite a lot larger than it was for the

280
00:10:06,710 --> 00:10:05,279
mars science laboratory different

281
00:10:09,110 --> 00:10:06,720
landing system

282
00:10:10,870 --> 00:10:09,120
and because of that the targets that we

283
00:10:12,870 --> 00:10:10,880
were interested in needed to be somewhat

284
00:10:14,389 --> 00:10:12,880
distributed oh sure we had favorites but

285
00:10:16,630 --> 00:10:14,399
they needed to be kind of spread across

286
00:10:17,829 --> 00:10:16,640
the ellipse so wherever we landed we

287
00:10:19,430 --> 00:10:17,839
could get to the things that we were

288
00:10:22,470 --> 00:10:19,440

interested in because remember this was

289

00:10:24,069 --> 00:10:22,480

only a 90 day mission or 90 saw mission

290

00:10:25,910 --> 00:10:24,079

with the mars science laboratory we have

291

00:10:27,910 --> 00:10:25,920

smaller ellipses but there's also now

292

00:10:30,870 --> 00:10:27,920

this understanding that once you get

293

00:10:32,310 --> 00:10:30,880

down to the surface of mars

294

00:10:34,069 --> 00:10:32,320

you may have a little more time on your

295

00:10:35,910 --> 00:10:34,079

hands than you thought you did and so

296

00:10:37,990 --> 00:10:35,920

the idea that you didn't have to really

297

00:10:39,910 --> 00:10:38,000

land on your

298

00:10:41,509 --> 00:10:39,920

distributed targets to guarantee the

299

00:10:43,670 --> 00:10:41,519

science you could maybe land next to it

300

00:10:46,230 --> 00:10:43,680

and then move over to it opened up a

301
00:10:47,829 --> 00:10:46,240
whole new set of landing sites that we

302
00:10:49,590 --> 00:10:47,839
couldn't consider

303
00:10:51,670 --> 00:10:49,600
for the mars exploration rovers and to

304
00:10:53,269 --> 00:10:51,680
give you an example of that gale crater

305
00:10:55,190 --> 00:10:53,279
was actually a landing site considered

306
00:10:56,949 --> 00:10:55,200
for spirit and opportunity but we could

307
00:10:59,269 --> 00:10:56,959
never get the ellipse to fit within the

308
00:11:02,069 --> 00:10:59,279
crater safely to make that landing

309
00:11:04,470 --> 00:11:02,079
happen with curiosity the ellipse got

310
00:11:06,150 --> 00:11:04,480
smaller and the ability or the knowledge

311
00:11:08,230 --> 00:11:06,160
that once we got on the surface we had a

312
00:11:09,910 --> 00:11:08,240
rover that could last a little longer we

313
00:11:11,350 --> 00:11:09,920

could place that ellipse next to mount

314

00:11:13,590 --> 00:11:11,360

sharp this mountain that we're trying to

315

00:11:15,190 --> 00:11:13,600

get to and we'll get to and then drive

316

00:11:16,870 --> 00:11:15,200

over to it we didn't have to land right

317

00:11:18,550 --> 00:11:16,880

on top of it so it's kind of a

318

00:11:20,790 --> 00:11:18,560

difference in the philosophy of how you

319

00:11:24,069 --> 00:11:20,800

approach the site selection

320

00:11:26,870 --> 00:11:24,079

thanks john thank you so dave

321

00:11:28,870 --> 00:11:26,880

when i first became a scientist was

322

00:11:30,790 --> 00:11:28,880

right after the time

323

00:11:33,350 --> 00:11:30,800

of the pathfinder

324

00:11:34,710 --> 00:11:33,360

and sojourner was this little shoe box

325

00:11:36,710 --> 00:11:34,720

on mars

326

00:11:41,269 --> 00:11:36,720

how in the heck did you get from a shoe

327

00:11:45,269 --> 00:11:43,829

the process that we use to develop all

328

00:11:48,470 --> 00:11:45,279

the technologies and the capabilities to

329

00:11:49,590 --> 00:11:48,480

advance from sojourner on to uh

330

00:11:51,350 --> 00:11:49,600

spirit and opportunity and then

331

00:11:53,190 --> 00:11:51,360

following that on to curiosity is really

332

00:11:57,350 --> 00:11:53,200

a story that goes back easily more than

333

00:11:59,350 --> 00:11:57,360

20 years it just so happens by accident

334

00:12:02,550 --> 00:11:59,360

that i've got uh

335

00:12:04,310 --> 00:12:02,560

an example here this is actually a spare

336

00:12:06,310 --> 00:12:04,320

wheel from the sojourner rover which

337

00:12:08,310 --> 00:12:06,320

landed in 1997 on the surface of mars

338

00:12:09,590 --> 00:12:08,320

you can see the size of it and we had

339

00:12:10,790 --> 00:12:09,600

we're called grousers on the outside

340

00:12:12,310 --> 00:12:10,800

that was used actually give us some

341

00:12:14,310 --> 00:12:12,320

traction on the surface

342

00:12:16,629 --> 00:12:14,320

of mars as we drove and as a size

343

00:12:18,230 --> 00:12:16,639

comparison then this is a wheel from

344

00:12:20,710 --> 00:12:18,240

spirit and opportunity and you can see

345

00:12:23,269 --> 00:12:20,720

how they grew uh in overall capability

346

00:12:24,870 --> 00:12:23,279

in size just one comparing the other i

347

00:12:26,550 --> 00:12:24,880

would actually normally have excuse me

348

00:12:28,069 --> 00:12:26,560

so i don't have it with me right now but

349

00:12:29,590 --> 00:12:28,079

in comparison again you can see the

350

00:12:31,829 --> 00:12:29,600

increase from sojourner to spirit and

351
00:12:33,910 --> 00:12:31,839
opportunity it's a similar ratio between

352
00:12:35,990 --> 00:12:33,920
spirit and opportunities wheel up to

353
00:12:38,629 --> 00:12:36,000
curiosity which would stand about this

354
00:12:40,310 --> 00:12:38,639
big

355
00:12:42,389 --> 00:12:40,320
but

356
00:12:44,790 --> 00:12:42,399
the some of the technologies that uh

357
00:12:47,350 --> 00:12:44,800
were developed over the course of the

358
00:12:50,150 --> 00:12:47,360
intervening uh set of years between

359
00:12:52,470 --> 00:12:50,160
sojourner and spirit and opportunity

360
00:12:54,150 --> 00:12:52,480
were full of all sorts of technology

361
00:12:55,190 --> 00:12:54,160
developments and advances and actually

362
00:12:56,470 --> 00:12:55,200
um

363
00:12:58,389 --> 00:12:56,480

before i get too deep into that i want

364

00:12:59,350 --> 00:12:58,399

to bring up one image and then i'll talk

365

00:13:00,949 --> 00:12:59,360

a little bit about some of the

366

00:13:05,269 --> 00:13:00,959

technologies and what they were if i if

367

00:13:09,829 --> 00:13:07,190

um one of the things that happens in the

368

00:13:12,870 --> 00:13:09,839

course of uh spirit's mission is she

369

00:13:15,350 --> 00:13:12,880

returned over 128 000 images from the

370

00:13:18,150 --> 00:13:15,360

surface of mars and from gusev crater

371

00:13:19,110 --> 00:13:18,160

out of that 128 000 this is my very

372

00:13:20,629 --> 00:13:19,120

favorite and i actually went through a

373

00:13:23,269 --> 00:13:20,639

process actually looked literally at all

374

00:13:25,269 --> 00:13:23,279

128 000 and you think i'm joking but we

375

00:13:26,790 --> 00:13:25,279

actually did go through all of them um

376

00:13:28,069 --> 00:13:26,800

but this is my very favorite and it's

377

00:13:30,230 --> 00:13:28,079

for a reason that might not be

378

00:13:32,310 --> 00:13:30,240

intuitively obvious at first one of the

379

00:13:34,150 --> 00:13:32,320

things that we did with sojourner first

380

00:13:35,509 --> 00:13:34,160

and it proved out a capability and then

381

00:13:37,110 --> 00:13:35,519

followed with spirit and opportunity was

382

00:13:39,269 --> 00:13:37,120

utilizing what we call the airbag

383

00:13:41,670 --> 00:13:39,279

landing system which uh if you are

384

00:13:43,269 --> 00:13:41,680

familiar with it basically was a system

385

00:13:45,590 --> 00:13:43,279

where the we hit the top of the mars

386

00:13:47,030 --> 00:13:45,600

atmosphere about 12 000 miles an hour

387

00:13:48,710 --> 00:13:47,040

relative to the planet

388

00:13:50,870 --> 00:13:48,720

descended through the atmosphere slowed

389

00:13:52,870 --> 00:13:50,880

down so on a supersonic parachute the

390

00:13:54,870 --> 00:13:52,880

heat shield fell away the spacecraft

391

00:13:56,470 --> 00:13:54,880

itself fell below that

392

00:13:59,269 --> 00:13:56,480

and we had a series of airbags that

393

00:14:00,790 --> 00:13:59,279

inflated that then absorbed the impact

394

00:14:02,310 --> 00:14:00,800

shock of actually coming down and

395

00:14:03,750 --> 00:14:02,320

touching down the surface of mars the

396

00:14:05,509 --> 00:14:03,760

whole stacks were bounced around for a

397

00:14:07,189 --> 00:14:05,519

little bit then came to rest deflated

398

00:14:09,189 --> 00:14:07,199

the airbags and the rover and the lander

399

00:14:11,189 --> 00:14:09,199

all tucked up safely inside which then

400

00:14:13,110 --> 00:14:11,199

deployed that that system was first used

401
00:14:14,389 --> 00:14:13,120
for spirit for excuse me for sojourner

402
00:14:16,790 --> 00:14:14,399
and then later on with spirit and

403
00:14:18,470 --> 00:14:16,800
opportunity if you look at this image on

404
00:14:21,590 --> 00:14:18,480
the right hand side you can see some

405
00:14:24,230 --> 00:14:21,600
discolored sort of darker patches those

406
00:14:26,150 --> 00:14:24,240
are actually the bounce marks from the

407
00:14:28,230 --> 00:14:26,160
airbags as we came in and landed a

408
00:14:30,949 --> 00:14:28,240
gooseb crater with spirit

409
00:14:33,430 --> 00:14:30,959
and if you take a step back apart from

410
00:14:34,550 --> 00:14:33,440
the pure technology that was being used

411
00:14:36,629 --> 00:14:34,560
the time and the technical

412
00:14:38,389 --> 00:14:36,639
implementation of what was going on but

413
00:14:40,470 --> 00:14:38,399

philosophically look at this image and

414

00:14:43,189 --> 00:14:40,480

recognize it for what it is those are

415

00:14:44,389 --> 00:14:43,199

the footprints of a lander from earth

416

00:14:46,470 --> 00:14:44,399

from another planet

417

00:14:48,550 --> 00:14:46,480

coming in and disturbing the surface of

418

00:14:52,069 --> 00:14:48,560

mars for the first time

419

00:14:54,710 --> 00:14:52,079

that's a physical signal that we have

420

00:14:57,350 --> 00:14:54,720

arrived on another planet and left our

421

00:14:59,110 --> 00:14:57,360

mark to show earth is here

422

00:15:01,350 --> 00:14:59,120

philosophically i love that image and

423

00:15:03,509 --> 00:15:01,360

what it actually represents in terms of

424

00:15:04,389 --> 00:15:03,519

the arrival of this mission on this

425

00:15:05,990 --> 00:15:04,399

planet

426
00:15:07,269 --> 00:15:06,000
its destination and what we're supposed

427
00:15:08,710 --> 00:15:07,279
to begin to be able to do for the

428
00:15:10,550 --> 00:15:08,720
science mission

429
00:15:11,509 --> 00:15:10,560
you go to the next image

430
00:15:12,949 --> 00:15:11,519
now let's talk about some of the

431
00:15:14,310 --> 00:15:12,959
technology that actually was developed

432
00:15:16,389 --> 00:15:14,320
for these missions and what we were able

433
00:15:17,990 --> 00:15:16,399
able to actually utilize

434
00:15:19,670 --> 00:15:18,000
the big most obvious thing is we had

435
00:15:21,269 --> 00:15:19,680
these rovers that were now capable of

436
00:15:23,590 --> 00:15:21,279
going out and traversing across the

437
00:15:25,590 --> 00:15:23,600
surface of mars sojourn

438
00:15:28,069 --> 00:15:25,600

sojourner as a technology validation

439

00:15:29,829 --> 00:15:28,079

mission demonstrated the idea of putting

440

00:15:31,509 --> 00:15:29,839

instruments on a mobile platform and

441

00:15:33,269 --> 00:15:31,519

being able to move around to a

442

00:15:34,710 --> 00:15:33,279

destination that you saw that was

443

00:15:37,269 --> 00:15:34,720

interesting and possibly intriguing

444

00:15:38,710 --> 00:15:37,279

scientifically that was a literally a

445

00:15:40,389 --> 00:15:38,720

technology demonstrator to sort of

446

00:15:41,590 --> 00:15:40,399

validate the concept spirit and

447

00:15:43,430 --> 00:15:41,600

opportunity were the first time we

448

00:15:45,110 --> 00:15:43,440

actually did that operationally said

449

00:15:47,189 --> 00:15:45,120

okay now we we've proven that it can be

450

00:15:49,350 --> 00:15:47,199

done now let's actually go and conduct

451
00:15:51,509 --> 00:15:49,360
science through the eyes of a rover that

452
00:15:53,189 --> 00:15:51,519
can go to where we want

453
00:15:56,230 --> 00:15:53,199
as part of that process we had to think

454
00:15:57,829 --> 00:15:56,240
about how do you operate these rovers

455
00:15:59,269 --> 00:15:57,839
what we had done up until that point in

456
00:16:00,310 --> 00:15:59,279
time was basically look through the eyes

457
00:16:01,509 --> 00:16:00,320
the rovers look through the rover

458
00:16:03,910 --> 00:16:01,519
cameras

459
00:16:05,509 --> 00:16:03,920
pick a path sort of manually and then

460
00:16:07,350 --> 00:16:05,519
tell the rover to follow the path that

461
00:16:09,269 --> 00:16:07,360
we had designated

462
00:16:10,470 --> 00:16:09,279
it worked but it was a very slow process

463
00:16:13,189 --> 00:16:10,480

because every time we wanted to drive

464

00:16:15,670 --> 00:16:13,199

and do a turn or find a hazard we had to

465

00:16:17,030 --> 00:16:15,680

stop put humans in the loop loop back

466

00:16:18,550 --> 00:16:17,040

all the way to earth and do a full

467

00:16:21,189 --> 00:16:18,560

command cycle or sometimes two or three

468

00:16:23,990 --> 00:16:21,199

command cycles which could take days

469

00:16:25,590 --> 00:16:24,000

this image is a very important image

470

00:16:27,590 --> 00:16:25,600

what we did on spirit and opportunity

471

00:16:29,670 --> 00:16:27,600

was institute a set of technologies that

472

00:16:32,150 --> 00:16:29,680

would allow the rover to drive itself

473

00:16:34,790 --> 00:16:32,160

automatically to recognize hazards on

474

00:16:37,030 --> 00:16:34,800

its own and and find its own path around

475

00:16:39,030 --> 00:16:37,040

them basically some capabilities called

476

00:16:40,550 --> 00:16:39,040

auto nav

477

00:16:42,230 --> 00:16:40,560

and visa dom and a few other

478

00:16:44,550 --> 00:16:42,240

capabilities that allowed the rover

479

00:16:46,550 --> 00:16:44,560

instead of being commanded by humans to

480

00:16:48,790 --> 00:16:46,560

follow a very specific path that

481

00:16:50,389 --> 00:16:48,800

required the humans to avoid hazards

482

00:16:52,550 --> 00:16:50,399

instead we could sit there and say

483

00:16:53,990 --> 00:16:52,560

here's your destination you figure out

484

00:16:55,749 --> 00:16:54,000

how to get there

485

00:16:57,509 --> 00:16:55,759

and this photograph was the first time

486

00:16:59,910 --> 00:16:57,519

we ever had proof by looking at the

487

00:17:01,590 --> 00:16:59,920

rover tracks of the rover recognizing a

488

00:17:03,110 --> 00:17:01,600

hazard that little rock that's on the

489

00:17:05,029 --> 00:17:03,120

right hand side of the frame and

490

00:17:07,110 --> 00:17:05,039

actually actively guiding its path

491

00:17:09,189 --> 00:17:07,120

around that hazard on its own and then

492

00:17:10,870 --> 00:17:09,199

continuing on to its destination and

493

00:17:12,390 --> 00:17:10,880

this was about a month and a half after

494

00:17:13,750 --> 00:17:12,400

uh spirit had landed that she was able

495

00:17:15,590 --> 00:17:13,760

to do this for the first time that

496

00:17:18,309 --> 00:17:15,600

little sort of diversion in the in the

497

00:17:19,590 --> 00:17:18,319

wheel tracks is the indication of that

498

00:17:20,870 --> 00:17:19,600

and then the last one if i go to the

499

00:17:22,789 --> 00:17:20,880

next image

500

00:17:25,189 --> 00:17:22,799

that we also had as i mentioned this

501
00:17:27,270 --> 00:17:25,199
landing system that we had the basics

502
00:17:28,630 --> 00:17:27,280
behind the landing system

503
00:17:30,310 --> 00:17:28,640
had its roots going all the way back to

504
00:17:31,590 --> 00:17:30,320
the early mars missions the mariners and

505
00:17:33,990 --> 00:17:31,600
the viking missions in terms of the

506
00:17:35,990 --> 00:17:34,000
basic technology associated with

507
00:17:37,669 --> 00:17:36,000
um the heat shield

508
00:17:40,070 --> 00:17:37,679
the parachute system and everything else

509
00:17:41,669 --> 00:17:40,080
that was used to get down to the surface

510
00:17:43,990 --> 00:17:41,679
the thing that we had never known up

511
00:17:45,350 --> 00:17:44,000
until uh this point with the mer

512
00:17:47,350 --> 00:17:45,360
missions this is actually a photograph

513
00:17:50,390 --> 00:17:47,360

from opportunity

514

00:17:52,150 --> 00:17:50,400

was we had designed these entry descent

515

00:17:53,669 --> 00:17:52,160

and landing systems

516

00:17:55,430 --> 00:17:53,679

we had watched them work we'd watch the

517

00:17:57,510 --> 00:17:55,440

successful results

518

00:17:59,110 --> 00:17:57,520

we'd never been able to actually measure

519

00:18:01,029 --> 00:17:59,120

how well did the entry descent landing

520

00:18:03,190 --> 00:18:01,039

system actually work because we could

521

00:18:05,110 --> 00:18:03,200

never see it after the fact to find out

522

00:18:06,230 --> 00:18:05,120

was our engineering right on was it out

523

00:18:08,630 --> 00:18:06,240

near the edge of the performance

524

00:18:09,510 --> 00:18:08,640

envelope were we about to break or we

525

00:18:11,110 --> 00:18:09,520

were right in the middle of where we

526
00:18:13,190 --> 00:18:11,120
wanted to be we were fortunate enough

527
00:18:15,430 --> 00:18:13,200
that with in the case of opportunity we

528
00:18:17,510 --> 00:18:15,440
actually were able to drive up to the

529
00:18:19,270 --> 00:18:17,520
heat shield after it had impacted on the

530
00:18:21,029 --> 00:18:19,280
surface a couple months after the

531
00:18:22,630 --> 00:18:21,039
mission started and we'd landed and

532
00:18:25,029 --> 00:18:22,640
actually drive up to it and find it and

533
00:18:26,950 --> 00:18:25,039
examine it and look at the heat shield

534
00:18:29,430 --> 00:18:26,960
and see visibly how well it had

535
00:18:31,350 --> 00:18:29,440
performed its job and validate what the

536
00:18:32,870 --> 00:18:31,360
engineering models had told us should be

537
00:18:35,029 --> 00:18:32,880
happening with it that was actually a

538
00:18:37,190 --> 00:18:35,039

very interesting way of closing the loop

539

00:18:38,549 --> 00:18:37,200

on the engineering life cycle to do this

540

00:18:39,830 --> 00:18:38,559

we didn't dwell in this area for too

541

00:18:41,510 --> 00:18:39,840

long in addition to the heat shield

542

00:18:43,110 --> 00:18:41,520

coming down impacting this area there

543

00:18:44,549 --> 00:18:43,120

was also a metallic meteorite that's

544

00:18:46,150 --> 00:18:44,559

sitting right next to it

545

00:18:48,070 --> 00:18:46,160

we realized that this was a place where

546

00:18:49,590 --> 00:18:48,080

lots of heavy metal things came down and

547

00:18:51,190 --> 00:18:49,600

landed and so we didn't want to stay

548

00:18:51,990 --> 00:18:51,200

here for too long so we zipped right out

549

00:18:53,669 --> 00:18:52,000

of here

550

00:18:55,270 --> 00:18:53,679

right afterwards but there were that and

551
00:18:56,870 --> 00:18:55,280
many many other technologies that were

552
00:18:58,630 --> 00:18:56,880
developed as a part of the process that

553
00:19:00,470 --> 00:18:58,640
actually enabled us to put these rovers

554
00:19:02,710 --> 00:19:00,480
down the surface and have them live not

555
00:19:05,669 --> 00:19:02,720
just once or twice but many multiples of

556
00:19:07,830 --> 00:19:05,679
tens of times past their lifetime

557
00:19:09,669 --> 00:19:07,840
i gotta have that auto nav thing for my

558
00:19:10,950 --> 00:19:09,679
car so i can eat a pop-tart on the way

559
00:19:12,710 --> 00:19:10,960
to work

560
00:19:14,789 --> 00:19:12,720
actually in a way there are a lot of

561
00:19:17,430 --> 00:19:14,799
tech uh technologies that sourced and

562
00:19:19,190 --> 00:19:17,440
have common sources with what were flown

563
00:19:20,789 --> 00:19:19,200

with autonav and visit dom and some of

564

00:19:22,230 --> 00:19:20,799

these other technologies that are now

565

00:19:23,590 --> 00:19:22,240

making their way out in the into the

566

00:19:25,669 --> 00:19:23,600

market i think we've all heard at this

567

00:19:27,029 --> 00:19:25,679

point about the the google autonomous

568

00:19:28,230 --> 00:19:27,039

cars that are now traversing the

569

00:19:29,830 --> 00:19:28,240

highways

570

00:19:31,270 --> 00:19:29,840

the technology that is used on board

571

00:19:33,110 --> 00:19:31,280

there in fact some of the people who

572

00:19:34,549 --> 00:19:33,120

developed that technology have common

573

00:19:36,150 --> 00:19:34,559

routes back in the technologies that

574

00:19:37,990 --> 00:19:36,160

were actually flown on the on the mars

575

00:19:39,909 --> 00:19:38,000

rovers

576

00:19:41,990 --> 00:19:39,919

that is so cool

577

00:19:43,909 --> 00:19:42,000

i have more for you but first i want to

578

00:19:46,310 --> 00:19:43,919

go to steve steve

579

00:19:49,190 --> 00:19:46,320

i have three questions for you

580

00:19:50,870 --> 00:19:49,200

the first one is

581

00:19:53,510 --> 00:19:50,880

if you had known these things were going

582

00:19:55,430 --> 00:19:53,520

to last longer than 90 days

583

00:19:57,350 --> 00:19:55,440

would you have done anything differently

584

00:20:00,870 --> 00:19:57,360

during that first part of the mission oh

585

00:20:03,029 --> 00:20:00,880

yeah um you know i look back now at

586

00:20:04,149 --> 00:20:03,039

decisions that we made i mean john will

587

00:20:06,390 --> 00:20:04,159

remember some of this some of the

588

00:20:08,789 --> 00:20:06,400

decisions that we made we we landed with

589

00:20:10,310 --> 00:20:08,799

opportunity in this marvelous treasure

590

00:20:11,590 --> 00:20:10,320

trove of crater that we named eagle

591

00:20:12,710 --> 00:20:11,600

crater

592

00:20:15,830 --> 00:20:12,720

and

593

00:20:17,270 --> 00:20:15,840

we're still tooling around in this

594

00:20:19,350 --> 00:20:17,280

little crater there was wonderful

595

00:20:20,789 --> 00:20:19,360

science there but i'm thinking 90 day

596

00:20:22,310 --> 00:20:20,799

mission and we're going to spend half of

597

00:20:24,470 --> 00:20:22,320

we've spent half of it already in a

598

00:20:27,430 --> 00:20:24,480

little hole in the ground and so i told

599

00:20:28,789 --> 00:20:27,440

the team you know sol 60 60th day of the

600

00:20:30,310 --> 00:20:28,799

mission we're going over the edge and

601
00:20:32,390 --> 00:20:30,320
we're heading out across the countryside

602
00:20:35,430 --> 00:20:32,400
i don't care what we have found we got

603
00:20:37,310 --> 00:20:35,440
to get moving and you know in retrospect

604
00:20:40,230 --> 00:20:37,320
today's day

605
00:20:42,149 --> 00:20:40,240
3500 and something i would have given

606
00:20:43,430 --> 00:20:42,159
him a little more time

607
00:20:45,270 --> 00:20:43,440
had i known

608
00:20:49,590 --> 00:20:45,280
what's the most surprising thing that

609
00:20:53,590 --> 00:20:51,350
the most surprising things

610
00:20:57,350 --> 00:20:53,600
scientifically

611
00:20:59,029 --> 00:20:57,360
i think came right when we first landed

612
00:21:00,149 --> 00:20:59,039
with opportunity

613
00:21:03,830 --> 00:21:00,159

um

614

00:21:06,230 --> 00:21:03,840

i did not expect that the evidence for

615

00:21:08,710 --> 00:21:06,240

liquid water at and below the surface of

616

00:21:11,350 --> 00:21:08,720

mars was going to be that compelling

617

00:21:14,149 --> 00:21:11,360

that much in our face you know when we

618

00:21:15,590 --> 00:21:14,159

first landed um the spirit site

619

00:21:16,390 --> 00:21:15,600

we landed and what we saw was a bunch of

620

00:21:18,630 --> 00:21:16,400

lava

621

00:21:20,549 --> 00:21:18,640

and that was all we saw for geez

622

00:21:21,750 --> 00:21:20,559

months until we finally reached this

623

00:21:23,270 --> 00:21:21,760

range of hills that we called the

624

00:21:25,669 --> 00:21:23,280

columbia hills where we went up spending

625

00:21:28,470 --> 00:21:25,679

most of the mission opportunity it was

626
00:21:31,270 --> 00:21:28,480
all right there i mean just from day one

627
00:21:33,190 --> 00:21:31,280
we looked the first picture that we took

628
00:21:34,789 --> 00:21:33,200
there was layered sedimentary rock right

629
00:21:36,870 --> 00:21:34,799
in front of the vehicle to me the most

630
00:21:38,630 --> 00:21:36,880
surprising thing with opportunity was

631
00:21:40,549 --> 00:21:38,640
how easy it was

632
00:21:43,029 --> 00:21:40,559
and spirit spirit had to work for

633
00:21:46,710 --> 00:21:44,789
wow i would never have guessed that any

634
00:21:48,950 --> 00:21:46,720
of this was easy but you certainly make

635
00:21:52,390 --> 00:21:48,960
it sound like it

636
00:21:54,870 --> 00:21:52,400
when you look in the sky at mars

637
00:21:56,710 --> 00:21:54,880
and you realize that you still have

638
00:21:58,549 --> 00:21:56,720

tools up there

639

00:22:00,070 --> 00:21:58,559

and you think about what you'd like to

640

00:22:02,549 --> 00:22:00,080

know

641

00:22:04,630 --> 00:22:02,559

what is burning in your mind that you

642

00:22:06,149 --> 00:22:04,640

just like to get the answer

643

00:22:07,909 --> 00:22:06,159

it's funny that you mentioned looking in

644

00:22:10,149 --> 00:22:07,919

the sky at mars because i was i was just

645

00:22:13,190 --> 00:22:10,159

recently down at cape canaveral

646

00:22:15,510 --> 00:22:13,200

and i remember vividly

647

00:22:16,950 --> 00:22:15,520

in the summer of 2003 in the spring

648

00:22:17,909 --> 00:22:16,960

leading up to when we were about to

649

00:22:20,710 --> 00:22:17,919

launch

650

00:22:24,390 --> 00:22:20,720

it was at a time when mars was close to

651
00:22:26,630 --> 00:22:24,400
being in opposition when mars is uh

652
00:22:29,350 --> 00:22:26,640
close to the earth and so it burns very

653
00:22:31,590 --> 00:22:29,360
very bright red in the sky at night

654
00:22:33,270 --> 00:22:31,600
and dave will remember this vividly but

655
00:22:35,270 --> 00:22:33,280
as we were getting the rovers ready to

656
00:22:36,549 --> 00:22:35,280
launch we had all kinds of problems and

657
00:22:38,549 --> 00:22:36,559
it wasn't even clear we were going to

658
00:22:39,909 --> 00:22:38,559
get to launch we had mechanical problems

659
00:22:41,110 --> 00:22:39,919
we had electrical problems we had all

660
00:22:43,350 --> 00:22:41,120
sorts of things

661
00:22:44,870 --> 00:22:43,360
and we were working 12 14 hour days and

662
00:22:47,590 --> 00:22:44,880
i can remember

663
00:22:50,789 --> 00:22:47,600

going out on the beach at night

664

00:22:52,950 --> 00:22:50,799

and watching mars rise

665

00:22:56,710 --> 00:22:52,960

over the atlantic and it just

666

00:22:58,710 --> 00:22:56,720

seemed impossibly far away

667

00:23:00,710 --> 00:22:58,720

and now

668

00:23:02,789 --> 00:23:00,720

when i look at mars in the sky

669

00:23:04,149 --> 00:23:02,799

it's a totally different feeling i can

670

00:23:06,070 --> 00:23:04,159

look at mars in the sky at night and say

671

00:23:07,990 --> 00:23:06,080

yeah i know that place

672

00:23:11,110 --> 00:23:08,000

and we all do that's the beauty of it is

673

00:23:14,070 --> 00:23:11,120

we've all gotten the chance to

674

00:23:16,390 --> 00:23:14,080

observe mars to experience mars through

675

00:23:17,669 --> 00:23:16,400

the eyes of these rovers for

676

00:23:20,070 --> 00:23:17,679

for a decade

677

00:23:22,230 --> 00:23:20,080

and to to me the burning question is

678

00:23:24,070 --> 00:23:22,240

what it was back then and what it what

679

00:23:25,669 --> 00:23:24,080

it has always been for mars and that is

680

00:23:27,350 --> 00:23:25,679

was there ever life there

681

00:23:28,549 --> 00:23:27,360

you know and we don't have the answer

682

00:23:31,669 --> 00:23:28,559

yet but we're a lot closer than we used

683

00:23:35,270 --> 00:23:33,110

i want to go back to you for a minute

684

00:23:38,470 --> 00:23:35,280

john

685

00:23:41,430 --> 00:23:38,480

you because you have spent so much time

686

00:23:43,110 --> 00:23:41,440

thinking about places to land on mars as

687

00:23:44,789 --> 00:23:43,120

well as operating rovers on two

688

00:23:47,909 --> 00:23:44,799

different missions

689

00:23:50,390 --> 00:23:47,919

where do you think we should go next

690

00:23:51,830 --> 00:23:50,400

no commitment here just an opinion well

691

00:23:53,750 --> 00:23:51,840

i'm going to give you my diplomatic

692

00:23:55,510 --> 00:23:53,760

answer

693

00:23:58,070 --> 00:23:55,520

um

694

00:24:01,669 --> 00:23:59,830

sometimes when the landing ellipse is

695

00:24:03,590 --> 00:24:01,679

big there's an element of picking a

696

00:24:06,710 --> 00:24:03,600

landing site that's easier because

697

00:24:08,310 --> 00:24:06,720

there's fewer places you can go

698

00:24:10,070 --> 00:24:08,320

when we started looking with the mars

699

00:24:12,310 --> 00:24:10,080

science laboratory

700

00:24:14,230 --> 00:24:12,320

the number of compelling sites

701

00:24:16,549 --> 00:24:14,240

that we had to consider

702

00:24:19,510 --> 00:24:16,559

just blossomed because we had data from

703

00:24:21,510 --> 00:24:19,520

other spacecraft in the mars exploration

704

00:24:23,190 --> 00:24:21,520

program the mars reconnaissance orbiter

705

00:24:25,110 --> 00:24:23,200

the chrism instrument that can tell us

706

00:24:27,830 --> 00:24:25,120

information about the composition of

707

00:24:30,630 --> 00:24:27,840

rocks at the surface high rise and ctx

708

00:24:32,310 --> 00:24:30,640

that really detail the textures in the

709

00:24:34,390 --> 00:24:32,320

in the context that we understand the

710

00:24:36,230 --> 00:24:34,400

geology from we didn't have that for

711

00:24:38,390 --> 00:24:36,240

mars exploration rovers we had some

712

00:24:41,029 --> 00:24:38,400

pretty amazing data from the mars global

713

00:24:43,750 --> 00:24:41,039

surveyor but for the future ones we had

714

00:24:46,630 --> 00:24:43,760

the next generation

715

00:24:49,269 --> 00:24:46,640

it's hard i've got probably a list of

716

00:24:51,029 --> 00:24:49,279

a dozen favorite sites and i'm kind of

717

00:24:52,549 --> 00:24:51,039

holding back because i think what will

718

00:24:55,590 --> 00:24:52,559

happen as we start to look at the

719

00:24:57,830 --> 00:24:55,600

landing site process for the next rover

720

00:24:59,510 --> 00:24:57,840

is that we're going to get new data

721

00:25:01,590 --> 00:24:59,520

and we're going to have discussions with

722

00:25:03,990 --> 00:25:01,600

scientists in the public that is going

723

00:25:05,990 --> 00:25:04,000

to provide insight and so i think well

724

00:25:08,070 --> 00:25:06,000

here's my short list but i'm going to

725

00:25:09,830 --> 00:25:08,080

hold back a little bit and find out what

726

00:25:12,710 --> 00:25:09,840

we really learned at these sites and

727

00:25:16,789 --> 00:25:14,870

steve

728

00:25:18,549 --> 00:25:16,799

i've got a question for you

729

00:25:20,310 --> 00:25:18,559

when you think about the things that

730

00:25:22,310 --> 00:25:20,320

you've learned using the tools with

731

00:25:24,149 --> 00:25:22,320

spirit and opportunity

732

00:25:28,390 --> 00:25:24,159

and the things that you've learned you

733

00:25:31,190 --> 00:25:28,400

also investigate mars through curiosity

734

00:25:33,269 --> 00:25:31,200

what do you think is the relationship

735

00:25:35,750 --> 00:25:33,279

between the things you've learned

736

00:25:37,909 --> 00:25:35,760

with the mars exploration rovers and the

737

00:25:40,070 --> 00:25:37,919

things that you learn with curiosity and

738

00:25:41,350 --> 00:25:40,080

where does that send your brain for the

739

00:25:42,950 --> 00:25:41,360

future

740

00:25:44,630 --> 00:25:42,960

you know i think one of the key things

741

00:25:46,950 --> 00:25:44,640

that we learned

742

00:25:48,870 --> 00:25:46,960

with opportunity and spirit

743

00:25:50,630 --> 00:25:48,880

is that there's real

744

00:25:51,830 --> 00:25:50,640

sedimentary geology

745

00:25:53,990 --> 00:25:51,840

on mars

746

00:25:55,510 --> 00:25:54,000

uh before we landed with these rovers

747

00:25:57,830 --> 00:25:55,520

the only kind of rocks on mars that we

748

00:25:59,990 --> 00:25:57,840

really knew much about were lavas

749

00:26:02,149 --> 00:26:00,000

explosive volcanic rocks

750

00:26:03,269 --> 00:26:02,159

effusive volcanic rocks lava flows in

751
00:26:04,950 --> 00:26:03,279
other words

752
00:26:07,430 --> 00:26:04,960
um

753
00:26:08,870 --> 00:26:07,440
nobody really studied

754
00:26:11,669 --> 00:26:08,880
sedimentary rocks but the thing about

755
00:26:13,909 --> 00:26:11,679
sedimentary rocks is that they preserve

756
00:26:16,470 --> 00:26:13,919
in their details in their chemistry in

757
00:26:18,789 --> 00:26:16,480
their texture information about what the

758
00:26:20,070 --> 00:26:18,799
conditions were like when the rocks were

759
00:26:21,750 --> 00:26:20,080
laid down

760
00:26:23,830 --> 00:26:21,760
and the missions of these rovers

761
00:26:26,310 --> 00:26:23,840
especially the mission of opportunity

762
00:26:29,110 --> 00:26:26,320
turned into this marvelous story

763
00:26:31,110 --> 00:26:29,120

of sedimentary geology and that was what

764

00:26:33,909 --> 00:26:31,120

drove the selection

765

00:26:37,510 --> 00:26:33,919

of the the gale crater landing site uh

766

00:26:40,470 --> 00:26:37,520

for curiosity uh curiosity was largely

767

00:26:43,190 --> 00:26:40,480

designed to exploit the way in which

768

00:26:44,630 --> 00:26:43,200

sedimentary rocks can preserve evidence

769

00:26:46,310 --> 00:26:44,640

of what was going on at the time

770

00:26:48,070 --> 00:26:46,320

evidence not just of water that's

771

00:26:49,510 --> 00:26:48,080

preserved in the minerals but maybe even

772

00:26:51,510 --> 00:26:49,520

of organic materials that can be

773

00:26:53,590 --> 00:26:51,520

preserved within sediments so

774

00:26:56,549 --> 00:26:53,600

it it it sort of transformed our

775

00:26:58,549 --> 00:26:56,559

understanding of martian geology

776

00:27:00,549 --> 00:26:58,559

yeah and as an interdisciplinary

777

00:27:03,350 --> 00:27:00,559

scientist myself i i certainly

778

00:27:05,590 --> 00:27:03,360

appreciate how fabulous an opportunity

779

00:27:07,750 --> 00:27:05,600

it is if you'll pardon the pun to

780

00:27:09,430 --> 00:27:07,760

understand how the materials recycle at

781

00:27:12,470 --> 00:27:09,440

the surface of mars and look at those

782

00:27:14,710 --> 00:27:12,480

processes and so that brings me to

783

00:27:17,269 --> 00:27:14,720

you dave

784

00:27:20,389 --> 00:27:17,279

you know it seems like all of this stuff

785

00:27:22,870 --> 00:27:20,399

works together the orbital missions the

786

00:27:25,269 --> 00:27:22,880

missions on the surface until you start

787

00:27:27,110 --> 00:27:25,279

assembling the puzzle from the bazillion

788

00:27:29,990 --> 00:27:27,120

foot view

789

00:27:32,950 --> 00:27:30,000

tell me what you think we need next to

790

00:27:35,430 --> 00:27:32,960

get from our robotic exploration to

791

00:27:36,870 --> 00:27:35,440

human exploration

792

00:27:38,070 --> 00:27:36,880

i think one of the things that you're

793

00:27:40,789 --> 00:27:38,080

touching on

794

00:27:43,029 --> 00:27:40,799

really has to do with the incredible

795

00:27:46,470 --> 00:27:43,039

value associated with

796

00:27:49,029 --> 00:27:46,480

looking how to explore mars as a planet

797

00:27:50,389 --> 00:27:49,039

through an entire program of missions

798

00:27:52,149 --> 00:27:50,399

rather than taking each one of these

799

00:27:54,149 --> 00:27:52,159

missions individually and saying this

800

00:27:55,269 --> 00:27:54,159

mission is going to go and do this and

801
00:27:58,070 --> 00:27:55,279
it's all going to be completely

802
00:27:59,909 --> 00:27:58,080
self-contained and its data is going to

803
00:28:01,590 --> 00:27:59,919
be 100 complete when the mission itself

804
00:28:03,510 --> 00:28:01,600
ends and we stop there and then we'll

805
00:28:05,590 --> 00:28:03,520
just do another one instead we've

806
00:28:07,430 --> 00:28:05,600
structured a mars exploration program

807
00:28:09,750 --> 00:28:07,440
that takes advantage of and builds and

808
00:28:11,990 --> 00:28:09,760
leverages upon the information both in

809
00:28:13,990 --> 00:28:12,000
terms of technology and science learned

810
00:28:16,710 --> 00:28:14,000
by the prior missions and we start to

811
00:28:18,710 --> 00:28:16,720
extend the capabilities as a sequence of

812
00:28:20,070 --> 00:28:18,720
missions rather than just one individual

813
00:28:23,110 --> 00:28:20,080

mission at a time

814

00:28:26,470 --> 00:28:23,120

that that view and the idea of we have a

815

00:28:28,230 --> 00:28:26,480

campaign of exploration to explore mars

816

00:28:29,990 --> 00:28:28,240

really has been invaluable in terms of

817

00:28:32,310 --> 00:28:30,000

how we both structure the missions we

818

00:28:34,549 --> 00:28:32,320

have and also how we

819

00:28:37,510 --> 00:28:34,559

incrementally increase our understanding

820

00:28:38,950 --> 00:28:37,520

of what the planet is really all about

821

00:28:41,830 --> 00:28:38,960

that goal and then leading to an

822

00:28:42,870 --> 00:28:41,840

eventual human mission on mars is

823

00:28:45,029 --> 00:28:42,880

is

824

00:28:47,269 --> 00:28:45,039

the ultimate end goal of of the entire

825

00:28:48,710 --> 00:28:47,279

sequence the mars exploration program

826

00:28:50,870 --> 00:28:48,720

and that what we're trying to do is

827

00:28:52,789 --> 00:28:50,880

answer the series of science-based

828

00:28:54,389 --> 00:28:52,799

questions to help us understand the

829

00:28:56,389 --> 00:28:54,399

environment what it means both

830

00:28:58,470 --> 00:28:56,399

scientifically in its own right but also

831

00:29:00,149 --> 00:28:58,480

what it means in terms of resources that

832

00:29:01,190 --> 00:29:00,159

might be of benefit to a future human

833

00:29:03,430 --> 00:29:01,200

mission

834

00:29:05,269 --> 00:29:03,440

and that set of not having just one

835

00:29:06,789 --> 00:29:05,279

mission to go to the planet to answer

836

00:29:09,110 --> 00:29:06,799

just the human questions but rather

837

00:29:10,549 --> 00:29:09,120

saying we're going to incrementally

838

00:29:12,310 --> 00:29:10,559

increase our knowledge about those

839

00:29:13,510 --> 00:29:12,320

answers with each successive mission

840

00:29:15,430 --> 00:29:13,520

until we get to the point we actually

841

00:29:17,430 --> 00:29:15,440

fly people is the approach that we've

842

00:29:18,950 --> 00:29:17,440

had for the past decade and we'll

843

00:29:21,029 --> 00:29:18,960

continue to have until we eventually

844

00:29:23,750 --> 00:29:21,039

have human footprints on mars in

845

00:29:25,430 --> 00:29:23,760

addition to the robotic ones

846

00:29:27,350 --> 00:29:25,440

and now i've been hogging up all the

847

00:29:29,110 --> 00:29:27,360

questions and i think some of you have

848

00:29:33,190 --> 00:29:29,120

questions and so duane's going to come

849

00:29:34,389 --> 00:29:33,200

back up here and wrangle them

850

00:29:35,269 --> 00:29:34,399

thanks penn

851
00:29:36,630 --> 00:29:35,279
yeah

852
00:29:38,310 --> 00:29:36,640
of course we can't have a mars

853
00:29:40,789 --> 00:29:38,320
conversation without having questions

854
00:29:42,389 --> 00:29:40,799
from the folks joining us here and on

855
00:29:44,070 --> 00:29:42,399
nasa television and particularly on

856
00:29:46,389 --> 00:29:44,080
social media for folks

857
00:29:48,149 --> 00:29:46,399
here there's a microphone

858
00:29:50,549 --> 00:29:48,159
please make your way there

859
00:29:54,630 --> 00:29:50,559
and of course join the conversation ask

860
00:29:55,750 --> 00:29:54,640
questions two hashtags hashtag 10 and

861
00:29:58,870 --> 00:29:55,760
10 years

862
00:30:00,870 --> 00:29:58,880
on mars just a reminder also that this

863
00:30:06,149 --> 00:30:00,880

event is being launched live streamed

864

00:30:09,269 --> 00:30:07,430

mars

865

00:30:12,149 --> 00:30:09,279

my first question and i have my handy

866

00:30:15,590 --> 00:30:12,159

dandy little phone here i think this is

867

00:30:17,990 --> 00:30:15,600

going to be for dr squires

868

00:30:21,830 --> 00:30:18,000

from the social media world

869

00:30:26,310 --> 00:30:24,070

extreme temperatures and there's some

870

00:30:27,669 --> 00:30:26,320

buzz on the uh social media site that's

871

00:30:28,789 --> 00:30:27,679

is this

872

00:30:30,630 --> 00:30:28,799

how could this compare to the

873

00:30:33,990 --> 00:30:30,640

temperatures on the red planet

874

00:30:36,630 --> 00:30:34,000

this would be a nice warm day on mars

875

00:30:40,789 --> 00:30:36,640

the average temperature on mars today is

876

00:30:43,590 --> 00:30:40,799

about minus 60 degrees celsius so way

877

00:30:45,590 --> 00:30:43,600

colder than any place in the united

878

00:30:48,070 --> 00:30:45,600

states right now uh you know in the

879

00:30:50,389 --> 00:30:48,080

middle of the day on a warm sunny summer

880

00:30:51,830 --> 00:30:50,399

afternoon it might get up to about zero

881

00:30:54,549 --> 00:30:51,840

degrees c

882

00:30:56,310 --> 00:30:54,559

but mars is a really cold nasty place

883

00:30:57,590 --> 00:30:56,320

compared even to the coldest nastiest

884

00:30:59,430 --> 00:30:57,600

place that you can imagine in the united

885

00:31:01,430 --> 00:30:59,440

states right now

886

00:31:03,190 --> 00:31:01,440

okay let's uh take some questions here

887

00:31:06,070 --> 00:31:03,200

again i'm going to thank the national

888

00:31:07,509 --> 00:31:06,080

aerospace museum for hosting us and

889

00:31:09,350 --> 00:31:07,519

first question sir

890

00:31:12,230 --> 00:31:09,360

my name is mark goldberg and i'm a

891

00:31:14,710 --> 00:31:12,240

docent here at the air and space museum

892

00:31:16,549 --> 00:31:14,720

my question is given the increasing

893

00:31:18,470 --> 00:31:16,559

sophistication and success of the

894

00:31:21,830 --> 00:31:18,480

robotic missions

895

00:31:24,950 --> 00:31:21,840

what is the goals that would justify the

896

00:31:27,990 --> 00:31:24,960

risks and costs of sending a human

897

00:31:33,029 --> 00:31:31,110

i'm going to give you a partial answer

898

00:31:34,310 --> 00:31:33,039

with a promise that if we want to pursue

899

00:31:35,590 --> 00:31:34,320

it uh with some of the people who will

900

00:31:36,710 --> 00:31:35,600

be more qualified to give you an answer

901
00:31:37,909 --> 00:31:36,720
about the human missions we can make

902
00:31:39,909 --> 00:31:37,919
that contact

903
00:31:42,310 --> 00:31:39,919
uh contact for you afterwards

904
00:31:45,190 --> 00:31:42,320
but fundamentally nasa has been given

905
00:31:47,269 --> 00:31:45,200
the goal of in the long term having a

906
00:31:48,310 --> 00:31:47,279
human mission to mars

907
00:31:50,230 --> 00:31:48,320
and there's a couple of different

908
00:31:51,830 --> 00:31:50,240
reasons that we are pursuing that goal

909
00:31:53,909 --> 00:31:51,840
one it is part of the national space

910
00:31:56,549 --> 00:31:53,919
policy and part of the reason that the

911
00:31:57,990 --> 00:31:56,559
agency now has uh and is chartered to

912
00:32:00,870 --> 00:31:58,000
continue to explore

913
00:32:02,710 --> 00:32:00,880

but fundamentally beyond that it's part

914

00:32:04,789 --> 00:32:02,720

of what we've always considered a human

915

00:32:06,070 --> 00:32:04,799

imperative of exploration

916

00:32:08,230 --> 00:32:06,080

uh we

917

00:32:10,870 --> 00:32:08,240

have long sought to expand human

918

00:32:13,509 --> 00:32:10,880

presence beyond earth in a permanent way

919

00:32:15,269 --> 00:32:13,519

and mars is basically the first stop on

920

00:32:16,870 --> 00:32:15,279

what will eventually be a solar

921

00:32:17,830 --> 00:32:16,880

system-wide and hopefully well beyond

922

00:32:19,830 --> 00:32:17,840

that

923

00:32:21,830 --> 00:32:19,840

uh journey of exploration with human

924

00:32:23,669 --> 00:32:21,840

presence mars is the one that's beckoned

925

00:32:25,110 --> 00:32:23,679

to us from the very beginnings of our

926
00:32:27,430 --> 00:32:25,120
understanding of the solar system and

927
00:32:29,990 --> 00:32:27,440
been so intriguing to reach out and try

928
00:32:32,870 --> 00:32:30,000
to grab that it's the the place we want

929
00:32:34,789 --> 00:32:32,880
to get to next to explore and we'll be

930
00:32:36,389 --> 00:32:34,799
the one that we'll get to first because

931
00:32:38,389 --> 00:32:36,399
it's just the next stepping stone to get

932
00:32:40,630 --> 00:32:38,399
out into the solar system

933
00:32:42,310 --> 00:32:40,640
the itch of exploration

934
00:32:45,190 --> 00:32:42,320
exactly

935
00:32:48,950 --> 00:32:47,029
hi uh thanks to the panel i'm joe

936
00:32:50,149 --> 00:32:48,960
mascaro i'm a fellow with the american

937
00:32:51,669 --> 00:32:50,159
association for the advancement of

938
00:32:53,830 --> 00:32:51,679

science and i'm currently at the u.s

939

00:32:55,990 --> 00:32:53,840

agency for international development

940

00:32:57,669 --> 00:32:56,000

um my question is about the the kind of

941

00:33:01,029 --> 00:32:57,679

perceived competition between the

942

00:33:03,830 --> 00:33:01,039

robotic programs and the man programs

943

00:33:04,950 --> 00:33:03,840

and i'm really curious to know uh if if

944

00:33:07,029 --> 00:33:04,960

you think there's possibility of

945

00:33:09,509 --> 00:33:07,039

hybridizing the robotic and man programs

946

00:33:11,909 --> 00:33:09,519

i i know the fans of both programs are

947

00:33:13,430 --> 00:33:11,919

obviously really not uh in competition

948

00:33:15,750 --> 00:33:13,440

with the other program we'd all like to

949

00:33:19,029 --> 00:33:15,760

see sort of the the robotic and man

950

00:33:21,110 --> 00:33:19,039

programs move forward simultaneously

951

00:33:22,149 --> 00:33:21,120

i'm going to start the answer to that

952

00:33:23,909 --> 00:33:22,159

one and then i'm going to let steve

953

00:33:25,909 --> 00:33:23,919

answer it as well

954

00:33:27,909 --> 00:33:25,919

but i'll just say from the standpoint of

955

00:33:30,549 --> 00:33:27,919

someone who builds robots for their

956

00:33:32,149 --> 00:33:30,559

career and i'm a roboticist by

957

00:33:34,149 --> 00:33:32,159

background and that's what i've done

958

00:33:36,870 --> 00:33:34,159

even before i got into the mars program

959

00:33:39,190 --> 00:33:36,880

i can't imagine anything better than

960

00:33:41,750 --> 00:33:39,200

human footprints on mars

961

00:33:44,310 --> 00:33:41,760

the robots are there as precursors and

962

00:33:47,110 --> 00:33:44,320

they are there as the tools paving the

963

00:33:49,110 --> 00:33:47,120

way and we use them now because that's

964

00:33:51,590 --> 00:33:49,120

all we can do at the moment

965

00:33:54,789 --> 00:33:51,600

but there's no misunderstanding that our

966

00:33:57,350 --> 00:33:54,799

long-term real goal is human exploration

967

00:33:58,950 --> 00:33:57,360

of the red planet we use robots as tools

968

00:34:00,950 --> 00:33:58,960

to help us get there to figure out the

969

00:34:03,669 --> 00:34:00,960

best ways to make that happen

970

00:34:06,149 --> 00:34:03,679

but we are as roboticists massively

971

00:34:08,069 --> 00:34:06,159

excited about what we can do as people

972

00:34:09,349 --> 00:34:08,079

as well i think steve can talk

973

00:34:11,510 --> 00:34:09,359

particular about

974

00:34:12,710 --> 00:34:11,520

rates of exploration and effectiveness

975

00:34:14,629 --> 00:34:12,720

and throughput of science and things

976
00:34:16,550 --> 00:34:14,639
like that that really are enabled by

977
00:34:19,510 --> 00:34:16,560
human presence

978
00:34:21,829 --> 00:34:19,520
yeah i'm a robot guy but uh humans can't

979
00:34:24,389 --> 00:34:21,839
get to mars soon enough for me i did an

980
00:34:25,829 --> 00:34:24,399
interesting experiment once

981
00:34:28,470 --> 00:34:25,839
we were out in the field with one of our

982
00:34:30,470 --> 00:34:28,480
test rovers and it was exploring around

983
00:34:32,629 --> 00:34:30,480
and i had some geologists with me

984
00:34:35,510 --> 00:34:32,639
and i would watch the

985
00:34:38,149 --> 00:34:35,520
human geologists do their thing

986
00:34:39,589 --> 00:34:38,159
on earth and then i would convert i

987
00:34:40,950 --> 00:34:39,599
would time how long it took them to do

988
00:34:42,310 --> 00:34:40,960

things and then i'd convert that into

989

00:34:44,629 --> 00:34:42,320

equivalent

990

00:34:46,869 --> 00:34:44,639

time for a robot and what our

991

00:34:48,710 --> 00:34:46,879

magnificent state-of-the-art vehicles

992

00:34:50,470 --> 00:34:48,720

can do in a day these guys could do in

993

00:34:52,310 --> 00:34:50,480

about 30 seconds

994

00:34:53,750 --> 00:34:52,320

so i'm a huge huge fan of human

995

00:34:55,030 --> 00:34:53,760

exploration

996

00:34:57,349 --> 00:34:55,040

okay we're going to take

997

00:34:58,870 --> 00:34:57,359

question i think we have a young person

998

00:35:01,109 --> 00:34:58,880

here that

999

00:35:03,109 --> 00:35:01,119

may be that human person that goes to

1000

00:35:05,190 --> 00:35:03,119

mars and and we have a panel coming up

1001
00:35:06,950 --> 00:35:05,200
that's going to be talking about that

1002
00:35:09,349 --> 00:35:06,960
yes young man

1003
00:35:11,990 --> 00:35:09,359
hi my name is xavier um i'm from

1004
00:35:14,710 --> 00:35:12,000
virginia um are you sure there's water

1005
00:35:17,270 --> 00:35:14,720
on there was water on mars

1006
00:35:23,349 --> 00:35:17,280
we're sure there's water on mars yes

1007
00:35:28,069 --> 00:35:26,150
a geologist is sort of like a detective

1008
00:35:30,710 --> 00:35:28,079
at the scene of a crime you're looking

1009
00:35:32,710 --> 00:35:30,720
for clues and the clues are in the rocks

1010
00:35:34,550 --> 00:35:32,720
and spirit and opportunity our two

1011
00:35:37,349 --> 00:35:34,560
detectives have been looking at the

1012
00:35:40,150 --> 00:35:37,359
clues in the rocks for 10 years now and

1013
00:35:42,069 --> 00:35:40,160

the clues are certain

1014

00:35:44,790 --> 00:35:42,079

there's no question there was water on

1015

00:35:46,710 --> 00:35:44,800

mars and plenty of it okay let's go to

1016

00:35:48,630 --> 00:35:46,720

social media we've got time for a few

1017

00:35:50,710 --> 00:35:48,640

more questions and we've got another uh

1018

00:35:53,349 --> 00:35:50,720

panel coming up uh this is from at

1019

00:35:55,670 --> 00:35:53,359

shadow 404

1020

00:35:56,950 --> 00:35:55,680

and certainly for dr squiers and others

1021

00:35:58,390 --> 00:35:56,960

what in your opinion are the most

1022

00:35:59,750 --> 00:35:58,400

amazing discoveries from spirit

1023

00:36:02,630 --> 00:35:59,760

opportunity

1024

00:36:04,790 --> 00:36:02,640

and curiosity so far and why

1025

00:36:05,990 --> 00:36:04,800

i think the most important discoveries

1026
00:36:08,230 --> 00:36:06,000
from spirit

1027
00:36:11,030 --> 00:36:08,240
are that at the spirit site

1028
00:36:13,829 --> 00:36:11,040
we see evidence of early mars that was a

1029
00:36:16,870 --> 00:36:13,839
hot place a violent place there were

1030
00:36:18,790 --> 00:36:16,880
volcanic explosions there were impacts

1031
00:36:20,310 --> 00:36:18,800
there was hydrothermal activity there

1032
00:36:21,910 --> 00:36:20,320
were steam vents there may have even

1033
00:36:23,349 --> 00:36:21,920
been geysers

1034
00:36:26,230 --> 00:36:23,359
coming out of the ground

1035
00:36:27,030 --> 00:36:26,240
at the opportunity site we see evidence

1036
00:36:29,190 --> 00:36:27,040
for

1037
00:36:31,109 --> 00:36:29,200
ancient water that was beneath the

1038
00:36:32,550 --> 00:36:31,119

ground it was acid we run around saying

1039

00:36:34,710 --> 00:36:32,560

water on mars water on mars it was

1040

00:36:35,990 --> 00:36:34,720

really sulfuric acid on mars and it

1041

00:36:37,109 --> 00:36:36,000

leached stuff out of the rocks and then

1042

00:36:38,950 --> 00:36:37,119

it came up to the surface and it

1043

00:36:42,230 --> 00:36:38,960

evaporated away and made these fantastic

1044

00:36:44,790 --> 00:36:42,240

salt deposits at the curiosity site we

1045

00:36:47,190 --> 00:36:44,800

see evidence for water at the surface

1046

00:36:49,109 --> 00:36:47,200

but it was water that was an acid it was

1047

00:36:50,630 --> 00:36:49,119

water you could drink it was water that

1048

00:36:51,910 --> 00:36:50,640

would have been an environment that

1049

00:36:52,950 --> 00:36:51,920

would have been really favorable for

1050

00:36:54,710 --> 00:36:52,960

life

1051
00:36:57,510 --> 00:36:54,720
water you can drink

1052
00:36:59,990 --> 00:36:57,520
you could have whoa

1053
00:37:01,990 --> 00:37:00,000
not anymore

1054
00:37:03,670 --> 00:37:02,000
okay final question from social media

1055
00:37:04,950 --> 00:37:03,680
and keep those questions coming we have

1056
00:37:06,470 --> 00:37:04,960
another panel maybe we get those

1057
00:37:07,510 --> 00:37:06,480
answered uh or we'll get them answered

1058
00:37:09,270 --> 00:37:07,520
later

1059
00:37:10,390 --> 00:37:09,280
at libby doodle i wonder which is

1060
00:37:11,990 --> 00:37:10,400
crazier

1061
00:37:18,310 --> 00:37:12,000
airbag landing

1062
00:37:23,030 --> 00:37:20,310
it all depends on how you define crazy i

1063
00:37:24,790 --> 00:37:23,040

think um yeah

1064

00:37:26,710 --> 00:37:24,800

steve's right it's only crazy if it

1065

00:37:27,589 --> 00:37:26,720

doesn't work yeah they both worked and

1066

00:37:29,349 --> 00:37:27,599

so

1067

00:37:31,510 --> 00:37:29,359

you know how crazy are you i i will just

1068

00:37:34,470 --> 00:37:31,520

say that the the first time that we all

1069

00:37:36,069 --> 00:37:34,480

saw the airbag concept and we understood

1070

00:37:37,910 --> 00:37:36,079

uh really what was going to be involved

1071

00:37:39,670 --> 00:37:37,920

with so we're talking now back in the in

1072

00:37:41,430 --> 00:37:39,680

the early 90s

1073

00:37:43,990 --> 00:37:41,440

when the idea was first being discussed

1074

00:37:46,870 --> 00:37:44,000

and then immediately as the idea of the

1075

00:37:48,230 --> 00:37:46,880

airbags was being presented it was also

1076
00:37:49,349 --> 00:37:48,240
accompanied by the comment oh this

1077
00:37:51,910 --> 00:37:49,359
actually is an idea that goes all the

1078
00:37:53,990 --> 00:37:51,920
way back to the mid-60s and an idea for

1079
00:37:55,750 --> 00:37:54,000
a lunar lander that had come out of

1080
00:37:57,030 --> 00:37:55,760
russia and we all said you know maybe

1081
00:37:58,470 --> 00:37:57,040
there's something to this okay let's

1082
00:38:00,550 --> 00:37:58,480
study this somewhere and we sort of got

1083
00:38:02,310 --> 00:38:00,560
past the wow factor pretty quickly and

1084
00:38:03,910 --> 00:38:02,320
then realize that this is a very viable

1085
00:38:05,910 --> 00:38:03,920
idea and from the engineering standpoint

1086
00:38:06,710 --> 00:38:05,920
it all worked quite well and we got past

1087
00:38:08,150 --> 00:38:06,720
that

1088
00:38:10,230 --> 00:38:08,160

when we started talking about the sky

1089

00:38:11,750 --> 00:38:10,240

crane for curiosity

1090

00:38:13,430 --> 00:38:11,760

it was maybe a little bit of a different

1091

00:38:14,630 --> 00:38:13,440

story in a different reaction i remember

1092

00:38:15,750 --> 00:38:14,640

the very first time that it was sort of

1093

00:38:16,950 --> 00:38:15,760

presented to a large group of the

1094

00:38:18,390 --> 00:38:16,960

engineers

1095

00:38:20,069 --> 00:38:18,400

by the people who developed the concept

1096

00:38:20,710 --> 00:38:20,079

where we basically took the entire thing

1097

00:38:22,390 --> 00:38:20,720

that

1098

00:38:23,829 --> 00:38:22,400

we would typically have as a lander and

1099

00:38:26,150 --> 00:38:23,839

flipped it on its head and did

1100

00:38:27,670 --> 00:38:26,160

everything backwards and upside down and

1101
00:38:29,510 --> 00:38:27,680
and i think the first reaction from most

1102
00:38:30,829 --> 00:38:29,520
of the room was wow the 60s were really

1103
00:38:32,390 --> 00:38:30,839
good to you

1104
00:38:34,630 --> 00:38:32,400
um

1105
00:38:36,390 --> 00:38:34,640
but then again once you decompose it you

1106
00:38:37,910 --> 00:38:36,400
took it all apart and you understood why

1107
00:38:40,310 --> 00:38:37,920
you were doing each of these things in a

1108
00:38:42,310 --> 00:38:40,320
backwards upside down way

1109
00:38:44,069 --> 00:38:42,320
from an engineering standpoint it all

1110
00:38:46,230 --> 00:38:44,079
made sense so yeah there was this

1111
00:38:48,470 --> 00:38:46,240
initial are you out of your mind factor

1112
00:38:49,910 --> 00:38:48,480
that went along with it but very quickly

1113
00:38:52,230 --> 00:38:49,920

we realized

1114

00:38:54,310 --> 00:38:52,240

it was all very logical and it made

1115

00:38:57,270 --> 00:38:54,320

sense given the problem that we had been

1116

00:38:58,870 --> 00:38:57,280

presented with and so and then the as i

1117

00:39:01,430 --> 00:38:58,880

say the proof is in the pudding it

1118

00:39:03,349 --> 00:39:01,440

worked in all the cases so far

1119

00:39:04,790 --> 00:39:03,359

okay so the the last question here and

1120

00:39:06,630 --> 00:39:04,800

i've got one minute but this is this is

1121

00:39:08,230 --> 00:39:06,640

so important and i'm going to ask the

1122

00:39:09,510 --> 00:39:08,240

director to give me a couple of more

1123

00:39:12,150 --> 00:39:09,520

minutes here

1124

00:39:15,910 --> 00:39:12,160

uh and a quick answer from everyone uh

1125

00:39:17,670 --> 00:39:15,920

at from at alex cg what can citizen

1126
00:39:19,750 --> 00:39:17,680
scientists

1127
00:39:22,069 --> 00:39:19,760
in the community do to help with mars

1128
00:39:24,150 --> 00:39:22,079
exploration

1129
00:39:26,230 --> 00:39:24,160
they can do a lot of things um in fact

1130
00:39:27,829 --> 00:39:26,240
we've got programs involved with some of

1131
00:39:29,510 --> 00:39:27,839
the missions where

1132
00:39:30,870 --> 00:39:29,520
the data analysis

1133
00:39:33,030 --> 00:39:30,880
things like counting craters on the

1134
00:39:34,950 --> 00:39:33,040
surface counting rocks and their shapes

1135
00:39:36,950 --> 00:39:34,960
and their numbers tell us something very

1136
00:39:39,190 --> 00:39:36,960
fundamental about the geology and how

1137
00:39:41,190 --> 00:39:39,200
the surface has been shaped the public

1138
00:39:43,349 --> 00:39:41,200

is involved in that there's a variety of

1139

00:39:45,109 --> 00:39:43,359

ways that people can do that but just

1140

00:39:47,510 --> 00:39:45,119

looking at the images

1141

00:39:49,589 --> 00:39:47,520

becoming a scientist exploring the

1142

00:39:51,430 --> 00:39:49,599

surface of mars with us

1143

00:39:53,670 --> 00:39:51,440

i can't tell you how many websites there

1144

00:39:55,670 --> 00:39:53,680

are out there where you see people that

1145

00:39:58,150 --> 00:39:55,680

are literally following along with these

1146

00:40:00,310 --> 00:39:58,160

missions as as we as scientists are

1147

00:40:01,990 --> 00:40:00,320

working on them and by golly they're

1148

00:40:04,230 --> 00:40:02,000

coming to the same conclusions that we

1149

00:40:06,230 --> 00:40:04,240

are these people are involved they're

1150

00:40:07,670 --> 00:40:06,240

looking at the data they're learning

1151

00:40:09,670 --> 00:40:07,680

they're understanding mars they're

1152

00:40:11,510 --> 00:40:09,680

understanding geology so i think there's

1153

00:40:13,510 --> 00:40:11,520

a variety of ways to get involved and i

1154

00:40:16,550 --> 00:40:13,520

think those ways lead to very very

1155

00:40:18,550 --> 00:40:16,560

worthwhile and important results

1156

00:40:20,069 --> 00:40:18,560

and the one thing in particular i'd like

1157

00:40:21,510 --> 00:40:20,079

to point out in addition to that is as

1158

00:40:22,390 --> 00:40:21,520

john mentioned there are several

1159

00:40:23,910 --> 00:40:22,400

different

1160

00:40:25,510 --> 00:40:23,920

methods by which the general public can

1161

00:40:28,230 --> 00:40:25,520

be involved but also we have a couple of

1162

00:40:30,230 --> 00:40:28,240

very targeted activities and portals for

1163

00:40:31,990 --> 00:40:30,240

student involvement both formerly within

1164

00:40:34,710 --> 00:40:32,000

the classroom as well as informally at

1165

00:40:36,309 --> 00:40:34,720

home we are actively constantly seeking

1166

00:40:37,349 --> 00:40:36,319

out opportunities and have presented a

1167

00:40:38,630 --> 00:40:37,359

lot of opportunities for student

1168

00:40:40,069 --> 00:40:38,640

participation

1169

00:40:42,230 --> 00:40:40,079

doing things as john mentioned like

1170

00:40:43,750 --> 00:40:42,240

crater counting but doing uh various

1171

00:40:44,950 --> 00:40:43,760

different experiments to understand what

1172

00:40:47,030 --> 00:40:44,960

you're actually able to see in the

1173

00:40:48,550 --> 00:40:47,040

images looking at data associated for

1174

00:40:50,390 --> 00:40:48,560

example with the spirit the opportunity

1175

00:40:52,069 --> 00:40:50,400

rovers we have these little sundials on

1176

00:40:53,510 --> 00:40:52,079

board and actually presenting

1177

00:40:55,030 --> 00:40:53,520

information allow a student to take a

1178

00:40:57,349 --> 00:40:55,040

look at the sundial in the shadows and

1179

00:40:58,950 --> 00:40:57,359

determine by back solving where is the

1180

00:41:00,309 --> 00:40:58,960

rover on the surface of the planet and

1181

00:41:02,069 --> 00:41:00,319

relative to the angles of the sun that

1182

00:41:03,030 --> 00:41:02,079

are coming in and things like that so

1183

00:41:05,109 --> 00:41:03,040

there are all sorts of different

1184

00:41:06,950 --> 00:41:05,119

activities in particular targeted at

1185

00:41:09,190 --> 00:41:06,960

student involvement ranging all the way

1186

00:41:11,670 --> 00:41:09,200

from very low elementary school grade

1187

00:41:14,069 --> 00:41:11,680

levels all the way up through

1188

00:41:16,630 --> 00:41:14,079

undergraduate student levels at college

1189

00:41:19,190 --> 00:41:16,640

that will allow an even more in-depth

1190

00:41:20,710 --> 00:41:19,200

level of participation

1191

00:41:22,630 --> 00:41:20,720

and i think finally there's there's

1192

00:41:24,790 --> 00:41:22,640

another element to the to the student

1193

00:41:26,870 --> 00:41:24,800

involvement in particular um

1194

00:41:28,950 --> 00:41:26,880

those of us who built these rovers many

1195

00:41:30,069 --> 00:41:28,960

of us grew up in the 60s and the 70s

1196

00:41:32,470 --> 00:41:30,079

watching

1197

00:41:34,550 --> 00:41:32,480

mercury and gemini and apollo on

1198

00:41:36,790 --> 00:41:34,560

television and dreaming of sending

1199

00:41:38,550 --> 00:41:36,800

spaceships to mars someday

1200

00:41:40,470 --> 00:41:38,560

and then we got to do that

1201
00:41:42,630 --> 00:41:40,480
and i hope that part of our mission's

1202
00:41:45,270 --> 00:41:42,640
legacy will be that young people will

1203
00:41:47,109 --> 00:41:45,280
look at these rovers that we built we'll

1204
00:41:48,790 --> 00:41:47,119
look at the videos of us jumping up and

1205
00:41:50,230 --> 00:41:48,800
down on landing night like we just won

1206
00:41:52,390 --> 00:41:50,240
the super bowl

1207
00:41:55,030 --> 00:41:52,400
and will think to themselves that's

1208
00:41:57,030 --> 00:41:55,040
really cool

1209
00:41:58,870 --> 00:41:57,040
but i bet i could do better

1210
00:42:00,069 --> 00:41:58,880
and if that's part of the legacy of this

1211
00:42:00,870 --> 00:42:00,079
mission that'll be one of the greatest

1212
00:42:02,710 --> 00:42:00,880
things i think we could have

1213
00:42:04,069 --> 00:42:02,720

accomplished

1214

00:42:05,270 --> 00:42:04,079

ladies and gentlemen

1215

00:42:07,190 --> 00:42:05,280

without

1216

00:42:10,150 --> 00:42:07,200

further ado please give these folks and

1217

00:42:11,270 --> 00:42:10,160

that the team of thousands 10 years on

1218

00:42:23,109 --> 00:42:11,280

mars

1219

00:42:27,270 --> 00:42:25,670

wow 90 days to 10 years what what you

1220

00:42:29,349 --> 00:42:27,280

guys know how to build things made in

1221

00:42:31,109 --> 00:42:29,359

the usa right okay

1222

00:42:32,790 --> 00:42:31,119

uh don't change that dial we have

1223

00:42:36,150 --> 00:42:32,800

another panel coming up you're gonna see

1224

00:42:38,390 --> 00:42:36,160

folks moving around and you heard

1225

00:42:39,750 --> 00:42:38,400

humans the missions to mars

1226

00:42:41,030 --> 00:42:39,760

that's coming

1227

00:42:43,270 --> 00:42:41,040

stay tuned

1228

00:42:45,829 --> 00:42:43,280

the panel and you're gonna there's a

1229

00:42:48,230 --> 00:42:45,839

young lady who is really serious about

1230

00:42:49,750 --> 00:42:48,240

being the first person on mars so stay

1231

00:42:51,910 --> 00:42:49,760

tuned remember keep those questions

1232

00:42:55,430 --> 00:42:51,920

coming this is being live stream

1233

00:42:55,440 --> 00:43:00,470

mars go to our website www.nasa.gov

1234

00:43:04,470 --> 00:43:01,990

mars

1235

00:43:07,270 --> 00:43:04,480

the iconic coming to you from the iconic

1236

00:43:09,510 --> 00:43:07,280

smithsonian national airspace museum our

1237

00:43:11,349 --> 00:43:09,520

second panel tom waters is going to come

1238

00:43:12,870 --> 00:43:11,359

back and talk to you more

1239

00:43:14,630 --> 00:43:12,880

there's also a new exhibit that opened

1240

00:43:16,309 --> 00:43:14,640

perhaps tom can talk to you about that

1241

00:43:19,030 --> 00:43:16,319

don't touch that dial the second panel

1242

00:43:41,750 --> 00:43:19,040

is coming momentarily this is nasa

1243

00:43:45,349 --> 00:43:43,510

well again it's uh

1244

00:43:47,109 --> 00:43:45,359

my pleasure to

1245

00:43:49,109 --> 00:43:47,119

welcome you all here again to the

1246

00:43:51,510 --> 00:43:49,119

national air and space museum

1247

00:43:54,150 --> 00:43:51,520

uh the program has been fascinating for

1248

00:43:57,190 --> 00:43:54,160

me as a scientist a planetary scientist

1249

00:43:59,910 --> 00:43:57,200

and someone who's worked on mars

1250

00:44:03,190 --> 00:43:59,920

i'm never ever

1251
00:44:04,630 --> 00:44:03,200
left without just being amazed by the

1252
00:44:05,430 --> 00:44:04,640
discoveries

1253
00:44:08,390 --> 00:44:05,440
of

1254
00:44:09,589 --> 00:44:08,400
those two rovers and again i want to

1255
00:44:12,950 --> 00:44:09,599
invite you

1256
00:44:15,430 --> 00:44:12,960
all to come to the exhibit

1257
00:44:18,150 --> 00:44:15,440
that is opening this week and

1258
00:44:20,230 --> 00:44:18,160
just view the the absolutely stunning

1259
00:44:23,510 --> 00:44:20,240
images that have been returned by the

1260
00:44:27,270 --> 00:44:23,520
murr rovers with that it's my pleasure

1261
00:44:29,910 --> 00:44:27,280
now to introduce the second moderator

1262
00:44:32,150 --> 00:44:29,920
for today's program and

1263
00:44:33,589 --> 00:44:32,160

that is dr jim green

1264

00:44:36,390 --> 00:44:33,599

and

1265

00:44:38,710 --> 00:44:36,400

jim is the director of nasa's planetary

1266

00:44:40,630 --> 00:44:38,720

science division and i want to say a

1267

00:44:42,630 --> 00:44:40,640

real true friend of the national air and

1268

00:44:47,430 --> 00:44:42,640

space museum jim

1269

00:44:51,190 --> 00:44:49,430

this is just a fabulous venue to be able

1270

00:44:52,550 --> 00:44:51,200

to talk about what we're learning from

1271

00:44:54,870 --> 00:44:52,560

mars today

1272

00:44:55,829 --> 00:44:54,880

but this panel is really about the

1273

00:44:58,069 --> 00:44:55,839

future

1274

00:45:00,390 --> 00:44:58,079

what are our plans on mars what are our

1275

00:45:01,990 --> 00:45:00,400

next steps and i am delighted with the

1276

00:45:05,670 --> 00:45:02,000

panel that we have here today to be able

1277

00:45:07,349 --> 00:45:05,680

to talk about this on my right is dr

1278

00:45:09,910 --> 00:45:07,359

mary boytech

1279

00:45:12,230 --> 00:45:09,920

mary has got a number of degrees in in

1280

00:45:15,589 --> 00:45:12,240

biology biochemistry

1281

00:45:16,870 --> 00:45:15,599

uh oceanography and just a

1282

00:45:18,390 --> 00:45:16,880

fabulous

1283

00:45:21,750 --> 00:45:18,400

person to study

1284

00:45:24,390 --> 00:45:21,760

microbial life and life beyond mars or

1285

00:45:26,710 --> 00:45:24,400

pardon me life beyond earth

1286

00:45:29,349 --> 00:45:26,720

and beyond mars too you bet she is the

1287

00:45:31,750 --> 00:45:29,359

head of our astrobiology program and she

1288

00:45:34,309 --> 00:45:31,760

goes to work every day and talks about

1289

00:45:35,990 --> 00:45:34,319

how do we look for life and and what do

1290

00:45:37,829 --> 00:45:36,000

we need to do next to be able to

1291

00:45:39,109 --> 00:45:37,839

determine if there is life beyond the

1292

00:45:41,349 --> 00:45:39,119

earth

1293

00:45:43,750 --> 00:45:41,359

sitting next to her is john connolly

1294

00:45:45,990 --> 00:45:43,760

i've known john for many years

1295

00:45:49,349 --> 00:45:46,000

john is based out of the johnson space

1296

00:45:51,030 --> 00:45:49,359

center and he is the chief exploration

1297

00:45:53,910 --> 00:45:51,040

scientist working in the human

1298

00:45:56,790 --> 00:45:53,920

exploration directorate

1299

00:45:58,710 --> 00:45:56,800

at not only jsc but comes back to nasa

1300

00:46:01,670 --> 00:45:58,720

headquarters and works with us a lot

1301

00:46:03,589 --> 00:46:01,680

john's been involved in architecting

1302

00:46:05,990 --> 00:46:03,599

how we would get to mars through a

1303

00:46:08,150 --> 00:46:06,000

variety of what we call design reference

1304

00:46:08,870 --> 00:46:08,160

missions for a number of years

1305

00:46:11,109 --> 00:46:08,880

so

1306

00:46:13,190 --> 00:46:11,119

if anyone's going to help us get there

1307

00:46:14,550 --> 00:46:13,200

for humans it'll be

1308

00:46:16,309 --> 00:46:14,560

john connolly

1309

00:46:19,030 --> 00:46:16,319

sitting next to john

1310

00:46:20,790 --> 00:46:19,040

is dr john grunsfeld

1311

00:46:22,950 --> 00:46:20,800

dr grunsfeld has been at nasa

1312

00:46:24,470 --> 00:46:22,960

headquarters for the last two years and

1313

00:46:25,670 --> 00:46:24,480

he's the associate

1314

00:46:28,230 --> 00:46:25,680

administrator

1315

00:46:29,270 --> 00:46:28,240

of the science mission directorate

1316

00:46:32,550 --> 00:46:29,280

john

1317

00:46:34,790 --> 00:46:32,560

began his astronaut career in 1992

1318

00:46:36,470 --> 00:46:34,800

making five flights

1319

00:46:38,150 --> 00:46:36,480

and in those flights not only did he

1320

00:46:41,030 --> 00:46:38,160

have an opportunity to crawl around the

1321

00:46:43,750 --> 00:46:41,040

mer space station but from a scientific

1322

00:46:46,710 --> 00:46:43,760

perspective and one close to my heart he

1323

00:46:48,069 --> 00:46:46,720

was able to be on three hubble upgrading

1324

00:46:50,069 --> 00:46:48,079

repair missions

1325

00:46:52,470 --> 00:46:50,079

and of course hubble is uh is just a

1326

00:46:54,710 --> 00:46:52,480

such a fabulous asset not only for

1327

00:46:56,870 --> 00:46:54,720

astrophysics but in planetary science as

1328

00:46:59,430 --> 00:46:56,880

well we use it a lot

1329

00:47:02,069 --> 00:46:59,440

now sitting next to john

1330

00:47:04,390 --> 00:47:02,079

is really the next generation

1331

00:47:07,670 --> 00:47:04,400

of explorers

1332

00:47:09,030 --> 00:47:07,680

this is a lisa carter alisa

1333

00:47:11,430 --> 00:47:09,040

has won

1334

00:47:13,349 --> 00:47:11,440

is our first winner of the nasa passport

1335

00:47:16,870 --> 00:47:13,359

program i know she'll tell us all about

1336

00:47:19,510 --> 00:47:16,880

that she's from uh louisiana

1337

00:47:21,910 --> 00:47:19,520

and she speaks several languages and of

1338

00:47:25,030 --> 00:47:21,920

course her from her perspective and ours

1339

00:47:27,910 --> 00:47:25,040

too she wants to be that next

1340

00:47:31,030 --> 00:47:27,920

uh person going to mars that first next

1341

00:47:33,670 --> 00:47:31,040

generation on mars that first human to

1342

00:47:35,990 --> 00:47:33,680

walk on the surface of mars

1343

00:47:38,230 --> 00:47:36,000

so with this distinguished panel let's

1344

00:47:40,549 --> 00:47:38,240

talk about the future

1345

00:47:41,670 --> 00:47:40,559

but before i do that and if i have my

1346

00:47:43,109 --> 00:47:41,680

first slide

1347

00:47:45,750 --> 00:47:43,119

i want to talk about some of our

1348

00:47:47,829 --> 00:47:45,760

operational assets that we have today

1349

00:47:49,750 --> 00:47:47,839

we've learned a lot about opportunity

1350

00:47:51,109 --> 00:47:49,760

which is still operating on the surface

1351
00:47:52,549 --> 00:47:51,119
and of course

1352
00:47:53,589 --> 00:47:52,559
spirit

1353
00:47:55,670 --> 00:47:53,599
which

1354
00:47:58,630 --> 00:47:55,680
didn't survive our our last couple

1355
00:48:00,790 --> 00:47:58,640
winners and and is not uh probably going

1356
00:48:03,190 --> 00:48:00,800
to come back to life

1357
00:48:05,190 --> 00:48:03,200
opportunity is working uh fabulous as we

1358
00:48:07,829 --> 00:48:05,200
as we've heard but we also have another

1359
00:48:09,750 --> 00:48:07,839
rover on mars it's called curiosity

1360
00:48:11,589 --> 00:48:09,760
in curiosity mary has been very much

1361
00:48:13,109 --> 00:48:11,599
involved in some of the uh some of the

1362
00:48:15,030 --> 00:48:13,119
data and some of the activities there

1363
00:48:16,630 --> 00:48:15,040

and we'll have an opportunity to talk a

1364

00:48:17,990 --> 00:48:16,640

little bit about her perspective on

1365

00:48:20,630 --> 00:48:18,000

curiosity

1366

00:48:22,470 --> 00:48:20,640

but what really helps make those

1367

00:48:24,870 --> 00:48:22,480

rovers work

1368

00:48:26,710 --> 00:48:24,880

is our orbital assets

1369

00:48:28,630 --> 00:48:26,720

we have three orbital assets there

1370

00:48:30,230 --> 00:48:28,640

currently and they are

1371

00:48:32,829 --> 00:48:30,240

mars odyssey

1372

00:48:35,430 --> 00:48:32,839

mars reconnaissance orbiter and mars

1373

00:48:37,510 --> 00:48:35,440

express and these are the guys that help

1374

00:48:38,470 --> 00:48:37,520

support not only the rovers on the

1375

00:48:40,390 --> 00:48:38,480

ground

1376

00:48:42,309 --> 00:48:40,400

and our pla and our landers that we've

1377

00:48:45,990 --> 00:48:42,319

had in the past

1378

00:48:48,549 --> 00:48:46,000

but they also make fabulous measurements

1379

00:48:50,790 --> 00:48:48,559

from space of the areas that the that

1380

00:48:54,230 --> 00:48:50,800

the rovers are moving into and actually

1381

00:48:55,990 --> 00:48:54,240

look now also for upcoming uh sites and

1382

00:48:58,390 --> 00:48:56,000

as john grant mentioned earlier there

1383

00:49:01,349 --> 00:48:58,400

are plenty of sites and exciting sites

1384

00:49:03,750 --> 00:49:01,359

to go to uh on mars that will also

1385

00:49:06,630 --> 00:49:03,760

enable us to learn much more about that

1386

00:49:09,190 --> 00:49:06,640

environment and move forward

1387

00:49:10,710 --> 00:49:09,200

recently in november we launched

1388

00:49:14,309 --> 00:49:10,720

maven

1389

00:49:17,190 --> 00:49:14,319

at mars in

1390

00:49:19,190 --> 00:49:17,200

september of uh of this year

1391

00:49:21,990 --> 00:49:19,200

uh maven is also going to join our

1392

00:49:23,910 --> 00:49:22,000

orbiter assets but it's going to look at

1393

00:49:26,150 --> 00:49:23,920

uh the interaction between the solar

1394

00:49:29,109 --> 00:49:26,160

wind the ionosphere and the atmosphere

1395

00:49:31,829 --> 00:49:29,119

of mars to see what it's like in a

1396

00:49:33,030 --> 00:49:31,839

planet that has no magnetic field it's

1397

00:49:34,790 --> 00:49:33,040

going to allow us to make a lot of

1398

00:49:36,549 --> 00:49:34,800

comparisons between what mars

1399

00:49:38,470 --> 00:49:36,559

environment is like in the earth's

1400

00:49:39,910 --> 00:49:38,480

environment and why they are so

1401

00:49:41,670 --> 00:49:39,920

different

1402

00:49:43,910 --> 00:49:41,680

now the future we'll talk about a little

1403

00:49:46,309 --> 00:49:43,920

later on but those are the basic orbital

1404

00:49:49,510 --> 00:49:46,319

assets that i wanted to start with

1405

00:49:52,390 --> 00:49:49,520

now what are our next steps on mars how

1406

00:49:54,870 --> 00:49:52,400

how will humans be able to

1407

00:49:56,950 --> 00:49:54,880

make those plans and execute those plans

1408

00:49:58,630 --> 00:49:56,960

over the next several years

1409

00:50:00,470 --> 00:49:58,640

and one of the burning questions that we

1410

00:50:02,309 --> 00:50:00,480

want to know well first from a

1411

00:50:04,710 --> 00:50:02,319

scientific perspective

1412

00:50:07,750 --> 00:50:04,720

we really want to know is there life on

1413

00:50:11,109 --> 00:50:07,760

mars is there life can life exist beyond

1414

00:50:13,190 --> 00:50:11,119

the atmosphere of the earth and so for

1415

00:50:14,950 --> 00:50:13,200

that i'd like to turn to mary and have

1416

00:50:17,030 --> 00:50:14,960

her give us a little explanation of what

1417

00:50:19,750 --> 00:50:17,040

we're up to in that area to determine

1418

00:50:22,069 --> 00:50:19,760

and understand these basic uh uh answer

1419

00:50:27,109 --> 00:50:22,079

these basic questions thank you jim

1420

00:50:31,190 --> 00:50:28,549

so um i'm going to tell you about

1421

00:50:33,030 --> 00:50:31,200

astrobiology it's the program that i run

1422

00:50:35,829 --> 00:50:33,040

i'll begin by telling you what it isn't

1423

00:50:38,950 --> 00:50:35,839

it isn't science fiction and it isn't

1424

00:50:41,430 --> 00:50:38,960

alien autopsies what it is is the study

1425

00:50:43,510 --> 00:50:41,440

of life in the context of the universe

1426
00:50:46,870 --> 00:50:43,520
and we focus on three fundamental

1427
00:50:48,549 --> 00:50:46,880
questions how did life begin and evolve

1428
00:50:50,790 --> 00:50:48,559
does life exist elsewhere in the

1429
00:50:54,309 --> 00:50:50,800
universe beyond earth and what is the

1430
00:50:56,309 --> 00:50:54,319
future for life here on earth and beyond

1431
00:50:59,349 --> 00:50:56,319
it's a program that's been ongoing at

1432
00:51:01,589 --> 00:50:59,359
nasa since the the mid 60s

1433
00:51:03,829 --> 00:51:01,599
addressing all of these questions now

1434
00:51:06,870 --> 00:51:03,839
one of the aspects of astrobiology is

1435
00:51:09,430 --> 00:51:06,880
that we have only or we only know of one

1436
00:51:10,630 --> 00:51:09,440
place in our universe in our solar

1437
00:51:12,150 --> 00:51:10,640
system

1438
00:51:14,309 --> 00:51:12,160

where there is life and that's here on

1439

00:51:15,750 --> 00:51:14,319

earth so we begin our study to

1440

00:51:17,510 --> 00:51:15,760

understand the potential for life

1441

00:51:20,829 --> 00:51:17,520

elsewhere by understanding as much as we

1442

00:51:23,670 --> 00:51:20,839

can about life here on earth next

1443

00:51:26,230 --> 00:51:23,680

slide so what have we learned about

1444

00:51:28,390 --> 00:51:26,240

searching for life by studying the earth

1445

00:51:30,710 --> 00:51:28,400

we've learned that they're really tough

1446

00:51:31,910 --> 00:51:30,720

um you find life almost everywhere we

1447

00:51:33,510 --> 00:51:31,920

look on this planet and i'm going to

1448

00:51:35,910 --> 00:51:33,520

talk a little bit about those extreme

1449

00:51:37,430 --> 00:51:35,920

environments and those extremophiles

1450

00:51:39,670 --> 00:51:37,440

those that like

1451

00:51:41,910 --> 00:51:39,680

those extreme environments life is

1452

00:51:44,710 --> 00:51:41,920

tenacious it survives

1453

00:51:47,589 --> 00:51:44,720

for many many generations under severe

1454

00:51:50,470 --> 00:51:47,599

conditions it's metabolically diverse it

1455

00:51:52,950 --> 00:51:50,480

eats everything it breeds anything

1456

00:51:55,750 --> 00:51:52,960

and it's when conditions are extremely

1457

00:51:58,390 --> 00:51:55,760

tough life moves inside the rocks

1458

00:51:59,670 --> 00:51:58,400

next slide please

1459

00:52:02,309 --> 00:51:59,680

so i'm going to go through what i call

1460

00:52:04,710 --> 00:52:02,319

the x-files or extremophiles

1461

00:52:07,190 --> 00:52:04,720

and just tell you about the the record

1462

00:52:09,030 --> 00:52:07,200

breakers for each of these categories

1463

00:52:10,950 --> 00:52:09,040

so up in the left-hand corner of my

1464

00:52:12,069 --> 00:52:10,960

slide there's a picture of the grand

1465

00:52:14,790 --> 00:52:12,079

prismatic

1466

00:52:17,109 --> 00:52:14,800

um spring in yellowstone and the

1467

00:52:18,470 --> 00:52:17,119

temperatures in this environment exceed

1468

00:52:19,510 --> 00:52:18,480

boiling

1469

00:52:21,349 --> 00:52:19,520

and the

1470

00:52:24,069 --> 00:52:21,359

highest temperature that we've

1471

00:52:26,150 --> 00:52:24,079

observed uh organisms growing and of

1472

00:52:30,069 --> 00:52:26,160

course these are microorganisms

1473

00:52:31,270 --> 00:52:30,079

is 121 degrees c water boils at 100 c

1474

00:52:34,150 --> 00:52:31,280

and i'll just point out that

1475

00:52:36,790 --> 00:52:34,160

extremophile or an extreme environment

1476
00:52:38,630 --> 00:52:36,800
is an anthropocentric definition it's an

1477
00:52:40,470 --> 00:52:38,640
environment that we as humans don't

1478
00:52:42,790 --> 00:52:40,480
think we would like to live in or could

1479
00:52:45,030 --> 00:52:42,800
even live in but in fact

1480
00:52:47,349 --> 00:52:45,040
there are organisms microorganisms on

1481
00:52:49,270 --> 00:52:47,359
earth that do just fine

1482
00:52:51,349 --> 00:52:49,280
now the coldest these are examples of

1483
00:52:53,430 --> 00:52:51,359
places in the arctic and antarctic where

1484
00:52:56,230 --> 00:52:53,440
organisms can live in ice or at

1485
00:52:58,549 --> 00:52:56,240
temperatures below freezing so the

1486
00:53:01,190 --> 00:52:58,559
record for cell replication or

1487
00:53:04,230 --> 00:53:01,200
the increase in and growth in cells is

1488
00:53:06,549 --> 00:53:04,240

minus 15 degrees c and remember water

1489

00:53:08,950 --> 00:53:06,559

freezes at zero

1490

00:53:11,030 --> 00:53:08,960

metabolism is even lower you can get it

1491

00:53:14,150 --> 00:53:11,040

to minus 20 and we have found cells that

1492

00:53:15,910 --> 00:53:14,160

survive for decades even millennia in

1493

00:53:17,430 --> 00:53:15,920

permafrost where temperatures can reach

1494

00:53:23,990 --> 00:53:17,440

minus 40.

1495

00:53:24,000 --> 00:53:29,190

okay the next one

1496

00:53:29,200 --> 00:53:32,150

there's no more

1497

00:53:35,109 --> 00:53:34,150

no i had five all right well let me tell

1498

00:53:37,750 --> 00:53:35,119

you about some other extreme

1499

00:53:39,349 --> 00:53:37,760

environments um we have records in

1500

00:53:42,309 --> 00:53:39,359

acidic environments

1501

00:53:44,150 --> 00:53:42,319

so everyone knows that that a neutral ph

1502

00:53:46,710 --> 00:53:44,160

or what our water tends to be around six

1503

00:53:47,589 --> 00:53:46,720

or seven the ocean is eight a ph of

1504

00:53:48,710 --> 00:53:47,599

eight

1505

00:53:51,990 --> 00:53:48,720

uh

1506

00:53:54,069 --> 00:53:52,000

battery acid is a ph of two coke is a ph

1507

00:53:58,630 --> 00:53:54,079

of three and we have organisms that can

1508

00:54:01,109 --> 00:53:58,640

live at ph zero not us microorganisms

1509

00:54:03,030 --> 00:54:01,119

the other end of the spectrum high ph's

1510

00:54:04,470 --> 00:54:03,040

this is something we call basic

1511

00:54:07,109 --> 00:54:04,480

environments

1512

00:54:10,150 --> 00:54:07,119

lye the stuff that you use to remove

1513

00:54:12,630 --> 00:54:10,160

hair and fur when you're tanning leather

1514

00:54:14,870 --> 00:54:12,640

is something like 12 or 13. we have

1515

00:54:16,630 --> 00:54:14,880

organisms that can live in a ph of 14 at

1516

00:54:18,950 --> 00:54:16,640

the top of the scale again

1517

00:54:21,430 --> 00:54:18,960

microorganisms that can have adapted to

1518

00:54:23,190 --> 00:54:21,440

these incredible environment

1519

00:54:25,430 --> 00:54:23,200

in addition we have organisms that are

1520

00:54:28,069 --> 00:54:25,440

able to withstand really high levels of

1521

00:54:31,030 --> 00:54:28,079

radiation we've isolated

1522

00:54:34,069 --> 00:54:31,040

organisms from cooling towers at

1523

00:54:37,109 --> 00:54:34,079

nuclear power plants we've isolated one

1524

00:54:39,589 --> 00:54:37,119

of the most famous organisms dinococcus

1525

00:54:41,349 --> 00:54:39,599

from inside a can of spam now what was

1526

00:54:44,390 --> 00:54:41,359

it doing inside a can of spam it was

1527

00:54:46,950 --> 00:54:44,400

part of a set of experiments looking at

1528

00:54:48,309 --> 00:54:46,960

how you could preserve food using gamma

1529

00:54:51,270 --> 00:54:48,319

radiation

1530

00:54:53,990 --> 00:54:51,280

and it was able to exist and grow even

1531

00:54:55,829 --> 00:54:54,000

after spam had been irradiated a number

1532

00:54:57,030 --> 00:54:55,839

of times with gamma radiation and very

1533

00:55:00,069 --> 00:54:57,040

high levels

1534

00:55:02,630 --> 00:55:00,079

it these organisms we stand a radiation

1535

00:55:05,349 --> 00:55:02,640

that's on the order of ten thousand

1536

00:55:07,670 --> 00:55:05,359

times what we as humans can withstand

1537

00:55:10,470 --> 00:55:07,680

and then finally organisms are able to

1538

00:55:13,270 --> 00:55:10,480

understand withstand really really dry

1539

00:55:15,349 --> 00:55:13,280

environments these are called zero files

1540

00:55:16,549 --> 00:55:15,359

and one of the ways that they survive it

1541

00:55:19,190 --> 00:55:16,559

and unfortunately i can't show you a

1542

00:55:21,510 --> 00:55:19,200

picture of it is they move into rocks so

1543

00:55:24,470 --> 00:55:21,520

in the dry valleys which is one of the

1544

00:55:27,109 --> 00:55:24,480

driest places on earth of antarctica you

1545

00:55:28,390 --> 00:55:27,119

find organisms actually living inside of

1546

00:55:31,829 --> 00:55:28,400

rock

1547

00:55:33,430 --> 00:55:31,839

able to make a living to grow to grow to

1548

00:55:34,710 --> 00:55:33,440

a level where you can actually visibly

1549

00:55:37,349 --> 00:55:34,720

see

1550

00:55:38,950 --> 00:55:37,359

a band of color where they can grow in

1551
00:55:41,910 --> 00:55:38,960
this rock

1552
00:55:44,150 --> 00:55:41,920
so um this is where we begin our search

1553
00:55:46,630 --> 00:55:44,160
in defining what the limits to life are

1554
00:55:48,549 --> 00:55:46,640
here on earth in order to understand the

1555
00:55:50,230 --> 00:55:48,559
type of environments that we can look

1556
00:55:53,349 --> 00:55:50,240
for those environments that are

1557
00:55:55,349 --> 00:55:53,359
habitable that could be located on mars

1558
00:55:57,349 --> 00:55:55,359
or other places in our solar system and

1559
00:55:59,430 --> 00:55:57,359
of course beyond and i think i'll just

1560
00:56:00,950 --> 00:55:59,440
stop there for now and let other people

1561
00:56:02,390 --> 00:56:00,960
speak

1562
00:56:05,510 --> 00:56:02,400
well let me ask you then

1563
00:56:07,670 --> 00:56:05,520

uh in terms of mars we know as we talked

1564

00:56:09,190 --> 00:56:07,680

about today the extremes in temperatures

1565

00:56:11,349 --> 00:56:09,200

you know even though we think it's cold

1566

00:56:13,190 --> 00:56:11,359

here today it's actually

1567

00:56:15,910 --> 00:56:13,200

that temperature is some of the higher

1568

00:56:18,309 --> 00:56:15,920

ranges of temperatures on mars so going

1569

00:56:20,390 --> 00:56:18,319

to mars knowing that if life does exist

1570

00:56:22,150 --> 00:56:20,400

there it has to live in extremes how

1571

00:56:23,910 --> 00:56:22,160

would we identify that

1572

00:56:25,510 --> 00:56:23,920

what are the signs that we need to seek

1573

00:56:26,470 --> 00:56:25,520

to be able to determine if there's life

1574

00:56:28,470 --> 00:56:26,480

there

1575

00:56:31,270 --> 00:56:28,480

well i see just in general our strategy

1576
00:56:32,789 --> 00:56:31,280
has been and our missions reflect this

1577
00:56:35,510 --> 00:56:32,799
is to look for some of the fundamental

1578
00:56:37,190 --> 00:56:35,520
things we believe life needs so for a

1579
00:56:39,990 --> 00:56:37,200
long time our mantra was followed the

1580
00:56:41,750 --> 00:56:40,000
water and as our young

1581
00:56:43,589 --> 00:56:41,760
young future scientists and mars

1582
00:56:45,349 --> 00:56:43,599
explorer asked earlier do we really

1583
00:56:47,430 --> 00:56:45,359
believe that there's

1584
00:56:49,030 --> 00:56:47,440
water or was water on mars and of course

1585
00:56:50,950 --> 00:56:49,040
the answer is yes we have lots of

1586
00:56:53,109 --> 00:56:50,960
evidence of that so we know that there

1587
00:56:54,549 --> 00:56:53,119
was water we've had missions that looked

1588
00:56:56,390 --> 00:56:54,559

at those for those habitable

1589

00:56:58,710 --> 00:56:56,400

environments environments where we know

1590

00:57:00,150 --> 00:56:58,720

that there are

1591

00:57:01,589 --> 00:57:00,160

the kinds of chemistry that you would

1592

00:57:02,789 --> 00:57:01,599

need to build life the kinds of

1593

00:57:04,710 --> 00:57:02,799

environments that

1594

00:57:07,270 --> 00:57:04,720

could support it temperatures that

1595

00:57:09,670 --> 00:57:07,280

exceed the lower limits and we find

1596

00:57:11,270 --> 00:57:09,680

places like that on mars as well and so

1597

00:57:14,230 --> 00:57:11,280

now we're getting a better sense of

1598

00:57:16,150 --> 00:57:14,240

where on mars we might look for

1599

00:57:17,589 --> 00:57:16,160

existing life and one of the most

1600

00:57:22,630 --> 00:57:17,599

promising

1601
00:57:24,630 --> 00:57:22,640
places to look is as i mentioned life

1602
00:57:25,829 --> 00:57:24,640
takes cover when things are really bad

1603
00:57:28,710 --> 00:57:25,839
and we believe that the harsh

1604
00:57:32,150 --> 00:57:28,720
environment on the surface really dry

1605
00:57:34,309 --> 00:57:32,160
high radiation may drive life today if

1606
00:57:36,069 --> 00:57:34,319
it exists underground and that would be

1607
00:57:37,910 --> 00:57:36,079
a place that we would look

1608
00:57:39,430 --> 00:57:37,920
now what would we look for we already

1609
00:57:40,630 --> 00:57:39,440
know that if we've landed there taken a

1610
00:57:42,950 --> 00:57:40,640
lot of pictures and there's something

1611
00:57:45,270 --> 00:57:42,960
with a face and waving we could probably

1612
00:57:46,470 --> 00:57:45,280
say that that's that's life but it's

1613
00:57:48,630 --> 00:57:46,480

more likely that it's going to be

1614

00:57:50,789 --> 00:57:48,640

microbial so we would start looking for

1615

00:57:53,349 --> 00:57:50,799

morphology that looked like a microbe

1616

00:57:55,510 --> 00:57:53,359

which is microscopic or the chemistry

1617

00:57:57,349 --> 00:57:55,520

that microbes would need to exist or

1618

00:57:59,510 --> 00:57:57,359

would use to build their their cell

1619

00:58:02,230 --> 00:57:59,520

walls and all of their cellular

1620

00:58:09,109 --> 00:58:06,470

okay that's great so now uh based on uh

1621

00:58:11,190 --> 00:58:09,119

our next set of missions and and and and

1622

00:58:13,349 --> 00:58:11,200

working in this particular area we're

1623

00:58:15,030 --> 00:58:13,359

getting ready for human exploration

1624

00:58:17,349 --> 00:58:15,040

because we need to know everything about

1625

00:58:19,270 --> 00:58:17,359

mars before we send humans you know

1626

00:58:21,349 --> 00:58:19,280

human exploration is not really star

1627

00:58:23,910 --> 00:58:21,359

trek it's not go where no man has gone

1628

00:58:26,710 --> 00:58:23,920

before and so that means scientists

1629

00:58:28,630 --> 00:58:26,720

planetary scientists are leading the way

1630

00:58:31,190 --> 00:58:28,640

but there's a but of course there's a

1631

00:58:33,349 --> 00:58:31,200

synergy here you know human exploration

1632

00:58:35,030 --> 00:58:33,359

also needs information and the kind of

1633

00:58:37,270 --> 00:58:35,040

information they need

1634

00:58:39,430 --> 00:58:37,280

is sometimes very different

1635

00:58:41,270 --> 00:58:39,440

and so let me ask john

1636

00:58:43,670 --> 00:58:41,280

if he would talk about

1637

00:58:45,589 --> 00:58:43,680

that next step and how we're merging

1638

00:58:47,510 --> 00:58:45,599

science and exploration

1639

00:58:49,510 --> 00:58:47,520

and what are the kind of technologies

1640

00:58:51,990 --> 00:58:49,520

that we're looking at to support

1641

00:58:53,430 --> 00:58:52,000

missions to mars for humans

1642

00:58:55,349 --> 00:58:53,440

thanks jim

1643

00:58:57,750 --> 00:58:55,359

um i think if we bring up the first

1644

00:59:00,230 --> 00:58:57,760

image i have this is one of my favorite

1645

00:59:02,549 --> 00:59:00,240

images that maybe illustrates how i feel

1646

00:59:04,789 --> 00:59:02,559

about the merge between human

1647

00:59:06,789 --> 00:59:04,799

exploration and the kind of robotic

1648

00:59:08,549 --> 00:59:06,799

science that we're doing right now

1649

00:59:11,270 --> 00:59:08,559

this was a painting done by one of our

1650

00:59:14,630 --> 00:59:11,280

fine space artists pat rawlings and this

1651
00:59:17,109 --> 00:59:14,640
show is a future astronaut finding the

1652
00:59:19,910 --> 00:59:17,119
the site of the pathfinder rover

1653
00:59:21,510 --> 00:59:19,920
much as alissa may find the the site of

1654
00:59:22,630 --> 00:59:21,520
the spirit rover at some point the

1655
00:59:24,789 --> 00:59:22,640
future

1656
00:59:28,230 --> 00:59:24,799
and i i think this is the essence of the

1657
00:59:31,349 --> 00:59:28,240
relationship between human and

1658
00:59:33,829 --> 00:59:31,359
robotic science exploration right now

1659
00:59:36,470 --> 00:59:33,839
the robots that we put down on mars both

1660
00:59:39,510 --> 00:59:36,480
on the surface and in orbit are our

1661
00:59:42,630 --> 00:59:39,520
avatars right now they are our

1662
00:59:44,309 --> 00:59:42,640
our eyes and our hands and our feet on

1663
00:59:46,309 --> 00:59:44,319

the ground

1664

00:59:48,309 --> 00:59:46,319

that are informing us how to get ready

1665

00:59:51,670 --> 00:59:48,319

to eventually send people there there

1666

00:59:54,390 --> 00:59:51,680

are a lot of unknowns about mars and um

1667

00:59:55,910 --> 00:59:54,400

without the robots going there uh first

1668

00:59:57,910 --> 00:59:55,920

and finding out a lot about these

1669

01:00:00,470 --> 00:59:57,920

unknowns it would be a very very risky

1670

01:00:03,270 --> 01:00:00,480

endeavor to send people there

1671

01:00:05,190 --> 01:00:03,280

if you go to the the next image

1672

01:00:07,349 --> 01:00:05,200

this kind of shows where we are today

1673

01:00:08,950 --> 01:00:07,359

and where we want to go in the future

1674

01:00:11,510 --> 01:00:08,960

now i could spend a lot of time talking

1675

01:00:13,349 --> 01:00:11,520

about mars mission design i've done a

1676

01:00:16,710 --> 01:00:13,359

lot of thinking about that but i wanted

1677

01:00:19,270 --> 01:00:16,720

to focus a little bit in on how these

1678

01:00:21,670 --> 01:00:19,280

robotic missions help us out because

1679

01:00:23,990 --> 01:00:21,680

they're really an important uh piece of

1680

01:00:25,829 --> 01:00:24,000

the the entire plan

1681

01:00:28,309 --> 01:00:25,839

right now we have the international

1682

01:00:31,510 --> 01:00:28,319

space station it's been crewed for over

1683

01:00:34,789 --> 01:00:31,520

13 years uh continuously we're learning

1684

01:00:37,109 --> 01:00:34,799

lots about how humans uh survive in

1685

01:00:39,270 --> 01:00:37,119

space uh what we call human health and

1686

01:00:41,589 --> 01:00:39,280

performance that's a big step that's a

1687

01:00:45,510 --> 01:00:41,599

big unknown how will humans handle that

1688

01:00:48,150 --> 01:00:45,520

500 to 1000 days of a mars trip

1689

01:00:49,670 --> 01:00:48,160

the other big unknowns have to do with

1690

01:00:51,670 --> 01:00:49,680

mars itself

1691

01:00:54,470 --> 01:00:51,680

what's the radiation like on the surface

1692

01:00:56,549 --> 01:00:54,480

is the soil toxic to humans

1693

01:00:58,549 --> 01:00:56,559

are there resources there we can use

1694

01:01:01,510 --> 01:00:58,559

there's lots of what we call strategic

1695

01:01:04,150 --> 01:01:01,520

knowledge gaps and the the robotic

1696

01:01:06,710 --> 01:01:04,160

missions are our way to fill in a lot of

1697

01:01:09,510 --> 01:01:06,720

those strategic knowledge gaps

1698

01:01:11,109 --> 01:01:09,520

and then thirdly there are new

1699

01:01:13,190 --> 01:01:11,119

technologies

1700

01:01:15,349 --> 01:01:13,200

going to mars with humans is going to

1701

01:01:17,349 --> 01:01:15,359

involve technologies that

1702

01:01:19,990 --> 01:01:17,359

we're trying out on robotic missions and

1703

01:01:21,910 --> 01:01:20,000

some that we haven't even developed yet

1704

01:01:23,990 --> 01:01:21,920

luckily we're starting to learn about

1705

01:01:26,470 --> 01:01:24,000

things like how to get through the mars

1706

01:01:28,710 --> 01:01:26,480

atmosphere and land the uh

1707

01:01:29,829 --> 01:01:28,720

however many minutes of terror it's

1708

01:01:31,510 --> 01:01:29,839

going to be shorter with the human

1709

01:01:33,030 --> 01:01:31,520

mission by the way it'll be about three

1710

01:01:35,750 --> 01:01:33,040

minutes of terror

1711

01:01:37,349 --> 01:01:35,760

um and uh and learning how to use the

1712

01:01:39,589 --> 01:01:37,359

resources on the surface so there's

1713

01:01:41,990 --> 01:01:39,599

these three big unknowns and in at least

1714

01:01:43,750 --> 01:01:42,000

two of those areas the robotic missions

1715

01:01:46,710 --> 01:01:43,760

that are on mars right now are helping

1716

01:01:50,710 --> 01:01:46,720

us to uh to answer those questions

1717

01:01:53,510 --> 01:01:50,720

and then uh finally uh one last image

1718

01:01:56,230 --> 01:01:53,520

a wise man uh once said

1719

01:01:58,710 --> 01:01:56,240

that science enables exploration and

1720

01:02:00,230 --> 01:01:58,720

exploration enables science and that's

1721

01:02:03,109 --> 01:02:00,240

absolutely true and that's how we feel

1722

01:02:05,670 --> 01:02:03,119

about the merger between uh the science

1723

01:02:07,750 --> 01:02:05,680

that we do at marge mars right now and

1724

01:02:09,990 --> 01:02:07,760

human exploration that will follow in

1725

01:02:12,470 --> 01:02:10,000

fact it's very hard to put a

1726

01:02:15,109 --> 01:02:12,480

a science instrument on mars on one of

1727

01:02:17,029 --> 01:02:15,119

these rovers or in orbit and not give us

1728

01:02:19,589 --> 01:02:17,039

some information that will help us

1729

01:02:21,910 --> 01:02:19,599

eventually with humans going there and

1730

01:02:23,829 --> 01:02:21,920

as it was stated before uh by steve

1731

01:02:26,630 --> 01:02:23,839

squires i think once we get humans to

1732

01:02:28,950 --> 01:02:26,640

mars the the science uh was just going

1733

01:02:31,270 --> 01:02:28,960

to go up by orders of magnitude

1734

01:02:33,430 --> 01:02:31,280

so uh so these these missions that we

1735

01:02:34,710 --> 01:02:33,440

have on the surface right now spirit and

1736

01:02:37,670 --> 01:02:34,720

opportunity

1737

01:02:40,230 --> 01:02:37,680

uh curiosity and pathfinder those uh

1738

01:02:42,150 --> 01:02:40,240

those are a legacy of

1739

01:02:45,349 --> 01:02:42,160

of great science that that's going to

1740

01:02:46,870 --> 01:02:45,359

eventually help get get humans there

1741

01:02:49,109 --> 01:02:46,880

thank you john now of course as

1742

01:02:51,589 --> 01:02:49,119

discoveries are being made by by uh

1743

01:02:54,230 --> 01:02:51,599

spirit opportunity or orbital assets

1744

01:02:56,710 --> 01:02:54,240

curiosity and that information is coming

1745

01:02:58,789 --> 01:02:56,720

back um what is the most surprising

1746

01:03:01,510 --> 01:02:58,799

thing that you've learned that then

1747

01:03:03,349 --> 01:03:01,520

changes the design or changes the way or

1748

01:03:05,109 --> 01:03:03,359

approach we would put

1749

01:03:06,789 --> 01:03:05,119

that we would implement to put humans on

1750

01:03:08,390 --> 01:03:06,799

mars

1751

01:03:09,109 --> 01:03:08,400

looking back at

1752

01:03:21,190 --> 01:03:09,119

the

1753

01:03:24,789 --> 01:03:21,200

equation entirely about how you explore

1754

01:03:26,870 --> 01:03:24,799

mars water is like finding gold it is

1755

01:03:29,109 --> 01:03:26,880

the most precious resource out in the

1756

01:03:31,430 --> 01:03:29,119

solar system that you can imagine it is

1757

01:03:34,069 --> 01:03:31,440

the stuff of rocket fuel it's the stuff

1758

01:03:35,670 --> 01:03:34,079

of life support um you know hydrogen

1759

01:03:37,829 --> 01:03:35,680

oxygen are those building blocks where

1760

01:03:40,470 --> 01:03:37,839

you can make a lot of other things out

1761

01:03:42,789 --> 01:03:40,480

of and so finding that there's there's

1762

01:03:44,630 --> 01:03:42,799

large amounts of water on mars was

1763

01:03:46,309 --> 01:03:44,640

probably the biggest finding from the

1764

01:03:47,990 --> 01:03:46,319

robotic missions and the one that's

1765

01:03:49,910 --> 01:03:48,000

really changed our thinking about how we

1766

01:03:52,069 --> 01:03:49,920

would eventually send people there so

1767

01:03:53,750 --> 01:03:52,079

instead of carting all this water we can

1768

01:03:55,430 --> 01:03:53,760

tell you bring a straw because we know

1769

01:03:57,510 --> 01:03:55,440

where it's at we're going to get at it

1770

01:04:00,150 --> 01:03:57,520

anyway not only water but rocket fuel

1771

01:04:03,109 --> 01:04:00,160

which is about 80 percent of the mass of

1772

01:04:05,029 --> 01:04:03,119

everything we launch into space

1773

01:04:07,910 --> 01:04:05,039

that's great thank you well let me now

1774

01:04:10,230 --> 01:04:07,920

turn to john grunsfeld and john of

1775

01:04:11,750 --> 01:04:10,240

course as the

1776

01:04:14,150 --> 01:04:11,760

associate administrator the science

1777

01:04:16,630 --> 01:04:14,160

mission directorate and oversees our

1778

01:04:18,470 --> 01:04:16,640

major program in mars we've worked hard

1779

01:04:19,910 --> 01:04:18,480

together over the last several years

1780

01:04:22,150 --> 01:04:19,920

that you've been here to chart that

1781

01:04:24,470 --> 01:04:22,160

course what is our immediate future on

1782

01:04:27,270 --> 01:04:24,480

mars relative to science and then how

1783

01:04:30,069 --> 01:04:27,280

would that lead into exploration

1784

01:04:32,230 --> 01:04:30,079

well let me make a few comments about uh

1785

01:04:34,309 --> 01:04:32,240

curiosity be i mean about opportunity

1786

01:04:35,829 --> 01:04:34,319

before we we get there but i shared an

1787

01:04:39,349 --> 01:04:35,839

office with john and we've had many many

1788

01:04:40,950 --> 01:04:39,359

discussions about how to get to mars and

1789

01:04:43,190 --> 01:04:40,960

you know that famous saying you know we

1790

01:04:45,589 --> 01:04:43,200

we would often have the discussion

1791

01:04:47,270 --> 01:04:45,599

well exploration is science and science

1792

01:04:48,630 --> 01:04:47,280

is exploration

1793

01:04:51,510 --> 01:04:48,640

as well

1794

01:04:53,349 --> 01:04:51,520

but i had the very good fortune to be

1795

01:04:55,670 --> 01:04:53,359

at the jet propulsion lab for

1796

01:04:57,270 --> 01:04:55,680

opportunities

1797

01:04:59,109 --> 01:04:57,280

entry descent and landing and it was

1798

01:05:00,309 --> 01:04:59,119

obviously a very tense time

1799

01:05:03,670 --> 01:05:00,319

and i was standing next to my

1800

01:05:05,349 --> 01:05:03,680

predecessor dr ed weiler and of course

1801
01:05:06,789 --> 01:05:05,359
at one point i had to be a smart guy and

1802
01:05:09,510 --> 01:05:06,799
i said ed it's already happened we just

1803
01:05:11,750 --> 01:05:09,520
don't know the answer yet

1804
01:05:14,630 --> 01:05:11,760
and you know but it really was amazing

1805
01:05:17,109 --> 01:05:14,640
to actually have radio signals

1806
01:05:19,190 --> 01:05:17,119
of the little rover tight in its

1807
01:05:21,349 --> 01:05:19,200
bouncing ball as it was bouncing on the

1808
01:05:23,270 --> 01:05:21,359
surface and the communication with the

1809
01:05:26,069 --> 01:05:23,280
rover kept going in and out and somebody

1810
01:05:27,430 --> 01:05:26,079
realized yes we're watching it bounce

1811
01:05:29,190 --> 01:05:27,440
just phenomenal

1812
01:05:30,950 --> 01:05:29,200
and of course at that time we thought we

1813
01:05:32,789 --> 01:05:30,960

had a 90-day mission

1814

01:05:34,549 --> 01:05:32,799

and so again being kind of a smart guy

1815

01:05:37,029 --> 01:05:34,559

said hey ed how long do you think it

1816

01:05:38,549 --> 01:05:37,039

would take steve squires

1817

01:05:40,390 --> 01:05:38,559

to do the same thing on the surface of

1818

01:05:42,470 --> 01:05:40,400

mars if he was there

1819

01:05:43,829 --> 01:05:42,480

of everything that the rovers will do in

1820

01:05:45,750 --> 01:05:43,839

90 days

1821

01:05:47,829 --> 01:05:45,760

and ed came up with an answer which was

1822

01:05:49,190 --> 01:05:47,839

you know weak or something like that and

1823

01:05:50,870 --> 01:05:49,200

i said i bet he could do it in four

1824

01:05:52,710 --> 01:05:50,880

hours

1825

01:05:54,950 --> 01:05:52,720

and they'd got mad at me

1826

01:05:56,470 --> 01:05:54,960

so then steve came in from you know all

1827

01:05:57,910 --> 01:05:56,480

jubilant and i said hey steve how long

1828

01:06:02,549 --> 01:05:57,920

would it take you to do the 90-day

1829

01:06:06,470 --> 01:06:04,309

and that's really one of the drivers is

1830

01:06:09,349 --> 01:06:06,480

that we are so capable and you know

1831

01:06:11,190 --> 01:06:09,359

working with robotics working with uh

1832

01:06:12,710 --> 01:06:11,200

you know our scientific partners you

1833

01:06:14,789 --> 01:06:12,720

know we're all that much more powerful

1834

01:06:16,390 --> 01:06:14,799

but the one perspective i want all of

1835

01:06:18,309 --> 01:06:16,400

you to leave with

1836

01:06:21,670 --> 01:06:18,319

is you know the really shocking

1837

01:06:24,230 --> 01:06:21,680

revelation from a nasa official

1838

01:06:27,270 --> 01:06:24,240

that spirit opportunity pathfinder

1839

01:06:30,230 --> 01:06:27,280

before it and curiosity now on mars will

1840

01:06:31,910 --> 01:06:30,240

discover nothing

1841

01:06:33,670 --> 01:06:31,920

they're just our tools it's people it's

1842

01:06:35,510 --> 01:06:33,680

scientists here on earth that are making

1843

01:06:37,829 --> 01:06:35,520

all the discoveries and we shouldn't

1844

01:06:40,549 --> 01:06:37,839

forget that it's great uh you know to

1845

01:06:44,230 --> 01:06:40,559

think of opportunity as our friend as

1846

01:06:46,309 --> 01:06:44,240

our robotic assistant as our avatar

1847

01:06:48,470 --> 01:06:46,319

but it's a scientific tool and i think

1848

01:06:51,109 --> 01:06:48,480

it it won't be until we get people on

1849

01:06:53,670 --> 01:06:51,119

mars that the big transformation in both

1850

01:06:55,750 --> 01:06:53,680

science and also uh humans as a species

1851

01:06:58,069 --> 01:06:55,760

will will occur

1852

01:06:59,270 --> 01:06:58,079

however we have to go one step at a time

1853

01:07:02,230 --> 01:06:59,280

and so

1854

01:07:04,309 --> 01:07:02,240

we do have uh opportunity still running

1855

01:07:05,910 --> 01:07:04,319

after 10 years that's phenomenal

1856

01:07:08,789 --> 01:07:05,920

you know steve could reflect on how long

1857

01:07:10,230 --> 01:07:08,799

would it take him to do 10 years

1858

01:07:14,309 --> 01:07:10,240

and it would have been a good question

1859

01:07:19,270 --> 01:07:16,630

curiosity is now roving and i asked john

1860

01:07:22,150 --> 01:07:19,280

gratziner the project scientist for for

1861

01:07:23,990 --> 01:07:22,160

curiosity the same question same answer

1862

01:07:26,069 --> 01:07:24,000

if only i was on mars we could make

1863

01:07:27,990 --> 01:07:26,079

progress much more quickly

1864

01:07:31,750 --> 01:07:28,000

and get answers to those critical

1865

01:07:34,230 --> 01:07:31,760

questions and curiosity's question was

1866

01:07:36,470 --> 01:07:34,240

did mars ever have an environment that

1867

01:07:38,390 --> 01:07:36,480

we would know would be habitable if

1868

01:07:40,710 --> 01:07:38,400

there were microbes there

1869

01:07:42,390 --> 01:07:40,720

and of course like opportunity we landed

1870

01:07:44,630 --> 01:07:42,400

in a spot where we will

1871

01:07:46,069 --> 01:07:44,640

able to answer that question right away

1872

01:07:48,549 --> 01:07:46,079

we now know

1873

01:07:50,230 --> 01:07:48,559

that mars had an environment some

1874

01:07:52,470 --> 01:07:50,240

billions of years ago that could have

1875

01:07:55,029 --> 01:07:52,480

supported life that had

1876

01:07:56,870 --> 01:07:55,039

liquid water with neutral ph

1877

01:07:59,510 --> 01:07:56,880

you could have put a cup in the water

1878

01:08:00,870 --> 01:07:59,520

and had a nice drink

1879

01:08:02,630 --> 01:08:00,880

and if you were a microbe you could have

1880

01:08:04,870 --> 01:08:02,640

thrived in that water all of the

1881

01:08:05,990 --> 01:08:04,880

nutrients that you would need

1882

01:08:07,670 --> 01:08:06,000

temperatures

1883

01:08:10,150 --> 01:08:07,680

that were above freezing that you would

1884

01:08:12,309 --> 01:08:10,160

have liquid water probably a dense

1885

01:08:14,549 --> 01:08:12,319

atmosphere clouds rain snow-capped

1886

01:08:16,309 --> 01:08:14,559

mountains really quite a nice place

1887

01:08:18,390 --> 01:08:16,319

now we're able to use curiosity and

1888

01:08:20,709 --> 01:08:18,400

drive towards the flanks of mount sharp

1889

01:08:22,870 --> 01:08:20,719

to figure out well what happened

1890

01:08:25,189 --> 01:08:22,880

hopefully and using the maven spacecraft

1891

01:08:27,430 --> 01:08:25,199

that's on its way to mars to figure out

1892

01:08:30,229 --> 01:08:27,440

you know how is mars losing water and

1893

01:08:32,550 --> 01:08:30,239

its atmosphere now so maybe we can use

1894

01:08:34,550 --> 01:08:32,560

all of the resources we have between

1895

01:08:36,870 --> 01:08:34,560

curiosity looking at the sedimentary

1896

01:08:38,630 --> 01:08:36,880

rocks and trying to trace back the

1897

01:08:40,229 --> 01:08:38,640

atmospheric history of mars back

1898

01:08:41,829 --> 01:08:40,239

billions of years

1899

01:08:43,990 --> 01:08:41,839

maven looking at the atmosphere today to

1900

01:08:45,430 --> 01:08:44,000

figure out what happened why isn't mars

1901

01:08:47,590 --> 01:08:45,440

a nice place

1902

01:08:49,269 --> 01:08:47,600

for human life now

1903

01:08:50,870 --> 01:08:49,279

so that you'd have to be in a spacesuit

1904

01:08:52,789 --> 01:08:50,880

now personally i love working in a

1905

01:08:54,470 --> 01:08:52,799

spacesuit it's actually the most fun

1906

01:08:56,390 --> 01:08:54,480

thing i've ever done so that doesn't

1907

01:08:58,870 --> 01:08:56,400

bother me at all that when we go to mars

1908

01:09:00,630 --> 01:08:58,880

today we'll have to wear spacesuits

1909

01:09:02,070 --> 01:09:00,640

but at one time it wouldn't have been

1910

01:09:04,470 --> 01:09:02,080

necessary

1911

01:09:06,789 --> 01:09:04,480

we're getting ready to send

1912

01:09:08,470 --> 01:09:06,799

another mission to mars called insight

1913

01:09:10,070 --> 01:09:08,480

it was a competitive mission in our

1914

01:09:12,070 --> 01:09:10,080

discovery program

1915

01:09:13,829 --> 01:09:12,080

we have looked at at

1916

01:09:15,829 --> 01:09:13,839

mars with the hubble space telescope

1917

01:09:17,669 --> 01:09:15,839

studies that studied its atmosphere with

1918

01:09:19,110 --> 01:09:17,679

the space telescope imaging spectrograph

1919

01:09:21,269 --> 01:09:19,120

and of course imaging

1920

01:09:24,070 --> 01:09:21,279

we have orbiters around mars that have

1921

01:09:25,669 --> 01:09:24,080

studied the surface in great detail

1922

01:09:27,349 --> 01:09:25,679

one of the big questions actually when

1923

01:09:29,349 --> 01:09:27,359

we sent spirit and opportunity to the

1924

01:09:31,349 --> 01:09:29,359

surface was that we looked at mars and

1925

01:09:34,789 --> 01:09:31,359

we saw a planet that looked pretty

1926

01:09:37,669 --> 01:09:34,799

simple from space more or less would we

1927

01:09:38,789 --> 01:09:37,679

discover that mars had a very complex

1928

01:09:40,870 --> 01:09:38,799

history

1929

01:09:42,550 --> 01:09:40,880

and lots of surprises and of course

1930

01:09:43,910 --> 01:09:42,560

within just a few days of landing spirit

1931

01:09:46,390 --> 01:09:43,920

and opportunity figured out that yeah in

1932

01:09:48,229 --> 01:09:46,400

fact mars really is a much more complex

1933

01:09:51,269 --> 01:09:48,239

planet than we ever imagined and had a

1934

01:09:53,269 --> 01:09:51,279

lot more geologic processes than we

1935

01:09:54,790 --> 01:09:53,279

could see from space and curiosity is

1936

01:09:56,310 --> 01:09:54,800

now confirming that

1937

01:09:59,669 --> 01:09:56,320

even further

1938

01:10:01,030 --> 01:09:59,679

but we've never looked inside of mars

1939

01:10:02,550 --> 01:10:01,040

of course on earth you walk around and

1940

01:10:04,070 --> 01:10:02,560

you put little

1941

01:10:05,910 --> 01:10:04,080

seismographs and you can learn a lot

1942

01:10:08,390 --> 01:10:05,920

about the inside of the earth that's how

1943

01:10:11,590 --> 01:10:08,400

we figured out you know that we have a

1944

01:10:13,030 --> 01:10:11,600

crust and a mantle and an iron core and

1945

01:10:14,870 --> 01:10:13,040

the circulation of that creates our

1946

01:10:17,830 --> 01:10:14,880

magnetic field well as you heard from

1947

01:10:19,510 --> 01:10:17,840

jim mars has lost its magnetic field

1948

01:10:21,510 --> 01:10:19,520

has the

1949

01:10:23,270 --> 01:10:21,520

has mars cooled off completely or is

1950

01:10:24,790 --> 01:10:23,280

there still some volcanic processes

1951

01:10:26,790 --> 01:10:24,800

going on well we're going to put a

1952

01:10:29,110 --> 01:10:26,800

geophysical monitoring station on the

1953

01:10:30,950 --> 01:10:29,120

surface of mars it's going to put a heat

1954

01:10:33,270 --> 01:10:30,960

probe in the surface to learn about if

1955

01:10:34,950 --> 01:10:33,280

is you know what's the conductivity of

1956

01:10:37,510 --> 01:10:34,960

heat through mars surface is it still

1957

01:10:39,830 --> 01:10:37,520

cooling off and a seismometer to see is

1958

01:10:42,070 --> 01:10:39,840

there still seismic activity

1959

01:10:44,550 --> 01:10:42,080

is there some analog of plate tectonics

1960

01:10:46,310 --> 01:10:44,560

of faults scraping against faults and

1961

01:10:47,910 --> 01:10:46,320

when mars gets hit by meteorites which

1962

01:10:49,669 --> 01:10:47,920

it does all the time we'll be able to

1963

01:10:50,950 --> 01:10:49,679

see the planet ringing and map out the

1964

01:10:52,470 --> 01:10:50,960

interior

1965

01:10:55,750 --> 01:10:52,480

we're also partners with the european

1966

01:10:58,709 --> 01:10:55,760

space agency they're sending an orbiter

1967

01:11:01,189 --> 01:10:58,719

in 2016 and a lander in 2018 and we have

1968

01:11:03,350 --> 01:11:01,199

experiments mass spectrometer

1969

01:11:05,590 --> 01:11:03,360

on the lander

1970

01:11:07,830 --> 01:11:05,600

and then in 2020

1971

01:11:09,030 --> 01:11:07,840

we're sending a brand new rover to the

1972

01:11:11,590 --> 01:11:09,040

surface

1973

01:11:13,910 --> 01:11:11,600

it may look a little bit like curiosity

1974

01:11:15,030 --> 01:11:13,920

but that's because you know

1975

01:11:17,030 --> 01:11:15,040

rovers

1976

01:11:18,390 --> 01:11:17,040

all cars kind of look alike

1977

01:11:19,910 --> 01:11:18,400

but you know what you do with the car

1978

01:11:22,709 --> 01:11:19,920

could be very different but this is

1979

01:11:24,950 --> 01:11:22,719

entirely a different analog which is the

1980

01:11:26,950 --> 01:11:24,960

rover will have you know similar driving

1981

01:11:28,630 --> 01:11:26,960

system and wheels and a deck and a

1982

01:11:30,390 --> 01:11:28,640

similar power supply but all the

1983

01:11:32,470 --> 01:11:30,400

experiments will be brand new and that's

1984

01:11:35,189 --> 01:11:32,480

the exciting part and i'd love to tell

1985

01:11:37,110 --> 01:11:35,199

you what those experiments will be

1986

01:11:39,669 --> 01:11:37,120

but we don't know yet

1987

01:11:40,950 --> 01:11:39,679

next week proposals will come into nasa

1988

01:11:43,590 --> 01:11:40,960

from around the country and in fact

1989

01:11:46,709 --> 01:11:43,600

around the world for the best ideas on

1990

01:11:48,149 --> 01:11:46,719

what new science to do on this rover

1991

01:11:51,110 --> 01:11:48,159

and we've only just scratched the

1992

01:11:52,870 --> 01:11:51,120

surface literally of mars

1993

01:11:55,510 --> 01:11:52,880

in all the interesting places that we

1994

01:11:57,990 --> 01:11:55,520

can go in fact the most interesting

1995

01:12:00,550 --> 01:11:58,000

places of all are where we currently

1996

01:12:03,590 --> 01:12:00,560

think we see liquid water leaking out

1997

01:12:06,070 --> 01:12:03,600

or where the interface between ice

1998

01:12:08,149 --> 01:12:06,080

and and the surface where it melts

1999

01:12:11,430 --> 01:12:08,159

because mars has polar ice caps and it

2000

01:12:13,350 --> 01:12:11,440

melts and thaws just like on earth

2001
01:12:15,669 --> 01:12:13,360
and so those places though we don't want

2002
01:12:17,189 --> 01:12:15,679
to go yet because if there's life

2003
01:12:19,830 --> 01:12:17,199
existing on mars today we don't want to

2004
01:12:22,390 --> 01:12:19,840
hurt that life so we have this grand

2005
01:12:25,350 --> 01:12:22,400
plan going out through 2020 the mars

2006
01:12:26,550 --> 01:12:25,360
2020 rover should last a number of years

2007
01:12:28,149 --> 01:12:26,560
we're going to plan for it to last at

2008
01:12:30,310 --> 01:12:28,159
least two years so i think we have at

2009
01:12:32,870 --> 01:12:30,320
least another decade

2010
01:12:35,510 --> 01:12:32,880
of plans on the books now

2011
01:12:36,550 --> 01:12:35,520
for amazing mars exploration that may

2012
01:12:38,790 --> 01:12:36,560
tell us

2013
01:12:40,790 --> 01:12:38,800

about signs of life on mars if it exists

2014

01:12:41,910 --> 01:12:40,800

certainly about past life on mars if it

2015

01:12:44,070 --> 01:12:41,920

existed

2016

01:12:46,310 --> 01:12:44,080

and so the story is still wide open

2017

01:12:48,390 --> 01:12:46,320

and for the first time on the mars 2020

2018

01:12:51,030 --> 01:12:48,400

rover a significant fraction of the

2019

01:12:53,030 --> 01:12:51,040

payload is being done in cooperation

2020

01:12:54,870 --> 01:12:53,040

between human space flight

2021

01:12:56,470 --> 01:12:54,880

and the science space flight which i you

2022

01:12:58,390 --> 01:12:56,480

know personally i see is linked because

2023

01:13:00,790 --> 01:12:58,400

that's how i've lived my life and as i

2024

01:13:02,709 --> 01:13:00,800

said all discoveries are made by humans

2025

01:13:05,590 --> 01:13:02,719

uh not the rovers and so it's a very

2026
01:13:08,149 --> 01:13:05,600
exciting future so that when alyssa you

2027
01:13:10,149 --> 01:13:08,159
go to mars you're going to know a lot

2028
01:13:12,149 --> 01:13:10,159
before you go

2029
01:13:14,470 --> 01:13:12,159
that's right in fact um

2030
01:13:17,350 --> 01:13:14,480
seeking signs of life is sort of the

2031
01:13:19,830 --> 01:13:17,360
plan that we have for for that rover for

2032
01:13:21,590 --> 01:13:19,840
that 2020 it's going to core it's going

2033
01:13:23,430 --> 01:13:21,600
to create cores and we're going to be

2034
01:13:25,030 --> 01:13:23,440
able to interrogate them

2035
01:13:27,830 --> 01:13:25,040
and and put them in sleeves and put them

2036
01:13:29,830 --> 01:13:27,840
in a cache uh for later analysis so it

2037
01:13:33,189 --> 01:13:29,840
is a hugely very much different than

2038
01:13:34,790 --> 01:13:33,199

curiosity and of course

2039

01:13:37,189 --> 01:13:34,800

hopefully

2040

01:13:38,950 --> 01:13:37,199

we're going to want to continue to do

2041

01:13:40,630 --> 01:13:38,960

science analysis and bring those samples

2042

01:13:41,910 --> 01:13:40,640

back well i'm counting on alyssa to

2043

01:13:44,310 --> 01:13:41,920

bring them back

2044

01:13:47,430 --> 01:13:44,320

that would be great that would be great

2045

01:13:49,830 --> 01:13:47,440

so alyssa carter you're our next

2046

01:13:51,990 --> 01:13:49,840

generation you're that mars scientist

2047

01:13:54,390 --> 01:13:52,000

that we hope will be walking around and

2048

01:13:56,709 --> 01:13:54,400

doing those geological experiments and

2049

01:13:58,470 --> 01:13:56,719

reporting back so why don't you tell us

2050

01:14:00,870 --> 01:13:58,480

a little bit about what's been happening

2051

01:14:03,830 --> 01:14:00,880

in your life

2052

01:14:05,430 --> 01:14:03,840

nihao bonjour hola hello my name is

2053

01:14:07,510 --> 01:14:05,440

alyssa carson

2054

01:14:09,510 --> 01:14:07,520

and i've been trained to be an astronaut

2055

01:14:11,990 --> 01:14:09,520

for nine years

2056

01:14:14,709 --> 01:14:12,000

currently i'm 12 years old so i kind of

2057

01:14:17,830 --> 01:14:14,719

started at three

2058

01:14:18,790 --> 01:14:17,840

i basically decided at three that

2059

01:14:20,950 --> 01:14:18,800

okay

2060

01:14:23,510 --> 01:14:20,960

being an astronaut

2061

01:14:24,470 --> 01:14:23,520

that sounds really cool and then i

2062

01:14:26,950 --> 01:14:24,480

learned

2063

01:14:29,430 --> 01:14:26,960

that we have only been to the moon so i

2064

01:14:31,510 --> 01:14:29,440

set my sights for mars and i haven't

2065

01:14:33,270 --> 01:14:31,520

changed my mind since

2066

01:14:35,590 --> 01:14:33,280

i attend the baton rouge international

2067

01:14:38,070 --> 01:14:35,600

school and there i speak four languages

2068

01:14:41,110 --> 01:14:38,080

english french spanish and chinese and i

2069

01:14:43,110 --> 01:14:41,120

hope to learn russian soon

2070

01:14:45,590 --> 01:14:43,120

um i've been to space camp in huntsville

2071

01:14:48,470 --> 01:14:45,600

11 times so far

2072

01:14:51,910 --> 01:14:48,480

uh usually i go about twice a year i've

2073

01:14:54,950 --> 01:14:51,920

also attended space camp in izmir turkey

2074

01:14:57,110 --> 01:14:54,960

and space camp in laval canada

2075

01:14:58,630 --> 01:14:57,120

so with attending all these space camps

2076

01:15:00,070 --> 01:14:58,640

i have become the first person to

2077

01:15:01,590 --> 01:15:00,080

complete all the space camps in the

2078

01:15:04,149 --> 01:15:01,600

world

2079

01:15:05,110 --> 01:15:04,159

also i have completed the nasa passport

2080

01:15:07,430 --> 01:15:05,120

program

2081

01:15:08,950 --> 01:15:07,440

so i visited all the nasa visitors

2082

01:15:10,470 --> 01:15:08,960

centers in the u.s

2083

01:15:14,709 --> 01:15:10,480

which is 14

2084

01:15:18,390 --> 01:15:16,550

i've been to multiple sally ride day

2085

01:15:20,630 --> 01:15:18,400

camps so

2086

01:15:23,110 --> 01:15:20,640

around my area we may have a day camping

2087

01:15:25,189 --> 01:15:23,120

go and you get to learn all about math

2088

01:15:28,630 --> 01:15:25,199

and science and do different experiments

2089

01:15:29,510 --> 01:15:28,640

i've also done the week-long camp at mit

2090

01:15:31,910 --> 01:15:29,520

so

2091

01:15:34,070 --> 01:15:31,920

we basically did a week-long camp and we

2092

01:15:35,590 --> 01:15:34,080

learned about marine biology and also

2093

01:15:37,030 --> 01:15:35,600

different sciences

2094

01:15:38,709 --> 01:15:37,040

i've witnessed three space shuttle

2095

01:15:42,630 --> 01:15:38,719

launches sts

2096

01:15:47,830 --> 01:15:42,640

132 134 and 135 which all were amazing

2097

01:15:54,149 --> 01:15:50,470

so i have done the

2098

01:15:56,630 --> 01:15:54,159

i have completed all the space camps and

2099

01:15:58,790 --> 01:15:56,640

completed the nasa passport program

2100

01:16:01,189 --> 01:15:58,800

basically because i would like something

2101
01:16:03,350 --> 01:16:01,199
unique on my resume for when i applied

2102
01:16:04,709 --> 01:16:03,360
to become an astronaut

2103
01:16:06,470 --> 01:16:04,719
because

2104
01:16:08,070 --> 01:16:06,480
i would like something to help me stand

2105
01:16:13,430 --> 01:16:08,080
out

2106
01:16:14,229 --> 01:16:13,440
major option

2107
01:16:19,669 --> 01:16:14,239
so

2108
01:16:21,910 --> 01:16:19,679
did this and they in both doing all the

2109
01:16:24,390 --> 01:16:21,920
space camps and completing the passport

2110
01:16:26,070 --> 01:16:24,400
it was all a lot of fun especially since

2111
01:16:27,990 --> 01:16:26,080
i completed the passport program by

2112
01:16:29,510 --> 01:16:28,000
doing it on a road trip

2113
01:16:32,870 --> 01:16:29,520

so that was

2114

01:16:36,709 --> 01:16:32,880

interesting but also very fun

2115

01:16:39,990 --> 01:16:36,719

as college goes i plan on attending

2116

01:16:41,430 --> 01:16:40,000

either cambridge or oxford

2117

01:16:43,110 --> 01:16:41,440

after that

2118

01:16:44,950 --> 01:16:43,120

most likely international space

2119

01:16:46,830 --> 01:16:44,960

university in france

2120

01:16:49,270 --> 01:16:46,840

and then attend

2121

01:16:51,750 --> 01:16:49,280

mit and i hope to get a degree in

2122

01:16:55,590 --> 01:16:51,760

astrophysics

2123

01:16:57,189 --> 01:16:55,600

so a lot of studying to do there

2124

01:16:59,189 --> 01:16:57,199

but

2125

01:17:01,430 --> 01:16:59,199

i don't know i guess

2126

01:17:04,709 --> 01:17:01,440

i've always had this dream

2127

01:17:06,709 --> 01:17:04,719

and i just follow it as best as i can no

2128

01:17:09,750 --> 01:17:06,719

matter where it takes me

2129

01:17:12,550 --> 01:17:09,760

so i've been to izmir turkey which

2130

01:17:14,550 --> 01:17:12,560

is sounds like such a strange place

2131

01:17:17,350 --> 01:17:14,560

but it's part of my dream and so i

2132

01:17:19,830 --> 01:17:17,360

follow it wherever it takes me

2133

01:17:23,110 --> 01:17:19,840

i am the mars generation

2134

01:17:24,790 --> 01:17:23,120

yeah absolutely and you've convinced me

2135

01:17:26,310 --> 01:17:24,800

and

2136

01:17:28,950 --> 01:17:26,320

you know

2137

01:17:30,870 --> 01:17:28,960

when you talk to kids your age do they

2138

01:17:33,030 --> 01:17:30,880

seem to be excited about mars do they

2139

01:17:35,030 --> 01:17:33,040

seem to be excited about space

2140

01:17:36,790 --> 01:17:35,040

or is it you know even a tenth of your

2141

01:17:40,070 --> 01:17:36,800

excitement

2142

01:17:40,950 --> 01:17:40,080

um i've talked to many groups of kids

2143

01:17:43,110 --> 01:17:40,960

and

2144

01:17:45,270 --> 01:17:43,120

most of them they have

2145

01:17:47,750 --> 01:17:45,280

lots of intriguing questions

2146

01:17:49,990 --> 01:17:47,760

after i'm done and i ask for questions

2147

01:17:53,270 --> 01:17:50,000

from the audience they all seem very

2148

01:17:54,950 --> 01:17:53,280

interested they're all excited wondering

2149

01:17:57,910 --> 01:17:54,960

where we're going

2150

01:18:00,630 --> 01:17:57,920

they're asking what nasa is doing now

2151
01:18:01,750 --> 01:18:00,640
they're asking all sorts of questions as

2152
01:18:10,310 --> 01:18:01,760
in

2153
01:18:12,790 --> 01:18:10,320
you know just some

2154
01:18:15,110 --> 01:18:12,800
simple questions that would be simple on

2155
01:18:17,750 --> 01:18:15,120
earth but get complicated spaces and

2156
01:18:20,630 --> 01:18:17,760
showers they ask about you know how life

2157
01:18:22,790 --> 01:18:20,640
is different on the iss

2158
01:18:25,350 --> 01:18:22,800
but they're all excited

2159
01:18:26,390 --> 01:18:25,360
they're all excited about going to mars

2160
01:18:29,669 --> 01:18:26,400
and

2161
01:18:31,430 --> 01:18:29,679
sending that next generation

2162
01:18:33,990 --> 01:18:31,440
that's great and i want to tell you and

2163
01:18:35,990 --> 01:18:34,000

encourage you follow your dream thank

2164

01:18:37,750 --> 01:18:36,000

you and i think with that let's ask

2165

01:18:39,270 --> 01:18:37,760

dwayne to come up and see if we can

2166

01:18:41,990 --> 01:18:39,280

answer some questions from the audience

2167

01:18:44,709 --> 01:18:42,000

and social media yes it's

2168

01:18:47,189 --> 01:18:44,719

q a time again and if you're just

2169

01:18:49,110 --> 01:18:47,199

joining us on nasa television

2170

01:18:50,550 --> 01:18:49,120

please this is the second panel the

2171

01:18:52,310 --> 01:18:50,560

first panel

2172

01:18:55,110 --> 01:18:52,320

talking about 10 years

2173

01:18:55,830 --> 01:18:55,120

on mars uh no worries

2174

01:18:58,709 --> 01:18:55,840

this

2175

01:19:02,149 --> 01:18:58,719

program is going to be archived at

2176
01:19:06,950 --> 01:19:04,709
mars we are coming to you

2177
01:19:08,310 --> 01:19:06,960
from the most visited

2178
01:19:09,669 --> 01:19:08,320
museum in the united states

2179
01:19:12,390 --> 01:19:09,679
smithsonian's

2180
01:19:14,229 --> 01:19:12,400
national air space museum two panels

2181
01:19:17,590 --> 01:19:14,239
talking about mars we're going to get

2182
01:19:19,430 --> 01:19:17,600
some questions here and a reminder

2183
01:19:21,590 --> 01:19:19,440
all of the data

2184
01:19:23,510 --> 01:19:21,600
from the mars exploration program

2185
01:19:25,270 --> 01:19:23,520
curiosity murray

2186
01:19:27,110 --> 01:19:25,280
all of that data is available to the

2187
01:19:33,430 --> 01:19:27,120
public

2188
01:19:34,950 --> 01:19:33,440

it's all about malls it's all about us

2189

01:19:36,790 --> 01:19:34,960

it's all about the future

2190

01:19:38,149 --> 01:19:36,800

okay so let's get with the q a we're

2191

01:19:40,870 --> 01:19:38,159

getting a lot of questions from social

2192

01:19:43,030 --> 01:19:40,880

media again two hashtags when it's mars

2193

01:19:45,510 --> 01:19:43,040

a lot of conversation on social media

2194

01:19:46,709 --> 01:19:45,520

hashtag mirror10 and hashtag 10 years on

2195

01:19:47,750 --> 01:19:46,719

mars

2196

01:19:49,590 --> 01:19:47,760

i'm gonna

2197

01:19:51,350 --> 01:19:49,600

ask folks to join us at the mic but i'm

2198

01:19:52,950 --> 01:19:51,360

gonna take one question actually from

2199

01:19:54,390 --> 01:19:52,960

our live stream

2200

01:19:58,790 --> 01:19:54,400

uh

2201
01:20:04,149 --> 01:19:58,800
how simple would it be to turn water on

2202
01:20:09,270 --> 01:20:07,350
well actually we have that technology uh

2203
01:20:10,470 --> 01:20:09,280
water processing technology is pretty

2204
01:20:12,950 --> 01:20:10,480
well known

2205
01:20:14,870 --> 01:20:12,960
and um the missions we have on mars

2206
01:20:17,110 --> 01:20:14,880
right now are telling us a lot about the

2207
01:20:19,669 --> 01:20:17,120
ph of the water and and what kind of

2208
01:20:21,510 --> 01:20:19,679
minerals might be dissolved in it and

2209
01:20:24,390 --> 01:20:21,520
i think it would be relatively easy to

2210
01:20:26,070 --> 01:20:24,400
make um a drinkable glass of water on

2211
01:20:28,149 --> 01:20:26,080
mars that would be one of those big

2212
01:20:29,830 --> 01:20:28,159
historical moments the first time a

2213
01:20:33,110 --> 01:20:29,840

human being took a drink of water that

2214

01:20:35,990 --> 01:20:33,120

was not from this planet okay

2215

01:20:39,030 --> 01:20:36,000

next question is for our

2216

01:20:40,790 --> 01:20:39,040

young human first human to mars person

2217

01:20:43,030 --> 01:20:40,800

miss carson um and i think you already

2218

01:20:44,950 --> 01:20:43,040

answered this but um you've excited a

2219

01:20:46,870 --> 01:20:44,960

lot of young folks watching the program

2220

01:20:48,390 --> 01:20:46,880

and they want to just say you talked

2221

01:20:51,110 --> 01:20:48,400

about your dreams

2222

01:20:53,590 --> 01:20:51,120

but what advice would you give them

2223

01:20:54,950 --> 01:20:53,600

if they too want to be inspired and be

2224

01:20:56,149 --> 01:20:54,960

sitting up here with these incredible

2225

01:20:58,070 --> 01:20:56,159

people what advice would you give the

2226

01:21:00,709 --> 01:20:58,080

young folks out there well i would tell

2227

01:21:03,270 --> 01:21:00,719

any child that are

2228

01:21:05,350 --> 01:21:03,280

looking for a dream or something that

2229

01:21:07,430 --> 01:21:05,360

really interests them i would tell them

2230

01:21:09,590 --> 01:21:07,440

to find subjects that you're interested

2231

01:21:10,950 --> 01:21:09,600

in and pick a career that goes along

2232

01:21:13,030 --> 01:21:10,960

with the subject you're really

2233

01:21:14,950 --> 01:21:13,040

interested because you really want to

2234

01:21:18,070 --> 01:21:14,960

love your career

2235

01:21:20,390 --> 01:21:18,080

and if you're finding your dream

2236

01:21:22,870 --> 01:21:20,400

you know just stick with it no matter

2237

01:21:24,790 --> 01:21:22,880

what obstacles get in the way

2238

01:21:26,950 --> 01:21:24,800

and don't let anyone tell you that you

2239

01:21:29,910 --> 01:21:26,960

can't fulfill your dream

2240

01:21:31,510 --> 01:21:29,920

i've been doing my uh trying to fulfill

2241

01:21:35,189 --> 01:21:31,520

my dream since three

2242

01:21:38,550 --> 01:21:35,199

and i'm still going and i do not plan on

2243

01:21:41,189 --> 01:21:38,560

stopping so just keep on going and never

2244

01:21:45,830 --> 01:21:41,199

stop believing in yourself and don't let

2245

01:21:49,030 --> 01:21:47,030

thank you

2246

01:21:50,310 --> 01:21:49,040

okay let's uh come to the mic we're

2247

01:21:54,790 --> 01:21:50,320

coming back to the national air space

2248

01:21:54,800 --> 01:21:57,990

you talk up a little louder

2249

01:21:58,000 --> 01:22:11,110

keep going

2250

01:22:11,120 --> 01:22:34,629

okay

2251

01:22:39,750 --> 01:22:37,669

well my main role model is basically

2252

01:22:41,830 --> 01:22:39,760

just all astronauts because they all

2253

01:22:44,870 --> 01:22:41,840

inspire me

2254

01:22:49,590 --> 01:22:46,709

here's one right here

2255

01:22:50,709 --> 01:22:49,600

but uh at my school we also learn

2256

01:22:52,310 --> 01:22:50,719

cultures

2257

01:22:54,390 --> 01:22:52,320

because with all my languages my

2258

01:22:57,830 --> 01:22:54,400

teachers are from the country that

2259

01:22:59,910 --> 01:22:57,840

speaks the language so they try to

2260

01:23:02,229 --> 01:22:59,920

tell us about the cultures the language

2261

01:23:04,550 --> 01:23:02,239

their traditions so i've gotten used to

2262

01:23:06,709 --> 01:23:04,560

some cultures and

2263

01:23:09,270 --> 01:23:06,719

so with that that has really helped me

2264

01:23:10,229 --> 01:23:09,280

become custom to most of most different

2265

01:23:11,110 --> 01:23:10,239

cultures

2266

01:23:13,910 --> 01:23:11,120

and

2267

01:23:16,070 --> 01:23:13,920

i'm pretty used to so used to you know

2268

01:23:18,310 --> 01:23:16,080

transitioning to different cultures

2269

01:23:20,070 --> 01:23:18,320

because at my school you may be in

2270

01:23:22,149 --> 01:23:20,080

spanish class and you're doing a spanish

2271

01:23:23,669 --> 01:23:22,159

culture then all of a sudden

2272

01:23:25,189 --> 01:23:23,679

oh it's time to change class now we're

2273

01:23:28,149 --> 01:23:25,199

going to a france

2274

01:23:29,910 --> 01:23:28,159

and we're doing a french culture so you

2275

01:23:31,910 --> 01:23:29,920

kind of learn to transition pretty well

2276

01:23:35,430 --> 01:23:31,920

my school with between cultures and

2277

01:23:35,440 --> 01:23:38,629

next question

2278

01:23:43,110 --> 01:23:41,270

hi my name is shauna and i live here in

2279

01:23:44,870 --> 01:23:43,120

dc i actually work here at the museum

2280

01:23:45,830 --> 01:23:44,880

i'm an educator well geologist turned

2281

01:23:46,950 --> 01:23:45,840

educator

2282

01:23:48,870 --> 01:23:46,960

um

2283

01:23:51,270 --> 01:23:48,880

elsa you give me so much hope for the

2284

01:23:53,910 --> 01:23:51,280

future and i am also a big astronaut fan

2285

01:23:56,790 --> 01:23:53,920

sally ride was my hero growing up so i

2286

01:23:58,709 --> 01:23:56,800

was wondering what are two traits that

2287

01:24:00,550 --> 01:23:58,719

you've seen in the astronauts that you

2288

01:24:02,629 --> 01:24:00,560

admire that you're working on

2289

01:24:04,390 --> 01:24:02,639

cultivating yourself as you prepare to

2290

01:24:06,229 --> 01:24:04,400

become one

2291

01:24:08,550 --> 01:24:06,239

two traits that i see

2292

01:24:10,870 --> 01:24:08,560

would be bravery

2293

01:24:14,149 --> 01:24:10,880

because we all know there are dangers in

2294

01:24:17,270 --> 01:24:14,159

going to space or going to any planet

2295

01:24:19,110 --> 01:24:17,280

yet in my opinion the benefits outweigh

2296

01:24:20,870 --> 01:24:19,120

the risk because it's just such an

2297

01:24:22,550 --> 01:24:20,880

adventure

2298

01:24:24,950 --> 01:24:22,560

also

2299

01:24:27,430 --> 01:24:24,960

i guess

2300

01:24:31,270 --> 01:24:27,440

loyalty to your crew members

2301

01:24:32,149 --> 01:24:31,280

having to be like be friends with people

2302

01:24:35,030 --> 01:24:32,159

that

2303

01:24:37,910 --> 01:24:35,040

you're going with because all astronauts

2304

01:24:40,470 --> 01:24:37,920

they just become one big happy family

2305

01:24:42,070 --> 01:24:40,480

and it's just

2306

01:24:44,070 --> 01:24:42,080

i don't know i guess

2307

01:24:47,030 --> 01:24:44,080

all the astronauts they just become

2308

01:24:49,669 --> 01:24:47,040

family and they all trust each other

2309

01:24:52,229 --> 01:24:49,679

with each other's lives basically

2310

01:24:55,910 --> 01:24:52,239

and i guess that's

2311

01:24:57,590 --> 01:24:55,920

a good thing to have as a trait

2312

01:24:59,110 --> 01:24:57,600

you know the questions from the audience

2313

01:25:01,270 --> 01:24:59,120

okay we go back to social media we have

2314

01:25:05,430 --> 01:25:01,280

time for a couple of more this is from

2315

01:25:08,550 --> 01:25:05,440

at terry universe u universe u i believe

2316

01:25:10,709 --> 01:25:08,560

uh for the panel where is the most

2317

01:25:15,830 --> 01:25:10,719

capital place on mars based

2318

01:25:21,189 --> 01:25:18,390

well as um curiosity has clearly

2319

01:25:24,470 --> 01:25:21,199

demonstrated it actually is landed in an

2320

01:25:26,950 --> 01:25:24,480

ancient riverbed and so

2321

01:25:29,910 --> 01:25:26,960

we now from orbit can take a look at

2322

01:25:31,590 --> 01:25:29,920

other similar locations and recognize

2323

01:25:33,830 --> 01:25:31,600

that there's been a fair amount of water

2324

01:25:34,950 --> 01:25:33,840

on mars in the past oceans of water

2325

01:25:37,430 --> 01:25:34,960

perhaps

2326

01:25:40,470 --> 01:25:37,440

and that water is carved out gullies and

2327

01:25:43,030 --> 01:25:40,480

valleys and so from a habitability

2328

01:25:45,350 --> 01:25:43,040

perspective going back in time when

2329

01:25:47,350 --> 01:25:45,360

water was plentiful on mars and the

2330

01:25:49,830 --> 01:25:47,360

atmosphere was thick enough to support

2331

01:25:50,870 --> 01:25:49,840

it those would be key locations to check

2332

01:25:51,590 --> 01:25:50,880

and see

2333

01:25:56,310 --> 01:25:51,600

if

2334

01:26:01,510 --> 01:25:58,629

um i think the most habitable place now

2335

01:26:03,510 --> 01:26:01,520

our best bet at finding extant life or

2336

01:26:05,750 --> 01:26:03,520

life that's currently there would be

2337

01:26:07,669 --> 01:26:05,760

underground i think again protecting

2338

01:26:09,590 --> 01:26:07,679

yourself from the surface is critical i

2339

01:26:10,709 --> 01:26:09,600

think sources of water that might be

2340

01:26:13,669 --> 01:26:10,719

accessible

2341

01:26:16,390 --> 01:26:13,679

without having to melt or process for

2342

01:26:21,350 --> 01:26:16,400

organisms currently on mars would also

2343

01:26:28,149 --> 01:26:24,709

okay uh final question and this deals

2344

01:26:29,510 --> 01:26:28,159

obviously with the activities on mars

2345

01:26:31,830 --> 01:26:29,520

and perhaps this is for for john

2346

01:26:33,830 --> 01:26:31,840

grunsfeld

2347

01:26:35,669 --> 01:26:33,840

dr grunzfeld

2348

01:26:37,430 --> 01:26:35,679

the mars program

2349

01:26:40,629 --> 01:26:37,440

lots of things going on are there any

2350

01:26:43,510 --> 01:26:40,639

other nasa projects that will help

2351

01:26:44,870 --> 01:26:43,520

get humans to mars

2352

01:26:46,310 --> 01:26:44,880

well i think there are

2353

01:26:47,990 --> 01:26:46,320

a number of projects that will help

2354

01:26:50,870 --> 01:26:48,000

humans get to mars starting with the

2355

01:26:52,390 --> 01:26:50,880

international space station

2356

01:26:54,070 --> 01:26:52,400

you can't see it in social networking

2357

01:26:56,149 --> 01:26:54,080

but in the back of the room here is a

2358

01:26:57,590 --> 01:26:56,159

circle suit which is the suit that

2359

01:26:59,030 --> 01:26:57,600

astronauts ride to and from the

2360

01:27:01,750 --> 01:26:59,040

international space station in when

2361

01:27:03,910 --> 01:27:01,760

they're flying on a soyuz vehicle

2362

01:27:05,430 --> 01:27:03,920

and i had the opportunity to train as a

2363

01:27:07,590 --> 01:27:05,440

backup crew member for the international

2364

01:27:09,350 --> 01:27:07,600

space station and when i was

2365

01:27:11,669 --> 01:27:09,360

contemplating you know what i would do

2366

01:27:14,229 --> 01:27:11,679

for six months on the space station i

2367

01:27:16,709 --> 01:27:14,239

thought great i'm gonna pretend that i'm

2368

01:27:19,669 --> 01:27:16,719

traveling to mars because traveling to

2369

01:27:21,510 --> 01:27:19,679

mars is probably about a six-month trip

2370

01:27:23,270 --> 01:27:21,520

you'll be in weightlessness

2371

01:27:24,070 --> 01:27:23,280

the whole time very likely depending

2372

01:27:26,070 --> 01:27:24,080

upon

2373

01:27:28,310 --> 01:27:26,080

specific architecture but i'll get to

2374

01:27:29,350 --> 01:27:28,320

experience that six months travel to

2375

01:27:31,270 --> 01:27:29,360

mars

2376

01:27:32,709 --> 01:27:31,280

and so every time we send a crew up to

2377

01:27:34,709 --> 01:27:32,719

the international space station and they

2378

01:27:36,470 --> 01:27:34,719

spend six months in weightlessness

2379

01:27:38,229 --> 01:27:36,480

eating sleeping

2380

01:27:40,229 --> 01:27:38,239

doing other things

2381

01:27:42,790 --> 01:27:40,239

living working in space

2382

01:27:44,870 --> 01:27:42,800

they are practicing a cruise to mars

2383

01:27:46,950 --> 01:27:44,880

other than radiation because the earth's

2384

01:27:48,310 --> 01:27:46,960

magnetosphere protects us from radiation

2385

01:27:50,709 --> 01:27:48,320

but in all other respects it's a

2386

01:27:53,350 --> 01:27:50,719

practice mission and so we're able to

2387

01:27:56,470 --> 01:27:53,360

test technology for processing water for

2388

01:27:57,990 --> 01:27:56,480

reprocessing urine for removing humidity

2389

01:28:00,149 --> 01:27:58,000

from the atmosphere from studying the

2390

01:28:02,310 --> 01:28:00,159

medical effects and what we're learning

2391

01:28:04,070 --> 01:28:02,320

is that in terms of things like muscle

2392

01:28:06,070 --> 01:28:04,080

and bone health we're able to keep

2393

01:28:07,830 --> 01:28:06,080

people healthy now in space

2394

01:28:09,590 --> 01:28:07,840

what we've learned from the radiation

2395

01:28:11,669 --> 01:28:09,600

detectors that we're on the curiosity

2396

01:28:13,910 --> 01:28:11,679

mission traveling to mars and to the

2397

01:28:16,229 --> 01:28:13,920

surface is that the radiation's

2398

01:28:17,590 --> 01:28:16,239

significant but it's only about double

2399

01:28:19,510 --> 01:28:17,600

what you would experience on a long

2400

01:28:21,270 --> 01:28:19,520

duration space flight uh on the

2401

01:28:23,030 --> 01:28:21,280

international space station but there's

2402

01:28:25,430 --> 01:28:23,040

still a lot of unanswered technology

2403

01:28:27,510 --> 01:28:25,440

questions about how to keep what kind of

2404

01:28:29,510 --> 01:28:27,520

food should humans eat on these long

2405

01:28:31,189 --> 01:28:29,520

missions we're still eating food that's

2406

01:28:33,990 --> 01:28:31,199

kind of derived from the space shuttle

2407

01:28:35,350 --> 01:28:34,000

missions that taste good a combination

2408

01:28:38,149 --> 01:28:35,360

of russian and american and an

2409

01:28:40,229 --> 01:28:38,159

international diet but we haven't really

2410

01:28:42,070 --> 01:28:40,239

asked the question or learned yet

2411

01:28:43,669 --> 01:28:42,080

what should be the diet for humans and

2412

01:28:45,030 --> 01:28:43,679

long-duration space flight or what

2413

01:28:47,510 --> 01:28:45,040

should be the diet

2414

01:28:49,750 --> 01:28:47,520

for mars to help tune human health and

2415

01:28:51,990 --> 01:28:49,760

performance to get the desired results

2416

01:28:53,910 --> 01:28:52,000

we want and have it store for a long

2417

01:28:56,629 --> 01:28:53,920

time i actually did an experiment for

2418

01:28:59,270 --> 01:28:56,639

two weeks where i ate nothing but food

2419

01:29:01,669 --> 01:28:59,280

bars but we chose those food bars very

2420

01:29:04,870 --> 01:29:01,679

carefully to have the right nutritious

2421

01:29:06,870 --> 01:29:04,880

balance and also to bring the caloric

2422

01:29:09,110 --> 01:29:06,880

quantity way down i actually was only

2423

01:29:11,510 --> 01:29:09,120

eating 1200 kilocalories normally called

2424

01:29:13,430 --> 01:29:11,520

calories a day but the body adapts very

2425

01:29:15,430 --> 01:29:13,440

quickly to that and can survive for

2426

01:29:17,189 --> 01:29:15,440

months and months on that level when

2427

01:29:18,950 --> 01:29:17,199

you're in weightlessness and at the end

2428

01:29:21,270 --> 01:29:18,960

of the two-week period the doctors did

2429

01:29:23,270 --> 01:29:21,280

my blood draw and they said john you're

2430

01:29:25,830 --> 01:29:23,280

the healthiest we've ever seen you in 18

2431

01:29:27,830 --> 01:29:25,840

years of studies as a guinea pig keep

2432

01:29:29,830 --> 01:29:27,840

eating this diet forever and you'll live

2433

01:29:31,350 --> 01:29:29,840

a long time

2434

01:29:33,430 --> 01:29:31,360

so we're doing a lot of work on the

2435

01:29:35,430 --> 01:29:33,440

international space station i think all

2436

01:29:37,350 --> 01:29:35,440

of our future mars explorers robotic

2437

01:29:39,270 --> 01:29:37,360

explorers will continue to have

2438

01:29:40,470 --> 01:29:39,280

experiments that help help us in human

2439

01:29:42,310 --> 01:29:40,480

space flight

2440

01:29:43,910 --> 01:29:42,320

so i think we're going to see a lot more

2441

01:29:45,590 --> 01:29:43,920

leading towards mars

2442

01:29:47,430 --> 01:29:45,600

and of course we can't forget that later

2443

01:29:49,750 --> 01:29:47,440

this year we have the first flight of

2444

01:29:52,070 --> 01:29:49,760

our orion capsule so in addition to the

2445

01:29:54,470 --> 01:29:52,080

work we're doing on iss we actually have

2446

01:29:57,430 --> 01:29:54,480

pieces of hardware in production

2447

01:29:59,110 --> 01:29:57,440

orion and our big heavy lift rocket the

2448

01:30:01,110 --> 01:29:59,120

space launch system

2449

01:30:03,510 --> 01:30:01,120

two essential pieces of getting people

2450

01:30:04,629 --> 01:30:03,520

to mars eventually

2451

01:30:07,030 --> 01:30:04,639

okay ladies and gentlemen that's going

2452

01:30:09,189 --> 01:30:07,040

to do it for today i want to thank

2453

01:30:11,590 --> 01:30:09,199

our panel here on our previous panel and

2454

01:30:15,430 --> 01:30:11,600

again it will be archived at

2455

01:30:19,189 --> 01:30:16,470

mars

2456

01:30:20,950 --> 01:30:19,199

i want to thank the most visited museum

2457

01:30:23,830 --> 01:30:20,960

in the united states for hosting us here

2458

01:30:26,310 --> 01:30:23,840

smithsonian's national air space museum

2459

01:30:28,470 --> 01:30:26,320

and to the thousands of folks who have

2460

01:30:30,390 --> 01:30:28,480

made this day possible with murr

2461

01:30:31,990 --> 01:30:30,400

happy birthday all the great work and a

2462

01:30:32,870 --> 01:30:32,000

special shout out to the jet propulsion

2463

01:30:34,629 --> 01:30:32,880

lab

2464

01:30:36,149 --> 01:30:34,639

managing the programs and doing the

2465

01:30:37,350 --> 01:30:36,159

incredible things you do in planetary

2466

01:30:39,430 --> 01:30:37,360

exploration

2467

01:30:42,310 --> 01:30:39,440

again we want to thank you

2468

01:30:45,270 --> 01:30:42,320

www.nasa.gov

2469

01:30:48,629 --> 01:30:45,280

mars for all of the moss exploration

2470

01:30:50,790 --> 01:30:48,639

and ladies and gentlemen we thank you

2471

01:30:53,189 --> 01:30:50,800

and go mars