



1
00:00:09,080 --> 00:00:04,880
NASA's Jet Propulsion Laboratory

2
00:00:11,509 --> 00:00:09,090
presents the von Karman lecture a series

3
00:00:14,150 --> 00:00:11,519
of talks by scientists and engineers who

4
00:00:16,640 --> 00:00:14,160
are exploring our planet our solar

5
00:00:23,950 --> 00:00:16,650
system and all that lies beyond

6
00:00:26,690 --> 00:00:23,960
[Music]

7
00:00:28,910 --> 00:00:26,700
good evening folks I am Brian White from

8
00:00:31,370 --> 00:00:28,920
JPL's office of communication and

9
00:00:33,590 --> 00:00:31,380
education and welcome to another edition

10
00:00:37,460 --> 00:00:33,600
of a remote version of the von Karman

11
00:00:39,320 --> 00:00:37,470
series now tonight as this reaches you

12
00:00:41,600 --> 00:00:39,330
at home wherever in the world that may

13
00:00:43,130 --> 00:00:41,610

be I want you to think about the

14

00:00:45,979 --> 00:00:43,140

logistics of how it's getting there

15

00:00:48,110 --> 00:00:45,989

these small moments of Engineering these

16

00:00:50,869 --> 00:00:48,120

small miracles that make what we're

17

00:00:53,000 --> 00:00:50,879

doing right now possible think about

18

00:00:55,160 --> 00:00:53,010

some of these things as we discuss the

19

00:00:57,229 --> 00:00:55,170

deep space network and how our

20

00:00:59,720 --> 00:00:57,239

conversation with the universe starts

21

00:01:01,640 --> 00:00:59,730

here and before we get started a few

22

00:01:03,920 --> 00:01:01,650

quick reminders we ask if there are any

23

00:01:05,660 --> 00:01:03,930

technical issues if any of them come up

24

00:01:07,070 --> 00:01:05,670

we ask that you stick with us we're

25

00:01:09,350 --> 00:01:07,080

gonna get them sorted out we'll be with

26

00:01:12,380 --> 00:01:09,360

you as best as we can we also want you

27

00:01:14,060 --> 00:01:12,390

to be involved in this conversation if

28

00:01:16,160 --> 00:01:14,070

you're joining us on YouTube or Facebook

29

00:01:17,870 --> 00:01:16,170

live you'll notice that there is a chat

30

00:01:18,320 --> 00:01:17,880

window now if you don't see the chat

31

00:01:20,420 --> 00:01:18,330

window

32

00:01:22,520 --> 00:01:20,430

don't fear just reload your page and

33

00:01:24,530 --> 00:01:22,530

refresh it and it should be right there

34

00:01:25,639 --> 00:01:24,540

so ask questions throughout the night

35

00:01:28,730 --> 00:01:25,649

and we'll bring them into our

36

00:01:29,959 --> 00:01:28,740

conversation as many of these questions

37

00:01:31,670 --> 00:01:29,969

as we possibly can throughout the

38

00:01:33,440 --> 00:01:31,680

evening and helping us out with these

39

00:01:35,029 --> 00:01:33,450

questions tonight is the manager for

40

00:01:37,929 --> 00:01:35,039

solar system Public Engagement and

41

00:01:43,219 --> 00:01:37,939

networks Heather Doyle hi Heather

42

00:01:44,510 --> 00:01:43,229

hello welcome so thanks Heather what we

43

00:01:44,899 --> 00:01:44,520

can see a lot of Heather throughout the

44

00:01:46,340 --> 00:01:44,909

evening

45

00:01:50,380 --> 00:01:46,350

but let's introduce our speaker for this

46

00:01:52,480 --> 00:01:50,390

evening dr. Joseph Lazio welcome Joe

47

00:01:54,590 --> 00:01:52,490

greetings

48

00:01:59,090 --> 00:01:54,600

thanks for joining us here on this

49

00:02:02,929 --> 00:01:59,100

Thursday evening what do you do for the

50

00:02:07,310 --> 00:02:02,939

deep space network I am the chief

51
00:02:09,740 --> 00:02:07,320
scientist of the deep space network so

52
00:02:13,130 --> 00:02:09,750
that means for the portion of JPL that

53
00:02:14,750 --> 00:02:13,140
manages the DSM we often this being NASA

54
00:02:18,740 --> 00:02:14,760
right everything's acronyms so it's the

55
00:02:20,900 --> 00:02:18,750
DSN I think about all the different ways

56
00:02:23,090 --> 00:02:20,910
that we can get science out of the DSM

57
00:02:25,940 --> 00:02:23,100
and that's gonna be I think one of the

58
00:02:27,710 --> 00:02:25,950
things that we explore this evening very

59
00:02:29,839 --> 00:02:27,720
cool well let's get right into it let's

60
00:02:31,790 --> 00:02:29,849
bring up our first image and let's talk

61
00:02:33,550 --> 00:02:31,800
about what is the DSN what's the Deep

62
00:02:36,620 --> 00:02:33,560
Space Network

63
00:02:39,080 --> 00:02:36,630

yeah this this is of course not the DSM

64

00:02:42,800 --> 00:02:39,090

this is the Mars Curiosity rover it's a

65

00:02:44,240 --> 00:02:42,810

selfie that it took and of course one of

66

00:02:46,520 --> 00:02:44,250

the one of the events that we are

67

00:02:48,620 --> 00:02:46,530

anticipating late this month is the

68

00:02:51,260 --> 00:02:48,630

launch of the Mars perseverance forever

69

00:02:54,800 --> 00:02:51,270

which will will join curiosity roaming

70

00:02:57,080 --> 00:02:54,810

around the surface of Mars but have you

71

00:02:59,150 --> 00:02:57,090

ever wondered how those selfies all

72

00:03:01,370 --> 00:02:59,160

those images get back from the surface

73

00:03:03,020 --> 00:03:01,380

of Mars because you know the soap that

74

00:03:05,750 --> 00:03:03,030

picture doesn't show an internet cable

75

00:03:07,190 --> 00:03:05,760

from the rover to earth right I don't I

76

00:03:10,070 --> 00:03:07,200

don't think the Wi-Fi and Mars is all

77

00:03:13,430 --> 00:03:10,080

that great yeah so if we bring up our

78

00:03:18,710 --> 00:03:13,440

second image we see one of the smaller

79

00:03:22,100 --> 00:03:18,720

antennas in the DSN this antenna is it's

80

00:03:23,660 --> 00:03:22,110

a 34 meter diameter antenna if you want

81

00:03:27,520 --> 00:03:23,670

to think about it it's about 120 feet

82

00:03:30,140 --> 00:03:27,530

but officially 34 meters located outside

83

00:03:33,560 --> 00:03:30,150

well it's at Goldstone California so

84

00:03:36,140 --> 00:03:33,570

it's kind of between Los Angeles and Las

85

00:03:38,360 --> 00:03:36,150

Vegas you go a third of the way and turn

86

00:03:41,870 --> 00:03:38,370

left and this is one of the connections

87

00:03:44,570 --> 00:03:41,880

between the universe and us so data from

88

00:03:46,820 --> 00:03:44,580

Mars in fact all over the solar system

89

00:03:49,449 --> 00:03:46,830

come down through this anti or one of

90

00:03:51,920 --> 00:03:49,459

its sister intents

91

00:03:54,199 --> 00:03:51,930

so that brings up a good point because

92

00:04:00,140 --> 00:03:54,209

we keep calling it the Deep Space

93

00:04:04,430 --> 00:04:00,150

Network what specifically do we consider

94

00:04:05,690 --> 00:04:04,440

deep space that that's an excellent

95

00:04:09,680 --> 00:04:05,700

question

96

00:04:12,310 --> 00:04:09,690

deep space we consider it anything

97

00:04:14,860 --> 00:04:12,320

beyond us there's a special orbit called

98

00:04:17,210 --> 00:04:14,870

sometimes goes by geosync or

99

00:04:20,599 --> 00:04:17,220

geostationary sorry geosynchronous or

100

00:04:24,680 --> 00:04:20,609

geostationary often just abbreviated to

101

00:04:27,230 --> 00:04:24,690

geo and if you place a satellite there

102

00:04:30,830 --> 00:04:27,240

it has an orbital period of one day

103

00:04:32,960 --> 00:04:30,840

which means as you look at the satellite

104

00:04:35,990 --> 00:04:32,970

in the sky it essentially stays in about

105

00:04:39,680 --> 00:04:36,000

the same spot in the sky once you go

106

00:04:42,320 --> 00:04:39,690

beyond that it becomes increasingly more

107

00:04:46,290 --> 00:04:42,330

difficult to communicate with spacecraft

108

00:04:48,439 --> 00:04:46,300

so beyond geo is the moon

109

00:04:53,670 --> 00:04:48,449

and essentially the rest of the universe

110

00:04:55,860 --> 00:04:53,680

so all of getting to getting to sending

111

00:04:58,529 --> 00:04:55,870

commands up and getting data down from

112

00:05:00,659 --> 00:04:58,539

spacecraft beyond geo is what we think

113

00:05:03,719 --> 00:05:00,669

of as deep space and that's what the DSN

114

00:05:05,249 --> 00:05:03,729

is designed to do mm-hmm well let's take

115

00:05:07,260 --> 00:05:05,259

a look at another one of those antennas

116

00:05:10,860 --> 00:05:07,270

bring up image 3 I love this one in

117

00:05:12,809 --> 00:05:10,870

particular that's Doug Doug is about my

118

00:05:15,960 --> 00:05:12,819

height about 5 foot 10 and he looks like

119

00:05:16,800 --> 00:05:15,970

a cactus in front of that so helping how

120

00:05:18,899 --> 00:05:16,810

does this help out with this

121

00:05:22,140 --> 00:05:18,909

geosynchronous orbit by I mean explain

122

00:05:23,969 --> 00:05:22,150

to us how this really helps out with

123

00:05:25,350 --> 00:05:23,979

that by keeping beyond that point

124

00:05:29,730 --> 00:05:25,360

because we're always spinning much to

125

00:05:31,469 --> 00:05:29,740

our chagrin yeah yeah and in fact you

126
00:05:33,270 --> 00:05:31,479
notice I called the previous antenna one

127
00:05:34,469 --> 00:05:33,280
of our smaller ones this is a 70-meter

128
00:05:36,330 --> 00:05:34,479
antenna which means you could almost

129
00:05:38,879 --> 00:05:36,340
play a football team in it and our

130
00:05:41,790 --> 00:05:38,889
antennas are so big because once you get

131
00:05:45,300 --> 00:05:41,800
me on geo it becomes the signals become

132
00:05:48,209 --> 00:05:45,310
increasingly faint so to pick them up we

133
00:05:52,680 --> 00:05:48,219
need increasingly large antennas and if

134
00:05:55,200 --> 00:05:52,690
we go to the next image you'll see that

135
00:05:57,390 --> 00:05:55,210
as you as you said we're always spinning

136
00:05:59,430 --> 00:05:57,400
so I talked about the antennas at

137
00:06:02,730 --> 00:05:59,440
Goldstone these the two pictures we've

138
00:06:05,100 --> 00:06:02,740

seen a book than Goldstone but sometimes

139

00:06:07,740 --> 00:06:05,110

Goldstone can't see a spacecraft so

140

00:06:09,240 --> 00:06:07,750

there are three DSN complexes there's

141

00:06:11,459 --> 00:06:09,250

one in California

142

00:06:14,219 --> 00:06:11,469

Goldstone there's one just outside

143

00:06:16,769 --> 00:06:14,229

Madrid the capital of Spain and one just

144

00:06:19,649 --> 00:06:16,779

outside outside Canberra the capital

145

00:06:22,320 --> 00:06:19,659

ball strike and if you look at this map

146

00:06:24,269 --> 00:06:22,330

map what you'll see is they're about the

147

00:06:26,939 --> 00:06:24,279

same distance apart and what that means

148

00:06:29,159 --> 00:06:26,949

is that no matter where a spacecraft is

149

00:06:32,159 --> 00:06:29,169

in the solar system we can we can either

150

00:06:34,379 --> 00:06:32,169

send commands up to it a point to it or

151

00:06:35,850 --> 00:06:34,389

we can receive data from it down so if

152

00:06:39,570 --> 00:06:35,860

you go to the next image which is

153

00:06:41,670 --> 00:06:39,580

actually a movie we show this visually

154

00:06:43,950 --> 00:06:41,680

if you imagine that you're a spacecraft

155

00:06:47,309 --> 00:06:43,960

somewhere in the solar system as the

156

00:06:49,680 --> 00:06:47,319

world turns you can see the complexes

157

00:06:51,510 --> 00:06:49,690

rotate in and out of you but no matter

158

00:06:53,159 --> 00:06:51,520

where you might imagine yourself to be

159

00:06:56,550 --> 00:06:53,169

in the solar system as long as you're

160

00:06:58,800 --> 00:06:56,560

above geo you can always see one or more

161

00:06:59,879 --> 00:06:58,810

the DSN complexes and we can always send

162

00:07:02,730 --> 00:06:59,889

a command up or get

163

00:07:04,409 --> 00:07:02,740

dated down so no matter where you go

164

00:07:07,140 --> 00:07:04,419

there we are with the Deep Space Network

165

00:07:09,600 --> 00:07:07,150

and it's but I just want to make sure

166

00:07:11,100 --> 00:07:09,610

clear on this it's not just us it's not

167

00:07:14,399 --> 00:07:11,110

just NASA in particular there's a lot of

168

00:07:15,450 --> 00:07:14,409

international cooperation with this what

169

00:07:16,800 --> 00:07:15,460

are what are some of the missions that

170

00:07:20,010 --> 00:07:16,810

we're helping out or we're working with

171

00:07:22,019 --> 00:07:20,020

on this yeah that's a great question if

172

00:07:26,189 --> 00:07:22,029

we go to the next image so this image

173

00:07:28,290 --> 00:07:26,199

actually shows the top three rows are

174

00:07:31,170 --> 00:07:28,300

the current missions that are being

175

00:07:33,839 --> 00:07:31,180

enabled by the DSN all over the solar

176
00:07:35,550 --> 00:07:33,849
system the bottom row is future missions

177
00:07:39,330 --> 00:07:35,560
of course highlighted by Mars

178
00:07:40,980 --> 00:07:39,340
perseverance and it's an amazing suite

179
00:07:43,589 --> 00:07:40,990
of course it varies a little bit right

180
00:07:46,110 --> 00:07:43,599
we said goodbye to Spitzer earlier this

181
00:07:48,330 --> 00:07:46,120
year where we're going to say hello to

182
00:07:51,689 --> 00:07:48,340
Mars perseverance over the course of the

183
00:07:54,450 --> 00:07:51,699
next year but it's about three dozen

184
00:07:58,409 --> 00:07:54,460
missions in any given time as you

185
00:08:01,159 --> 00:07:58,419
indicated it's from not only for NASA

186
00:08:03,689 --> 00:08:01,169
so it's NASA's DSN but it really enables

187
00:08:07,800 --> 00:08:03,699
exploration for all of humanity because

188
00:08:10,320 --> 00:08:07,810

in about the center-left there's an XM

189

00:08:12,779 --> 00:08:10,330

ammunition that's actually a European

190

00:08:15,450 --> 00:08:12,789

x-ray Observatory so it's a it's

191

00:08:17,490 --> 00:08:15,460

observing x-rays coming essentially from

192

00:08:19,110 --> 00:08:17,500

beyond the solar system but it's a

193

00:08:24,779 --> 00:08:19,120

European mission some of the data flow

194

00:08:27,659 --> 00:08:24,789

through the the DSN to the right of XM m

195

00:08:29,279 --> 00:08:27,669

is Hayabusa - this is a Japanese mission

196

00:08:31,110 --> 00:08:29,289

in fact that spacecraft is on its way

197

00:08:33,719 --> 00:08:31,120

back from an asteroid is gathered

198

00:08:38,130 --> 00:08:33,729

samples and is coming back to the earth

199

00:08:41,100 --> 00:08:38,140

with them and then in the upper right is

200

00:08:44,040 --> 00:08:41,110

the Mars orbiter mission this is an

201
00:08:47,910 --> 00:08:44,050
Indian mission that is orbiting Mars or

202
00:08:51,449 --> 00:08:47,920
mom and again we are enabling missions

203
00:08:53,939 --> 00:08:51,459
for all of humanity essentially that's

204
00:08:55,230 --> 00:08:53,949
that's pretty amazing that's I mean

205
00:08:56,840 --> 00:08:55,240
number one that we've got that there's a

206
00:09:00,090 --> 00:08:56,850
spacecraft called mom but number two

207
00:09:02,550 --> 00:09:00,100
that we can really this really is

208
00:09:04,500 --> 00:09:02,560
everybody's space doesn't just belong

209
00:09:06,180 --> 00:09:04,510
it's for everybody and that we are so

210
00:09:07,170 --> 00:09:06,190
evolved in that I do want to bring

211
00:09:11,910 --> 00:09:07,180
Heather back into the conversation

212
00:09:13,620 --> 00:09:11,920
because there are ways that you folks at

213
00:09:15,030 --> 00:09:13,630

home can be involved in

214

00:09:17,309 --> 00:09:15,040

the Deep Space Network and some of the

215

00:09:18,600 --> 00:09:17,319

great stuff that they do Heather come on

216

00:09:22,050 --> 00:09:18,610

in here why don't you talk about some of

217

00:09:25,620 --> 00:09:22,060

those outreach areas that they can well

218

00:09:27,300 --> 00:09:25,630

learn about this sure now that you know

219

00:09:28,920 --> 00:09:27,310

a little more about the DSN and I'd love

220

00:09:30,960 --> 00:09:28,930

to share this really cool interactive we

221

00:09:34,740 --> 00:09:30,970

hope we have it's called DSN now and

222

00:09:37,530 --> 00:09:34,750

it's found at eyes.nasa.gov slash DSN

223

00:09:39,269 --> 00:09:37,540

and it shows you what spacecraft the DSN

224

00:09:41,639 --> 00:09:39,279

is communicating with right now in a

225

00:09:43,139 --> 00:09:41,649

real-time the interactive tells you a

226

00:09:44,819 --> 00:09:43,149

bit about the spacecraft that each

227

00:09:46,829 --> 00:09:44,829

antenna is communicating with so if you

228

00:09:48,090 --> 00:09:46,839

click on one of the active antennas it

229

00:09:49,439 --> 00:09:48,100

will bring up the spacecraft on the

230

00:09:51,240 --> 00:09:49,449

right-hand side with some additional

231

00:09:53,759 --> 00:09:51,250

information like what it looks like and

232

00:09:55,499 --> 00:09:53,769

how far away it is from Earth so that's

233

00:09:57,749 --> 00:09:55,509

one really cool way to engage with the

234

00:09:59,430 --> 00:09:57,759

DSN live but for those who want to get

235

00:10:01,860 --> 00:09:59,440

the kids involved we also have a fun

236

00:10:04,499 --> 00:10:01,870

video game it's called DSN uplink

237

00:10:07,379 --> 00:10:04,509

downlink and it's found on nasa's space

238

00:10:09,090 --> 00:10:07,389

place website for kids the game involves

239

00:10:10,920 --> 00:10:09,100

moving antennas to uplink and downlink

240

00:10:12,960 --> 00:10:10,930

data from the spacecraft as they quickly

241

00:10:14,699 --> 00:10:12,970

fly by and you have to try to do it in

242

00:10:16,470 --> 00:10:14,709

the shortest amount of time possible so

243

00:10:19,650 --> 00:10:16,480

it's fun to challenge each other to beat

244

00:10:21,150 --> 00:10:19,660

your lowest time with your video we also

245

00:10:22,829 --> 00:10:21,160

have one last kids activity that I'd

246

00:10:25,829 --> 00:10:22,839

like to mention and it's called color

247

00:10:27,569 --> 00:10:25,839

with NASA and our color with NASA DSN

248

00:10:29,939 --> 00:10:27,579

video is with Amy Smith and amy is an

249

00:10:32,009 --> 00:10:29,949

engineer for the DSN who builds these

250

00:10:33,749 --> 00:10:32,019

giant antennas and with her video you

251
00:10:35,850 --> 00:10:33,759
have the option to download videos on

252
00:10:37,350 --> 00:10:35,860
coloring page ahead of time and then as

253
00:10:39,900 --> 00:10:37,360
you watch her video you can color along

254
00:10:41,129 --> 00:10:39,910
along with Amy and her two sons as she

255
00:10:44,400 --> 00:10:41,139
explains the different parts of the

256
00:10:46,620 --> 00:10:44,410
antenna and what they do so now a couple

257
00:10:49,949 --> 00:10:46,630
of questions for dr. Lazio I think we

258
00:10:52,379 --> 00:10:49,959
have a few here to pick from so Joseph

259
00:10:57,300 --> 00:10:52,389
on YouTube wants to know how old is the

260
00:11:01,220 --> 00:10:57,310
Deep Space Network a great question it

261
00:11:03,389 --> 00:11:01,230
celebrated its 50th anniversary in 2013

262
00:11:06,600 --> 00:11:03,399
so I always have to do the math that

263
00:11:09,300 --> 00:11:06,610

makes it fifteen seven years old this

264

00:11:10,470 --> 00:11:09,310

year but yeah it's been around in fact

265

00:11:16,559 --> 00:11:10,480

some of the antennas have been around

266

00:11:19,259 --> 00:11:16,569

since essentially before NASA Wow great

267

00:11:21,240 --> 00:11:19,269

and Timmy on Facebook asks how often our

268

00:11:27,329 --> 00:11:21,250

communications disrupted by solar flares

269

00:11:35,009 --> 00:11:32,069

if they are disrupt infrequent if it's

270

00:11:39,150 --> 00:11:35,019

disrupted it's most likely an issue with

271

00:11:41,699 --> 00:11:39,160

the spacecraft that some aspect of the

272

00:11:44,009 --> 00:11:41,709

Sun stellar went the solar wind will

273

00:11:47,699 --> 00:11:44,019

cause a problem with the spacecraft it

274

00:11:49,079 --> 00:11:47,709

will go into a safe mode but again one

275

00:11:50,519 --> 00:11:49,089

of the reasons for having such large

276

00:11:52,829 --> 00:11:50,529

antennas is that the spacecraft

277

00:11:56,490 --> 00:11:52,839

essentially backup systems or they have

278

00:11:59,309 --> 00:11:56,500

ways of communicating even if they've

279

00:12:02,249 --> 00:11:59,319

been zapped if as it were so they can

280

00:12:03,809 --> 00:12:02,259

essentially call for help and the DSN

281

00:12:05,429 --> 00:12:03,819

antennas are still sensitive enough to

282

00:12:07,920 --> 00:12:05,439

be able to receive their signals and

283

00:12:13,139 --> 00:12:07,930

then send commands up to us some sense

284

00:12:16,290 --> 00:12:13,149

often reboot them great another question

285

00:12:18,689 --> 00:12:16,300

from Facebook from Tim and he asks do

286

00:12:26,610 --> 00:12:18,699

transmissions for the DSN propagate in a

287

00:12:31,670 --> 00:12:26,620

vacuum the same as in air yes the only

288

00:12:34,710 --> 00:12:31,680

difference between going through air and

289

00:12:37,170 --> 00:12:34,720

space is that they travel a little bit

290

00:12:39,960 --> 00:12:37,180

slower fractional amount slower when

291

00:12:44,879 --> 00:12:39,970

they go through air when then when they

292

00:12:47,519 --> 00:12:44,889

go through space and in fact you will

293

00:12:48,720 --> 00:12:47,529

not really touch on it too much but

294

00:12:51,960 --> 00:12:48,730

that's one of the ways we extract

295

00:12:53,670 --> 00:12:51,970

science out of the DSN is by watching

296

00:12:58,100 --> 00:12:53,680

how the signals propagate through

297

00:13:01,259 --> 00:12:58,110

another planet's atmosphere for instance

298

00:13:04,110 --> 00:13:01,269

wow that's really cool and we have 12

299

00:13:06,269 --> 00:13:04,120

year-old astro boy 25 on YouTube who

300

00:13:12,079 --> 00:13:06,279

would like to know how long are the

301
00:13:19,559 --> 00:13:17,850
excellent yeah the DSN still there are

302
00:13:22,710 --> 00:13:19,569
some spacecraft in there that are old

303
00:13:25,530 --> 00:13:22,720
enough that they still use what what in

304
00:13:28,650 --> 00:13:25,540
the DSN is called s-band so this is a

305
00:13:33,360 --> 00:13:28,660
frequency of about 2.3 gigahertz or it's

306
00:13:37,170 --> 00:13:33,370
wavelengths of about 13 centimetres most

307
00:13:40,440 --> 00:13:37,180
of the spacecraft these days use x-band

308
00:13:43,170 --> 00:13:40,450
which is about 8 gigahertz

309
00:13:47,730 --> 00:13:43,180
about four centimeters something like

310
00:13:49,920 --> 00:13:47,740
that and for a variety of reasons it

311
00:13:52,800 --> 00:13:49,930
would be nice to have spacecraft move to

312
00:13:55,400 --> 00:13:52,810
what we call typically around ka-band

313
00:13:57,840 --> 00:13:55,410

which is about 30 gigahertz so that's a

314

00:13:59,550 --> 00:13:57,850

wavelength of about one centimeter and

315

00:14:02,189 --> 00:13:59,560

in fact one of the reasons for moving to

316

00:14:04,769 --> 00:14:02,199

ka-band is it is generally less

317

00:14:14,310 --> 00:14:04,779

susceptible to effects from the solar

318

00:14:16,410 --> 00:14:14,320

wind great Jose on Facebook asks what's

319

00:14:18,449 --> 00:14:16,420

your receiver dynamic range and what is

320

00:14:24,420 --> 00:14:18,459

the faintest signal you can recover and

321

00:14:26,550 --> 00:14:24,430

demodulate well of course the one

322

00:14:28,319 --> 00:14:26,560

example of faintest signal is the

323

00:14:30,420 --> 00:14:28,329

Voyager spacecraft both of which are

324

00:14:34,740 --> 00:14:30,430

beyond now officially beyond the solar

325

00:14:38,550 --> 00:14:34,750

system on you know the the signals are

326

00:14:40,769 --> 00:14:38,560

given in billionths of a watt a better

327

00:14:43,199 --> 00:14:40,779

way of thinking about it is that if you

328

00:14:45,840 --> 00:14:43,209

were to add up all of if you imagine

329

00:14:47,579 --> 00:14:45,850

receiving the signals from Voyager and

330

00:14:49,319 --> 00:14:47,589

asking how long would it take the

331

00:14:51,630 --> 00:14:49,329

antennas to collect enough energy to

332

00:14:53,790 --> 00:14:51,640

power say the light in your refrigerator

333

00:14:55,889 --> 00:14:53,800

that takes something like the age of the

334

00:14:58,620 --> 00:14:55,899

universe so the signals are incredibly

335

00:15:00,269 --> 00:14:58,630

faint and they have to you know the

336

00:15:02,400 --> 00:15:00,279

signal the streamers have to have a

337

00:15:03,689 --> 00:15:02,410

decent dynamic range in order to pick

338

00:15:06,240 --> 00:15:03,699

them out it's actually more about the

339

00:15:08,579 --> 00:15:06,250

backend processing even the receiver

340

00:15:10,740 --> 00:15:08,589

dynamic range per se but but the signals

341

00:15:17,460 --> 00:15:10,750

are incredibly faint and it's measured

342

00:15:20,069 --> 00:15:17,470

in billions of a billions of a lot James

343

00:15:22,769 --> 00:15:20,079

on a yeah one last question yeah okay

344

00:15:24,630 --> 00:15:22,779

our uplink and downlink capabilities of

345

00:15:28,740 --> 00:15:24,640

the DSN sufficient for future manned

346

00:15:31,800 --> 00:15:28,750

lunar and Mars missions yes yes in fact

347

00:15:34,079 --> 00:15:31,810

the DSN some of the things that the DSN

348

00:15:36,210 --> 00:15:34,089

is doing right now is preparing for the

349

00:15:40,290 --> 00:15:36,220

future Artemis launches both the

350

00:15:43,350 --> 00:15:40,300

uncrewed and crewed missions in fact the

351
00:15:45,960 --> 00:15:43,360
DSN was integral to the Apollo missions

352
00:15:50,430 --> 00:15:45,970
and it will be an integral part of the

353
00:15:53,009 --> 00:15:50,440
Artemis missions as well there are a lot

354
00:15:53,790 --> 00:15:53,019
of great science questions that were in

355
00:15:57,600 --> 00:15:53,800
that

356
00:15:59,009 --> 00:15:57,610
this has been called the world's largest

357
00:16:00,829 --> 00:15:59,019
science instrument so it's not just

358
00:16:03,210 --> 00:16:00,839
about sending and receiving data

359
00:16:06,480 --> 00:16:03,220
something's coming up this month and

360
00:16:07,829 --> 00:16:06,490
it's not just Mars 2020 it might be good

361
00:16:09,930 --> 00:16:07,839
way to explain how we use some of these

362
00:16:12,600 --> 00:16:09,940
sites this as a science instrument so if

363
00:16:14,690 --> 00:16:12,610

we bring up image eight tell us what's

364

00:16:17,430 --> 00:16:14,700

going to happen later this month Joe

365

00:16:19,590 --> 00:16:17,440

yeah this is a another example of one of

366

00:16:21,509 --> 00:16:19,600

the missions in the solar system this is

367

00:16:25,410 --> 00:16:21,519

an artist's impression of the Juno

368

00:16:27,860 --> 00:16:25,420

spacecraft over Jupiter later this month

369

00:16:30,750 --> 00:16:27,870

Juno will do what is called a Perry Jove

370

00:16:32,790 --> 00:16:30,760

it has a very elliptical orbit so it

371

00:16:35,519 --> 00:16:32,800

goes very far out for a long time and

372

00:16:39,269 --> 00:16:35,529

then it comes sweeping by Jupiter very

373

00:16:41,790 --> 00:16:39,279

quickly just skimming the cloud tops and

374

00:16:44,220 --> 00:16:41,800

so that is called a Perry Jove that

375

00:16:47,250 --> 00:16:44,230

event is is occurring later this month

376

00:16:48,990 --> 00:16:47,260

so we actually the reason there are a

377

00:16:51,569 --> 00:16:49,000

couple reasons for doing this one of

378

00:16:57,660 --> 00:16:51,579

them is illustrated in the next actually

379

00:17:01,019 --> 00:16:57,670

video the the spacecraft swoops very

380

00:17:03,300 --> 00:17:01,029

close to the cloud tops and if you see

381

00:17:06,510 --> 00:17:03,310

there's a blue curve here so the blue

382

00:17:08,850 --> 00:17:06,520

curve is what we might predict the orbit

383

00:17:12,000 --> 00:17:08,860

the trajectory the path of the

384

00:17:14,309 --> 00:17:12,010

spacecraft to be and then the orange

385

00:17:17,329 --> 00:17:14,319

curve is actually what the measured

386

00:17:21,419 --> 00:17:17,339

looking orbit is measured to be so as

387

00:17:24,600 --> 00:17:21,429

the spacecraft moves past Jupiter the

388

00:17:27,150 --> 00:17:24,610

clouds are different height and that

389

00:17:29,580 --> 00:17:27,160

affects the orbit ever-so-slight in fact

390

00:17:31,380 --> 00:17:29,590

let me back up for a second why does the

391

00:17:33,510 --> 00:17:31,390

spacecraft have its orbit it's because

392

00:17:35,909 --> 00:17:33,520

it's being tugged on by the gravity of

393

00:17:38,040 --> 00:17:35,919

Jupiter what causes the gravity of

394

00:17:40,320 --> 00:17:38,050

Jupiter it's the mass of Jupiter

395

00:17:43,680 --> 00:17:40,330

so there's slight changes where the mass

396

00:17:47,100 --> 00:17:43,690

is in Jupiter or any planet that will

397

00:17:48,900 --> 00:17:47,110

affect that will slightly tug on the

398

00:17:50,490 --> 00:17:48,910

orbit of the spacecraft the path of the

399

00:17:53,400 --> 00:17:50,500

spacecraft and so that's what you're

400

00:17:55,650 --> 00:17:53,410

seeing is in this video the orange are

401
00:17:57,419 --> 00:17:55,660
the slight tugs caused by slight

402
00:18:01,020 --> 00:17:57,429
deviation and slight differences in

403
00:18:02,460 --> 00:18:01,030
where the mass is in Jupiter and then

404
00:18:04,890 --> 00:18:02,470
the signal the wavy thing at the bottom

405
00:18:06,900 --> 00:18:04,900
illustrates the that's actually an

406
00:18:07,470 --> 00:18:06,910
example of how one measures the signal

407
00:18:10,590 --> 00:18:07,480
with the D

408
00:18:12,870 --> 00:18:10,600
and the key aspect of the DSN as a

409
00:18:15,480 --> 00:18:12,880
science instrument is that it's

410
00:18:18,350 --> 00:18:15,490
precision is is so high that it can make

411
00:18:21,360 --> 00:18:18,360
these kind of measurements and discern

412
00:18:23,340 --> 00:18:21,370
differences in for instance how deep the

413
00:18:28,200 --> 00:18:23,350

clouds are so if you go to the next

414

00:18:31,080 --> 00:18:28,210

video one of the key one of the key

415

00:18:33,780 --> 00:18:31,090

science aspects of the Juno mission is

416

00:18:35,640 --> 00:18:33,790

to unveiled Jupiter so I've sort of

417

00:18:38,220 --> 00:18:35,650

hinted at it the different clouds are

418

00:18:41,340 --> 00:18:38,230

actually slightly different layers which

419

00:18:43,170 --> 00:18:41,350

means that gravity the tug on the

420

00:18:45,720 --> 00:18:43,180

spacecraft orbit is slightly different

421

00:18:48,090 --> 00:18:45,730

but the precision is so high the

422

00:18:50,820 --> 00:18:48,100

scientists the science team can actually

423

00:18:54,020 --> 00:18:50,830

peer essentially peer into the core of

424

00:18:57,570 --> 00:18:54,030

Jupiter so prior to Geno's launch

425

00:19:00,780 --> 00:18:57,580

everybody expected that it had a rocky

426
00:19:03,210 --> 00:19:00,790
core several times the mass of Earth and

427
00:19:05,850 --> 00:19:03,220
what has been found is that in fact the

428
00:19:08,550 --> 00:19:05,860
core is somewhat more diffuse the

429
00:19:10,830 --> 00:19:08,560
overlying hydrogen has diffused into

430
00:19:12,840 --> 00:19:10,840
that rock and often the technical term

431
00:19:16,740 --> 00:19:12,850
used as the core is more fuzzy than we

432
00:19:21,180 --> 00:19:16,750
thought not before the genome is a

433
00:19:23,040 --> 00:19:21,190
technical term fuzzy I just amazed that

434
00:19:25,110 --> 00:19:23,050
this can be used in that way that this

435
00:19:27,030 --> 00:19:25,120
is used as a science instrument when

436
00:19:29,460 --> 00:19:27,040
we're pretty and that wasn't what it was

437
00:19:31,560 --> 00:19:29,470
designed for back when it was the

438
00:19:33,600 --> 00:19:31,570

origins of this when it was built it's

439

00:19:36,420 --> 00:19:33,610

not just planets it can also work and

440

00:19:40,560 --> 00:19:36,430

detect other things correct that's right

441

00:19:42,500 --> 00:19:40,570

if we go to the next video you couldn't

442

00:19:45,600 --> 00:19:42,510

ask the question well if we can send

443

00:19:48,780 --> 00:19:45,610

commands radio signals up to spacecraft

444

00:19:49,980 --> 00:19:48,790

then the DSN team antennas can send them

445

00:19:52,560 --> 00:19:49,990

to other things as well

446

00:19:54,660 --> 00:19:52,570

this video is illustrating how one would

447

00:19:56,340 --> 00:19:54,670

send a radio signal and have it reflect

448

00:20:00,090 --> 00:19:56,350

off something else in the solar system

449

00:20:01,380 --> 00:20:00,100

like an asteroid or planet and the

450

00:20:03,120 --> 00:20:01,390

listeners may have already figured out

451
00:20:07,140 --> 00:20:03,130
well this is essentially radar so the

452
00:20:09,420 --> 00:20:07,150
DSN does radar by sending powerful radio

453
00:20:10,980 --> 00:20:09,430
signals out into the solar system and

454
00:20:13,590 --> 00:20:10,990
then measuring what happens when they're

455
00:20:16,100 --> 00:20:13,600
reflected off planets or for instance

456
00:20:19,110 --> 00:20:16,110
off asteroids

457
00:20:20,070 --> 00:20:19,120
so science for the DSN just takes us all

458
00:20:22,140 --> 00:20:20,080
over it doesn't just have to be

459
00:20:24,539 --> 00:20:22,150
asteroids or I mean there's some pretty

460
00:20:27,570 --> 00:20:24,549
big discoveries for from using the DSN

461
00:20:31,710 --> 00:20:27,580
as a science instrument that's right if

462
00:20:33,630 --> 00:20:31,720
you go to the next image it shows some

463
00:20:36,180 --> 00:20:33,640

of the key DSN radiant radar

464

00:20:40,320 --> 00:20:36,190

accomplishments everything from

465

00:20:43,289 --> 00:20:40,330

measuring Venus Venus orbits sorry it

466

00:20:47,190 --> 00:20:43,299

rotates the opposite way from Earth

467

00:20:49,140 --> 00:20:47,200

mercury mean and Mars some of the

468

00:20:52,500 --> 00:20:49,150

first-fruit well the first reflections

469

00:20:54,899 --> 00:20:52,510

from the surface of Titan Saturn's mean

470

00:20:59,340 --> 00:20:54,909

that might be kind of what like the

471

00:21:01,770 --> 00:20:59,350

earth was early in its history first

472

00:21:03,060 --> 00:21:01,780

reflections from mercury showing it even

473

00:21:05,370 --> 00:21:03,070

though it's the closest planet to the

474

00:21:07,980 --> 00:21:05,380

Sun and you think maybe really hot there

475

00:21:09,390 --> 00:21:07,990

is what appears to be ice in its polar

476
00:21:12,419 --> 00:21:09,400
regions and it's a North and South Pole

477
00:21:13,980 --> 00:21:12,429
and all of the image that you images

478
00:21:17,399 --> 00:21:13,990
that are seen here on the right hand

479
00:21:20,250 --> 00:21:17,409
side these are radar images from

480
00:21:22,500 --> 00:21:20,260
spacecraft that actually went visited

481
00:21:25,049 --> 00:21:22,510
these different places being as Titan

482
00:21:26,640 --> 00:21:25,059
and Mercury but the key thing is one of

483
00:21:29,399 --> 00:21:26,650
the reasons that they carried radar was

484
00:21:32,610 --> 00:21:29,409
the fundamental foundational work that

485
00:21:34,590 --> 00:21:32,620
the DSN radar did to suggest here are

486
00:21:37,560 --> 00:21:34,600
new science questions that really demand

487
00:21:43,440 --> 00:21:37,570
a spacecraft carry a very big powerful

488
00:21:45,510 --> 00:21:43,450

radar instruments on this feels awesome

489

00:21:47,039 --> 00:21:45,520

but it also feels far away I mean it is

490

00:21:48,149 --> 00:21:47,049

the Deep Space Network so that makes

491

00:21:50,760 --> 00:21:48,159

sense

492

00:21:54,570 --> 00:21:50,770

but are there any practical aspects for

493

00:21:57,570 --> 00:21:54,580

us here on earth and that this could be

494

00:22:01,140 --> 00:21:57,580

relevant for us oh definitely

495

00:22:03,810 --> 00:22:01,150

the next image shows or the next both

496

00:22:05,310 --> 00:22:03,820

yeah the next image shows an example one

497

00:22:07,289 --> 00:22:05,320

of the things that the the Goldstone

498

00:22:10,740 --> 00:22:07,299

radar does very frequently these days

499

00:22:11,850 --> 00:22:10,750

which is observe asteroids and there are

500

00:22:16,500 --> 00:22:11,860

a couple of reasons for observing

501
00:22:19,350 --> 00:22:16,510
asteroids one is against audience this

502
00:22:23,720 --> 00:22:19,360
this asteroid that you see here which

503
00:22:26,580 --> 00:22:23,730
goes by the prosaic name of 2017 dq6

504
00:22:28,620 --> 00:22:26,590
you can see that it's it's not round it

505
00:22:31,260 --> 00:22:28,630
has these very sharp angular

506
00:22:33,300 --> 00:22:31,270
features with facets and in fact when

507
00:22:34,920 --> 00:22:33,310
press release came out showing his image

508
00:22:38,910 --> 00:22:34,930
it said it compared it to a dungeon &

509
00:22:40,380 --> 00:22:38,920
dragon die one of the other important

510
00:22:41,670 --> 00:22:40,390
reasons there are there will be

511
00:22:43,350 --> 00:22:41,680
spacecraft Dhoni

512
00:22:46,320 --> 00:22:43,360
actually there are spacecraft at

513
00:22:49,620 --> 00:22:46,330

asteroids now going soon but that first

514

00:22:52,800 --> 00:22:49,630

video of the radar you could think about

515

00:22:56,070 --> 00:22:52,810

well if I can time how long it takes to

516

00:22:58,590 --> 00:22:56,080

go from the radar the radio radar signal

517

00:23:00,300 --> 00:22:58,600

go from the DSN bounce off and come back

518

00:23:02,610 --> 00:23:00,310

there are no how far way they the

519

00:23:04,530 --> 00:23:02,620

asteroid is and so that allows me to get

520

00:23:07,200 --> 00:23:04,540

its orbit which is important for sending

521

00:23:09,510 --> 00:23:07,210

a spacecraft there this movie is

522

00:23:13,260 --> 00:23:09,520

actually showing an example another de

523

00:23:15,240 --> 00:23:13,270

science discovery of a little moon

524

00:23:18,000 --> 00:23:15,250

around one of the asteroids one of the

525

00:23:20,040 --> 00:23:18,010

final reasons for doing the radar work

526

00:23:22,650 --> 00:23:20,050

is that if we get the orbit very

527

00:23:25,770 --> 00:23:22,660

precisely we can predict where the

528

00:23:27,330 --> 00:23:25,780

asteroid will be in the future and that

529

00:23:29,130 --> 00:23:27,340

allows us to assess what is the

530

00:23:31,050 --> 00:23:29,140

probability what is the chance that it's

531

00:23:34,170 --> 00:23:31,060

going to hit the earth now at the moment

532

00:23:36,720 --> 00:23:34,180

you know of nothing and absolutely no

533

00:23:38,940 --> 00:23:36,730

chance but there are our new asteroids

534

00:23:41,190 --> 00:23:38,950

being discovered all the time so when

535

00:23:43,740 --> 00:23:41,200

the radar can illuminate one of these

536

00:23:45,660 --> 00:23:43,750

things and determine its orbit that is

537

00:23:49,580 --> 00:23:45,670

used as part of the determination of

538

00:23:53,580 --> 00:23:49,590

what is the possibility of future impact

539

00:23:57,120 --> 00:23:53,590

so orbit determination with objects that

540

00:23:59,190 --> 00:23:57,130

are coming towards us the DSN is a part

541

00:24:02,700 --> 00:23:59,200

of it really helps us detect those

542

00:24:05,480 --> 00:24:02,710

things out there but they're the only

543

00:24:08,780 --> 00:24:05,490

ones that are doing that right now right

544

00:24:11,460 --> 00:24:08,790

not quite the the next image shows

545

00:24:13,080 --> 00:24:11,470

actually the world's radar in for

546

00:24:16,110 --> 00:24:13,090

planetary invade our infrastructure so

547

00:24:19,680 --> 00:24:16,120

the the antenna in the upper left is the

548

00:24:22,500 --> 00:24:19,690

Goldstone radar the antenna in the upper

549

00:24:26,460 --> 00:24:22,510

right is the Arecibo Observatory Arecibo

550

00:24:29,640 --> 00:24:26,470

telescope in Puerto Rico and these are

551

00:24:33,390 --> 00:24:29,650

all most if so Arecibo has a very

552

00:24:35,700 --> 00:24:33,400

powerful radar it's a very it's it's 300

553

00:24:38,880 --> 00:24:35,710

meters in diameter but as you can tell

554

00:24:42,399 --> 00:24:38,890

it's built into a valley so it can only

555

00:24:46,999 --> 00:24:42,409

see a fraction in the sky about 1/3

556

00:24:49,580 --> 00:24:47,009

goldstone is a little bit smaller but it

557

00:24:52,039 --> 00:24:49,590

can observe us as you can sort of hint

558

00:24:55,009 --> 00:24:52,049

by the shape of it it can be pointed

559

00:24:56,450 --> 00:24:55,019

nearly anywhere in the sky at least in

560

00:24:59,060 --> 00:24:56,460

the northern hemisphere so we can see

561

00:25:01,909 --> 00:24:59,070

about 75% of its stock and the two of

562

00:25:04,490 --> 00:25:01,919

them together is what we use for some of

563

00:25:07,879 --> 00:25:04,500

the orbit determination from asteroid

564

00:25:10,700 --> 00:25:07,889

radar in the lower right is the Green

565

00:25:12,799 --> 00:25:10,710

Bank telescope this is does not have a

566

00:25:14,720 --> 00:25:12,809

radar attached to it but it's a very

567

00:25:17,299 --> 00:25:14,730

it's a hundred meter telescope it's big

568

00:25:19,940 --> 00:25:17,309

it's sensitive so it sometimes is used

569

00:25:22,310 --> 00:25:19,950

for by static observations in which

570

00:25:24,619 --> 00:25:22,320

Goldstone or Arecibo transmits and

571

00:25:26,419 --> 00:25:24,629

Greenbank which seems and that's

572

00:25:29,090 --> 00:25:26,429

particularly important when an asteroid

573

00:25:33,049 --> 00:25:29,100

is close by and then the lower left is

574

00:25:34,759 --> 00:25:33,059

the Canberra 70 antenna this is one of

575

00:25:37,789 --> 00:25:34,769

the sisters to Goldstone 70-meter

576

00:25:39,110 --> 00:25:37,799

antenna and it has a not quite as part

577

00:25:42,499 --> 00:25:39,120

back it's at the moment it's being

578

00:25:45,320 --> 00:25:42,509

upgraded but next year it will come back

579

00:25:47,810 --> 00:25:45,330

it will have a more powerful transmitter

580

00:25:50,389 --> 00:25:47,820

than it did last year it won't be quite

581

00:25:51,919 --> 00:25:50,399

as strong as Goldstone still but it will

582

00:25:53,539 --> 00:25:51,929

form the complement it will help form

583

00:25:57,169 --> 00:25:53,549

the complement of what the world has for

584

00:25:59,509 --> 00:25:57,179

for planetary makeup so there's a lot of

585

00:26:01,639 --> 00:25:59,519

collaboration not just with the Deep

586

00:26:04,480 --> 00:26:01,649

Space Network helping other agencies but

587

00:26:06,470 --> 00:26:04,490

also with this with orbit trajectory

588

00:26:09,230 --> 00:26:06,480

Heather you know something a little bit

589

00:26:11,029 --> 00:26:09,240

about collaboration why don't you come

590

00:26:13,389 --> 00:26:11,039

back in here and tell us a few things

591

00:26:16,399 --> 00:26:13,399

that might be helpful for everybody

592

00:26:18,379 --> 00:26:16,409

sure another amazing thing about the DSN

593

00:26:20,749 --> 00:26:18,389

is we have 134 meter antennas

594

00:26:22,730 --> 00:26:20,759

specifically dedicated only to education

595

00:26:24,830 --> 00:26:22,740

so it's called the Goldstone Apple

596

00:26:27,049 --> 00:26:24,840

Valley radio telescope or gabart and

597

00:26:29,180 --> 00:26:27,059

it's found at the Goldstone DSN Complex

598

00:26:31,009 --> 00:26:29,190

here in California it's a one-of-a-kind

599

00:26:32,629 --> 00:26:31,019

educational program in partnership with

600

00:26:34,759 --> 00:26:32,639

the Louis Center for educational

601
00:26:36,649 --> 00:26:34,769
research and after a teacher training

602
00:26:38,869 --> 00:26:36,659
and some initial lessons students get to

603
00:26:40,700 --> 00:26:38,879
control the gabart antenna live by

604
00:26:42,799 --> 00:26:40,710
typing in coordinates to a specific

605
00:26:44,990 --> 00:26:42,809
target that relates to one of the four

606
00:26:47,509 --> 00:26:45,000
programs they get to choose from which

607
00:26:49,610 --> 00:26:47,519
are SETI Jupiter quest Solar patrol or

608
00:26:51,169 --> 00:26:49,620
black hole patrol then the students

609
00:26:53,210 --> 00:26:51,179
watch the data come down and help

610
00:26:55,880 --> 00:26:53,220
process it there by participating in

611
00:26:57,740 --> 00:26:55,890
real scientific research so teach

612
00:26:59,210 --> 00:26:57,750
or informal educators who are interested

613
00:27:03,650 --> 00:26:59,220

in learning more about this program can

614

00:27:06,290 --> 00:27:03,660

go to gabart Gav Artie Lewis Center org

615

00:27:09,260 --> 00:27:06,300

and I see there are a few more questions

616

00:27:12,020 --> 00:27:09,270

for dr. Lazio Ronald on YouTube would

617

00:27:17,320 --> 00:27:12,030

like to know how long does it take to

618

00:27:29,450 --> 00:27:20,480

the furthest would be the voyagers and

619

00:27:31,700 --> 00:27:29,460

that takes about 40 hours alright on

620

00:27:33,920 --> 00:27:31,710

YouTube is asking how do you gain

621

00:27:41,500 --> 00:27:33,930

control of communication when an antenna

622

00:27:49,400 --> 00:27:46,190

well we actually I guess I didn't quite

623

00:27:53,180 --> 00:27:49,410

say this earlier each complex has

624

00:27:55,640 --> 00:27:53,190

multiple antennas so there's 170 meter

625

00:27:57,710 --> 00:27:55,650

ready antenna each complex and then

626

00:28:00,020 --> 00:27:57,720

there are multiple 34 meter at PI

627

00:28:02,660 --> 00:28:00,030

antennas in fact there are two under

628

00:28:05,720 --> 00:28:02,670

construction currently in Madrid in

629

00:28:06,950 --> 00:28:05,730

Spain and preparations are being our

630

00:28:10,850 --> 00:28:06,960

preparations are underway to build

631

00:28:12,980 --> 00:28:10,860

another one at Goldstone so the idea is

632

00:28:15,560 --> 00:28:12,990

if something were to happen to one of

633

00:28:18,980 --> 00:28:15,570

the antennas at a complex there are

634

00:28:21,110 --> 00:28:18,990

other antennas around to essentially

635

00:28:24,800 --> 00:28:21,120

pick up the load or that can shuffle

636

00:28:28,040 --> 00:28:24,810

things around and it depends upon the

637

00:28:29,990 --> 00:28:28,050

severity of what's happening when there

638

00:28:32,780 --> 00:28:30,000

are particularly high-profile events of

639

00:28:35,350 --> 00:28:32,790

course often multiple antennas will be

640

00:28:39,530 --> 00:28:35,360

directed toward that particular

641

00:28:41,120 --> 00:28:39,540

high-profile event so that if for some

642

00:28:42,410 --> 00:28:41,130

reason something happens to want to

643

00:28:49,050 --> 00:28:42,420

intent of this there's another one

644

00:28:52,620 --> 00:28:49,060

that's on on the target as well great

645

00:28:54,360 --> 00:28:52,630

James on Facebook asks is NASA looking

646

00:28:56,670 --> 00:28:54,370

at replacement of the DSN with

647

00:29:02,100 --> 00:28:56,680

navigation systems such as the pulsar

648

00:29:05,940 --> 00:29:02,110

x-ray navigation no not at the current

649

00:29:09,120 --> 00:29:05,950

time there's that's been in a research

650

00:29:12,510 --> 00:29:09,130

project but certainly for the

651
00:29:16,020 --> 00:29:12,520
foreseeable future the navigation will

652
00:29:18,240 --> 00:29:16,030
be performed either by radio possibly in

653
00:29:22,350 --> 00:29:18,250
the future by some optical means in fact

654
00:29:24,750 --> 00:29:22,360
I guess I should clarify that a bit in

655
00:29:28,830 --> 00:29:24,760
some cases for instance when New

656
00:29:30,840 --> 00:29:28,840
Horizons swung past Pluto part of the

657
00:29:33,120 --> 00:29:30,850
navigation was done by taking pictures

658
00:29:35,340 --> 00:29:33,130
and optical pictures visible wavelength

659
00:29:37,770 --> 00:29:35,350
pictures from the spacecraft and using

660
00:29:41,490 --> 00:29:37,780
that to position where the spacecraft is

661
00:29:45,510 --> 00:29:41,500
relative to the well relatively where it

662
00:29:47,370 --> 00:29:45,520
was papito but that that is a well proof

663
00:29:50,460 --> 00:29:47,380

both of those are well proven techniques

664

00:29:51,960 --> 00:29:50,470

they make use of the technologies that

665

00:29:54,060 --> 00:29:51,970

are probably going to be carried by the

666

00:29:55,860 --> 00:29:54,070

spacecraft anyway so for the foreseeable

667

00:29:57,570 --> 00:29:55,870

future certainly for the next half

668

00:30:02,010 --> 00:29:57,580

century or so I think radio and optical

669

00:30:04,800 --> 00:30:02,020

will be the way to go so lots of DSN for

670

00:30:08,760 --> 00:30:04,810

a while that's wonderful got time for a

671

00:30:10,530 --> 00:30:08,770

few more Heather okay veikkaus on

672

00:30:12,810 --> 00:30:10,540

youtube wants to know how do you ensure

673

00:30:17,540 --> 00:30:12,820

that the signals coming from Voyager are

674

00:30:26,460 --> 00:30:23,970

the well actually I suppose the most

675

00:30:28,590 --> 00:30:26,470

simple answer to that is if you imagine

676

00:30:31,620 --> 00:30:28,600

all those science fiction movies with a

677

00:30:36,630 --> 00:30:31,630

very dense asteroid though that science

678

00:30:39,240 --> 00:30:36,640

fiction the asteroid belt is a belt in

679

00:30:41,730 --> 00:30:39,250

the sense of it has more asteroids in it

680

00:30:43,320 --> 00:30:41,740

than elsewhere in the solar system but

681

00:30:45,120 --> 00:30:43,330

you could travel a long time in the

682

00:30:48,150 --> 00:30:45,130

asteroid belt but never hit anything big

683

00:30:50,570 --> 00:30:48,160

and certainly nothing there's not enough

684

00:30:53,220 --> 00:30:50,580

material in the asteroid belt to absorb

685

00:30:56,490 --> 00:30:53,230

anything anything close to any of the

686

00:30:59,400 --> 00:30:56,500

signals and and for that matter even you

687

00:31:02,330 --> 00:30:59,410

know the signals from Voyager penetrate

688

00:31:04,370 --> 00:31:02,340

clouds quite happily here on earth

689

00:31:08,750 --> 00:31:04,380

so the for all intents and purposes the

690

00:31:12,090 --> 00:31:08,760

asteroid belt is is transparent

691

00:31:18,000 --> 00:31:15,990

okay mark on Facebook wants to know what

692

00:31:24,150 --> 00:31:18,010

happens to the DSN when we switch over

693

00:31:28,020 --> 00:31:24,160

to optical signals a good question

694

00:31:30,810 --> 00:31:28,030

in fact I alluded to the preparations

695

00:31:33,960 --> 00:31:30,820

that are being done at Goldstone for the

696

00:31:36,180 --> 00:31:33,970

next 34 meter antenna that antenna is

697

00:31:37,410 --> 00:31:36,190

intended to be a hybrid antenna so it

698

00:31:39,660 --> 00:31:37,420

will be a radio antenna

699

00:31:42,750 --> 00:31:39,670

it will look all we essentially like all

700

00:31:45,570 --> 00:31:42,760

of its 34 meter sisters except that the

701
00:31:48,300 --> 00:31:45,580
inner portions of the panel's the

702
00:31:52,200 --> 00:31:48,310
metallic panels or will be replaced by

703
00:31:54,210 --> 00:31:52,210
nears and the intent is to enable both

704
00:31:59,400 --> 00:31:54,220
radio and optical functions from the

705
00:32:01,920 --> 00:31:59,410
same antenna and/or laser communication

706
00:32:04,040 --> 00:32:01,930
and the idea part of the idea is that

707
00:32:06,210 --> 00:32:04,050
the antenna is already a big stiff

708
00:32:08,340 --> 00:32:06,220
platform on which you can mount the

709
00:32:10,020 --> 00:32:08,350
mirror so you can use it either as a

710
00:32:13,050 --> 00:32:10,030
receiver for an optical or laser

711
00:32:19,590 --> 00:32:13,060
communication or as the standard radio

712
00:32:22,170 --> 00:32:19,600
frequency right cool very schewe on

713
00:32:28,620 --> 00:32:22,180

facebook asks is the DSN being used to

714

00:32:31,050 --> 00:32:28,630

look for any et signals not not

715

00:32:33,660 --> 00:32:31,060

intentionally other than Heather you

716

00:32:36,510 --> 00:32:33,670

already referred to the the SETI prior

717

00:32:37,350 --> 00:32:36,520

project within gabart study of course

718

00:32:38,610 --> 00:32:37,360

stands for the search for

719

00:32:41,150 --> 00:32:38,620

extraterrestrial intelligence so

720

00:32:44,490 --> 00:32:41,160

students are certainly engaged through

721

00:32:49,020 --> 00:32:44,500

the gabart and town in conducting SETI

722

00:32:53,130 --> 00:32:49,030

observations and I think we've got time

723

00:32:55,890 --> 00:32:53,140

for one more question Heather okay Fred

724

00:32:58,410 --> 00:32:55,900

on Facebook asks how does the receive

725

00:33:02,370 --> 00:32:58,420

data get back to JPL does it go back via

726

00:33:04,260 --> 00:33:02,380

satellite or terrestrial networks yes it

727

00:33:07,760 --> 00:33:04,270

goes by terrestrial network so that's

728

00:33:10,710 --> 00:33:07,770

another part of how the signals of the

729

00:33:13,290 --> 00:33:10,720

aspects to which Brian what started the

730

00:33:15,120 --> 00:33:13,300

signals once they were hit the complexes

731

00:33:17,280 --> 00:33:15,130

then they get transformed into

732

00:33:18,540 --> 00:33:17,290

electrical signals they're sent over

733

00:33:23,010 --> 00:33:18,550

essentially over the Internet

734

00:33:24,870 --> 00:33:23,020

well back to JPL so in fact sometime in

735

00:33:25,769 --> 00:33:24,880

the future if you're when you are able

736

00:33:28,289 --> 00:33:25,779

to take a tour

737

00:33:29,580 --> 00:33:28,299

JPL there is a place at JPL called the

738

00:33:32,339 --> 00:33:29,590

center of the universe because all the

739

00:33:35,969 --> 00:33:32,349

DSN signals run through the Charles

740

00:33:37,589 --> 00:33:35,979

elachi Control Center at JPL before then

741

00:33:42,359 --> 00:33:37,599

they go out to the science teams across

742

00:33:44,450 --> 00:33:42,369

the world so before we wrap up because

743

00:33:47,159 --> 00:33:44,460

though there's so many great questions

744

00:33:48,509 --> 00:33:47,169

and thank you everybody for being

745

00:33:51,239 --> 00:33:48,519

involved in this conversation tonight

746

00:33:52,619 --> 00:33:51,249

but before we go Joe I showed us the

747

00:33:55,320 --> 00:33:52,629

amazing capabilities of the Deep Space

748

00:33:59,820 --> 00:33:55,330

Network I mean if you really had to boil

749

00:34:03,570 --> 00:33:59,830

it down why is the Deep Space Network so

750

00:34:05,549 --> 00:34:03,580

important it's it's one of those

751

00:34:08,430 --> 00:34:05,559

foundational aspects of space

752

00:34:11,039 --> 00:34:08,440

exploration so it's it's very easy to

753

00:34:12,659 --> 00:34:11,049

get attracted to the intrepid spacecraft

754

00:34:16,379 --> 00:34:12,669

going where no spacecraft has gone

755

00:34:19,139 --> 00:34:16,389

before right but if that spacecraft

756

00:34:20,460 --> 00:34:19,149

doesn't have a way to send data back to

757

00:34:22,529 --> 00:34:20,470

the earth if you don't have a way to

758

00:34:26,190 --> 00:34:22,539

send commands to it without that

759

00:34:29,609 --> 00:34:26,200

foundational infrastructure such as the

760

00:34:31,529 --> 00:34:29,619

DSN then we can't make the discoveries

761

00:34:34,919 --> 00:34:31,539

that we want to make we can't in the

762

00:34:37,049 --> 00:34:34,929

future send humans out into space so if

763

00:34:38,639 --> 00:34:37,059

you just think of the same thing as the

764

00:34:41,460 --> 00:34:38,649

internet connections or a cell phone

765

00:34:43,919 --> 00:34:41,470

connection if you lose that it can be a

766

00:34:46,349 --> 00:34:43,929

really bad day and so the DSN it's one

767

00:34:49,609 --> 00:34:46,359

of these foundational aspects sometimes

768

00:34:52,049 --> 00:34:49,619

that invisible but always there and

769

00:34:55,440 --> 00:34:52,059

don't leave earth without us if you want

770

00:34:57,029 --> 00:34:55,450

to go explore space don't leave work

771

00:34:59,670 --> 00:34:57,039

without you if you want to go in the

772

00:35:01,589 --> 00:34:59,680

Splore space I think that's a wonderful

773

00:35:03,180 --> 00:35:01,599

thing to end this on I'm folks that's

774

00:35:05,190 --> 00:35:03,190

all the time we have for this evening I

775

00:35:07,289 --> 00:35:05,200

would like to thank dr. Joe Lazio

776

00:35:08,910 --> 00:35:07,299

Heather Doyle and everyone involved

777

00:35:11,250 --> 00:35:08,920

behind the scenes that really make these

778

00:35:12,720 --> 00:35:11,260

talks possible and I'd like to thank you

779

00:35:15,660 --> 00:35:12,730

once again our audience at home for

780

00:35:17,789 --> 00:35:15,670

tuning in and engaging with us your

781

00:35:19,740 --> 00:35:17,799

voice is your questions really this is

782

00:35:22,079 --> 00:35:19,750

your space program and we want you to be

783

00:35:24,900 --> 00:35:22,089

a part of it next month we will be

784

00:35:27,569 --> 00:35:24,910

asking the question Venus Earth's evil

785

00:35:30,420 --> 00:35:27,579

twin or just misunderstood we hope to