

The CSIRO Parkes Radio Telescope



One of the
world's great
research
instruments

Commonwealth Scientific and Industrial
Research Organisation (CSIRO)

1
00:00:06,070 --> 00:00:03,510
good afternoon

2
00:00:08,870 --> 00:00:06,080
my name is joan johnson freeze and it is

3
00:00:10,950 --> 00:00:08,880
my pleasure to share this fifth panel on

4
00:00:13,030 --> 00:00:10,960
institutional arrangements in solar

5
00:00:15,110 --> 00:00:13,040
system exploration

6
00:00:17,510 --> 00:00:15,120
we have four papers prison to be

7
00:00:19,269 --> 00:00:17,520
presented by for astute individuals who

8
00:00:21,670 --> 00:00:19,279
will consider relevant issues based on

9
00:00:24,310 --> 00:00:21,680
their experience and their research all

10
00:00:26,150 --> 00:00:24,320
their bios are available to you so i

11
00:00:26,870 --> 00:00:26,160
won't take the time to go through them i

12
00:00:29,669 --> 00:00:26,880
will

13
00:00:32,310 --> 00:00:29,679

just briefly mention we have jim burke

14

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

from jpl the legendary jim burke it's

15

00:00:35,670 --> 00:00:34,160

been my pleasure to work with him for

16

00:00:36,950 --> 00:00:35,680

years with the international space

17

00:00:39,670 --> 00:00:36,960

university

18

00:00:42,470 --> 00:00:39,680

john cercosian an operations scientist

19

00:00:44,549 --> 00:00:42,480

at csiro which i looked up in its

20

00:00:48,150 --> 00:00:44,559

commonwealth scientific and industrial

21

00:00:50,549 --> 00:00:48,160

research organization from australia

22

00:00:52,549 --> 00:00:50,559

michael neufeld museum curator in the

23

00:00:56,229 --> 00:00:52,559

space history division at the national

24

00:00:58,709 --> 00:00:56,239

air and space museum and peter markovsky

25

00:01:01,349 --> 00:00:58,719

a phd candidate in history of science at

26

00:01:03,189 --> 00:01:01,359

the university of oklahoma

27

00:01:05,429 --> 00:01:03,199

the issues they will be considering are

28

00:01:07,350 --> 00:01:05,439

several institutional management for

29

00:01:09,350 --> 00:01:07,360

example will be considered as will

30

00:01:11,990 --> 00:01:09,360

institutional focus

31

00:01:14,070 --> 00:01:12,000

how management issues arrangements and

32

00:01:15,990 --> 00:01:14,080

focus can affect the ability to execute

33

00:01:18,469 --> 00:01:16,000

a highly sophisticated

34

00:01:20,310 --> 00:01:18,479

science and engineering pro program and

35

00:01:21,990 --> 00:01:20,320

we've already been hearing about that

36

00:01:25,030 --> 00:01:22,000

this morning through different

37

00:01:27,030 --> 00:01:25,040

international collaboration uh examples

38

00:01:29,109 --> 00:01:27,040

and these papers will consider and go

39

00:01:30,550 --> 00:01:29,119

into depth on those issues including

40

00:01:31,990 --> 00:01:30,560

international collaboration the

41

00:01:33,910 --> 00:01:32,000

complexity

42

00:01:36,230 --> 00:01:33,920

and the potential that is added by

43

00:01:37,990 --> 00:01:36,240

expanding missions beyond national or

44

00:01:39,030 --> 00:01:38,000

extending missions beyond national

45

00:01:41,270 --> 00:01:39,040

borders

46

00:01:43,350 --> 00:01:41,280

and clearly the complexity expansion is

47

00:01:44,870 --> 00:01:43,360

across the board not just

48

00:01:46,950 --> 00:01:44,880

with the science and engineering

49

00:01:48,389 --> 00:01:46,960

considerations but with the political

50

00:01:50,310 --> 00:01:48,399

and legal

51
00:01:52,069 --> 00:01:50,320
one point that has really fascinated me

52
00:01:54,630 --> 00:01:52,079
over the years as an

53
00:01:57,270 --> 00:01:54,640
observer and analyst of these

54
00:02:00,550 --> 00:01:57,280
institutional arrangements

55
00:02:02,550 --> 00:02:00,560
is the role and perhaps changing role of

56
00:02:05,030 --> 00:02:02,560
the program manager

57
00:02:06,789 --> 00:02:05,040
i'll give fair warning now to the

58
00:02:09,109 --> 00:02:06,799
panelists that that'll be a question i

59
00:02:10,630 --> 00:02:09,119
will be raising to them and i hope you

60
00:02:12,949 --> 00:02:10,640
the audience will be noting your

61
00:02:15,510 --> 00:02:12,959
questions that they can

62
00:02:17,589 --> 00:02:15,520
address as well we'll follow the same

63
00:02:20,070 --> 00:02:17,599

format as we have

64

00:02:22,390 --> 00:02:20,080

already 20 minute presentations five

65

00:02:24,390 --> 00:02:22,400

minutes of q a and then the panel will

66

00:02:26,630 --> 00:02:24,400

assemble at the end

67

00:02:28,630 --> 00:02:26,640

so with that i would like to introduce

68

00:02:31,430 --> 00:02:28,640

jim burke on to talk about the

69

00:02:33,589 --> 00:02:31,440

foundations of solar system exploration

70

00:02:41,509 --> 00:02:33,599

at jpl how the first mariners and

71

00:02:46,390 --> 00:02:43,589

thank you joan i'd like to begin by

72

00:02:47,830 --> 00:02:46,400

giving you a little background on the

73

00:02:50,790 --> 00:02:47,840

co-author

74

00:02:52,869 --> 00:02:50,800

and my successor as ranger project

75

00:02:55,350 --> 00:02:52,879

manager bud schermeier

76

00:02:58,390 --> 00:02:55,360

many of you of course know him from his

77

00:03:00,390 --> 00:02:58,400

distinguished later uh reputation at jpl

78

00:03:03,910 --> 00:03:00,400

as project manager of

79

00:03:06,070 --> 00:03:03,920

various projects mariner 6 and 7 and uh

80

00:03:07,990 --> 00:03:06,080

the voyagers as of when they were

81

00:03:10,149 --> 00:03:08,000

launched he was one of the

82

00:03:13,270 --> 00:03:10,159

first of a long succession of uh

83

00:03:14,550 --> 00:03:13,280

excellent project managers on voyager

84

00:03:16,070 --> 00:03:14,560

but

85

00:03:17,589 --> 00:03:16,080

what i'd like to do here is take a

86

00:03:19,750 --> 00:03:17,599

couple minutes to tell you a little bit

87

00:03:23,509 --> 00:03:19,760

about the earlier part of

88

00:03:26,309 --> 00:03:23,519

his life he and i graduated from caltech

89

00:03:27,990 --> 00:03:26,319

after meeting each other as freshmen

90

00:03:32,630 --> 00:03:28,000

70 years ago

91

00:03:38,869 --> 00:03:34,149

and

92

00:03:42,470 --> 00:03:38,879

of course enjoyed all the

93

00:03:44,550 --> 00:03:42,480

southern california recreations soaring

94

00:03:46,630 --> 00:03:44,560

sailing skiing

95

00:03:48,309 --> 00:03:46,640

surfing whatever else there is that

96

00:03:50,710 --> 00:03:48,319

doesn't begin with s

97

00:03:52,710 --> 00:03:50,720

uh he brought me down off the mountain

98

00:03:55,670 --> 00:03:52,720

with a broken leg

99

00:04:01,509 --> 00:03:59,910

so we know each other pretty well and uh

100

00:04:04,710 --> 00:04:01,519

in any case

101
00:04:07,990 --> 00:04:04,720
it was my very good fortune to have

102
00:04:09,990 --> 00:04:08,000
him in position as manager of jpl's

103
00:04:12,149 --> 00:04:10,000
systems division which is where all the

104
00:04:13,429 --> 00:04:12,159
subsystems get to try to work with each

105
00:04:15,429 --> 00:04:13,439
other

106
00:04:16,789 --> 00:04:15,439
that's what he was doing

107
00:04:18,789 --> 00:04:16,799
while i was

108
00:04:19,830 --> 00:04:18,799
being the first project manager of

109
00:04:22,790 --> 00:04:19,840
ranger

110
00:04:27,670 --> 00:04:22,800
but our experience at jpl went way back

111
00:04:33,030 --> 00:04:30,390
so that by the time ranger came along we

112
00:04:35,510 --> 00:04:33,040
both had been working at jpl for more

113
00:04:36,629 --> 00:04:35,520

than 10 years

114

00:04:38,629 --> 00:04:36,639

and

115

00:04:40,310 --> 00:04:38,639

one part of what i'm

116

00:04:44,790 --> 00:04:40,320

going to tell you from

117

00:04:47,030 --> 00:04:44,800

here on uh is how there was a collision

118

00:04:50,230 --> 00:04:47,040

between us and everybody else involved

119

00:04:52,710 --> 00:04:50,240

in the project uh all the way up to

120

00:04:54,550 --> 00:04:52,720

congress and later in the game

121

00:04:56,469 --> 00:04:54,560

uh because we really thought we knew

122

00:04:58,390 --> 00:04:56,479

what we were doing we were experienced

123

00:05:01,830 --> 00:04:58,400

both of us were experienced project

124

00:05:04,870 --> 00:05:01,840

managers under the army and we knew how

125

00:05:06,390 --> 00:05:04,880

to do what we were doing

126
00:05:08,390 --> 00:05:06,400
ranger

127
00:05:10,550 --> 00:05:08,400
presented us with

128
00:05:11,990 --> 00:05:10,560
a more complicated and

129
00:05:15,670 --> 00:05:12,000
bigger

130
00:05:17,830 --> 00:05:15,680
project to do uh but not one that was in

131
00:05:20,070 --> 00:05:17,840
different in any essential way from the

132
00:05:21,270 --> 00:05:20,080
things we'd been doing before

133
00:05:24,070 --> 00:05:21,280
therefore

134
00:05:25,909 --> 00:05:24,080
there was a definite collision between

135
00:05:27,430 --> 00:05:25,919
us

136
00:05:28,790 --> 00:05:27,440
and

137
00:05:29,990 --> 00:05:28,800
our

138
00:05:32,710 --> 00:05:30,000

leaders

139

00:05:34,390 --> 00:05:32,720

once we were transferred out of the army

140

00:05:35,990 --> 00:05:34,400

and into nasa

141

00:05:38,150 --> 00:05:36,000

because nasa had a whole lot of

142

00:05:39,990 --> 00:05:38,160

engineers who were just as experienced

143

00:05:41,909 --> 00:05:40,000

and just as smart as us

144

00:05:43,909 --> 00:05:41,919

and it took us a while to realize that

145

00:05:45,590 --> 00:05:43,919

they were our bosses

146

00:05:46,469 --> 00:05:45,600

well that's a little bit the theme of

147

00:05:48,070 --> 00:05:46,479

this

148

00:05:51,189 --> 00:05:48,080

presentation

149

00:05:55,189 --> 00:05:53,270

no i don't have a screen well

150

00:05:57,590 --> 00:05:55,199

no i can't read it up there i'll have to

151
00:05:59,990 --> 00:05:57,600
read it here sorry about that

152
00:06:03,670 --> 00:06:02,150
jpl

153
00:06:05,430 --> 00:06:03,680
of course

154
00:06:08,550 --> 00:06:05,440
launched the first earth satellites

155
00:06:10,629 --> 00:06:08,560
explorer one four five

156
00:06:13,270 --> 00:06:10,639
but uh

157
00:06:14,790 --> 00:06:13,280
quickly it was determined that earth

158
00:06:17,029 --> 00:06:14,800
satellites were going to be a big

159
00:06:20,150 --> 00:06:17,039
business in a crowded field

160
00:06:22,070 --> 00:06:20,160
and we as a university laboratory

161
00:06:24,710 --> 00:06:22,080
shouldn't really

162
00:06:25,749 --> 00:06:24,720
be in that field so

163
00:06:27,350 --> 00:06:25,759

we

164

00:06:30,790 --> 00:06:27,360

chose to go

165

00:06:32,390 --> 00:06:30,800

beyond low earth orbit first target

166

00:06:33,430 --> 00:06:32,400

being

167

00:06:35,670 --> 00:06:33,440

mars

168

00:06:39,510 --> 00:06:35,680

for the 1960

169

00:06:41,430 --> 00:06:39,520

opposition uh the 1960 launch window

170

00:06:44,230 --> 00:06:41,440

uh which was the first time in human

171

00:06:45,909 --> 00:06:44,240

history that something could be launched

172

00:06:49,029 --> 00:06:45,919

to mars

173

00:06:50,950 --> 00:06:49,039

so that was the objective initially

174

00:06:54,710 --> 00:06:50,960

retreated back from that driven by

175

00:06:57,589 --> 00:06:54,720

circumstances to the moon

176

00:07:00,469 --> 00:06:57,599

that was the process as of

177

00:07:02,390 --> 00:07:00,479

1958

178

00:07:06,070 --> 00:07:02,400

okay the von braun team

179

00:07:06,950 --> 00:07:06,080

uh very experienced of course uh

180

00:07:09,510 --> 00:07:06,960

we

181

00:07:10,950 --> 00:07:09,520

had to go through quite a transition

182

00:07:12,629 --> 00:07:10,960

with them

183

00:07:14,469 --> 00:07:12,639

because they ended up in a very

184

00:07:17,270 --> 00:07:14,479

anomalous position

185

00:07:19,350 --> 00:07:17,280

once nasa was formed

186

00:07:22,309 --> 00:07:19,360

the phone brown people

187

00:07:25,110 --> 00:07:22,319

were nasa's agent for procuring launch

188

00:07:27,270 --> 00:07:25,120

services from the air force

189

00:07:29,749 --> 00:07:27,280

if you can find a more difficult

190

00:07:31,350 --> 00:07:29,759

situation for somebody

191

00:07:33,749 --> 00:07:31,360

that's where they were

192

00:07:35,670 --> 00:07:33,759

and it's to their great credit that

193

00:07:38,870 --> 00:07:35,680

individuals in

194

00:07:40,950 --> 00:07:38,880

both the air force and the army

195

00:07:43,189 --> 00:07:40,960

saw to it that in spite of all the

196

00:07:45,510 --> 00:07:43,199

institutional rivalries and other things

197

00:07:47,510 --> 00:07:45,520

that were happening at the time

198

00:07:50,950 --> 00:07:47,520

they managed to pull it off they got us

199

00:07:54,950 --> 00:07:53,029

tremendous confusion not just about

200

00:07:56,790 --> 00:07:54,960

launch vehicles but really about

201
00:07:59,510 --> 00:07:56,800
everything

202
00:08:01,270 --> 00:07:59,520
as to who was going to do what

203
00:08:02,710 --> 00:08:01,280
but uh

204
00:08:06,869 --> 00:08:02,720
rather quickly

205
00:08:09,990 --> 00:08:06,879
in 1958 and 59

206
00:08:13,029 --> 00:08:10,000
we discovered that we just couldn't do

207
00:08:15,270 --> 00:08:13,039
that mars launch window it was way

208
00:08:16,070 --> 00:08:15,280
beyond anything we could logically hope

209
00:08:19,029 --> 00:08:16,080
to

210
00:08:20,950 --> 00:08:19,039
so the big mariner

211
00:08:23,110 --> 00:08:20,960
called mariner a

212
00:08:25,430 --> 00:08:23,120
that was planned for that mission

213
00:08:28,869 --> 00:08:25,440

was abandoned and

214

00:08:31,189 --> 00:08:28,879

uh was decided to build a mariner for

215

00:08:33,110 --> 00:08:31,199

venus in 1962

216

00:08:35,990 --> 00:08:33,120

a couple of them

217

00:08:37,190 --> 00:08:36,000

that would be derived from the smaller

218

00:08:39,269 --> 00:08:37,200

ranger

219

00:08:40,709 --> 00:08:39,279

lunar spacecraft

220

00:08:42,870 --> 00:08:40,719

that we were building

221

00:08:46,070 --> 00:08:42,880

ranger already had

222

00:08:48,470 --> 00:08:46,080

solar mantles solar panels and a high

223

00:08:50,550 --> 00:08:48,480

gain antenna because those are features

224

00:08:52,389 --> 00:08:50,560

that you have to have for interplanetary

225

00:08:53,430 --> 00:08:52,399

missions you don't need them for the

226
00:08:56,070 --> 00:08:53,440
moon

227
00:08:58,710 --> 00:08:56,080
but we we had them on ranger because we

228
00:09:01,509 --> 00:08:58,720
visualized it as a precursor to

229
00:09:03,829 --> 00:09:01,519
planetary missions three-axis attitude

230
00:09:05,190 --> 00:09:03,839
control pointing an antenna getting

231
00:09:06,550 --> 00:09:05,200
solar power

232
00:09:09,430 --> 00:09:06,560
and

233
00:09:10,790 --> 00:09:09,440
being execute a being able to execute a

234
00:09:13,350 --> 00:09:10,800
mid-course

235
00:09:14,870 --> 00:09:13,360
maneuver trajectory correction those

236
00:09:17,350 --> 00:09:14,880
were the features

237
00:09:19,110 --> 00:09:17,360
that had to be on the mariner so they

238
00:09:21,430 --> 00:09:19,120

were on the ranger

239

00:09:25,350 --> 00:09:21,440

and the mariner became to be called

240

00:09:27,590 --> 00:09:25,360

ranger uh mariner r derived from ranger

241

00:09:30,630 --> 00:09:27,600

okay

242

00:09:33,670 --> 00:09:30,640

mariner a became mariner r

243

00:09:37,509 --> 00:09:33,680

okay the air force and our huntsville

244

00:09:40,070 --> 00:09:37,519

friends got us the atlas agena

245

00:09:43,910 --> 00:09:40,080

the deep space net and space

246

00:09:46,790 --> 00:09:43,920

flight operations facility necessary for

247

00:09:57,750 --> 00:09:46,800

both lunar and planetary missions

248

00:10:03,269 --> 00:10:01,110

common bus variable payloads

249

00:10:05,430 --> 00:10:03,279

everything you see on this slide was an

250

00:10:07,030 --> 00:10:05,440

attempt by us

251
00:10:08,870 --> 00:10:07,040
to try to

252
00:10:10,630 --> 00:10:08,880
meet the requirement of building

253
00:10:13,670 --> 00:10:10,640
reliability

254
00:10:15,269 --> 00:10:13,680
through successive operations

255
00:10:16,310 --> 00:10:15,279
and still meeting

256
00:10:18,550 --> 00:10:16,320
the

257
00:10:20,230 --> 00:10:18,560
difficult demands of planetary missions

258
00:10:22,230 --> 00:10:20,240
where you can't change the schedule

259
00:10:23,269 --> 00:10:22,240
unless you're prepared to slip it for

260
00:10:25,910 --> 00:10:23,279
years

261
00:10:28,389 --> 00:10:25,920
uh as in fact did happen with curiosity

262
00:10:32,949 --> 00:10:28,399
the big rover

263
00:10:38,069 --> 00:10:35,750

science on every flight

264

00:10:41,350 --> 00:10:38,079

i had what now seems a very peculiar

265

00:10:43,750 --> 00:10:41,360

attitude about science

266

00:10:45,670 --> 00:10:43,760

i insisted that every flight carry

267

00:10:47,910 --> 00:10:45,680

scientific instruments

268

00:10:49,190 --> 00:10:47,920

for two reasons

269

00:10:51,190 --> 00:10:49,200

one

270

00:10:53,350 --> 00:10:51,200

we didn't know which flight or flights

271

00:10:54,630 --> 00:10:53,360

might succeed

272

00:10:56,710 --> 00:10:54,640

two

273

00:10:58,630 --> 00:10:56,720

engineering development of science

274

00:11:01,190 --> 00:10:58,640

instruments in flight

275

00:11:04,230 --> 00:11:01,200

is as important as that of any other

276

00:11:06,389 --> 00:11:04,240

subsystem on the spacecraft

277

00:11:08,630 --> 00:11:06,399

and i

278

00:11:11,269 --> 00:11:08,640

simply thought it's up to the project

279

00:11:13,990 --> 00:11:11,279

manager to figure out after receiving

280

00:11:15,750 --> 00:11:14,000

advice from scientists and comparing

281

00:11:17,030 --> 00:11:15,760

that with what you can do what you can

282

00:11:18,949 --> 00:11:17,040

accommodate

283

00:11:20,949 --> 00:11:18,959

then i'll tell the scientists which of

284

00:11:23,829 --> 00:11:20,959

them get to come and which other ones

285

00:11:25,670 --> 00:11:23,839

have to wait for another launch

286

00:11:27,590 --> 00:11:25,680

can you imagine a viewpoint more

287

00:11:28,949 --> 00:11:27,600

different from

288

00:11:31,190 --> 00:11:28,959

that of

289

00:11:32,949 --> 00:11:31,200

first science is the objective of the

290

00:11:34,710 --> 00:11:32,959

mission come on guys

291

00:11:36,310 --> 00:11:34,720

two

292

00:11:38,790 --> 00:11:36,320

there's a whole structure out there of

293

00:11:40,150 --> 00:11:38,800

scientific advisory committees nasa and

294

00:11:42,230 --> 00:11:40,160

this and that

295

00:11:44,069 --> 00:11:42,240

project manager simply has to sit and

296

00:11:45,590 --> 00:11:44,079

watch all of that happen and then deal

297

00:11:46,470 --> 00:11:45,600

with the result

298

00:11:55,110 --> 00:11:46,480

well

299

00:11:59,910 --> 00:11:58,069

october 1960 i was appointed

300

00:12:02,790 --> 00:11:59,920

project manager

301
00:12:05,269 --> 00:12:02,800
on the 10th of october uh

302
00:12:07,350 --> 00:12:05,279
big rocket takes off

303
00:12:09,509 --> 00:12:07,360
it was the

304
00:12:11,670 --> 00:12:09,519
classic old original one except the

305
00:12:14,069 --> 00:12:11,680
upper stages

306
00:12:16,230 --> 00:12:14,079
weighed more than 30 tons and we watched

307
00:12:18,069 --> 00:12:16,240
the very slow acceleration of that and

308
00:12:18,870 --> 00:12:18,079
thought oh my goodness what is this

309
00:12:20,389 --> 00:12:18,880
thing

310
00:12:22,470 --> 00:12:20,399
then on the second

311
00:12:25,350 --> 00:12:22,480
one on the 14th

312
00:12:27,590 --> 00:12:25,360
of october uh our telemetry was good

313
00:12:30,069 --> 00:12:27,600

enough to show that it had four big engi

314

00:12:31,829 --> 00:12:30,079

big boosters going off like that

315

00:12:33,269 --> 00:12:31,839

so that was when we first began to

316

00:12:37,030 --> 00:12:33,279

understand

317

00:12:39,990 --> 00:12:37,040

uh what the malnea configuration

318

00:12:43,030 --> 00:12:40,000

of the soviet launch vehicle

319

00:12:47,829 --> 00:12:44,949

uh when president kennedy was

320

00:12:50,150 --> 00:12:47,839

inaugurated he gave a talk that was very

321

00:12:52,629 --> 00:12:50,160

largely about the contest between

322

00:12:55,430 --> 00:12:52,639

american values and the

323

00:12:57,269 --> 00:12:55,440

subversive and uh threatening

324

00:12:59,670 --> 00:12:57,279

emanations that were coming out of the

325

00:13:01,750 --> 00:12:59,680

ussr

326

00:13:03,190 --> 00:13:01,760

on the 4th and 12th of february as you

327

00:13:05,190 --> 00:13:03,200

heard this morning

328

00:13:08,870 --> 00:13:05,200

they got two launches off and the second

329

00:13:10,710 --> 00:13:08,880

one sent the nero one on its way

330

00:13:13,110 --> 00:13:10,720

then yuri gagarin

331

00:13:14,069 --> 00:13:13,120

kennedy announced apollo

332

00:13:17,509 --> 00:13:14,079

uh

333

00:13:19,670 --> 00:13:17,519

if you can imagine a more

334

00:13:21,030 --> 00:13:19,680

propulsive environment than the one we

335

00:13:24,069 --> 00:13:21,040

were in

336

00:13:27,190 --> 00:13:24,079

to get ranger one and two going uh

337

00:13:31,670 --> 00:13:27,200

we had a lot of uh pressure on us

338

00:13:33,430 --> 00:13:31,680

much of it provided by ourselves uh and

339

00:13:38,710 --> 00:13:33,440

we you know we really wanted to get

340

00:13:38,720 --> 00:13:45,509

things moved fast

341

00:13:51,430 --> 00:13:49,110

i skipped over a whole lot of trouble

342

00:13:53,030 --> 00:13:51,440

originally when nasa

343

00:13:55,189 --> 00:13:53,040

first

344

00:13:56,629 --> 00:13:55,199

when we and the germans were transferred

345

00:13:59,189 --> 00:13:56,639

into nasa

346

00:14:02,629 --> 00:13:59,199

we already had a plan

347

00:14:04,550 --> 00:14:02,639

for upper stages on the atlas but they

348

00:14:06,790 --> 00:14:04,560

were not the right ones

349

00:14:08,949 --> 00:14:06,800

the air force agena was the right upper

350

00:14:10,230 --> 00:14:08,959

stage to use but it took oops how did

351
00:14:14,310 --> 00:14:10,240
that happen

352
00:14:14,320 --> 00:14:19,829
i went back too far sorry okay

353
00:14:23,350 --> 00:14:21,670
oh

354
00:14:26,069 --> 00:14:23,360
what happened

355
00:14:27,990 --> 00:14:26,079
okay never mind they uh

356
00:14:31,269 --> 00:14:28,000
something about the launch vehicles was

357
00:14:36,389 --> 00:14:31,279
on the slide that is now missing

358
00:14:41,269 --> 00:14:39,110
marshall was placed in a very tough

359
00:14:43,670 --> 00:14:41,279
position but we did

360
00:14:45,910 --> 00:14:43,680
end up again because of the dedication

361
00:14:46,870 --> 00:14:45,920
of individuals in the agencies who put

362
00:14:47,829 --> 00:14:46,880
our

363
00:14:50,710 --> 00:14:47,839

needs

364

00:14:53,030 --> 00:14:50,720

above the interagency disputes that were

365

00:14:54,629 --> 00:14:53,040

all going on then

366

00:14:58,069 --> 00:14:54,639

we got

367

00:15:00,389 --> 00:14:58,079

the launch vehicles that we needed

368

00:15:01,590 --> 00:15:00,399

i told you about how we didn't

369

00:15:03,910 --> 00:15:01,600

really

370

00:15:05,910 --> 00:15:03,920

like being jerked around by people who

371

00:15:07,750 --> 00:15:05,920

were our essential colleagues

372

00:15:10,550 --> 00:15:07,760

professionally and suddenly turned out

373

00:15:12,550 --> 00:15:10,560

to be from nasa a new agency that we'd

374

00:15:15,110 --> 00:15:12,560

never heard of and they were they were

375

00:15:18,069 --> 00:15:15,120

in charge

376

00:15:21,509 --> 00:15:18,079

our lunar scientists

377

00:15:24,550 --> 00:15:21,519

were the leaders in the profession

378

00:15:29,269 --> 00:15:27,430

gamma ray spectrometer

379

00:15:31,269 --> 00:15:29,279

geophysics

380

00:15:32,749 --> 00:15:31,279

seismometer

381

00:15:35,110 --> 00:15:32,759

and

382

00:15:37,110 --> 00:15:35,120

geomorphology the television

383

00:15:39,590 --> 00:15:37,120

those were the instruments on the lunar

384

00:15:40,550 --> 00:15:39,600

rangers and the scientists in charge of

385

00:15:42,870 --> 00:15:40,560

those

386

00:15:45,030 --> 00:15:42,880

did not give us any trouble

387

00:15:47,749 --> 00:15:45,040

they really did a tremendous job and

388

00:15:49,670 --> 00:15:47,759

they are famous for it they were already

389

00:15:52,150 --> 00:15:49,680

famous for their in their own

390

00:15:54,230 --> 00:15:52,160

professions of course

391

00:15:55,509 --> 00:15:54,240

we had a problem with non-lunar

392

00:15:57,430 --> 00:15:55,519

scientists

393

00:16:01,030 --> 00:15:57,440

space physics

394

00:16:02,710 --> 00:16:01,040

uh and i'll get to that a little later

395

00:16:05,829 --> 00:16:02,720

okay and

396

00:16:07,110 --> 00:16:05,839

we had a sort of a philosophical problem

397

00:16:09,509 --> 00:16:07,120

with

398

00:16:11,829 --> 00:16:09,519

not the lunar scientists they were fine

399

00:16:14,230 --> 00:16:11,839

they were on board they followed our

400

00:16:17,590 --> 00:16:14,240

schedule

401
00:16:19,590 --> 00:16:17,600
ranger one and two were planned as test

402
00:16:21,030 --> 00:16:19,600
flights not aimed at the moon but to

403
00:16:22,389 --> 00:16:21,040
have a high enough

404
00:16:24,629 --> 00:16:22,399
apogee

405
00:16:26,949 --> 00:16:24,639
that they would take the spacecraft out

406
00:16:28,470 --> 00:16:26,959
to where it could acquire the sun and

407
00:16:30,949 --> 00:16:28,480
earth references

408
00:16:33,269 --> 00:16:30,959
and since it was going to do that out in

409
00:16:34,310 --> 00:16:33,279
the magnetosphere it might as well have

410
00:16:36,790 --> 00:16:34,320
some

411
00:16:40,069 --> 00:16:36,800
space physics instruments on board it

412
00:16:42,790 --> 00:16:40,079
had an excellent payload designed by the

413
00:16:45,030 --> 00:16:42,800

prominent space physicists of the day

414

00:16:47,910 --> 00:16:45,040

plus an ultraviolet telescope looking

415

00:16:49,829 --> 00:16:47,920

back at the earth's hydrogen corona

416

00:16:52,389 --> 00:16:49,839

three four and five i told you about

417

00:16:54,069 --> 00:16:52,399

their instruments and on ranger six to

418

00:16:58,710 --> 00:16:54,079

nine the

419

00:17:01,990 --> 00:16:58,720

objective was reduced to just television

420

00:17:03,590 --> 00:17:02,000

now here's the example of the bus

421

00:17:06,630 --> 00:17:03,600

with one of the several different

422

00:17:11,029 --> 00:17:06,640

payloads the bus is hexagonal because of

423

00:17:13,750 --> 00:17:11,039

a vanished upper stage configuration

424

00:17:16,309 --> 00:17:13,760

so it was adapted to the agenda

425

00:17:18,390 --> 00:17:16,319

the tower on the top has the space

426

00:17:21,270 --> 00:17:18,400

physics instruments and at the very top

427

00:17:24,309 --> 00:17:21,280

the omnidirectional antenna

428

00:17:29,830 --> 00:17:24,319

so that was the configuration of rangers

429

00:17:35,669 --> 00:17:32,870

range of one and two because of uh genia

430

00:17:37,669 --> 00:17:35,679

upper stage troubles never got to their

431

00:17:41,190 --> 00:17:37,679

high apogee orbits

432

00:17:44,150 --> 00:17:41,200

they were stranded in low earth orbit

433

00:17:49,190 --> 00:17:46,630

they the spacecraft appeared to be okay

434

00:17:51,750 --> 00:17:49,200

as far as you could tell in that orbit

435

00:17:54,789 --> 00:17:51,760

a ranger three we had a spacecraft that

436

00:17:57,029 --> 00:17:54,799

was fine it was injected the atlas had a

437

00:17:59,430 --> 00:17:57,039

guidance error but the ranger acquired

438

00:18:00,549 --> 00:17:59,440

the sun on earth and began to do what it

439

00:18:02,230 --> 00:18:00,559

should do

440

00:18:04,630 --> 00:18:02,240

but then when the mid-course maneuver

441

00:18:06,870 --> 00:18:04,640

happened one vector was pointed the

442

00:18:08,870 --> 00:18:06,880

wrong way there had been a double sign

443

00:18:12,150 --> 00:18:08,880

inversion between the spacecraft and the

444

00:18:13,830 --> 00:18:12,160

ground equipment so it missed the moon

445

00:18:16,630 --> 00:18:13,840

range of four

446

00:18:17,990 --> 00:18:16,640

something got across a couple of pins

447

00:18:20,390 --> 00:18:18,000

between

448

00:18:22,630 --> 00:18:20,400

the agena when the when the spacecraft

449

00:18:25,029 --> 00:18:22,640

came away from the agena something

450

00:18:27,590 --> 00:18:25,039

shorted out the ranger

451
00:18:29,590 --> 00:18:27,600
if it had had the female side of the

452
00:18:32,150 --> 00:18:29,600
separation connector that probably

453
00:18:34,150 --> 00:18:32,160
wouldn't have happened

454
00:18:36,870 --> 00:18:34,160
on ranger five i'll show you a picture

455
00:18:39,750 --> 00:18:36,880
of that one a ranger six

456
00:18:42,470 --> 00:18:39,760
this is after i had been replaced as

457
00:18:44,390 --> 00:18:42,480
project manager by bud shermeyer and

458
00:18:45,750 --> 00:18:44,400
i'll tell you more about that later but

459
00:18:47,510 --> 00:18:45,760
here's this

460
00:18:51,350 --> 00:18:47,520
brief version of the story when the

461
00:18:53,750 --> 00:18:51,360
atlas staged its first stage engines off

462
00:18:57,430 --> 00:18:53,760
a plasma cloud enveloped the vehicle and

463
00:19:05,029 --> 00:18:57,440

shorted out the television

464

00:19:09,430 --> 00:19:07,190

this is the configuration of the lunar

465

00:19:10,549 --> 00:19:09,440

ones with the seismometer ball at the

466

00:19:12,870 --> 00:19:10,559

top

467

00:19:13,909 --> 00:19:12,880

and the gamma ray spectrometer out on a

468

00:19:20,549 --> 00:19:13,919

boom

469

00:19:28,950 --> 00:19:22,710

i see i seem to keep

470

00:19:34,230 --> 00:19:30,950

well okay

471

00:19:38,470 --> 00:19:36,789

power switching and logic unit in range

472

00:19:40,630 --> 00:19:38,480

of ranger 5

473

00:19:43,830 --> 00:19:40,640

proof test model of it shows you

474

00:19:46,150 --> 00:19:43,840

something about our packaging

475

00:19:49,110 --> 00:19:46,160

people look at jpl's packaging and they

476
00:19:51,110 --> 00:19:49,120
say hey those look like locomotive parts

477
00:19:53,029 --> 00:19:51,120
well we found out they have to look like

478
00:19:55,110 --> 00:19:53,039
locomotive parts if you don't want to

479
00:19:57,510 --> 00:19:55,120
amplify vibrations from the launch

480
00:19:59,990 --> 00:19:57,520
vehicle etc

481
00:20:03,029 --> 00:20:00,000
and that's why our packages look the way

482
00:20:07,110 --> 00:20:04,870
a backside of this

483
00:20:08,310 --> 00:20:07,120
little item you see the arrow pointing

484
00:20:11,350 --> 00:20:08,320
there

485
00:20:13,990 --> 00:20:11,360
uh that screw got warm and that hit us

486
00:20:16,070 --> 00:20:14,000
in we had a good spacecraft again it had

487
00:20:18,310 --> 00:20:16,080
acquired the sun on earth was on its way

488
00:20:19,270 --> 00:20:18,320

to the moon this time atlas regina was

489

00:20:21,110 --> 00:20:19,280

okay

490

00:20:24,870 --> 00:20:21,120

fine

491

00:20:24,880 --> 00:20:29,470

we went to the ranger

492

00:20:37,909 --> 00:20:33,110

6789 configuration with just television

493

00:20:42,870 --> 00:20:39,590

okay

494

00:20:47,190 --> 00:20:42,880

that's what i'm here to tell you

495

00:20:49,990 --> 00:20:47,200

robotic sp deep space exploration

496

00:20:52,230 --> 00:20:50,000

demands extreme attention to risk and

497

00:20:53,750 --> 00:20:52,240

even then

498

00:20:57,430 --> 00:20:53,760

you don't always

499

00:21:01,750 --> 00:20:59,510

technical risks all the ones in the

500

00:21:03,669 --> 00:21:01,760

ranger both in the launch vehicles and

501
00:21:07,510 --> 00:21:03,679
the spacecraft

502
00:21:10,470 --> 00:21:07,520
the failures were at interfaces

503
00:21:12,950 --> 00:21:10,480
management risks i guess i don't need to

504
00:21:14,230 --> 00:21:12,960
go too much into that

505
00:21:16,789 --> 00:21:14,240
but

506
00:21:17,909 --> 00:21:16,799
after ranger

507
00:21:21,270 --> 00:21:17,919
five

508
00:21:23,350 --> 00:21:21,280
uh the project capsized and

509
00:21:25,669 --> 00:21:23,360
schermer replaced me

510
00:21:28,830 --> 00:21:25,679
then he had the failure of ranger six

511
00:21:31,430 --> 00:21:28,840
which took it all the way up to congress

512
00:21:32,470 --> 00:21:31,440
uh enormous

513
00:21:33,750 --> 00:21:32,480

trouble

514

00:21:37,110 --> 00:21:33,760

and

515

00:21:39,029 --> 00:21:37,120

everything was focused on the rca camera

516

00:21:41,350 --> 00:21:39,039

payload

517

00:21:42,789 --> 00:21:41,360

while in fact

518

00:21:45,270 --> 00:21:42,799

the failure

519

00:21:48,310 --> 00:21:45,280

happened during the atlas booster

520

00:21:52,789 --> 00:21:48,320

staging back during ascent

521

00:21:55,590 --> 00:21:52,799

so a big long failure investigation

522

00:21:58,630 --> 00:21:55,600

entirely focused on

523

00:22:00,549 --> 00:21:58,640

the place where the failure didn't occur

524

00:22:02,870 --> 00:22:00,559

and we may never have known about the

525

00:22:05,190 --> 00:22:02,880

cause of that failure had not a solar

526

00:22:07,909 --> 00:22:05,200

physicist among us

527

00:22:10,789 --> 00:22:07,919

continued to persist in looking into it

528

00:22:12,870 --> 00:22:10,799

and investigating all the records and he

529

00:22:13,990 --> 00:22:12,880

finally decided he had a convincing

530

00:22:16,630 --> 00:22:14,000

story

531

00:22:19,669 --> 00:22:16,640

and he took it uh not to the project

532

00:22:21,430 --> 00:22:19,679

manager but to his division manager who

533

00:22:22,470 --> 00:22:21,440

uh thought about it and said that's

534

00:22:24,470 --> 00:22:22,480

interesting

535

00:22:27,190 --> 00:22:24,480

but it was quite a while before

536

00:22:29,110 --> 00:22:27,200

everybody became convinced that that was

537

00:22:30,870 --> 00:22:29,120

the actual cause of the failure when a

538

00:22:32,710 --> 00:22:30,880

plasma cloud

539

00:22:33,750 --> 00:22:32,720

went up the sides of the atlas and back

540

00:22:35,750 --> 00:22:33,760

down

541

00:22:37,830 --> 00:22:35,760

for just less than a second

542

00:22:45,270 --> 00:22:37,840

it was enough to turn on the tvs and

543

00:22:49,110 --> 00:22:46,710

thank you

544

00:22:50,950 --> 00:22:49,120

i put a couple of my references in here

545

00:22:52,950 --> 00:22:50,960

i i sort of

546

00:22:58,950 --> 00:22:52,960

stretched the point a little bit thank

547

00:23:04,070 --> 00:23:02,230

so go ahead and take five minutes

548

00:23:08,870 --> 00:23:04,080

okay

549

00:23:12,710 --> 00:23:08,880

one question why did you

550

00:23:15,870 --> 00:23:12,720

why did you put this in about the uh

551
00:23:19,270 --> 00:23:15,880
the uh yes reference four decla

552
00:23:21,830 --> 00:23:19,280
1966 declassified 94.

553
00:23:22,630 --> 00:23:21,840
the beautiful book

554
00:23:25,510 --> 00:23:22,640
by

555
00:23:28,470 --> 00:23:25,520
wes huntress and mikhail maroff

556
00:23:31,110 --> 00:23:28,480
tells the real story about

557
00:23:33,750 --> 00:23:31,120
all of the soviet missions

558
00:23:36,310 --> 00:23:33,760
what this reference is is

559
00:23:37,669 --> 00:23:36,320
my story about what we thought they were

560
00:23:38,789 --> 00:23:37,679
doing

561
00:23:41,590 --> 00:23:38,799
published

562
00:23:43,510 --> 00:23:41,600
in the studies in intelligence and

563
00:23:52,630 --> 00:23:43,520

wasn't declassified for a number of

564

00:23:57,909 --> 00:23:53,510

during

565

00:23:59,350 --> 00:23:57,919

your days under jpl i was at abma

566

00:24:00,950 --> 00:23:59,360

i was at the army ballistic missile

567

00:24:03,110 --> 00:24:00,960

agency back in those

568

00:24:05,909 --> 00:24:03,120

in those 50s years and you guys were

569

00:24:08,870 --> 00:24:05,919

transferred in october 58

570

00:24:10,390 --> 00:24:08,880

we held out with the army until july

571

00:24:11,510 --> 00:24:10,400

1960.

572

00:24:15,269 --> 00:24:11,520

the

573

00:24:16,870 --> 00:24:15,279

team it was finally eisenhower who

574

00:24:19,350 --> 00:24:16,880

personally intervened

575

00:24:22,390 --> 00:24:19,360

and so we transferred officially

576

00:24:25,990 --> 00:24:22,400

on the first of july 1960.

577

00:24:28,149 --> 00:24:26,000

also we developed the the jupiter irbm

578

00:24:30,070 --> 00:24:28,159

but then you got the air force we were

579

00:24:32,230 --> 00:24:30,080

told that the army was not going to

580

00:24:34,870 --> 00:24:32,240

deploy that missile that was going to be

581

00:24:37,269 --> 00:24:34,880

deployed by the air force so we had to

582

00:24:39,830 --> 00:24:37,279

paint out u.s army put u.s air force in

583

00:24:42,149 --> 00:24:39,840

there redstone arsenal filled with air

584

00:24:44,070 --> 00:24:42,159

force personnel learning how to operate

585

00:24:47,110 --> 00:24:44,080

the the jupiter

586

00:24:49,909 --> 00:24:47,120

irbm which was deployed in turkey but

587

00:24:52,070 --> 00:24:49,919

the but that jupiter put in your upper

588

00:24:53,830 --> 00:24:52,080

stages you remember the juno too oh yes

589

00:24:57,190 --> 00:24:53,840

of course you didn't talk about that

590

00:24:59,029 --> 00:24:57,200

could you say a few words about juno too

591

00:25:01,029 --> 00:24:59,039

i said the launch vehicle picture was a

592

00:25:03,190 --> 00:25:01,039

little bit confused that was a strong

593

00:25:04,950 --> 00:25:03,200

understatement and you've just

594

00:25:07,269 --> 00:25:04,960

heard a little more about some of the

595

00:25:10,549 --> 00:25:07,279

various pieces of spaghetti that were

596

00:25:14,789 --> 00:25:10,559

all squirming around there go ahead

597

00:25:17,590 --> 00:25:14,799

jim can you just talk a little bit about

598

00:25:19,350 --> 00:25:17,600

how everybody how you and and everybody

599

00:25:20,390 --> 00:25:19,360

realized

600

00:25:23,909 --> 00:25:20,400

the

601
00:25:26,230 --> 00:25:23,919
issues

602
00:25:28,390 --> 00:25:26,240
what what did you expect going in did

603
00:25:30,070 --> 00:25:28,400
you think you could just get away with

604
00:25:32,310 --> 00:25:30,080
you know seeing if it worked and if it

605
00:25:34,549 --> 00:25:32,320
didn't work you'd you'd fix it but then

606
00:25:36,630 --> 00:25:34,559
was there a moment when you all realized

607
00:25:38,789 --> 00:25:36,640
that you were in a much much much more

608
00:25:40,710 --> 00:25:38,799
unforgiving game

609
00:25:43,269 --> 00:25:40,720
i think the answer to the best less

610
00:25:44,710 --> 00:25:43,279
simple quick answer short answer to that

611
00:25:47,430 --> 00:25:44,720
question is

612
00:25:49,830 --> 00:25:47,440
yes reliability was dominant in our

613
00:25:51,190 --> 00:25:49,840

minds and we tried to test everything

614

00:25:52,870 --> 00:25:51,200

you can test

615

00:25:54,710 --> 00:25:52,880

and you get to a point where you've

616

00:25:57,430 --> 00:25:54,720

tested something so many times that

617

00:25:58,870 --> 00:25:57,440

you've worn it out and it's better to

618

00:25:59,909 --> 00:25:58,880

leave it alone

619

00:26:01,430 --> 00:25:59,919

but

620

00:26:03,110 --> 00:26:01,440

as i said

621

00:26:06,149 --> 00:26:03,120

these failures

622

00:26:07,909 --> 00:26:06,159

happened with extremely subtle causes

623

00:26:09,430 --> 00:26:07,919

none of which would have been revealed

624

00:26:12,710 --> 00:26:09,440

in a ground test

625

00:26:15,990 --> 00:26:12,720

for example on ranger 2

626
00:26:18,990 --> 00:26:16,000
gyros in the agina were not turning when

627
00:26:21,669 --> 00:26:19,000
it took off why because the block house

628
00:26:23,909 --> 00:26:21,679
instrumentation was designed in such a

629
00:26:25,750 --> 00:26:23,919
way no matter how much you test it you

630
00:26:26,789 --> 00:26:25,760
can't tell whether the gyros are turning

631
00:26:27,669 --> 00:26:26,799
or not

632
00:26:28,549 --> 00:26:27,679
okay

633
00:26:30,789 --> 00:26:28,559
well

634
00:26:33,750 --> 00:26:30,799
that was corrected

635
00:26:35,830 --> 00:26:33,760
but we'd already lost one mission so

636
00:26:40,310 --> 00:26:35,840
fine the next agena the gyros were

637
00:26:41,430 --> 00:26:40,320
indeed turning but we didn't have 50

638
00:26:44,149 --> 00:26:41,440

missions

639

00:26:49,909 --> 00:26:44,159

the way you do in the army

640

00:26:53,990 --> 00:26:51,510

jim

641

00:26:56,789 --> 00:26:54,000

in one of your slide and concluding one

642

00:27:00,789 --> 00:26:56,799

i guess uh it was said that the

643

00:27:02,070 --> 00:27:00,799

politicians invention of policy do not

644

00:27:04,789 --> 00:27:02,080

help but

645

00:27:08,070 --> 00:27:04,799

probably worsened the situation you know

646

00:27:11,190 --> 00:27:08,080

i completely agree with you because i

647

00:27:12,789 --> 00:27:11,200

just experienced it in my own career you

648

00:27:15,830 --> 00:27:12,799

know but

649

00:27:20,070 --> 00:27:15,840

was it just the case in the ranger

650

00:27:22,789 --> 00:27:20,080

program when the policy tried to assist

651
00:27:29,110 --> 00:27:22,799
you somehow you know but actually

652
00:27:29,120 --> 00:27:33,590
oh all the politicians

653
00:27:38,149 --> 00:27:36,230
the politic politicians were faced with

654
00:27:39,669 --> 00:27:38,159
a problem that's very difficult for a

655
00:27:42,389 --> 00:27:39,679
politician

656
00:27:45,190 --> 00:27:42,399
uh to us it looked as if they were

657
00:27:47,510 --> 00:27:45,200
wasting their time and hours

658
00:27:50,710 --> 00:27:47,520
but in their world

659
00:27:52,230 --> 00:27:50,720
they really did have to consider

660
00:27:55,590 --> 00:27:52,240
whether we were

661
00:27:57,430 --> 00:27:55,600
we happy engineers who were just going

662
00:27:59,590 --> 00:27:57,440
along always thinking we could make the

663
00:28:01,990 --> 00:27:59,600

next one work and eventually we did make

664

00:28:04,470 --> 00:28:02,000

the next three of them work fine

665

00:28:06,789 --> 00:28:04,480

everybody ended up a hero so from an

666

00:28:08,630 --> 00:28:06,799

engineering standpoint we did exactly

667

00:28:10,230 --> 00:28:08,640

the same thing we'd always previously

668

00:28:12,549 --> 00:28:10,240

done in the army

669

00:28:14,149 --> 00:28:12,559

you find a failure you fix it launch the

670

00:28:15,430 --> 00:28:14,159

next thing it has a different failure

671

00:28:17,110 --> 00:28:15,440

you fix that

672

00:28:18,149 --> 00:28:17,120

eventually you get to where you want to

673

00:28:20,789 --> 00:28:18,159

be

674

00:28:25,510 --> 00:28:20,799

okay but ranger

675

00:28:28,789 --> 00:28:25,520

was operating in a different environment

676

00:28:31,029 --> 00:28:28,799

and the answer to mikhail's question is

677

00:28:33,990 --> 00:28:31,039

politicians

678

00:28:36,549 --> 00:28:34,000

could have done us tremendous damage

679

00:28:38,710 --> 00:28:36,559

because one question that was arose and

680

00:28:39,590 --> 00:28:38,720

it was treated in the aeronautical press

681

00:28:42,149 --> 00:28:39,600

then

682

00:28:44,310 --> 00:28:42,159

is what's a university laboratory doing

683

00:28:46,070 --> 00:28:44,320

in this business anyway with a 60

684

00:28:49,029 --> 00:28:46,080

million dollar mission

685

00:28:49,990 --> 00:28:49,039

500 people working on a big deal

686

00:28:52,149 --> 00:28:50,000

you know

687

00:28:54,070 --> 00:28:52,159

so that question

688

00:28:55,830 --> 00:28:54,080

had it gone the other way

689

00:28:58,149 --> 00:28:55,840

had nasa not

690

00:29:00,470 --> 00:28:58,159

told the politicians to hey get off our

691

00:29:02,950 --> 00:29:00,480

backs we the jpl knows what it's doing

692

00:29:04,149 --> 00:29:02,960

leave us alone

693

00:29:10,070 --> 00:29:04,159

thank you very much we're gonna have

694

00:29:14,149 --> 00:29:12,230

our next presenter is john sarkisian who

695

00:29:35,909 --> 00:29:14,159

is going to talk about mariner 2 and the

696

00:29:35,919 --> 00:29:41,190

nope

697

00:29:41,200 --> 00:29:50,549

wrong john

698

00:29:50,559 --> 00:29:54,789

oh which one was that

699

00:29:59,269 --> 00:29:56,710

okay

700

00:30:01,510 --> 00:29:59,279

well firstly um i'd first like to thank

701

00:30:03,669 --> 00:30:01,520

um bill barry and the organizers for

702

00:30:05,430 --> 00:30:03,679

inviting me along here to to address you

703

00:30:10,310 --> 00:30:05,440

this afternoon and it really is a great

704

00:30:15,029 --> 00:30:13,669

the csiro parks radio telescope is one

705

00:30:16,310 --> 00:30:15,039

of the world's great research

706

00:30:18,549 --> 00:30:16,320

instruments

707

00:30:20,710 --> 00:30:18,559

it is arguably the finest single dish

708

00:30:23,269 --> 00:30:20,720

radio telescope in the world

709

00:30:24,710 --> 00:30:23,279

back in 2006 a study published in the

710

00:30:26,549 --> 00:30:24,720

journal nature

711

00:30:29,430 --> 00:30:26,559

ranked it second only to the vla in

712

00:30:31,830 --> 00:30:29,440

terms of its scientific impact

713

00:30:34,070 --> 00:30:31,840

it is owned and operated by the

714

00:30:35,990 --> 00:30:34,080

commonwealth scientific and

715

00:30:37,750 --> 00:30:36,000

industrial research organization or

716

00:30:39,029 --> 00:30:37,760

csiro

717

00:30:41,669 --> 00:30:39,039

of australia

718

00:30:44,310 --> 00:30:41,679

and when it was built in 1961 it was the

719

00:30:46,149 --> 00:30:44,320

most advanced radio telescope

720

00:30:48,630 --> 00:30:46,159

in the world

721

00:30:50,870 --> 00:30:48,640

it was also recognized very early on

722

00:30:53,190 --> 00:30:50,880

that its design made it a near ideal

723

00:30:54,870 --> 00:30:53,200

instrument for tracking spacecraft in

724

00:30:58,230 --> 00:30:54,880

deep space

725

00:31:00,149 --> 00:30:58,240

this attracted the attention of nasa jpl

726
00:31:02,389 --> 00:31:00,159
where it had its most profound impact in

727
00:31:05,269 --> 00:31:02,399
the design of the large aperture

728
00:31:08,310 --> 00:31:05,279
antennas of the the the deep space

729
00:31:13,509 --> 00:31:10,630
as you can see from this table

730
00:31:15,590 --> 00:31:13,519
um the space missions that the the parks

731
00:31:18,630 --> 00:31:15,600
telescope has been involved in

732
00:31:20,870 --> 00:31:18,640
um spans the the five decades of the

733
00:31:22,710 --> 00:31:20,880
salt system exploration from mariner 2

734
00:31:24,789 --> 00:31:22,720
at the very beginning all the way

735
00:31:27,269 --> 00:31:24,799
through to the latest mission curiosity

736
00:31:29,590 --> 00:31:27,279
just a few months ago

737
00:31:32,230 --> 00:31:29,600
the highlight was undoubtedly the apollo

738
00:31:34,470 --> 00:31:32,240

missions from especially apollo 11

739

00:31:36,230 --> 00:31:34,480
through to 17.

740

00:31:39,430 --> 00:31:36,240
we also played a critical role in the

741

00:31:41,029 --> 00:31:39,440
galileo mission to jupiter and also in

742

00:31:43,509 --> 00:31:41,039
the huygens

743

00:31:45,110 --> 00:31:43,519
landing on titan where we actually were

744

00:31:51,269 --> 00:31:45,120
able to salvage the doppler wind

745

00:31:55,190 --> 00:31:54,070
but how did it all begin

746

00:31:57,269 --> 00:31:55,200
well

747

00:31:59,430 --> 00:31:57,279
it was conceived by edward taffy bowen

748

00:32:01,430 --> 00:31:59,440
in 1954

749

00:32:03,350 --> 00:32:01,440
taffy was the visionary and dynamic

750

00:32:07,669 --> 00:32:03,360
chief of the csiro's radio physics

751
00:32:09,909 --> 00:32:07,679
division for 25 years from 1946 to 1971.

752
00:32:11,830 --> 00:32:09,919
under his leadership the radio physics

753
00:32:13,669 --> 00:32:11,840
division developed as a pioneer and

754
00:32:15,750 --> 00:32:13,679
world leader in the emerging science of

755
00:32:17,990 --> 00:32:15,760
radio astronomy in the immediate

756
00:32:20,549 --> 00:32:18,000
post-war years

757
00:32:22,389 --> 00:32:20,559
but by the early 1950s

758
00:32:24,070 --> 00:32:22,399
taffy was thinking of the next stage of

759
00:32:26,149 --> 00:32:24,080
development of radio astronomy in

760
00:32:28,789 --> 00:32:26,159
australia and he determined that the

761
00:32:31,750 --> 00:32:28,799
best all-round instrument for continuing

762
00:32:33,509 --> 00:32:31,760
the csiro's pioneering efforts in radio

763
00:32:37,269 --> 00:32:33,519

astronomy

764

00:32:39,029 --> 00:32:37,279

was a large fully steerable dish antenna

765

00:32:41,110 --> 00:32:39,039

at the time such an instrument was

766

00:32:43,029 --> 00:32:41,120

beyond the budget of the csiro so he

767

00:32:45,190 --> 00:32:43,039

called on his old boy network so to

768

00:32:47,269 --> 00:32:45,200

speak of contacts that he built up

769

00:32:51,590 --> 00:32:47,279

during the war

770

00:32:55,509 --> 00:32:53,110

firstly

771

00:32:56,710 --> 00:32:55,519

he approached the carnegie corporation

772

00:32:59,269 --> 00:32:56,720

at the time

773

00:33:01,750 --> 00:32:59,279

it was the president of the carnegie

774

00:33:03,190 --> 00:33:01,760

institute in washington was headed by uh

775

00:33:04,149 --> 00:33:03,200

well the president of it was vanneva

776
00:33:04,950 --> 00:33:04,159
bush

777
00:33:06,389 --> 00:33:04,960
who

778
00:33:08,389 --> 00:33:06,399
during the war was

779
00:33:10,310 --> 00:33:08,399
president roosevelt's um science advisor

780
00:33:12,950 --> 00:33:10,320
the man who initiated the the manhattan

781
00:33:15,350 --> 00:33:12,960
project and he was also the the founder

782
00:33:17,830 --> 00:33:15,360
of the national science foundation

783
00:33:19,669 --> 00:33:17,840
and from his very close personal

784
00:33:21,830 --> 00:33:19,679
relationships um professional

785
00:33:23,909 --> 00:33:21,840
relationship with um

786
00:33:25,350 --> 00:33:23,919
vaneva bush he acquired a quarter of a

787
00:33:27,029 --> 00:33:25,360
million dollars to get the project

788
00:33:28,789 --> 00:33:27,039

started

789

00:33:30,630 --> 00:33:28,799

he then followed up with

790

00:33:32,789 --> 00:33:30,640

a similar

791

00:33:34,789 --> 00:33:32,799

amount from the rockefeller foundation

792

00:33:37,029 --> 00:33:34,799

the the president of of the rockefeller

793

00:33:39,509 --> 00:33:37,039

foundation was dean rusk the future

794

00:33:41,669 --> 00:33:39,519

secretary of state of um in the kennedy

795

00:33:44,710 --> 00:33:41,679

and johnson administrations again he

796

00:33:46,310 --> 00:33:44,720

knew taffy during the the war period

797

00:33:48,549 --> 00:33:46,320

and

798

00:33:50,470 --> 00:33:48,559

richard casey who is the the man who

799

00:33:52,870 --> 00:33:50,480

actually set up the radio physics

800

00:33:54,630 --> 00:33:52,880

laboratory within the csiro as a secret

801
00:33:56,870 --> 00:33:54,640
wartime laboratory

802
00:33:59,269 --> 00:33:56,880
was a minister in the then australian

803
00:34:01,990 --> 00:33:59,279
government and responsible for the csiro

804
00:34:04,549 --> 00:34:02,000
and he managed to convince and he was a

805
00:34:06,630 --> 00:34:04,559
great supporter of the of taffy and the

806
00:34:08,310 --> 00:34:06,640
telescope project and he managed to

807
00:34:09,990 --> 00:34:08,320
convince the australian

808
00:34:11,990 --> 00:34:10,000
prime minister to support it with

809
00:34:14,230 --> 00:34:12,000
matching funds and then combined with

810
00:34:15,669 --> 00:34:14,240
additional private donations and with

811
00:34:17,349 --> 00:34:15,679
the additional

812
00:34:19,510 --> 00:34:17,359
funds from the australian government and

813
00:34:21,430 --> 00:34:19,520

the rockefeller to make up a shortfall

814

00:34:24,149 --> 00:34:21,440

towards the end of the project he was

815

00:34:26,149 --> 00:34:24,159

able to acquire just over 1.4 million

816

00:34:28,230 --> 00:34:26,159

dollars to build the telescope which

817

00:34:32,790 --> 00:34:28,240

even in those days was considered

818

00:34:35,990 --> 00:34:34,710

the telescope itself

819

00:34:38,470 --> 00:34:36,000

um

820

00:34:40,389 --> 00:34:38,480

was designed by the freeman fox and

821

00:34:42,069 --> 00:34:40,399

partners a british firm they were

822

00:34:44,629 --> 00:34:42,079

actually famous especially in australia

823

00:34:46,069 --> 00:34:44,639

as being the the designers of the sydney

824

00:34:47,669 --> 00:34:46,079

harbour bridge

825

00:34:49,109 --> 00:34:47,679

and

826
00:34:52,310 --> 00:34:49,119
they were contracted to design the

827
00:34:53,109 --> 00:34:52,320
telescope to csiro specifications

828
00:34:55,109 --> 00:34:53,119
and

829
00:34:57,270 --> 00:34:55,119
the csro engineer harry minnett

830
00:35:04,069 --> 00:34:57,280
supervised the design of the telescope

831
00:35:07,829 --> 00:35:06,310
this was much longer than they expected

832
00:35:11,030 --> 00:35:07,839
but it paid off in the end because it

833
00:35:13,510 --> 00:35:11,040
meant that they got the design right

834
00:35:14,550 --> 00:35:13,520
the telescope um actually incorporated

835
00:35:17,270 --> 00:35:14,560
several

836
00:35:20,390 --> 00:35:17,280
um very innovative design features i'll

837
00:35:23,589 --> 00:35:20,400
just come to them firstly it was

838
00:35:26,069 --> 00:35:23,599

pivoted in the center it's like an

839

00:35:27,670 --> 00:35:26,079

inverted umbrella

840

00:35:30,150 --> 00:35:27,680

as you can see

841

00:35:31,990 --> 00:35:30,160

it used it was it had an azimuth mount

842

00:35:33,430 --> 00:35:32,000

which is unusual for its time for a

843

00:35:35,829 --> 00:35:33,440

structure that large

844

00:35:37,910 --> 00:35:35,839

also um in order for it to track objects

845

00:35:39,190 --> 00:35:37,920

smoothly across the sky it incorporated

846

00:35:41,030 --> 00:35:39,200

a new

847

00:35:42,630 --> 00:35:41,040

invention of the master equatorial

848

00:35:44,550 --> 00:35:42,640

system

849

00:35:46,550 --> 00:35:44,560

and it was a basically just a small

850

00:35:48,550 --> 00:35:46,560

equatorially mounted optical telescope

851
00:35:50,310 --> 00:35:48,560
located at the intersection of the

852
00:35:53,670 --> 00:35:50,320
altitude and azimuth axis of the

853
00:35:57,910 --> 00:35:55,829
um and um

854
00:35:59,589 --> 00:35:57,920
essentially the dish was slaved to that

855
00:36:02,069 --> 00:35:59,599
equatorially op mounted optical

856
00:36:04,630 --> 00:36:02,079
telescope via a servo drive system that

857
00:36:07,510 --> 00:36:04,640
enabled it to very smoothly track

858
00:36:08,390 --> 00:36:07,520
objects across the sky and finally

859
00:36:10,630 --> 00:36:08,400
it had

860
00:36:13,430 --> 00:36:10,640
spiral purlins on the dish to to give it

861
00:36:15,349 --> 00:36:13,440
strength

862
00:36:16,950 --> 00:36:15,359
the site chosen for the telescope was

863
00:36:20,230 --> 00:36:16,960

near the town of parks

864

00:36:21,990 --> 00:36:20,240

about 350 kilometers west of sydney in

865

00:36:24,230 --> 00:36:22,000

the central west of new south wales in

866

00:36:25,670 --> 00:36:24,240

australia and the reason it was chosen

867

00:36:27,829 --> 00:36:25,680

was because of those mountains in the

868

00:36:29,349 --> 00:36:27,839

background of the photograph there

869

00:36:31,030 --> 00:36:29,359

they protected us from the radio

870

00:36:32,710 --> 00:36:31,040

emissions from the larger population

871

00:36:35,030 --> 00:36:32,720

centers further east

872

00:36:38,069 --> 00:36:35,040

such as sydney for example i mean so the

873

00:36:39,990 --> 00:36:38,079

area was a very radio quiet site which

874

00:36:41,829 --> 00:36:40,000

was essential for a large sensitive

875

00:36:43,109 --> 00:36:41,839

instrument like parks

876

00:36:45,349 --> 00:36:43,119

that young

877

00:36:47,109 --> 00:36:45,359

fellow there um standing next to the

878

00:36:48,069 --> 00:36:47,119

stake where the actual telescope was

879

00:36:49,750 --> 00:36:48,079

built

880

00:36:53,990 --> 00:36:49,760

he's now 59 years old and he's a good

881

00:36:56,710 --> 00:36:54,000

friend of mine is the local farmer still

882

00:36:59,589 --> 00:36:56,720

um the main constructor for the the

883

00:37:01,990 --> 00:36:59,599

telescope was man of west germany

884

00:37:04,550 --> 00:37:02,000

um and so already you can see that it's

885

00:37:07,030 --> 00:37:04,560

it's beginning to take on the after

886

00:37:09,430 --> 00:37:07,040

of an international project with

887

00:37:11,349 --> 00:37:09,440

the united states australia um the

888

00:37:12,950 --> 00:37:11,359

british and the germans all involved in

889

00:37:18,870 --> 00:37:12,960

the construction

890

00:37:21,349 --> 00:37:18,880

1959 and over the next 21 months

891

00:37:23,829 --> 00:37:21,359

when the germans arrived to to build the

892

00:37:25,990 --> 00:37:23,839

the turret they're able to to weld the

893

00:37:27,750 --> 00:37:26,000

the ribs into into shape and then they

894

00:37:30,230 --> 00:37:27,760

lifted them one at a time bolted them

895

00:37:31,990 --> 00:37:30,240

onto the the turret and then when that

896

00:37:35,670 --> 00:37:32,000

was done they then put the focus cabin

897

00:37:38,069 --> 00:37:35,680

up on the the the apex and then paneled

898

00:37:40,230 --> 00:37:38,079

the the dish and it said it was all done

899

00:37:42,470 --> 00:37:40,240

in the amazingly short period of just 21

900

00:37:44,150 --> 00:37:42,480

months and that was a and there was very

901
00:37:45,829 --> 00:37:44,160
little problems encountered in the

902
00:37:48,870 --> 00:37:45,839
construction and it was mainly due to

903
00:37:50,950 --> 00:37:48,880
the the time spent in designing it

904
00:37:52,630 --> 00:37:50,960
initially

905
00:37:54,630 --> 00:37:52,640
the first tip of the telescope occurred

906
00:37:56,870 --> 00:37:54,640
in october 1961

907
00:37:58,390 --> 00:37:56,880
and then a mid-october 61 and then two

908
00:38:00,630 --> 00:37:58,400
weeks later it was officially opened by

909
00:38:03,589 --> 00:38:00,640
the governor general of australia

910
00:38:07,109 --> 00:38:05,510
the first director of the observatory

911
00:38:10,150 --> 00:38:07,119
was john bolton

912
00:38:11,910 --> 00:38:10,160
he was a legendary figure um

913
00:38:15,589 --> 00:38:11,920

a pioneer of radio astronomy in

914

00:38:17,349 --> 00:38:15,599

australia and he also in 1955

915

00:38:19,670 --> 00:38:17,359

moved to caltech and and started the

916

00:38:21,750 --> 00:38:19,680

radio astronomy program there

917

00:38:24,390 --> 00:38:21,760

and founded the owens valley observatory

918

00:38:26,550 --> 00:38:24,400

which is um

919

00:38:30,870 --> 00:38:26,560

which we had very close um contacts with

920

00:38:34,230 --> 00:38:32,470

but how do we get involved in the space

921

00:38:36,230 --> 00:38:34,240

missions

922

00:38:37,030 --> 00:38:36,240

well the story goes back to the period

923

00:38:39,430 --> 00:38:37,040

um

924

00:38:40,390 --> 00:38:39,440

the interest that that jpl had in in

925

00:38:43,030 --> 00:38:40,400

parks

926

00:38:45,750 --> 00:38:43,040

um went to before even that when the

927

00:38:48,630 --> 00:38:45,760

telescope was was built began on the 6th

928

00:38:52,390 --> 00:38:48,640

of march 1959 when the us army's pioneer

929

00:38:55,190 --> 00:38:52,400

4 spacecraft flew by the moon um at what

930

00:38:57,750 --> 00:38:55,200

was then a record distance of 650 000

931

00:38:59,910 --> 00:38:57,760

kilometers and unfortunately

932

00:39:01,109 --> 00:38:59,920

nasa jpl could not communicate with it

933

00:39:02,150 --> 00:39:01,119

effectively

934

00:39:04,950 --> 00:39:02,160

even though it was a perfectly

935

00:39:07,190 --> 00:39:04,960

functioning spacecraft because its small

936

00:39:09,190 --> 00:39:07,200

26 meter antenna at goldstone just

937

00:39:12,630 --> 00:39:09,200

didn't have the sensitivity to

938

00:39:13,670 --> 00:39:12,640

to communicate with it effectively

939

00:39:16,310 --> 00:39:13,680

and so

940

00:39:18,390 --> 00:39:16,320

jpl realized that what it needed was the

941

00:39:21,190 --> 00:39:18,400

it was a much larger and more sensitive

942

00:39:22,870 --> 00:39:21,200

antenna than this 26 meter antennas that

943

00:39:25,510 --> 00:39:22,880

it was planning for its deep space

944

00:39:28,069 --> 00:39:25,520

network or the fledgling deep space

945

00:39:30,230 --> 00:39:28,079

and so the requirements for such a an

946

00:39:32,310 --> 00:39:30,240

antenna were that it

947

00:39:34,550 --> 00:39:32,320

needed to be six to 12 db improvement

948

00:39:36,630 --> 00:39:34,560

over the existing 26 meter array they

949

00:39:38,069 --> 00:39:36,640

were planning

950

00:39:41,829 --> 00:39:38,079

which meant it had to be somewhere in

951
00:39:43,750 --> 00:39:41,839
the order of 60 to 80 meters in diameter

952
00:39:46,710 --> 00:39:43,760
it had to have optimum performance at

953
00:39:49,589 --> 00:39:46,720
2.2 gigahertz at s-band in other words

954
00:39:51,109 --> 00:39:49,599
the surface had to be extremely accurate

955
00:39:54,550 --> 00:39:51,119
um you needed to have a pointing

956
00:39:55,750 --> 00:39:54,560
accuracy of about 1.2 minutes of arc

957
00:39:57,430 --> 00:39:55,760
and

958
00:39:59,270 --> 00:39:57,440
finally needed to have a slew rate of

959
00:40:01,510 --> 00:39:59,280
around 10 degrees a minute

960
00:40:03,750 --> 00:40:01,520
and it was no surprise at all that these

961
00:40:07,589 --> 00:40:03,760
requirements match the the proposed park

962
00:40:09,510 --> 00:40:07,599
telescope very very closely

963
00:40:11,910 --> 00:40:09,520

consequently during the the tender and

964

00:40:14,309 --> 00:40:11,920

construction phase of the telescope

965

00:40:17,430 --> 00:40:14,319

jpl made several representations to the

966

00:40:19,270 --> 00:40:17,440

csiro with the view of of formally

967

00:40:20,630 --> 00:40:19,280

incorporating it into the deep space

968

00:40:22,309 --> 00:40:20,640

network

969

00:40:24,550 --> 00:40:22,319

finally however a cooperative space

970

00:40:25,910 --> 00:40:24,560

exploration program was proposed

971

00:40:28,150 --> 00:40:25,920

and you can see that it was for the

972

00:40:30,390 --> 00:40:28,160

occasional use of parks for data

973

00:40:32,470 --> 00:40:30,400

requisition of a short-term nature where

974

00:40:33,750 --> 00:40:32,480

an extremely strong and reliable signal

975

00:40:35,670 --> 00:40:33,760

was required

976

00:40:37,829 --> 00:40:35,680

and in fact to this day

977

00:40:39,829 --> 00:40:37,839

it is still the basis in rationale for

978

00:40:42,870 --> 00:40:39,839

parks's inclusion in space tracking

979

00:40:48,309 --> 00:40:45,910

in 1962 a nasa research grant was

980

00:40:50,630 --> 00:40:48,319

awarded to the csiro to study the dish

981

00:40:52,309 --> 00:40:50,640

characteristics with a view to it

982

00:40:55,829 --> 00:40:52,319

contributing toward the design of the

983

00:40:58,069 --> 00:40:55,839

proposed jpl large aperture antennas

984

00:41:00,630 --> 00:40:58,079

william pickering the jpl director

985

00:41:02,470 --> 00:41:00,640

invited the csro to to participate in

986

00:41:05,349 --> 00:41:02,480

the feasibility studies and

987

00:41:09,109 --> 00:41:05,359

specification reviews of the the jpl

988

00:41:13,109 --> 00:41:11,270

um the giant the grant also called for a

989

00:41:15,270 --> 00:41:13,119

detailed study to determine the

990

00:41:17,589 --> 00:41:15,280

performance parameters of the parks

991

00:41:18,950 --> 00:41:17,599

telescope in regards to to those

992

00:41:21,030 --> 00:41:18,960

premises you see there the structural

993

00:41:23,270 --> 00:41:21,040

behavior characteristics of the drive

994

00:41:25,349 --> 00:41:23,280

system radio frequency performance

995

00:41:26,870 --> 00:41:25,359

vibration characteristics but also

996

00:41:29,990 --> 00:41:26,880

measurements of the disc shape in the

997

00:41:32,550 --> 00:41:30,000

zenith and tilted positions

998

00:41:34,470 --> 00:41:32,560

as a result of these studies

999

00:41:37,190 --> 00:41:34,480

over the next few over the the next few

1000

00:41:38,550 --> 00:41:37,200

years um more than 30 research papers

1001
00:41:40,870 --> 00:41:38,560
were published on the design and

1002
00:41:42,390 --> 00:41:40,880
performance of the telescope parks was

1003
00:41:44,470 --> 00:41:42,400
not only the most advanced radio

1004
00:41:48,309 --> 00:41:44,480
telescope in the world it also became

1005
00:41:49,670 --> 00:41:48,319
the most extensively studied

1006
00:41:51,349 --> 00:41:49,680
and the reason was because this

1007
00:41:53,030 --> 00:41:51,359
information was considered to be of

1008
00:41:58,230 --> 00:41:53,040
critical importance in the design and

1009
00:42:02,550 --> 00:42:00,630
the caltech and jpl luminaries involved

1010
00:42:05,589 --> 00:42:02,560
in that design were people such as bruce

1011
00:42:07,670 --> 00:42:05,599
rule bill merrick ebrechten and sononai

1012
00:42:10,150 --> 00:42:07,680
liaise very closely with the csro

1013
00:42:14,470 --> 00:42:10,160

engineers harry minet and and others to

1014

00:42:16,950 --> 00:42:14,480

to ensure that the the dsn antennas were

1015

00:42:18,550 --> 00:42:16,960

operated as and as well as as they'd

1016

00:42:19,990 --> 00:42:18,560

hope

1017

00:42:22,550 --> 00:42:20,000

now another aspect of the park's

1018

00:42:25,510 --> 00:42:22,560

telescope impact on space tracking was

1019

00:42:27,030 --> 00:42:25,520

in the location of the dsn stations

1020

00:42:28,710 --> 00:42:27,040

as you can see the very first station

1021

00:42:31,670 --> 00:42:28,720

was located at goldstone because only

1022

00:42:33,190 --> 00:42:31,680

just a few hours drive from from jpl but

1023

00:42:34,950 --> 00:42:33,200

that then dictated where the other two

1024

00:42:36,870 --> 00:42:34,960

stations would go they needed to have

1025

00:42:39,910 --> 00:42:36,880

their stations roughly equidistant

1026
00:42:42,390 --> 00:42:39,920
around the globe um 120 degrees apart

1027
00:42:44,870 --> 00:42:42,400
roughly and so in the early 19 early

1028
00:42:46,950 --> 00:42:44,880
late 50s early 60s the other two

1029
00:42:49,750 --> 00:42:46,960
stations were located at johannesburg in

1030
00:42:51,670 --> 00:42:49,760
western um in south africa and also at

1031
00:42:53,990 --> 00:42:51,680
ireland lagoon at the women rocket range

1032
00:42:55,990 --> 00:42:54,000
in south australia but for various

1033
00:42:58,309 --> 00:42:56,000
reasons which i won't go into just lack

1034
00:43:01,190 --> 00:42:58,319
of time there they had to to shift the

1035
00:43:03,670 --> 00:43:01,200
locations of those other stations and um

1036
00:43:06,470 --> 00:43:03,680
one went to to madrid and the other went

1037
00:43:08,950 --> 00:43:06,480
to the tidman villa nature reserve very

1038
00:43:11,430 --> 00:43:08,960

close to canberra the australian capital

1039

00:43:13,510 --> 00:43:11,440

um and the reason tidbinbilla was chosen

1040

00:43:15,589 --> 00:43:13,520

was because taffy bone was the chairman

1041

00:43:17,750 --> 00:43:15,599

of the site selection committee and he

1042

00:43:19,750 --> 00:43:17,760

chose that site because

1043

00:43:22,309 --> 00:43:19,760

ted ben biller was on almost exactly the

1044

00:43:24,550 --> 00:43:22,319

same longitude as the parks telescope

1045

00:43:27,109 --> 00:43:24,560

because he argued that being on the same

1046

00:43:29,270 --> 00:43:27,119

longitude the two would see the same sky

1047

00:43:31,109 --> 00:43:29,280

simultaneously and that in the future

1048

00:43:34,710 --> 00:43:31,119

nasa may want to

1049

00:43:38,230 --> 00:43:34,720

link or array the dishes together

1050

00:43:39,910 --> 00:43:38,240

to enhance the capabilities so that

1051
00:43:41,670 --> 00:43:39,920
the two working together would be a much

1052
00:43:43,829 --> 00:43:41,680
more powerful more useful instrument

1053
00:43:46,069 --> 00:43:43,839
than the two working individually and of

1054
00:43:47,829 --> 00:43:46,079
course that was realized some 20 or so

1055
00:43:50,710 --> 00:43:47,839
years later with the voyager 2

1056
00:43:53,109 --> 00:43:50,720
encounters of uranus and neptune and

1057
00:43:58,150 --> 00:43:53,119
also very critically with the galileo

1058
00:44:03,510 --> 00:44:00,950
now it was during the this design and

1059
00:44:04,550 --> 00:44:03,520
study period that that mariner 2 was

1060
00:44:05,510 --> 00:44:04,560
launched

1061
00:44:08,230 --> 00:44:05,520
um

1062
00:44:11,030 --> 00:44:08,240
as you all know it was it flew by venus

1063
00:44:13,510 --> 00:44:11,040

on the 14th of december 1962 and it flew

1064

00:44:16,230 --> 00:44:13,520

within just under 35 000 kilometers of

1065

00:44:18,470 --> 00:44:16,240

the of the surface

1066

00:44:20,470 --> 00:44:18,480

now taffy bone harry minnett decided

1067

00:44:22,150 --> 00:44:20,480

that tracking mariner 2 would be the

1068

00:44:24,630 --> 00:44:22,160

would be an excellent demonstration of

1069

00:44:27,190 --> 00:44:24,640

the parks telescope's capabilities for

1070

00:44:28,950 --> 00:44:27,200

communication at great distances

1071

00:44:30,790 --> 00:44:28,960

and essentially the experiment would be

1072

00:44:32,630 --> 00:44:30,800

a simple one involving the measurement

1073

00:44:35,750 --> 00:44:32,640

of spacecraft position

1074

00:44:37,829 --> 00:44:35,760

signal level and doppler frequency

1075

00:44:40,309 --> 00:44:37,839

it did not include the reception of

1076

00:44:42,309 --> 00:44:40,319

telemetry but was simply intended to

1077

00:44:45,030 --> 00:44:42,319

establish the technique and measure the

1078

00:44:47,670 --> 00:44:45,040

performance of a 64 metre

1079

00:44:52,550 --> 00:44:49,430

parks tracked it for two weeks beginning

1080

00:44:54,309 --> 00:44:52,560

on the 20th of december 1962 until the

1081

00:44:56,390 --> 00:44:54,319

3rd of january

1082

00:44:58,950 --> 00:44:56,400

when the signal was finally

1083

00:45:00,870 --> 00:44:58,960

finally lost

1084

00:45:03,829 --> 00:45:00,880

jpl loaned

1085

00:45:05,829 --> 00:45:03,839

parks a nail band transportable phase

1086

00:45:07,349 --> 00:45:05,839

lock receiver which the astronomers

1087

00:45:08,630 --> 00:45:07,359

dubbed the ancient mariner as you can

1088

00:45:10,150 --> 00:45:08,640

see

1089

00:45:11,990 --> 00:45:10,160

because it looked quite old even then i

1090

00:45:13,910 --> 00:45:12,000

think

1091

00:45:16,069 --> 00:45:13,920

but but the thing that i found most

1092

00:45:18,230 --> 00:45:16,079

amazing was that it had a 20 hertz gate

1093

00:45:19,829 --> 00:45:18,240

that could be manually tuned so the

1094

00:45:22,790 --> 00:45:19,839

astronomers had to know the the

1095

00:45:23,670 --> 00:45:22,800

frequency very very precisely and tune

1096

00:45:27,109 --> 00:45:23,680

the tune

1097

00:45:29,109 --> 00:45:27,119

to with to very close to the um to the

1098

00:45:30,950 --> 00:45:29,119

um frequent doppler shifted frequency in

1099

00:45:32,870 --> 00:45:30,960

the pass span and so they could get it

1100

00:45:35,109 --> 00:45:32,880

in that 20 hertz gate and then lock on

1101

00:45:37,430 --> 00:45:35,119

to the to the signal

1102

00:45:41,910 --> 00:45:39,270

because these tracks were and if we're

1103

00:45:44,630 --> 00:45:41,920

on an informal basis jpl did not provide

1104

00:45:48,069 --> 00:45:44,640

position and frequency predicts so harry

1105

00:45:49,190 --> 00:45:48,079

minette resorted to calculating um these

1106

00:45:51,829 --> 00:45:49,200

himself

1107

00:45:54,230 --> 00:45:51,839

using slide rule and pencil and paper

1108

00:45:56,150 --> 00:45:54,240

but he needed to know both the position

1109

00:45:58,069 --> 00:45:56,160

and the frequency to lock onto the

1110

00:45:59,910 --> 00:45:58,079

signal

1111

00:46:01,270 --> 00:45:59,920

he experienced great trouble at this as

1112

00:46:03,430 --> 00:46:01,280

you could imagine because he was never

1113

00:46:06,230 --> 00:46:03,440

sure whether the position was right and

1114

00:46:07,109 --> 00:46:06,240

the frequency is wrong or vice versa or

1115

00:46:09,030 --> 00:46:07,119

both

1116

00:46:11,670 --> 00:46:09,040

um so eventually after a week of

1117

00:46:13,270 --> 00:46:11,680

fruitless effort he contacted jpl who

1118

00:46:14,390 --> 00:46:13,280

sent him the predicts and he immediately

1119

00:46:16,309 --> 00:46:14,400

was able to

1120

00:46:18,950 --> 00:46:16,319

to to lock on to the

1121

00:46:21,589 --> 00:46:18,960

um to the signal

1122

00:46:23,190 --> 00:46:21,599

um as you see there and here i found um

1123

00:46:25,270 --> 00:46:23,200

in the national archives um he's

1124

00:46:28,150 --> 00:46:25,280

hand-drawn plot of the results and we

1125

00:46:29,750 --> 00:46:28,160

just zoom in a little bit then

1126

00:46:33,430 --> 00:46:29,760

you can see that the park's telescope

1127

00:46:35,910 --> 00:46:33,440

had an overall 5 db um advantage over

1128

00:46:37,430 --> 00:46:35,920

the 26 meter antennas in this case um

1129

00:46:39,109 --> 00:46:37,440

the one at warmer

1130

00:46:42,630 --> 00:46:39,119

and it should have actually had a have

1131

00:46:44,150 --> 00:46:42,640

had an 8 db advantage but because

1132

00:46:45,829 --> 00:46:44,160

a circularly polarized feed was

1133

00:46:47,670 --> 00:46:45,839

unavailable the astronomers had used the

1134

00:46:51,910 --> 00:46:47,680

linearly polarized astronomy feed

1135

00:46:53,670 --> 00:46:51,920

instead that included a 3db penalty

1136

00:46:55,589 --> 00:46:53,680

nonetheless the experiment was

1137

00:46:57,750 --> 00:46:55,599

considered a great success and the

1138

00:46:59,670 --> 00:46:57,760

results were included in the the study

1139

00:47:02,710 --> 00:46:59,680

reports that verified the soundness of

1140

00:47:05,190 --> 00:47:02,720

the the of the design

1141

00:47:07,430 --> 00:47:05,200

and as a result of as a consequence of

1142

00:47:10,069 --> 00:47:07,440

these parks became the model for the jpl

1143

00:47:11,750 --> 00:47:10,079

large aperture antennas

1144

00:47:13,829 --> 00:47:11,760

as you can see they were all pivoted in

1145

00:47:16,150 --> 00:47:13,839

the center just like parks they had an

1146

00:47:17,910 --> 00:47:16,160

alt azimuth mount and they incorporated

1147

00:47:20,549 --> 00:47:17,920

the master equatorial system and they

1148

00:47:21,829 --> 00:47:20,559

were all 64 meters in diameter the

1149

00:47:24,390 --> 00:47:21,839

goldstone dish was eventually

1150

00:47:27,190 --> 00:47:24,400

commissioned in may 1966

1151
00:47:29,589 --> 00:47:27,200
but before then mariner 4 was flying by

1152
00:47:31,910 --> 00:47:29,599
mars and the goldstone dish was still a

1153
00:47:33,990 --> 00:47:31,920
year away from completion so pax was

1154
00:47:36,790 --> 00:47:34,000
approached to provide the

1155
00:47:39,510 --> 00:47:36,800
64 meter capability for the dsn

1156
00:47:41,670 --> 00:47:39,520
22 images were returned of the martian

1157
00:47:44,630 --> 00:47:41,680
surface and parks provided a three db

1158
00:47:46,630 --> 00:47:44,640
improvement of the existing um dsn array

1159
00:47:50,309 --> 00:47:46,640
in fact all antennas combined parks

1160
00:47:52,069 --> 00:47:50,319
provided double the the strength of that

1161
00:47:54,710 --> 00:47:52,079
the data from parks was combined with

1162
00:47:56,150 --> 00:47:54,720
those um from the other stations and

1163
00:47:57,990 --> 00:47:56,160

used to produce

1164

00:47:59,750 --> 00:47:58,000

improved images of the martian surface

1165

00:48:02,150 --> 00:47:59,760

and you've all seen this one the famous

1166

00:48:03,510 --> 00:48:02,160

image 11 which made astronomers very

1167

00:48:05,030 --> 00:48:03,520

very disappointed because they're

1168

00:48:06,549 --> 00:48:05,040

expecting to see burdened forests

1169

00:48:11,109 --> 00:48:06,559

instead they had

1170

00:48:14,309 --> 00:48:12,549

now

1171

00:48:17,829 --> 00:48:14,319

perhaps the most famous mission parks

1172

00:48:19,589 --> 00:48:17,839

was involved in was the was apollo 11.

1173

00:48:21,670 --> 00:48:19,599

no history of parks could be complete

1174

00:48:24,309 --> 00:48:21,680

without a mention of its role

1175

00:48:26,549 --> 00:48:24,319

it began in october 1968 when john

1176

00:48:29,109 --> 00:48:26,559

bolton was visiting caltech he was

1177

00:48:30,630 --> 00:48:29,119

invited to to dinner at the home of bob

1178

00:48:31,589 --> 00:48:30,640

leighton the friend and colleague of

1179

00:48:33,510 --> 00:48:31,599

john's

1180

00:48:34,390 --> 00:48:33,520

and one of the pis for the mariner 4

1181

00:48:36,230 --> 00:48:34,400

mission

1182

00:48:37,670 --> 00:48:36,240

i'm also at the dinner was ed brechton

1183

00:48:39,589 --> 00:48:37,680

the head of the goldstone project and

1184

00:48:41,349 --> 00:48:39,599

during the course of the dinner john was

1185

00:48:43,030 --> 00:48:41,359

asked if you could make available the

1186

00:48:45,589 --> 00:48:43,040

the parks telescope for the upcoming

1187

00:48:47,030 --> 00:48:45,599

apollo 11 mission but in particular for

1188

00:48:49,109 --> 00:48:47,040

those few short hours when the lunar

1189

00:48:51,430 --> 00:48:49,119

module was on the lunar surface and

1190

00:48:53,270 --> 00:48:51,440

because human lives were

1191

00:48:56,309 --> 00:48:53,280

were at risk both he and taffy bowen

1192

00:48:58,549 --> 00:48:56,319

agreed and as he's well known now 600

1193

00:48:59,750 --> 00:48:58,559

million people one-sixth of mankind at

1194

00:49:01,829 --> 00:48:59,760

the time

1195

00:49:04,390 --> 00:49:01,839

witnessed the apollo 11

1196

00:49:05,910 --> 00:49:04,400

moonwalk live on tv through pictures

1197

00:49:07,750 --> 00:49:05,920

received at parks

1198

00:49:09,510 --> 00:49:07,760

the story is far too long for me to go

1199

00:49:11,510 --> 00:49:09,520

into

1200

00:49:13,510 --> 00:49:11,520

detail in this short presentation but i

1201

00:49:15,750 --> 00:49:13,520

i invite you to check the park's website

1202

00:49:18,390 --> 00:49:15,760

and also the honeysuckle creek website

1203

00:49:21,270 --> 00:49:18,400

um for more details on on that

1204

00:49:23,349 --> 00:49:21,280

and um i think um oh yeah it's just that

1205

00:49:25,430 --> 00:49:23,359

there and the beginning of the broadcast

1206

00:49:27,109 --> 00:49:25,440

nasa would just um

1207

00:49:28,549 --> 00:49:27,119

tv is the thing that everyone remembers

1208

00:49:30,390 --> 00:49:28,559

nowadays

1209

00:49:32,470 --> 00:49:30,400

and um

1210

00:49:34,470 --> 00:49:32,480

but at the beginning of the broadcast

1211

00:49:36,230 --> 00:49:34,480

nasa houston was switching between the

1212

00:49:38,150 --> 00:49:36,240

signals being received at goldstone and

1213

00:49:39,829 --> 00:49:38,160

honeysuckle creek when they finally

1214

00:49:41,510 --> 00:49:39,839

switched to parks it was so much better

1215

00:49:43,430 --> 00:49:41,520

they stayed with parks for the remainder

1216

00:49:45,430 --> 00:49:43,440

of the two and a half hour moonwalk and

1217

00:49:46,309 --> 00:49:45,440

just to give you an idea of why they did

1218

00:49:47,829 --> 00:49:46,319

that

1219

00:49:49,589 --> 00:49:47,839

on the right

1220

00:49:51,829 --> 00:49:49,599

outside the left

1221

00:49:53,270 --> 00:49:51,839

you have an image of armstrong

1222

00:49:55,589 --> 00:49:53,280

descending the ladder source from

1223

00:49:57,750 --> 00:49:55,599

goldstone 20 minutes later when they

1224

00:49:59,670 --> 00:49:57,760

were using the parks feed you can see

1225

00:50:02,390 --> 00:49:59,680

aldrin coming down the ladder you can

1226

00:50:04,870 --> 00:50:02,400

see the improvement in the picture

1227

00:50:07,750 --> 00:50:04,880

honeysuckle creek had a had a very good

1228

00:50:10,150 --> 00:50:07,760

image also but because of its um

1229

00:50:12,790 --> 00:50:10,160

smaller size and lower signal to noise

1230

00:50:15,190 --> 00:50:12,800

ratio had a grainier image

1231

00:50:17,030 --> 00:50:15,200

the equivalent picture um 20 minutes

1232

00:50:19,109 --> 00:50:17,040

later when alden was about to step on

1233

00:50:20,710 --> 00:50:19,119

the lunar surface was from parks and

1234

00:50:23,589 --> 00:50:20,720

again you can see the improvement and

1235

00:50:25,430 --> 00:50:23,599

understand why it was involved

1236

00:50:27,430 --> 00:50:25,440

over the years the the we've had a

1237

00:50:30,950 --> 00:50:27,440

mutually beneficial partnership the

1238

00:50:33,349 --> 00:50:30,960

csiro and and nasa whenever parks has

1239

00:50:35,510 --> 00:50:33,359

supported a nation's nasa space mission

1240

00:50:37,270 --> 00:50:35,520

uh we've we've gotten a better radio

1241

00:50:40,150 --> 00:50:37,280

telescope out of it as a result and in

1242

00:50:41,589 --> 00:50:40,160

return nasa has a more capable antenna

1243

00:50:43,829 --> 00:50:41,599

for the next mission that they approach

1244

00:50:45,910 --> 00:50:43,839

us for you can see all the surface

1245

00:50:48,069 --> 00:50:45,920

upgrades and the focus cabin and so on

1246

00:50:50,710 --> 00:50:48,079

we're all funded by by nasa over the

1247

00:50:52,870 --> 00:50:50,720

years and we've got a much much better

1248

00:50:55,910 --> 00:50:52,880

telescope and nasa has a more capable

1249

00:50:57,829 --> 00:50:55,920

antenna for for its next mission also

1250

00:51:00,549 --> 00:50:57,839

so in conclusion i'd like to finish with

1251
00:51:03,109 --> 00:51:00,559
a quote by the us ambassador to

1252
00:51:04,150 --> 00:51:03,119
australia in 2003 when he was at parks

1253
00:51:06,829 --> 00:51:04,160
to

1254
00:51:08,870 --> 00:51:06,839
launch the the mars tracks

1255
00:51:11,270 --> 00:51:08,880
um um

1256
00:51:13,910 --> 00:51:11,280
tom schieffer um

1257
00:51:16,710 --> 00:51:13,920
and basically he said to to quote the

1258
00:51:18,630 --> 00:51:16,720
parks telescope is like a trusted friend

1259
00:51:21,750 --> 00:51:18,640
always there when we need a when we need

1260
00:51:24,150 --> 00:51:21,760
a hand the relationship between csiro

1261
00:51:26,790 --> 00:51:24,160
and nasa is very much like that between

1262
00:51:28,790 --> 00:51:26,800
the united states and australia

1263
00:51:31,109 --> 00:51:28,800

a friend that

1264

00:51:33,510 --> 00:51:31,119

has friends that share common values and

1265

00:51:35,510 --> 00:51:33,520

dreams and i have a picture there of the

1266

00:51:37,430 --> 00:51:35,520

ambassador and the officer in charge of

1267

00:51:38,950 --> 00:51:37,440

the parks telescope john reynolds

1268

00:51:41,109 --> 00:51:38,960

playing a spotted cricket on the dish

1269

00:51:42,549 --> 00:51:41,119

during the opening the ambassador had to

1270

00:51:44,309 --> 00:51:42,559

learn how to hold the cricket back

1271

00:51:46,790 --> 00:51:44,319

correctly he was he thought it was a

1272

00:51:49,270 --> 00:51:46,800

baseball bat at the time but um that it

1273

00:51:51,190 --> 00:51:49,280

worked and just to finish up just 30

1274

00:51:53,030 --> 00:51:51,200

seconds there is an epilogue to the

1275

00:51:56,230 --> 00:51:53,040

story

1276
00:51:58,150 --> 00:51:56,240
on the 27th of august 1962 mariner 2 the

1277
00:51:59,589 --> 00:51:58,160
first interplanetary spacecraft was

1278
00:52:01,109 --> 00:51:59,599
launched to venus

1279
00:52:02,549 --> 00:52:01,119
that just happened to be the day that i

1280
00:52:06,309 --> 00:52:02,559
was born

1281
00:52:10,390 --> 00:52:06,319
okay and when new horizons arrives at

1282
00:52:11,750 --> 00:52:10,400
pluto in july 2015.

1283
00:52:13,910 --> 00:52:11,760
we could say

1284
00:52:16,710 --> 00:52:13,920
in all honesty that in the space of a

1285
00:52:18,470 --> 00:52:16,720
single human lifetime um the entire

1286
00:52:20,470 --> 00:52:18,480
solar system would have been

1287
00:52:21,910 --> 00:52:20,480
explored and i think that's pretty

1288
00:52:40,790 --> 00:52:21,920

impressive and parks was there from the

1289

00:52:47,270 --> 00:52:44,390

but my my serious question is

1290

00:52:49,750 --> 00:52:47,280

i had not realized before actually that

1291

00:52:52,069 --> 00:52:49,760

uh parks was if you will a prototype of

1292

00:52:55,990 --> 00:52:52,079

these large steerable antennas

1293

00:52:57,510 --> 00:52:56,000

and what amazes me is that uh i got it

1294

00:52:59,990 --> 00:52:57,520

right the first time in terms of

1295

00:53:02,630 --> 00:53:00,000

critical things like the the loading on

1296

00:53:04,309 --> 00:53:02,640

the figure of the of the was of the

1297

00:53:06,230 --> 00:53:04,319

telescope was there was there some

1298

00:53:07,750 --> 00:53:06,240

special innovation that

1299

00:53:09,990 --> 00:53:07,760

enabled that or was it just real

1300

00:53:11,910 --> 00:53:10,000

attention to details it was it was

1301
00:53:14,150 --> 00:53:11,920
essentially just the attention to detail

1302
00:53:17,109 --> 00:53:14,160
but also i didn't have time to to go

1303
00:53:19,270 --> 00:53:17,119
into great detail but one of the the the

1304
00:53:20,950 --> 00:53:19,280
engineers that provided the the really

1305
00:53:22,870 --> 00:53:20,960
innovative ideas on how it should be

1306
00:53:24,950 --> 00:53:22,880
done was barnes wallace a famous british

1307
00:53:26,710 --> 00:53:24,960
engineer he was famous during the world

1308
00:53:29,030 --> 00:53:26,720
war during world war ii as the inventor

1309
00:53:31,829 --> 00:53:29,040
of the bouncing bombs and it was his

1310
00:53:33,270 --> 00:53:31,839
idea essentially to to have an out as a

1311
00:53:35,750 --> 00:53:33,280
mounted telescope with the master

1312
00:53:37,349 --> 00:53:35,760
recorder he invented that concept and

1313
00:53:39,510 --> 00:53:37,359

also the spiral purlins he actually

1314

00:53:41,510 --> 00:53:39,520

developed that that idea for the r 100

1315

00:53:43,430 --> 00:53:41,520

airship and the wellington bombers and

1316

00:53:45,270 --> 00:53:43,440

that's what gave the dish that that that

1317

00:53:47,190 --> 00:53:45,280

strength and it's also the reason why

1318

00:53:50,230 --> 00:53:47,200

we've been able to upgrade the surface

1319

00:53:53,030 --> 00:53:50,240

continually over the years and because

1320

00:53:55,190 --> 00:53:53,040

that it did have that strength and um

1321

00:53:57,589 --> 00:53:55,200

and the the designers of the jpl

1322

00:53:59,510 --> 00:53:57,599

antennas were extremely extremely

1323

00:54:01,270 --> 00:53:59,520

interested in that and they

1324

00:54:02,710 --> 00:54:01,280

they took a lot of those design fishes

1325

00:54:04,230 --> 00:54:02,720

as you saw

1326
00:54:05,349 --> 00:54:04,240
and incorporated

1327
00:54:06,309 --> 00:54:05,359
with the

1328
00:54:08,150 --> 00:54:06,319
added

1329
00:54:10,470 --> 00:54:08,160
they have to be able to transmit as well

1330
00:54:12,470 --> 00:54:10,480
as received so they they had a cast of

1331
00:54:13,430 --> 00:54:12,480
grain feed rather than prime focus as we

1332
00:54:16,390 --> 00:54:13,440
do but

1333
00:54:18,150 --> 00:54:16,400
um but it really did come down to the to

1334
00:54:19,430 --> 00:54:18,160
the designers designing it properly at

1335
00:54:20,870 --> 00:54:19,440
the beginning which is why they took

1336
00:54:22,870 --> 00:54:20,880
their time and then built it quickly

1337
00:54:25,030 --> 00:54:22,880
it's a good case of hastening slowly

1338
00:54:26,870 --> 00:54:25,040

where take your time design and then do

1339

00:54:28,390 --> 00:54:26,880

it quickly at the end and of course they

1340

00:54:29,750 --> 00:54:28,400

were the same people that designed the

1341

00:54:32,230 --> 00:54:29,760

sydney harbour bridge and that's still

1342

00:54:33,829 --> 00:54:32,240

up and still will be for a century or