
HUBBLE
hangouts
The History of Hubble
Thursday October 30, 2014 3pm EDT 7pm GMT

1
00:00:10,430 --> 00:00:08,600
hello everybody and welcome to today's

2
00:00:12,169 --> 00:00:10,440
Hubble hang out my name is Tony Darnell

3
00:00:14,660 --> 00:00:12,179
I work at the Space Telescope Science

4
00:00:16,129 --> 00:00:14,670
Institute and it is great we have a

5
00:00:17,240 --> 00:00:16,139
really interesting hangout planned I

6
00:00:18,920 --> 00:00:17,250
think we're going to be talking about

7
00:00:21,560 --> 00:00:18,930
the history of the Hubble Space

8
00:00:23,420 --> 00:00:21,570
Telescope now before I introduce my

9
00:00:24,890 --> 00:00:23,430
guests so I just want to say I better

10
00:00:27,140 --> 00:00:24,900
warn you we've been having some

11
00:00:30,439 --> 00:00:27,150
technical glitches it started this

12
00:00:32,600 --> 00:00:30,449
broadcast so if we start freezing and

13
00:00:35,209 --> 00:00:32,610

stuff I think it's an issue with the

14
00:00:37,729 --> 00:00:35,219
google hangout system so we hope you'll

15
00:00:40,729 --> 00:00:37,739
be paid holidays in advance if it gets

16
00:00:46,880 --> 00:00:40,739
really really bad so I just wanted to

17
00:00:49,369 --> 00:00:46,890
say that Hubble servicing mission yes

18
00:00:52,880 --> 00:00:49,379
that's right that's right so as many of

19
00:00:54,950 --> 00:00:52,890
you know Hubble has been in orbit for 24

20
00:00:57,410 --> 00:00:54,960
years now taking data and we're

21
00:01:00,500 --> 00:00:57,420
approaching its approaching its 25th

22
00:01:02,810 --> 00:01:00,510
year and this hangout is going to be the

23
00:01:05,270 --> 00:01:02,820
first in a series of heading outs that

24
00:01:07,520 --> 00:01:05,280
we do to help celebrate Hubble's 25

25
00:01:09,320 --> 00:01:07,530
years in space so this is the first one

26
00:01:12,020 --> 00:01:09,330
of those hangouts in that series so we

27
00:01:14,030 --> 00:01:12,030
are excited to be able to offer this to

28
00:01:15,469 --> 00:01:14,040
you if you want it we hope you're going

29
00:01:17,840 --> 00:01:15,479
to give us comments and questions you

30
00:01:20,240 --> 00:01:17,850
can do it on the YouTube and G+ event

31
00:01:22,039 --> 00:01:20,250
pages when we're monitoring those

32
00:01:24,320 --> 00:01:22,049
comments you could also use the Q&A app

33
00:01:26,780 --> 00:01:24,330
that's on the video screen itself as

34
00:01:29,450 --> 00:01:26,790
well as tweeting with the Hubble hang

35
00:01:30,800 --> 00:01:29,460
out hashtag so we hope to see we hope to

36
00:01:34,460 --> 00:01:30,810
see some comments and questions for you

37
00:01:36,590 --> 00:01:34,470
and we will we will look at I'll read

38
00:01:39,740 --> 00:01:36,600

them out and as the Hangout progresses

39
00:01:42,560 --> 00:01:39,750
so our guest today is we have some guys

40
00:01:45,679 --> 00:01:42,570
from the goddard space flight center we

41
00:01:48,800 --> 00:01:45,689
have rust weren't it werneth he's the

42
00:01:50,990 --> 00:01:48,810
former EV a manager for Hubble and he is

43
00:01:53,389 --> 00:01:51,000
uh he is now joining us to talk about

44
00:01:55,010 --> 00:01:53,399
some of the some of his experiences with

45
00:01:57,740 --> 00:01:55,020
the Hubble Space Telescope we also have

46
00:01:59,840 --> 00:01:57,750
dr. Kenneth carpenter he is the

47
00:02:03,859 --> 00:01:59,850
operations project scientist for Hubble

48
00:02:06,800 --> 00:02:03,869
at Goddard welcome guys great today ok

49
00:02:11,630 --> 00:02:06,810
also joining me as always dr. carol

50
00:02:13,610 --> 00:02:11,640
christian and scott lewis driving our

51
00:02:15,920 --> 00:02:13,620
internet for us thank you guys all right

52
00:02:18,430 --> 00:02:15,930
the Internet's driving itself apparently

53
00:02:23,449 --> 00:02:18,440
I know I know I really hope that the

54
00:02:24,949 --> 00:02:23,459
doesn't get too bad so um so Hubble's

55
00:02:27,559 --> 00:02:24,959
been around for a while I want to start

56
00:02:29,270 --> 00:02:27,569
at the very beginning and I might

57
00:02:30,680 --> 00:02:29,280
mention that I think Carol Scott and I

58
00:02:33,680 --> 00:02:30,690
are going to be doing more of these

59
00:02:35,449 --> 00:02:33,690
Hubble hangouts on the history part of

60
00:02:37,039 --> 00:02:35,459
it anyway too so we're not I don't think

61
00:02:39,110 --> 00:02:37,049
we're going to plan on trying to cover

62
00:02:40,280 --> 00:02:39,120
every single bit of the history of

63
00:02:42,619 --> 00:02:40,290

Hubble but we are going to get to the

64
00:02:46,699 --> 00:02:42,629
focus primarily on the early parts and

65
00:02:49,460 --> 00:02:46,709
so I guess some can cannot let me let me

66
00:02:53,050 --> 00:02:49,470
start with you I'd like to add where did

67
00:02:55,270 --> 00:02:53,060
the idea of putting a telescope in orbit

68
00:02:59,210 --> 00:02:55,280
come from where did it originate

69
00:03:01,300 --> 00:02:59,220
actually it's a story for this goes back

70
00:03:04,250 --> 00:03:01,310
quite away I think the earliest

71
00:03:06,259 --> 00:03:04,260
suggestions of doing an orbiting space

72
00:03:10,160 --> 00:03:06,269
telescope we're back in the 1920s

73
00:03:12,229 --> 00:03:10,170
actually there was a man named and we

74
00:03:14,599 --> 00:03:12,239
wrote an article describing the

75
00:03:16,789 --> 00:03:14,609
possibility of launching an observer

76
00:03:18,140 --> 00:03:16,799
Richard into space on a rocket he was

77
00:03:24,790 --> 00:03:18,150
more into Rockets just like Robert

78
00:03:28,810 --> 00:03:26,590
hang out again I can see that already

79
00:03:30,790 --> 00:03:28,820
could you hear that or did it all

80
00:03:33,130 --> 00:03:30,800
disappear close up again yeah it all

81
00:03:36,370 --> 00:03:33,140
just froze up I'm sorry okay well

82
00:03:38,170 --> 00:03:36,380
basically I said that it in 1923 a guy

83
00:03:40,570 --> 00:03:38,180
named Herman or Burruss actually wrote

84
00:03:41,950 --> 00:03:40,580
about launching an observatory into

85
00:03:44,320 --> 00:03:41,960
space in Iraq and he was looking for

86
00:03:48,040 --> 00:03:44,330
applications of rockets that they were

87
00:03:51,070 --> 00:03:48,050
starting to play around with and 1946

88
00:03:54,130 --> 00:03:51,080

was probably the seminal article about a

89
00:03:56,950 --> 00:03:54,140
Space Telescope a professor named lyman

90
00:03:59,860 --> 00:03:56,960
spitzer at princeton wrote for project

91
00:04:02,110 --> 00:03:59,870
rand which was a think tank back in the

92
00:04:03,880 --> 00:04:02,120
1940s and he wrote an article about the

93
00:04:06,340 --> 00:04:03,890
advantages of putting an astronomical

94
00:04:07,720 --> 00:04:06,350
telescope into space noting that you

95
00:04:09,430 --> 00:04:07,730
wouldn't be looking through the

96
00:04:11,440 --> 00:04:09,440
atmosphere which blurs things out from

97
00:04:12,760 --> 00:04:11,450
the ground noting you see a broader

98
00:04:14,140 --> 00:04:12,770
wavelength of colors if you weren't

99
00:04:16,390 --> 00:04:14,150
looking through the atmosphere and that

100
00:04:18,430 --> 00:04:16,400
you had a darker background so that's

101
00:04:20,620 --> 00:04:18,440
really sort of the beginning of the idea

102
00:04:26,950 --> 00:04:20,630
of an HST so way back in nineteen forty

103
00:04:28,450 --> 00:04:26,960
six through the set XD there were

104
00:04:36,520 --> 00:04:28,460
various conversations about Hubble in

105
00:04:38,290 --> 00:04:36,530
the 60s would hope you're muted okay

106
00:04:40,800 --> 00:04:38,300
where people talked about what size

107
00:04:44,010 --> 00:04:40,810
telescope they might do and it actually

108
00:04:46,510 --> 00:04:44,020
started out as a four meter telescope

109
00:04:48,460 --> 00:04:46,520
the idea of launching it on a Saturn 5

110
00:04:50,140 --> 00:04:48,470
rocket so as four meters on a Saturn

111
00:04:52,810 --> 00:04:50,150
rocket instead of two and a half meters

112
00:04:55,870 --> 00:04:52,820
in the space shuttle and we actually got

113
00:04:57,130 --> 00:04:55,880

there in pieces basically in 1968 there

114
00:04:59,409 --> 00:04:57,140
was something called the large space

115
00:05:03,130 --> 00:04:59,419
telescope the LST which was supposed to

116
00:05:05,800 --> 00:05:03,140
be a 3-meter telescope and that went

117
00:05:07,330 --> 00:05:05,810
along for a couple years in 1974

118
00:05:09,370 --> 00:05:07,340
basically all funding got cut by

119
00:05:11,230 --> 00:05:09,380
Congress and there was a regrouping

120
00:05:13,270 --> 00:05:11,240
people got together and worked with

121
00:05:14,650 --> 00:05:13,280
Congress and various politicians and the

122
00:05:17,440 --> 00:05:14,660
astronomical community to figure out

123
00:05:19,840 --> 00:05:17,450
what is reasonable and out of that game

124
00:05:22,480 --> 00:05:19,850
in the way we know today the two and a

125
00:05:25,690 --> 00:05:22,490
half meters flown on the shuttle and in

126
00:05:29,140 --> 00:05:25,700
a mode of that it could be rest every

127
00:05:31,270 --> 00:05:29,150
three to five years so the the idea it

128
00:05:33,790 --> 00:05:31,280
float I'm glad you brought up a good

129
00:05:37,629 --> 00:05:33,800
point about the the atmosphere and being

130
00:05:41,140 --> 00:05:37,639
being you well

131
00:05:44,649 --> 00:05:41,150
while the atmosphere does protecta the

132
00:05:46,540 --> 00:05:44,659
Sun and radiation at all blocks outs and

133
00:05:49,200 --> 00:05:46,550
valuable wavelengths that we'd like to

134
00:05:53,499 --> 00:05:49,210
be able to see in astronomy and so

135
00:05:56,409 --> 00:05:53,509
strongly sand was the was the was a

136
00:05:59,550 --> 00:05:56,419
process back then similar to what it is

137
00:06:04,610 --> 00:06:01,590
these things called decadence at the

138
00:06:07,340 --> 00:06:05,750

they are all ranked in order of

139
00:06:10,520 --> 00:06:07,350
priorities or was getting up on a

140
00:06:12,460 --> 00:06:10,530
soapbox and saying I wanted almost wait

141
00:06:19,250 --> 00:06:12,470
I want to face telescope on his face

142
00:06:20,750 --> 00:06:19,260
hello well it wasn't you were breaking

143
00:06:25,790 --> 00:06:20,760
up at her there weren't thee they will

144
00:06:28,990 --> 00:06:25,800
weren't the regular deck every 10 near

145
00:06:31,760 --> 00:06:29,000
studies that you were talking about that

146
00:06:33,980 --> 00:06:31,770
but there was a lot of on both of the

147
00:06:36,200 --> 00:06:33,990
astronomical community and with Congress

148
00:06:50,670 --> 00:06:36,210
and the president to try to get a new

149
00:06:55,320 --> 00:06:53,390
cost had to abandon his gonna cost

150
00:07:02,030 --> 00:06:55,330
versus the other things NASA was doing

151
00:07:04,940 --> 00:07:03,770
a huge issue because people knew that

152
00:07:06,890 --> 00:07:04,950
wouldn't be cheap and that's one reason

153
00:07:08,750 --> 00:07:06,900
it went from four meters down to three

154
00:07:17,750 --> 00:07:08,760
meters down to two and a half meters was

155
00:07:19,780 --> 00:07:17,760
to try to control the cost but in kind

156
00:07:21,890 --> 00:07:19,790
of science that you would do with an

157
00:07:23,720 --> 00:07:21,900
orbiting telescope that would look at

158
00:07:26,570 --> 00:07:23,730
high energy events in the cosmos wanted

159
00:07:29,320 --> 00:07:26,580
to launch an x-ray satellite the UV

160
00:07:31,790 --> 00:07:29,330
optical community which served by Hubble

161
00:07:33,320 --> 00:07:31,800
wanted Hubble to do their kind of

162
00:07:37,400 --> 00:07:33,330
science so there was trade-offs about

163
00:07:39,470 --> 00:07:37,410

which kind of telescope would be watched

164
00:07:41,120 --> 00:07:39,480
first one request versus the other so it

165
00:07:43,940 --> 00:07:41,130
was always a constant pressure to do it

166
00:07:45,110 --> 00:07:43,950
as cheaply as you could but make sure it

167
00:07:46,610 --> 00:07:45,120
was big enough to do the science that

168
00:07:51,080 --> 00:07:46,620
you had proposed otherwise it would be

169
00:07:53,200 --> 00:07:51,090
worth anything these guys I need to

170
00:07:55,970 --> 00:07:53,210
apologize to everyone about this this

171
00:07:57,140 --> 00:07:55,980
this connection it's not anything we can

172
00:07:59,360 --> 00:07:57,150
do about it but I do want to apologize

173
00:08:01,010 --> 00:07:59,370
for the quality we all keep cutting out

174
00:08:03,320 --> 00:08:01,020
so please bear with us and we'll try to

175
00:08:05,150 --> 00:08:03,330
do the best we can with it Russ let me

176
00:08:06,890 --> 00:08:05,160
ask you something uh let me ask you a

177
00:08:09,170 --> 00:08:06,900
quick question here the in the early

178
00:08:11,390 --> 00:08:09,180
days of the design did the design of the

179
00:08:12,980 --> 00:08:11,400
telescope as you could tell what did it

180
00:08:15,200 --> 00:08:12,990
change much from the early days I mean

181
00:08:16,550 --> 00:08:15,210
was it or what were some of the factors

182
00:08:19,700 --> 00:08:16,560
that went into designing the Hubble

183
00:08:24,440 --> 00:08:19,710
Space Telescope the things that chains

184
00:08:27,050 --> 00:08:24,450
were first on the software side because

185
00:08:30,290 --> 00:08:27,060
of delays we were able to make changes

186
00:08:32,900 --> 00:08:30,300
relative to software also battery

187
00:08:36,350 --> 00:08:32,910
improvement so I think they were the two

188
00:08:38,659 --> 00:08:36,360

big areas during that time and during

189
00:08:42,250 --> 00:08:38,669
the delays caused by different reasons

190
00:08:47,030 --> 00:08:42,260
that we essentially bought some time

191
00:08:50,450 --> 00:08:47,040
although we paid for it because it added

192
00:08:53,150 --> 00:08:50,460
total cost and allow some improvements

193
00:08:54,320 --> 00:08:53,160
during that development stage isn't it

194
00:08:58,040 --> 00:08:54,330
true that when you're building a

195
00:09:00,740 --> 00:08:58,050
spacecraft you have to kind of design it

196
00:09:03,170 --> 00:09:00,750
with technology that's already proven

197
00:09:05,360 --> 00:09:03,180
and reliable at the time you're building

198
00:09:07,550 --> 00:09:05,370
it and over the course of the the

199
00:09:09,560 --> 00:09:07,560
construction of the spacecraft like I'm

200
00:09:11,480 --> 00:09:09,570
thinking for example detector design if

201
00:09:12,890 --> 00:09:11,490
you're building a camera and you want to

202
00:09:15,860 --> 00:09:12,900
have a certain detector any of you in

203
00:09:18,200 --> 00:09:15,870
your building it in 1985

204
00:09:19,670 --> 00:09:18,210
uh you know and then you're not going to

205
00:09:21,650 --> 00:09:19,680
have it finished for another seven or

206
00:09:22,940 --> 00:09:21,660
eight years we'll see CDs and detectors

207
00:09:26,269 --> 00:09:22,950
have gotten a lot better over that time

208
00:09:27,950 --> 00:09:26,279
scale you have to kind of your they're

209
00:09:31,750 --> 00:09:27,960
almost obsolete from the beginning

210
00:09:35,240 --> 00:09:31,760
weren't they space are that's true and

211
00:09:38,540 --> 00:09:35,250
it also brings out the advantage of

212
00:09:41,810 --> 00:09:38,550
Hubble Space Telescope in that the

213
00:09:46,040 --> 00:09:41,820

initial concept was that as we had new

214
00:09:48,380 --> 00:09:46,050
technology or things needed repair we

215
00:09:50,150 --> 00:09:48,390
could go back to it so during our

216
00:09:52,760 --> 00:09:50,160
servicing missions the five servicing

217
00:09:54,740 --> 00:09:52,770
missions that we had we essentially left

218
00:09:57,769 --> 00:09:54,750
the new telescope because we repair

219
00:10:00,680 --> 00:09:57,779
things and we put in that new technology

220
00:10:04,760 --> 00:10:00,690
that we didn't know back when Hubble was

221
00:10:06,620 --> 00:10:04,770
first designed and or the previous

222
00:10:10,300 --> 00:10:06,630
servicing mission so that points out one

223
00:10:14,510 --> 00:10:10,310
of the great advantages of home oh so

224
00:10:16,490 --> 00:10:14,520
the at you when I introduced you your

225
00:10:18,050 --> 00:10:16,500
title was Evie a manager for Hubble can

226
00:10:21,800 --> 00:10:18,060
you give me something that what is that

227
00:10:24,019 --> 00:10:21,810
what does an EV a manager do well of

228
00:10:28,400 --> 00:10:24,029
course in NASA we have to talk in

229
00:10:32,300 --> 00:10:28,410
acronyms EV a stands for extra vehicular

230
00:10:35,329 --> 00:10:32,310
activity and extra vehicular activity is

231
00:10:38,000 --> 00:10:35,339
a fancy word for spacewalks getting out

232
00:10:41,990 --> 00:10:38,010
of a getting out of outside and outside

233
00:10:44,810 --> 00:10:42,000
uh back when Neil Armstrong walked on

234
00:10:48,230 --> 00:10:44,820
the moon certainly he got out walked on

235
00:10:50,840 --> 00:10:48,240
the moon that was an EBA when the

236
00:10:55,430 --> 00:10:50,850
astronauts got out of the shuttle which

237
00:10:57,920 --> 00:10:55,440
had met up with Hubble and they went

238
00:11:00,920 --> 00:10:57,930

outside to do what we had planned for

239
00:11:02,570 --> 00:11:00,930
them to do they were doing ebas because

240
00:11:05,480 --> 00:11:02,580
they were in their astronaut suits and

241
00:11:10,310 --> 00:11:05,490
they were outside of the environment of

242
00:11:12,590 --> 00:11:10,320
the show so the EV a manager from the

243
00:11:16,610 --> 00:11:12,600
payload side from Hubble Space Telescope

244
00:11:19,519 --> 00:11:16,620
at Goddard Space Flight Center was in

245
00:11:21,769 --> 00:11:19,529
charge of developing all the special

246
00:11:24,370 --> 00:11:21,779
tools that were needed to meet the

247
00:11:28,550 --> 00:11:24,380
requirements for that particular mission

248
00:11:29,780 --> 00:11:28,560
to come up with procedures and working

249
00:11:34,070 --> 00:11:29,790
with Johnson Space

250
00:11:36,710 --> 00:11:34,080
enter and build those tools build the

251
00:11:39,500 --> 00:11:36,720
procedures and to do our part in

252
00:11:41,990 --> 00:11:39,510
training for what the astronauts had to

253
00:11:45,620 --> 00:11:42,000
do for all the eda days that won't be

254
00:11:48,200 --> 00:11:45,630
that plan for them okay so so that we

255
00:11:49,730 --> 00:11:48,210
know from early on that the I mean

256
00:11:52,130 --> 00:11:49,740
anybody who knows Hubble knows it was

257
00:11:53,780 --> 00:11:52,140
designed to be serviced by shuttles it

258
00:11:57,290 --> 00:11:53,790
was put up there by a shuttle was that

259
00:11:58,430 --> 00:11:57,300
always the case and I'm not sure who was

260
00:11:59,690 --> 00:11:58,440
better able to answer this question so i

261
00:12:02,450 --> 00:11:59,700
want to put both can and russ and you

262
00:12:04,940 --> 00:12:02,460
guys can decide was it always the case

263
00:12:06,410 --> 00:12:04,950

that Hubble was going to be an integral

264
00:12:08,840 --> 00:12:06,420
part of the shuttle mission or was there

265
00:12:09,950 --> 00:12:08,850
ever a time when you know they were it

266
00:12:11,330 --> 00:12:09,960
wasn't that we're going to just use a

267
00:12:13,910 --> 00:12:11,340
rocket or something like that to get it

268
00:12:15,440 --> 00:12:13,920
up in space I can start on that if you

269
00:12:18,440 --> 00:12:15,450
want then rest you can comment further

270
00:12:21,440 --> 00:12:18,450
okay go ahead yeah originally the the

271
00:12:24,200 --> 00:12:21,450
concept for HST was for orbiting space

272
00:12:26,330 --> 00:12:24,210
telescope was to launch it on a Saturn 5

273
00:12:29,360 --> 00:12:26,340
so the the moon rocket that wants the

274
00:12:31,370 --> 00:12:29,370
Apollo missions yeah because there were

275
00:12:32,960 --> 00:12:31,380
some left over after the Apollo missions

276
00:12:34,340 --> 00:12:32,970
right after the Apollo program ended

277
00:12:38,030 --> 00:12:34,350
that's right and some of them were in

278
00:12:39,680 --> 00:12:38,040
museums nowadays yeah get some fuel and

279
00:12:42,650 --> 00:12:39,690
those guys maybe they'd still go you

280
00:12:44,210 --> 00:12:42,660
know were you one of the things I

281
00:12:46,700 --> 00:12:44,220
discovered in the last couple of months

282
00:12:48,350 --> 00:12:46,710
when looking back at the older history

283
00:12:52,540 --> 00:12:48,360
of Hubble is one of the early concepts

284
00:12:55,130 --> 00:12:52,550
actually had a crew crew person on board

285
00:12:56,960 --> 00:12:55,140
helping to run the telescope oh now that

286
00:12:58,910 --> 00:12:56,970
would be cool I would sign up for that

287
00:13:00,080 --> 00:12:58,920
job I don't know that they ever followed

288
00:13:03,170 --> 00:13:00,090

this up out of this scott can you get

289
00:13:04,820 --> 00:13:03,180
that graphic up I I love this idea i

290
00:13:07,190 --> 00:13:04,830
remember reading about this i was like

291
00:13:09,440 --> 00:13:07,200
oh that's amazing and there's all kinds

292
00:13:11,810 --> 00:13:09,450
of documentation and arguments about

293
00:13:13,730 --> 00:13:11,820
what you know what is it feasible and

294
00:13:16,520 --> 00:13:13,740
this is when they're gonna send film

295
00:13:18,230 --> 00:13:16,530
canisters down right yeah exactly so if

296
00:13:19,880 --> 00:13:18,240
you can see the graphic now you see in

297
00:13:22,070 --> 00:13:19,890
that the back end and on the right side

298
00:13:25,040 --> 00:13:22,080
of the telescope behind the north as it

299
00:13:28,040 --> 00:13:25,050
up now there's actually a person

300
00:13:30,680 --> 00:13:28,050
floating sort of horizontally above the

301
00:13:32,300 --> 00:13:30,690
instrumentation and because exactly he

302
00:13:35,090 --> 00:13:32,310
said Carol they were going to go and

303
00:13:37,190 --> 00:13:35,100
actually use film they the person would

304
00:13:38,930 --> 00:13:37,200
then take film out of the cameras roll

305
00:13:40,220 --> 00:13:38,940
it up and then somehow get it back to

306
00:13:41,510 --> 00:13:40,230
the earth I never actually saw an

307
00:13:42,890 --> 00:13:41,520
explanation of how in the world they

308
00:13:43,460 --> 00:13:42,900
were planning to but they were going to

309
00:13:50,249 --> 00:13:43,470
have

310
00:13:58,629 --> 00:13:53,229
to support that's what I was waiting

311
00:13:59,919 --> 00:13:58,639
right here for the Hangout I think one

312
00:14:00,910 --> 00:13:59,929
of the reasons they went away from that

313
00:14:03,400 --> 00:14:00,920

year in addition to all the

314
00:14:05,410 --> 00:14:03,410
complications and trying to support life

315
00:14:06,970 --> 00:14:05,420
up there was the contamination issue

316
00:14:09,039 --> 00:14:06,980
because there's a lot of contaminants

317
00:14:10,600 --> 00:14:09,049
coming out of a even a single person in

318
00:14:12,489 --> 00:14:10,610
the background and one of the things

319
00:14:14,259 --> 00:14:12,499
we've done very carefully over the years

320
00:14:16,150 --> 00:14:14,269
is to try to keep all possible

321
00:14:19,329 --> 00:14:16,160
contaminations off the surfaces of the

322
00:14:22,479 --> 00:14:19,339
the mirrors and the detectors because it

323
00:14:24,100 --> 00:14:22,489
would hinder their people out of the

324
00:14:26,350 --> 00:14:24,110
immediate equation actually it was a

325
00:14:28,989 --> 00:14:26,360
very positive thing let's say that would

326
00:14:31,869 --> 00:14:28,999
be I mean beyond being an astronaut

327
00:14:34,210 --> 00:14:31,879
which would be an awesome job being the

328
00:14:37,059 --> 00:14:34,220
person inside the Hubble Space Telescope

329
00:14:40,449 --> 00:14:37,069
I think would be the perfect job like

330
00:14:42,759 --> 00:14:40,459
sign me up I would be amazing I couldn't

331
00:14:46,629 --> 00:14:42,769
agree more obvious i do i work a

332
00:14:48,309 --> 00:14:46,639
telescope in space and that was supposed

333
00:14:49,900 --> 00:14:48,319
to be a shirtsleeve environment it

334
00:14:52,059 --> 00:14:49,910
wasn't big astronaut clunky suit or

335
00:14:53,710 --> 00:14:52,069
anything amazed to be pressurized cabin

336
00:14:57,249 --> 00:14:53,720
so you could go there and your YouTube

337
00:14:59,859 --> 00:14:57,259
t-shirt and work mark I could do a

338
00:15:03,819 --> 00:14:59,869

Hubble hangout from space from Hubble oh

339
00:15:06,309 --> 00:15:03,829
yeah that would be I'd watch that that'd

340
00:15:07,449 --> 00:15:06,319
be great okay so i would really look

341
00:15:08,979 --> 00:15:07,459
through Hubble which no one's ever

342
00:15:11,799 --> 00:15:08,989
really done you know we do it all with

343
00:15:13,659 --> 00:15:11,809
remote detectors now oh man that would

344
00:15:16,299 --> 00:15:13,669
my other show the virtual star party

345
00:15:18,669 --> 00:15:16,309
would add more depth and oh wow never

346
00:15:20,229 --> 00:15:18,679
mind exploding my brain with

347
00:15:23,049 --> 00:15:20,239
possibilities of this thing that never

348
00:15:24,639 --> 00:15:23,059
happened maybe we should be me anyways

349
00:15:27,340 --> 00:15:24,649
we should do it in the future anyway to

350
00:15:28,659 --> 00:15:27,350
have it in Earth orbit playbook what

351
00:15:30,489 --> 00:15:28,669
about well that's a different topic I

352
00:15:32,530 --> 00:15:30,499
won't go there I was going to ask about

353
00:15:37,809 --> 00:15:32,540
the space station but that's that's off

354
00:15:39,789 --> 00:15:37,819
topic so the so the the decision was

355
00:15:42,100 --> 00:15:39,799
made at some point that it was going to

356
00:15:43,569 --> 00:15:42,110
go in the shuttle what were the what

357
00:15:45,400 --> 00:15:43,579
were the circumstances of that what was

358
00:15:47,679 --> 00:15:45,410
the final driver for saying hey no we're

359
00:15:49,269 --> 00:15:47,689
not doing this no no sir shirtsleeve

360
00:15:51,249 --> 00:15:49,279
environment no launching on a Saturn 5

361
00:15:52,780 --> 00:15:51,259
we're using the shuttle what was it what

362
00:15:55,269 --> 00:15:52,790
was a driver for that Russ is that

363
00:16:01,330 --> 00:15:55,279

something you can comment on I believe I

364
00:16:03,850 --> 00:16:01,340
can the pants for the space shuttle and

365
00:16:07,900 --> 00:16:03,860
Hubble Space Telescope merged about that

366
00:16:10,510 --> 00:16:07,910
time about one time up within a time

367
00:16:13,050 --> 00:16:10,520
frame I'd say within the 70s okay so

368
00:16:16,990 --> 00:16:13,060
this is we're talking 70 still yes ah

369
00:16:18,760 --> 00:16:17,000
actually the funding for Hubble or the

370
00:16:21,670 --> 00:16:18,770
authorization from Congress came out in

371
00:16:24,780 --> 00:16:21,680
about nineteen seventy-seven and of

372
00:16:29,110 --> 00:16:24,790
course the first shuttle launch was in

373
00:16:32,260 --> 00:16:29,120
81 so around the time when proponents to

374
00:16:33,940 --> 00:16:32,270
reach of these programs were trying to

375
00:16:37,780 --> 00:16:33,950
get approval for Hubble and for the

376
00:16:45,340 --> 00:16:37,790
shuttle with the shuttle doing Earth

377
00:16:47,500 --> 00:16:45,350
orbit to get up and back to Hubble which

378
00:16:49,930 --> 00:16:47,510
would be in low-earth orbit it made

379
00:16:55,030 --> 00:16:49,940
sense to make certain that Hubble was

380
00:16:57,550 --> 00:16:55,040
designed to fit in like gin and be a

381
00:17:03,220 --> 00:16:57,560
wanna be seller

382
00:17:06,579 --> 00:17:03,230
those two press how Hubble came about so

383
00:17:11,309 --> 00:17:06,589
English out so that would turn out to be

384
00:17:13,870 --> 00:17:11,319
a very pivotal decision to to to make a

385
00:17:16,540 --> 00:17:13,880
the shuttle be able to go up and get

386
00:17:21,120 --> 00:17:16,550
this thing later in its in its history

387
00:17:23,770 --> 00:17:21,130
but uh but it sounds like you know that

388
00:17:25,750 --> 00:17:23,780

I'm sorry folks it looks like I think

389
00:17:27,730 --> 00:17:25,760
we've identified that it's an

390
00:17:31,150 --> 00:17:27,740
infrastructure issue with the Google

391
00:17:33,070 --> 00:17:31,160
stuff and it's it's still happening here

392
00:17:38,560 --> 00:17:33,080
and there intermittently my again my

393
00:17:40,750 --> 00:17:38,570
apologies on that so the the so the

394
00:17:42,670 --> 00:17:40,760
decision to actually service it would be

395
00:17:44,640 --> 00:17:42,680
turn out to be an important one if we

396
00:17:48,280 --> 00:17:44,650
had launched it with the Saturn five

397
00:17:49,840 --> 00:17:48,290
probably well maybe I don't know could

398
00:17:50,950 --> 00:17:49,850
we have gone up and shut and serviced it

399
00:17:54,940 --> 00:17:50,960
with the shuttle anyway if we had

400
00:17:57,490 --> 00:17:54,950
launched it with Centrify we could have

401
00:18:00,760 --> 00:17:57,500
if we had planned ahead as we would have

402
00:18:06,940 --> 00:18:00,770
if we if that were to be the plan Google

403
00:18:10,300 --> 00:18:06,950
to have fixtures on it as we but the

404
00:18:12,810 --> 00:18:10,310
interfaces were yes we we could do that

405
00:18:14,919 --> 00:18:12,820
if it were launched by another vehicle

406
00:18:16,210 --> 00:18:14,929
okay so we've made decisions we're going

407
00:18:19,570 --> 00:18:16,220
to have a Space Telescope it's going to

408
00:18:21,640 --> 00:18:19,580
go in wait wait I have a question so

409
00:18:23,500 --> 00:18:21,650
from the timeline understanding from

410
00:18:26,650 --> 00:18:23,510
Canon rods it sounds like there was a

411
00:18:28,690 --> 00:18:26,660
long period of time deciding to do a

412
00:18:30,970 --> 00:18:28,700
Space Telescope but then it was pretty

413
00:18:34,060 --> 00:18:30,980

quick to switch from for the launch

414
00:18:35,800 --> 00:18:34,070
vehicle I mean it was like over five to

415
00:18:39,880 --> 00:18:35,810
ten years is that right I mean that's

416
00:18:43,080 --> 00:18:39,890
quick in the space arena is that right I

417
00:18:45,970 --> 00:18:43,090
think so there was a huge push in the

418
00:18:49,870 --> 00:18:45,980
mid-70s I think by the astronomical

419
00:18:52,030 --> 00:18:49,880
community was led by involved in the

420
00:18:54,100 --> 00:18:52,040
early portion of the telescope and John

421
00:18:55,900 --> 00:18:54,110
Bacall who also happened to be at for

422
00:18:58,870 --> 00:18:55,910
instant they managed to get the

423
00:19:01,180 --> 00:18:58,880
community together a group of

424
00:19:03,190 --> 00:19:01,190
politicians and public together to

425
00:19:05,440 --> 00:19:03,200
actually supports idea and then they

426
00:19:06,850 --> 00:19:05,450
worked with manned spaceflight on the

427
00:19:08,500 --> 00:19:06,860
shuttle and sort of got everybody

428
00:19:11,410 --> 00:19:08,510
converges very fascinating with all the

429
00:19:12,910 --> 00:19:11,420
different pieces coming together

430
00:19:15,340 --> 00:19:12,920
and the fact that they brought the price

431
00:19:17,230 --> 00:19:15,350
down at the same time I think is what it

432
00:19:19,350 --> 00:19:17,240
allowed it to finally move forward and

433
00:19:23,260 --> 00:19:19,360
gain the traction that it hadn't had

434
00:19:24,670 --> 00:19:23,270
okay cool thanks yeah thank you uh okay

435
00:19:26,860 --> 00:19:24,680
so we got it in the shuttlebay it's

436
00:19:29,680 --> 00:19:26,870
going it's going to be that's because

437
00:19:33,460 --> 00:19:29,690
it's constrained obviously by the site

438
00:19:36,310 --> 00:19:33,470

of the the what the shuttle can do so

439
00:19:39,100 --> 00:19:36,320
the design B was was primarily

440
00:19:40,720 --> 00:19:39,110
constrained tie the size of the shuttle

441
00:19:48,670 --> 00:19:40,730
bay but I'm if i remember right Russ

442
00:19:49,990 --> 00:19:48,680
that didn't it take up Eric in there can

443
00:19:56,860 --> 00:19:50,000
you ask that again you broke out though

444
00:20:01,510 --> 00:19:56,870
oh I did constrained about the size of

445
00:20:04,630 --> 00:20:01,520
the shuttle bay in my still bear picking

446
00:20:08,410 --> 00:20:04,640
up then I think I remember it taking up

447
00:20:11,620 --> 00:20:08,420
every square empty space in the shuttle

448
00:20:15,750 --> 00:20:11,630
bay itself is that true that's that's

449
00:20:21,670 --> 00:20:15,760
pretty much true we had of course Tareq

450
00:20:24,730 --> 00:20:21,680
hope to it that was in the bay and at

451
00:20:27,220 --> 00:20:24,740
that time we had her rolled up and then

452
00:20:30,370 --> 00:20:27,230
each mast of the solar array was folded

453
00:20:32,580 --> 00:20:30,380
up against the side and that's about all

454
00:20:38,410 --> 00:20:32,590
that would fit in that shuttle bay and

455
00:20:40,090 --> 00:20:38,420
to get employed that's all so I guess

456
00:20:42,370 --> 00:20:40,100
the way NASA does things is it always

457
00:20:44,050 --> 00:20:42,380
uses contractors I did that with Apollo

458
00:20:46,690 --> 00:20:44,060
and it does it with doing it now at the

459
00:20:48,400 --> 00:20:46,700
James Webb Space Telescope whoo-hoo

460
00:20:49,960 --> 00:20:48,410
built who built this thing whoo what was

461
00:20:53,200 --> 00:20:49,970
the primary contractor for the Hubble

462
00:20:56,290 --> 00:20:53,210
Space Telescope primary contractor for

463
00:21:00,910 --> 00:20:56,300

the structure was Lockheed Martin out in

464
00:21:02,800 --> 00:21:00,920
sunnyvale california the there were many

465
00:21:06,070 --> 00:21:02,810
other contractors that were building

466
00:21:10,990 --> 00:21:06,080
scientific instruments various parts

467
00:21:14,320 --> 00:21:11,000
solar arrays and the mirror so there are

468
00:21:17,320 --> 00:21:14,330
many many contractors but for the main

469
00:21:19,900 --> 00:21:17,330
part of Hubble it was Lockheed Martin

470
00:21:22,300 --> 00:21:19,910
and Scott has an image up of some of the

471
00:21:23,590 --> 00:21:22,310
various integration or building phases

472
00:21:25,160 --> 00:21:23,600
of the telescope which is kind of cool

473
00:21:27,170 --> 00:21:25,170
since need to see that

474
00:21:32,380 --> 00:21:27,180
bill so it was built it looks like in

475
00:21:41,720 --> 00:21:38,090
you back Kenneth well it was pretty much

476
00:21:43,910 --> 00:21:41,730
what was ready to go in January of 86

477
00:21:45,520 --> 00:21:43,920
and would have gone if it hadn't

478
00:21:48,920 --> 00:21:45,530
happened for the the Challenger accident

479
00:21:53,060 --> 00:21:48,930
which to lead us another four years into

480
00:21:55,430 --> 00:21:53,070
the actual lunch in 1990 so you know if

481
00:21:59,150 --> 00:21:55,440
you figure it started basically in the

482
00:22:02,900 --> 00:21:59,160
late 70s you're you're talking well yeah

483
00:22:04,730 --> 00:22:02,910
nice or so so and you know we did make

484
00:22:06,890 --> 00:22:04,740
further improvements in whatever between

485
00:22:09,730 --> 00:22:06,900
86 and 91 look like well are some of the

486
00:22:12,710 --> 00:22:09,740
things that you were changed you know oh

487
00:22:14,360 --> 00:22:12,720
you're able to update detectors for

488
00:22:16,190 --> 00:22:14,370

instance and some of the instruments

489
00:22:17,930 --> 00:22:16,200
either the can't even respect to grass

490
00:22:21,650 --> 00:22:17,940
where you could get higher sensitivity

491
00:22:23,570 --> 00:22:21,660
see fainter objects on the sky we're

492
00:22:25,670 --> 00:22:23,580
able to improve the ground system

493
00:22:28,850 --> 00:22:25,680
software a lot to improve the scheduling

494
00:22:31,430 --> 00:22:28,860
and the data reduction and archiving of

495
00:22:32,780 --> 00:22:31,440
material so basically you know because

496
00:22:34,820 --> 00:22:32,790
we had the extra time people just kept

497
00:22:36,440 --> 00:22:34,830
working and improving things and what

498
00:22:37,810 --> 00:22:36,450
went to orbit and what was in the ground

499
00:22:39,830 --> 00:22:37,820
system at launch was actually

500
00:22:41,810 --> 00:22:39,840
substantially better just because we had

501
00:22:43,340 --> 00:22:41,820
the luxury of time the that well you

502
00:22:46,160 --> 00:22:43,350
don't have in a rushed lunch schedule

503
00:22:48,530 --> 00:22:46,170
yeah sounds kind of a silver lining out

504
00:22:52,970 --> 00:22:48,540
of a bad situation so that would ya yes

505
00:22:55,030 --> 00:22:52,980
to it okay well so let's just go ahead

506
00:22:59,060 --> 00:22:55,040
and talk briefly about so it gets it

507
00:23:01,130 --> 00:22:59,070
launched in 1990 it goes up we turn it

508
00:23:03,830 --> 00:23:01,140
on and we start looking through it and

509
00:23:05,930 --> 00:23:03,840
the images are a little bit fuzzy one of

510
00:23:11,660 --> 00:23:05,940
the contractors the guy the people that

511
00:23:13,880 --> 00:23:11,670
built the the mirror a perkin-elmer had

512
00:23:16,550 --> 00:23:13,890
introduced an aberration into the prime

513
00:23:20,660 --> 00:23:16,560

the primary mirror did that affect the

514
00:23:24,710 --> 00:23:20,670
science very much okay well it certainly

515
00:23:27,410 --> 00:23:24,720
did because the telescope wasn't as well

516
00:23:29,300 --> 00:23:27,420
focused due to the aberration you

517
00:23:30,890 --> 00:23:29,310
couldn't get the resolution between

518
00:23:33,260 --> 00:23:30,900
objects on the sky that you were hoping

519
00:23:36,110 --> 00:23:33,270
to get otherwise and the sensitivity of

520
00:23:37,850 --> 00:23:36,120
the various instruments went down

521
00:23:38,400 --> 00:23:37,860
because it was less light falling on a

522
00:23:41,850 --> 00:23:38,410
good

523
00:23:43,770 --> 00:23:41,860
in pixel on the detectors one bright

524
00:23:46,320 --> 00:23:43,780
spot there and that was pretty much the

525
00:23:48,300 --> 00:23:46,330
case for the the imaging instruments

526
00:23:50,550 --> 00:23:48,310
some of the performance there was

527
00:23:52,350 --> 00:23:50,560
recovered in the end by some after the

528
00:23:55,380 --> 00:23:52,360
fact software reduction which packed the

529
00:23:58,890 --> 00:23:55,390
light back in to a smaller space on the

530
00:24:00,600 --> 00:23:58,900
image but one thing that sometimes gets

531
00:24:02,790 --> 00:24:00,610
forgotten is that the spectrographs

532
00:24:05,880 --> 00:24:02,800
which usually have a little opening a

533
00:24:07,800 --> 00:24:05,890
slit at the front to narrow the beam of

534
00:24:11,250 --> 00:24:07,810
light coming in they could still perform

535
00:24:13,080 --> 00:24:11,260
at their original specification level in

536
00:24:15,690 --> 00:24:13,090
terms of resolution and how well they

537
00:24:18,180 --> 00:24:15,700
could separate colors or places on the

538
00:24:20,640 --> 00:24:18,190

sky because of that narrow slit now you

539
00:24:22,080 --> 00:24:20,650
did lose light because the image wasn't

540
00:24:23,550 --> 00:24:22,090
as well focused some of the light didn't

541
00:24:25,800 --> 00:24:23,560
make it through the slit so you had to

542
00:24:27,900 --> 00:24:25,810
expose longer so in the case of the

543
00:24:30,420 --> 00:24:27,910
spectrographs the quality of the data

544
00:24:32,610 --> 00:24:30,430
you could get the same quality of the

545
00:24:34,440 --> 00:24:32,620
day as long as you were we will get in

546
00:24:36,150 --> 00:24:34,450
it so you could do fewer objects you

547
00:24:37,560 --> 00:24:36,160
could still do the same quality science

548
00:24:40,260 --> 00:24:37,570
and that's something that was a little

549
00:24:41,760 --> 00:24:40,270
harder to do with the the imagers until

550
00:24:43,680 --> 00:24:41,770
we put the corrective optics in place

551
00:24:45,270 --> 00:24:43,690
right and i think that's amazing you're

552
00:24:47,520 --> 00:24:45,280
in but the cleverness that was in those

553
00:24:49,710 --> 00:24:47,530
years and then so that brings us uh to

554
00:24:51,420 --> 00:24:49,720
some servicing missions then we we had

555
00:24:54,240 --> 00:24:51,430
we had found our need for the first one

556
00:24:58,590 --> 00:24:54,250
you want to come at us back up a minute

557
00:25:02,670 --> 00:24:58,600
oh yeah yeah I like to add what what to

558
00:25:06,360 --> 00:25:02,680
what Ken said by all means I like to say

559
00:25:09,990 --> 00:25:06,370
that the mirror was ground with a very

560
00:25:17,370 --> 00:25:10,000
high technology process absolutely

561
00:25:19,260 --> 00:25:17,380
perfectly to the wrong spec they did it

562
00:25:20,820 --> 00:25:19,270
they did it the way it was supposed to

563
00:25:24,300 --> 00:25:20,830

be done just with the wrong instructions

564
00:25:26,340 --> 00:25:24,310
wrong recipe right and the amount that

565
00:25:28,380 --> 00:25:26,350
it was off it was too flat around the

566
00:25:32,910 --> 00:25:28,390
outside edge of this two point four

567
00:25:35,940 --> 00:25:32,920
meter mirror by 150th the diameter of a

568
00:25:39,300 --> 00:25:35,950
piece of human hair but it in space

569
00:25:42,420 --> 00:25:39,310
optics it it doesn't take much and Ray

570
00:25:46,620 --> 00:25:42,430
was a tremendous problem but i Ken said

571
00:25:50,670 --> 00:25:46,630
anything that was uh using the center

572
00:25:51,720 --> 00:25:50,680
part of the mirror for three years or so

573
00:25:54,630 --> 00:25:51,730
we did get pretty good

574
00:25:57,090 --> 00:25:54,640
it opted expac but again that leads into

575
00:25:59,400 --> 00:25:57,100
your question about servicing missions

576
00:26:00,810 --> 00:25:59,410
right so how many were there Russ how

577
00:26:02,610 --> 00:26:00,820
many altogether how many servicing

578
00:26:06,390 --> 00:26:02,620
missions were there for how we went from

579
00:26:10,170 --> 00:26:06,400
sm one servicing mission 1 up to sm for

580
00:26:12,510 --> 00:26:10,180
Scott how the graphic up oh good that so

581
00:26:18,080 --> 00:26:12,520
that sounds like we had for servicing

582
00:26:22,440 --> 00:26:18,090
missions however we really had 50 room

583
00:26:25,830 --> 00:26:22,450
for sm-3 because we were coming up on a

584
00:26:29,400 --> 00:26:25,840
potential y2k problem at the end of 1999

585
00:26:32,970 --> 00:26:29,410
we had a requirement to get up there get

586
00:26:35,370 --> 00:26:32,980
back be safe on the ground by December

587
00:26:37,860 --> 00:26:35,380
thirty first nineteen ninety nine I did

588
00:26:39,960 --> 00:26:37,870

not know that that yeah we were

589
00:26:43,500 --> 00:26:39,970
everybody was sweating bullets are you

590
00:26:45,600 --> 00:26:43,510
friggin busy oh my gosh yeah I had no

591
00:26:50,280 --> 00:26:45,610
idea sir war they were free the fallout

592
00:26:56,070 --> 00:26:50,290
expired well yeah we have just gravity

593
00:26:58,380 --> 00:26:56,080
and momentum stops with wife that's what

594
00:27:00,780 --> 00:26:58,390
we heard so NASA had a requirement

595
00:27:02,520 --> 00:27:00,790
everybody's on the ground yeah during

596
00:27:06,840 --> 00:27:02,530
that that when the clocks turn over

597
00:27:08,730 --> 00:27:06,850
that's why I know that now yeah from the

598
00:27:11,250 --> 00:27:08,740
servicing viewpoint from the EDA

599
00:27:15,330 --> 00:27:11,260
viewpoint we had a lot on our plate in

600
00:27:17,700 --> 00:27:15,340
what originally was called sm-3 so in

601
00:27:20,100 --> 00:27:17,710
order that nobody forgot that we

602
00:27:21,660 --> 00:27:20,110
couldn't do all that since we had a new

603
00:27:26,340 --> 00:27:21,670
requirement to be back on the ground

604
00:27:28,890 --> 00:27:26,350
before New Year's Eve 2000 we broke it

605
00:27:32,010 --> 00:27:28,900
up into two servicing missions so we

606
00:27:33,930 --> 00:27:32,020
have a 3 a and a 3 B so in answer to

607
00:27:36,510 --> 00:27:33,940
your question the total number of

608
00:27:41,520 --> 00:27:36,520
servicing missions was five but the last

609
00:27:43,320 --> 00:27:41,530
one was sm4 in 2009 oh that's there was

610
00:27:45,480 --> 00:27:43,330
actually a second reason why the

611
00:27:49,230 --> 00:27:45,490
servicing mission 3 was split into two

612
00:27:52,320 --> 00:27:49,240
and that's because we had a increasing

613
00:27:55,010 --> 00:27:52,330

number of gyro failures yes in to that

614
00:27:57,390 --> 00:27:55,020
mission and eventually ran out of

615
00:27:59,040 --> 00:27:57,400
sufficient gyros to operate the mission

616
00:28:00,570 --> 00:27:59,050
so we did what's called a call-up

617
00:28:02,580 --> 00:28:00,580
mission which was has always been an

618
00:28:04,590 --> 00:28:02,590
option we had the option to tell manned

619
00:28:05,370 --> 00:28:04,600
spaceflight we need an emergency mission

620
00:28:06,540 --> 00:28:05,380
now

621
00:28:08,460 --> 00:28:06,550
that's a service Hubble because

622
00:28:10,920 --> 00:28:08,470
something's gone wrong so we said we're

623
00:28:12,480 --> 00:28:10,930
going to exercise that option now we're

624
00:28:14,400 --> 00:28:12,490
just going to do the gyros which are

625
00:28:16,350 --> 00:28:14,410
absolutely critical and a few other

626
00:28:18,300 --> 00:28:16,360
things that are ready to go like the

627
00:28:22,290 --> 00:28:18,310
advanced computer and the fine guidance

628
00:28:33,330 --> 00:28:22,300
sensor and we're getting before 2000 and

629
00:28:34,830 --> 00:28:33,340
get HST back into operation graphic

630
00:28:36,630 --> 00:28:34,840
after you can see the things that are

631
00:28:38,430 --> 00:28:36,640
installed and of course the astronomers

632
00:28:39,960 --> 00:28:38,440
had to wait for 3 B to get their

633
00:28:43,770 --> 00:28:39,970
instrument but it was more important to

634
00:28:47,700 --> 00:28:43,780
put these technical instrumentation in

635
00:28:52,500 --> 00:28:47,710
there to maintain the kitchen gyros so

636
00:28:54,480 --> 00:28:52,510
you could told ya pretty far yeah right

637
00:28:56,100 --> 00:28:54,490
so cut out right there explain what the

638
00:29:01,530 --> 00:28:56,110

gyros do because there are an important

639
00:29:03,810 --> 00:29:01,540
part the dry road so control the the

640
00:29:05,430 --> 00:29:03,820
pointing of the spacecraft across the

641
00:29:07,050 --> 00:29:05,440
sky so if there if you don't have a

642
00:29:09,090 --> 00:29:07,060
sufficient number to operate the

643
00:29:11,160 --> 00:29:09,100
telescope you basically can't do any

644
00:29:13,770 --> 00:29:11,170
science at all so they're sort of the

645
00:29:15,330 --> 00:29:13,780
base basic level of support that the

646
00:29:16,860 --> 00:29:15,340
telescope needs to move around in the

647
00:29:20,250 --> 00:29:16,870
state pointed at a particular direction

648
00:29:21,930 --> 00:29:20,260
on the sky so that's why that got top

649
00:29:25,230 --> 00:29:21,940
priority over everything else at that

650
00:29:27,210 --> 00:29:25,240
point right it's very it's very critical

651
00:29:28,770 --> 00:29:27,220
so the first to the first servicing

652
00:29:30,990 --> 00:29:28,780
mission we put in a new camera wide

653
00:29:36,060 --> 00:29:31,000
field planetary camera up taking some

654
00:29:37,620 --> 00:29:36,070
amazingly uh I humanity altering images

655
00:29:40,530 --> 00:29:37,630
and I'm not overstating it when I say it

656
00:29:44,580 --> 00:29:40,540
that way uh there was also co-star which

657
00:29:46,350 --> 00:29:44,590
was the fix for the the error in the

658
00:29:49,380 --> 00:29:46,360
mirror Russ can you tell us a little bit

659
00:29:53,720 --> 00:29:49,390
about what co-star did what it was well

660
00:29:56,670 --> 00:29:53,730
casar became a new requirement for our

661
00:30:00,030 --> 00:29:56,680
1993 servicing mission we had already

662
00:30:02,340 --> 00:30:00,040
been planning for it at lunchtime but it

663
00:30:04,860 --> 00:30:02,350

turned out that we had to add something

664
00:30:09,060 --> 00:30:04,870
new and that was a new scientific

665
00:30:11,730 --> 00:30:09,070
instrument that would by itself correct

666
00:30:17,640 --> 00:30:11,740
the optics going to the other axial

667
00:30:19,170 --> 00:30:17,650
instruments and to our credit at NASA we

668
00:30:23,130 --> 00:30:19,180
came up with a

669
00:30:25,740 --> 00:30:23,140
a innovative relatively simple way to

670
00:30:29,220 --> 00:30:25,750
solve the problem as best we could and

671
00:30:31,980 --> 00:30:29,230
that was in the lake path of this big

672
00:30:35,040 --> 00:30:31,990
scientific instrument to put in small

673
00:30:37,950 --> 00:30:35,050
mirrors that were trainable and and

674
00:30:40,470 --> 00:30:37,960
allow corrective optics to the lake path

675
00:30:44,010 --> 00:30:40,480
coming in to be passed along to the

676
00:30:46,530 --> 00:30:44,020
other estimates and not and we were

677
00:30:50,280 --> 00:30:46,540
successful in 1993 with that first

678
00:30:53,880 --> 00:30:50,290
servicing mission yet but we back at the

679
00:30:55,620 --> 00:30:53,890
time we launched in 1990 we didn't know

680
00:30:57,780 --> 00:30:55,630
how important that mission was going to

681
00:31:00,390 --> 00:30:57,790
be so you have a model there right next

682
00:31:02,730 --> 00:31:00,400
to you of the Hubble where was co-star

683
00:31:08,100 --> 00:31:02,740
placed you say in the light path where

684
00:31:10,800 --> 00:31:08,110
was it where does it put co-star what

685
00:31:13,710 --> 00:31:10,810
well first off there are Bay these big

686
00:31:18,320 --> 00:31:13,720
doors that open up so the astronauts can

687
00:31:21,000 --> 00:31:18,330
access for axial mission actual axial

688
00:31:24,480 --> 00:31:21,010

scientific instruments so this

689
00:31:27,540 --> 00:31:24,490
particular bay door here is where

690
00:31:29,700 --> 00:31:27,550
co-star was we had sacrificed the

691
00:31:31,680 --> 00:31:29,710
original instrument so I was gonna ask

692
00:31:33,060 --> 00:31:31,690
you how'd you find space for it okay so

693
00:31:35,220 --> 00:31:33,070
you took something out to put the

694
00:31:37,560 --> 00:31:35,230
hammock yeah any extra there's a

695
00:31:39,680 --> 00:31:37,570
question on the on Twitter right now

696
00:31:42,480 --> 00:31:39,690
from Daniel Fisher about this is that

697
00:31:44,610 --> 00:31:42,490
Hubble's high-speed photometer never got

698
00:31:50,940 --> 00:31:44,620
a chance and had to go for co-star why

699
00:31:54,080 --> 00:31:50,950
do we never fly one again but this all

700
00:31:57,600 --> 00:31:54,090
has to do with scientific importance and

701
00:32:00,510 --> 00:31:57,610
decisions as time went on as we were

702
00:32:03,570 --> 00:32:00,520
leading up to nineteen ninety three the

703
00:32:06,360 --> 00:32:03,580
scientists had to make a decision as to

704
00:32:08,430 --> 00:32:06,370
which instrument could be sacrificed so

705
00:32:11,250 --> 00:32:08,440
that we could correct every other xeo

706
00:32:13,850 --> 00:32:11,260
instrument yeah I think what it amounts

707
00:32:16,680 --> 00:32:13,860
to is that the high-speed photometer

708
00:32:19,200 --> 00:32:16,690
although very doing important science

709
00:32:21,900 --> 00:32:19,210
was the least use of the scientific

710
00:32:24,150 --> 00:32:21,910
instruments and you know if you were

711
00:32:26,010 --> 00:32:24,160
forced to get rid of something you know

712
00:32:28,530 --> 00:32:26,020
the best thing to do is to go with the

713
00:32:29,940 --> 00:32:28,540

one that was being least productive out

714
00:32:32,700 --> 00:32:29,950
of the crew it was a painful decision

715
00:32:34,320 --> 00:32:32,710
for everybody to make yeah but

716
00:32:36,299 --> 00:32:34,330
seemed to be the right thing to do and

717
00:32:37,769 --> 00:32:36,309
to answer your question about why it

718
00:32:40,440 --> 00:32:37,779
wasn't flown again or a similar

719
00:32:42,110 --> 00:32:40,450
instrument every time we put a new set

720
00:32:45,480 --> 00:32:42,120
of instruments up we had a competition

721
00:32:48,510 --> 00:32:45,490
where various groups in the astronomical

722
00:32:52,110 --> 00:32:48,520
new era would get together and propose

723
00:32:54,240 --> 00:32:52,120
new instruments and it's just a Fatah

724
00:32:57,600 --> 00:32:54,250
meter never rose to the top again in

725
00:32:58,980 --> 00:32:57,610
that very very strict competition very

726
00:33:04,200 --> 00:32:58,990
heavy competition there were always

727
00:33:08,490 --> 00:33:04,210
newer and better ideas will wanted to

728
00:33:10,470 --> 00:33:08,500
invest okay well I don't want to go over

729
00:33:12,529 --> 00:33:10,480
all the details of every servicing

730
00:33:17,519 --> 00:33:12,539
mission but I would like to ask you uh

731
00:33:19,350 --> 00:33:17,529
either us or can I sister r us actually

732
00:33:22,680 --> 00:33:19,360
lunging servicing mission ever done on

733
00:33:28,430 --> 00:33:22,690
the Hubble Space Telescope are was it

734
00:33:34,409 --> 00:33:28,440
the latest one what was the hardest did

735
00:33:37,289 --> 00:33:34,419
overall mr. instrument hello I'm sorry

736
00:33:40,230 --> 00:33:37,299
are you good we were frozen hello we are

737
00:33:44,310 --> 00:33:40,240
preferred so good to answer both

738
00:33:46,649 --> 00:33:44,320

questions my question was oh okay yeah

739
00:33:48,480 --> 00:33:46,659
most complicated instrument and most

740
00:33:53,490 --> 00:33:48,490
complicated mission both of those who

741
00:34:01,310 --> 00:33:53,500
have interests right okay complicated

742
00:34:04,200 --> 00:34:01,320
instructions were probably stiff and

743
00:34:06,090 --> 00:34:04,210
power control unit and for different

744
00:34:10,409 --> 00:34:06,100
reasons what's the app the power control

745
00:34:14,389 --> 00:34:10,419
yet without an acronym this disk space

746
00:34:17,129 --> 00:34:14,399
telescope tell us what this is I'm sorry

747
00:34:21,510 --> 00:34:17,139
tell you break it up space telescope

748
00:34:28,859 --> 00:34:21,520
imaging system yeah so are you we all

749
00:34:32,970 --> 00:34:28,869
are i think and pc you is power the pad

750
00:34:35,599 --> 00:34:32,980
our control that was very critical

751
00:34:38,820 --> 00:34:35,609
because for the first time in his life

752
00:34:42,690 --> 00:34:38,830
we have had to completely found the

753
00:34:46,919 --> 00:34:42,700
power or to the telescope so i think a

754
00:34:53,230 --> 00:34:46,929
lot of us we're not breathing for a long

755
00:35:00,170 --> 00:34:57,139
the power control unit was in the sub 3

756
00:35:05,450 --> 00:35:00,180
b's i was two thousand two ish i'll try

757
00:35:08,300 --> 00:35:05,460
be yes and then first time the power had

758
00:35:11,290 --> 00:35:08,310
been shut down it was a tricky task as

759
00:35:14,240 --> 00:35:11,300
far as the astronauts were concerned

760
00:35:17,960 --> 00:35:14,250
because we had 30 some connectors to

761
00:35:20,180 --> 00:35:17,970
take off temporarily store and then get

762
00:35:22,240 --> 00:35:20,190
back on and get back on so that the

763
00:35:26,420 --> 00:35:22,250

electrical connections were made and

764
00:35:28,790 --> 00:35:26,430
then I had to turn the power back on

765
00:35:31,880 --> 00:35:28,800
since power had never been turned off it

766
00:35:34,220 --> 00:35:31,890
had never been turned back on so those

767
00:35:38,510 --> 00:35:34,230
of us on the ground and the astronauts

768
00:35:42,140 --> 00:35:38,520
up there had a sigh of relief and proud

769
00:35:45,890 --> 00:35:42,150
accomplishment that it worked fine I can

770
00:35:48,650 --> 00:35:45,900
back around the sm to time i should i

771
00:35:51,530 --> 00:35:48,660
tell me you will never be able to change

772
00:35:54,710 --> 00:35:51,540
out that power control unit it was one

773
00:35:56,870 --> 00:35:54,720
of the units on hubble that wasn't ever

774
00:36:00,260 --> 00:35:56,880
thought we'd be back in there to want

775
00:36:04,130 --> 00:36:00,270
anything with that and there were other

776
00:36:07,550 --> 00:36:04,140
things on how old it for us for reasons

777
00:36:09,770 --> 00:36:07,560
that make sense you just couldn't change

778
00:36:11,480 --> 00:36:09,780
out power control unit was one of them

779
00:36:15,020 --> 00:36:11,490
the astronaut told me he'd never be able

780
00:36:18,350 --> 00:36:15,030
to do it uh it essentially set up set up

781
00:36:22,130 --> 00:36:18,360
a challenge to us and guess what from sm

782
00:36:26,270 --> 00:36:22,140
2 up the sm-3 be we figured out a way to

783
00:36:29,320 --> 00:36:26,280
do it and the astronauts did it power

784
00:36:32,300 --> 00:36:29,330
came back on how was still working yeah

785
00:36:34,160 --> 00:36:32,310
wow so i did none that so the power

786
00:36:39,410 --> 00:36:34,170
control unit just was never thought to a

787
00:36:43,370 --> 00:36:39,420
new he deserves why was that well the

788
00:36:45,050 --> 00:36:43,380

people time first off it wouldn't be a

789
00:36:51,860 --> 00:36:45,060
requirement that everything had to be

790
00:36:54,710 --> 00:36:51,870
replaceable um and looked at fault tree

791
00:36:57,350 --> 00:36:54,720
analysis determined that there's

792
00:37:01,070 --> 00:36:57,360
probably chance that that whole unit

793
00:37:04,310 --> 00:37:01,080
would ever have to be replaced so it was

794
00:37:06,560 --> 00:37:04,320
on the list of things that did

795
00:37:09,590 --> 00:37:06,570
necessarily was not

796
00:37:14,030 --> 00:37:09,600
expected to be replaced it certainly

797
00:37:18,050 --> 00:37:14,040
could be but and we did hope sent and

798
00:37:21,110 --> 00:37:18,060
the mounting structure and all those

799
00:37:24,290 --> 00:37:21,120
electrical connections sure we could do

800
00:37:26,450 --> 00:37:24,300
it but it was a very tight space it was

801
00:37:28,460 --> 00:37:26,460
not an easy task either designing it on

802
00:37:30,890 --> 00:37:28,470
the ground designing the replacement all

803
00:37:33,920 --> 00:37:30,900
of them and training the astronauts and

804
00:37:36,920 --> 00:37:33,930
having them do it on spec in space so

805
00:37:39,110 --> 00:37:36,930
Russ I mean in your story you talk about

806
00:37:41,510 --> 00:37:39,120
how you figure out how I mean this is

807
00:37:44,600 --> 00:37:41,520
required tools astronauts can't just

808
00:37:47,390 --> 00:37:44,610
take it after swim fins replace the

809
00:37:51,200 --> 00:37:47,400
power unit requires very specialized

810
00:37:53,030 --> 00:37:51,210
tools talk about that a little well

811
00:37:56,210 --> 00:37:53,040
everything we did had it had a

812
00:37:59,840 --> 00:37:56,220
requirement for either replacement kind

813
00:38:01,910 --> 00:37:59,850

of repair and as you mentioned you just

814
00:38:05,270 --> 00:38:01,920
can't take up normal will totally

815
00:38:09,020 --> 00:38:05,280
everything we took up heading for Hubble

816
00:38:12,230 --> 00:38:09,030
missions had to be specially designed to

817
00:38:16,790 --> 00:38:12,240
consider safety being able to complete

818
00:38:19,790 --> 00:38:16,800
the mission successfully and and the

819
00:38:21,770 --> 00:38:19,800
materials in the environment so there

820
00:38:24,170 --> 00:38:21,780
wasn't any grease that would be out

821
00:38:27,800 --> 00:38:24,180
guessing at the time there weren't sharp

822
00:38:30,770 --> 00:38:27,810
edges it had to withstand the changes in

823
00:38:32,780 --> 00:38:30,780
temperature and in the case pro unit

824
00:38:35,810 --> 00:38:32,790
with all those electrical connectors on

825
00:38:37,670 --> 00:38:35,820
it big circular connectors we had to

826
00:38:41,150 --> 00:38:37,680
make sure we did neither put too much

827
00:38:44,150 --> 00:38:41,160
torque or too little torque either in

828
00:38:46,690 --> 00:38:44,160
removing or replacing so we had all

829
00:38:49,340 --> 00:38:46,700
those challenges to make certain that

830
00:38:51,350 --> 00:38:49,350
mechanically and electrically it could

831
00:38:54,530 --> 00:38:51,360
be the old one could be taken out the

832
00:38:57,140 --> 00:38:54,540
new one could be put in and it worked

833
00:38:59,270 --> 00:38:57,150
afterwards my favorite about that on

834
00:39:01,910 --> 00:38:59,280
this topic is was with SM for when they

835
00:39:03,110 --> 00:39:01,920
had a design that's been I guess it John

836
00:39:06,110 --> 00:39:03,120
Grunsfeld had to used they were

837
00:39:08,000 --> 00:39:06,120
unscrewing all these screws and so to in

838
00:39:09,380 --> 00:39:08,010

so to get all of those screws off

839
00:39:10,850 --> 00:39:09,390
without them floating around and

840
00:39:13,100 --> 00:39:10,860
becoming their own little satellites

841
00:39:15,590 --> 00:39:13,110
they designed this thing that look like

842
00:39:17,510 --> 00:39:15,600
a tackle box and you you screw through

843
00:39:20,120 --> 00:39:17,520
you you operated the screwdriver and

844
00:39:21,320 --> 00:39:20,130
screws and nuts or whatever they were

845
00:39:22,910 --> 00:39:21,330
I'll into their so they could they

846
00:39:25,780 --> 00:39:22,920
wouldn't be lost I thought that was my

847
00:39:27,830 --> 00:39:25,790
that was clever I thought this was good

848
00:39:31,490 --> 00:39:27,840
that was going to be the second answer

849
00:39:34,130 --> 00:39:31,500
to my question they said this did to

850
00:39:40,910 --> 00:39:34,140
your question this disrepair that we did

851
00:39:42,920 --> 00:39:40,920
in sm 4 in 2009 and that we always plan

852
00:39:45,110 --> 00:39:42,930
for a nominal operation and nominal

853
00:39:46,900 --> 00:39:45,120
operation for that was to have this big

854
00:39:49,910 --> 00:39:46,910
blue plate that you're talking about

855
00:39:55,910 --> 00:39:49,920
donec and a special tool that we built

856
00:39:58,340 --> 00:39:55,920
to be able to have have that with it say

857
00:40:01,310 --> 00:39:58,350
a screwdriver bit go in for all the

858
00:40:05,380 --> 00:40:01,320
different fasteners and there were over

859
00:40:13,070 --> 00:40:05,390
100 teen fasteners or so washers

860
00:40:24,090 --> 00:40:19,260
sleep oh look you mentioned it hey there

861
00:40:28,880 --> 00:40:24,100
it is to reach through each one of these

862
00:40:33,090 --> 00:40:28,890
opening count the fastener watch

863
00:40:35,940 --> 00:40:33,100

whatever was with it and essentially we

864
00:40:37,980 --> 00:40:35,950
made a sandwich we designed this so it

865
00:40:39,720 --> 00:40:37,990
would be bolted to the plate that we're

866
00:40:43,710 --> 00:40:39,730
trying to take off to get to a circuit

867
00:40:46,410 --> 00:40:43,720
board on hub so in that sandwich we had

868
00:40:49,320 --> 00:40:46,420
this outer plate there are cavities in

869
00:40:52,650 --> 00:40:49,330
between here so as each faster came out

870
00:40:54,660 --> 00:40:52,660
it floated with in that cavity and they

871
00:40:58,740 --> 00:40:54,670
went through with proper tools that were

872
00:41:00,930 --> 00:40:58,750
needed got all of those off and then

873
00:41:04,290 --> 00:41:00,940
this whole sandwich of this special

874
00:41:06,330 --> 00:41:04,300
plate that we designed and they the

875
00:41:09,930 --> 00:41:06,340
plate on hole that we're trying to get

876
00:41:12,690 --> 00:41:09,940
to behind it or bolted together and that

877
00:41:20,360 --> 00:41:12,700
the actual one is the one you were used

878
00:41:23,070 --> 00:41:20,370
uh truth in it ever tell you this is an

879
00:41:25,550 --> 00:41:23,080
engineering unit that we used in neutral

880
00:41:28,920 --> 00:41:25,560
buoyancy testing and training the extra

881
00:41:30,270 --> 00:41:28,930
but with our video connection you

882
00:41:32,490 --> 00:41:30,280
probably wouldn't tell the difference

883
00:41:35,370 --> 00:41:32,500
but they are the actual flight hardware

884
00:41:38,070 --> 00:41:35,380
in this total thank you for your honesty

885
00:41:41,730 --> 00:41:38,080
you know what so that we had when we got

886
00:41:45,420 --> 00:41:41,740
it back on go ahead and finish sorry the

887
00:41:47,430 --> 00:41:45,430
first thing we did I'm sorry I'm sorry

888
00:41:49,500 --> 00:41:47,440

tiny go ahead no I was telling you to go

889
00:41:53,040 --> 00:41:49,510
ahead I we're all cutting out now oh

890
00:41:54,840 --> 00:41:53,050
okay the first thing we did was to count

891
00:41:57,180 --> 00:41:54,850
all those fasteners said that none would

892
00:42:00,000 --> 00:41:57,190
be floating loose floating back down the

893
00:42:03,210 --> 00:42:00,010
barrel the telescope and they were all

894
00:42:06,570 --> 00:42:03,220
there so this was the type of design we

895
00:42:09,570 --> 00:42:06,580
had to go through to have a specialized

896
00:42:12,660 --> 00:42:09,580
design and design this on the ground it

897
00:42:14,370 --> 00:42:12,670
has to fit up there and and we went back

898
00:42:17,640 --> 00:42:14,380
through the drawings & and the

899
00:42:19,590 --> 00:42:17,650
photographs to be able to tell all these

900
00:42:22,650 --> 00:42:19,600
dimensions that we have on this to make

901
00:42:24,420 --> 00:42:22,660
it work properly so this believes me to

902
00:42:25,530 --> 00:42:24,430
my next question which is

903
00:42:26,850 --> 00:42:25,540
when you guys are when you're working

904
00:42:29,460 --> 00:42:26,860
through these procedures for how to

905
00:42:33,960 --> 00:42:29,470
repair things on Hubble you have a full

906
00:42:35,910 --> 00:42:33,970
mock-up of Hubble around and you said in

907
00:42:39,630 --> 00:42:35,920
the neutral buoyancy tank right is it

908
00:42:42,050 --> 00:42:39,640
and then you practice your rehearsals

909
00:42:45,300 --> 00:42:42,060
there correct in assuming that's what

910
00:42:49,230 --> 00:42:45,310
one thing we do we have low scale

911
00:42:51,660 --> 00:42:49,240
mock-ups that we put in the water 6.2

912
00:42:54,120 --> 00:42:51,670
million gallon swimming pool essentially

913
00:42:58,410 --> 00:42:54,130

down at Johnson Space Center in Houston

914
00:43:01,440 --> 00:42:58,420
Texas the astronauts go in on old suits

915
00:43:07,380 --> 00:43:01,450
uh we take advantage of neutral buoyancy

916
00:43:11,280 --> 00:43:07,390
we give them the Tauri underwater and we

917
00:43:13,110 --> 00:43:11,290
go in on scuba and make sure that we

918
00:43:15,930 --> 00:43:13,120
know what they're doing and that they're

919
00:43:18,510 --> 00:43:15,940
doing the things that will link to a

920
00:43:20,340 --> 00:43:18,520
successful change out right okay so

921
00:43:21,600 --> 00:43:20,350
we're getting close to the end of the

922
00:43:24,000 --> 00:43:21,610
hanging out here I want to get to some

923
00:43:26,610 --> 00:43:24,010
questions on the Q&A app Cecil Morgan is

924
00:43:29,610 --> 00:43:26,620
asking wasn't HST originally designed to

925
00:43:31,470 --> 00:43:29,620
be brought back to ground by shuttle for

926
00:43:35,310 --> 00:43:31,480
servicing I can do you have any comment

927
00:43:38,930 --> 00:43:35,320
on that yeah that was the the concept of

928
00:43:42,060 --> 00:43:38,940
thought it would might be Rock every

929
00:43:47,040 --> 00:43:42,070
read if I guess fixed up on the ground

930
00:43:50,010 --> 00:43:47,050
and sent back into orbit happen ended up

931
00:43:55,890 --> 00:43:50,020
not doing that for a couple reasons

932
00:43:59,900 --> 00:43:55,900
women that's not doing that uh-uh it is

933
00:44:05,940 --> 00:44:02,880
yeah I know we all are no I can't hear

934
00:44:08,130 --> 00:44:05,950
you I ribes I was asking you I was

935
00:44:10,470 --> 00:44:08,140
asking you why why that it didn't end up

936
00:44:11,940 --> 00:44:10,480
happening I was just I was just asking

937
00:44:14,850 --> 00:44:11,950
why that didn't end up happening that

938
00:44:16,830 --> 00:44:14,860

way well right and the end of people

939
00:44:18,540 --> 00:44:16,840
thought it would be actually too

940
00:44:20,880 --> 00:44:18,550
complicated and too expensive to bring

941
00:44:23,370 --> 00:44:20,890
the telescope down refurbish it and

942
00:44:25,650 --> 00:44:23,380
sending send it up there was a lot of

943
00:44:27,690 --> 00:44:25,660
concern about possible contamination as

944
00:44:29,790 --> 00:44:27,700
the telescope was back down to the

945
00:44:31,860 --> 00:44:29,800
ground there'd be in addition to the

946
00:44:34,110 --> 00:44:31,870
chemical contamination you have a lot of

947
00:44:36,480 --> 00:44:34,120
forces exerted on the telescope during

948
00:44:37,920 --> 00:44:36,490
reentry and relaunched and the ability

949
00:44:38,279 --> 00:44:37,930
the possibility that you'd shake things

950
00:44:41,370 --> 00:44:38,289
apart

951
00:44:43,549 --> 00:44:41,380
mine in the end do more damage than he

952
00:44:45,989 --> 00:44:43,559
would gain advantage so that ear of

953
00:44:47,669 --> 00:44:45,999
servicing and orbit sidesteps the

954
00:44:50,279 --> 00:44:47,679
contamination issue to a large degree

955
00:44:54,029 --> 00:44:50,289
and the additional stresses from launch

956
00:44:55,229 --> 00:44:54,039
so there were also concerns that landing

957
00:44:56,849 --> 00:44:55,239
with the telescope in the back of the

958
00:45:01,199 --> 00:44:56,859
shuttle could be very dangerous or you

959
00:45:04,650 --> 00:45:01,209
had a unusually sharp deceleration of

960
00:45:06,150 --> 00:45:04,660
the shuttle landing at the airport that

961
00:45:09,719 --> 00:45:06,160
the whole telescope might just come

962
00:45:12,630 --> 00:45:09,729
through the crew bay and desirable event

963
00:45:14,489 --> 00:45:12,640

as well the whole pile of reasons while

964
00:45:16,319 --> 00:45:14,499
we thought well you know it sounded good

965
00:45:18,380 --> 00:45:16,329
on paper but it would be much better if

966
00:45:20,699 --> 00:45:18,390
we just serviced in orbit and the

967
00:45:22,529 --> 00:45:20,709
techniques for doing that in orbit came

968
00:45:24,630 --> 00:45:22,539
along quickly enough that they were

969
00:45:26,400 --> 00:45:24,640
rapidly adopted and we switched to the

970
00:45:30,209 --> 00:45:26,410
bus service in orbit every three to five

971
00:45:34,259 --> 00:45:30,219
years ok so there's another reason from

972
00:45:37,829 --> 00:45:34,269
from an EV a viewpoint we we added solar

973
00:45:39,989 --> 00:45:37,839
rays that no longer would allow the

974
00:45:43,349 --> 00:45:39,999
telescope to fit in the shuttle that's

975
00:45:46,499 --> 00:45:43,359
right we also put panels on the outside

976
00:45:50,370 --> 00:45:46,509
for thermal control we put things inside

977
00:45:52,679 --> 00:45:50,380
and it would probably take in two or

978
00:45:55,529 --> 00:45:52,689
three trips of a shuttle to go up to

979
00:45:58,409 --> 00:45:55,539
bring back all the pieces that yeah

980
00:46:01,499 --> 00:45:58,419
that's it's not very efficient I guess

981
00:46:04,259 --> 00:46:01,509
so I did we would have loved to have it

982
00:46:06,299 --> 00:46:04,269
brought back and we could go down to DC

983
00:46:09,959 --> 00:46:06,309
and see it in the Smithsonian but that

984
00:46:12,209 --> 00:46:09,969
that was not a practical way to do it

985
00:46:14,489 --> 00:46:12,219
that's too bad it really is now this

986
00:46:16,079 --> 00:46:14,499
isn't directly related to Hubble but did

987
00:46:18,359 --> 00:46:16,089
I think your shuttle was pretty much

988
00:46:19,649 --> 00:46:18,369

designed to land without anything in the

989
00:46:22,559 --> 00:46:19,659
cargo bay wasn't it let me do but it

990
00:46:23,849 --> 00:46:22,569
didn't ever land full of stuff the unit

991
00:46:25,649 --> 00:46:23,859
does anybody know I mean it's not a

992
00:46:29,130 --> 00:46:25,659
Hubble question for exactly but I'm just

993
00:46:30,630 --> 00:46:29,140
curious well ldf didn't it long duration

994
00:46:32,579 --> 00:46:30,640
facility I think came back in the

995
00:46:34,499 --> 00:46:32,589
initial did it okay okay i wasn't i

996
00:46:36,359 --> 00:46:34,509
don't i don't recall that that's

997
00:46:37,949 --> 00:46:36,369
probably not nearly as heavy or as dense

998
00:46:40,589 --> 00:46:37,959
as some would have been because it was

999
00:46:42,630 --> 00:46:40,599
basically a an outer shell with samples

1000
00:46:44,909 --> 00:46:42,640
of material all around the periphery but

1001
00:46:46,769 --> 00:46:44,919
but remember for servicing missions they

1002
00:46:50,039 --> 00:46:46,779
take instruments up and they take stuff

1003
00:46:52,320 --> 00:46:50,049
out look so it's never coming back empty

1004
00:46:53,730 --> 00:46:52,330
from a certain equipment

1005
00:46:55,020 --> 00:46:53,740
right yeah as a matter of fact a number

1006
00:46:58,350 --> 00:46:55,030
of those instruments are down in the

1007
00:47:01,950 --> 00:46:58,360
Smithsonian for jobs to do and say hi as

1008
00:47:06,030 --> 00:47:01,960
well as well as co-star which you to see

1009
00:47:10,080 --> 00:47:06,040
the correction that we may in 1993 with

1010
00:47:11,940 --> 00:47:10,090
the corrective optics so Eamonn Fenton

1011
00:47:13,950 --> 00:47:11,950
on the Q&A app as asking an interesting

1012
00:47:15,870 --> 00:47:13,960
question would it not be a future option

1013
00:47:18,420 --> 00:47:15,880

to have multiple smaller aperture

1014
00:47:19,920 --> 00:47:18,430
telescopes like Hubble acting like an

1015
00:47:21,720 --> 00:47:19,930
interferometer rather than a single

1016
00:47:24,000 --> 00:47:21,730
larger telescope like James wow that's

1017
00:47:26,640 --> 00:47:24,010
an interesting idea sort of a series or

1018
00:47:28,290 --> 00:47:26,650
a network of telescopes pointing up in

1019
00:47:31,620 --> 00:47:28,300
orbit what do you think of that Kenneth

1020
00:47:33,150 --> 00:47:31,630
what 61 read my webpage I've actually

1021
00:47:36,170 --> 00:47:33,160
worked tonight dear called stellar

1022
00:47:39,300 --> 00:47:36,180
imager which was exactly that basically

1023
00:47:41,190 --> 00:47:39,310
31 meter mirrors working together in

1024
00:47:43,530 --> 00:47:41,200
space all pointing at the same target at

1025
00:47:46,230 --> 00:47:43,540
the same time and focusing light onto a

1026
00:47:48,000 --> 00:47:46,240
central hub and you could indeed it

1027
00:47:50,040 --> 00:47:48,010
would be kind of like a James Webb which

1028
00:47:52,650 --> 00:47:50,050
already has segments but separating them

1029
00:47:54,300 --> 00:47:52,660
out over much longer baseline so instead

1030
00:47:56,490 --> 00:47:54,310
of having a six and a half meter

1031
00:47:59,040 --> 00:47:56,500
diameter you might have a virtual mirror

1032
00:48:01,110 --> 00:47:59,050
that could be 500 meters or a kilometer

1033
00:48:03,000 --> 00:48:01,120
in diameter with a lot of open spaces

1034
00:48:04,530 --> 00:48:03,010
between it but you would observe an

1035
00:48:08,250 --> 00:48:04,540
object and then move the mirrors around

1036
00:48:10,410 --> 00:48:08,260
and kind of fill in that virtual mirror

1037
00:48:12,330 --> 00:48:10,420
and get the resolving power on the sky

1038
00:48:15,300 --> 00:48:12,340

of something a kilometer in diameter

1039
00:48:16,710 --> 00:48:15,310
instead of six or 10 meters and that

1040
00:48:19,050 --> 00:48:16,720
something like that would actually allow

1041
00:48:21,060 --> 00:48:19,060
you to resolve features on the surfaces

1042
00:48:23,310 --> 00:48:21,070
of other stars you can see spots and

1043
00:48:25,260 --> 00:48:23,320
flares just like you see on the Sun on

1044
00:48:29,370 --> 00:48:25,270
very distant stars if you had so I

1045
00:48:33,810 --> 00:48:29,380
diameter that's day going I don't winds

1046
00:48:35,760 --> 00:48:33,820
that lunch thing I guess I broke so you

1047
00:48:38,220 --> 00:48:35,770
know it's it's uh it's it's probably

1048
00:48:40,710 --> 00:48:38,230
decades off now we know how to do it but

1049
00:48:42,540 --> 00:48:40,720
it would be a tremendous technologies

1050
00:48:44,880 --> 00:48:42,550
development but it is possible there's

1051
00:48:46,590 --> 00:48:44,890
not a lot like something like that I

1052
00:48:47,430 --> 00:48:46,600
would totally love it okay Scott I might

1053
00:48:51,030 --> 00:48:47,440
could you have anything i'm missing

1054
00:48:53,520 --> 00:48:51,040
somewhere not that I'm seeing the ones

1055
00:48:57,390 --> 00:48:53,530
from Twitter are mainly just awesome

1056
00:49:02,730 --> 00:48:57,400
responses to demand to the demand option

1057
00:49:04,380 --> 00:49:02,740
for it so let's see here sand archons is

1058
00:49:05,870 --> 00:49:04,390
well my daughter is going to freak when

1059
00:49:08,000 --> 00:49:05,880
I relay this

1060
00:49:10,370 --> 00:49:08,010
yeah that would be an awesome job to

1061
00:49:12,590 --> 00:49:10,380
grow up to want to be I mean what

1062
00:49:14,090 --> 00:49:12,600
inspiring the use of the future like

1063
00:49:16,580 --> 00:49:14,100

what you wanna do I want to go man a

1064
00:49:18,500 --> 00:49:16,590
telescope in space that would yes I know

1065
00:49:21,380 --> 00:49:18,510
it would be a great job no question

1066
00:49:24,500 --> 00:49:21,390
about it well I I'm really sorry about

1067
00:49:26,300 --> 00:49:24,510
all the technical problems guys but this

1068
00:49:27,470 --> 00:49:26,310
will not be the only history hang out

1069
00:49:29,390 --> 00:49:27,480
that we do for Hubble cuz we just

1070
00:49:31,340 --> 00:49:29,400
touched the surface on this one so

1071
00:49:32,840 --> 00:49:31,350
hopefully the the technical issues won't

1072
00:49:34,190 --> 00:49:32,850
be around the next time and where I'm

1073
00:49:38,120 --> 00:49:34,200
going to invite both of these guys back

1074
00:49:39,620 --> 00:49:38,130
again and I also want to have a Caroline

1075
00:49:41,780 --> 00:49:39,630
I talked about this we also want to have

1076
00:49:43,250 --> 00:49:41,790
a hangout that's dedicated to the nuts

1077
00:49:46,220 --> 00:49:43,260
and bolts of Hubble you know how do we

1078
00:49:47,480 --> 00:49:46,230
actually operate it and so that's in the

1079
00:49:50,060 --> 00:49:47,490
pipeline to and hopefully these guys

1080
00:49:51,950 --> 00:49:50,070
will join us again for that I want to

1081
00:49:53,540 --> 00:49:51,960
ask this last question to all of you and

1082
00:49:56,840 --> 00:49:53,550
Scott that I'd like to get your feedback

1083
00:49:59,360 --> 00:49:56,850
your reaction to this too can you can

1084
00:50:01,340 --> 00:49:59,370
you give me can each of you give me some

1085
00:50:03,740 --> 00:50:01,350
comments on what Hubble the Hubble Space

1086
00:50:13,510 --> 00:50:03,750
Telescope has meant to you personally

1087
00:50:16,480 --> 00:50:13,520
and I'll start with you Carol really ok

1088
00:50:21,140 --> 00:50:16,490

well I came from the ground-based

1089
00:50:23,270 --> 00:50:21,150
astronomical community and we had some

1090
00:50:26,240 --> 00:50:23,280
pretty good instrumentation there and

1091
00:50:33,050 --> 00:50:26,250
did some interesting science I think the

1092
00:50:37,280 --> 00:50:33,060
Hubble then opens a lot of new areas of

1093
00:50:39,800 --> 00:50:37,290
study so technologically I think the

1094
00:50:42,650 --> 00:50:39,810
telescope is magnificent and astronomers

1095
00:50:44,930 --> 00:50:42,660
just just love it for the technology and

1096
00:50:47,900 --> 00:50:44,940
the amazing instrumentation on it and

1097
00:50:50,090 --> 00:50:47,910
the fact that you know every few years

1098
00:50:53,360 --> 00:50:50,100
it turned into a brand new telescope

1099
00:50:56,300 --> 00:50:53,370
somebody said these comment about oh you

1100
00:50:59,180 --> 00:50:56,310
know it's a you know 25 years old yeah

1101
00:51:01,340 --> 00:50:59,190
but the last servicing mission was 2009

1102
00:51:04,130 --> 00:51:01,350
so it's it's really a five year old

1103
00:51:07,250 --> 00:51:04,140
telescope so it's like fantastic and the

1104
00:51:10,460 --> 00:51:07,260
mirror is beautiful even though it's not

1105
00:51:12,830 --> 00:51:10,470
the perfect curvature the as rust talked

1106
00:51:15,290 --> 00:51:12,840
about the ingenuity of the instrument

1107
00:51:17,990 --> 00:51:15,300
building got around that and now we can

1108
00:51:19,880 --> 00:51:18,000
take full advantage of it I also think

1109
00:51:22,130 --> 00:51:19,890
that for Hubble the

1110
00:51:24,109 --> 00:51:22,140
changed a little bit the way people do

1111
00:51:26,150 --> 00:51:24,119
science the fact that we have large

1112
00:51:29,900 --> 00:51:26,160
groups they collaborate frontier fields

1113
00:51:32,000 --> 00:51:29,910

as an example of the field now all these

1114
00:51:35,140 --> 00:51:32,010
other telescopes are working together

1115
00:51:38,089 --> 00:51:35,150
people who are using kinds of facilities

1116
00:51:41,029 --> 00:51:38,099
to look at specific problems in

1117
00:51:43,640 --> 00:51:41,039
astronomy which we never did before so I

1118
00:51:45,980 --> 00:51:43,650
think it changed the culture of science

1119
00:51:48,529 --> 00:51:45,990
and it's just it's a magnificent that's

1120
00:51:49,880 --> 00:51:48,539
helped it's just fantastic thank you

1121
00:51:51,680 --> 00:51:49,890
Scott can you give us some personal

1122
00:51:53,329 --> 00:51:51,690
comments about what you know about what

1123
00:51:54,890 --> 00:51:53,339
it's meant for you yeah I mean it's

1124
00:51:57,890 --> 00:51:54,900
something that you and I have talked

1125
00:51:59,870 --> 00:51:57,900
about privately but you know I remember

1126
00:52:03,109 --> 00:51:59,880
when Hubble launched and it you know I

1127
00:52:07,579 --> 00:52:03,119
was fairly young at the time we're for

1128
00:52:11,480 --> 00:52:07,589
sniper right young whippersnapper but so

1129
00:52:13,579 --> 00:52:11,490
seeing and being excited about it uh and

1130
00:52:15,859 --> 00:52:13,589
seeing you know the the beautiful images

1131
00:52:18,680 --> 00:52:15,869
have come down over time as I've grown

1132
00:52:22,400 --> 00:52:18,690
up to really appreciate science and

1133
00:52:24,230 --> 00:52:22,410
astronomy MIT and as it's become a more

1134
00:52:26,930 --> 00:52:24,240
important part of my life now to the

1135
00:52:29,420 --> 00:52:26,940
point where I'm working help telling the

1136
00:52:31,039 --> 00:52:29,430
story of a bubble through Hubble

1137
00:52:32,690 --> 00:52:31,049
hangouts it really means a lot to me

1138
00:52:34,670 --> 00:52:32,700

personally that I'm able to get back in

1139
00:52:38,720 --> 00:52:34,680
this way because it has really inspired

1140
00:52:41,509 --> 00:52:38,730
me to learn more about our universe and

1141
00:52:44,089 --> 00:52:41,519
being able to share that with with

1142
00:52:45,950 --> 00:52:44,099
people that's really how it affected me

1143
00:52:47,420 --> 00:52:45,960
if watching the servicing missions and

1144
00:52:50,089 --> 00:52:47,430
learning more and seeing a lot of the

1145
00:52:52,039 --> 00:52:50,099
the the ultra deep field limits and

1146
00:52:53,990 --> 00:52:52,049
learning more and being able to share

1147
00:52:57,799 --> 00:52:54,000
that with with more and more people and

1148
00:52:59,269 --> 00:52:57,809
now even in a larger scope now doing

1149
00:53:01,730 --> 00:52:59,279
with double hangouts so it's something

1150
00:53:04,190 --> 00:53:01,740
that's really really inspired me and

1151
00:53:05,390 --> 00:53:04,200
many different ways love it good and

1152
00:53:06,829 --> 00:53:05,400
you're doing great with the Hubble

1153
00:53:08,809 --> 00:53:06,839
hangouts to it we could imagine doing

1154
00:53:11,029 --> 00:53:08,819
these without you so I rest you got any

1155
00:53:15,499 --> 00:53:11,039
comments on I'm from a personal nature

1156
00:53:18,220 --> 00:53:15,509
on the Hubble well Hubble weren't

1157
00:53:21,819 --> 00:53:18,230
working on Hubble from the eda viewpoint

1158
00:53:26,779 --> 00:53:21,829
I personally have tremendous pride in

1159
00:53:28,849 --> 00:53:26,789
how it has resulted that you can talk to

1160
00:53:32,240 --> 00:53:28,859
almost anybody they know a little bit

1161
00:53:33,230 --> 00:53:32,250
about Hubble ah the tremendous

1162
00:53:37,609 --> 00:53:33,240
accomplished

1163
00:53:40,990 --> 00:53:37,619

that it has made and the images that it

1164
00:53:43,760 --> 00:53:41,000
brings back when I talk to school kids

1165
00:53:45,500 --> 00:53:43,770
their teachers don't like it but I tell

1166
00:53:49,160 --> 00:53:45,510
them to throw away their science books

1167
00:53:51,830 --> 00:53:49,170
they're astronomy get all of that and

1168
00:53:54,950 --> 00:53:51,840
then I so that I get invited back I have

1169
00:53:59,060 --> 00:53:54,960
to explain I just got your attention by

1170
00:54:02,510 --> 00:53:59,070
saying that don't you dare spines books

1171
00:54:06,800 --> 00:54:02,520
away the fact that it's made on science

1172
00:54:09,940 --> 00:54:06,810
and to be a small part of the team of

1173
00:54:13,400 --> 00:54:09,950
astronauts scientists engineers

1174
00:54:15,859 --> 00:54:13,410
technicians that nASA has put together

1175
00:54:19,220 --> 00:54:15,869
to do this I couldn't have asked for a

1176
00:54:21,950 --> 00:54:19,230
better job wonderful right now Ken I'll

1177
00:54:24,560 --> 00:54:21,960
leave that last word it's been a fun

1178
00:54:27,230 --> 00:54:24,570
ride you know who thought when I signed

1179
00:54:29,359 --> 00:54:27,240
on to this for a couple of years back in

1180
00:54:32,690 --> 00:54:29,369
the mid-80s that it would have gone on

1181
00:54:35,720 --> 00:54:32,700
so long it's a it's been a privilege to

1182
00:54:37,070 --> 00:54:35,730
be able to stay with this observatory

1183
00:54:39,770 --> 00:54:37,080
that's up the leading edge of science

1184
00:54:41,330 --> 00:54:39,780
and has been there continuously now for

1185
00:54:43,250 --> 00:54:41,340
25 years and that's only possible

1186
00:54:44,840 --> 00:54:43,260
because we were able to do the servicing

1187
00:54:46,660 --> 00:54:44,850
otherwise we wouldn't have been able to

1188
00:54:49,849 --> 00:54:46,670

stay ahead of advancements on the ground

1189
00:54:51,620 --> 00:54:49,859
but it's it's been a privilege to be

1190
00:54:53,840 --> 00:54:51,630
here and be involved and watch all of

1191
00:54:55,670 --> 00:54:53,850
the unexpected discoveries that were

1192
00:54:58,820 --> 00:54:55,680
made along with all the things that we

1193
00:55:01,280 --> 00:54:58,830
thought Hubble would be capable of doing

1194
00:55:03,290 --> 00:55:01,290
of helping to verify the accelerating

1195
00:55:05,420 --> 00:55:03,300
expansion of the universe which no one

1196
00:55:07,920 --> 00:55:05,430
in their right mind remotely she seemed

1197
00:55:10,320 --> 00:55:07,930
of back when we

1198
00:55:12,240 --> 00:55:10,330
we were watching comets collide in the

1199
00:55:14,160 --> 00:55:12,250
Jupiter's a whole string of things that

1200
00:55:15,360 --> 00:55:14,170
we didn't really anticipate and it's

1201
00:55:17,220 --> 00:55:15,370
been a whole lot of fun seeing them and

1202
00:55:19,770 --> 00:55:17,230
being able to observe them and actually

1203
00:55:21,180 --> 00:55:19,780
get real information out of them so

1204
00:55:23,430 --> 00:55:21,190
there's that and then there's just the

1205
00:55:26,910 --> 00:55:23,440
whole story of the lesson to be learned

1206
00:55:28,890 --> 00:55:26,920
from never giving up and you know being

1207
00:55:30,480 --> 00:55:28,900
up to overcome adversity first you had

1208
00:55:31,740 --> 00:55:30,490
the spherical aberration which looked

1209
00:55:33,990 --> 00:55:31,750
like it was going to kill the mission

1210
00:55:36,630 --> 00:55:34,000
that we bounced back from very rapidly

1211
00:55:39,690 --> 00:55:36,640
with a lot of talented people finding

1212
00:55:41,070 --> 00:55:39,700
the solution and then later on when the

1213
00:55:42,930 --> 00:55:41,080

last servicing mission looked like it

1214
00:55:45,090 --> 00:55:42,940
was cancelled and Hubble was going to

1215
00:55:48,570 --> 00:55:45,100
stop operating you know 2010 or

1216
00:55:50,640 --> 00:55:48,580
something we stuck with it found a way

1217
00:55:52,620 --> 00:55:50,650
to keep people employed and productive

1218
00:55:55,290 --> 00:55:52,630
until the decision got reversed and we

1219
00:55:56,700 --> 00:55:55,300
got the last mission in 2009 which now

1220
00:55:58,350 --> 00:55:56,710
looks critical for getting Hubble to

1221
00:56:04,710 --> 00:55:58,360
opera

1222
00:56:05,880 --> 00:56:04,720
James Webb Space Telescope I think it's

1223
00:56:11,430 --> 00:56:05,890
critical to have both of them up there

1224
00:56:13,500 --> 00:56:11,440
at the same time send the sky from the

1225
00:56:16,140 --> 00:56:13,510
far UV ultraviolet bluer than the eye

1226
00:56:18,330 --> 00:56:16,150
sees out to the far read that James Webb

1227
00:56:20,220 --> 00:56:18,340
will be able to detect well I couldn't

1228
00:56:23,280 --> 00:56:20,230
agree more in the public outcry from the

1229
00:56:25,500 --> 00:56:23,290
last supper Hubble mission servicing

1230
00:56:28,260 --> 00:56:25,510
mission was I was very humbling and I

1231
00:56:29,400 --> 00:56:28,270
was very amazing to watch the amount of

1232
00:56:33,390 --> 00:56:29,410
support that the Hubble Space Telescope

1233
00:56:35,070 --> 00:56:33,400
has for mine go ahead Tony I was just

1234
00:56:37,290 --> 00:56:35,080
going to say like this even we're

1235
00:56:40,770 --> 00:56:37,300
talking about this service mission back

1236
00:56:43,290 --> 00:56:40,780
in 2009 we're still putting out new

1237
00:56:45,360 --> 00:56:43,300
information we just released so that's

1238
00:56:49,170 --> 00:56:45,370

from today's press today's press release

1239
00:56:51,210 --> 00:56:49,180
I mean just is seeing the ghost to these

1240
00:56:52,950 --> 00:56:51,220
ghetto if you guys might go to a hubble

1241
00:56:55,050 --> 00:56:52,960
site that Oregon check out today's press

1242
00:56:56,160 --> 00:56:55,060
release with this brand new image that's

1243
00:56:58,740 --> 00:56:56,170
come out there and it's absolutely

1244
00:57:02,190 --> 00:56:58,750
fantastic it can it's because we've been

1245
00:57:05,100 --> 00:57:02,200
able to continue along and upgrade the

1246
00:57:08,250 --> 00:57:05,110
telescope and and and stay wanting to do

1247
00:57:10,260 --> 00:57:08,260
more science that were allowed to do

1248
00:57:12,960 --> 00:57:10,270
even more discoveries like these and

1249
00:57:14,550 --> 00:57:12,970
continue it going nice and I often

1250
00:57:17,130 --> 00:57:14,560
argued that the Hubble Space Telescope

1251
00:57:19,470 --> 00:57:17,140
is probably the most important

1252
00:57:21,060 --> 00:57:19,480
scientific instrument ever built since

1253
00:57:23,700 --> 00:57:21,070
the telescope from Galileo because I

1254
00:57:26,160 --> 00:57:23,710
don't think there's a single instrument

1255
00:57:28,200 --> 00:57:26,170
that has ever changed the course and the

1256
00:57:30,630 --> 00:57:28,210
way we look at the universe more then

1257
00:57:32,910 --> 00:57:30,640
that telescope has and so and it has

1258
00:57:34,440 --> 00:57:32,920
literally changed my life I can I can

1259
00:57:35,880 --> 00:57:34,450
trace a path from the first time I ever

1260
00:57:39,000 --> 00:57:35,890
watched the Hubble Deep Field in my

1261
00:57:40,440 --> 00:57:39,010
career to here and it has been so Hubble

1262
00:57:42,510 --> 00:57:40,450
has been an intimate part of my life

1263
00:57:44,940 --> 00:57:42,520

ever since I first saw that first deep

1264
00:57:46,440 --> 00:57:44,950
field in the mid 90s well folks I want

1265
00:57:48,030 --> 00:57:46,450
to thank everybody I'm sorry about the

1266
00:57:50,220 --> 00:57:48,040
technical difficulties that's it for

1267
00:57:53,460 --> 00:57:50,230
this week though next week we are going

1268
00:57:55,950 --> 00:57:53,470
to have a hangout on the a on Hubble

1269
00:57:58,440 --> 00:57:55,960
observations which have been put

1270
00:58:02,370 --> 00:57:58,450
together that allowed astronomers to

1271
00:58:04,560 --> 00:58:02,380
make a thermal map of an exoplanet this

1272
00:58:05,820 --> 00:58:04,570
is the temperature variations across the

1273
00:58:08,040 --> 00:58:05,830
planet itself and we're going to have

1274
00:58:10,260 --> 00:58:08,050
the principal investigators involved in

1275
00:58:12,000 --> 00:58:10,270
that science next week so that's next

1276
00:58:13,920 --> 00:58:12,010
Thursday 3 p.m.

1277
00:58:16,200 --> 00:58:13,930
look forward to seeing you there Russ

1278
00:58:17,670 --> 00:58:16,210
can thank you very much this has been a

1279
00:58:18,930 --> 00:58:17,680
great hangout I hope you'll come back

1280
00:58:20,760 --> 00:58:18,940
and do another one with us because this

1281
00:58:23,010 --> 00:58:20,770
is we're not done we're not done with up

1282
00:58:25,380 --> 00:58:23,020
with the history of Hubble yet so I hope

1283
00:58:27,630 --> 00:58:25,390
you're awesome thank you both thank you

1284
00:58:29,580 --> 00:58:27,640
I don't understand it I want to have a

1285
00:58:32,970 --> 00:58:29,590
hangout from Russia's office I think

1286
00:58:35,820 --> 00:58:32,980
he's got a lot of cool all right what is

1287
00:58:44,040 --> 00:58:35,830
time oh look at this look at that what's

1288
00:58:52,230 --> 00:58:44,050

wrong yes all right so I'm having a

1289
00:58:54,840 --> 00:58:52,240
field trip from LA you're waking so glad

1290
00:58:57,300 --> 00:58:54,850
have this great room yeah thank you very

1291
00:58:59,940 --> 00:58:57,310
much everybody all right close yeah

1292
00:59:01,950 --> 00:58:59,950
that's it that's it for this week thank