The Challenges of Servicing in Space

Panel Session with Hubble Astronauts

From NASA's Goddard Space Flight Center, Greenbelt, MD

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1
00:00:15,350 --> 00:00:13,509
we are live at goddard space flight

2
00:00:17,189 --> 00:00:15,360
center here in greenbelt maryland i'm

3
00:00:20,150 --> 00:00:17,199
erin kislik and today we are celebrating

4
00:00:22,150 --> 00:00:20,160
25 years of hubble servicing so you may

5
00:00:24,150 --> 00:00:22,160
be wondering what exactly is servicing

6
00:00:26,150 --> 00:00:24,160
the same way that you take your car in

7
00:00:29,029 --> 00:00:26,160
to get the tires rotated to get the oil

8
00:00:31,189 --> 00:00:29,039
changed sometimes satellites in space

9
00:00:33,990 --> 00:00:31,199
need a little help luckily today we've

10
00:00:35,670 --> 00:00:34,000
got a panel of astronauts from all

11
00:00:37,270 --> 00:00:35,680
hubble servicing missions here to tell

12
00:00:39,190 --> 00:00:37,280
us a little bit about their experience

13
00:00:41,430 --> 00:00:39,200

and about servicing

14
00:00:42,790 --> 00:00:41,440
so stay tuned for a great show take it

15
00:00:45,830 --> 00:00:42,800
away george

16
00:00:47,750 --> 00:00:45,840
right thank you aaron good afternoon i'm

17
00:00:50,150 --> 00:00:47,760
george morrow i'm the deputy director of

18
00:00:51,830 --> 00:00:50,160
nasa's goddard space flight center i

19
00:00:53,510 --> 00:00:51,840
supported the hubble project as a

20
00:00:55,029 --> 00:00:53,520
systems engineer at the time of the

21
00:00:57,670 --> 00:00:55,039
deployment mission

22
00:00:58,630 --> 00:00:57,680
i was the observatory development

23
00:01:00,869 --> 00:00:58,640
manager

24
00:01:03,510 --> 00:01:00,879
for the first servicing mission hard to

25
00:01:05,670 --> 00:01:03,520
believe that was 25 years ago i

26
00:01:07,429 --> 00:01:05,680
i still can't believe it and i was the

27
00:01:09,910 --> 00:01:07,439
flight systems and servicing deputy

28
00:01:12,390 --> 00:01:09,920
project manager for the second servicing

29
00:01:13,830 --> 00:01:12,400
mission so i have quite a background on

30
00:01:15,990 --> 00:01:13,840
on hubble

31
00:01:19,030 --> 00:01:16,000
uh the agenda this morning concentrated

32
00:01:20,789 --> 00:01:19,040
on the situation nasa found itself in

33
00:01:22,630 --> 00:01:20,799
after hubble's launch when it was

34
00:01:24,230 --> 00:01:22,640
discovered that the main mirror was not

35
00:01:26,149 --> 00:01:24,240
figured correctly

36
00:01:27,830 --> 00:01:26,159
and then the heroic first servicing

37
00:01:29,109 --> 00:01:27,840
mission that corrected the problem was

38
00:01:31,109 --> 00:01:29,119

discussed

39
00:01:32,710 --> 00:01:31,119
there would be five servicing missions

40
00:01:34,710 --> 00:01:32,720
in all that required years of

41
00:01:36,950 --> 00:01:34,720
preparatory work on the ground by

42
00:01:38,789 --> 00:01:36,960
scientists and engineers

43
00:01:40,870 --> 00:01:38,799
but after all the tools were developed

44
00:01:42,950 --> 00:01:40,880
the hardware for the observatory built

45
00:01:45,670 --> 00:01:42,960
and tested and the upgrades to the

46
00:01:47,830 --> 00:01:45,680
ground system finished it fell to 32

47
00:01:50,149 --> 00:01:47,840
astronauts to execute these missions and

48
00:01:53,109 --> 00:01:50,159
the original deployment mission

49
00:01:55,429 --> 00:01:53,119
each mission had its uh own overall

50
00:01:58,030 --> 00:01:55,439
purpose some were to save hubble that

51
00:02:00,789 --> 00:01:58,040
was hobbled by the the blurred vision or

52
00:02:02,789 --> 00:02:00,799
incapacitated by broken gyros other

53
00:02:04,630 --> 00:02:02,799
missions were created to expand hubble's

54
00:02:07,109 --> 00:02:04,640
vision with new instruments designed to

55
00:02:10,070 --> 00:02:07,119
detect different wavelengths of light

56
00:02:12,150 --> 00:02:10,080
and one was to simultaneously upgrade

57
00:02:14,790 --> 00:02:12,160
its science capabilities while

58
00:02:16,390 --> 00:02:14,800
outfitting it to last for as long as

59
00:02:18,070 --> 00:02:16,400
possible

60
00:02:19,190 --> 00:02:18,080
each mission had its own set of

61
00:02:22,070 --> 00:02:19,200
challenges

62
00:02:24,710 --> 00:02:22,080
yet they all had the same amazing result

63
00:02:27,350 --> 00:02:24,720

the astronauts succeeded in every task

64
00:02:28,949 --> 00:02:27,360
on every mission making each flight a

65
00:02:31,110 --> 00:02:28,959
complete success

66
00:02:33,030 --> 00:02:31,120
we are fortunate to have with us seven

67
00:02:34,949 --> 00:02:33,040
astronauts representing the deployment

68
00:02:37,350 --> 00:02:34,959
mission and all five servicing missions

69
00:02:39,670 --> 00:02:37,360
today they're here to tell us about the

70
00:02:42,150 --> 00:02:39,680
challenges of working in space so now

71
00:02:44,229 --> 00:02:42,160
let's meet them

72
00:02:47,270 --> 00:02:44,239
so the first he piloted two shuttle

73
00:02:49,030 --> 00:02:47,280
missions including sts-31 that deployed

74
00:02:51,430 --> 00:02:49,040
hubble and commanded two additional

75
00:02:53,589 --> 00:02:51,440
missions including the historic

76
00:02:56,229 --> 00:02:53,599
first joint american russian space

77
00:02:59,670 --> 00:02:56,239
shuttle mission in 1994.

78
00:03:01,990 --> 00:02:59,680
he has a distinguished 34-year career in

79
00:03:04,710 --> 00:03:02,000
the marine corps that included flying

80
00:03:05,750 --> 00:03:04,720
over 100 combat missions over southeast

81
00:03:07,509 --> 00:03:05,760
asia

82
00:03:10,229 --> 00:03:07,519
he would go on to serve as the 12th

83
00:03:12,309 --> 00:03:10,239
administrator of nasa for over seven

84
00:03:15,350 --> 00:03:12,319
years he is currently an independent

85
00:03:18,390 --> 00:03:15,360
consultant in aerospace steam education

86
00:03:20,630 --> 00:03:18,400
leadership and national security affairs

87
00:03:31,589 --> 00:03:20,640
please welcome major general charles

88
00:03:36,070 --> 00:03:33,670

the second is a veteran of five shuttle

89
00:03:39,030 --> 00:03:36,080
flights on his first mission he made the

90
00:03:40,949 --> 00:03:39,040
first sts contingency spacewalk in an

91
00:03:43,030 --> 00:03:40,959
attempt and rescue of a malfunctioning

92
00:03:45,110 --> 00:03:43,040
satellite his fourth flight he would

93
00:03:46,869 --> 00:03:45,120
conduct three evas as part of the first

94
00:03:48,710 --> 00:03:46,879
servicing mission to hubble and

95
00:03:51,430 --> 00:03:48,720
installed a historic wide-field

96
00:03:53,670 --> 00:03:51,440
planetary camera too he would move on to

97
00:03:55,990 --> 00:03:53,680
become nasa's european representative in

98
00:03:57,910 --> 00:03:56,000
paris he is currently a professor in the

99
00:04:00,070 --> 00:03:57,920
department of aeronautics and

100
00:04:02,550 --> 00:04:00,080
astronautics at the massachusetts

101
00:04:11,509 --> 00:04:02,560
institute of technology please welcome

102
00:04:15,350 --> 00:04:13,509
she was a mission specialist on four

103
00:04:17,830 --> 00:04:15,360
shuttle flights her first flight was a

104
00:04:19,590 --> 00:04:17,840
department of defense mission her second

105
00:04:21,509 --> 00:04:19,600
was on the maiden voyage of space

106
00:04:23,909 --> 00:04:21,519
shuttle endeavour where she evaluated

107
00:04:26,390 --> 00:04:23,919
space station assembly techniques and

108
00:04:28,790 --> 00:04:26,400
her third flight was the first servicing

109
00:04:29,990 --> 00:04:28,800
mission for hubble where she installed

110
00:04:32,070 --> 00:04:30,000
costar

111
00:04:34,310 --> 00:04:32,080
the robotic device with corrective

112
00:04:37,270 --> 00:04:34,320
mirrors that compensated for the

113
00:04:39,510 --> 00:04:37,280

inaccurately figured primary mirror she

114
00:04:41,990 --> 00:04:39,520
is currently a professor of mechanical

115
00:04:44,710 --> 00:04:42,000
and aerospace engineering at my album

116
00:04:54,790 --> 00:04:44,720
water the university of virginia please

117
00:04:58,230 --> 00:04:56,710
he flew four shuttle missions including

118
00:04:59,350 --> 00:04:58,240
the one that launched the magellan probe

119
00:05:01,189 --> 00:04:59,360
to venus

120
00:05:02,950 --> 00:05:01,199
on his last mission hubble's second

121
00:05:05,670 --> 00:05:02,960
servicing mission he performed three

122
00:05:08,469 --> 00:05:05,680
evas and installed two new instruments

123
00:05:10,310 --> 00:05:08,479
the space telescope imaging spectrograph

124
00:05:12,390 --> 00:05:10,320
and the near infrared camera and a

125
00:05:14,390 --> 00:05:12,400
multi-object spectrometer

126
00:05:17,749 --> 00:05:14,400
he completed a distinguished career as a

127
00:05:19,510 --> 00:05:17,759
pilot flying mostly f-4s and f-16s and

128
00:05:21,430 --> 00:05:19,520
as a commander in united states air

129
00:05:23,749 --> 00:05:21,440
force and is now the director of

130
00:05:26,310 --> 00:05:23,759
aerospace facilities for affiliated

131
00:05:34,870 --> 00:05:26,320
engineering incorporated please welcome

132
00:05:39,270 --> 00:05:36,870
our next astronaut visited hubble more

133
00:05:41,510 --> 00:05:39,280
than any other with three servicing

134
00:05:44,390 --> 00:05:41,520
missions to his credit during those he

135
00:05:46,150 --> 00:05:44,400
conducted eight spacewalks he also flew

136
00:05:48,230 --> 00:05:46,160
on two earlier shuttle missions

137
00:05:49,749 --> 00:05:48,240
including one to the russian space

138
00:05:51,830 --> 00:05:49,759

station mir

139
00:05:53,590 --> 00:05:51,840
a physicist by education he would serve

140
00:05:55,990 --> 00:05:53,600
as nasa's chief scientist and would

141
00:05:58,469 --> 00:05:56,000
later lead all science for nasa as the

142
00:06:00,790 --> 00:05:58,479
associate administrator for the science

143
00:06:02,790 --> 00:06:00,800
mission directorate at nasa headquarters

144
00:06:04,390 --> 00:06:02,800
he is currently an emeritus scientist

145
00:06:06,390 --> 00:06:04,400
here at goddard working on hubble

146
00:06:08,710 --> 00:06:06,400
observations of your europa

147
00:06:10,469 --> 00:06:08,720
and collaborating with goddard and jpl

148
00:06:12,790 --> 00:06:10,479
on the next

149
00:06:15,510 --> 00:06:12,800
on the design of the next generation of

150
00:06:24,390 --> 00:06:15,520
serviceable telescopes please welcome dr

151
00:06:28,790 --> 00:06:26,870
he piloted two shuttle missions sir and

152
00:06:30,629 --> 00:06:28,800
served as commander of the last two

153
00:06:32,710 --> 00:06:30,639
hubble servicing missions

154
00:06:35,270 --> 00:06:32,720
he was assigned to nasa headquarters as

155
00:06:37,189 --> 00:06:35,280
deputy director requirements division of

156
00:06:39,510 --> 00:06:37,199
the exploration systems mission

157
00:06:41,830 --> 00:06:39,520
directorate and later served as the

158
00:06:43,430 --> 00:06:41,840
chief of the exploration branch of the

159
00:06:45,510 --> 00:06:43,440
astronaut office

160
00:06:49,430 --> 00:06:45,520
he was an accomplished pilot in the navy

161
00:06:51,909 --> 00:06:49,440
flying f-14a and f-14d tomcats and made

162
00:06:54,150 --> 00:06:51,919
his hollywood hollywood

163
00:06:54,950 --> 00:06:54,160

debut buzzing the tower in the movie top

164
00:06:56,950 --> 00:06:54,960
gun

165
00:06:59,270 --> 00:06:56,960
he is now the senior vice president for

166
00:07:01,029 --> 00:06:59,280
civil programs at asrc federal

167
00:07:03,189 --> 00:07:01,039
engineering aerospace and mission

168
00:07:11,670 --> 00:07:03,199
systems group please welcome captain

169
00:07:15,909 --> 00:07:14,070
and last but certainly not least he is a

170
00:07:18,230 --> 00:07:15,919
veteran of the last two hubble servicing

171
00:07:19,589 --> 00:07:18,240
missions he performed four spacewalks

172
00:07:21,189 --> 00:07:19,599
and one of the

173
00:07:23,749 --> 00:07:21,199
was one of the first to repair an

174
00:07:26,309 --> 00:07:23,759
instrument in space an activity that was

175
00:07:28,469 --> 00:07:26,319
not designed into the hardware he holds

176
00:07:30,870 --> 00:07:28,479
five degrees and has been on the faculty

177
00:07:32,710 --> 00:07:30,880
at rice and georgia tech and is now a

178
00:07:35,430 --> 00:07:32,720
professor of mechanical engineering at

179
00:07:37,510 --> 00:07:35,440
columbia university you often see them

180
00:07:39,670 --> 00:07:37,520
in documentaries on the national

181
00:07:41,749 --> 00:07:39,680
geographic and science channels but

182
00:07:51,110 --> 00:07:41,759
today we get to see them here live

183
00:07:55,029 --> 00:07:52,790
so it's great to have all of you here

184
00:07:56,070 --> 00:07:55,039
please make yourselves comfortable

185
00:07:58,550 --> 00:07:56,080
uh

186
00:08:00,070 --> 00:07:58,560
and so we're we're really jumping at the

187
00:08:01,990 --> 00:08:00,080
bit to hear about the challenges and

188
00:08:04,790 --> 00:08:02,000

lessons learned across all the missions

189
00:08:07,589 --> 00:08:04,800
each had its own amazing stories so now

190
00:08:09,510 --> 00:08:07,599
we'll hear from them i'll ask them some

191
00:08:10,710 --> 00:08:09,520
some things and uh get them to talk

192
00:08:14,390 --> 00:08:10,720
about them

193
00:08:16,230 --> 00:08:14,400
so first really for charlie

194
00:08:17,990 --> 00:08:16,240
charlie i'd like to ask you the first

195
00:08:19,990 --> 00:08:18,000
question from a former astronaut

196
00:08:22,390 --> 00:08:20,000
perspective as well as from a nasa

197
00:08:24,629 --> 00:08:22,400
administrator perspective what do you

198
00:08:27,749 --> 00:08:24,639
think were the top one or two most

199
00:08:30,230 --> 00:08:27,759
challenging aspects of hubble servicing

200
00:08:33,269 --> 00:08:30,240
oh i'm not the right person to ask first

201
00:08:35,350 --> 00:08:33,279
of all since i was not a servicer but uh

202
00:08:36,630 --> 00:08:35,360
i can tell you about the one or two of

203
00:08:38,469 --> 00:08:36,640
the most challenging things about

204
00:08:40,469 --> 00:08:38,479
delivering it and

205
00:08:42,949 --> 00:08:40,479
and the people here at goddard played a

206
00:08:44,389 --> 00:08:42,959
key role in in working through it one

207
00:08:47,030 --> 00:08:44,399
was getting it out of the payload bay

208
00:08:50,710 --> 00:08:47,040
when we uh had the rms the remote

209
00:08:53,030 --> 00:08:50,720
manipulator system the uh robotic arm

210
00:08:54,949 --> 00:08:53,040
didn't work exactly the way that that we

211
00:08:57,350 --> 00:08:54,959
had trained it actually was not

212
00:08:59,430 --> 00:08:57,360
accustomed i think to the

213
00:09:01,269 --> 00:08:59,440

to the just the mass of hubble and so

214
00:09:04,230 --> 00:09:01,279
when we started what was to be a

215
00:09:06,230 --> 00:09:04,240
straightforward just lifted out uh dr

216
00:09:08,310 --> 00:09:06,240
steve hawley who was the rms operator

217
00:09:10,630 --> 00:09:08,320
found that it was beginning to pitch and

218
00:09:11,670 --> 00:09:10,640
roll and do all kinds of things so

219
00:09:19,269 --> 00:09:11,680
i

220
00:09:20,790 --> 00:09:19,279
took a uh what was supposed to be about

221
00:09:23,110 --> 00:09:20,800
a five or ten minute evolution and

222
00:09:24,949 --> 00:09:23,120
turning it into maybe an hour or more

223
00:09:26,790 --> 00:09:24,959
and then we got uh high gain antenna

224
00:09:28,949 --> 00:09:26,800
deployed got the first solar array out

225
00:09:31,430 --> 00:09:28,959
second solar ray started and i'm looking

226
00:09:33,110 --> 00:09:31,440
at sepi because i think we got 16 inches

227
00:09:34,310 --> 00:09:33,120
out or something like that and it

228
00:09:37,190 --> 00:09:34,320
stopped

229
00:09:39,590 --> 00:09:37,200
and we spent the rest of the day

230
00:09:41,829 --> 00:09:39,600
um trying to figure out what was wrong

231
00:09:43,509 --> 00:09:41,839
and in fact if i get the story wrong

232
00:09:44,389 --> 00:09:43,519
somebody in the audience say that's not

233
00:09:46,310 --> 00:09:44,399
right

234
00:09:48,389 --> 00:09:46,320
but i was we were told that there was a

235
00:09:50,630 --> 00:09:48,399
young engineer here at goddard who said

236
00:09:52,310 --> 00:09:50,640
very early on that i don't think there's

237
00:09:53,990 --> 00:09:52,320
anything mechanically wrong i think it's

238
00:09:55,269 --> 00:09:54,000

something called the tension monitoring

239
00:09:56,949 --> 00:09:55,279
module

240
00:09:58,710 --> 00:09:56,959
the irony is that the late bruce

241
00:10:00,470 --> 00:09:58,720
mccandless who was on the crew with us

242
00:10:02,310 --> 00:10:00,480
as soon as it stopped

243
00:10:03,910 --> 00:10:02,320
bruce said

244
00:10:05,269 --> 00:10:03,920
i think it's the tension monitoring

245
00:10:07,670 --> 00:10:05,279
module

246
00:10:09,509 --> 00:10:07,680
and for those of you who knew bruce the

247
00:10:11,430 --> 00:10:09,519
rest of us on the crew looked at bruce

248
00:10:13,269 --> 00:10:11,440
and said what the hell is a tension

249
00:10:15,670 --> 00:10:13,279
monitoring module

250
00:10:17,509 --> 00:10:15,680
and several hours later it turned out

251
00:10:20,150 --> 00:10:17,519
that that's what it was because they

252
00:10:21,990 --> 00:10:20,160
turned a one into a zero and the solar

253
00:10:23,509 --> 00:10:22,000
array went out and we hustled to get

254
00:10:25,670 --> 00:10:23,519
into the appropriate attitude and

255
00:10:27,590 --> 00:10:25,680
deployed it so those were the the two

256
00:10:30,150 --> 00:10:27,600
things that almost stopped hubble from

257
00:10:31,829 --> 00:10:30,160
being hubble although bruce and kathy

258
00:10:35,430 --> 00:10:31,839
never got to see the deploy because they

259
00:10:37,030 --> 00:10:35,440
were in the airlock uh at at vacuum

260
00:10:39,910 --> 00:10:37,040
getting ready to go out and actually

261
00:10:41,750 --> 00:10:39,920
perform a manual deploy of the final sub

262
00:10:43,990 --> 00:10:41,760
uh solar array

263
00:10:46,470 --> 00:10:44,000

right so even on the deployment mission

264
00:10:48,069 --> 00:10:46,480
the crew train for contingencies and as

265
00:10:49,910 --> 00:10:48,079
charlie said they were in the airlock

266
00:10:52,310 --> 00:10:49,920
waiting to go out yep i remember that

267
00:10:54,069 --> 00:10:52,320
very well

268
00:10:56,550 --> 00:10:54,079
if they had just waited

269
00:10:58,710 --> 00:10:56,560
another minute or two to reset that

270
00:10:59,910 --> 00:10:58,720
tension monitoring device the airlock

271
00:11:01,990 --> 00:10:59,920
would have been open and they'd have

272
00:11:03,829 --> 00:11:02,000
been out of there but two ways that's

273
00:11:06,310 --> 00:11:03,839
why they have never forgiven me to this

274
00:11:13,509 --> 00:11:08,150
they blame me for the guys here at

275
00:11:19,030 --> 00:11:15,430
all right thank you charlie

276
00:11:20,630 --> 00:11:19,040
let's see for for jeff and kathy maybe

277
00:11:22,150 --> 00:11:20,640
you had the honor of being assigned to

278
00:11:24,069 --> 00:11:22,160
the first servicing mission which was

279
00:11:25,829 --> 00:11:24,079
much more complex than anything that had

280
00:11:32,470 --> 00:11:25,839
been done previously

281
00:11:35,670 --> 00:11:33,670
they

282
00:11:37,350 --> 00:11:35,680
this mission was

283
00:11:39,670 --> 00:11:37,360
certainly the most complex shuttle

284
00:11:41,990 --> 00:11:39,680
mission that had ever been attempted

285
00:11:45,030 --> 00:11:42,000
and there were so many people along the

286
00:11:47,910 --> 00:11:45,040
lines who had felt that it was

287
00:11:53,269 --> 00:11:47,920
too complicated that the chances of

288
00:11:57,030 --> 00:11:55,590

but when you really come down to it i

289
00:11:58,629 --> 00:11:57,040
think the thing that goes through the

290
00:12:00,710 --> 00:11:58,639
mind of everybody when you're getting

291
00:12:03,590 --> 00:12:00,720
ready to open the airlock and go out is

292
00:12:05,350 --> 00:12:03,600
just don't screw up

293
00:12:07,190 --> 00:12:05,360
i don't want to be the person who breaks

294
00:12:09,190 --> 00:12:07,200
something on this telescope that isn't

295
00:12:12,310 --> 00:12:09,200
already broken and then of course we got

296
00:12:14,389 --> 00:12:12,320
to get our job done which we did

297
00:12:15,910 --> 00:12:14,399
i was concerned that the instruments

298
00:12:18,150 --> 00:12:15,920
weren't going to slide in the way they

299
00:12:20,150 --> 00:12:18,160
were supposed to i think every satellite

300
00:12:22,790 --> 00:12:20,160
which touched in orbit before that there

301
00:12:24,710 --> 00:12:22,800
had been some problem and some work

302
00:12:26,870 --> 00:12:24,720
around to get it to work or not work and

303
00:12:28,790 --> 00:12:26,880
i would bet you money that we would have

304
00:12:30,949 --> 00:12:28,800
run into something when in installing

305
00:12:32,710 --> 00:12:30,959
the costar and the woof pick too that

306
00:12:34,870 --> 00:12:32,720
something wouldn't have been built to

307
00:12:35,990 --> 00:12:34,880
the drawings we had or whatever

308
00:12:37,269 --> 00:12:36,000
something would have gone wrong and they

309
00:12:38,870 --> 00:12:37,279
wouldn't have gone in

310
00:12:40,310 --> 00:12:38,880
and we would have had to

311
00:12:43,110 --> 00:12:40,320
you know back out and think about it

312
00:12:45,110 --> 00:12:43,120
some more hopefully be successful but it

313
00:12:46,710 --> 00:12:45,120

just went amazingly smoothly and that's

314
00:12:49,269 --> 00:12:46,720
thanks to the folks here at goddard that

315
00:12:51,829 --> 00:12:49,279
maintain that high fidelity simulator

316
00:12:53,829 --> 00:12:51,839
yeah i think the configuration control

317
00:12:57,750 --> 00:12:53,839
the attention that was spent on

318
00:12:59,670 --> 00:12:57,760
configuration control knowing exactly

319
00:13:02,790 --> 00:12:59,680
what tools were going to go on what

320
00:13:04,470 --> 00:13:02,800
bolts and everything that that was a

321
00:13:06,389 --> 00:13:04,480
had a lot of responsibility for the

322
00:13:08,310 --> 00:13:06,399
success of the mission you just you

323
00:13:10,150 --> 00:13:08,320
can't forget about that

324
00:13:12,550 --> 00:13:10,160
as i remember working working the

325
00:13:15,509 --> 00:13:12,560
mission uh uh

326
00:13:17,590 --> 00:13:15,519
frank zepolina's mantra was test test

327
00:13:20,150 --> 00:13:17,600
and re-test train train and retrain and

328
00:13:22,870 --> 00:13:20,160
i think it uh it really paid off for us

329
00:13:24,790 --> 00:13:22,880
all absolutely following on to that so

330
00:13:27,190 --> 00:13:24,800
you actually experienced you both

331
00:13:29,269 --> 00:13:27,200
actually experienced some unexpected

332
00:13:31,509 --> 00:13:29,279
talent challenges during your mission if

333
00:13:35,829 --> 00:13:31,519
you can tell us about those some ideas

334
00:13:38,710 --> 00:13:35,839
might be uh the doors uh chasing a screw

335
00:13:40,389 --> 00:13:38,720
and maybe uh solar of the iconic image

336
00:13:41,910 --> 00:13:40,399
of a solar panel well i'll talk about

337
00:13:44,389 --> 00:13:41,920
the great screw chaser talked a little

338
00:13:47,750 --> 00:13:44,399

bit about the doors this morning but

339
00:13:49,509 --> 00:13:47,760
on the last eva day

340
00:13:51,990 --> 00:13:49,519
well there were these two solar array

341
00:13:53,990 --> 00:13:52,000
drive electronics again very simple

342
00:13:55,910 --> 00:13:54,000
pieces of equipment so

343
00:13:57,590 --> 00:13:55,920
chances of failure are very small and

344
00:13:59,910 --> 00:13:57,600
anyway there are two of them

345
00:14:02,150 --> 00:13:59,920
so they weren't actually designed to be

346
00:14:04,389 --> 00:14:02,160
what we call eva compatible you know

347
00:14:06,230 --> 00:14:04,399
instead of one big bolt that you could

348
00:14:07,990 --> 00:14:06,240
loosen and pull the whole thing out they

349
00:14:09,990 --> 00:14:08,000
had a few all

350
00:14:11,829 --> 00:14:10,000
the people old enough here remember

351
00:14:13,670 --> 00:14:11,839
scuzzy connectors so we had about eight

352
00:14:14,870 --> 00:14:13,680
scuzzy connectors with little two

353
00:14:16,710 --> 00:14:14,880
millimeter

354
00:14:19,750 --> 00:14:16,720
screws which

355
00:14:22,069 --> 00:14:19,760
are supposed to be captive but uh up in

356
00:14:24,069 --> 00:14:22,079
space that the wires don't just lie on

357
00:14:27,030 --> 00:14:24,079
the ground they're sort of floating and

358
00:14:28,230 --> 00:14:27,040
as they move around the the screws start

359
00:14:30,550 --> 00:14:28,240
to spin

360
00:14:31,990 --> 00:14:30,560
and half of them spin clockwise which is

361
00:14:33,910 --> 00:14:32,000
okay but the other half spin

362
00:14:34,710 --> 00:14:33,920
counterclockwise and they come out and

363
00:14:37,030 --> 00:14:34,720

so

364
00:14:39,509 --> 00:14:37,040
as we were doing the work to try to

365
00:14:42,310 --> 00:14:39,519
remove these and put the new ones in

366
00:14:44,550 --> 00:14:42,320
um because yeah one of them did fail and

367
00:14:46,389 --> 00:14:44,560
that got people scared that well if one

368
00:14:47,990 --> 00:14:46,399
failed maybe the other one would fail

369
00:14:50,230 --> 00:14:48,000
which in fact it did and they had to

370
00:14:52,389 --> 00:14:50,240
replace it on the second mission but

371
00:14:53,509 --> 00:14:52,399
so we were

372
00:14:55,590 --> 00:14:53,519
basically

373
00:14:57,110 --> 00:14:55,600
these little two millimeter screws were

374
00:15:00,069 --> 00:14:57,120
floating around well we have little

375
00:15:03,509 --> 00:15:00,079
trash containers that we have on our our

376
00:15:05,750 --> 00:15:03,519
chests so you grab a screw and and put

377
00:15:08,230 --> 00:15:05,760
it in but after a while when you would

378
00:15:10,790 --> 00:15:08,240
open the trash container to put another

379
00:15:13,350 --> 00:15:10,800
screw in you know two screws would would

380
00:15:14,949 --> 00:15:13,360
come out it's a diffusion process right

381
00:15:16,790 --> 00:15:14,959
well they've they since they they

382
00:15:18,629 --> 00:15:16,800
redesigned those trash containers so

383
00:15:19,590 --> 00:15:18,639
that that wouldn't happen we learned a

384
00:15:23,750 --> 00:15:19,600
lot

385
00:15:25,829 --> 00:15:23,760
uh anyway at one point story he was

386
00:15:28,150 --> 00:15:25,839
on the arm that day with his feet locked

387
00:15:30,470 --> 00:15:28,160
in so his mobility was limited i was

388
00:15:31,670 --> 00:15:30,480

free-floating so i was just holding on

389
00:15:34,949 --> 00:15:31,680
story

390
00:15:37,350 --> 00:15:34,959
reached for a screw didn't quite get it

391
00:15:39,350 --> 00:15:37,360
and and tapped it so that the screw was

392
00:15:40,949 --> 00:15:39,360
headed down towards the payload bay

393
00:15:42,550 --> 00:15:40,959
which you don't really want stuff

394
00:15:44,230 --> 00:15:42,560
floating around in there it might get in

395
00:15:45,829 --> 00:15:44,240
a piece of

396
00:15:47,990 --> 00:15:45,839
a motor or something

397
00:15:49,430 --> 00:15:48,000
mess up the payload bay doors anyway i

398
00:15:52,389 --> 00:15:49,440
tried to grab it

399
00:15:55,269 --> 00:15:52,399
but it was about a foot farther than i

400
00:15:56,310 --> 00:15:55,279
could reach i was holding all the way on

401
00:15:58,470 --> 00:15:56,320
claude

402
00:16:00,629 --> 00:15:58,480
who was operating the arm said

403
00:16:02,150 --> 00:16:00,639
okay hold on jeff i'll drive the arm and

404
00:16:04,710 --> 00:16:02,160
you can get it well it turned out that

405
00:16:07,030 --> 00:16:04,720
the maximum speed at which the arm could

406
00:16:09,509 --> 00:16:07,040
move was exactly the speed that the

407
00:16:13,189 --> 00:16:09,519
screw was moving away from us so you

408
00:16:16,389 --> 00:16:14,710
and this is where the training really

409
00:16:19,030 --> 00:16:16,399
comes in because

410
00:16:21,509 --> 00:16:19,040
ken bowersox who was the backup arm

411
00:16:24,629 --> 00:16:21,519
operator remembered that there's a

412
00:16:27,110 --> 00:16:24,639
certain bit in the software that tells

413
00:16:29,030 --> 00:16:27,120

the arm that it's loaded and if the arm

414
00:16:30,389 --> 00:16:29,040
is loaded either with a satellite or a

415
00:16:33,269 --> 00:16:30,399
person its

416
00:16:34,710 --> 00:16:33,279
maximum speed is limited so he quickly

417
00:16:37,030 --> 00:16:34,720
floated over

418
00:16:39,509 --> 00:16:37,040
reset that bit to tell the arm that it

419
00:16:41,509 --> 00:16:39,519
was not loaded and the arm speeded up

420
00:16:45,829 --> 00:16:41,519
and i was able to get the screw and that

421
00:16:49,189 --> 00:16:47,430
there was a i'll talk about the solar

422
00:16:50,550 --> 00:16:49,199
ray but there was also another chase if

423
00:16:52,710 --> 00:16:50,560
you remember at the end of your fifth

424
00:16:54,710 --> 00:16:52,720
eva where story had a whole string of

425
00:16:55,749 --> 00:16:54,720
tools that got away from him you know

426
00:16:56,949 --> 00:16:55,759
you have all this stuff and it's

427
00:16:59,189 --> 00:16:56,959
floating around you like this giant

428
00:17:01,030 --> 00:16:59,199
cloud of junk and sometimes you don't

429
00:17:03,350 --> 00:17:01,040
know whether it's connected or not so it

430
00:17:05,590 --> 00:17:03,360
turns out this whole stringer of tools

431
00:17:09,429 --> 00:17:05,600
was not connected and it got away from

432
00:17:11,590 --> 00:17:09,439
story and claude claude was awesome

433
00:17:12,870 --> 00:17:11,600
story just said up claude and claude

434
00:17:14,789 --> 00:17:12,880
looked and he saw story and you saw the

435
00:17:16,230 --> 00:17:14,799
tools and the arm went oh and he was

436
00:17:19,350 --> 00:17:16,240
able to grab it and we i don't think we

437
00:17:20,789 --> 00:17:19,360
ever reported that to the ground

438
00:17:22,710 --> 00:17:20,799

the only thing the ground ever heard was

439
00:17:24,870 --> 00:17:22,720
up clawed which is not an unusual

440
00:17:26,710 --> 00:17:24,880
command to hear

441
00:17:27,750 --> 00:17:26,720
the thing that that i got to do which

442
00:17:29,510 --> 00:17:27,760
was

443
00:17:31,350 --> 00:17:29,520
something we trained for but not fully

444
00:17:33,909 --> 00:17:31,360
expected and that's to release one of

445
00:17:35,350 --> 00:17:33,919
the solar arrays into orbit so one of

446
00:17:36,150 --> 00:17:35,360
them rolled up just like it was supposed

447
00:17:38,789 --> 00:17:36,160
to

448
00:17:41,990 --> 00:17:38,799
and then the other one was retracting

449
00:17:43,909 --> 00:17:42,000
and um there was a kink in the bystand

450
00:17:46,390 --> 00:17:43,919
so it wasn't going to retract properly

451
00:17:48,470 --> 00:17:46,400
and as soon as covey saw the

452
00:17:50,549 --> 00:17:48,480
blankets go slack he stopped the

453
00:17:51,750 --> 00:17:50,559
retraction and we knew at that point

454
00:17:54,070 --> 00:17:51,760
that the next day we were going to have

455
00:17:56,230 --> 00:17:54,080
to go out and toss it overboard

456
00:17:58,470 --> 00:17:56,240
so tom and i went out for eva 2 and that

457
00:18:00,390 --> 00:17:58,480
was our first job was to go up there and

458
00:18:01,190 --> 00:18:00,400
disconnect it so tom

459
00:18:02,630 --> 00:18:01,200
um

460
00:18:04,549 --> 00:18:02,640
i put a a

461
00:18:06,950 --> 00:18:04,559
grapple fixture or a hand fixture on to

462
00:18:09,110 --> 00:18:06,960
hold it tom was disconnected it from the

463
00:18:11,190 --> 00:18:09,120

telescope the electrical connections in

464
00:18:13,110 --> 00:18:11,200
the night pass in the dark so it wasn't

465
00:18:15,590 --> 00:18:13,120
producing electricity

466
00:18:17,750 --> 00:18:15,600
and then we claude moved me and the

467
00:18:19,350 --> 00:18:17,760
solar array away from everything and we

468
00:18:21,110 --> 00:18:19,360
just sort of hung out there until

469
00:18:23,990 --> 00:18:21,120
sunrise because we wanted to be able to

470
00:18:25,590 --> 00:18:24,000
see the the solar ray as it was drifting

471
00:18:27,669 --> 00:18:25,600
away from us and we were drifting away

472
00:18:29,990 --> 00:18:27,679
from it to make sure that there was no

473
00:18:32,549 --> 00:18:30,000
contact so i was just hanging in there

474
00:18:34,390 --> 00:18:32,559
just holding the thing and one of the

475
00:18:35,669 --> 00:18:34,400
other concerns that we'd had on the

476
00:18:38,310 --> 00:18:35,679
ground

477
00:18:40,390 --> 00:18:38,320
before flight was that if i ever got in

478
00:18:42,150 --> 00:18:40,400
a position where i had to just hold out

479
00:18:43,430 --> 00:18:42,160
and do nothing for a while that i would

480
00:18:45,909 --> 00:18:43,440
get very cold

481
00:18:48,150 --> 00:18:45,919
because my resting metabolic rate is

482
00:18:50,230 --> 00:18:48,160
lower than the minimum metabolic or

483
00:18:51,350 --> 00:18:50,240
minimum heat produced or

484
00:18:52,549 --> 00:18:51,360
in the suit

485
00:18:54,549 --> 00:18:52,559
and i was going to get very cold so

486
00:18:56,150 --> 00:18:54,559
maybe put on these over gloves

487
00:18:57,750 --> 00:18:56,160
as if the gloves aren't clumsy enough i

488
00:18:58,710 --> 00:18:57,760

had to put on over gloves over the top

489
00:19:01,190 --> 00:18:58,720
of those

490
00:19:03,270 --> 00:19:01,200
so i just held on to it until

491
00:19:05,430 --> 00:19:03,280
the sun came up and then everybody got

492
00:19:07,669 --> 00:19:05,440
in position tom got in position where he

493
00:19:09,909 --> 00:19:07,679
could actually see what's going on and i

494
00:19:11,350 --> 00:19:09,919
just turned loose i didn't shove it it

495
00:19:12,870 --> 00:19:11,360
looks like i did but i really didn't i

496
00:19:15,350 --> 00:19:12,880
just let it go and we were floating

497
00:19:17,909 --> 00:19:15,360
along together with no rates claude

498
00:19:20,310 --> 00:19:17,919
moved me back away from it and then ken

499
00:19:23,590 --> 00:19:20,320
bowersox the pilot fired the jets to

500
00:19:25,270 --> 00:19:23,600
separate the orbiter from the solar rays

501
00:19:27,510 --> 00:19:25,280
if you've seen video that we showed some

502
00:19:29,830 --> 00:19:27,520
this morning that when the the jet

503
00:19:32,230 --> 00:19:29,840
plumes hit the solar rays it sort of

504
00:19:35,029 --> 00:19:32,240
bent over and then flapped back

505
00:19:37,270 --> 00:19:35,039
and it looked like this giant

506
00:19:39,190 --> 00:19:37,280
pterodactyl cruising over it turns out

507
00:19:41,590 --> 00:19:39,200
the deserts of the middle east it was

508
00:19:43,909 --> 00:19:41,600
the most mesmerizing beautiful

509
00:19:45,750 --> 00:19:43,919
image that i could imagine and and i had

510
00:19:47,029 --> 00:19:45,760
the best view of anybody so i hung out

511
00:19:49,029 --> 00:19:47,039
there and watched it for a while and we

512
00:19:51,110 --> 00:19:49,039
all did for a little bit until we

513
00:19:53,110 --> 00:19:51,120

decided we had to get back to work but

514
00:19:54,630 --> 00:19:53,120
it was pretty awesome thing to see

515
00:19:56,789 --> 00:19:54,640
it was an amazing thing to watch from

516
00:19:59,110 --> 00:19:56,799
the ground

517
00:20:00,870 --> 00:19:59,120
let's see that will move on to mark mark

518
00:20:05,029 --> 00:20:00,880
you had your own challenges during

519
00:20:07,990 --> 00:20:05,039
servicing mission two the first involved

520
00:20:09,430 --> 00:20:08,000
some paint and handrails could you tell

521
00:20:11,830 --> 00:20:09,440
us about that

522
00:20:13,830 --> 00:20:11,840
well uh when we finally uh went up the

523
00:20:15,909 --> 00:20:13,840
stubble had been up there for about six

524
00:20:18,470 --> 00:20:15,919
years and it's the first time we really

525
00:20:20,390 --> 00:20:18,480
saw the effects of being in space

526
00:20:24,149 --> 00:20:20,400
for that length of time some of the

527
00:20:26,549 --> 00:20:24,159
handrails had the paint uh yellow paint

528
00:20:28,390 --> 00:20:26,559
and it came off and it kind of as it

529
00:20:30,310 --> 00:20:28,400
came off it stayed in one piece but it

530
00:20:31,669 --> 00:20:30,320
just kind of wrapped around the handrail

531
00:20:33,350 --> 00:20:31,679
so it was kind of like this little

532
00:20:34,870 --> 00:20:33,360
curlicue fry

533
00:20:36,950 --> 00:20:34,880
that's kind of sitting on on the

534
00:20:39,830 --> 00:20:36,960
handrail and it's one of those things

535
00:20:41,190 --> 00:20:39,840
where you know the regulations within

536
00:20:43,270 --> 00:20:41,200
nasa said well you got to paint the

537
00:20:45,190 --> 00:20:43,280
handrails yellow well it's not like we

538
00:20:47,430 --> 00:20:45,200

didn't know what the handrails were and

539
00:20:49,350 --> 00:20:47,440
haven't having paint on them for 25

540
00:20:50,870 --> 00:20:49,360
years you know when you look back at it

541
00:20:52,630 --> 00:20:50,880
you know that probably didn't make a lot

542
00:20:55,029 --> 00:20:52,640
of you know sense they should have been

543
00:20:56,870 --> 00:20:55,039
anodized or something else if you wanted

544
00:20:58,390 --> 00:20:56,880
to highlight them but the other thing

545
00:21:00,070 --> 00:20:58,400
about hubble is you know you look at the

546
00:21:02,789 --> 00:21:00,080
picture you see this beautiful thing

547
00:21:04,549 --> 00:21:02,799
even from the from inside the cabin and

548
00:21:06,230 --> 00:21:04,559
you go up next to it and there's all

549
00:21:07,990 --> 00:21:06,240
kinds of little craters like from you

550
00:21:09,430 --> 00:21:08,000
know grains of sand and different things

551
00:21:11,190 --> 00:21:09,440
that have hit it and it's kind of like

552
00:21:12,630 --> 00:21:11,200
looking at the the moon where you can

553
00:21:13,750 --> 00:21:12,640
see that it's been up there and it's

554
00:21:16,549 --> 00:21:13,760
been taken

555
00:21:18,630 --> 00:21:16,559
uh some hits and the other thing that as

556
00:21:19,830 --> 00:21:18,640
a result of being up there i think i

557
00:21:23,029 --> 00:21:19,840
don't know if they notice it on

558
00:21:25,110 --> 00:21:23,039
servicing mission uh one or not but uh

559
00:21:27,510 --> 00:21:25,120
as we undid the bolts they were holding

560
00:21:30,390 --> 00:21:27,520
the doors closed the plating on the

561
00:21:33,029 --> 00:21:30,400
bolts i think it was nickel plating

562
00:21:35,750 --> 00:21:33,039
was coming off as well so you had some

563
00:21:38,390 --> 00:21:35,760

debris from the paint on the handrails

564
00:21:40,870 --> 00:21:38,400
and you had little pieces of metal or

565
00:21:43,190 --> 00:21:40,880
metal plating that were coming off and

566
00:21:45,430 --> 00:21:43,200
as everyone's talked about before you

567
00:21:48,789 --> 00:21:45,440
know having that kind of stuff

568
00:21:51,190 --> 00:21:48,799
inside hubble you know or get up in

569
00:21:53,110 --> 00:21:51,200
in uh you know if when the lid is open

570
00:21:55,990 --> 00:21:53,120
if some of those particles get up there

571
00:21:58,630 --> 00:21:56,000
it could affect the science on board so

572
00:22:00,630 --> 00:21:58,640
it was something that over time we just

573
00:22:03,270 --> 00:22:00,640
started to see a little bit more of the

574
00:22:06,390 --> 00:22:03,280
degradation and a lot of lessons learned

575
00:22:07,909 --> 00:22:06,400
there as far as what you want to do with

576
00:22:09,669 --> 00:22:07,919
a satellite that's going to be up there

577
00:22:10,710 --> 00:22:09,679
for a long period of time and people are

578
00:22:13,350 --> 00:22:10,720
going to go

579
00:22:15,270 --> 00:22:13,360
back to is that there are things and i

580
00:22:17,750 --> 00:22:15,280
don't think they expected the bolts to

581
00:22:20,549 --> 00:22:17,760
fall apart i don't think they expected

582
00:22:23,909 --> 00:22:20,559
the paint to come off like that

583
00:22:26,950 --> 00:22:23,919
but we learned from things like that

584
00:22:29,190 --> 00:22:26,960
you also had some experience with uh the

585
00:22:31,190 --> 00:22:29,200
the external insulation on hubble

586
00:22:33,750 --> 00:22:31,200
degrading right and that's that's

587
00:22:35,750 --> 00:22:33,760
another one uh where someone here could

588
00:22:38,070 --> 00:22:35,760

tell me if they anticipated that where

589
00:22:40,789 --> 00:22:38,080
the aluminum basically it's aluminum

590
00:22:43,110 --> 00:22:40,799
foil that's on the doors because of the

591
00:22:45,590 --> 00:22:43,120
heat or the sun being on it it would

592
00:22:48,549 --> 00:22:45,600
cycle you know back and forth and

593
00:22:50,950 --> 00:22:48,559
eventually it fatigued and you know

594
00:22:52,710 --> 00:22:50,960
there was big pieces of it that were

595
00:22:54,870 --> 00:22:52,720
starting to come off so it really wasn't

596
00:22:56,470 --> 00:22:54,880
doing its job anymore because it was

597
00:22:58,950 --> 00:22:56,480
just like a sheet of paper that had been

598
00:23:00,149 --> 00:22:58,960
ripped up and was still hanging on

599
00:23:04,549 --> 00:23:00,159
so

600
00:23:07,510 --> 00:23:04,559
having

601
00:23:13,110 --> 00:23:07,520
nobody's raising their hand i see so

602
00:23:21,510 --> 00:23:14,230
okay

603
00:23:25,990 --> 00:23:23,750
so we had so we had to put together

604
00:23:28,390 --> 00:23:26,000
inside doc horowitz who's not here he

605
00:23:30,950 --> 00:23:28,400
was one of the guys that inside he was a

606
00:23:31,909 --> 00:23:30,960
pilot and he had to fashion some

607
00:23:35,430 --> 00:23:31,919
um

608
00:23:36,549 --> 00:23:35,440
some uh you know makeshift uh panels to

609
00:23:38,950 --> 00:23:36,559
put on

610
00:23:41,110 --> 00:23:38,960
which were then not subsequent missions

611
00:23:43,269 --> 00:23:41,120
they were replaced so

612
00:23:45,830 --> 00:23:43,279
but it was something that you know i

613
00:23:47,350 --> 00:23:45,840

didn't know about but it was just the

614
00:23:49,669 --> 00:23:47,360
results of being in space for that

615
00:23:51,750 --> 00:23:49,679
length of time and somebody going back

616
00:23:53,190 --> 00:23:51,760
and visiting it

617
00:23:54,789 --> 00:23:53,200
yeah it seems like the first servicing

618
00:23:57,430 --> 00:23:54,799
mission was just the right amount of

619
00:23:59,510 --> 00:23:57,440
time in orbit for hubble to have uh to

620
00:24:02,149 --> 00:23:59,520
have those materials issues showing up

621
00:24:05,110 --> 00:24:02,159
and both the both the uh the handrails

622
00:24:08,870 --> 00:24:05,120
and and then the the insulation were

623
00:24:11,350 --> 00:24:08,880
were worked on in in subsequent missions

624
00:24:13,110 --> 00:24:11,360
so let's see moving on to uh to scott

625
00:24:18,549 --> 00:24:13,120
john and mass

626
00:24:20,870 --> 00:24:18,559
uh u3 teamed up for both sm-3b and sm-4

627
00:24:22,710 --> 00:24:20,880
your sm-3b mission had a different type

628
00:24:25,190 --> 00:24:22,720
of malfunction that almost stopped the

629
00:24:27,909 --> 00:24:25,200
critical repair can you describe and

630
00:24:29,350 --> 00:24:27,919
talk about that for us

631
00:24:31,669 --> 00:24:29,360
sure we

632
00:24:33,110 --> 00:24:31,679
had like all the missions very ambitious

633
00:24:35,430 --> 00:24:33,120
profile

634
00:24:37,909 --> 00:24:35,440
five back-to-back evas

635
00:24:40,070 --> 00:24:37,919
and on the third eva

636
00:24:41,990 --> 00:24:40,080
our job was to replace the power control

637
00:24:43,430 --> 00:24:42,000
unit so this is the central switch box

638
00:24:45,909 --> 00:24:43,440

for hubble

639
00:24:47,909 --> 00:24:45,919
and that in itself was very challenging

640
00:24:49,510 --> 00:24:47,919
we had 36

641
00:24:52,470 --> 00:24:49,520
connectors that we had to remove it was

642
00:24:56,070 --> 00:24:52,480
not intended to be replaced uh very

643
00:24:58,870 --> 00:24:56,080
simple bus bars and and lear switches

644
00:25:03,669 --> 00:25:01,830
but uh we had to change it

645
00:25:06,789 --> 00:25:03,679
and in fact i remember

646
00:25:08,950 --> 00:25:06,799
with ed weiler going to see dan golden

647
00:25:10,149 --> 00:25:08,960
uh to brief him because

648
00:25:12,549 --> 00:25:10,159
uh

649
00:25:15,110 --> 00:25:12,559
it was a big enough risk to the hubble

650
00:25:17,510 --> 00:25:15,120
that if we didn't fix it we knew we'd

651
00:25:19,110 --> 00:25:17,520
lose the hubble in a period of years

652
00:25:20,789 --> 00:25:19,120
if we tried to fix it there was a pretty

653
00:25:21,830 --> 00:25:20,799
good chance we'd lose the hubble during

654
00:25:24,390 --> 00:25:21,840
the mission

655
00:25:25,990 --> 00:25:24,400
because we had to for the first time

656
00:25:28,549 --> 00:25:26,000
in hubble's history and for the first

657
00:25:30,230 --> 00:25:28,559
time for any spacecraft entirely powered

658
00:25:33,669 --> 00:25:30,240
off

659
00:25:35,990 --> 00:25:33,679
spacecraft it starts getting cold so

660
00:25:38,390 --> 00:25:36,000
there were time clocks so everything was

661
00:25:40,230 --> 00:25:38,400
choreographed there was a

662
00:25:42,789 --> 00:25:40,240
huge macro of commands that was

663
00:25:44,870 --> 00:25:42,799

developed a super command set

664
00:25:47,029 --> 00:25:44,880
and even before we started the eva they

665
00:25:49,830 --> 00:25:47,039
started one after another shutting down

666
00:25:51,750 --> 00:25:49,840
hubble systems and so as we started into

667
00:25:54,149 --> 00:25:51,760
eda prep they started shutting down the

668
00:25:56,149 --> 00:25:54,159
hubble i'm going to pass it over to mass

669
00:25:58,390 --> 00:25:56,159
who is in the airlock so rick went ahead

670
00:25:59,990 --> 00:25:58,400
and myself we got into our spacesuits we

671
00:26:01,590 --> 00:26:00,000
were up against the wall we were doing

672
00:26:03,830 --> 00:26:01,600
our pre-breathe to purge all the

673
00:26:06,149 --> 00:26:03,840
nitrogen out of our bloodstream

674
00:26:08,230 --> 00:26:06,159
and there's a certain step where

675
00:26:09,990 --> 00:26:08,240
you get taken off of the wall to float

676
00:26:12,310 --> 00:26:10,000
free you know you're in getting into

677
00:26:13,750 --> 00:26:12,320
your suit bolted to the wall and then

678
00:26:15,510 --> 00:26:13,760
you're released to float around the

679
00:26:17,110 --> 00:26:15,520
airlock then you take you know then the

680
00:26:18,870 --> 00:26:17,120
crew gets out closes the hatch and you

681
00:26:21,350 --> 00:26:18,880
start depressing

682
00:26:25,750 --> 00:26:21,360
and mike massimino and jim newman you

683
00:26:27,190 --> 00:26:25,760
know flipped the latches to unlatch me

684
00:26:29,190 --> 00:26:27,200
and then

685
00:26:30,549 --> 00:26:29,200
uh yeah well first of all it's great to

686
00:26:31,430 --> 00:26:30,559
be here everybody thank you thanks for

687
00:26:33,269 --> 00:26:31,440
coming

688
00:26:34,549 --> 00:26:33,279

seeing everyone here it's just uh really

689
00:26:36,310 --> 00:26:34,559
i don't know who thought of this i guess

690
00:26:38,390 --> 00:26:36,320
it was just 25 years and so you had to

691
00:26:40,149 --> 00:26:38,400
have a party or something but it's just

692
00:26:42,149 --> 00:26:40,159
really great to see all these great

693
00:26:44,070 --> 00:26:42,159
faces of people here and be with these

694
00:26:46,070 --> 00:26:44,080
guys again uh so thanks for whoever is

695
00:26:47,909 --> 00:26:46,080
responsible for making this happen this

696
00:26:49,990 --> 00:26:47,919
is great um but what happened on that

697
00:26:52,950 --> 00:26:50,000
day i was the new guy on uh you know in

698
00:26:55,269 --> 00:26:52,960
the crew there a dick dwayne gary

699
00:26:58,230 --> 00:26:55,279
digger was the other rookie and and uh

700
00:27:00,149 --> 00:26:58,240
so i was just i remember

701
00:27:02,149 --> 00:27:00,159
jim newman uh and i were in the airlock

702
00:27:03,750 --> 00:27:02,159
and i remember jim felt he must have

703
00:27:05,190 --> 00:27:03,760
felt water on you you didn't know what

704
00:27:06,870 --> 00:27:05,200
was going on you couldn't see a thing

705
00:27:08,710 --> 00:27:06,880
right so john was kind of getting moved

706
00:27:10,149 --> 00:27:08,720
around you know

707
00:27:12,870 --> 00:27:10,159
not knowing really what was happening

708
00:27:15,430 --> 00:27:12,880
and jim and jim noticed all this water

709
00:27:17,110 --> 00:27:15,440
and he grabbed the towel and i remember

710
00:27:18,389 --> 00:27:17,120
someone said i don't know who it was

711
00:27:19,430 --> 00:27:18,399
maybe i don't think it was me but

712
00:27:21,750 --> 00:27:19,440
someone else on the crew said are we

713
00:27:24,070 --> 00:27:21,760

going to be able to you know go out and

714
00:27:26,070 --> 00:27:24,080
remember newman saying he's not not in

715
00:27:27,430 --> 00:27:26,080
this suit he's not and it was just that

716
00:27:28,710 --> 00:27:27,440
we had we had the water leak and then i

717
00:27:30,070 --> 00:27:28,720
remember getting into the procedure and

718
00:27:31,909 --> 00:27:30,080
john the whole time you stayed in a suit

719
00:27:34,710 --> 00:27:31,919
i think the whole time didn't you know

720
00:27:35,990 --> 00:27:34,720
i got you nick stayed

721
00:27:37,510 --> 00:27:36,000
but we were kind of manhandling you a

722
00:27:38,630 --> 00:27:37,520
bit there for a while then eventually it

723
00:27:40,149 --> 00:27:38,640
was decided we were going to have to

724
00:27:42,789 --> 00:27:40,159
reconfigure one of those

725
00:27:44,950 --> 00:27:42,799
face down on the mid deck now i'm the

726
00:27:46,710 --> 00:27:44,960
commander i haven't trained with the

727
00:27:48,470 --> 00:27:46,720
suit text or anything but we got john

728
00:27:50,230 --> 00:27:48,480
face down on the mid deck we're wiping

729
00:27:52,310 --> 00:27:50,240
up all this thing and i'm screwing

730
00:27:54,389 --> 00:27:52,320
around here and somebody it was probably

731
00:27:55,990 --> 00:27:54,399
me pushed something that disconnected

732
00:27:58,149 --> 00:27:56,000
the box and all of a sudden his suit

733
00:28:00,230 --> 00:27:58,159
depressed like ah we just

734
00:28:04,870 --> 00:28:00,240
where was that yes

735
00:28:09,669 --> 00:28:07,510
i forgot about that but uh but

736
00:28:11,350 --> 00:28:09,679
the bottom line is if you have water in

737
00:28:13,029 --> 00:28:11,360
the back of the space suit and you go

738
00:28:14,870 --> 00:28:13,039

outside

739
00:28:16,870 --> 00:28:14,880
as soon as you get to low pressure that

740
00:28:18,389 --> 00:28:16,880
water is going to flash freeze and if

741
00:28:20,470 --> 00:28:18,399
there's water on electrical connectors

742
00:28:22,310 --> 00:28:20,480
and plumbing water expands a little bit

743
00:28:23,430 --> 00:28:22,320
when it freezes and it'll break the suit

744
00:28:24,870 --> 00:28:23,440
and you know that would have been the

745
00:28:27,669 --> 00:28:24,880
end of me and then we wouldn't have

746
00:28:29,269 --> 00:28:27,679
finished the epa

747
00:28:31,110 --> 00:28:29,279
in the meantime the ground is freaking

748
00:28:32,710 --> 00:28:31,120
out because suddenly they're turning

749
00:28:35,190 --> 00:28:32,720
hubble off and they're

750
00:28:37,590 --> 00:28:35,200
put in position well you know do we undo

751
00:28:39,590 --> 00:28:37,600
that it could take hours to change the

752
00:28:41,510 --> 00:28:39,600
suit yeah um

753
00:28:43,590 --> 00:28:41,520
you know scooters trying scooters trying

754
00:28:46,230 --> 00:28:43,600
scott allman's scooter trying to manage

755
00:28:48,230 --> 00:28:46,240
you know this whole thing on board to to

756
00:28:50,389 --> 00:28:48,240
figure out how we recover but we had

757
00:28:53,190 --> 00:28:50,399
trained pretty well and we had trained

758
00:28:55,350 --> 00:28:53,200
how to resize suits and chain suits not

759
00:28:57,029 --> 00:28:55,360
on time pressure now this would be an

760
00:28:59,350 --> 00:28:57,039
overnight thing

761
00:29:01,110 --> 00:28:59,360
and and we said yeah we can switch suits

762
00:29:03,750 --> 00:29:01,120
and we know we know what parts to change

763
00:29:05,990 --> 00:29:03,760

and so i got a newman suit

764
00:29:06,870 --> 00:29:06,000
uh but jim newman's you know six feet

765
00:29:09,029 --> 00:29:06,880
tall

766
00:29:10,470 --> 00:29:09,039
and you know i'm 5'8 so we had to shrink

767
00:29:12,710 --> 00:29:10,480
it a little bit

768
00:29:15,350 --> 00:29:12,720
and change gloves and all of that and

769
00:29:17,830 --> 00:29:15,360
when training i had a rule which is if

770
00:29:20,310 --> 00:29:17,840
you're going out eva that day you don't

771
00:29:23,110 --> 00:29:20,320
help resize the suit because it involves

772
00:29:25,190 --> 00:29:23,120
a lot of tense difficult hand operations

773
00:29:27,269 --> 00:29:25,200
and moving things but we threw that out

774
00:29:29,830 --> 00:29:27,279
the window too because because we had to

775
00:29:32,950 --> 00:29:29,840
go fast and i had never resized the

776
00:29:34,630 --> 00:29:32,960
superior okay do it like this

777
00:29:36,149 --> 00:29:34,640
all right yeah we worked we dragged

778
00:29:38,070 --> 00:29:36,159
everybody into it and so in the matter

779
00:29:40,630 --> 00:29:38,080
of an hour we'd resize the suit i was

780
00:29:43,029 --> 00:29:40,640
back into a new suit back in the airlock

781
00:29:44,310 --> 00:29:43,039
and uh and went fairly quickly you know

782
00:29:46,549 --> 00:29:44,320
i remember we hopped right to with the

783
00:29:48,710 --> 00:29:46,559
help of the ground and uh and i got rid

784
00:29:50,149 --> 00:29:48,720
of the airlock in a new suit i looked

785
00:29:52,950 --> 00:29:50,159
over and rick was sound asleep in a

786
00:29:56,149 --> 00:29:54,389
hanging out on the wall for like a

787
00:29:58,149 --> 00:29:56,159
couple hours yeah and then i think that

788
00:30:00,070 --> 00:29:58,159

spacewalk is and that was the thing is

789
00:30:01,269 --> 00:30:00,080
that we were so concerned about that pcu

790
00:30:03,029 --> 00:30:01,279
eva

791
00:30:05,430 --> 00:30:03,039
and then to have this happen before we

792
00:30:06,870 --> 00:30:05,440
even got out the door uh and worried

793
00:30:09,029 --> 00:30:06,880
about timing how long it was going to

794
00:30:11,110 --> 00:30:09,039
take but that was that ended up being or

795
00:30:14,310 --> 00:30:11,120
or something space walk out of this out

796
00:30:16,070 --> 00:30:14,320
of the fashion it was and and this task

797
00:30:18,470 --> 00:30:16,080
was so complex and believed to be so

798
00:30:19,669 --> 00:30:18,480
difficult that we had all these portions

799
00:30:20,789 --> 00:30:19,679
where if we ended up at the end of the

800
00:30:22,630 --> 00:30:20,799
day and it was all those breakouts

801
00:30:24,549 --> 00:30:22,640
halfway through you know we'd figure out

802
00:30:26,870 --> 00:30:24,559
some way to jury rig wiring to keep

803
00:30:29,029 --> 00:30:26,880
hubble alive overnight and finish it the

804
00:30:30,389 --> 00:30:29,039
next day and

805
00:30:33,110 --> 00:30:30,399
you know jim and mass have been trained

806
00:30:36,549 --> 00:30:33,120
how to finish it up but

807
00:30:37,990 --> 00:30:36,559
you know the amazing folks uh here and

808
00:30:39,269 --> 00:30:38,000
there's too many people who have been

809
00:30:41,830 --> 00:30:39,279
involved in each of these missions to

810
00:30:44,149 --> 00:30:41,840
thank individually but you know led by

811
00:30:45,830 --> 00:30:44,159
you know frank sepulina the eva ops team

812
00:30:48,389 --> 00:30:45,840
the folks at johnson

813
00:30:49,990 --> 00:30:48,399

uh that we had trained this difficult

814
00:30:52,310 --> 00:30:50,000
test over and over and over again in

815
00:30:53,990 --> 00:30:52,320
fact we had a this is uh was talked

816
00:30:55,669 --> 00:30:54,000
about this morning but a high fidelity

817
00:30:57,909 --> 00:30:55,679
pcu trainer

818
00:30:59,669 --> 00:30:57,919
in the big shuttle simulator building at

819
00:31:01,669 --> 00:30:59,679
johnson and every night when i went home

820
00:31:03,509 --> 00:31:01,679
i would do this task so i had done this

821
00:31:05,750 --> 00:31:03,519
hundreds of times by the time we got to

822
00:31:08,149 --> 00:31:05,760
orbit i knew every connector personally

823
00:31:09,669 --> 00:31:08,159
every key way every wire you know and

824
00:31:11,190 --> 00:31:09,679
and rick too

825
00:31:12,549 --> 00:31:11,200
that this was the only eva that actually

826
00:31:14,710 --> 00:31:12,559
took the amount of time that we said it

827
00:31:16,710 --> 00:31:14,720
would which was six hours and 30 minutes

828
00:31:19,029 --> 00:31:16,720
now of course plus the hour hour and a

829
00:31:20,230 --> 00:31:19,039
half to resize the suit so it was still

830
00:31:22,549 --> 00:31:20,240
a long day

831
00:31:23,750 --> 00:31:22,559
but but what's really amazing to me

832
00:31:25,190 --> 00:31:23,760
personally

833
00:31:27,990 --> 00:31:25,200
is you know that

834
00:31:29,590 --> 00:31:28,000
you know everybody on board

835
00:31:31,669 --> 00:31:29,600
accommodated the fact that we almost

836
00:31:33,110 --> 00:31:31,679
lost that eva that we figured out how to

837
00:31:35,190 --> 00:31:33,120
solve it we got back in the game the

838
00:31:37,909 --> 00:31:35,200

ground was back in the game the the

839
00:31:40,070 --> 00:31:37,919
hubble ops team you know was able to get

840
00:31:41,590 --> 00:31:40,080
hubble into the right place and so by

841
00:31:43,590 --> 00:31:41,600
the time we were

842
00:31:45,669 --> 00:31:43,600
you know 15 20 minutes into the space

843
00:31:47,590 --> 00:31:45,679
walk i'd totally forgotten that we'd had

844
00:31:49,830 --> 00:31:47,600
the whole suit issue and everybody just

845
00:31:52,310 --> 00:31:49,840
operated right back on track

846
00:31:54,389 --> 00:31:52,320
now on the inside remember we were on

847
00:31:56,549 --> 00:31:54,399
columbia which had an internal airlock

848
00:31:59,669 --> 00:31:56,559
sticking in the middle of the

849
00:32:01,269 --> 00:31:59,679
mid deck which takes up a ton

850
00:32:02,470 --> 00:32:01,279
we were happy when they were outside

851
00:32:04,549 --> 00:32:02,480
because there was a little more room

852
00:32:07,909 --> 00:32:04,559
inside

853
00:32:11,350 --> 00:32:07,919
i noticed a lot of my food was missing

854
00:32:14,070 --> 00:32:11,360
so on the same mission he also had uh

855
00:32:16,549 --> 00:32:14,080
trouble with a stripped screw on the

856
00:32:18,149 --> 00:32:16,559
handle of the spectrograph tell us how

857
00:32:20,149 --> 00:32:18,159
you got around that yeah that was the

858
00:32:22,149 --> 00:32:20,159
next mission that was it yes that was

859
00:32:23,029 --> 00:32:22,159
yes right that was uh four

860
00:32:24,310 --> 00:32:23,039
yeah

861
00:32:26,230 --> 00:32:24,320
so the uh

862
00:32:28,149 --> 00:32:26,240
yeah the uh you talk about the handrail

863
00:32:29,110 --> 00:32:28,159

join about the mistake i made that's

864
00:32:30,230 --> 00:32:29,120
what you

865
00:32:32,070 --> 00:32:30,240
didn't want to say that you got a

866
00:32:34,470 --> 00:32:32,080
problem with a strip screw that's not a

867
00:32:35,909 --> 00:32:34,480
mistake it's an opportunity it's an

868
00:32:37,669 --> 00:32:35,919
opportunity yeah you know it's funny

869
00:32:39,350 --> 00:32:37,679
mark mark turns we were just talking

870
00:32:41,269 --> 00:32:39,360
about that we were saying you know how

871
00:32:42,789 --> 00:32:41,279
how frank you know how frantic he was

872
00:32:44,549 --> 00:32:42,799
you know i don't want to speak for him

873
00:32:45,990 --> 00:32:44,559
but you know everyone was nervous i've

874
00:32:47,669 --> 00:32:46,000
heard a lot of stories of what was going

875
00:32:48,950 --> 00:32:47,679
through the team's mind and when i

876
00:32:50,630 --> 00:32:48,960
stripped that screw on this hand drill

877
00:32:52,549 --> 00:32:50,640
that needed to be removed so we could

878
00:32:55,190 --> 00:32:52,559
access the power supply and he said but

879
00:32:57,909 --> 00:32:55,200
it's turned into a good story and it has

880
00:32:59,509 --> 00:32:57,919
so now yes you have to ask yourself was

881
00:33:01,190 --> 00:32:59,519
the there's a good story you know the

882
00:33:02,950 --> 00:33:01,200
way we had the way we fixed that i'll

883
00:33:04,710 --> 00:33:02,960
get to that i guess in a second here but

884
00:33:05,990 --> 00:33:04,720
but was it worth the aggravation and i

885
00:33:07,669 --> 00:33:06,000
looked at him and both of us said no it

886
00:33:09,350 --> 00:33:07,679
wasn't you know that whole that whole

887
00:33:11,350 --> 00:33:09,360
that that experience of going through

888
00:33:12,630 --> 00:33:11,360

that i uh i think it was the easiest

889
00:33:14,230 --> 00:33:12,640
thing we we thought we were going to do

890
00:33:15,750 --> 00:33:14,240
that day right john on that space wall

891
00:33:17,430 --> 00:33:15,760
those bolts out yeah those buttons we

892
00:33:19,350 --> 00:33:17,440
were worried about yeah

893
00:33:21,990 --> 00:33:19,360
so that task in general the whole task

894
00:33:24,389 --> 00:33:22,000
and then the acs test that that

895
00:33:26,710 --> 00:33:24,399
occurred the day earlier right on eva3

896
00:33:29,590 --> 00:33:26,720
so this is eva 4 on our mission

897
00:33:31,669 --> 00:33:29,600
and um it was this that we started

898
00:33:33,350 --> 00:33:31,679
working this task years before we were

899
00:33:34,549 --> 00:33:33,360
assigned although you know the mission

900
00:33:36,870 --> 00:33:34,559
got turned on but we were looking at

901
00:33:38,470 --> 00:33:36,880
ways you could repair stiffs this was

902
00:33:40,470 --> 00:33:38,480
the challenge for the team and we were

903
00:33:42,630 --> 00:33:40,480
trying to help as much as we could but

904
00:33:44,149 --> 00:33:42,640
it was the people

905
00:33:45,190 --> 00:33:44,159
many people in this room that made it

906
00:33:47,029 --> 00:33:45,200
all happen

907
00:33:49,350 --> 00:33:47,039
and i think over 100 new tools were

908
00:33:50,630 --> 00:33:49,360
designed for that task and a lot of

909
00:33:51,830 --> 00:33:50,640
effort was put into this because for the

910
00:33:53,909 --> 00:33:51,840
first time we weren't just going to

911
00:33:55,430 --> 00:33:53,919
remove an instrument and replace it with

912
00:33:57,509 --> 00:33:55,440
a new one but we had two instruments

913
00:33:59,830 --> 00:33:57,519

with power supply failures and we had to

914
00:34:01,350 --> 00:33:59,840
figure it out to undo something that was

915
00:34:03,110 --> 00:34:01,360
never intended to be

916
00:34:04,710 --> 00:34:03,120
undone you know these the instruments

917
00:34:06,389 --> 00:34:04,720
were all buttoned up and ready for

918
00:34:07,509 --> 00:34:06,399
launch and never no one was ever

919
00:34:08,869 --> 00:34:07,519
supposed to mess with them ever again

920
00:34:11,430 --> 00:34:08,879
but that's exactly what we did on our

921
00:34:13,750 --> 00:34:11,440
mission so took a lot of creativity

922
00:34:15,510 --> 00:34:13,760
to figure out ways to remove what we

923
00:34:17,589 --> 00:34:15,520
needed to remove to get inside and then

924
00:34:19,349 --> 00:34:17,599
remove these power supplies and put a

925
00:34:21,109 --> 00:34:19,359
new one in and

926
00:34:23,030 --> 00:34:21,119
i think we had backups for just about

927
00:34:25,030 --> 00:34:23,040
every other screw we were we had 111

928
00:34:27,270 --> 00:34:25,040
small screws on the panel

929
00:34:29,030 --> 00:34:27,280
two more on the on the clamp

930
00:34:31,510 --> 00:34:29,040
and then there were four on that on the

931
00:34:33,030 --> 00:34:31,520
bigger screws on that on that hand drill

932
00:34:35,030 --> 00:34:33,040
and we weren't worried about those those

933
00:34:36,389 --> 00:34:35,040
were big hex head screws that we were

934
00:34:38,389 --> 00:34:36,399
going to use with the pgt that was the

935
00:34:40,230 --> 00:34:38,399
only screws i was going to undo with the

936
00:34:42,389 --> 00:34:40,240
pgt that day or big power tool as

937
00:34:43,510 --> 00:34:42,399
opposed to the mini power tool and of

938
00:34:45,510 --> 00:34:43,520

course uh

939
00:34:47,829 --> 00:34:45,520
i stripped the head on one of them and

940
00:34:49,270 --> 00:34:47,839
the bottom on the bottom right the the

941
00:34:50,790 --> 00:34:49,280
two on the top and the one on the lower

942
00:34:52,230 --> 00:34:50,800
left came out fine but the one on the

943
00:34:54,389 --> 00:34:52,240
right just wasn't going i looked and i

944
00:34:55,990 --> 00:34:54,399
saw what i had done and i destroyed this

945
00:34:57,510 --> 00:34:56,000
and my heart just sunk and i can't take

946
00:34:58,950 --> 00:34:57,520
the panel off unless the hand drills

947
00:35:00,310 --> 00:34:58,960
right we can't yeah and i quickly did

948
00:35:01,430 --> 00:35:00,320
the deduction now that screw doesn't

949
00:35:03,349 --> 00:35:01,440
come off the handrail doesn't come off

950
00:35:04,710 --> 00:35:03,359
111 screws don't come off the panel

951
00:35:06,710 --> 00:35:04,720
power supply doesn't come out new one

952
00:35:08,630 --> 00:35:06,720
doesn't come go back in this does not

953
00:35:10,230 --> 00:35:08,640
come back to life we'll never find out

954
00:35:11,990 --> 00:35:10,240
if there's a life in the universe and

955
00:35:13,430 --> 00:35:12,000
everyone's going to blame me that's the

956
00:35:16,150 --> 00:35:13,440
way i figured that's that was quickly

957
00:35:17,589 --> 00:35:16,160
how i went to massachusetts outside with

958
00:35:18,470 --> 00:35:17,599
this problem

959
00:35:20,150 --> 00:35:18,480
and

960
00:35:21,910 --> 00:35:20,160
you know inside we're trying to think of

961
00:35:23,030 --> 00:35:21,920
ideas the ground is trying to think of

962
00:35:25,510 --> 00:35:23,040
ideas

963
00:35:26,870 --> 00:35:25,520

eventually on board we did identify that

964
00:35:28,470 --> 00:35:26,880
we had a socket

965
00:35:30,390 --> 00:35:28,480
that could take the big bolts that hold

966
00:35:31,750 --> 00:35:30,400
the stanchions on which the handrail was

967
00:35:33,990 --> 00:35:31,760
on

968
00:35:36,310 --> 00:35:34,000
but that socket was inside with us

969
00:35:39,750 --> 00:35:36,320
but but the ground was working on other

970
00:35:41,990 --> 00:35:39,760
ideas yeah and and i it took four hours

971
00:35:44,390 --> 00:35:42,000
for us to eventually get the solution

972
00:35:47,750 --> 00:35:44,400
called up from the ground

973
00:35:50,230 --> 00:35:47,760
and you know we're inside watching mass

974
00:35:52,950 --> 00:35:50,240
mike massimino here and mike good

975
00:35:56,230 --> 00:35:52,960
outside and thinking you know this has

976
00:35:58,470 --> 00:35:56,240
to just be you know nearly impossible

977
00:36:00,390 --> 00:35:58,480
you know for those guys to be out there

978
00:36:02,150 --> 00:36:00,400
not knowing that we have a solution you

979
00:36:03,109 --> 00:36:02,160
know we can talk we can go get something

980
00:36:04,390 --> 00:36:03,119
to eat

981
00:36:05,670 --> 00:36:04,400
you know i think you just i'm just here

982
00:36:07,270 --> 00:36:05,680
to look now you could have told me a lot

983
00:36:09,270 --> 00:36:07,280
earlier and uh you know we're thinking

984
00:36:10,470 --> 00:36:09,280
okay we got to keep their spirits up you

985
00:36:12,150 --> 00:36:10,480
know because this this could be

986
00:36:13,430 --> 00:36:12,160
devastating you know you don't want

987
00:36:14,310 --> 00:36:13,440
somebody to make a mistake you don't

988
00:36:15,829 --> 00:36:14,320

want to

989
00:36:17,910 --> 00:36:15,839
you know to cry in the suit you know

990
00:36:19,990 --> 00:36:17,920
that water could cause float around and

991
00:36:21,430 --> 00:36:20,000
getting something but it was you know it

992
00:36:22,630 --> 00:36:21,440
must have been incredibly challenging to

993
00:36:23,589 --> 00:36:22,640
be out it was it was tough there's a

994
00:36:25,030 --> 00:36:23,599
couple things i remember one thing that

995
00:36:27,430 --> 00:36:25,040
i learned from jim newman on my first

996
00:36:30,069 --> 00:36:27,440
flight that i kept in mind was

997
00:36:32,790 --> 00:36:30,079
no matter how bad things seem to appear

998
00:36:34,230 --> 00:36:32,800
no matter how hopeless the situation is

999
00:36:36,310 --> 00:36:34,240
you have to remember

1000
00:36:38,470 --> 00:36:36,320
you can make it worse that's right and

1001
00:36:39,670 --> 00:36:38,480
that's and that's what i kept thinking

1002
00:36:40,950 --> 00:36:39,680
i'm serious that's right that's what we

1003
00:36:43,030 --> 00:36:40,960
used to say and that's what i kept

1004
00:36:44,710 --> 00:36:43,040
thinking that as bad as this was if i

1005
00:36:46,470 --> 00:36:44,720
started losing tools or fire and hooked

1006
00:36:47,910 --> 00:36:46,480
myself and at that point you might not

1007
00:36:49,349 --> 00:36:47,920
want to come back and get me i was

1008
00:36:50,630 --> 00:36:49,359
worried about that too so i knew i had

1009
00:36:51,990 --> 00:36:50,640
to you know i had to stay in the game

1010
00:36:53,829 --> 00:36:52,000
and not make things worse and let the

1011
00:36:56,630 --> 00:36:53,839
team do their do what they need it to do

1012
00:36:58,550 --> 00:36:56,640
but so jeff uh jeff roden's there and

1013
00:36:59,910 --> 00:36:58,560

and rezak and thousands of others are

1014
00:37:01,270 --> 00:36:59,920
out here that worked that problem here

1015
00:37:03,430 --> 00:37:01,280
or not thousands but a lot of you are

1016
00:37:05,109 --> 00:37:03,440
out here um and i i think you know there

1017
00:37:06,790 --> 00:37:05,119
is it was a very tough moment and i was

1018
00:37:09,030 --> 00:37:06,800
kidding around earlier about we would

1019
00:37:12,390 --> 00:37:09,040
i would rather that spacewalk go

1020
00:37:14,710 --> 00:37:12,400
go uh smoothly but it turned out okay

1021
00:37:17,030 --> 00:37:14,720
and i think what it showed to me was i

1022
00:37:19,589 --> 00:37:17,040
learned so much on that spacewalk about

1023
00:37:21,750 --> 00:37:19,599
my friends and the team here getting

1024
00:37:23,190 --> 00:37:21,760
through that that i'm glad it worked out

1025
00:37:24,069 --> 00:37:23,200
the way it did even with that strip

1026
00:37:25,750 --> 00:37:24,079
screw

1027
00:37:27,829 --> 00:37:25,760
i'll never forget you guys were trying

1028
00:37:29,190 --> 00:37:27,839
to get my attention in the window i was

1029
00:37:30,550 --> 00:37:29,200
i was fetching some tools i think i was

1030
00:37:32,310 --> 00:37:30,560
getting vice grips and tape i still

1031
00:37:34,390 --> 00:37:32,320
didn't know what the solution was

1032
00:37:36,230 --> 00:37:34,400
and i had to come up to the

1033
00:37:38,710 --> 00:37:36,240
to the toolbox at the front of the

1034
00:37:40,390 --> 00:37:38,720
orbiter and you guys were in the window

1035
00:37:41,670 --> 00:37:40,400
and i didn't want to look at you guys i

1036
00:37:44,390 --> 00:37:41,680
felt terrible

1037
00:37:45,910 --> 00:37:44,400
like i had i had messed up our mission

1038
00:37:47,190 --> 00:37:45,920

and i just felt horrible about just

1039
00:37:48,630 --> 00:37:47,200
trying to get you know not make it worse

1040
00:37:49,589 --> 00:37:48,640
maybe we'll get over the solution i

1041
00:37:51,430 --> 00:37:49,599
really think we were going to come up

1042
00:37:53,510 --> 00:37:51,440
with one i remember looking up at the

1043
00:37:55,190 --> 00:37:53,520
window at you guys finally and you guys

1044
00:37:56,790 --> 00:37:55,200
are giving me thumbs up and okay signs

1045
00:37:57,910 --> 00:37:56,800
and i'm like what the heck is going on

1046
00:37:59,589 --> 00:37:57,920
here wait i thought there was another

1047
00:38:00,870 --> 00:37:59,599
space walk going on

1048
00:38:02,550 --> 00:38:00,880
but what they were what they were doing

1049
00:38:04,790 --> 00:38:02,560
was they were trying to get me going and

1050
00:38:05,829 --> 00:38:04,800
i realized at that point that we were a

1051
00:38:07,589 --> 00:38:05,839
team

1052
00:38:09,430 --> 00:38:07,599
and we were going to either succeed or

1053
00:38:11,750 --> 00:38:09,440
fail as a as a team

1054
00:38:13,190 --> 00:38:11,760
and you guys kept me in the game and i

1055
00:38:14,710 --> 00:38:13,200
realized that well we might be going

1056
00:38:16,470 --> 00:38:14,720
down but at least i'm going down my best

1057
00:38:17,990 --> 00:38:16,480
friends is the way i figured this out

1058
00:38:21,030 --> 00:38:18,000
but it all worked out i gotta throw a

1059
00:38:22,790 --> 00:38:21,040
shot out to the ground

1060
00:38:24,630 --> 00:38:22,800
which actually

1061
00:38:26,310 --> 00:38:24,640
went back to army that was your fault

1062
00:38:29,349 --> 00:38:26,320
actually well that was that was the

1063
00:38:31,190 --> 00:38:29,359

thing just just briefly because you know

1064
00:38:33,109 --> 00:38:31,200
the whiff pick two that we put in you

1065
00:38:35,190 --> 00:38:33,119
had to take out in order to put in with

1066
00:38:37,030 --> 00:38:35,200
pig three yeah and you over torqued it

1067
00:38:39,190 --> 00:38:37,040
well

1068
00:38:41,109 --> 00:38:39,200
i wasn't gonna bring that up

1069
00:38:43,349 --> 00:38:41,119
so so they

1070
00:38:44,710 --> 00:38:43,359
you know they it was true who was doing

1071
00:38:47,349 --> 00:38:44,720
that right so

1072
00:38:50,230 --> 00:38:47,359
yeah the torque limiter

1073
00:38:52,550 --> 00:38:50,240
um it wouldn't move so they said you

1074
00:38:54,550 --> 00:38:52,560
know increase the torque still wouldn't

1075
00:38:56,630 --> 00:38:54,560
move you know that we use the torque

1076
00:38:58,550 --> 00:38:56,640
limiters because you don't want to break

1077
00:39:00,150 --> 00:38:58,560
the bolt because if if you break the

1078
00:39:01,030 --> 00:39:00,160
bolt then you're never going to get it

1079
00:39:03,270 --> 00:39:01,040
out

1080
00:39:04,950 --> 00:39:03,280
but finally they said and and i was

1081
00:39:07,430 --> 00:39:04,960
watching this and i was thinking to

1082
00:39:09,990 --> 00:39:07,440
myself i put that bolt in

1083
00:39:13,270 --> 00:39:10,000
and i did use a torque limiter and i

1084
00:39:15,510 --> 00:39:13,280
called out the number that was and i

1085
00:39:18,310 --> 00:39:15,520
actually i called milt heflin you

1086
00:39:21,670 --> 00:39:18,320
remember that milt um

1087
00:39:23,270 --> 00:39:21,680
um you remember and i said you know what

1088
00:39:26,630 --> 00:39:23,280

what's going on here and i think you

1089
00:39:28,310 --> 00:39:26,640
called sue who was the eva lead

1090
00:39:29,430 --> 00:39:28,320
it turns out we had different torque

1091
00:39:32,150 --> 00:39:29,440
limiters

1092
00:39:35,030 --> 00:39:32,160
and and there's a there there is a an

1093
00:39:36,870 --> 00:39:35,040
error bar on torque limiters oh

1094
00:39:39,270 --> 00:39:36,880
actually now i mean the full story is

1095
00:39:41,109 --> 00:39:39,280
that that torque limit had air bars yeah

1096
00:39:42,390 --> 00:39:41,119
and it's temperature dependent yeah and

1097
00:39:44,310 --> 00:39:42,400
you were at the cold side of the

1098
00:39:46,790 --> 00:39:44,320
temperature and it was well out of the

1099
00:39:48,550 --> 00:39:46,800
range of it was actually very close to

1100
00:39:49,670 --> 00:39:48,560
the breaking torque for that particular

1101
00:39:51,030 --> 00:39:49,680
bolt

1102
00:39:53,190 --> 00:39:51,040
so as my

1103
00:39:54,870 --> 00:39:53,200
two-year-old son always used to say when

1104
00:39:59,829 --> 00:39:54,880
when something went wrong with one of

1105
00:40:04,710 --> 00:40:01,829
but in the end finally the call came up

1106
00:40:06,870 --> 00:40:04,720
from the ground and it was uh it was not

1107
00:40:09,270 --> 00:40:06,880
a this is how you fix it it was a

1108
00:40:13,349 --> 00:40:11,190
and the question was

1109
00:40:15,270 --> 00:40:13,359
do you think mass can pull that handrail

1110
00:40:18,150 --> 00:40:15,280
with 60 pounds of force

1111
00:40:19,589 --> 00:40:18,160
and instantly i knew we were saved

1112
00:40:21,589 --> 00:40:19,599
because

1113
00:40:24,470 --> 00:40:21,599

where mass was at that point he probably

1114
00:40:26,069 --> 00:40:24,480
could have gotten 200 pounds i i think i

1115
00:40:27,430 --> 00:40:26,079
could have removed the instrument if i

1116
00:40:29,510 --> 00:40:27,440
needed to i was

1117
00:40:30,790 --> 00:40:29,520
so we're talking about that i'm as the

1118
00:40:32,870 --> 00:40:30,800
commander i'm thinking okay what could

1119
00:40:35,109 --> 00:40:32,880
happen here when he pulls this panel i'm

1120
00:40:35,990 --> 00:40:35,119
thinking math goes wham he breaks his

1121
00:40:38,710 --> 00:40:36,000
eyes

1122
00:40:40,710 --> 00:40:38,720
wham rips his suit i'm like ah

1123
00:40:42,390 --> 00:40:40,720
but the ground said okay it's only 60

1124
00:40:44,550 --> 00:40:42,400
pounds like okay i think we can handle

1125
00:40:46,870 --> 00:40:44,560
that and the way they knew it was 60

1126
00:40:49,190 --> 00:40:46,880
pounds was they mocked it up in a room

1127
00:40:51,030 --> 00:40:49,200
and put a fish gauge on it and pulled it

1128
00:40:52,950 --> 00:40:51,040
until it broke and they had a video of

1129
00:40:54,710 --> 00:40:52,960
it but thank god they didn't send that

1130
00:40:55,829 --> 00:40:54,720
up to us because if i'd seen that video

1131
00:40:58,950 --> 00:40:55,839
cause when the thing breaks you know

1132
00:41:02,630 --> 00:41:00,710
that was after the mission when we got

1133
00:41:04,150 --> 00:41:02,640
done at okay oh no it was all right you

1134
00:41:05,750 --> 00:41:04,160
can find that on youtube by the way and

1135
00:41:07,190 --> 00:41:05,760
they didn't show it to tony seccacci our

1136
00:41:10,790 --> 00:41:07,200
flight director either thank goodness i

1137
00:41:15,430 --> 00:41:12,309
that is one of the most remarkable

1138
00:41:18,230 --> 00:41:15,440

things i've i saw in any of the missions

1139
00:41:22,150 --> 00:41:18,240
um well let's see let's move on so

1140
00:41:24,630 --> 00:41:22,160
so uh back to scooter and charlie

1141
00:41:26,790 --> 00:41:24,640
you were both commanders of of two

1142
00:41:28,630 --> 00:41:26,800
missions i think uh scooter for two

1143
00:41:29,589 --> 00:41:28,640
hubble missions charlie for two other

1144
00:41:31,030 --> 00:41:29,599
missions

1145
00:41:33,109 --> 00:41:31,040
what what

1146
00:41:35,829 --> 00:41:33,119
in your mind are the biggest challenges

1147
00:41:37,829 --> 00:41:35,839
that you know hubble servicing is is is

1148
00:41:40,470 --> 00:41:37,839
one thing and unique but what are the

1149
00:41:42,390 --> 00:41:40,480
challenges that crews in orbit on your

1150
00:41:44,069 --> 00:41:42,400
missions faced

1151
00:41:45,190 --> 00:41:44,079
you want to go first i'll i'll follow

1152
00:41:48,150 --> 00:41:45,200
you sir

1153
00:41:50,309 --> 00:41:48,160
i i was going to go back to the the

1154
00:41:52,950 --> 00:41:50,319
lesson that jim newman

1155
00:41:55,030 --> 00:41:52,960
mentioned to tomas

1156
00:41:57,430 --> 00:41:55,040
that's actually hoots law

1157
00:41:59,990 --> 00:41:57,440
that's what's wrong who's law is is the

1158
00:42:01,589 --> 00:42:00,000
it's the law called hoots law and

1159
00:42:04,230 --> 00:42:01,599
the first from who gibson who was my

1160
00:42:06,309 --> 00:42:04,240
first commander my my mentor and whose

1161
00:42:08,069 --> 00:42:06,319
law was stated when jim newman was one

1162
00:42:09,349 --> 00:42:08,079
of our train he was not an astronaut he

1163
00:42:11,510 --> 00:42:09,359

was a trainer

1164
00:42:14,870 --> 00:42:11,520
and i killed my crew one day

1165
00:42:16,950 --> 00:42:14,880
on an ascent sim i i shut down

1166
00:42:18,870 --> 00:42:16,960
uh a good bus

1167
00:42:21,510 --> 00:42:18,880
when we had a bus short and it took out

1168
00:42:23,750 --> 00:42:21,520
the second main engine and we went

1169
00:42:25,589 --> 00:42:23,760
into the atlantic ocean and died

1170
00:42:27,510 --> 00:42:25,599
and as we're laying there hoot reached

1171
00:42:29,270 --> 00:42:27,520
over and he put his hand on my shoulder

1172
00:42:31,430 --> 00:42:29,280
and he said charles

1173
00:42:33,030 --> 00:42:31,440
and i knew i was in trouble

1174
00:42:34,790 --> 00:42:33,040
because when i got in trouble as a

1175
00:42:36,150 --> 00:42:34,800
little kid my mother always said charles

1176
00:42:38,550 --> 00:42:36,160
frank

1177
00:42:40,470 --> 00:42:38,560
so i said yes hoot he said did i ever

1178
00:42:42,870 --> 00:42:40,480
teach you hoot's law

1179
00:42:44,630 --> 00:42:42,880
i said no sir you did not he said well

1180
00:42:47,349 --> 00:42:44,640
it goes like this

1181
00:42:49,510 --> 00:42:47,359
no matter how bad things are you can

1182
00:42:51,190 --> 00:42:49,520
always make them worse

1183
00:42:52,790 --> 00:42:51,200
so that was hoot's law and that's where

1184
00:42:54,710 --> 00:42:52,800
jim neumann got it from and it and it

1185
00:42:57,510 --> 00:42:54,720
served us very well throughout the rest

1186
00:42:59,589 --> 00:42:57,520
of the program but anyway going back to

1187
00:43:00,630 --> 00:42:59,599
the most difficult thing i think it was

1188
00:43:02,790 --> 00:43:00,640

people

1189
00:43:05,190 --> 00:43:02,800
my most my most difficult challenge on

1190
00:43:07,430 --> 00:43:05,200
my two missions as a commander was

1191
00:43:10,390 --> 00:43:07,440
trying to make sure that we had a

1192
00:43:14,230 --> 00:43:10,400
collegial crew that we all worked as a

1193
00:43:16,390 --> 00:43:14,240
team that we all understood that um this

1194
00:43:18,550 --> 00:43:16,400
you know like you said man this is a

1195
00:43:20,630 --> 00:43:18,560
it's a team effort we we either all

1196
00:43:22,710 --> 00:43:20,640
succeed together or we fail together it

1197
00:43:24,390 --> 00:43:22,720
doesn't make any difference and and we

1198
00:43:26,950 --> 00:43:24,400
actually i did something that mike coats

1199
00:43:29,270 --> 00:43:26,960
had actually done and we were heavily

1200
00:43:30,790 --> 00:43:29,280
chastised for it because no no

1201
00:43:33,109 --> 00:43:30,800
commanders had ever done it before i

1202
00:43:36,309 --> 00:43:33,119
actually brought the psychiatrist in

1203
00:43:37,510 --> 00:43:36,319
and um and we did the myers-briggs and

1204
00:43:39,430 --> 00:43:37,520
everything we brought we even brought

1205
00:43:41,270 --> 00:43:39,440
spouses in and

1206
00:43:43,270 --> 00:43:41,280
and what i wanted the crew to understand

1207
00:43:45,990 --> 00:43:43,280
was we knew each other working around

1208
00:43:47,750 --> 00:43:46,000
the simulator none of us had ever failed

1209
00:43:50,150 --> 00:43:47,760
together none of us had ever been under

1210
00:43:52,710 --> 00:43:50,160
stress together and so what i wanted the

1211
00:43:54,630 --> 00:43:52,720
crew to understand was how does a person

1212
00:43:56,470 --> 00:43:54,640
with this personality type

1213
00:43:58,150 --> 00:43:56,480

generally react when under a lot of

1214
00:44:00,150 --> 00:43:58,160
stress and it turned out to be

1215
00:44:02,390 --> 00:44:00,160
incredibly useful to us

1216
00:44:04,470 --> 00:44:02,400
because we did have one situation that

1217
00:44:06,069 --> 00:44:04,480
was totally unexpected because you

1218
00:44:08,710 --> 00:44:06,079
always have crew members that are kind

1219
00:44:10,550 --> 00:44:08,720
of you know you just kind of say boy are

1220
00:44:12,550 --> 00:44:10,560
they going to be okay when we when we

1221
00:44:14,550 --> 00:44:12,560
when we when something comes up

1222
00:44:17,109 --> 00:44:14,560
but it was invaluable to us to

1223
00:44:19,270 --> 00:44:17,119
understand how we could help each other

1224
00:44:21,109 --> 00:44:19,280
if we got under into a real stressful

1225
00:44:22,790 --> 00:44:21,119
situation and i had learned that from

1226
00:44:26,230 --> 00:44:22,800
mike coats who did the same thing with

1227
00:44:28,950 --> 00:44:26,240
one of his crews so i think the people

1228
00:44:30,630 --> 00:44:28,960
skill uh it was the hardest thing for me

1229
00:44:32,870 --> 00:44:30,640
as a commander

1230
00:44:33,990 --> 00:44:32,880
well i have to agree with you and not

1231
00:44:35,589 --> 00:44:34,000
just because you're a former

1232
00:44:37,750 --> 00:44:35,599
administrator but

1233
00:44:40,710 --> 00:44:37,760
because i had the same same experience i

1234
00:44:42,870 --> 00:44:40,720
mean because you had to fly with me

1235
00:44:44,790 --> 00:44:42,880
you take a group of incredibly talented

1236
00:44:47,510 --> 00:44:44,800
people and the thing that you want to do

1237
00:44:50,069 --> 00:44:47,520
is take all those individual skills and

1238
00:44:51,670 --> 00:44:50,079

form a team and especially a team with

1239
00:44:54,309 --> 00:44:51,680
all the folks on the ground that are

1240
00:44:56,069 --> 00:44:54,319
training you and working with you and

1241
00:44:58,710 --> 00:44:56,079
going through those sims coming up here

1242
00:45:00,069 --> 00:44:58,720
to goddard working with people was a

1243
00:45:02,230 --> 00:45:00,079
key part of

1244
00:45:03,349 --> 00:45:02,240
bringing success on the flight now

1245
00:45:04,950 --> 00:45:03,359
something we did that was kind of

1246
00:45:06,550 --> 00:45:04,960
similar to what charlie mentioned is

1247
00:45:09,109 --> 00:45:06,560
before the flight

1248
00:45:10,630 --> 00:45:09,119
uh my crew and our flight director did a

1249
00:45:13,349 --> 00:45:10,640
national outdoor leadership school

1250
00:45:16,069 --> 00:45:13,359
experience where we went kayaking up in

1251
00:45:18,390 --> 00:45:16,079
prince william sound in alaska for 10

1252
00:45:19,910 --> 00:45:18,400
days out in the middle of nowhere

1253
00:45:21,990 --> 00:45:19,920
giving each other a chance to be a

1254
00:45:23,349 --> 00:45:22,000
leader one day a follower

1255
00:45:26,150 --> 00:45:23,359
there was a lot of stress when you've

1256
00:45:27,750 --> 00:45:26,160
been paddling for eight hours and you're

1257
00:45:29,349 --> 00:45:27,760
coming in to land and you see a bunch of

1258
00:45:31,030 --> 00:45:29,359
bears where you're supposed to camp

1259
00:45:33,670 --> 00:45:31,040
you're like

1260
00:45:36,550 --> 00:45:33,680
we're going somewhere else tonight uh

1261
00:45:39,190 --> 00:45:36,560
and a chance to understand what was

1262
00:45:41,910 --> 00:45:39,200
important to people like uh i had a crew

1263
00:45:43,670 --> 00:45:41,920

member who was very vocal about what the

1264
00:45:45,030 --> 00:45:43,680
opinion was all right this is the thing

1265
00:45:46,550 --> 00:45:45,040
we should do

1266
00:45:47,990 --> 00:45:46,560
this is the only thing i think that you

1267
00:45:50,550 --> 00:45:48,000
should be thinking about

1268
00:45:52,150 --> 00:45:50,560
and then we'd talk about it and say okay

1269
00:45:53,829 --> 00:45:52,160
well we're gonna do this and i was

1270
00:45:56,069 --> 00:45:53,839
worried that uh they were just like no

1271
00:45:58,309 --> 00:45:56,079
way but i found out the person as long

1272
00:46:00,470 --> 00:45:58,319
as you've been listened to said okay

1273
00:46:02,470 --> 00:46:00,480
i had my chance to talk now i'm willing

1274
00:46:04,150 --> 00:46:02,480
to go with the group so it was really

1275
00:46:05,990 --> 00:46:04,160
good insight into the crew i helped i

1276
00:46:07,589 --> 00:46:06,000
think it helped us bond having our

1277
00:46:09,589 --> 00:46:07,599
flight director there helped keep us

1278
00:46:11,430 --> 00:46:09,599
from having that us versus them from up

1279
00:46:13,510 --> 00:46:11,440
there to down there so

1280
00:46:15,349 --> 00:46:13,520
yeah it's just really great

1281
00:46:18,069 --> 00:46:15,359
one other thing i'll add and that was

1282
00:46:20,230 --> 00:46:18,079
because scooter mentioned it was for the

1283
00:46:22,230 --> 00:46:20,240
commander establishing a rapport with

1284
00:46:23,829 --> 00:46:22,240
the with the flight directors the

1285
00:46:24,710 --> 00:46:23,839
particularly the lead flight director

1286
00:46:26,950 --> 00:46:24,720
and i

1287
00:46:30,470 --> 00:46:26,960
we had a thing about landing and we had

1288
00:46:31,990 --> 00:46:30,480

a a close ending point and a

1289
00:46:34,790 --> 00:46:32,000
normal aim point

1290
00:46:37,510 --> 00:46:34,800
and i just had this habit of

1291
00:46:39,910 --> 00:46:37,520
i believed i believed in the orbiter as

1292
00:46:41,750 --> 00:46:39,920
a system and i was never worried about

1293
00:46:44,069 --> 00:46:41,760
running off the other end of the runway

1294
00:46:46,069 --> 00:46:44,079
the engineers were deathly afraid that

1295
00:46:47,910 --> 00:46:46,079
one of these days we're going to run an

1296
00:46:50,630 --> 00:46:47,920
orbiter off the other end of the runway

1297
00:46:51,910 --> 00:46:50,640
so so they were always they always

1298
00:46:53,670 --> 00:46:51,920
wanted you to

1299
00:46:55,510 --> 00:46:53,680
use the nominal lane point which put

1300
00:46:57,589 --> 00:46:55,520
your father away from the runway you got

1301
00:47:00,790 --> 00:46:57,599
to remember the orbit is a glider

1302
00:47:03,030 --> 00:47:00,800
and it's just coming down and but i knew

1303
00:47:05,510 --> 00:47:03,040
that i was always more comfortable

1304
00:47:08,150 --> 00:47:05,520
just getting me to the runway i can stop

1305
00:47:10,710 --> 00:47:08,160
it there's no problem and we

1306
00:47:13,430 --> 00:47:10,720
more than enough runway and um so i

1307
00:47:15,990 --> 00:47:13,440
remember one day we had had a session an

1308
00:47:17,829 --> 00:47:16,000
entry session when the computer all the

1309
00:47:18,950 --> 00:47:17,839
thing that figures out which aim point

1310
00:47:21,349 --> 00:47:18,960
you go to

1311
00:47:23,190 --> 00:47:21,359
uh was going to send us to the normal

1312
00:47:24,790 --> 00:47:23,200
aim point when when the winds were a

1313
00:47:27,109 --> 00:47:24,800

little bit higher than i was comfortable

1314
00:47:29,030 --> 00:47:27,119
with and so i said no i'm not going to

1315
00:47:30,549 --> 00:47:29,040
do that i'm going to go to the to the

1316
00:47:32,710 --> 00:47:30,559
close end aim point

1317
00:47:34,230 --> 00:47:32,720
and before we went down to the cape for

1318
00:47:35,349 --> 00:47:34,240
that particular flight i remember

1319
00:47:36,950 --> 00:47:35,359
sitting down with the lead flight

1320
00:47:39,430 --> 00:47:36,960
director and i said like let's get one

1321
00:47:42,150 --> 00:47:39,440
thing straight right now so that we so

1322
00:47:44,230 --> 00:47:42,160
that we can be happy when we come back

1323
00:47:45,109 --> 00:47:44,240
if you try to send me to the nominal aim

1324
00:47:47,190 --> 00:47:45,119
point

1325
00:47:50,470 --> 00:47:47,200
uh on a day when the wind is like this

1326
00:47:53,670 --> 00:47:50,480
i'm gonna politely tell you that i'm not

1327
00:47:55,670 --> 00:47:53,680
gonna do that so so do me one favor

1328
00:47:57,990 --> 00:47:55,680
don't you know leave the selection of

1329
00:48:00,790 --> 00:47:58,000
the aim point up to me unless it's

1330
00:48:02,710 --> 00:48:00,800
really extreme because i do not want to

1331
00:48:04,710 --> 00:48:02,720
land in the water

1332
00:48:06,390 --> 00:48:04,720
uh and i do not want to land short of

1333
00:48:07,990 --> 00:48:06,400
the runway we had two

1334
00:48:10,230 --> 00:48:08,000
shuttle landings that actually when you

1335
00:48:12,589 --> 00:48:10,240
normalize everything we didn't make the

1336
00:48:14,710 --> 00:48:12,599
runway because the touchdown was like

1337
00:48:17,510 --> 00:48:14,720
165 knots or something like that and

1338
00:48:19,990 --> 00:48:17,520

you're supposed to land 195 so go figure

1339
00:48:22,309 --> 00:48:20,000
so that was i i always talk to the

1340
00:48:24,630 --> 00:48:22,319
flight milders here and mill to tell you

1341
00:48:26,950 --> 00:48:24,640
i i think the com the camaraderie

1342
00:48:29,190 --> 00:48:26,960
between the flight directors and the

1343
00:48:31,349 --> 00:48:29,200
commander the whole crew actually was

1344
00:48:32,710 --> 00:48:31,359
again it's a people thing and it was

1345
00:48:35,109 --> 00:48:32,720
really critical

1346
00:48:37,109 --> 00:48:35,119
for for us to get into each other's head

1347
00:48:38,950 --> 00:48:37,119
and know what to ex he he needed to know

1348
00:48:40,309 --> 00:48:38,960
what to expect from me as much as i

1349
00:48:43,430 --> 00:48:40,319
needed to know what he was thinking

1350
00:48:45,349 --> 00:48:43,440
about uh on the ground

1351
00:48:47,270 --> 00:48:45,359
we certainly felt that camaraderie with

1352
00:48:49,349 --> 00:48:47,280
mildly after

1353
00:48:51,030 --> 00:48:49,359
every flight we go on a post-flight trip

1354
00:48:53,349 --> 00:48:51,040
and because of

1355
00:48:55,430 --> 00:48:53,359
being in with a european connection we

1356
00:48:57,750 --> 00:48:55,440
we had some nice trips over over in

1357
00:48:58,710 --> 00:48:57,760
europe and we insisted that milk come

1358
00:49:00,230 --> 00:48:58,720
with us

1359
00:49:01,990 --> 00:49:00,240
and milk wasn't the flight director by

1360
00:49:03,829 --> 00:49:02,000
the way i didn't want to imply that he

1361
00:49:04,870 --> 00:49:03,839
was our flight director no no i mean he

1362
00:49:10,150 --> 00:49:04,880
wasn't the one that i had this

1363
00:49:14,790 --> 00:49:13,109

i'm gonna bring you up here

1364
00:49:17,510 --> 00:49:14,800
all right opening it up a little bit as

1365
00:49:20,069 --> 00:49:17,520
far as uh hubble and serviceability goes

1366
00:49:22,950 --> 00:49:20,079
so with all of your experiences tell

1367
00:49:25,270 --> 00:49:22,960
tell us a little bit about what um so

1368
00:49:27,430 --> 00:49:25,280
hubble was

1369
00:49:28,630 --> 00:49:27,440
designed to be serviced so to speak

1370
00:49:30,790 --> 00:49:28,640
right

1371
00:49:31,670 --> 00:49:30,800
there were things that were designed in

1372
00:49:33,430 --> 00:49:31,680
it

1373
00:49:35,589 --> 00:49:33,440
and intended to be serviceable and there

1374
00:49:37,910 --> 00:49:35,599
was things that you all did that were

1375
00:49:39,990 --> 00:49:37,920
never intended to be done but tell us a

1376
00:49:41,990 --> 00:49:40,000
little bit about how hubble was designed

1377
00:49:45,190 --> 00:49:42,000
to be serviceable and what

1378
00:49:47,270 --> 00:49:45,200
about the observatory made that um the

1379
00:49:49,430 --> 00:49:47,280
most friendly

1380
00:49:52,309 --> 00:49:49,440
and and on the opposite side tell us

1381
00:49:54,309 --> 00:49:52,319
what uh what you saw about hubble that

1382
00:49:56,950 --> 00:49:54,319
could have uh could have been done to

1383
00:49:58,630 --> 00:49:56,960
make it more friendly

1384
00:50:01,670 --> 00:49:58,640
well you know from the very beginning

1385
00:50:05,109 --> 00:50:01,680
when we talk about eva service ability

1386
00:50:08,230 --> 00:50:05,119
um you're working in a bulky suit your

1387
00:50:10,710 --> 00:50:08,240
visibility is limited your your tactile

1388
00:50:13,030 --> 00:50:10,720

capabilities are limited and so the

1389
00:50:15,190 --> 00:50:13,040
object is to make the interfaces as

1390
00:50:17,829 --> 00:50:15,200
simple as possible i mean ideally if you

1391
00:50:19,750 --> 00:50:17,839
have to take something out if it's held

1392
00:50:22,470 --> 00:50:19,760
in just with one or two

1393
00:50:25,829 --> 00:50:22,480
large bolts that you can put a big

1394
00:50:27,190 --> 00:50:25,839
uh wrench on that that's a much easier

1395
00:50:29,270 --> 00:50:27,200
way than when you have these little two

1396
00:50:31,510 --> 00:50:29,280
millimeter screws so

1397
00:50:34,069 --> 00:50:31,520
and then uh

1398
00:50:36,549 --> 00:50:34,079
as far as taking the big instruments in

1399
00:50:37,670 --> 00:50:36,559
and out they were really well designed

1400
00:50:40,230 --> 00:50:37,680
with with

1401
00:50:41,990 --> 00:50:40,240
mechanisms so that you know if you push

1402
00:50:44,069 --> 00:50:42,000
them in you know we had to sort of get

1403
00:50:46,630 --> 00:50:44,079
them started but then there was kind of

1404
00:50:48,870 --> 00:50:46,640
a little triangular mechanism so that as

1405
00:50:50,390 --> 00:50:48,880
you got further and further in you were

1406
00:50:51,829 --> 00:50:50,400
guaranteed that they were going to end

1407
00:50:54,069 --> 00:50:51,839
up in the right place and that was

1408
00:50:56,390 --> 00:50:54,079
critical for the optical alignment so i

1409
00:50:58,630 --> 00:50:56,400
mean all of those aspects were

1410
00:51:00,710 --> 00:50:58,640
interesting let someone else talk about

1411
00:51:02,390 --> 00:51:00,720
the things that didn't work so well that

1412
00:51:04,470 --> 00:51:02,400
weren't designed for services i think

1413
00:51:07,270 --> 00:51:04,480

things that were designed for us to take

1414
00:51:08,950 --> 00:51:07,280
apart had captive features on it so if

1415
00:51:10,470 --> 00:51:08,960
you had to back out a bolt some way it

1416
00:51:11,829 --> 00:51:10,480
was captive it wouldn't be floating

1417
00:51:13,349 --> 00:51:11,839
around and have you know one more thing

1418
00:51:15,030 --> 00:51:13,359
for you to chase after

1419
00:51:16,470 --> 00:51:15,040
but then even on the first service

1420
00:51:17,990 --> 00:51:16,480
mission and certainly on the later ones

1421
00:51:20,230 --> 00:51:18,000
we ended up doing things that were never

1422
00:51:22,790 --> 00:51:20,240
intended to be done and so they didn't

1423
00:51:25,270 --> 00:51:22,800
have captive features so jeff talked

1424
00:51:27,270 --> 00:51:25,280
about the great screw chase and

1425
00:51:29,910 --> 00:51:27,280
i know on one of our evas we took off

1426
00:51:32,069 --> 00:51:29,920
the solar ray deploy electronics box

1427
00:51:33,430 --> 00:51:32,079
which was bolted to the inside of one of

1428
00:51:35,270 --> 00:51:33,440
the doors there

1429
00:51:37,829 --> 00:51:35,280
and it had

1430
00:51:40,390 --> 00:51:37,839
you know a bolt and two washers

1431
00:51:41,910 --> 00:51:40,400
i guess maybe eight of those so if you

1432
00:51:43,190 --> 00:51:41,920
think about it you back off this bolt

1433
00:51:44,630 --> 00:51:43,200
you're not only chasing the bolt but

1434
00:51:46,630 --> 00:51:44,640
you're chasing the two washers trying to

1435
00:51:48,309 --> 00:51:46,640
get them in that trash bag thing

1436
00:51:50,470 --> 00:51:48,319
so knowing that we were going to do that

1437
00:51:51,990 --> 00:51:50,480
for that mission um i think it was tom

1438
00:51:54,390 --> 00:51:52,000

akers who came up with the idea of a

1439
00:51:56,630 --> 00:51:54,400
hairpin so these really simple fixes

1440
00:51:57,510 --> 00:51:56,640
that you can do to make it

1441
00:51:59,670 --> 00:51:57,520
um

1442
00:52:02,710 --> 00:51:59,680
eva compatible so

1443
00:52:05,430 --> 00:52:02,720
we we backed off the bolt a little bit

1444
00:52:07,270 --> 00:52:05,440
moved the washers out away from the box

1445
00:52:09,829 --> 00:52:07,280
and then stuck this hairpin on it that

1446
00:52:11,990 --> 00:52:09,839
had a cat had a tether hook on it and

1447
00:52:13,349 --> 00:52:12,000
were managed then capture the bolt and

1448
00:52:16,230 --> 00:52:13,359
two washers

1449
00:52:17,910 --> 00:52:16,240
you know with one device there so um you

1450
00:52:19,510 --> 00:52:17,920
know things like that we can if we know

1451
00:52:21,510 --> 00:52:19,520
we're going to do it we can find ways to

1452
00:52:23,270 --> 00:52:21,520
make it eva compatible but some of the

1453
00:52:25,270 --> 00:52:23,280
things that they did

1454
00:52:26,870 --> 00:52:25,280
and and some things that we did as well

1455
00:52:28,230 --> 00:52:26,880
we didn't um

1456
00:52:29,829 --> 00:52:28,240
didn't know we were going to do them but

1457
00:52:32,470 --> 00:52:29,839
i think if there's anything we've

1458
00:52:34,069 --> 00:52:32,480
learned it's that the ability to predict

1459
00:52:36,309 --> 00:52:34,079
what you're going to have to service and

1460
00:52:38,470 --> 00:52:36,319
what you're not going to have to service

1461
00:52:39,990 --> 00:52:38,480
we have a great track record i mean a

1462
00:52:41,670 --> 00:52:40,000
lot of things that we

1463
00:52:43,349 --> 00:52:41,680

didn't think we'd ever have to service

1464
00:52:44,870 --> 00:52:43,359
we ended up servicing

1465
00:52:46,710 --> 00:52:44,880
well i think going in it might have been

1466
00:52:48,150 --> 00:52:46,720
that it's impossible it can't be done

1467
00:52:50,309 --> 00:52:48,160
that's why it wasn't designed to be

1468
00:52:51,910 --> 00:52:50,319
serviced and then it became possible

1469
00:52:54,549 --> 00:52:51,920
or they were so simple that they would

1470
00:52:57,270 --> 00:52:54,559
never fail and they did fail both the

1471
00:52:59,030 --> 00:52:57,280
magnetometers and and mercedes yeah yeah

1472
00:53:00,790 --> 00:52:59,040
one of the most important things i think

1473
00:53:02,549 --> 00:53:00,800
about hubble is it was the proving

1474
00:53:03,829 --> 00:53:02,559
ground for a lot of the stuff we did on

1475
00:53:05,270 --> 00:53:03,839
station

1476
00:53:06,549 --> 00:53:05,280
because it was

1477
00:53:09,430 --> 00:53:06,559
you know the

1478
00:53:13,190 --> 00:53:11,589
payload that was built to be serviced

1479
00:53:15,270 --> 00:53:13,200
and we went up there several times we

1480
00:53:17,510 --> 00:53:15,280
learned a lot from that

1481
00:53:19,589 --> 00:53:17,520
and a lot of our testing that we did for

1482
00:53:22,150 --> 00:53:19,599
space station components

1483
00:53:24,710 --> 00:53:22,160
fed off of the experiences on hubble so

1484
00:53:26,630 --> 00:53:24,720
it was extremely valuable for the whole

1485
00:53:28,870 --> 00:53:26,640
shuttle program and that we learned so

1486
00:53:29,829 --> 00:53:28,880
much about going eva

1487
00:53:32,230 --> 00:53:29,839
doing

1488
00:53:33,910 --> 00:53:32,240

five in a row or things like that

1489
00:53:34,950 --> 00:53:33,920
how the suit works

1490
00:53:37,190 --> 00:53:34,960
there are a lot of things that were

1491
00:53:40,230 --> 00:53:37,200
proven on hubble that had benefits for

1492
00:53:42,390 --> 00:53:40,240
the station program

1493
00:53:44,870 --> 00:53:42,400
you know my my experience you know i

1494
00:53:46,549 --> 00:53:44,880
felt like mikey in the life cereal

1495
00:53:48,470 --> 00:53:46,559
commercial where

1496
00:53:49,750 --> 00:53:48,480
you know the the kids say oh it's good

1497
00:53:52,069 --> 00:53:49,760
for you i'm not going to try it i'm not

1498
00:53:53,510 --> 00:53:52,079
going to try it we'll let you try it you

1499
00:53:55,910 --> 00:53:53,520
know there were always things that folks

1500
00:53:57,109 --> 00:53:55,920
said well it's impossible to fix that

1501
00:53:58,870 --> 00:53:57,119
and i'd say well

1502
00:53:59,910 --> 00:53:58,880
you know i'll do it

1503
00:54:01,430 --> 00:53:59,920
and

1504
00:54:03,589 --> 00:54:01,440
you know that's to me that the lesson

1505
00:54:04,790 --> 00:54:03,599
that you know i think we've learned and

1506
00:54:06,470 --> 00:54:04,800
i know mass

1507
00:54:07,589 --> 00:54:06,480
has experienced that that

1508
00:54:09,589 --> 00:54:07,599
you know things that folks say are

1509
00:54:11,910 --> 00:54:09,599
impossible you know we can do and you

1510
00:54:13,670 --> 00:54:11,920
know i believe that there's nothing uh

1511
00:54:16,790 --> 00:54:13,680
on hubble anyway

1512
00:54:18,950 --> 00:54:16,800
and i think doing space walks that

1513
00:54:20,309 --> 00:54:18,960

you can't do in a space suit that you

1514
00:54:21,349 --> 00:54:20,319
can do in

1515
00:54:25,109 --> 00:54:21,359
you know

1516
00:54:26,630 --> 00:54:25,119
basically that you can learn how to do

1517
00:54:28,950 --> 00:54:26,640
it and that's the

1518
00:54:30,790 --> 00:54:28,960
amazing interface between

1519
00:54:32,309 --> 00:54:30,800
incredible human hands

1520
00:54:33,750 --> 00:54:32,319
and really good

1521
00:54:36,309 --> 00:54:33,760
gloves now

1522
00:54:38,549 --> 00:54:36,319
eda gloves but the amazing human hands

1523
00:54:41,109 --> 00:54:38,559
the human brain and the ability of tool

1524
00:54:42,870 --> 00:54:41,119
makers to build tools

1525
00:54:44,950 --> 00:54:42,880
to do these tasks that are sometimes

1526
00:54:47,510 --> 00:54:44,960
specialized tools sometimes really

1527
00:54:48,789 --> 00:54:47,520
simple tools a better connector tool

1528
00:54:50,710 --> 00:54:48,799
and

1529
00:54:52,150 --> 00:54:50,720
you know the group that that sepi led

1530
00:54:54,549 --> 00:54:52,160
that didn't believe anything was

1531
00:54:56,870 --> 00:54:54,559
impossible you know we you know we

1532
00:54:58,950 --> 00:54:56,880
rewired the telescope we re-plumbed the

1533
00:55:00,069 --> 00:54:58,960
telescope to fix the nick moss cooling

1534
00:55:02,870 --> 00:55:00,079
problem

1535
00:55:05,349 --> 00:55:02,880
we pulled circuit boards out with you

1536
00:55:07,670 --> 00:55:05,359
know tiny number four torque set screws

1537
00:55:09,190 --> 00:55:07,680
remember torx torque set screws are

1538
00:55:11,109 --> 00:55:09,200

designed to go in

1539
00:55:13,670 --> 00:55:11,119
and not come out you know that's the way

1540
00:55:15,829 --> 00:55:13,680
they're designed and yet we did that

1541
00:55:18,150 --> 00:55:15,839
and the handrails you know we developed

1542
00:55:21,109 --> 00:55:18,160
covers for the handrails we cross

1543
00:55:23,349 --> 00:55:21,119
strapped the power supplies now the just

1544
00:55:25,349 --> 00:55:23,359
enormous number of tiny details of

1545
00:55:27,589 --> 00:55:25,359
things that you know

1546
00:55:28,870 --> 00:55:27,599
in general folks said well there's no

1547
00:55:31,190 --> 00:55:28,880
way you can do it or there's no way you

1548
00:55:32,710 --> 00:55:31,200
can do it on a spacewalk i will be so

1549
00:55:35,349 --> 00:55:32,720
bold is to say

1550
00:55:36,950 --> 00:55:35,359
and i could be wrong we we may not have

1551
00:55:38,870 --> 00:55:36,960
undertaken

1552
00:55:41,430 --> 00:55:38,880
the international space station

1553
00:55:43,589 --> 00:55:41,440
had it not been for hubble because we

1554
00:55:45,109 --> 00:55:43,599
i mean right up and it just got harder

1555
00:55:47,430 --> 00:55:45,119
and harder and harder and i remember

1556
00:55:49,829 --> 00:55:47,440
getting ready for sm4

1557
00:55:51,750 --> 00:55:49,839
because i was the the head of the

1558
00:55:53,670 --> 00:55:51,760
the review the independent review panel

1559
00:55:56,470 --> 00:55:53,680
and and we all said

1560
00:55:58,710 --> 00:55:56,480
we can't do this we cannot this i

1561
00:55:59,670 --> 00:55:58,720
remember saying but i won't say we all

1562
00:56:02,630 --> 00:55:59,680
said

1563
00:56:04,549 --> 00:56:02,640

i remember you telling me this is too

1564
00:56:06,950 --> 00:56:04,559
much and i remember fighting we got too

1565
00:56:08,870 --> 00:56:06,960
much on our plate and so

1566
00:56:11,030 --> 00:56:08,880
let's spend some time thinking about how

1567
00:56:14,230 --> 00:56:11,040
we're going to deal with the press

1568
00:56:16,069 --> 00:56:14,240
because we are not i remember seeing

1569
00:56:18,549 --> 00:56:16,079
this we are not going to finish all this

1570
00:56:21,190 --> 00:56:18,559
stuff so we need to be able to deal with

1571
00:56:23,670 --> 00:56:21,200
the press to help them understand that

1572
00:56:26,309 --> 00:56:23,680
this has still been an incredibly

1573
00:56:29,589 --> 00:56:26,319
successful mission although we didn't

1574
00:56:30,390 --> 00:56:29,599
get all five days worth of stuff done

1575
00:56:32,549 --> 00:56:30,400
that

1576
00:56:34,870 --> 00:56:32,559
even though we only did two or whatever

1577
00:56:36,710 --> 00:56:34,880
it was this is an incredibly successful

1578
00:56:38,710 --> 00:56:36,720
mission so let's and we spent a lot of

1579
00:56:40,870 --> 00:56:38,720
time on that on trying to be prepared

1580
00:56:42,870 --> 00:56:40,880
and then we went and did everything

1581
00:56:44,710 --> 00:56:42,880
and and then having lived through i

1582
00:56:46,630 --> 00:56:44,720
don't know how many iterations of a

1583
00:56:48,789 --> 00:56:46,640
space station with a lot of people

1584
00:56:51,030 --> 00:56:48,799
sitting down here on the first two rows

1585
00:56:53,829 --> 00:56:51,040
we said we can't do this this is

1586
00:56:55,430 --> 00:56:53,839
too eva intensive we will never be able

1587
00:56:57,430 --> 00:56:55,440
to do something like the international

1588
00:56:58,950 --> 00:56:57,440

space station and i think a lot of us

1589
00:57:00,470 --> 00:56:58,960
said you know but

1590
00:57:02,789 --> 00:57:00,480
we think we can

1591
00:57:05,190 --> 00:57:02,799
and and we found ourselves doing some

1592
00:57:06,950 --> 00:57:05,200
things we had never dreamed of repairing

1593
00:57:09,349 --> 00:57:06,960
a solar array i mean you know by putting

1594
00:57:11,349 --> 00:57:09,359
an astronaut on the end of an arm and

1595
00:57:12,470 --> 00:57:11,359
having them go up and and literally

1596
00:57:15,030 --> 00:57:12,480
stitch

1597
00:57:17,190 --> 00:57:15,040
a solar array that's

1598
00:57:19,910 --> 00:57:17,200
that we didn't shut down as a matter of

1599
00:57:21,190 --> 00:57:19,920
fact i'm not sure we would have we would

1600
00:57:23,750 --> 00:57:21,200
have had the people who would have had

1601
00:57:25,270 --> 00:57:23,760
the confidence to try any of that had

1602
00:57:27,589 --> 00:57:25,280
they not seen

1603
00:57:29,670 --> 00:57:27,599
that you know hubble showed us that

1604
00:57:31,270 --> 00:57:29,680
we're a lot better than we think we are

1605
00:57:32,710 --> 00:57:31,280
and we're a lot more capable than we

1606
00:57:34,789 --> 00:57:32,720
think we are so

1607
00:57:36,950 --> 00:57:34,799
so building on that though so

1608
00:57:39,829 --> 00:57:36,960
um as i said in the introductory

1609
00:57:40,950 --> 00:57:39,839
comments you know the the 32 crew

1610
00:57:43,109 --> 00:57:40,960
members

1611
00:57:44,630 --> 00:57:43,119
every task that was

1612
00:57:46,470 --> 00:57:44,640
planned to be undertaken was

1613
00:57:49,750 --> 00:57:46,480

successfully completed say a few words

1614
00:57:51,829 --> 00:57:49,760
about why you all think what the reasons

1615
00:57:54,309 --> 00:57:51,839
for the missions being so successful

1616
00:57:56,069 --> 00:57:54,319
were

1617
00:57:57,510 --> 00:57:56,079
well i think it

1618
00:57:59,430 --> 00:57:57,520
comes down to what we've all been saying

1619
00:58:01,750 --> 00:57:59,440
which it's really the the talent the

1620
00:58:03,190 --> 00:58:01,760
creativity the skill and the hard work

1621
00:58:04,870 --> 00:58:03,200
of all the teams

1622
00:58:06,870 --> 00:58:04,880
you know not just us who were lucky

1623
00:58:08,470 --> 00:58:06,880
enough to go up there and do it you know

1624
00:58:10,789 --> 00:58:08,480
but starting from you know every

1625
00:58:12,630 --> 00:58:10,799
technician every engineer

1626
00:58:15,670 --> 00:58:12,640
uh the scientific community being

1627
00:58:17,670 --> 00:58:15,680
supportive uh even management you know

1628
00:58:19,190 --> 00:58:17,680
all these review teams but

1629
00:58:20,390 --> 00:58:19,200
you know we could have done it fine

1630
00:58:22,390 --> 00:58:20,400
without all those review teams but

1631
00:58:25,190 --> 00:58:22,400
occasionally you know gene oliver or

1632
00:58:27,190 --> 00:58:25,200
somebody would catch something important

1633
00:58:28,630 --> 00:58:27,200
and and so everybody you know provided

1634
00:58:30,309 --> 00:58:28,640
some value but it was

1635
00:58:32,069 --> 00:58:30,319
you know this is something that

1636
00:58:34,150 --> 00:58:32,079
folks believed in in their hearts that

1637
00:58:37,030 --> 00:58:34,160
it was a good thing to do and would put

1638
00:58:37,910 --> 00:58:37,040

off all the stops and sacrificing family

1639
00:58:40,069 --> 00:58:37,920
time

1640
00:58:41,990 --> 00:58:40,079
and you know and friends and recreation

1641
00:58:43,270 --> 00:58:42,000
and you know basically not putting their

1642
00:58:45,030 --> 00:58:43,280
lives on hold

1643
00:58:48,069 --> 00:58:45,040
but championing something that was

1644
00:58:50,309 --> 00:58:48,079
really important and they believed in

1645
00:58:53,829 --> 00:58:50,319
and everyone was working together in the

1646
00:58:56,069 --> 00:58:53,839
same direction i mean every center

1647
00:58:57,510 --> 00:58:56,079
every contractor

1648
00:58:59,349 --> 00:58:57,520
um

1649
00:59:01,190 --> 00:58:59,359
we've got to

1650
00:59:03,349 --> 00:59:01,200
fix hubble and then

1651
00:59:05,910 --> 00:59:03,359
for subsequent missions i think the

1652
00:59:08,150 --> 00:59:05,920
importance of hubble had been recognized

1653
00:59:09,589 --> 00:59:08,160
and people were willing to put in the

1654
00:59:11,430 --> 00:59:09,599
extra effort

1655
00:59:14,549 --> 00:59:11,440
you know the the

1656
00:59:15,910 --> 00:59:14,559
care to configuration control the the

1657
00:59:18,549 --> 00:59:15,920
incredible

1658
00:59:20,549 --> 00:59:18,559
preparation and training and

1659
00:59:23,030 --> 00:59:20,559
yeah we spent a lot of time away from

1660
00:59:25,990 --> 00:59:23,040
home and and but so did all of our

1661
00:59:28,390 --> 00:59:26,000
trainers and and the technicians and the

1662
00:59:31,510 --> 00:59:28,400
engineers who were working with us

1663
00:59:34,789 --> 00:59:31,520

um and and that's what it took and it

1664
00:59:34,799 --> 00:59:38,230
okay

1665
00:59:43,270 --> 00:59:40,549
let's see let's go back to

1666
00:59:44,309 --> 00:59:43,280
to some more specific questions so one

1667
00:59:45,750 --> 00:59:44,319
from mark

1668
00:59:47,510 --> 00:59:45,760
so in the mission you flew before

1669
00:59:49,109 --> 00:59:47,520
servicing mission two

1670
00:59:51,910 --> 00:59:49,119
you were the first to test another

1671
00:59:53,990 --> 00:59:51,920
contingency piece of hardware can you uh

1672
00:59:57,030 --> 00:59:54,000
tell us a little bit about that and uh

1673
00:59:58,150 --> 00:59:57,040
whether we was used during hubble

1674
00:59:59,430 --> 00:59:58,160
okay

1675
01:00:01,190 --> 00:59:59,440
yeah there probably aren't too many

1676
01:00:03,349 --> 01:00:01,200
things better than getting assigned to

1677
01:00:04,789 --> 01:00:03,359
build a jet pack to fly in space i mean

1678
01:00:06,069 --> 01:00:04,799
literally i mean that's just one of

1679
01:00:08,150 --> 01:00:06,079
those things where

1680
01:00:10,630 --> 01:00:08,160
you know most of us kind of dream about

1681
01:00:14,309 --> 01:00:10,640
doing that so we built this unit called

1682
01:00:16,150 --> 01:00:14,319
uh safer simplified aid for eva rescue

1683
01:00:18,150 --> 01:00:16,160
that kind of goes on the bottom of the

1684
01:00:20,150 --> 01:00:18,160
backpack of the of the suit it's only

1685
01:00:21,510 --> 01:00:20,160
weighs about 80 pounds has thruster

1686
01:00:23,430 --> 01:00:21,520
towers

1687
01:00:25,349 --> 01:00:23,440
and our particular flight

1688
01:00:26,549 --> 01:00:25,359

was or the

1689
01:00:31,190 --> 01:00:26,559
up

1690
01:00:33,829 --> 01:00:31,200
was not only develop the jet pack but

1691
01:00:34,950 --> 01:00:33,839
develop the training test it and do all

1692
01:00:39,270 --> 01:00:34,960
that sort of

1693
01:00:42,390 --> 01:00:39,280
uh work to have a self-rescue device now

1694
01:00:44,630 --> 01:00:42,400
i don't think you guys wore the hubble

1695
01:00:47,109 --> 01:00:44,640
missions it's primarily for space

1696
01:00:48,549 --> 01:00:47,119
station uh where if you fall off space

1697
01:00:50,470 --> 01:00:48,559
station you're going to be a really long

1698
01:00:53,349 --> 01:00:50,480
space walk all right if you can't you

1699
01:00:55,829 --> 01:00:53,359
know get your get yourself uh back but

1700
01:00:58,309 --> 01:00:55,839
uh yeah there's only been eight people

1701
01:01:00,309 --> 01:00:58,319
that have ever flown untethered in space

1702
01:01:01,910 --> 01:01:00,319
not counting george clooney and sandra

1703
01:01:02,789 --> 01:01:01,920
bullock

1704
01:01:03,910 --> 01:01:02,799
so

1705
01:01:06,390 --> 01:01:03,920
you know

1706
01:01:08,950 --> 01:01:06,400
it was a pretty special thing to do

1707
01:01:11,109 --> 01:01:08,960
as far as training for it

1708
01:01:14,789 --> 01:01:11,119
earlier this morning they talked about

1709
01:01:17,349 --> 01:01:14,799
starting virtual reality training uh on

1710
01:01:19,270 --> 01:01:17,359
uh servicing mission one uh we took it

1711
01:01:21,349 --> 01:01:19,280
quite a bit farther because that was the

1712
01:01:23,030 --> 01:01:21,359
only way to train was within virtual

1713
01:01:24,870 --> 01:01:23,040

reality you couldn't use an air bearing

1714
01:01:26,470 --> 01:01:24,880
floor or anything

1715
01:01:28,230 --> 01:01:26,480
you know like that

1716
01:01:29,910 --> 01:01:28,240
the only thing that was kind of

1717
01:01:31,990 --> 01:01:29,920
difficult about it was we had to have a

1718
01:01:34,150 --> 01:01:32,000
hand controller that they had from

1719
01:01:35,270 --> 01:01:34,160
apollo that only had four degrees of

1720
01:01:38,710 --> 01:01:35,280
freedom

1721
01:01:41,030 --> 01:01:38,720
and so you could do x y and z plus pitch

1722
01:01:43,990 --> 01:01:41,040
or you could do you know pitch yawn roll

1723
01:01:45,670 --> 01:01:44,000
plus x so as you're flying it you had to

1724
01:01:47,430 --> 01:01:45,680
switch back and forth the whole time

1725
01:01:48,470 --> 01:01:47,440
between these two different

1726
01:01:49,990 --> 01:01:48,480
modes

1727
01:01:52,150 --> 01:01:50,000
that was probably the only tricky thing

1728
01:01:53,670 --> 01:01:52,160
about it it worked perfectly and it was

1729
01:01:55,829 --> 01:01:53,680
you know a lot of fun

1730
01:01:57,029 --> 01:01:55,839
uh to fly up in space but it's something

1731
01:01:58,549 --> 01:01:57,039
that

1732
01:01:59,829 --> 01:01:58,559
you know we haven't used we hope we

1733
01:02:01,990 --> 01:01:59,839
never use

1734
01:02:04,829 --> 01:02:02,000
but it is uh was a great great

1735
01:02:07,829 --> 01:02:04,839
assignment to have a job like

1736
01:02:09,270 --> 01:02:07,839
that yeah and as mark said we didn't fly

1737
01:02:11,910 --> 01:02:09,280
them on any of the subsequent hubble

1738
01:02:13,349 --> 01:02:11,920

missions so for me if we came loose we'd

1739
01:02:15,829 --> 01:02:13,359
have to commit scooter to come and get

1740
01:02:20,390 --> 01:02:18,069
i always wondered about that you know

1741
01:02:22,470 --> 01:02:20,400
we we were on the fifth day of

1742
01:02:25,270 --> 01:02:22,480
of uh mission one

1743
01:02:26,630 --> 01:02:25,280
uh story and i were in the airlock and

1744
01:02:31,349 --> 01:02:26,640
uh

1745
01:02:33,990 --> 01:02:31,359
reboost maneuver which which they do

1746
01:02:36,630 --> 01:02:34,000
with the vernier jet so it's about as

1747
01:02:38,069 --> 01:02:36,640
small an impulse that you can possibly

1748
01:02:41,270 --> 01:02:38,079
put in

1749
01:02:43,589 --> 01:02:41,280
but man the telescope was going

1750
01:02:45,109 --> 01:02:43,599
back and forth and back and forth and i

1751
01:02:47,270 --> 01:02:45,119
was thinking to myself you know if i

1752
01:02:48,870 --> 01:02:47,280
really did come loose

1753
01:02:51,670 --> 01:02:48,880
and

1754
01:02:52,870 --> 01:02:51,680
covey had to fly the shuttle to get us i

1755
01:02:54,710 --> 01:02:52,880
don't like to think of what would have

1756
01:02:56,069 --> 01:02:54,720
happened to the telescope well see

1757
01:02:57,670 --> 01:02:56,079
that's why i was worried about it

1758
01:02:59,510 --> 01:02:57,680
because scooter had to decide between

1759
01:03:01,510 --> 01:02:59,520
dumping the telescope and getting us

1760
01:03:03,829 --> 01:03:01,520
which might mean no more hubble or

1761
01:03:06,309 --> 01:03:03,839
keeping hubble and writing us off that's

1762
01:03:08,630 --> 01:03:06,319
exactly i know what trade i would make

1763
01:03:10,950 --> 01:03:08,640

he said he would come get us well hang

1764
01:03:12,789 --> 01:03:10,960
on a second because that's what he said

1765
01:03:14,230 --> 01:03:12,799
now we're gonna get the real scoop here

1766
01:03:16,150 --> 01:03:14,240
i cautioned them

1767
01:03:18,150 --> 01:03:16,160
before they went out on their spacewalks

1768
01:03:19,430 --> 01:03:18,160
because you know i'm having to stay in

1769
01:03:20,950 --> 01:03:19,440
i'm looking through this little window

1770
01:03:23,430 --> 01:03:20,960
they're going out on a spacewalk they

1771
01:03:25,990 --> 01:03:23,440
got yeah don't be out there going oh

1772
01:03:27,510 --> 01:03:26,000
scooter the view here is incredible you

1773
01:03:29,349 --> 01:03:27,520
only have a little window but this is

1774
01:03:31,349 --> 01:03:29,359
awesome as i said at the end of your

1775
01:03:33,029 --> 01:03:31,359
spacewalk there's one thing for sure

1776
01:03:35,910 --> 01:03:33,039
you're going to want to come in and i

1777
01:03:38,710 --> 01:03:35,920
got the key to the door

1778
01:03:39,510 --> 01:03:38,720
how's the view now

1779
01:03:43,109 --> 01:03:39,520
but

1780
01:03:44,950 --> 01:03:43,119
after they were done with all their

1781
01:03:47,190 --> 01:03:44,960
walks i had nothing to hold over their

1782
01:03:49,270 --> 01:03:47,200
head anymore

1783
01:03:50,549 --> 01:03:49,280
we so we used to brief uh before we

1784
01:03:52,789 --> 01:03:50,559
remember strong was to go through the

1785
01:03:53,829 --> 01:03:52,799
cue card right eva q card it was all

1786
01:03:55,670 --> 01:03:53,839
these things about you know for the

1787
01:03:58,549 --> 01:03:55,680
suits and where we're doing that day and

1788
01:03:59,510 --> 01:03:58,559

it was that line that said uh eva crew

1789
01:04:01,910 --> 01:03:59,520
rescue

1790
01:04:03,990 --> 01:04:01,920
so if you got untethered somehow

1791
01:04:06,230 --> 01:04:04,000
you would uh the scooter would come get

1792
01:04:08,309 --> 01:04:06,240
you and we used to do that line and the

1793
01:04:10,069 --> 01:04:08,319
joke was i don't know if you when rick i

1794
01:04:11,910 --> 01:04:10,079
remember rick always saying this eva

1795
01:04:19,990 --> 01:04:11,920
crew rescue don't worry about it we got

1796
01:04:24,549 --> 01:04:22,789
so uh uh back to hubble for for a minute

1797
01:04:27,510 --> 01:04:24,559
and really something common to all the

1798
01:04:29,510 --> 01:04:27,520
missions um on almost all the missions

1799
01:04:32,069 --> 01:04:29,520
gyros were changed out

1800
01:04:34,390 --> 01:04:32,079
uh that was a difficult task to do the

1801
01:04:35,910 --> 01:04:34,400
where they were situated i can remember

1802
01:04:38,829 --> 01:04:35,920
you know the practice and the high

1803
01:04:42,710 --> 01:04:38,839
fidelity mechanical simulator and and

1804
01:04:44,870 --> 01:04:42,720
just can't imagine how you all

1805
01:04:46,789 --> 01:04:44,880
you know uh were able to do that task

1806
01:04:49,270 --> 01:04:46,799
talk a little bit about that on for

1807
01:04:49,990 --> 01:04:49,280
those of you that did gyro change out

1808
01:04:52,150 --> 01:04:50,000
yeah

1809
01:04:53,349 --> 01:04:52,160
and in fact you might you might

1810
01:04:56,630 --> 01:04:53,359
know that

1811
01:04:59,349 --> 01:04:56,640
we've had some gyro uh uh excitement uh

1812
01:05:01,270 --> 01:04:59,359
in the last few weeks on hubble too

1813
01:05:03,910 --> 01:05:01,280

well i mean the gyros themselves they're

1814
01:05:06,230 --> 01:05:03,920
just you know little rectangular box and

1815
01:05:09,109 --> 01:05:06,240
with with a couple of bolts on the front

1816
01:05:10,230 --> 01:05:09,119
the problem is is getting access in

1817
01:05:11,910 --> 01:05:10,240
there to

1818
01:05:15,109 --> 01:05:11,920
to get at them

1819
01:05:17,109 --> 01:05:15,119
um when when the job was originally

1820
01:05:19,589 --> 01:05:17,119
designed uh

1821
01:05:21,670 --> 01:05:19,599
and by the way the doors that that

1822
01:05:23,589 --> 01:05:21,680
enclosed the gyro compartment they also

1823
01:05:25,829 --> 01:05:23,599
have the star trackers and and they have

1824
01:05:27,670 --> 01:05:25,839
big star tracker sun shades on them

1825
01:05:29,270 --> 01:05:27,680
which kind of get in the way and so the

1826
01:05:32,309 --> 01:05:29,280
original idea

1827
01:05:34,150 --> 01:05:32,319
was you have to remove those sun shades

1828
01:05:37,190 --> 01:05:34,160
and stow them somewhere

1829
01:05:39,750 --> 01:05:37,200
do the gyro job uh which you could then

1830
01:05:41,589 --> 01:05:39,760
do sort of from the outside

1831
01:05:44,390 --> 01:05:41,599
and then put all the sun shades back

1832
01:05:46,710 --> 01:05:44,400
well given the time criticality

1833
01:05:49,270 --> 01:05:46,720
um we had the idea that you know if you

1834
01:05:53,190 --> 01:05:49,280
could actually slide underneath the

1835
01:05:53,990 --> 01:05:53,200
gyros and inside the telescope

1836
01:05:55,990 --> 01:05:54,000
then

1837
01:05:57,910 --> 01:05:56,000
we could do the job without having to

1838
01:05:59,510 --> 01:05:57,920

remove those sun shades and save a lot

1839
01:06:00,710 --> 01:05:59,520
of time

1840
01:06:02,870 --> 01:06:00,720
story was

1841
01:06:06,470 --> 01:06:02,880
shorter than me so he was the one who

1842
01:06:07,829 --> 01:06:06,480
went inside and and i would sort of

1843
01:06:09,589 --> 01:06:07,839
insert him

1844
01:06:11,510 --> 01:06:09,599
uh because he couldn't see that's the

1845
01:06:12,950 --> 01:06:11,520
thing you know you're in a spacesuit you

1846
01:06:15,270 --> 01:06:12,960
have a pretty good view of what's in

1847
01:06:17,190 --> 01:06:15,280
front of you but what's on top of you to

1848
01:06:20,390 --> 01:06:17,200
the sides and especially what's behind

1849
01:06:22,230 --> 01:06:20,400
you you can't see and and so

1850
01:06:24,230 --> 01:06:22,240
when you're actually inside the

1851
01:06:25,910 --> 01:06:24,240
telescope we were always

1852
01:06:27,589 --> 01:06:25,920
had to be really careful you know you

1853
01:06:29,029 --> 01:06:27,599
don't want to break anything that isn't

1854
01:06:30,150 --> 01:06:29,039
already broken

1855
01:06:32,470 --> 01:06:30,160
so

1856
01:06:35,270 --> 01:06:32,480
that's what we continually practice and

1857
01:06:37,589 --> 01:06:35,280
there was some skepticism among the

1858
01:06:40,230 --> 01:06:37,599
engineers who were responsible for

1859
01:06:42,150 --> 01:06:40,240
hubble that you know can you really

1860
01:06:43,109 --> 01:06:42,160
do this without breaking anything and i

1861
01:06:46,870 --> 01:06:43,119
remember

1862
01:06:49,589 --> 01:06:46,880
uh what what story did at one point we

1863
01:06:52,470 --> 01:06:49,599

had practiced this over and over for

1864
01:06:53,990 --> 01:06:52,480
quite a few different water runs

1865
01:06:56,230 --> 01:06:54,000
and and

1866
01:06:58,549 --> 01:06:56,240
at that point he said all right i'm

1867
01:07:01,029 --> 01:06:58,559
telling to the engineers

1868
01:07:03,510 --> 01:07:01,039
this is our final exam come in the water

1869
01:07:06,470 --> 01:07:03,520
with us watch it on tv

1870
01:07:08,150 --> 01:07:06,480
let us know if you are satisfied that

1871
01:07:10,870 --> 01:07:08,160
you think it's safe

1872
01:07:12,630 --> 01:07:10,880
and if not we won't do it but we did it

1873
01:07:14,549 --> 01:07:12,640
and they were happy and and so that's

1874
01:07:16,069 --> 01:07:14,559
how we did it and it and it worked and i

1875
01:07:18,309 --> 01:07:16,079
i guess that's what's been done that

1876
01:07:21,589 --> 01:07:18,319
technique more or less is has remained

1877
01:07:23,829 --> 01:07:21,599
with it for the other replacements

1878
01:07:26,150 --> 01:07:23,839
that's a fair characterization i think

1879
01:07:28,069 --> 01:07:26,160
you know for me personally putting in

1880
01:07:29,430 --> 01:07:28,079
rsu number two which is the middle one

1881
01:07:30,390 --> 01:07:29,440
and there was a picture shown this

1882
01:07:31,910 --> 01:07:30,400
morning

1883
01:07:33,670 --> 01:07:31,920
uh

1884
01:07:35,109 --> 01:07:33,680
you know i was on the robotic arm and

1885
01:07:37,109 --> 01:07:35,119
inserted into the middle of the

1886
01:07:39,829 --> 01:07:37,119
telescope facing up

1887
01:07:41,589 --> 01:07:39,839
uh and relatively straightforward so you

1888
01:07:42,549 --> 01:07:41,599

did a little differently did well we did

1889
01:07:44,950 --> 01:07:42,559
all three

1890
01:07:47,670 --> 01:07:44,960
yeah okay um and so for the side ones

1891
01:07:51,430 --> 01:07:47,680
you know got inserted into the telescope

1892
01:07:53,829 --> 01:07:51,440
and i i had steve smith's feet and he's

1893
01:07:55,829 --> 01:07:53,839
tall and inserted him using the same

1894
01:07:57,109 --> 01:07:55,839
technique where you didn't want to touch

1895
01:07:59,190 --> 01:07:57,119
anything else

1896
01:08:02,150 --> 01:07:59,200
you know we were allowed and he was

1897
01:08:03,270 --> 01:08:02,160
allowed one tap on the handrail with his

1898
01:08:04,710 --> 01:08:03,280
backpack

1899
01:08:06,150 --> 01:08:04,720
and then he had to stay fixed and the

1900
01:08:07,910 --> 01:08:06,160
rest was all with his arms because we

1901
01:08:08,829 --> 01:08:07,920
didn't we saw where story had scratched

1902
01:08:10,710 --> 01:08:08,839
that

1903
01:08:12,710 --> 01:08:10,720
handrail and uh

1904
01:08:14,870 --> 01:08:12,720
it actually said story on it he signed

1905
01:08:17,430 --> 01:08:16,229
but for me it was really neat because i

1906
01:08:19,110 --> 01:08:17,440
was being inserted into the middle of a

1907
01:08:20,309 --> 01:08:19,120
telescope and i suddenly had this

1908
01:08:22,390 --> 01:08:20,319
thought you know although you couldn't

1909
01:08:37,110 --> 01:08:22,400
see out the aperture door was closed it

1910
01:08:40,630 --> 01:08:38,709
that you know we available warned that

1911
01:08:42,630 --> 01:08:40,640
you know there were these delicate flex

1912
01:08:44,070 --> 01:08:42,640
leads and that you had to minimize the

1913
01:08:45,430 --> 01:08:44,080

rates and you couldn't bump it and there

1914
01:08:47,430 --> 01:08:45,440
were ceramic

1915
01:08:49,110 --> 01:08:47,440
spacers that were easy to chip you know

1916
01:08:50,789 --> 01:08:49,120
you guys learned learned that and the

1917
01:08:52,229 --> 01:08:50,799
text had learned that through through

1918
01:08:54,229 --> 01:08:52,239
testing and if one of them gets chipped

1919
01:08:56,630 --> 01:08:54,239
then it may not sit flat and so there

1920
01:08:58,709 --> 01:08:56,640
are all kinds of hazards and warnings

1921
01:08:59,910 --> 01:08:58,719
and don't do this don't do that and by

1922
01:09:02,070 --> 01:08:59,920
the time you're done you're just

1923
01:09:03,990 --> 01:09:02,080
frightened to death of these things

1924
01:09:06,390 --> 01:09:04,000
and so that's why on the last mission i

1925
01:09:07,510 --> 01:09:06,400
said we'll let mass do that yeah

1926
01:09:08,789 --> 01:09:07,520
we learned we learned a lot from the

1927
01:09:10,229 --> 01:09:08,799
other missions though because they had

1928
01:09:12,070 --> 01:09:10,239
the door trouble on the first one so we

1929
01:09:14,229 --> 01:09:12,080
knew when he gave us a door trainer

1930
01:09:16,149 --> 01:09:14,239
um and then we learned more from when

1931
01:09:19,669 --> 01:09:16,159
john and steve then the team did it on

1932
01:09:21,349 --> 01:09:19,679
on the next that uh on 3a and then

1933
01:09:23,189 --> 01:09:21,359
before we had a pick stick

1934
01:09:24,709 --> 01:09:23,199
and i think it was you and drew i think

1935
01:09:26,229 --> 01:09:24,719
came up with that idea of trying to get

1936
01:09:27,749 --> 01:09:26,239
a tool to insert them instead of having

1937
01:09:29,189 --> 01:09:27,759
i went to the hardware store

1938
01:09:30,630 --> 01:09:29,199

was the hardware store was it the kids

1939
01:09:32,550 --> 01:09:30,640
store was the toy store i thought it

1940
01:09:34,309 --> 01:09:32,560
came in like a kid you know grabber

1941
01:09:35,669 --> 01:09:34,319
hardware whatever so they came back with

1942
01:09:37,110 --> 01:09:35,679
a little gra and we tried it in the pool

1943
01:09:38,789 --> 01:09:37,120
and that was i think that's a great

1944
01:09:40,550 --> 01:09:38,799
example of how the team worked

1945
01:09:42,789 --> 01:09:40,560
and and we tried it concept wise with

1946
01:09:44,709 --> 01:09:42,799
this with this grabber garbage thing or

1947
01:09:46,789 --> 01:09:44,719
toy whatever it was and just that we got

1948
01:09:48,630 --> 01:09:46,799
off the shelf and then i think the next

1949
01:09:49,829 --> 01:09:48,640
series of runs we had a prototype and we

1950
01:09:51,669 --> 01:09:49,839
were able to use it but i'll tell you

1951
01:09:53,349 --> 01:09:51,679
what i remember about this so i want to

1952
01:09:55,030 --> 01:09:53,359
tell you guys is when i got inside that

1953
01:09:56,550 --> 01:09:55,040
telescope let me ask this

1954
01:09:57,510 --> 01:09:56,560
the uh the cover was the star tracker

1955
01:09:58,790 --> 01:09:57,520
cover that was right in front of me

1956
01:10:00,790 --> 01:09:58,800
right there and it was number two on the

1957
01:10:05,669 --> 01:10:00,800
right correct okay so

1958
01:10:08,630 --> 01:10:07,030
number one on the right so that's of

1959
01:10:11,110 --> 01:10:08,640
course from brain oh threads me in there

1960
01:10:12,950 --> 01:10:11,120
and i'm in there and like right the the

1961
01:10:14,310 --> 01:10:12,960
the covers right in front of me

1962
01:10:15,990 --> 01:10:14,320
does anyone in this room know who

1963
01:10:17,830 --> 01:10:16,000

manufactured that cover i can't remember

1964
01:10:21,189 --> 01:10:17,840
the name of the company does anyone know

1965
01:10:22,550 --> 01:10:21,199
who manufactured the star tracker cover

1966
01:10:24,630 --> 01:10:22,560
all right well i get inside of this

1967
01:10:25,910 --> 01:10:24,640
thing and i never i was i wasn't warned

1968
01:10:28,070 --> 01:10:25,920
about this right

1969
01:10:30,070 --> 01:10:28,080
but there's a little placard on that on

1970
01:10:31,350 --> 01:10:30,080
that star tracker cover right i didn't

1971
01:10:32,390 --> 01:10:31,360
know this was going to be there it's a

1972
01:10:33,669 --> 01:10:32,400
little metal it looks like a little

1973
01:10:34,950 --> 01:10:33,679
metal thing right in front of me as

1974
01:10:37,669 --> 01:10:34,960
again i see the thing right in front of

1975
01:10:39,030 --> 01:10:37,679
me and this is manufactured by like acme

1976
01:10:41,510 --> 01:10:39,040
corporation

1977
01:10:44,070 --> 01:10:41,520
bayonne new jersey

1978
01:10:47,110 --> 01:10:44,080
so 350 miles up on inside of this great

1979
01:10:48,550 --> 01:10:47,120
telescope the words bayonne new jersey

1980
01:10:50,310 --> 01:10:48,560
are staring right at me i couldn't

1981
01:10:51,669 --> 01:10:50,320
believe this i had to come all this way

1982
01:10:53,189 --> 01:10:51,679
to see a sign about but if anyone's

1983
01:10:54,550 --> 01:10:53,199
familiar with bayonne new jersey it's

1984
01:10:55,270 --> 01:10:54,560
like a bunch of gas tanks when you're

1985
01:10:56,709 --> 01:10:55,280
lying

1986
01:10:58,229 --> 01:10:56,719
next time you're going into newark

1987
01:10:59,750 --> 01:10:58,239
newark new jersey look to the right or

1988
01:11:01,910 --> 01:10:59,760

left and you'll see a bunch of gigantic

1989
01:11:03,270 --> 01:11:01,920
gas tanks that's bayonne new jersey

1990
01:11:05,350 --> 01:11:03,280
right well we're not too far from new

1991
01:11:06,550 --> 01:11:05,360
jersey anyway so i see this i thought

1992
01:11:07,990 --> 01:11:06,560
this is the most incredible thing i've

1993
01:11:09,430 --> 01:11:08,000
ever seen how could this be inside i

1994
01:11:10,709 --> 01:11:09,440
could bail new jersey inside hubble

1995
01:11:13,189 --> 01:11:10,719
space telescope

1996
01:11:15,110 --> 01:11:13,199
so steve uh story did that on the first

1997
01:11:17,270 --> 01:11:15,120
mission steve had that role in a second

1998
01:11:19,750 --> 01:11:17,280
i was so you know one of one of these

1999
01:11:21,830 --> 01:11:19,760
guys i've seen as well so when we landed

2000
01:11:23,510 --> 01:11:21,840
soon after that i i think the story was

2001
01:11:24,950 --> 01:11:23,520
for some reason the story was i think kt

2002
01:11:27,189 --> 01:11:24,960
maybe you were there two he came to see

2003
01:11:29,430 --> 01:11:27,199
us or somebody was a few of the

2004
01:11:31,189 --> 01:11:29,440
uh sm one crew was there

2005
01:11:32,709 --> 01:11:31,199
and and so i see story he's okay you

2006
01:11:34,950 --> 01:11:32,719
know congratulations you go story did

2007
01:11:37,350 --> 01:11:34,960
you see that in that right on that on

2008
01:11:39,189 --> 01:11:37,360
that plaque that at bayou new jersey a

2009
01:11:41,510 --> 01:11:39,199
little placard and he goes no i didn't

2010
01:11:43,430 --> 01:11:41,520
go how did you miss it and he goes maybe

2011
01:11:45,110 --> 01:11:43,440
i was thinking about the telescope in

2012
01:11:46,709 --> 01:11:45,120
morning

2013
01:11:48,310 --> 01:11:46,719

okay fine

2014
01:11:50,310 --> 01:11:48,320
i thought you were the same he had my

2015
01:11:51,830 --> 01:11:50,320
eyes closed

2016
01:11:53,830 --> 01:11:51,840
yeah there you go

2017
01:11:55,750 --> 01:11:53,840
well i'm also interested you said it was

2018
01:11:57,590 --> 01:11:55,760
the acme tool company i don't know acne

2019
01:11:58,870 --> 01:11:57,600
i made up i couldn't remember the name

2020
01:12:00,310 --> 01:11:58,880
like that you know

2021
01:12:02,310 --> 01:12:00,320
the star trek that would have been too

2022
01:12:04,550 --> 01:12:02,320
much somebody no it wasn't me but i

2023
01:12:05,910 --> 01:12:04,560
wonder it's got to be somewhere someone

2024
01:12:07,669 --> 01:12:05,920
in this room is going to be able to find

2025
01:12:08,709 --> 01:12:07,679
out somebody will find it out so we have

2026
01:12:11,590 --> 01:12:08,719
about

2027
01:12:13,910 --> 01:12:11,600
two or three minutes left uh i'm told

2028
01:12:15,910 --> 01:12:13,920
say a word or two about uh been only a

2029
01:12:18,550 --> 01:12:15,920
word or two two or three minutes we need

2030
01:12:20,709 --> 01:12:18,560
to uh to wrap up on on time

2031
01:12:23,510 --> 01:12:20,719
word or two though about how training in

2032
01:12:24,870 --> 01:12:23,520
the facilities evolved for training from

2033
01:12:27,350 --> 01:12:24,880
the time of the preparation for the

2034
01:12:31,990 --> 01:12:27,360
deployment mission until 19 years later

2035
01:12:36,229 --> 01:12:33,350
well the one

2036
01:12:37,350 --> 01:12:36,239
i mean we talked about how much time it

2037
01:12:39,350 --> 01:12:37,360
took

2038
01:12:42,950 --> 01:12:39,360

there was

2039
01:12:45,669 --> 01:12:42,960
one new development in eva

2040
01:12:47,750 --> 01:12:45,679
underwater training because

2041
01:12:49,350 --> 01:12:47,760
hubble being so tall we were spending a

2042
01:12:51,669 --> 01:12:49,360
lot of time

2043
01:12:53,669 --> 01:12:51,679
pretty deep in the water

2044
01:12:56,070 --> 01:12:53,679
and you actually were getting to the

2045
01:12:58,070 --> 01:12:56,080
point where in principle we we would

2046
01:13:01,110 --> 01:12:58,080
have had to do a decompression stop and

2047
01:13:03,430 --> 01:13:01,120
so they instituted a nitrox system there

2048
01:13:05,830 --> 01:13:03,440
any scuba divers here that means you

2049
01:13:08,070 --> 01:13:05,840
have a little bit less nitrogen and more

2050
01:13:10,709 --> 01:13:08,080
oxygen so that you don't have to do that

2051
01:13:13,350 --> 01:13:10,719
decompression so just one more example

2052
01:13:15,590 --> 01:13:13,360
of the lengths to which the system was

2053
01:13:17,270 --> 01:13:15,600
willing to go to make it possible to do

2054
01:13:21,350 --> 01:13:17,280
the sort of training that we needed to

2055
01:13:23,750 --> 01:13:21,360
do to accomplish the task okay

2056
01:13:26,149 --> 01:13:23,760
for uh you know i had the

2057
01:13:28,709 --> 01:13:26,159
luxury the privilege that i was

2058
01:13:30,630 --> 01:13:28,719
picked as an astronaut in 92

2059
01:13:32,310 --> 01:13:30,640
and so even before the first servicing

2060
01:13:33,590 --> 01:13:32,320
mission i got to dive on a hubble

2061
01:13:35,189 --> 01:13:33,600
mock-up

2062
01:13:36,790 --> 01:13:35,199
at marshall

2063
01:13:39,270 --> 01:13:36,800

of course these folks practically lived

2064
01:13:41,510 --> 01:13:39,280
there and flew back and forth

2065
01:13:44,229 --> 01:13:41,520
but a huge development was when we went

2066
01:13:46,229 --> 01:13:44,239
from the marshall tank to the neutral

2067
01:13:48,070 --> 01:13:46,239
buoyancy laboratory at johnson now it

2068
01:13:49,830 --> 01:13:48,080
wasn't as deep so we had to split hubble

2069
01:13:50,870 --> 01:13:49,840
in two

2070
01:13:53,110 --> 01:13:50,880
but it's

2071
01:13:55,669 --> 01:13:53,120
you know really the philosophy you know

2072
01:13:57,990 --> 01:13:55,679
that we trained over and over and over

2073
01:14:00,310 --> 01:13:58,000
again in the pool with other simulators

2074
01:14:02,149 --> 01:14:00,320
as we were going to fly and so there

2075
01:14:04,790 --> 01:14:02,159
were times on orbit where i forgot that

2076
01:14:07,189 --> 01:14:04,800
we were on orbit it was just another day

2077
01:14:09,590 --> 01:14:07,199
higher fidelity at the nbl

2078
01:14:13,430 --> 01:14:09,600
the other change that i think

2079
01:14:16,149 --> 01:14:13,440
started with sm1 continued with sm2 then

2080
01:14:19,669 --> 01:14:16,159
3a 3b and 4

2081
01:14:21,189 --> 01:14:19,679
is that we got ever increasing fidelity

2082
01:14:22,630 --> 01:14:21,199
simulators whether they were big

2083
01:14:24,790 --> 01:14:22,640
simulators

2084
01:14:26,709 --> 01:14:24,800
or small so for instance the door

2085
01:14:28,790 --> 01:14:26,719
trouble you had

2086
01:14:30,149 --> 01:14:28,800
you know the team built as closely as

2087
01:14:32,149 --> 01:14:30,159
they could

2088
01:14:34,790 --> 01:14:32,159

uh a door simulator so that we could

2089
01:14:36,149 --> 01:14:34,800
practice that and and mess up as much as

2090
01:14:39,030 --> 01:14:36,159
we could so we knew how to close the

2091
01:14:40,870 --> 01:14:39,040
doors uh and the pcu trainer and the

2092
01:14:43,590 --> 01:14:40,880
stis trainer and you know i really have

2093
01:14:46,550 --> 01:14:43,600
to give you know enormous credit on all

2094
01:14:48,790 --> 01:14:46,560
fronts uh and folks have talked about

2095
01:14:51,350 --> 01:14:48,800
him already but frank zeppelin so john

2096
01:14:53,830 --> 01:14:51,360
let me let me stop you there so we're we

2097
01:14:56,229 --> 01:14:53,840
are out of time unfortunately i want to

2098
01:14:58,310 --> 01:14:56,239
uh i want to thank you all for being

2099
01:15:00,310 --> 01:14:58,320
with us today and sharing your memories

2100
01:15:22,870 --> 01:15:00,320
and your thoughts and let's give them

2101
01:15:25,510 --> 01:15:24,550
five four

2102
01:15:26,470 --> 01:15:25,520
three

2103
01:15:29,350 --> 01:15:26,480
two

2104
01:15:31,110 --> 01:15:29,360
one and liftoff of the space shuttle

2105
01:16:56,630 --> 01:15:31,120
discovery with the hubble space

2106
01:16:59,830 --> 01:16:58,870
trouble isn't just a satellite

2107
01:17:02,390 --> 01:16:59,840
it's

2108
01:17:03,830 --> 01:17:02,400
about humanity's quest for knowledge the

2109
01:17:05,110 --> 01:17:03,840
only way of finding the limits of the

2110
01:17:07,350 --> 01:17:05,120
possible

2111
01:17:08,950 --> 01:17:07,360
is by going beyond them into the

2112
01:17:10,790 --> 01:17:08,960
impossible

2113
01:17:13,669 --> 01:17:10,800

i want to wish hubble its own set of

2114
01:17:22,870 --> 01:17:13,679
adventures that it may unlock further

2115
01:17:27,270 --> 01:17:24,630
hubble's space telescope imaging

2116
01:17:29,030 --> 01:17:27,280
spectrograph or stis has capabilities

2117
01:17:30,550 --> 01:17:29,040
like searching for black holes and

2118
01:17:32,310 --> 01:17:30,560
looking at the atmospheres of planets

2119
01:17:34,870 --> 01:17:32,320
orbiting other stars

2120
01:17:36,149 --> 01:17:34,880
after stis had a power failure in 2004

2121
01:17:38,070 --> 01:17:36,159
the hubble team was tasked with

2122
01:17:39,750 --> 01:17:38,080
replacing stitches damaged electronics

2123
01:17:42,630 --> 01:17:39,760
boards on the final servicing mission in

2124
01:17:51,270 --> 01:17:42,640
2009 which would turn out to be a

2125
01:17:55,830 --> 01:17:53,270
so for about two years i spent almost

2126
01:17:57,510 --> 01:17:55,840
every day with the eva team four crew

2127
01:17:59,590 --> 01:17:57,520
members we practiced that repair many

2128
01:18:01,590 --> 01:17:59,600
many times and we practice it in the

2129
01:18:03,669 --> 01:18:01,600
water start to finish in the pool

2130
01:18:05,270 --> 01:18:03,679
many times we spent hours and days and

2131
01:18:07,270 --> 01:18:05,280
weeks and months going through what if

2132
01:18:09,350 --> 01:18:07,280
this bolt fails uh what if the cable

2133
01:18:10,709 --> 01:18:09,360
doesn't mate so i felt that we had

2134
01:18:12,470 --> 01:18:10,719
covered you know as much as we could

2135
01:18:19,910 --> 01:18:12,480
have thought of going into this

2136
01:18:24,470 --> 01:18:22,630
so we came in to work here at the space

2137
01:18:27,510 --> 01:18:24,480
telescope operations control center at

2138
01:18:29,270 --> 01:18:27,520

goddard our mechanical response team was

2139
01:18:31,510 --> 01:18:29,280
was watching the eva in a conference

2140
01:18:33,750 --> 01:18:31,520
room in building29 i was located down at

2141
01:18:35,590 --> 01:18:33,760
johnson space center along with a

2142
01:18:37,430 --> 01:18:35,600
servicing mission manager the day

2143
01:18:39,510 --> 01:18:37,440
started out really well you know i was i

2144
01:18:40,950 --> 01:18:39,520
was trying to make it a perfect day no

2145
01:18:42,310 --> 01:18:40,960
problems so they get to the section

2146
01:18:44,229 --> 01:18:42,320
where they have to remove the handrail

2147
01:18:45,510 --> 01:18:44,239
on stairs and you have to remove this

2148
01:18:47,430 --> 01:18:45,520
handrail that was designed actually to

2149
01:18:48,630 --> 01:18:47,440
help remove and install the entire

2150
01:18:51,030 --> 01:18:48,640
instrument

2151
01:18:53,510 --> 01:18:51,040
in order to access the electronics board

2152
01:18:56,149 --> 01:18:53,520
underneath and we watched mike massimino

2153
01:18:57,830 --> 01:18:56,159
attempt to do a rather simple task all

2154
01:19:00,070 --> 01:18:57,840
you had to do was remove four screws

2155
01:19:02,149 --> 01:19:00,080
from a handrail so the two screws at the

2156
01:19:03,830 --> 01:19:02,159
top of the hand drill came off fine the

2157
01:19:06,149 --> 01:19:03,840
one on the bottom left comes out fine i

2158
01:19:08,870 --> 01:19:06,159
go to the bottom right we could see

2159
01:19:09,990 --> 01:19:08,880
the pistol grip tool spinning in the

2160
01:19:12,390 --> 01:19:10,000
bolt head

2161
01:19:15,270 --> 01:19:12,400
and the bolt wasn't coming out

2162
01:19:17,590 --> 01:19:15,280
i don't want to strip the thing

2163
01:19:18,709 --> 01:19:17,600

oh my god um that was the first thing

2164
01:19:20,550 --> 01:19:18,719
you know it's what are we going to do

2165
01:19:22,630 --> 01:19:20,560
because this is a

2166
01:19:25,110 --> 01:19:22,640
show stopper right here for a while

2167
01:19:26,630 --> 01:19:25,120
probably about an hour so we were trying

2168
01:19:28,870 --> 01:19:26,640
different bits on the end of the power

2169
01:19:29,990 --> 01:19:28,880
tool and we were trying all kinds of

2170
01:19:31,189 --> 01:19:30,000
things

2171
01:19:33,270 --> 01:19:31,199
you know and one thing that crossed my

2172
01:19:34,550 --> 01:19:33,280
mind was what would you do what would

2173
01:19:35,750 --> 01:19:34,560
you do at home you know what would you

2174
01:19:37,430 --> 01:19:35,760
do in your garage you know and i was

2175
01:19:38,790 --> 01:19:37,440
thinking back to my garage you know and

2176
01:19:40,390 --> 01:19:38,800
sometimes what would i do you know and i

2177
01:19:41,669 --> 01:19:40,400
just kind of you know use the brute

2178
01:19:43,510 --> 01:19:41,679
force you know so i thought you know

2179
01:19:45,110 --> 01:19:43,520
what about just trying to break it

2180
01:19:46,070 --> 01:19:45,120
it didn't even occur to a lot of us just

2181
01:19:47,910 --> 01:19:46,080
because it's something that you're not

2182
01:19:49,110 --> 01:19:47,920
really ever trained to do or think of so

2183
01:19:50,390 --> 01:19:49,120
one of the things i did was i called

2184
01:19:52,229 --> 01:19:50,400
back to james cooper

2185
01:19:53,990 --> 01:19:52,239
back here at goddard james cooper called

2186
01:19:55,910 --> 01:19:54,000
us on the speaker phone and said hey

2187
01:19:57,510 --> 01:19:55,920
guys we you're watching this right and

2188
01:20:00,630 --> 01:19:57,520

he said yeah yeah of course we found out

2189
01:20:02,550 --> 01:20:00,640
we did have a mock-up of this disc front

2190
01:20:04,709 --> 01:20:02,560
panel with the handrail on it we came up

2191
01:20:06,950 --> 01:20:04,719
with a quick plan bill mitchell said

2192
01:20:09,110 --> 01:20:06,960
i've got two handrails inside the clean

2193
01:20:11,669 --> 01:20:09,120
room and ken dickinson and i came up

2194
01:20:13,910 --> 01:20:11,679
with a plan for how to rig up the test

2195
01:20:15,430 --> 01:20:13,920
so we scattered into the building to get

2196
01:20:17,830 --> 01:20:15,440
all the materials we were going to need

2197
01:20:20,149 --> 01:20:17,840
well it was a sunday nobody was around

2198
01:20:22,229 --> 01:20:20,159
so i i'm literally running through the

2199
01:20:24,390 --> 01:20:22,239
halls and i run to where the text would

2200
01:20:26,070 --> 01:20:24,400
be and i find a guy gene mccallicker who

2201
01:20:27,750 --> 01:20:26,080
would happen to be in the building

2202
01:20:30,470 --> 01:20:27,760
working on another project so he said

2203
01:20:32,310 --> 01:20:30,480
what do you mean he seemed to pick up on

2204
01:20:34,149 --> 01:20:32,320
my body language before i even ask my

2205
01:20:36,870 --> 01:20:34,159
question but i told him i need a torque

2206
01:20:39,110 --> 01:20:36,880
wrench and uh i need a digital fish

2207
01:20:42,149 --> 01:20:39,120
skill he takes off to go get it i go to

2208
01:20:44,709 --> 01:20:42,159
190 ken dickinson's already in there and

2209
01:20:46,470 --> 01:20:44,719
within minutes bill mitchell comes

2210
01:20:49,110 --> 01:20:46,480
busting through the door carrying the

2211
01:20:51,030 --> 01:20:49,120
handrail still in his bunny suit and his

2212
01:20:53,189 --> 01:20:51,040
clean room garment to get the handrail

2213
01:20:55,030 --> 01:20:53,199

all set up everything's ready to go we

2214
01:20:56,950 --> 01:20:55,040
text a couple pictures back and forth

2215
01:20:58,950 --> 01:20:56,960
james gives us the green light

2216
01:21:00,470 --> 01:20:58,960
and gene stands up on the table and

2217
01:21:02,310 --> 01:21:00,480
starts pulling the handrail and right

2218
01:21:03,590 --> 01:21:02,320
when he got to 60 pounds

2219
01:21:05,189 --> 01:21:03,600
it snapped

2220
01:21:07,030 --> 01:21:05,199
actually the bolt went flying once we'd

2221
01:21:09,270 --> 01:21:07,040
done that test then

2222
01:21:10,390 --> 01:21:09,280
i got on our communication loops and

2223
01:21:13,030 --> 01:21:10,400
called it to

2224
01:21:14,550 --> 01:21:13,040
jim corbo so ultimately you know james

2225
01:21:16,870 --> 01:21:14,560
came back and said you know take about

2226
01:21:18,870 --> 01:21:16,880
60 pounds of force for them to break it

2227
01:21:20,390 --> 01:21:18,880
off so goddard had done this test fed

2228
01:21:21,590 --> 01:21:20,400
the information to us we talked to the

2229
01:21:24,470 --> 01:21:21,600
flight director about it to get him

2230
01:21:26,950 --> 01:21:24,480
comfortable okay mass you copy that 60

2231
01:21:28,950 --> 01:21:26,960
pounds linear at the top of the handrail

2232
01:21:31,430 --> 01:21:28,960
to bust off that bottom bolt i think

2233
01:21:32,950 --> 01:21:31,440
you've got that in you can try i knew i

2234
01:21:34,629 --> 01:21:32,960
could do that what if he pulls it off

2235
01:21:36,790 --> 01:21:34,639
and there's debris what if he pulls off

2236
01:21:38,149 --> 01:21:36,800
the handrail and there's a sharp edge

2237
01:21:39,430 --> 01:21:38,159
what if he it takes a lot of force and

2238
01:21:41,350 --> 01:21:39,440

it comes back and hits him mike

2239
01:21:42,950 --> 01:21:41,360
massimino was able to

2240
01:21:45,110 --> 01:21:42,960
put some tape over the head of the boat

2241
01:21:46,070 --> 01:21:45,120
to contain debris that that might go

2242
01:21:47,669 --> 01:21:46,080
flying

2243
01:21:49,590 --> 01:21:47,679
and so i taped it as best i could and

2244
01:21:51,030 --> 01:21:49,600
bueno was with me helping me to take

2245
01:21:52,390 --> 01:21:51,040
that thing and then

2246
01:22:03,750 --> 01:21:52,400
we don't have video right now but uh

2247
01:22:07,990 --> 01:22:06,709
everyone erupted in tears uh because

2248
01:22:10,070 --> 01:22:08,000
when he pulled it off he didn't see any

2249
01:22:11,590 --> 01:22:10,080
debris i mean he knew not to touch the

2250
01:22:13,430 --> 01:22:11,600
potential sharp edges and then we could

2251
01:22:15,270 --> 01:22:13,440
just put that fastener capture plate on

2252
01:22:17,430 --> 01:22:15,280
and complete the assist task the rest of

2253
01:22:19,669 --> 01:22:17,440
the repair went fairly well so this i

2254
01:22:22,229 --> 01:22:19,679
mean it was fine actually and

2255
01:22:24,070 --> 01:22:22,239
it's this is working that one or two

2256
01:22:26,310 --> 01:22:24,080
hours that i worked on breaking the

2257
01:22:29,430 --> 01:22:26,320
handrail that task that very well could

2258
01:22:31,750 --> 01:22:29,440
go down as a highlight of my career so

2259
01:22:32,550 --> 01:22:31,760
the goddard team did a did a great job

2260
01:22:45,110 --> 01:22:32,560
and

2261
01:22:45,120 --> 01:22:51,189
we are all explorers

2262
01:22:51,199 --> 01:22:56,470
it's in our dna

2263
01:22:56,480 --> 01:23:00,709

we explore the depths of our oceans

2264
01:23:00,719 --> 01:23:05,990
our planet's inner regions

2265
01:23:06,000 --> 01:23:11,270
its desolate outposts

2266
01:23:11,280 --> 01:23:20,950
we never stop exploring

2267
01:23:24,709 --> 01:23:23,110
galileo opened our eyes to the heavens

2268
01:23:27,910 --> 01:23:24,719
with his use of a newly invented

2269
01:23:30,149 --> 01:23:27,920
instrument the telescope

2270
01:23:33,189 --> 01:23:30,159
he started an exploration renaissance of

2271
01:23:40,709 --> 01:23:36,070
it would take us to the moon

2272
01:23:45,030 --> 01:23:42,950
for over a quarter century the hubble

2273
01:23:51,110 --> 01:23:45,040
space telescope has been unlocking the

2274
01:24:00,550 --> 01:23:53,270
allowing us to explore the edges of

2275
01:24:00,560 --> 01:24:04,950
from nebulas

2276
01:24:04,960 --> 01:24:09,350
to galaxies

2277
01:24:09,360 --> 01:24:13,030
from newborn stars

2278
01:24:13,040 --> 01:24:17,189
to planet formation

2279
01:24:17,199 --> 01:24:21,030
from exoplanets

2280
01:24:21,040 --> 01:24:25,110
to our own planets

2281
01:24:25,120 --> 01:24:29,350
and from dark matter

2282
01:24:29,360 --> 01:24:35,750
to dark energy

2283
01:24:39,350 --> 01:24:37,270
hubble has allowed us to see the

2284
01:24:44,790 --> 01:24:39,360
breathtaking details of the universe

2285
01:24:49,830 --> 01:24:47,110
we salute the thousands of men and women

2286
01:24:51,830 --> 01:24:49,840
from around the world and in space

2287
01:24:56,149 --> 01:24:51,840
that have given humanity this incredible

2288
01:24:56,159 --> 01:24:59,910

while we celebrate its past

2289
01:24:59,920 --> 01:25:06,310
and dream of its future discoveries

2290
01:25:58,950 --> 01:25:08,870
the hubble space telescope

2291
01:28:21,590 --> 01:26:40,950
so