
EPISODE 1
DRIVING THE TELESCOPE

1
00:00:10,310 --> 00:00:08,070
we're locked and we're going to send

2
00:00:11,910 --> 00:00:10,320
that command

3
00:00:12,870 --> 00:00:11,920
31 minutes and 32 seconds for our

4
00:00:15,270 --> 00:00:12,880
support

5
00:00:23,750 --> 00:00:15,280
[Music]

6
00:00:25,589 --> 00:00:23,760
since the retirement of the space

7
00:00:27,830 --> 00:00:25,599
shuttle the engineering team is

8
00:00:31,029 --> 00:00:27,840
absolutely critical for hubble

9
00:00:32,630 --> 00:00:31,039
it always has been without the shuttle

10
00:00:34,549 --> 00:00:32,640
going up to replace any equipment

11
00:00:36,150 --> 00:00:34,559
failures that we have we have to make do

12
00:00:37,990 --> 00:00:36,160
with what we have

13
00:00:39,910 --> 00:00:38,000

what we really are concentrating on is

14
00:00:42,069 --> 00:00:39,920
just keeping the telescope working and

15
00:00:44,229 --> 00:00:42,079
keep the science going

16
00:00:46,150 --> 00:00:44,239
and everything looks excellent and we

17
00:00:48,470 --> 00:00:46,160
have no reason not to expect that hubble

18
00:00:49,690 --> 00:00:48,480
will last until the late 2020s and

19
00:00:57,590 --> 00:00:49,700
beyond

20
00:01:01,670 --> 00:00:59,670
my name is mike wins and i'm the lead

21
00:01:03,750 --> 00:01:01,680
systems engineer for what's known as the

22
00:01:05,590 --> 00:01:03,760
optical telescope assembly of the hubble

23
00:01:08,070 --> 00:01:05,600
space telescope i'm in charge of what's

24
00:01:09,910 --> 00:01:08,080
known as defined guidance sensors these

25
00:01:11,990 --> 00:01:09,920
are the instruments that actually help

26
00:01:13,429 --> 00:01:12,000
hubble do the exquisite and precise

27
00:01:14,950 --> 00:01:13,439
pointing that it does

28
00:01:16,870 --> 00:01:14,960
right now we're getting ready to perform

29
00:01:19,190 --> 00:01:16,880
an observation telescope is going to be

30
00:01:21,590 --> 00:01:19,200
trying to go to acquire some guide stars

31
00:01:23,830 --> 00:01:21,600
in just a few minutes here the stock is

32
00:01:25,510 --> 00:01:23,840
the space telescope operations control

33
00:01:26,550 --> 00:01:25,520
center where we send commands to the

34
00:01:28,469 --> 00:01:26,560
spacecraft

35
00:01:30,230 --> 00:01:28,479
on a daily basis we have to send up

36
00:01:32,390 --> 00:01:30,240
what's known as command loads except the

37
00:01:34,710 --> 00:01:32,400
dtmr is good step three is complete

38
00:01:36,950 --> 00:01:34,720

because the computers on hubble are very

39
00:01:38,710 --> 00:01:36,960
old and they have very little memory in

40
00:01:41,510 --> 00:01:38,720
fact most of your memory sticks today

41
00:01:44,149 --> 00:01:41,520
are 20 30 100 times bigger than hubble

42
00:01:45,510 --> 00:01:44,159
we have to send up essentially a load of

43
00:01:47,590 --> 00:01:45,520
all the commands hubble's going to be

44
00:01:49,910 --> 00:01:47,600
doing for the next 24 hours

45
00:01:52,469 --> 00:01:49,920
on a routine basis we always keep 24

46
00:01:54,950 --> 00:01:52,479
hours of instructions on board so it's

47
00:01:56,870 --> 00:01:54,960
routinely updating for the new sequence

48
00:01:59,910 --> 00:01:56,880
24 hours in advance we'll start with

49
00:02:01,749 --> 00:01:59,920
doing our thermostat blink

50
00:02:03,510 --> 00:02:01,759
hubble is always working it's always

51
00:02:05,030 --> 00:02:03,520
doing something it's always

52
00:02:06,709 --> 00:02:05,040
doing some sort of observation or

53
00:02:09,029 --> 00:02:06,719
calibration or getting ready for the

54
00:02:13,910 --> 00:02:09,039
next task we'll be logging on board at

55
00:02:15,990 --> 00:02:13,920
14 33 17. hubble is truly a 24 7 365 day

56
00:02:18,070 --> 00:02:16,000
a year instrument so the hubble can keep

57
00:02:20,869 --> 00:02:18,080
on going it never stops and we are

58
00:02:22,710 --> 00:02:20,879
configured it's been verified

59
00:02:24,070 --> 00:02:22,720
now we do have to because of this low

60
00:02:25,750 --> 00:02:24,080
earth orbit we're in the actual

61
00:02:27,350 --> 00:02:25,760
observations when we're taking a picture

62
00:02:28,949 --> 00:02:27,360
of something we're doing a science

63
00:02:30,150 --> 00:02:28,959

observation we actually have to wait

64
00:02:32,470 --> 00:02:30,160
because sometimes the earth gets in the

65
00:02:33,990 --> 00:02:32,480
way so we have to pause wait until the

66
00:02:37,430 --> 00:02:34,000
earth gets out of the way as we go back

67
00:02:39,750 --> 00:02:37,440
around and start the observation back up

68
00:02:41,750 --> 00:02:39,760
you have constraints you don't want the

69
00:02:43,110 --> 00:02:41,760
optics pointing at the sun and you don't

70
00:02:45,030 --> 00:02:43,120
want the instruments to have their

71
00:02:46,630 --> 00:02:45,040
shutters open when you're looking at the

72
00:02:48,710 --> 00:02:46,640
earth because the earth is bright for

73
00:02:51,430 --> 00:02:48,720
them and then we have the south atlantic

74
00:02:52,550 --> 00:02:51,440
anomaly the saa which is a portion of

75
00:02:55,350 --> 00:02:52,560
the earth

76
00:02:57,350 --> 00:02:55,360
where we get proton hits that will

77
00:02:59,030 --> 00:02:57,360
affect the electronics in hubble and can

78
00:03:01,110 --> 00:02:59,040
also affect the instruments in hubble

79
00:03:04,070 --> 00:03:01,120
and so we have to plan out very

80
00:03:06,149 --> 00:03:04,080
carefully our targets and observations

81
00:03:08,949 --> 00:03:06,159
we have a timeline that's laid out to

82
00:03:10,949 --> 00:03:08,959
maximize the efficiency of it

83
00:03:14,149 --> 00:03:10,959
hubble can actually take observations

84
00:03:16,470 --> 00:03:14,159
during day and night passes every 95

85
00:03:18,070 --> 00:03:16,480
minutes we go around the earth the

86
00:03:19,990 --> 00:03:18,080
batteries will charge from the solar

87
00:03:22,229 --> 00:03:20,000
arrays during the day pass and then at

88
00:03:24,229 --> 00:03:22,239

night batteries power the observatory so

89
00:03:25,830 --> 00:03:24,239
we can continue observing

90
00:03:27,830 --> 00:03:25,840
the scheduling with hubble we're trying

91
00:03:30,789 --> 00:03:27,840
to put it together as efficiently as

92
00:03:33,030 --> 00:03:30,799
possible minimize our gaps the goal is

93
00:03:35,509 --> 00:03:33,040
to constantly keep it busy

94
00:03:38,149 --> 00:03:35,519
we're constrained to a certain extent

95
00:03:39,990 --> 00:03:38,159
but whenever we have visibility we are

96
00:03:42,949 --> 00:03:40,000
observing

97
00:03:44,710 --> 00:03:42,959
the demand for use of the hubble space

98
00:03:47,030 --> 00:03:44,720
telescope from scientists around the

99
00:03:49,509 --> 00:03:47,040
world is very high

100
00:03:51,350 --> 00:03:49,519
hubble it's at its most productive it's

101
00:03:53,270 --> 00:03:51,360
got some of the best instruments that

102
00:03:55,830 --> 00:03:53,280
have ever been aboard it there's a very

103
00:03:57,750 --> 00:03:55,840
high demand of olds performing

104
00:03:58,949 --> 00:03:57,760
exceptionally well two

105
00:04:02,710 --> 00:03:58,959
one

106
00:04:04,789 --> 00:04:02,720
and liftoff of space shuttle atlantis

107
00:04:07,190 --> 00:04:04,799
final visit to enhance the vision of

108
00:04:09,670 --> 00:04:07,200
hubble into the deepest grandeur of our

109
00:04:11,830 --> 00:04:09,680
universe since the final space shuttle

110
00:04:13,990 --> 00:04:11,840
servicing mission we're using hubble to

111
00:04:16,229 --> 00:04:14,000
get the best kind of science return we

112
00:04:18,710 --> 00:04:16,239
can from the suite of instruments that

113
00:04:21,270 --> 00:04:18,720

we have so our focus now is on making

114
00:04:23,350 --> 00:04:21,280
sure we get the best science while it's

115
00:04:25,189 --> 00:04:23,360
still operating so well

116
00:04:27,430 --> 00:04:25,199
luckily at the end of the last servicing

117
00:04:29,990 --> 00:04:27,440
mission we were actually left with

118
00:04:31,590 --> 00:04:30,000
telescope in great condition but hubble

119
00:04:33,590 --> 00:04:31,600
is getting older and older it's a very

120
00:04:35,670 --> 00:04:33,600
old telescope

121
00:04:36,710 --> 00:04:35,680
now ten years after the last servicing

122
00:04:41,430 --> 00:04:36,720
mission

123
00:04:43,990 --> 00:04:41,440
fix things so we have to rely upon our

124
00:04:45,830 --> 00:04:44,000
own ingenuity to be able to figure out

125
00:04:48,310 --> 00:04:45,840
if something does fail what are the

126
00:04:51,110 --> 00:04:48,320
alternative paths that we have

127
00:04:53,350 --> 00:04:51,120
for the telescope to keep giving us this

128
00:04:55,030 --> 00:04:53,360
peak science we need lots of things to

129
00:04:57,670 --> 00:04:55,040
be working together very well on the

130
00:04:59,749 --> 00:04:57,680
telescope we need a pointing accuracy

131
00:05:01,590 --> 00:04:59,759
system that is outstanding and keeping

132
00:05:04,469 --> 00:05:01,600
that whole system healthy and

133
00:05:07,029 --> 00:05:04,479
functioning so that we can point hubble

134
00:05:08,830 --> 00:05:07,039
very accurately even while it's whizzing

135
00:05:11,350 --> 00:05:08,840
around earth in its

136
00:05:12,950 --> 00:05:11,360
orbit for the telescope to be able to do

137
00:05:15,350 --> 00:05:12,960
the science it needs to do we have to

138
00:05:16,629 --> 00:05:15,360

hold it very very steady

139
00:05:18,070 --> 00:05:16,639
there is actually a little bit of motion

140
00:05:20,469 --> 00:05:18,080
i mean it's hard we're zooming around

141
00:05:21,830 --> 00:05:20,479
the earth at 17 000 miles an hour so

142
00:05:23,189 --> 00:05:21,840
it's hard to hold the telescope

143
00:05:25,749 --> 00:05:23,199
perfectly like that the gyros are

144
00:05:27,270 --> 00:05:25,759
working really good the gyroscopes can

145
00:05:29,909 --> 00:05:27,280
sense motion

146
00:05:32,150 --> 00:05:29,919
in each direction and so because of the

147
00:05:34,070 --> 00:05:32,160
gyroscopes that we have on board and how

148
00:05:36,230 --> 00:05:34,080
sensitive they are in terms of sensing

149
00:05:38,710 --> 00:05:36,240
motion that we can keep our cameras

150
00:05:41,110 --> 00:05:38,720
steady gyros are very good at measuring

151
00:05:42,710 --> 00:05:41,120
these very small rates the fine guidance

152
00:05:44,469 --> 00:05:42,720
sensors are actually sort of used i

153
00:05:46,310 --> 00:05:44,479
always like to describe it as backseat

154
00:05:49,029 --> 00:05:46,320
drivers and they constantly tap on the

155
00:05:51,189 --> 00:05:49,039
gyro's shoulders about once a second

156
00:05:52,230 --> 00:05:51,199
they keep saying turn left a little bit

157
00:05:53,510 --> 00:05:52,240
right a little bit left a little bit

158
00:05:54,870 --> 00:05:53,520
right i mean it must be driving the

159
00:05:56,710 --> 00:05:54,880
driver was nuts

160
00:05:58,950 --> 00:05:56,720
so to find guidance sensors allow you

161
00:06:00,550 --> 00:05:58,960
that really fine control but actually

162
00:06:02,070 --> 00:06:00,560
it's the gyroscopes

163
00:06:03,990 --> 00:06:02,080

driving the telescope and they're doing

164
00:06:05,670 --> 00:06:04,000
a perfectly good job here everything

165
00:06:07,430 --> 00:06:05,680
looks good where our star is the right

166
00:06:09,110 --> 00:06:07,440
brightness the reason that is because we

167
00:06:10,710 --> 00:06:09,120
need to make sure we have to correct the

168
00:06:11,990 --> 00:06:10,720
guide stars one of the things we look at

169
00:06:13,990 --> 00:06:12,000
is the brightness is and that's what

170
00:06:15,990 --> 00:06:14,000
we're measuring here those are about

171
00:06:17,749 --> 00:06:16,000
right for what the stars were but also

172
00:06:19,350 --> 00:06:17,759
we wanted to make sure they were exactly

173
00:06:21,430 --> 00:06:19,360
as far apart as we thought they were

174
00:06:23,029 --> 00:06:21,440
going to be and it did it did a check

175
00:06:25,270 --> 00:06:23,039
and it passed a very very tight

176
00:06:27,110 --> 00:06:25,280
tolerance check to make sure that those

177
00:06:28,629 --> 00:06:27,120
were the right stars so we know we're

178
00:06:30,469 --> 00:06:28,639
locked up on the stars we've got a good

179
00:06:32,070 --> 00:06:30,479
lock here the gyroscopes are very

180
00:06:33,830 --> 00:06:32,080
critical because be able to move from

181
00:06:35,430 --> 00:06:33,840
one position to another position the

182
00:06:37,590 --> 00:06:35,440
gyroscopes are the only thing that can

183
00:06:40,150 --> 00:06:37,600
tell us how we can do that

184
00:06:41,749 --> 00:06:40,160
we have six gyroscopes on board hubble

185
00:06:44,230 --> 00:06:41,759
currently three of them are still

186
00:06:45,990 --> 00:06:44,240
working and three is sort of what people

187
00:06:47,510 --> 00:06:46,000
used to think of as the minimum number

188
00:06:49,749 --> 00:06:47,520

but we have developed a science mode

189
00:06:52,309 --> 00:06:49,759
where we only need one gyro

190
00:06:55,189 --> 00:06:52,319
a big part of our job is to make sure

191
00:06:57,670 --> 00:06:55,199
that we can extend the life of hubble

192
00:06:59,670 --> 00:06:57,680
and continue doing the high performance

193
00:07:00,710 --> 00:06:59,680
science that we're doing for many more

194
00:07:02,070 --> 00:07:00,720
years

195
00:07:03,909 --> 00:07:02,080
what we've done is we've gone through

196
00:07:06,070 --> 00:07:03,919
all the critical components of hubble

197
00:07:07,670 --> 00:07:06,080
and said how can we potentially make

198
00:07:09,749 --> 00:07:07,680
them last longer as you might do with

199
00:07:11,749 --> 00:07:09,759
your own cars it's getting more miles on

200
00:07:13,670 --> 00:07:11,759
it the gyroscopes have been our most

201
00:07:14,710 --> 00:07:13,680
problematic piece of hardware so i

202
00:07:17,510 --> 00:07:14,720
helped

203
00:07:18,790 --> 00:07:17,520
lead an effort to develop a two gyro

204
00:07:21,350 --> 00:07:18,800
science mode

205
00:07:24,230 --> 00:07:21,360
and we were able to use that mode on

206
00:07:26,550 --> 00:07:24,240
orbit and be able to perform science

207
00:07:29,029 --> 00:07:26,560
and then learning from that we actually

208
00:07:30,790 --> 00:07:29,039
developed a one gyro science mode that

209
00:07:32,950 --> 00:07:30,800
we've been able to test on orbit but we

210
00:07:35,029 --> 00:07:32,960
haven't been called on to use but in the

211
00:07:36,469 --> 00:07:35,039
end possibly five to ten to fifteen

212
00:07:38,469 --> 00:07:36,479
years from now when we're down to

213
00:07:40,309 --> 00:07:38,479

potentially our last gyroscope that is

214
00:07:42,150 --> 00:07:40,319
the mode we'll be in

215
00:07:44,230 --> 00:07:42,160
before we do anything on orbit for the

216
00:07:46,550 --> 00:07:44,240
first time we have to test it out on the

217
00:07:48,790 --> 00:07:46,560
ground and we're very lucky to have what

218
00:07:51,110 --> 00:07:48,800
we call the vest the vehicle electrical

219
00:07:53,029 --> 00:07:51,120
system test facility and the key with

220
00:07:55,510 --> 00:07:53,039
the vehicle electrical system test

221
00:07:57,189 --> 00:07:55,520
facility is it's an exact copy of the

222
00:07:59,270 --> 00:07:57,199
main part of the telescope where all the

223
00:08:02,869 --> 00:07:59,280
electronics are and it has the

224
00:08:04,950 --> 00:08:02,879
mechanical bays it has the computers the

225
00:08:06,950 --> 00:08:04,960
electronic box is installed in there and

226
00:08:08,629 --> 00:08:06,960
it has the cables and harnesses in there

227
00:08:10,869 --> 00:08:08,639
and in fact when we were building the

228
00:08:12,790 --> 00:08:10,879
vest we had the quality engineers came

229
00:08:14,629 --> 00:08:12,800
to us and said you're not doing these

230
00:08:16,150 --> 00:08:14,639
cables exactly the way you should be

231
00:08:18,230 --> 00:08:16,160
doing them you know we've got better

232
00:08:20,070 --> 00:08:18,240
standards now and our thing was we're

233
00:08:22,070 --> 00:08:20,080
trying to build a copy of what we have

234
00:08:24,629 --> 00:08:22,080
on orbit and so what you have in the

235
00:08:26,550 --> 00:08:24,639
vest is an exact electrical copy of the

236
00:08:28,309 --> 00:08:26,560
hubble space telescope

237
00:08:30,230 --> 00:08:28,319
every orbit as we come around the earth

238
00:08:32,149 --> 00:08:30,240

to be able to get our attitude correct

239
00:08:33,670 --> 00:08:32,159
to get ourselves steady and locked on

240
00:08:35,829 --> 00:08:33,680
the fine guidance sensors and the

241
00:08:37,750 --> 00:08:35,839
gyroscopes are key to that and that's

242
00:08:39,589 --> 00:08:37,760
why those are the two of the subsystems

243
00:08:42,070 --> 00:08:39,599
that are on the top of our list as far

244
00:08:43,589 --> 00:08:42,080
as having contingency plans for and

245
00:08:45,110 --> 00:08:43,599
monitoring the health and safety of

246
00:08:46,630 --> 00:08:45,120
those and making sure we have them in

247
00:08:48,630 --> 00:08:46,640
peak performance

248
00:08:50,070 --> 00:08:48,640
when something fails on hubble or we

249
00:08:51,910 --> 00:08:50,080
have an anomaly something we don't

250
00:08:54,070 --> 00:08:51,920
understand one of my jobs is to bring

251
00:08:56,630 --> 00:08:54,080
together the experts which may be a

252
00:08:58,550 --> 00:08:56,640
thermal engineer a mechanical engineer

253
00:09:00,070 --> 00:08:58,560
an electrical engineer software engineer

254
00:09:02,550 --> 00:09:00,080
all these different people and we'll say

255
00:09:04,470 --> 00:09:02,560
you know how do we deal with this issue

256
00:09:06,389 --> 00:09:04,480
and how can we work around it and return

257
00:09:07,990 --> 00:09:06,399
back to peak science what you do is you

258
00:09:09,750 --> 00:09:08,000
come up with a list of what is available

259
00:09:12,070 --> 00:09:09,760
to you on the telescope in terms of

260
00:09:15,269 --> 00:09:12,080
potential i could close this relay or

261
00:09:17,509 --> 00:09:15,279
open that relay or turn on this box and

262
00:09:19,350 --> 00:09:17,519
i am continually amazed you have a

263
00:09:21,030 --> 00:09:19,360

telescope on orbit that you can't even

264
00:09:22,550 --> 00:09:21,040
see and all you're doing is looking at

265
00:09:23,590 --> 00:09:22,560
the data coming down to you from the

266
00:09:25,990 --> 00:09:23,600
ground

267
00:09:27,829 --> 00:09:26,000
these experts are able to use their

268
00:09:29,750 --> 00:09:27,839
ingenuity and come up with ways to

269
00:09:31,829 --> 00:09:29,760
continue to operate hubble and

270
00:09:33,910 --> 00:09:31,839
everything looks excellent and we have

271
00:09:38,470 --> 00:09:33,920
no reason not to expect that hubble will

272
00:09:43,910 --> 00:09:41,509
i personally am extremely grateful to

273
00:09:46,949 --> 00:09:43,920
the hubble operations team these people

274
00:09:48,829 --> 00:09:46,959
who work day and night to keep hubble

275
00:09:51,590 --> 00:09:48,839
operating

276
00:09:53,829 --> 00:09:51,600
providing exquisite science return

277
00:09:56,470 --> 00:09:53,839
giving us the information that we need

278
00:09:58,389 --> 00:09:56,480
to know how hubble's doing is it doing

279
00:10:00,710 --> 00:09:58,399
the kind of accurate pointing that we

280
00:10:02,790 --> 00:10:00,720
need is it getting the sensitivity in

281
00:10:05,110 --> 00:10:02,800
the various wavelengths of light in the

282
00:10:07,110 --> 00:10:05,120
various instruments that we need to have

283
00:10:09,670 --> 00:10:07,120
to do the science are we able to

284
00:10:11,829 --> 00:10:09,680
calibrate those observations in an

285
00:10:14,150 --> 00:10:11,839
accurate way we couldn't do any of those

286
00:10:16,949 --> 00:10:14,160
scientific analyses if we didn't have

287
00:10:19,030 --> 00:10:16,959
this team of operations experts behind

288
00:10:21,350 --> 00:10:19,040

the scenes making sure

289
00:10:24,150 --> 00:10:21,360
that the details of hubble's technical

290
00:10:27,030 --> 00:10:24,160
operations are being monitored being

291
00:10:28,150 --> 00:10:27,040
handled being managed being planned

292
00:10:33,070 --> 00:10:28,160
in