

1  
00:00:06,200 --> 00:00:09,780  
hello everybody and welcome to this

2  
00:00:08,369 --> 00:00:11,279  
week's Hubble hangout we have another

3  
00:00:09,779 --> 00:00:13,138  
great planet hangout plan for you this

4  
00:00:11,279 --> 00:00:14,939  
week my name is Tony Darnell I work at

5  
00:00:13,138 --> 00:00:16,378  
the Space Telescope Science Institute

6  
00:00:14,939 --> 00:00:20,429  
but before we get started on today's

7  
00:00:16,379 --> 00:00:23,700  
hangout I have big news everyone our own

8  
00:00:20,429 --> 00:00:25,589  
dr. Jason Keller lets be the JWST

9  
00:00:23,699 --> 00:00:27,809  
project scientist at the Space Telescope

10  
00:00:25,589 --> 00:00:29,460  
Science Institute has released or

11  
00:00:27,809 --> 00:00:31,969  
earlier this summer had released an

12  
00:00:29,460 --> 00:00:34,770  
audio segment for academic minute on

13  
00:00:31,969 --> 00:00:37,109  
exploring exoplanets and he is up for a

14  
00:00:34,770 --> 00:00:39,030  
listener's choice award and so I'd like

15  
00:00:37,109 --> 00:00:40,829  
to have to give a shout-out and ask you

16  
00:00:39,030 --> 00:00:43,320  
guys if you want to support help support

17  
00:00:40,829 --> 00:00:45,899  
some of the JWST mission I put a link to

18  
00:00:43,320 --> 00:00:47,730  
where you can vote on his audio segment

19  
00:00:45,899 --> 00:00:49,500  
down in the description box on both the

20  
00:00:47,729 --> 00:00:51,509  
G+ page and the youtube channel so

21  
00:00:49,500 --> 00:00:53,759  
please click on it and look for his uh

22  
00:00:51,509 --> 00:00:55,589  
look for his segment listen to it and if

23  
00:00:53,759 --> 00:00:57,899  
you'd like it even move out it's you

24  
00:00:55,590 --> 00:01:00,540  
it's a it's a good way to support the

25  
00:00:57,899 --> 00:01:03,210  
jdub ust project and dr. Jason Keller I

26  
00:01:00,539 --> 00:01:06,329  
so I encourage you to check it out and

27  
00:01:03,210 --> 00:01:07,890  
and let us know what you think I'd also

28  
00:01:06,329 --> 00:01:09,299  
like to take a minute on behalf of the

29

00:01:07,890 --> 00:01:11,609  
Space Telescope Science Institute and

30  
00:01:09,299 --> 00:01:16,048  
give a big congratulations to esa's

31  
00:01:11,609 --> 00:01:18,120  
rosetta canoe yeah because yesterday

32  
00:01:16,049 --> 00:01:20,940  
they successfully landed the fillet

33  
00:01:18,120 --> 00:01:22,020  
lander on comet 67p that's all i'm going

34  
00:01:20,939 --> 00:01:23,399  
to call it because I can't ever

35  
00:01:22,019 --> 00:01:25,829  
pronounce the rest of the stuff it was

36  
00:01:23,400 --> 00:01:28,590  
still awesome it was it was watching it

37  
00:01:25,829 --> 00:01:30,689  
the separation end and the landing live

38  
00:01:28,590 --> 00:01:34,140  
and I'm just like Nura on the edge of my

39  
00:01:30,689 --> 00:01:38,039  
seat like can you believe it we are on a

40  
00:01:34,140 --> 00:01:39,900  
comet now yeah we live in the Golden Age

41  
00:01:38,040 --> 00:01:41,970  
of astronomy one groups times anyway

42  
00:01:39,900 --> 00:01:43,950  
congrats all you guys wonderful work and

43  
00:01:41,969 --> 00:01:46,170

we look forward to seeing some science

44

00:01:43,950 --> 00:01:49,079

that come out of this stuff so anyway

45

00:01:46,170 --> 00:01:52,920

good job guys um okay today's hangout

46

00:01:49,079 --> 00:01:54,989

have you ever wondered how people point

47

00:01:52,920 --> 00:01:56,790

the Hubble Space Telescope how do you

48

00:01:54,989 --> 00:01:58,259

use this thing how does it work I mean

49

00:01:56,790 --> 00:02:00,900

we learned a couple of weeks ago that

50

00:01:58,259 --> 00:02:02,609

there's not astronauts up there steering

51

00:02:00,900 --> 00:02:04,350

and driving it around with as far as I

52

00:02:02,609 --> 00:02:06,599

know there's not little hamsters on

53

00:02:04,349 --> 00:02:08,638

wheels running around up there so how do

54

00:02:06,599 --> 00:02:10,769

you point and use the Hubble Space

55

00:02:08,639 --> 00:02:12,150

Telescope and how do you talk to it

56

00:02:10,769 --> 00:02:13,680

woody how do you know if something's

57

00:02:12,150 --> 00:02:14,439

gone wrong well today we've got some

58  
00:02:13,680 --> 00:02:15,849  
NASA

59  
00:02:14,439 --> 00:02:17,859  
we got some engineers from NASA Goddard

60  
00:02:15,849 --> 00:02:20,139  
who are here to help answer all of those

61  
00:02:17,860 --> 00:02:22,960  
questions and tell us how the Hubble is

62  
00:02:20,139 --> 00:02:25,750  
operated on a day to day basis before I

63  
00:02:22,960 --> 00:02:29,430  
get started though let me introduce my

64  
00:02:25,750 --> 00:02:32,349  
cohorts dr. carol christian from the HST

65  
00:02:29,430 --> 00:02:34,800  
she's the HSE outreach scientist she's

66  
00:02:32,349 --> 00:02:39,189  
here I she was every week hi Carol hello

67  
00:02:34,800 --> 00:02:43,510  
and soon-to-be doctor one day anyway uh

68  
00:02:39,189 --> 00:02:45,400  
Scott Lewis from talk is I would I don't

69  
00:02:43,509 --> 00:02:48,639  
know about that oh okay well it was a

70  
00:02:45,400 --> 00:02:51,730  
good I don't hate myself that much fair

71  
00:02:48,639 --> 00:02:55,179  
enough he's also here to help us drive

72  
00:02:51,729 --> 00:02:57,129  
the internet and do all things uh social

73  
00:02:55,180 --> 00:02:58,629  
media so welcome Scott and while we're

74  
00:02:57,129 --> 00:03:00,460  
on you why don't you give everybody an

75  
00:02:58,629 --> 00:03:02,740  
idea how they can interact with us

76  
00:03:00,460 --> 00:03:04,570  
during this hangout yes so the the

77  
00:03:02,740 --> 00:03:07,150  
biggest way to interact with us which

78  
00:03:04,569 --> 00:03:08,680  
just allows us to answer your questions

79  
00:03:07,150 --> 00:03:11,439  
is on the Q&A app so we have that

80  
00:03:08,680 --> 00:03:12,879  
enabled on both google+ and youtube if

81  
00:03:11,439 --> 00:03:14,109  
you're on youtube watching embedded

82  
00:03:12,879 --> 00:03:16,750  
somewhere will be on a lower left-hand

83  
00:03:14,110 --> 00:03:18,220  
side and yellow link it pops up and

84  
00:03:16,750 --> 00:03:19,840  
you're able to ask questions we're able

85  
00:03:18,219 --> 00:03:23,229  
to select them and answer them live on

86

00:03:19,840 --> 00:03:25,300  
air you can leave us our comments on the

87  
00:03:23,229 --> 00:03:28,060  
event page and google+ or comments on

88  
00:03:25,300 --> 00:03:31,209  
YouTube we will be seeing those and I am

89  
00:03:28,060 --> 00:03:34,090  
monitoring the Hubble hangout hashtag on

90  
00:03:31,209 --> 00:03:35,590  
Twitter and be sending out a bunch of

91  
00:03:34,090 --> 00:03:37,569  
other things out there too so we'd love

92  
00:03:35,590 --> 00:03:41,530  
to hear your comments and questions over

93  
00:03:37,569 --> 00:03:43,209  
on the Twitterverse awesome well done so

94  
00:03:41,530 --> 00:03:45,640  
let me introduce our guests let me start

95  
00:03:43,209 --> 00:03:48,280  
we have three engineers all of whom are

96  
00:03:45,639 --> 00:03:50,979  
in the control room of the Hubble Space

97  
00:03:48,280 --> 00:03:53,289  
Telescope the nerve center if you will

98  
00:03:50,979 --> 00:03:55,060  
I'll start with Scotts Wayne he is a

99  
00:03:53,289 --> 00:03:57,159  
systems engineer in charge of keeping

100  
00:03:55,060 --> 00:03:58,539

all the science instruments working it's

101

00:03:57,159 --> 00:03:59,769

his job to keep an eye on all the

102

00:03:58,539 --> 00:04:01,120

science instruments to make sure that

103

00:03:59,769 --> 00:04:03,760

they're working properly and it was

104

00:04:01,120 --> 00:04:05,879

stalled new software to help them do to

105

00:04:03,759 --> 00:04:09,129

help him go even better so welcome Scott

106

00:04:05,879 --> 00:04:12,219

I'm glad to have you here also with me

107

00:04:09,129 --> 00:04:13,930

is uh is Mike when's he is in charge of

108

00:04:12,219 --> 00:04:15,009

the fine guidance sensors on Hubble and

109

00:04:13,930 --> 00:04:17,680

we'll talk about what those are the

110

00:04:15,009 --> 00:04:20,250

Hangout progresses that responsible for

111

00:04:17,680 --> 00:04:23,949

holder for keeping Hubble pointed super

112

00:04:20,250 --> 00:04:26,978

accurately so he will be talking to us

113

00:04:23,949 --> 00:04:28,199

about those hi Mike glad to be here hey

114

00:04:26,978 --> 00:04:30,668

thank you



115  
00:04:28,199 --> 00:04:34,030  
Morgan van ours arsenal did I pronounce

116  
00:04:30,668 --> 00:04:36,099  
that right yeah okay she uh she works on

117  
00:04:34,029 --> 00:04:38,019  
all of it apparently she's a UH she

118  
00:04:36,100 --> 00:04:40,000  
works on everything so she's going to

119  
00:04:38,019 --> 00:04:41,319  
give us she's really going to give us a

120  
00:04:40,000 --> 00:04:43,660  
sort of a look at all the different

121  
00:04:41,319 --> 00:04:45,129  
aspects but most importantly you're

122  
00:04:43,660 --> 00:04:46,930  
going to talk about what they do when

123  
00:04:45,129 --> 00:04:48,870  
something goes wrong on Hubble and and

124  
00:04:46,930 --> 00:04:52,150  
how they handle it how they know so

125  
00:04:48,870 --> 00:04:53,978  
welcome guys so let me get started with

126  
00:04:52,149 --> 00:04:56,769  
what did we just start with you Mike are

127  
00:04:53,978 --> 00:04:59,319  
I'm sorry Morgan why don't you describe

128  
00:04:56,769 --> 00:05:02,049  
for us where you are right now where are

129  
00:04:59,319 --> 00:05:04,839  
you sitting okay so we are in the Space

130  
00:05:02,050 --> 00:05:07,210  
Telescope operations control center this

131  
00:05:04,839 --> 00:05:09,879  
room that we're in right now you can see

132  
00:05:07,209 --> 00:05:11,620  
um I'll hold my computer office for a

133  
00:05:09,879 --> 00:05:14,860  
second you can see a lot of different

134  
00:05:11,620 --> 00:05:17,168  
banks of computers a lot of stations and

135  
00:05:14,860 --> 00:05:19,210  
during activities if we're installing a

136  
00:05:17,168 --> 00:05:21,819  
new flight software or we have a problem

137  
00:05:19,209 --> 00:05:23,859  
going on this room will be full of

138  
00:05:21,819 --> 00:05:26,769  
systems engineers looking at the data

139  
00:05:23,860 --> 00:05:29,288  
and sending watching commands to the

140  
00:05:26,769 --> 00:05:31,598  
telescope in the room right next door to

141  
00:05:29,288 --> 00:05:34,449  
us is the mission operations room and

142  
00:05:31,598 --> 00:05:37,329  
that's where day-to-day rolling and

143

00:05:34,449 --> 00:05:39,038  
commanding comes from so we can that's

144  
00:05:37,329 --> 00:05:40,719  
where the flight ops team sets when

145  
00:05:39,038 --> 00:05:42,969  
they're doing operations that's also

146  
00:05:40,720 --> 00:05:45,699  
where we is really the heart of our

147  
00:05:42,970 --> 00:05:47,470  
automated operations um oh that's the

148  
00:05:45,699 --> 00:05:49,750  
room we don't want to be hitting ctrl

149  
00:05:47,470 --> 00:05:55,599  
alt delete I take it right that's what

150  
00:05:49,750 --> 00:05:57,038  
they do okay so so Mike want to give us

151  
00:05:55,598 --> 00:05:59,199  
a little background on what you do what

152  
00:05:57,038 --> 00:06:02,319  
you do and what your responsibilities

153  
00:05:59,199 --> 00:06:04,419  
are okay I'm responsible for what is

154  
00:06:02,319 --> 00:06:06,158  
defined idence sensors on the telescope

155  
00:06:04,418 --> 00:06:10,019  
these are actually there there there's a

156  
00:06:06,158 --> 00:06:12,550  
free sepron instrument um is it original

157  
00:06:10,019 --> 00:06:15,370

model which mints are actually placed

158

00:06:12,550 --> 00:06:16,538

about 90 degrees apart around Hubble so

159

00:06:15,370 --> 00:06:18,310

I'm actually putting guys who actually

160

00:06:16,538 --> 00:06:21,009

has three separate instruments that I

161

00:06:18,310 --> 00:06:22,930

get responsible for and these actually

162

00:06:21,009 --> 00:06:26,259

help help through the final bit of

163

00:06:22,930 --> 00:06:28,720

holding total lockdown at target to be

164

00:06:26,259 --> 00:06:31,990

able to telescope it moves in very

165

00:06:28,720 --> 00:06:33,669

interesting ways um knock on it exactly

166

00:06:31,990 --> 00:06:36,370

a multitude of different instruments

167

00:06:33,668 --> 00:06:38,500

working sort of been there but to find

168

00:06:36,370 --> 00:06:41,228

items sensors are the last ones they are

169

00:06:38,500 --> 00:06:42,060

to put lock it on supposed perfectly

170

00:06:41,228 --> 00:06:44,668

aligned for those

171

00:06:42,060 --> 00:06:46,079

very very long very funny okay I want to

172  
00:06:44,668 --> 00:06:47,849  
get to I want to get to some of the

173  
00:06:46,079 --> 00:06:49,319  
specifics of how Hubble is pointed and

174  
00:06:47,850 --> 00:06:52,680  
in particular the fine guidance sensor

175  
00:06:49,319 --> 00:06:54,750  
but so but but for now we'll just say

176  
00:06:52,680 --> 00:06:56,639  
that these are detectors that are on the

177  
00:06:54,750 --> 00:06:58,949  
focal plane of the telescope that are

178  
00:06:56,639 --> 00:07:00,569  
responsible for keeping track of stars

179  
00:06:58,949 --> 00:07:04,259  
and nearby objects to make sure that's

180  
00:07:00,569 --> 00:07:08,790  
pointed very precisely correct yes okay

181  
00:07:04,259 --> 00:07:12,930  
awesome so uh Scott science instruments

182  
00:07:08,790 --> 00:07:15,540  
all of them really know wow so you're

183  
00:07:12,930 --> 00:07:17,970  
the man if if it's tough if this stuff

184  
00:07:15,540 --> 00:07:20,810  
goes down you're having a bad day right

185  
00:07:17,970 --> 00:07:23,040  
so tell us a little bit about what your

186  
00:07:20,810 --> 00:07:25,228  
responsibilities are and maybe give us a

187  
00:07:23,040 --> 00:07:28,590  
quick overview of some of the science

188  
00:07:25,228 --> 00:07:30,180  
instruments on the on the Hubble um well

189  
00:07:28,589 --> 00:07:31,529  
we are responsible for all Sciences

190  
00:07:30,180 --> 00:07:34,199  
prints on Hubble as well as the computer

191  
00:07:31,529 --> 00:07:36,809  
that controls them there are five

192  
00:07:34,199 --> 00:07:38,478  
currently on board the first is the

193  
00:07:36,810 --> 00:07:41,069  
advanced camera for surveys or ACS

194  
00:07:38,478 --> 00:07:42,899  
second is the near infrared camera and

195  
00:07:41,069 --> 00:07:45,269  
multi-object spectrometer or Nick moss

196  
00:07:42,899 --> 00:07:47,819  
we have the space telescope imaging

197  
00:07:45,269 --> 00:07:50,699  
spectrograph or stiffs the cosmic

198  
00:07:47,819 --> 00:07:54,810  
origins spectrograph cos and wife is

199  
00:07:50,699 --> 00:07:57,719  
number three wide field or wfc3 my

200

00:07:54,810 --> 00:07:59,728  
personal favorite all on course we also

201  
00:07:57,720 --> 00:08:01,350  
have a sixth pseudo instrument that's

202  
00:07:59,728 --> 00:08:03,899  
the Nick most cooling system that we use

203  
00:08:01,350 --> 00:08:06,600  
to keep the infrared cameras in Nick

204  
00:08:03,899 --> 00:08:07,949  
moss cool what's in there is it does

205  
00:08:06,600 --> 00:08:09,510  
that have like liquid nitrogen or

206  
00:08:07,949 --> 00:08:12,930  
something liquid helium or something

207  
00:08:09,509 --> 00:08:14,550  
exactly cool helium yes okay and and

208  
00:08:12,930 --> 00:08:17,699  
what temperatures do these need to be op

209  
00:08:14,550 --> 00:08:18,990  
kept at when the system is operating

210  
00:08:17,699 --> 00:08:20,310  
it's currently dormant right now but

211  
00:08:18,990 --> 00:08:24,060  
when the system is operating and keeps

212  
00:08:20,310 --> 00:08:25,889  
the detectors at about 72 k ice and then

213  
00:08:24,060 --> 00:08:28,918  
things why do these instruments need to

214  
00:08:25,889 --> 00:08:30,449

be cold uh well if the instant the

215

00:08:28,918 --> 00:08:32,250  
infrared instrument especially needs to

216

00:08:30,449 --> 00:08:34,559  
be cold because it's really detecting

217

00:08:32,250 --> 00:08:36,240  
infrared radiation from you know the

218

00:08:34,559 --> 00:08:39,359  
very beginnings of the universe the

219

00:08:36,240 --> 00:08:42,000  
cosmic background so it's it's looking

220

00:08:39,360 --> 00:08:44,099  
at very long wavelengths I our imagery

221

00:08:42,000 --> 00:08:46,139  
so the detector needs to be cold for

222

00:08:44,099 --> 00:08:47,700  
that it also needs to be kind of cooled

223

00:08:46,139 --> 00:08:49,769  
and kept in an optimum temperature to

224

00:08:47,700 --> 00:08:51,870  
keep electronic noise from the detector

225

00:08:49,769 --> 00:08:53,879  
away from you know contaminating the

226

00:08:51,870 --> 00:08:55,929  
image as well right so the colder it is

227

00:08:53,879 --> 00:08:58,720  
the less noise and the less thermal

228

00:08:55,929 --> 00:09:00,219  
a signature it has to pick up I'm so



229  
00:08:58,720 --> 00:09:01,690  
happy I'm doing this hangout because one

230  
00:09:00,220 --> 00:09:04,720  
question I've been dying to ask somebody

231  
00:09:01,690 --> 00:09:06,460  
is I've use telescopes a lot and I've

232  
00:09:04,720 --> 00:09:08,350  
worked on telescopes on the ground in

233  
00:09:06,460 --> 00:09:09,910  
Chile and places like that and always

234  
00:09:08,350 --> 00:09:13,028  
whenever you build an instrument a big

235  
00:09:09,909 --> 00:09:14,620  
concern is stray light uh that's the

236  
00:09:13,028 --> 00:09:16,539  
light that doesn't you know it's just

237  
00:09:14,620 --> 00:09:18,580  
kind of reflects off of stuff inside the

238  
00:09:16,539 --> 00:09:21,699  
optical tube or it just reflects off of

239  
00:09:18,580 --> 00:09:24,940  
things in the telescope how bad or how

240  
00:09:21,700 --> 00:09:26,980  
good is the Hubble stray light situation

241  
00:09:24,940 --> 00:09:28,839  
I mean there is there a lot of a lot of

242  
00:09:26,980 --> 00:09:31,420  
it in theirs are very little compared to

243  
00:09:28,839 --> 00:09:34,360  
say a ground-based telescope what's the

244  
00:09:31,419 --> 00:09:36,699  
sense of that I like a pro actually it's

245  
00:09:34,360 --> 00:09:38,350  
all okay I'm sorry go ahead Mike well

246  
00:09:36,700 --> 00:09:42,129  
because I'm actually the one responsible

247  
00:09:38,350 --> 00:09:44,200  
for focusing the telescope um yeah when

248  
00:09:42,129 --> 00:09:45,879  
the astronomers come back and say the

249  
00:09:44,200 --> 00:09:47,350  
telescope isn't perfectly in focus i'm

250  
00:09:45,879 --> 00:09:48,879  
actually you have to command the

251  
00:09:47,350 --> 00:09:50,740  
secondary mirror we actually focus the

252  
00:09:48,879 --> 00:09:52,028  
telescope by moving the mirror you

253  
00:09:50,740 --> 00:09:54,940  
answered my question I'm just gonna ask

254  
00:09:52,028 --> 00:09:56,528  
you how it's done good going actually

255  
00:09:54,940 --> 00:09:58,330  
move it by microns I mean they'll

256  
00:09:56,528 --> 00:10:00,778  
actually come and say we want the mirror

257

00:09:58,330 --> 00:10:04,150  
move by two microns millions of an inch

258  
00:10:00,778 --> 00:10:05,980  
we can actually actually have it slicing

259  
00:10:04,149 --> 00:10:08,588  
it up but to answer your question by a

260  
00:10:05,980 --> 00:10:11,350  
straight line bubbles is extremely

261  
00:10:08,589 --> 00:10:14,290  
baffled on there actually 24 the tubes

262  
00:10:11,350 --> 00:10:17,860  
come to cut exactly down on that on the

263  
00:10:14,289 --> 00:10:19,689  
inside of the telescope is gamblers

264  
00:10:17,860 --> 00:10:22,120  
different model but it's got a very very

265  
00:10:19,690 --> 00:10:25,839  
special black paint on it that's baked

266  
00:10:22,120 --> 00:10:28,720  
not scatter light at all it great pains

267  
00:10:25,839 --> 00:10:31,330  
at on every anything bright that can

268  
00:10:28,720 --> 00:10:34,480  
start reflecting off on we actually

269  
00:10:31,330 --> 00:10:36,190  
can't on cams are very close to the Sun

270  
00:10:34,480 --> 00:10:39,670  
we actually have a very large angle that

271  
00:10:36,190 --> 00:10:42,700

we can't get close next any like we need

272

00:10:39,669 --> 00:10:44,110

parts the 52 the 28 like I need to

273

00:10:42,700 --> 00:10:46,690

interrupt you for just a moment can you

274

00:10:44,110 --> 00:10:48,459

please move closer to the mic all right

275

00:10:46,690 --> 00:10:50,950

thank you yeah you're just at the edge

276

00:10:48,458 --> 00:10:53,679

where it keeps up go ahead I'm sorry to

277

00:10:50,950 --> 00:10:56,079

interrupt no no no profit in it so

278

00:10:53,679 --> 00:10:58,208

mainly we keep this header light down by

279

00:10:56,078 --> 00:11:01,239

making sure we aren't making any sort of

280

00:10:58,208 --> 00:11:03,969

external light entering the IP on the

281

00:11:01,240 --> 00:11:07,990

planet even away from both the balloon

282

00:11:03,970 --> 00:11:09,759

in the Sun all right so so it

283

00:11:07,990 --> 00:11:11,409

the baffles which all telescopes have

284

00:11:09,759 --> 00:11:15,250

sort of reduced as sort of reflectivity

285

00:11:11,409 --> 00:11:16,838

in there and so let's get back to the

286  
00:11:15,250 --> 00:11:18,370  
focusing now you so you move this so

287  
00:11:16,839 --> 00:11:19,930  
there's a primary mirror that's the big

288  
00:11:18,370 --> 00:11:21,580  
mirror at the bottom of the two of the

289  
00:11:19,929 --> 00:11:23,469  
tube and inside that big cylinder and

290  
00:11:21,580 --> 00:11:25,870  
then up toward the end of the tube by

291  
00:11:23,470 --> 00:11:28,870  
the end by the by the cap that opens and

292  
00:11:25,870 --> 00:11:31,240  
closes is the secondary mirror and that

293  
00:11:28,870 --> 00:11:33,429  
is what you move back and forth in very

294  
00:11:31,240 --> 00:11:36,940  
tiny amounts to focus it and you could

295  
00:11:33,429 --> 00:11:38,319  
do it on order of microns what how it is

296  
00:11:36,940 --> 00:11:40,029  
that that can't be a stepper motor I

297  
00:11:38,320 --> 00:11:42,820  
mean what kind of how do you move things

298  
00:11:40,028 --> 00:11:45,519  
that way actually there there are

299  
00:11:42,820 --> 00:11:48,910  
separate stepper motors in there ganged

300  
00:11:45,519 --> 00:11:51,579  
up there's three sets of two reason you

301  
00:11:48,909 --> 00:11:53,199  
do this is one of those different motors

302  
00:11:51,580 --> 00:11:57,100  
brakes you want to be able to still

303  
00:11:53,200 --> 00:11:59,980  
focused telescope all right they are

304  
00:11:57,100 --> 00:12:01,269  
actually who redundant so we have sort

305  
00:11:59,980 --> 00:12:03,430  
of three sets of two but they are

306  
00:12:01,269 --> 00:12:05,829  
stepper motors in there just just gear

307  
00:12:03,429 --> 00:12:08,588  
down to where each of our steps is

308  
00:12:05,830 --> 00:12:11,290  
actually we could focus less than 1

309  
00:12:08,589 --> 00:12:16,600  
micron we actually are steps are about 6

310  
00:12:11,289 --> 00:12:18,250  
microns it's not hard because that's

311  
00:12:16,600 --> 00:12:20,320  
point since microns is very little

312  
00:12:18,250 --> 00:12:23,620  
motion at all but we can actually focus

313  
00:12:20,320 --> 00:12:26,230  
with when we focus really focusing about

314

00:12:23,620 --> 00:12:28,328  
my crop defiance instrument guys come

315  
00:12:26,230 --> 00:12:31,899  
back and they say oh yeah that's much

316  
00:12:28,328 --> 00:12:34,419  
better yeah majan really funny no one's

317  
00:12:31,899 --> 00:12:35,889  
saying much better much better okay so

318  
00:12:34,419 --> 00:12:37,569  
this may or may not be in your purview

319  
00:12:35,889 --> 00:12:39,699  
but let me ask you about flexure we all

320  
00:12:37,570 --> 00:12:42,700  
know that the Hubble is in orbit around

321  
00:12:39,700 --> 00:12:44,528  
the earth it goes it goes in bright

322  
00:12:42,700 --> 00:12:46,089  
spots where the temperature gets warm

323  
00:12:44,528 --> 00:12:49,299  
and then it goes behind the earth if

324  
00:12:46,089 --> 00:12:51,310  
it's dark and cold so this is this does

325  
00:12:49,299 --> 00:12:53,319  
the Hubble do much of this expanding and

326  
00:12:51,309 --> 00:12:56,708  
contracting over the course of an orbit

327  
00:12:53,320 --> 00:12:59,350  
and do is it much of a worry when you're

328  
00:12:56,708 --> 00:13:02,169

trying to focus it yeah actually they

329

00:12:59,350 --> 00:13:06,100  
eat telescope doesn't do a lot of

330

00:13:02,169 --> 00:13:09,849  
bending lecture because that pipe it all

331

00:13:06,100 --> 00:13:14,889  
covered in the insulation or get very

332

00:13:09,850 --> 00:13:17,769  
little on thermal changes on it and it's

333

00:13:14,889 --> 00:13:20,889  
a graphite epoxy record epoxy structure

334

00:13:17,769 --> 00:13:25,109  
to it but what we what's happened is

335

00:13:20,889 --> 00:13:28,448  
breathing in telescope actually it go it

336

00:13:25,109 --> 00:13:31,209  
moved a little bit in and out um that's

337

00:13:28,448 --> 00:13:32,498  
actually that says function of orbital

338

00:13:31,208 --> 00:13:35,498  
temperature that's actually something

339

00:13:32,499 --> 00:13:37,839  
the scientists have to live if they'd

340

00:13:35,499 --> 00:13:42,220  
actually take it out actually for the

341

00:13:37,839 --> 00:13:44,049  
temperatures then so we go on the

342

00:13:42,220 --> 00:13:47,678  
science data but it actually does change



343  
00:13:44,048 --> 00:13:49,298  
yeah order not to make month so we're

344  
00:13:47,678 --> 00:13:52,720  
focusing within two and the breathing is

345  
00:13:49,298 --> 00:13:55,418  
good Wow so yeah so that I can imagine

346  
00:13:52,720 --> 00:13:57,699  
that effect being really huge and and so

347  
00:13:55,418 --> 00:13:59,078  
they have a way of correcting for that

348  
00:13:57,698 --> 00:14:00,368  
after they get their images that is that

349  
00:13:59,078 --> 00:14:02,438  
what you're saying yeah yeah it's

350  
00:14:00,369 --> 00:14:05,649  
actually very well modeled because it's

351  
00:14:02,438 --> 00:14:08,409  
it's fairly well behaved and so actually

352  
00:14:05,649 --> 00:14:11,649  
they monitor a bunch of the temperature

353  
00:14:08,409 --> 00:14:12,850  
uh Elementary they'll actually to take

354  
00:14:11,649 --> 00:14:14,948  
it out from the data that they'll be

355  
00:14:12,850 --> 00:14:17,230  
able to wreck the date on the ground no

356  
00:14:14,948 --> 00:14:20,108  
it's out of focus by this much at this

357  
00:14:17,230 --> 00:14:23,019  
time so I was just going to say that

358  
00:14:20,109 --> 00:14:25,119  
that might just said something

359  
00:14:23,019 --> 00:14:26,980  
interesting you said telemetry so in it

360  
00:14:25,119 --> 00:14:29,439  
when you're getting images or science

361  
00:14:26,980 --> 00:14:31,600  
information there's a whole bucket load

362  
00:14:29,438 --> 00:14:34,149  
of other parameters that come down from

363  
00:14:31,600 --> 00:14:36,639  
the spacecraft that tell you things like

364  
00:14:34,149 --> 00:14:38,289  
temperature voltages all that kind of

365  
00:14:36,639 --> 00:14:40,709  
thing so it turns out that that

366  
00:14:38,289 --> 00:14:43,509  
engineering data is very useful for

367  
00:14:40,708 --> 00:14:45,188  
parameterizing these kind of things when

368  
00:14:43,509 --> 00:14:46,568  
you're trying to calibrate your science

369  
00:14:45,188 --> 00:14:49,149  
instrument you have to have all those

370  
00:14:46,568 --> 00:14:51,368  
engineering values it's it's a pain but

371

00:14:49,149 --> 00:14:54,278  
the astronomers love to be you know get

372  
00:14:51,369 --> 00:14:56,290  
the best data that we can and correct

373  
00:14:54,278 --> 00:14:58,899  
for you know model and correct for

374  
00:14:56,289 --> 00:15:01,988  
anything we can so that we remove all

375  
00:14:58,899 --> 00:15:05,470  
that instrument signature or telescope

376  
00:15:01,989 --> 00:15:09,309  
signature from the data so Morgan in the

377  
00:15:05,470 --> 00:15:10,928  
description i got from from mike to sort

378  
00:15:09,308 --> 00:15:13,719  
of describing what you did he used the

379  
00:15:10,928 --> 00:15:15,730  
term hurting cat so what I guess what

380  
00:15:13,720 --> 00:15:18,399  
you what a part of your job is you need

381  
00:15:15,730 --> 00:15:19,959  
to make sure that when the engineers and

382  
00:15:18,399 --> 00:15:22,720  
all the different subsystems need to be

383  
00:15:19,958 --> 00:15:24,698  
either worked on or maintained in some

384  
00:15:22,720 --> 00:15:26,259  
way you kind of coordinate that can you

385  
00:15:24,698 --> 00:15:29,498

385 speak a little bit about that right

386

00:15:26,259 --> 00:15:31,239

exactly so if you have we have a lot of

387

00:15:29,499 --> 00:15:33,189

different subsystems on the telescope

388

00:15:31,239 --> 00:15:34,810

you have the power subsystem obviously

389

00:15:33,188 --> 00:15:37,539

supplying power and everybody

390

00:15:34,809 --> 00:15:39,609

Scott's science instruments make and

391

00:15:37,539 --> 00:15:42,339

another group is working on the pointing

392

00:15:39,610 --> 00:15:43,930

and the fine guidance but really it's a

393

00:15:42,340 --> 00:15:45,730

whole system that has to work together

394

00:15:43,929 --> 00:15:48,399

it's a telescope but it's also a

395

00:15:45,730 --> 00:15:50,230

spacecraft and you need everything to

396

00:15:48,399 --> 00:15:52,659

get the picture out at the end right you

397

00:15:50,230 --> 00:15:54,159

need the power to be supplying power to

398

00:15:52,659 --> 00:15:56,230

get the communications and the

399

00:15:54,159 --> 00:15:58,028

instruments all working together so

400  
00:15:56,230 --> 00:15:59,860  
there are three of us on the systems

401  
00:15:58,028 --> 00:16:02,080  
management team that really try to make

402  
00:15:59,860 --> 00:16:04,000  
sure everybody talking to each other

403  
00:16:02,080 --> 00:16:06,490  
everybody's aware of what's going on on

404  
00:16:04,000 --> 00:16:08,350  
the telescope and if that needs to

405  
00:16:06,490 --> 00:16:10,659  
upload some new flight software to one

406  
00:16:08,350 --> 00:16:12,430  
of the instruments for example that's

407  
00:16:10,659 --> 00:16:14,409  
going to involve the management group

408  
00:16:12,429 --> 00:16:15,819  
that's sending up the commands and the

409  
00:16:14,409 --> 00:16:17,350  
flight software group it's obviously

410  
00:16:15,820 --> 00:16:19,690  
developing and testing the flight

411  
00:16:17,350 --> 00:16:21,460  
software and so I'll be involved to make

412  
00:16:19,690 --> 00:16:23,620  
sure that everything's tested correctly

413  
00:16:21,460 --> 00:16:26,080  
make sure that all the commands going to

414  
00:16:23,620 --> 00:16:27,669  
work together correctly and just that

415  
00:16:26,080 --> 00:16:30,220  
everybody's pointing in the same

416  
00:16:27,669 --> 00:16:31,838  
direction and on the same page so how

417  
00:16:30,220 --> 00:16:33,250  
much power does Hubble use let's say

418  
00:16:31,839 --> 00:16:34,870  
everything's cranking and you're doing

419  
00:16:33,250 --> 00:16:38,320  
an observation how much power does it

420  
00:16:34,870 --> 00:16:40,720  
use oh goodness oh this is actually an

421  
00:16:38,320 --> 00:16:43,570  
interesting number in dissin it's always

422  
00:16:40,720 --> 00:16:45,430  
amazes me when we're running up with all

423  
00:16:43,570 --> 00:16:49,810  
the instruments and do from observations

424  
00:16:45,429 --> 00:16:52,359  
will be pulling 88 on our our buses now

425  
00:16:49,809 --> 00:16:56,229  
hearing the day during the day the solar

426  
00:16:52,360 --> 00:16:58,330  
arrays give it by that be for 45 minutes

427  
00:16:56,230 --> 00:16:59,950  
every orbit we found like a 96 minute

428

00:16:58,330 --> 00:17:01,810  
orbit half of its during the day half of

429  
00:16:59,950 --> 00:17:05,980  
its of the night roughly for half that

430  
00:17:01,809 --> 00:17:08,230  
night we pull 80 amps out of bad wait a

431  
00:17:05,980 --> 00:17:09,730  
minute wow that's got to be letting out

432  
00:17:08,230 --> 00:17:12,370  
some he too so I guess you got to

433  
00:17:09,730 --> 00:17:15,699  
protect from that as well right yeah

434  
00:17:12,369 --> 00:17:17,169  
cool okay well uh so-so Hubble's up

435  
00:17:15,699 --> 00:17:20,949  
there I'm like maybe this one's one for

436  
00:17:17,170 --> 00:17:24,459  
Scott Swain so we're up Hubble's up

437  
00:17:20,949 --> 00:17:27,429  
there you're doing some observations do

438  
00:17:24,459 --> 00:17:29,230  
the images go straight to earth or do

439  
00:17:27,429 --> 00:17:31,960  
they sit on Hubble for a while for a

440  
00:17:29,230 --> 00:17:35,079  
transmission period they actually do

441  
00:17:31,960 --> 00:17:37,360  
they on board for a limited time there's

442  
00:17:35,079 --> 00:17:39,879

what we call buffer RAM in each of the

443

00:17:37,359 --> 00:17:41,649  
instruments so when an instrument

444

00:17:39,880 --> 00:17:44,370  
collects a given image it sits in its

445

00:17:41,650 --> 00:17:47,230  
its own buffer ram for a period of time

446

00:17:44,369 --> 00:17:48,459  
until the solid-state recorders on board

447

00:17:47,230 --> 00:17:49,690  
are available

448

00:17:48,460 --> 00:17:51,309  
and then we can move that data to the

449

00:17:49,690 --> 00:17:53,289  
solid state quarters that we have on

450

00:17:51,309 --> 00:17:56,470  
board we have two of them on board there

451

00:17:53,289 --> 00:17:58,450  
are about 12 gate capacity each all is a

452

00:17:56,470 --> 00:18:00,039  
solid state drives you mean yeah so

453

00:17:58,450 --> 00:18:04,120  
essentially basically solid state hard

454

00:18:00,039 --> 00:18:06,940  
drives and about 10 depending on how

455

00:18:04,119 --> 00:18:09,250  
much data we collect in a day about 10

456

00:18:06,940 --> 00:18:12,279  
to 15 times per day we'll dump those



457  
00:18:09,250 --> 00:18:13,930  
recorders to the ground and then get

458  
00:18:12,279 --> 00:18:16,899  
that data on on the ground to be

459  
00:18:13,930 --> 00:18:18,610  
processed so so let's talk about that

460  
00:18:16,900 --> 00:18:22,810  
how much data does it generally produce

461  
00:18:18,609 --> 00:18:23,829  
on average a day ah on average and it's

462  
00:18:22,809 --> 00:18:25,720  
going to depend on what observations

463  
00:18:23,829 --> 00:18:28,599  
you're doing and you know what

464  
00:18:25,720 --> 00:18:31,120  
configuration is but usually it's taking

465  
00:18:28,599 --> 00:18:32,769  
down about 25 gigabits a day right

466  
00:18:31,119 --> 00:18:35,079  
because spectrograph data that doesn't

467  
00:18:32,769 --> 00:18:36,609  
take up as much space to say a whip c3

468  
00:18:35,079 --> 00:18:38,559  
image might or something like that what

469  
00:18:36,609 --> 00:18:40,089  
are the okay I just this is a real nerdy

470  
00:18:38,559 --> 00:18:43,210  
question and most people may not know

471  
00:18:40,089 --> 00:18:46,899  
and but I want to know what are what is

472  
00:18:43,210 --> 00:18:49,329  
the bit depth on the on the hip with c3

473  
00:18:46,900 --> 00:18:52,090  
that is every pixel is is it a is it a

474  
00:18:49,329 --> 00:18:53,949  
float is it a double because every in a

475  
00:18:52,089 --> 00:18:57,099  
camera and a CCD just so you know there

476  
00:18:53,950 --> 00:18:59,920  
are raised of charges that get turned

477  
00:18:57,099 --> 00:19:03,009  
into a number based on the readout of

478  
00:18:59,920 --> 00:19:04,150  
the thing and they can be different bit

479  
00:19:03,009 --> 00:19:05,289  
depths those numbers actually mean

480  
00:19:04,150 --> 00:19:07,690  
something there are actually a

481  
00:19:05,289 --> 00:19:09,789  
scientific unit and I'm just curious for

482  
00:19:07,690 --> 00:19:11,140  
my own my own site what are though what

483  
00:19:09,789 --> 00:19:14,500  
is the bit depth of the whiskey three

484  
00:19:11,140 --> 00:19:17,200  
you know well it's a working porque

485

00:19:14,500 --> 00:19:20,349  
detector I though you know 16 million

486  
00:19:17,200 --> 00:19:22,240  
pixels Oh exactly the depth I'm not

487  
00:19:20,349 --> 00:19:23,740  
exactly sure that would probably be a

488  
00:19:22,240 --> 00:19:25,930  
better question for one of the detector

489  
00:19:23,740 --> 00:19:27,880  
or scientists okay I'll ask that too i'm

490  
00:19:25,930 --> 00:19:29,440  
just you just popped in my head i know

491  
00:19:27,880 --> 00:19:31,420  
there are some cameras there doubles in

492  
00:19:29,440 --> 00:19:32,529  
which case there are huge images that

493  
00:19:31,420 --> 00:19:34,120  
come down and sometimes they're just

494  
00:19:32,529 --> 00:19:36,849  
regular floats I was just curious about

495  
00:19:34,119 --> 00:19:39,579  
that yeah so this is okay so is our

496  
00:19:36,849 --> 00:19:41,799  
their largest image definite okay so in

497  
00:19:39,579 --> 00:19:44,189  
addition Morgan to the images that Mike

498  
00:19:41,799 --> 00:19:46,389  
are that that Scott is dealing with or

499  
00:19:44,190 --> 00:19:47,890

coordinating there's this thing Carol

500

00:19:46,390 --> 00:19:50,950

talked about with telemetry is that a

501

00:19:47,890 --> 00:19:53,530

constant stream of data or is it only

502

00:19:50,950 --> 00:19:55,750

coming with the other stuff it's only

503

00:19:53,529 --> 00:19:57,460

coming with the other stuff but as Scott

504

00:19:55,750 --> 00:20:00,640

said you have all the reporters on board

505

00:19:57,460 --> 00:20:02,329

so all the telemetry is recorded and

506

00:20:00,640 --> 00:20:04,100

then when we get data back

507

00:20:02,329 --> 00:20:05,928

if we go through a time when we don't

508

00:20:04,099 --> 00:20:08,808

have communication when we get the data

509

00:20:05,929 --> 00:20:11,450

back all of the telemetry comes down so

510

00:20:08,808 --> 00:20:14,058

by be it by the end of any given 24 hour

511

00:20:11,450 --> 00:20:16,909

period will have the telemetry for that

512

00:20:14,058 --> 00:20:19,428

whole day so you know something in real

513

00:20:16,909 --> 00:20:22,190

time will still get it you're not in

514  
00:20:19,429 --> 00:20:27,769  
actual constant contact then with Hubble

515  
00:20:22,190 --> 00:20:29,899  
right right hmm I'm close to 50 at the

516  
00:20:27,769 --> 00:20:31,278  
time when we can see real data versus

517  
00:20:29,898 --> 00:20:33,319  
the time when we're recording and then

518  
00:20:31,278 --> 00:20:35,058  
we'll get the data back down and you do

519  
00:20:33,319 --> 00:20:37,428  
this through is it through the tea dress

520  
00:20:35,058 --> 00:20:40,038  
system yeah exactly so let's talk about

521  
00:20:37,429 --> 00:20:42,590  
that a little bit I'll have I think I

522  
00:20:40,038 --> 00:20:44,480  
have Scott has a graphic of what the

523  
00:20:42,589 --> 00:20:45,709  
teacher system looks like Morgan are you

524  
00:20:44,480 --> 00:20:48,860  
the one to talk about that or should I

525  
00:20:45,710 --> 00:20:52,159  
ask Mike um I think any other scandal

526  
00:20:48,859 --> 00:20:54,619  
all right ok so the tea dress let's talk

527  
00:20:52,159 --> 00:20:57,440  
this is the main system that nASA has in

528  
00:20:54,619 --> 00:21:00,558  
orbit over the planet earth that is

529  
00:20:57,440 --> 00:21:02,840  
designed to do what so cheaters works

530  
00:21:00,558 --> 00:21:05,509  
not just with Hubble but with most of

531  
00:21:02,839 --> 00:21:08,028  
NASA satellites it tracks the satellites

532  
00:21:05,509 --> 00:21:10,158  
and then also relays the data from the

533  
00:21:08,028 --> 00:21:13,638  
satellites which may be in lower for bed

534  
00:21:10,159 --> 00:21:16,070  
or various orbit up to the two satellite

535  
00:21:13,638 --> 00:21:17,750  
and then down to the ground system so we

536  
00:21:16,069 --> 00:21:20,119  
don't the ground station so we don't

537  
00:21:17,750 --> 00:21:22,609  
need to always be within view of the

538  
00:21:20,119 --> 00:21:26,148  
ground station to be communicating and

539  
00:21:22,609 --> 00:21:28,219  
is there a primary a zero is there a

540  
00:21:26,148 --> 00:21:30,109  
primary station that we use for Hubble

541  
00:21:28,220 --> 00:21:33,200  
or is it just where ever happens to be

542

00:21:30,109 --> 00:21:36,199  
in range and the as far as how Scott has

543  
00:21:33,200 --> 00:21:38,480  
it up now oh great as far as the

544  
00:21:36,200 --> 00:21:40,220  
satellites go will use whatever to frisk

545  
00:21:38,480 --> 00:21:42,230  
we're assigned whichever we can see and

546  
00:21:40,220 --> 00:21:45,950  
then the data for Hubble get sent down

547  
00:21:42,230 --> 00:21:48,409  
to white sands and they expert out here

548  
00:21:45,950 --> 00:21:50,269  
via on the ground I usually live in

549  
00:21:48,409 --> 00:21:53,990  
Alamogordo I didn't know that so Hubble

550  
00:21:50,269 --> 00:21:55,579  
data goes down to white sands and thinks

551  
00:21:53,990 --> 00:21:58,730  
that's got another graphic that actually

552  
00:21:55,579 --> 00:22:00,109  
shows on the sort of data path yeah

553  
00:21:58,730 --> 00:22:02,210  
there should be a data flow graphic in

554  
00:22:00,109 --> 00:22:09,009  
there that shows that bad okay well he's

555  
00:22:02,210 --> 00:22:11,419  
looking that up so the the the the

556  
00:22:09,009 --> 00:22:13,398

teedra system which is not as you point

557

00:22:11,419 --> 00:22:15,409

out not necessarily just for Hubble it's

558

00:22:13,398 --> 00:22:15,919

used for lots of other I think GISS uses

559

00:22:15,409 --> 00:22:17,480

it

560

00:22:15,920 --> 00:22:20,690

and anything in orbit it needs to

561

00:22:17,480 --> 00:22:23,660

communicate with ground stations does

562

00:22:20,690 --> 00:22:26,150

this so I hear it is he's got it up now

563

00:22:23,660 --> 00:22:30,050

so uh let's see uh who wants to talk

564

00:22:26,150 --> 00:22:32,360

about this mike is this you um yeah I is

565

00:22:30,049 --> 00:22:34,339

earline can i I mean okay this like this

566

00:22:32,359 --> 00:22:37,659

is this is a schematic showing how data

567

00:22:34,339 --> 00:22:39,889

get off of Hubble and down to Goddard

568

00:22:37,660 --> 00:22:41,420

yeah we actually have what's known as

569

00:22:39,890 --> 00:22:43,130

high gain antennas and those are little

570

00:22:41,420 --> 00:22:45,050

antennas are sticking off the sides and



571  
00:22:43,130 --> 00:22:47,240  
we actually have to point those at the t

572  
00:22:45,049 --> 00:22:51,019  
/ satellites those are Hubble earrings

573  
00:22:47,240 --> 00:22:54,109  
yeah yeah the periods um and so our data

574  
00:22:51,019 --> 00:22:55,759  
goes to Tigres it's a relay satellite

575  
00:22:54,109 --> 00:22:57,679  
which means it just bounces it back down

576  
00:22:55,759 --> 00:22:58,910  
to ground but the nice thing about the

577  
00:22:57,680 --> 00:23:00,470  
teacher satellites they're always

578  
00:22:58,910 --> 00:23:03,019  
pointed down they always go down to the

579  
00:23:00,470 --> 00:23:04,759  
same ground station at White Sands um so

580  
00:23:03,019 --> 00:23:07,190  
that's coming down you know that's ready

581  
00:23:04,759 --> 00:23:10,339  
munication from white sands it comes

582  
00:23:07,190 --> 00:23:12,529  
over here to Goddard it comes across the

583  
00:23:10,339 --> 00:23:15,259  
data line we actually ship it up to the

584  
00:23:12,529 --> 00:23:17,269  
Institute so it's actually traveled way

585  
00:23:15,259 --> 00:23:19,039  
down in there's actually a significant

586  
00:23:17,269 --> 00:23:21,410  
enough delay we actually have to account

587  
00:23:19,039 --> 00:23:22,849  
for the light travel time for the data

588  
00:23:21,410 --> 00:23:25,310  
coming down when we're looking at our

589  
00:23:22,849 --> 00:23:26,599  
clock signals oh I can imagine yeah

590  
00:23:25,309 --> 00:23:28,609  
because it's hot it's all it's high

591  
00:23:26,599 --> 00:23:31,189  
enough up I would imagine so what about

592  
00:23:28,609 --> 00:23:32,569  
that data link between New Mexico and

593  
00:23:31,190 --> 00:23:35,390  
Goddard is that just a regular internet

594  
00:23:32,569 --> 00:23:37,639  
connection or is it something else it's

595  
00:23:35,390 --> 00:23:40,460  
a very little high speed being with

596  
00:23:37,640 --> 00:23:42,620  
special i mean connected dedicated

597  
00:23:40,460 --> 00:23:46,370  
landline dedicated data connection

598  
00:23:42,619 --> 00:23:48,409  
between else in there so i think that if

599

00:23:46,369 --> 00:23:50,199  
i remember right nasa is upgrading tea

600  
00:23:48,410 --> 00:23:52,820  
dress as well or maybe they already have

601  
00:23:50,200 --> 00:23:54,890  
but this is supposed to give us i think

602  
00:23:52,819 --> 00:23:57,049  
more coverage and more capability as

603  
00:23:54,890 --> 00:23:59,560  
well so how powerful are those little

604  
00:23:57,049 --> 00:24:04,789  
earrings there there's old dish antennas

605  
00:23:59,559 --> 00:24:07,000  
um um not all that powerful i don't off

606  
00:24:04,789 --> 00:24:09,079  
tell my head i don't remember what the

607  
00:24:07,000 --> 00:24:10,700  
but they don't need to be that powerful

608  
00:24:09,079 --> 00:24:12,710  
since the satellites not that far away

609  
00:24:10,700 --> 00:24:14,120  
all right thing is we have to be able to

610  
00:24:12,710 --> 00:24:16,610  
point out the satellites we actually

611  
00:24:14,119 --> 00:24:18,949  
have a only like a five-degree tolerance

612  
00:24:16,609 --> 00:24:21,079  
we have the chant in as pointed exactly

613  
00:24:18,950 --> 00:24:22,640

where tea dresses and we gotta realize

614

00:24:21,079 --> 00:24:25,039

we're zooming around the earth at eight

615

00:24:22,640 --> 00:24:29,030

else might you know 18,000 miles an hour

616

00:24:25,039 --> 00:24:29,569

and theorists are the air geo station

617

00:24:29,029 --> 00:24:31,399

there there

618

00:24:29,569 --> 00:24:33,109

stationary so you have to be swinging

619

00:24:31,400 --> 00:24:34,970

this antenna as we're moving around to

620

00:24:33,109 --> 00:24:37,039

keep peterson subtract and that's part

621

00:24:34,970 --> 00:24:38,420

of what the qur'an board does it knows

622

00:24:37,039 --> 00:24:39,980

where teeters is it knows where the

623

00:24:38,420 --> 00:24:42,080

telescope isn't it therefore it knows

624

00:24:39,980 --> 00:24:43,640

how to move the antennas so you take

625

00:24:42,079 --> 00:24:45,470

some observations you gather some data

626

00:24:43,640 --> 00:24:46,910

you fill up the salt the solid state

627

00:24:45,470 --> 00:24:49,579

hard drives on there and then you got to

628  
00:24:46,910 --> 00:24:52,460  
point it over at teedra satellite to get

629  
00:24:49,579 --> 00:24:55,250  
it all off of there right yeah now I

630  
00:24:52,460 --> 00:24:57,019  
mean a lot of times when we if we can

631  
00:24:55,250 --> 00:24:58,549  
see it whenever we can see the teeter

632  
00:24:57,019 --> 00:25:00,859  
satellites will be streaming what we

633  
00:24:58,549 --> 00:25:02,509  
call real time to limit rate down as

634  
00:25:00,859 --> 00:25:04,759  
long as the teacher satellites are busy

635  
00:25:02,509 --> 00:25:06,650  
with someone else let us blim tree down

636  
00:25:04,759 --> 00:25:08,569  
don't get science data down that way all

637  
00:25:06,650 --> 00:25:11,300  
the science data comes down and dumps I

638  
00:25:08,569 --> 00:25:13,309  
mean these are people out there there's

639  
00:25:11,299 --> 00:25:15,349  
a whole scheduling system of the figure

640  
00:25:13,309 --> 00:25:18,440  
out how how and when to dump to tape

641  
00:25:15,349 --> 00:25:19,909  
recorders because um eight recorders are

642  
00:25:18,440 --> 00:25:21,170  
great because you can be dumping them at

643  
00:25:19,910 --> 00:25:22,580  
the same time you're filling the other

644  
00:25:21,170 --> 00:25:24,289  
end of them you're dumping the backside

645  
00:25:22,579 --> 00:25:26,089  
as you're filling the front end but you

646  
00:25:24,289 --> 00:25:29,420  
have to this is they don't ever over

647  
00:25:26,089 --> 00:25:32,869  
right so that's all taken care of by our

648  
00:25:29,420 --> 00:25:34,940  
ground system computers all pre-planned

649  
00:25:32,869 --> 00:25:38,239  
everything that happens on hubble free

650  
00:25:34,940 --> 00:25:39,860  
plan to the second and this is an load

651  
00:25:38,240 --> 00:25:41,210  
for sending up we actually send up

652  
00:25:39,859 --> 00:25:43,339  
here's what you're doing for the next

653  
00:25:41,210 --> 00:25:47,150  
eight hours every second for the next

654  
00:25:43,339 --> 00:25:49,039  
hours back to what I just had this image

655  
00:25:47,150 --> 00:25:52,280  
when you said dump have not but not very

656

00:25:49,039 --> 00:25:57,109  
scientific terminology ready for the

657  
00:25:52,279 --> 00:25:59,240  
Hubble dump today today today I just

658  
00:25:57,109 --> 00:26:01,399  
thought you were talking about I am I'm

659  
00:25:59,240 --> 00:26:03,140  
like 12 years old I just I can actually

660  
00:26:01,400 --> 00:26:06,440  
a question no that was brought up last

661  
00:26:03,140 --> 00:26:08,210  
week in our past Hubble hang out but I

662  
00:26:06,440 --> 00:26:09,590  
think it really ties in with the

663  
00:26:08,210 --> 00:26:11,660  
gathering the data and sending it back

664  
00:26:09,589 --> 00:26:15,589  
is where we talked about the South

665  
00:26:11,660 --> 00:26:17,660  
Atlantic anomaly and how you guys work

666  
00:26:15,589 --> 00:26:19,639  
with that and if if if someone could

667  
00:26:17,660 --> 00:26:21,560  
explain what that is and then what you

668  
00:26:19,640 --> 00:26:26,270  
have to do to compensate for that sounds

669  
00:26:21,559 --> 00:26:29,929  
Atlantic anomaly okay I can take a first

670  
00:26:26,269 --> 00:26:31,819

practice the South Atlantic anomaly is

671

00:26:29,930 --> 00:26:34,340

it's a region of space where there's

672

00:26:31,819 --> 00:26:36,919

actually just higher radiation than the

673

00:26:34,339 --> 00:26:38,869

normal and so we actually happened to

674

00:26:36,920 --> 00:26:41,150

travel through it orbit takes us through

675

00:26:38,869 --> 00:26:43,189

this alpha lambda novel much once in

676

00:26:41,150 --> 00:26:44,780

orbit they're actually some orbits that

677

00:26:43,190 --> 00:26:47,680

because if you look at the way the orbit

678

00:26:44,779 --> 00:26:50,000

tracks across sometimes we put out of it

679

00:26:47,680 --> 00:26:52,130

then we're inside of it we actually

680

00:26:50,000 --> 00:26:54,529

don't do any observations because um

681

00:26:52,130 --> 00:26:57,230

everyone who passes the computers will

682

00:26:54,529 --> 00:26:59,180

get what we call a zero will turn to a

683

00:26:57,230 --> 00:27:00,680

one in the mills sometimes do something

684

00:26:59,180 --> 00:27:03,529

you don't want them to be viewing so we



685  
00:27:00,680 --> 00:27:05,060  
tend to shut down um guiding you just

686  
00:27:03,529 --> 00:27:08,089  
tell the telescope wait until you're out

687  
00:27:05,059 --> 00:27:10,159  
of here and continue on doing what your

688  
00:27:08,089 --> 00:27:12,319  
observation is and so we sort of ride

689  
00:27:10,160 --> 00:27:14,509  
through the Southland not only we sort

690  
00:27:12,319 --> 00:27:18,200  
of cover our eyes and ears and go okay

691  
00:27:14,509 --> 00:27:19,549  
we are going for actually something we

692  
00:27:18,200 --> 00:27:23,330  
can actually do through this health

693  
00:27:19,549 --> 00:27:26,599  
clinic ok I want to I want to ask about

694  
00:27:23,329 --> 00:27:28,009  
pointing again the does how so you

695  
00:27:26,599 --> 00:27:29,689  
you're in charge of the fine guidance

696  
00:27:28,009 --> 00:27:33,980  
system which is responsible for keeping

697  
00:27:29,690 --> 00:27:37,130  
Hubble very closely uh in line with what

698  
00:27:33,980 --> 00:27:38,900  
it's observing well how do you move

699

00:27:37,130 --> 00:27:41,150

Hubble there are their jets on it are

700

00:27:38,900 --> 00:27:43,970

there little little rockets at fire what

701

00:27:41,150 --> 00:27:46,550

what makes Hubble move you know now no

702

00:27:43,970 --> 00:27:48,200

that's actually good one because people

703

00:27:46,549 --> 00:27:51,169

don't know this thing is the size of a

704

00:27:48,200 --> 00:27:53,059

school bus and you about the weight the

705

00:27:51,170 --> 00:27:55,220

question do you move it there are no

706

00:27:53,059 --> 00:27:57,799

jets there are no gas that there's no

707

00:27:55,220 --> 00:28:00,529

propulsion system on it what we have are

708

00:27:57,799 --> 00:28:04,779

what we call reaction they're very big

709

00:28:00,529 --> 00:28:06,649

very very heavy feels that we spend and

710

00:28:04,779 --> 00:28:08,629

imagined a lot of you people have been

711

00:28:06,650 --> 00:28:10,850

at science museums where you take the

712

00:28:08,630 --> 00:28:12,290

spinning bicycle wheel and you twist it

713

00:28:10,849 --> 00:28:14,209  
on when you're sitting on the stool and

714  
00:28:12,289 --> 00:28:16,159  
it turns you well it turns out by these

715  
00:28:14,210 --> 00:28:19,130  
wheels that you're held at certain

716  
00:28:16,160 --> 00:28:21,230  
angles when we speed them up it actually

717  
00:28:19,130 --> 00:28:22,940  
cause it's a telescope to twist its

718  
00:28:21,230 --> 00:28:25,339  
conservation of angular momentum for you

719  
00:28:22,940 --> 00:28:27,559  
physics spoke about um and so we

720  
00:28:25,339 --> 00:28:30,859  
actually move the telescope I spitting

721  
00:28:27,559 --> 00:28:33,139  
up wheels and it it's a slow way to do

722  
00:28:30,859 --> 00:28:35,389  
it in fact Hubble takes a long time to

723  
00:28:33,140 --> 00:28:36,980  
move and the fastest trouble really

724  
00:28:35,390 --> 00:28:41,090  
moves from one point the sky to the

725  
00:28:36,980 --> 00:28:43,400  
other is about the scenes on a clock as

726  
00:28:41,089 --> 00:28:46,369  
is the what on a clock you word and you

727  
00:28:43,400 --> 00:28:48,530

committed the minute he no okay the

728

00:28:46,369 --> 00:28:51,619

clock and so for us to do a 90 degrees

729

00:28:48,529 --> 00:28:53,389

flew it takes us about 15 minutes but we

730

00:28:51,619 --> 00:28:56,569

do it like speak about turning up these

731

00:28:53,390 --> 00:28:58,100

needs so we actually we just need

732

00:28:56,569 --> 00:29:00,109

he ducked wheels in either one direction

733

00:28:58,099 --> 00:29:02,359

or the other direction they work the

734

00:29:00,109 --> 00:29:04,339

telescope do it and so we can do that as

735

00:29:02,359 --> 00:29:06,199

long as we have power will never run out

736

00:29:04,339 --> 00:29:09,019

of capability to what speeds them up

737

00:29:06,200 --> 00:29:10,278

electric motors or what yeah yeah yeah

738

00:29:09,019 --> 00:29:13,069

we're actually pulling power off the

739

00:29:10,278 --> 00:29:14,808

batteries and its motor the computer on

740

00:29:13,069 --> 00:29:16,879

board that says I need to move it this

741

00:29:14,808 --> 00:29:18,168

direction so I need to spend up you know

742  
00:29:16,880 --> 00:29:20,840  
there's three wheels that are spaced

743  
00:29:18,169 --> 00:29:22,850  
different angles so it knows and one up

744  
00:29:20,839 --> 00:29:25,308  
this much to up this much up that much

745  
00:29:22,849 --> 00:29:28,038  
now move the telescope and then it spins

746  
00:29:25,308 --> 00:29:29,240  
it down to stop up is there any mo is

747  
00:29:28,038 --> 00:29:30,440  
there any redundancy built in that

748  
00:29:29,240 --> 00:29:32,058  
system are there more than are there any

749  
00:29:30,440 --> 00:29:35,058  
backup momentum wheels or anything like

750  
00:29:32,058 --> 00:29:37,128  
that but we actually have developed ways

751  
00:29:35,058 --> 00:29:39,678  
we can run with two reaction wheels and

752  
00:29:37,128 --> 00:29:41,869  
we can actually do it with one you have

753  
00:29:39,679 --> 00:29:44,149  
to only point certain directions he

754  
00:29:41,869 --> 00:29:46,219  
takes a long time to get from one point

755  
00:29:44,148 --> 00:29:48,668  
to the other we only have one reaction

756  
00:29:46,220 --> 00:29:52,159  
wheel but we've actually developed

757  
00:29:48,669 --> 00:29:54,620  
suburban modes where we can operate with

758  
00:29:52,159 --> 00:29:57,259  
or less than three meals because they

759  
00:29:54,619 --> 00:29:59,148  
aren't redundant okay yeah and Andy are

760  
00:29:57,259 --> 00:30:00,319  
you hardcore space fans who followed me

761  
00:29:59,148 --> 00:30:01,489  
for any length of time you will remember

762  
00:30:00,319 --> 00:30:04,788  
the first time we learned about momentum

763  
00:30:01,490 --> 00:30:06,710  
wheels was with Kepler when it had a

764  
00:30:04,788 --> 00:30:09,319  
problem with it and it can no longer

765  
00:30:06,710 --> 00:30:11,690  
complete its mission as person could no

766  
00:30:09,319 --> 00:30:13,720  
longer point as precisely as it was

767  
00:30:11,690 --> 00:30:15,649  
originally designed so they were

768  
00:30:13,720 --> 00:30:17,058  
repurposing and I I wonder what ever

769  
00:30:15,648 --> 00:30:18,949  
happened to that I should follow up on

770

00:30:17,058 --> 00:30:20,119  
that anyway so that's what we first

771  
00:30:18,950 --> 00:30:23,058  
learned about him Hubble has them to a

772  
00:30:20,119 --> 00:30:25,479  
lot it's very common thing Morgan I want

773  
00:30:23,058 --> 00:30:28,278  
to get to you about commanding Hubble um

774  
00:30:25,480 --> 00:30:31,278  
how do you do it how do you tell Hubble

775  
00:30:28,278 --> 00:30:32,750  
what to do give us a real nerdy view of

776  
00:30:31,278 --> 00:30:35,619  
that what's a tough what's it look like

777  
00:30:32,750 --> 00:30:40,638  
it's what authority she commands

778  
00:30:35,619 --> 00:30:43,158  
absolute I command thee we really have

779  
00:30:40,638 --> 00:30:46,459  
two different ways to command right so

780  
00:30:43,159 --> 00:30:48,860  
the normal everyday way once a week this

781  
00:30:46,460 --> 00:30:51,139  
telescope science institute scientists

782  
00:30:48,859 --> 00:30:54,199  
put together and their schedule what we

783  
00:30:51,138 --> 00:30:55,819  
want to point out how we're taking what

784  
00:30:54,200 --> 00:30:58,009

instruments are going to use and they

785

00:30:55,819 --> 00:31:01,278

deliver to us I'm usually on Thursday

786

00:30:58,009 --> 00:31:03,169

the week before on the SMS the service

787

00:31:01,278 --> 00:31:06,470

English or the science Mission schedule

788

00:31:03,169 --> 00:31:08,960

and that gets loaded onto the computers

789

00:31:06,470 --> 00:31:10,150

here and there's sort of two parts to it

790

00:31:08,960 --> 00:31:12,919

one that can

791

00:31:10,150 --> 00:31:14,840

the computer that Scott had in the

792

00:31:12,919 --> 00:31:17,900

science computer and then the other that

793

00:31:14,839 --> 00:31:22,069

controls the 46 telescope computer and

794

00:31:17,900 --> 00:31:25,309

so you say 486 sorry what was that did

795

00:31:22,069 --> 00:31:29,539

you say 486 yes it's a known as a

796

00:31:25,308 --> 00:31:31,879

Pentium what that's our upgrade yeah it

797

00:31:29,539 --> 00:31:33,918

was great there's a 486 running the

798

00:31:31,880 --> 00:31:36,830

Hubble Space Telescope reusing those are



799  
00:31:33,919 --> 00:31:43,520  
the fancy computer thing is there an AOL

800  
00:31:36,829 --> 00:31:45,409  
disk in there put it in oh that's that's

801  
00:31:43,519 --> 00:31:47,720  
brilliant i love it okay good that's the

802  
00:31:45,410 --> 00:31:51,110  
upgrade if i was in there before 286 it

803  
00:31:47,720 --> 00:31:54,620  
was a two- computer before it was yeah

804  
00:31:51,109 --> 00:31:58,639  
yeah now to be fair folks Hubble's been

805  
00:31:54,619 --> 00:32:00,918  
up there for 25 years ne5 me really all

806  
00:31:58,640 --> 00:32:02,840  
right so 486 is in charge of Hubble okay

807  
00:32:00,919 --> 00:32:04,610  
all right so throughout throughout the

808  
00:32:02,839 --> 00:32:07,569  
day automatically these commands are

809  
00:32:04,609 --> 00:32:09,979  
sent up in the normal course of things

810  
00:32:07,569 --> 00:32:11,750  
and then if we have to do any real time

811  
00:32:09,980 --> 00:32:14,089  
commanding either because there's a

812  
00:32:11,750 --> 00:32:17,029  
problem or because we need to change

813  
00:32:14,089 --> 00:32:18,649  
configuration or do something up all

814  
00:32:17,029 --> 00:32:21,410  
sorts of different reasons but we can

815  
00:32:18,650 --> 00:32:23,390  
also do real-time commanding I'm the

816  
00:32:21,410 --> 00:32:26,179  
computers in this room in the room next

817  
00:32:23,390 --> 00:32:27,890  
door and that's literally with one of

818  
00:32:26,179 --> 00:32:31,490  
the flight ops team sitting down at the

819  
00:32:27,890 --> 00:32:33,890  
computers behind behind us behind me and

820  
00:32:31,490 --> 00:32:35,990  
sending the commands straight up to the

821  
00:32:33,890 --> 00:32:38,450  
telescope okay but what are they typing

822  
00:32:35,990 --> 00:32:41,058  
are they typing go to m31 are they

823  
00:32:38,450 --> 00:32:44,419  
typing in some Python code what are they

824  
00:32:41,058 --> 00:32:45,980  
typing at I'm CCL is the language that

825  
00:32:44,419 --> 00:32:47,990  
we wrote right missed the real-time

826  
00:32:45,980 --> 00:32:51,380  
commanding in it's always a special

827

00:32:47,990 --> 00:32:53,329  
language then yes commander control

828  
00:32:51,380 --> 00:32:55,460  
language i think is what's AC L stands

829  
00:32:53,329 --> 00:32:58,879  
for although I'm not president it make

830  
00:32:55,460 --> 00:33:01,759  
sense to me is called CCS or there come

831  
00:32:58,880 --> 00:33:05,210  
in control center system the specific

832  
00:33:01,759 --> 00:33:07,759  
language is is it's actually it's based

833  
00:33:05,210 --> 00:33:10,548  
off of TCL which is a standard like Rob

834  
00:33:07,759 --> 00:33:12,619  
what's good yeah I'd love to get into

835  
00:33:10,548 --> 00:33:13,548  
what a real-time operating system is but

836  
00:33:12,619 --> 00:33:15,439  
I don't think we'll have time for that

837  
00:33:13,548 --> 00:33:16,910  
right this particular time but so yeah

838  
00:33:15,440 --> 00:33:19,308  
so you're sending in a special commands

839  
00:33:16,910 --> 00:33:22,370  
and it's just a list it's at is it a

840  
00:33:19,308 --> 00:33:22,808  
text file do you encrypt it all or you

841  
00:33:22,369 --> 00:33:25,479

know

842

00:33:22,808 --> 00:33:27,579

gonna be hacked okay well it's all very

843

00:33:25,480 --> 00:33:29,110

very controlled as you can imagine right

844

00:33:27,579 --> 00:33:32,109

everything that we send off has been

845

00:33:29,109 --> 00:33:34,119

tested many many times um so there's

846

00:33:32,109 --> 00:33:37,719

basically they're just mini scripts many

847

00:33:34,119 --> 00:33:41,199

programs and so the flight up the like

848

00:33:37,720 --> 00:33:43,538

controllers will end you know I'll beat

849

00:33:41,200 --> 00:33:45,278

up to or whatever to transition that's

850

00:33:43,538 --> 00:33:47,048

one of our commands to transition one of

851

00:33:45,278 --> 00:33:48,909

the instruments for example and that

852

00:33:47,048 --> 00:33:51,638

will go through the sequence of commands

853

00:33:48,909 --> 00:33:55,360

to reconfigure whatever you want to be

854

00:33:51,638 --> 00:33:58,658

doing at the time okay how many people

855

00:33:55,359 --> 00:34:00,008

at a time are actually in that control

856  
00:33:58,659 --> 00:34:01,539  
Mike over there are next door how many

857  
00:34:00,009 --> 00:34:07,240  
people are in there usually right now

858  
00:34:01,538 --> 00:34:09,789  
zero I think oh that's not good nobody's

859  
00:34:07,240 --> 00:34:13,719  
driving Hubble and a few years ago we

860  
00:34:09,789 --> 00:34:15,909  
switched from 24-7 staffing um for most

861  
00:34:13,719 --> 00:34:19,500  
the Hubble's history we've been staffed

862  
00:34:15,909 --> 00:34:21,519  
in there with about five people 24 7 365

863  
00:34:19,500 --> 00:34:23,739  
but a few years ago we switched to

864  
00:34:21,519 --> 00:34:25,780  
automated operations so now we actually

865  
00:34:23,739 --> 00:34:28,509  
have a computer in their sending up the

866  
00:34:25,780 --> 00:34:30,579  
routine commands and monitoring all the

867  
00:34:28,510 --> 00:34:32,770  
telemetry and it's tied into an

868  
00:34:30,579 --> 00:34:35,200  
automated system that will alert us if

869  
00:34:32,769 --> 00:34:36,818  
anything goes wrong so if we all have

870  
00:34:35,199 --> 00:34:39,428  
our iphones and we'll all get a text

871  
00:34:36,818 --> 00:34:41,529  
message if there's a problem the flight

872  
00:34:39,429 --> 00:34:44,050  
operations team does go in there once a

873  
00:34:41,530 --> 00:34:46,510  
day to do some maintenance obviously we

874  
00:34:44,050 --> 00:34:48,429  
check up on things all the time but for

875  
00:34:46,510 --> 00:34:49,929  
the most part it's automated at this

876  
00:34:48,429 --> 00:34:52,450  
auto mode okay i want to get back to

877  
00:34:49,929 --> 00:34:53,829  
getting when the things go wrong in just

878  
00:34:52,449 --> 00:34:56,049  
a minute but let me ask scott a question

879  
00:34:53,829 --> 00:35:00,010  
here on the scientific instrumentation

880  
00:34:56,050 --> 00:35:02,440  
which of the science instruments on on

881  
00:35:00,010 --> 00:35:03,790  
hubble are the most used and which are

882  
00:35:02,440 --> 00:35:06,130  
the most complicated for you to have to

883  
00:35:03,789 --> 00:35:07,690  
deal with in other words which ones do

884

00:35:06,130 --> 00:35:09,160  
any of them keep you up at night as far

885  
00:35:07,690 --> 00:35:12,940  
as oh my god I hope this thing you know

886  
00:35:09,159 --> 00:35:15,068  
doesn't break down or any of that pretty

887  
00:35:12,940 --> 00:35:17,050  
much my job is all of them if any of

888  
00:35:15,068 --> 00:35:19,480  
them down it's going to keep me up at

889  
00:35:17,050 --> 00:35:21,839  
night they break it's three o'clock in

890  
00:35:19,480 --> 00:35:26,530  
the morning always and on Friday too

891  
00:35:21,838 --> 00:35:28,150  
well sometimes yeah yeah Christmas was

892  
00:35:26,530 --> 00:35:32,260  
was particularly exciting a couple years

893  
00:35:28,150 --> 00:35:34,809  
ago but now all are pretty well behaved

894  
00:35:32,260 --> 00:35:36,790  
at this point um it's funny we

895  
00:35:34,809 --> 00:35:38,710  
definitely attribute

896  
00:35:36,789 --> 00:35:40,989  
personnel at hubbell and each of the

897  
00:35:38,710 --> 00:35:44,019  
instruments and we kind of joked that it

898  
00:35:40,989 --> 00:35:47,619

knows when holidays and and in certain

899

00:35:44,019 --> 00:35:51,309

mountains are so it knows when to hit us

900

00:35:47,619 --> 00:35:53,139

but um the probably the moon the one

901

00:35:51,309 --> 00:35:55,719

would give me the most consternation

902

00:35:53,139 --> 00:35:58,239

right now be wide field camera 3 just

903

00:35:55,719 --> 00:36:00,429

because it's the most used of the

904

00:35:58,239 --> 00:36:02,439

instruments on board that imagine

905

00:36:00,429 --> 00:36:03,849

accounts for will be fifty to sixty

906

00:36:02,440 --> 00:36:06,130

percent of the observations that we do

907

00:36:03,849 --> 00:36:08,769

right that's the infrared camera that

908

00:36:06,130 --> 00:36:11,800

takes on by the way Tony and everyone

909

00:36:08,769 --> 00:36:15,190

its 16-bit data and each pixel can

910

00:36:11,800 --> 00:36:17,710

accommodate 78,000 electrons when it's

911

00:36:15,190 --> 00:36:19,960

saturated awesome thank you that's a

912

00:36:17,710 --> 00:36:21,429

real I'm sorry that's just nerdy i love



913

00:36:19,960 --> 00:36:24,490  
that stuff that's what i like to hear

914

00:36:21,429 --> 00:36:28,529  
16-bit numbers okay good well there's

915

00:36:24,489 --> 00:36:30,939  
the bit depth of the whiff c3 okay so

916

00:36:28,530 --> 00:36:32,920  
you're everything's automated hopefully

917

00:36:30,940 --> 00:36:34,090  
you've got a true computer in the in

918

00:36:32,920 --> 00:36:35,430  
that other room over there that's a

919

00:36:34,090 --> 00:36:39,120  
little more powerful than a 486

920

00:36:35,429 --> 00:36:42,549  
controlling it will you said earlier

921

00:36:39,119 --> 00:36:44,859  
morgan that you guys get text messages

922

00:36:42,550 --> 00:36:47,200  
when something goes wrong right that's

923

00:36:44,860 --> 00:36:49,480  
that's your alert what what safeguards

924

00:36:47,199 --> 00:36:51,939  
are in place and what do you guys do

925

00:36:49,480 --> 00:36:53,559  
when something goes wrong with Hubble it

926

00:36:51,940 --> 00:36:55,539  
goes wrong ok so we've literally

927  
00:36:53,559 --> 00:36:57,610  
thousands of telemetry points that are

928  
00:36:55,539 --> 00:37:00,279  
being monitored by the automated

929  
00:36:57,610 --> 00:37:02,079  
computer and when it detects something

930  
00:37:00,280 --> 00:37:04,110  
out of limits which is just however we

931  
00:37:02,079 --> 00:37:06,639  
defined it you know if a power gets

932  
00:37:04,110 --> 00:37:09,760  
drawing too much power or gets too hot

933  
00:37:06,639 --> 00:37:11,920  
or whatever on the computer sends out

934  
00:37:09,760 --> 00:37:13,840  
really literally a text message to our

935  
00:37:11,920 --> 00:37:16,720  
iphones at three in the morning or

936  
00:37:13,840 --> 00:37:19,390  
whatever and that's when me is the

937  
00:37:16,719 --> 00:37:21,879  
anomaly response manager will start to

938  
00:37:19,389 --> 00:37:24,460  
touch base with all the subsystems and

939  
00:37:21,880 --> 00:37:25,900  
make sure everything everyone not

940  
00:37:24,460 --> 00:37:28,300  
obviously everything isn't fine but make

941

00:37:25,900 --> 00:37:30,910  
sure that the subsystems are all expect

942  
00:37:28,300 --> 00:37:32,769  
in their expected state and meanwhile

943  
00:37:30,909 --> 00:37:35,469  
scott and mike and all the other sub

944  
00:37:32,769 --> 00:37:37,119  
system engineers start looking at their

945  
00:37:35,469 --> 00:37:38,589  
telemetry like I said sometimes we have

946  
00:37:37,119 --> 00:37:41,139  
real telemetry real-time telemetry

947  
00:37:38,590 --> 00:37:44,410  
hopefully we do if not we'll wait till

948  
00:37:41,139 --> 00:37:47,469  
we get it and evaluate what the real

949  
00:37:44,409 --> 00:37:50,179  
problem is and so there's two kind of

950  
00:37:47,469 --> 00:37:52,159  
anomaly responses the first is immediate

951  
00:37:50,179 --> 00:37:55,250  
and that's going to be sometimes taken

952  
00:37:52,159 --> 00:37:57,619  
autonomously by the telescope element x

953  
00:37:55,250 --> 00:38:00,199  
by very quick ground commanding to put

954  
00:37:57,619 --> 00:38:02,449  
us to a safe skates if you had a problem

955  
00:38:00,199 --> 00:38:05,089

we're not sure what's going on we can

956

00:38:02,449 --> 00:38:07,579

just turn off some of the detectors if

957

00:38:05,090 --> 00:38:10,970

it's a very serious issue we can even

958

00:38:07,579 --> 00:38:13,610

close the telescope's aperture door load

959

00:38:10,969 --> 00:38:15,859

shed power if we need to just depending

960

00:38:13,610 --> 00:38:17,960

on exactly what the anomaly was so we

961

00:38:15,860 --> 00:38:19,849

have an initial response to safe the

962

00:38:17,960 --> 00:38:21,590

telescope that's our primary goal at

963

00:38:19,849 --> 00:38:23,569

that moment make sure everything's safe

964

00:38:21,590 --> 00:38:25,730

no more damage is going to get done and

965

00:38:23,570 --> 00:38:28,340

then we can actually start trying to

966

00:38:25,730 --> 00:38:30,079

figure out what happened and if it's

967

00:38:28,340 --> 00:38:31,850

something that we can easily recover

968

00:38:30,079 --> 00:38:35,000

from or if it's something that we need

969

00:38:31,849 --> 00:38:37,750

to figure out how to rig a telescope or

970  
00:38:35,000 --> 00:38:40,340  
maybe even a new plate software or new

971  
00:38:37,750 --> 00:38:42,710  
switch to a redundant side or something

972  
00:38:40,340 --> 00:38:44,900  
like that and that response is going to

973  
00:38:42,710 --> 00:38:47,119  
happen over the course of weeks rather

974  
00:38:44,900 --> 00:38:48,170  
than an immediate response you're really

975  
00:38:47,119 --> 00:38:49,489  
going to take your time and figure it

976  
00:38:48,170 --> 00:38:50,900  
out and just make sure that you

977  
00:38:49,489 --> 00:38:53,059  
understand the problem well that's good

978  
00:38:50,900 --> 00:38:54,400  
okay so this safe mode that you're

979  
00:38:53,059 --> 00:38:56,509  
talking about this is just a

980  
00:38:54,400 --> 00:38:59,090  
configuration that you put the telescope

981  
00:38:56,510 --> 00:39:01,040  
in that is not pointing at the Sun not

982  
00:38:59,090 --> 00:39:02,450  
pointing anything bad it's you know

983  
00:39:01,039 --> 00:39:05,420  
you've just got to calm down a little

984  
00:39:02,449 --> 00:39:07,460  
bit the instruments are are waiting you

985  
00:39:05,420 --> 00:39:12,380  
to figure it out do you ever have to

986  
00:39:07,460 --> 00:39:13,789  
reboot Hubble and in in a sense one of

987  
00:39:12,380 --> 00:39:16,190  
the science instruments the science

988  
00:39:13,789 --> 00:39:20,480  
computer actually sometimes gets hung up

989  
00:39:16,190 --> 00:39:26,750  
just locks up I I knew Scott did you do

990  
00:39:20,480 --> 00:39:28,460  
that yeah Paul actually we had one of

991  
00:39:26,750 --> 00:39:31,130  
those recently just become the the 20th

992  
00:39:28,460 --> 00:39:32,420  
of October work essentially the computer

993  
00:39:31,130 --> 00:39:35,090  
just essentially stops responding

994  
00:39:32,420 --> 00:39:36,650  
commands and stop sending telemetry the

995  
00:39:35,090 --> 00:39:39,590  
first time it happened on orbit was

996  
00:39:36,650 --> 00:39:40,970  
really pretty scary since we didn't know

997  
00:39:39,590 --> 00:39:42,289  
exactly what state the science

998

00:39:40,969 --> 00:39:43,819  
instruments were in we couldn't get any

999  
00:39:42,289 --> 00:39:46,610  
information about them out of the

1000  
00:39:43,820 --> 00:39:48,830  
telescope but eventually we figured out

1001  
00:39:46,610 --> 00:39:51,140  
kind of what was going on and understood

1002  
00:39:48,829 --> 00:39:53,599  
that the instruments were taking some

1003  
00:39:51,139 --> 00:39:55,119  
action to protect themselves if it's

1004  
00:39:53,599 --> 00:39:58,130  
elves in a safe state when they lost

1005  
00:39:55,119 --> 00:40:00,139  
contact with the computer but there for

1006  
00:39:58,130 --> 00:40:02,099  
a while it was it was not a comfortable

1007  
00:40:00,139 --> 00:40:03,808  
situation to be in so

1008  
00:40:02,099 --> 00:40:05,369  
I heard a rumor I heard someone a

1009  
00:40:03,809 --> 00:40:07,440  
comment somewhere I don't remember where

1010  
00:40:05,369 --> 00:40:09,119  
and this is for any three of you if you

1011  
00:40:07,440 --> 00:40:12,420  
want to comment on it the door out front

1012  
00:40:09,119 --> 00:40:14,608

Oh is always open you really are sort of

1013

00:40:12,420 --> 00:40:16,528

loath to close it I think of it for fear

1014

00:40:14,608 --> 00:40:17,759

that it won't reopen again is that I

1015

00:40:16,528 --> 00:40:22,228

hear that right or is that just

1016

00:40:17,759 --> 00:40:23,670

something yeah yeah no and you're

1017

00:40:22,228 --> 00:40:25,528

exactly right the reason we leave it

1018

00:40:23,670 --> 00:40:26,880

open is you know if you ever close it

1019

00:40:25,528 --> 00:40:28,469

chances are you know what if you can't

1020

00:40:26,880 --> 00:40:31,140

open it and boy you close that and

1021

00:40:28,469 --> 00:40:34,768

Hubble will not work there's nothing is

1022

00:40:31,139 --> 00:40:37,078

going to go that way in oh we don't ever

1023

00:40:34,768 --> 00:40:38,578

really we don't ever close it the only

1024

00:40:37,079 --> 00:40:41,400

thing that can close it is if the

1025

00:40:38,579 --> 00:40:43,950

computer on board says something's wrong

1026

00:40:41,400 --> 00:40:46,259

I don't know where the telescope is



1027  
00:40:43,949 --> 00:40:48,478  
pointed or I can't control the telescope

1028  
00:40:46,259 --> 00:40:50,699  
then it will close it there is actually

1029  
00:40:48,478 --> 00:40:52,228  
a eponymous closing me it's very rare I

1030  
00:40:50,699 --> 00:40:54,149  
mean we've done it during the servicing

1031  
00:40:52,228 --> 00:40:56,788  
mission we've a commanded it closed um

1032  
00:40:54,150 --> 00:40:58,858  
but but typically um you know we don't

1033  
00:40:56,789 --> 00:41:00,329  
want to do that I'm even though there's

1034  
00:40:58,858 --> 00:41:02,998  
redundancy there's there's multiple

1035  
00:41:00,329 --> 00:41:04,589  
motors up there to open it up but it's

1036  
00:41:02,998 --> 00:41:06,778  
really the only person really closes the

1037  
00:41:04,588 --> 00:41:08,518  
door the computer goes into one of these

1038  
00:41:06,778 --> 00:41:10,170  
say folks or certain levels of state

1039  
00:41:08,518 --> 00:41:12,028  
mode what own is the computer says I

1040  
00:41:10,170 --> 00:41:14,460  
know what I'm doing i know where i am

1041  
00:41:12,028 --> 00:41:17,248  
and i can control the telescope but if

1042  
00:41:14,460 --> 00:41:19,528  
when we lose a gyro or if we lose one of

1043  
00:41:17,248 --> 00:41:21,058  
the reaction wheels it's locked control

1044  
00:41:19,528 --> 00:41:23,969  
of the telescope it says i don't have

1045  
00:41:21,059 --> 00:41:25,680  
the control i need i can't point it so

1046  
00:41:23,969 --> 00:41:27,929  
i'm going to close the door just make

1047  
00:41:25,679 --> 00:41:29,788  
sure because we can't ever get bumped

1048  
00:41:27,929 --> 00:41:31,288  
down in here um if the Sun ever does

1049  
00:41:29,789 --> 00:41:34,049  
shine down in here really bad things

1050  
00:41:31,289 --> 00:41:36,028  
happen right and closing the door is a

1051  
00:41:34,048 --> 00:41:37,079  
really good way to break the whole thing

1052  
00:41:36,028 --> 00:41:38,728  
even though everything it could be

1053  
00:41:37,079 --> 00:41:39,749  
working perfectly but if no light gets

1054  
00:41:38,728 --> 00:41:43,288  
to the primary and then you've got

1055

00:41:39,748 --> 00:41:45,718  
nothing so yeah I can understand that so

1056  
00:41:43,289 --> 00:41:48,920  
I want to address the gyros for a minute

1057  
00:41:45,719 --> 00:41:52,650  
a really huge important part of Hubble

1058  
00:41:48,920 --> 00:41:55,048  
what do they do and they were recently

1059  
00:41:52,650 --> 00:41:58,108  
replaced in service mission for it

1060  
00:41:55,048 --> 00:42:00,268  
basically gave Hubble new life basically

1061  
00:41:58,108 --> 00:42:01,710  
it's like the the heart of the Hubble

1062  
00:42:00,268 --> 00:42:05,568  
Space Telescope isn't it who wants to

1063  
00:42:01,710 --> 00:42:08,460  
tell us about those the gyros well I'll

1064  
00:42:05,568 --> 00:42:10,108  
try Mike okay go ahead yeah we'll see

1065  
00:42:08,460 --> 00:42:12,749  
what they are how important they are on

1066  
00:42:10,108 --> 00:42:14,699  
what they do well the gyroscope are what

1067  
00:42:12,748 --> 00:42:16,009  
you think of as a gyroscope it's they

1068  
00:42:14,699 --> 00:42:17,929  
aren't very go there

1069  
00:42:16,010 --> 00:42:19,490

larger they have a very good spinning

1070

00:42:17,929 --> 00:42:21,549

wheel inside of own and essentially

1071

00:42:19,489 --> 00:42:24,679

they're very sensitive to motion

1072

00:42:21,550 --> 00:42:27,980

gyroscopes tell us how to telescope is

1073

00:42:24,679 --> 00:42:30,199

moving on and so we have six gyroscopes

1074

00:42:27,980 --> 00:42:31,880

on board we've actually been replaced it

1075

00:42:30,199 --> 00:42:33,799

pretty much every servicing mission we

1076

00:42:31,880 --> 00:42:36,380

try to replace as many as we can on

1077

00:42:33,800 --> 00:42:38,300

these are actually mechanical gyroscopes

1078

00:42:36,380 --> 00:42:40,400

there's a spinning gyroscope that's

1079

00:42:38,300 --> 00:42:42,980

spinning it at very high revolutions I'm

1080

00:42:40,400 --> 00:42:44,630

very extremely precise of these were

1081

00:42:42,980 --> 00:42:47,030

probably some of the most the mole

1082

00:42:44,630 --> 00:42:50,750

precise mechanical gyroscopes ever made

1083

00:42:47,030 --> 00:42:52,310

um in fact we will be tardy they don't

1084  
00:42:50,750 --> 00:42:53,869  
make them mechanically this more and

1085  
00:42:52,309 --> 00:42:56,750  
more they've gone to optical and laser

1086  
00:42:53,869 --> 00:42:58,099  
gyroscopes but what they do is they

1087  
00:42:56,750 --> 00:42:59,809  
allowed a telescope know where it's

1088  
00:42:58,099 --> 00:43:02,269  
plumb gyroscopes when the telescope's

1089  
00:42:59,809 --> 00:43:04,489  
moving gyroscope is eating a signal

1090  
00:43:02,269 --> 00:43:06,590  
saying remove this direction at this

1091  
00:43:04,489 --> 00:43:08,119  
rate so we've got six of them that

1092  
00:43:06,590 --> 00:43:09,820  
they're also their their axes are

1093  
00:43:08,119 --> 00:43:12,349  
pointed at different locations so they

1094  
00:43:09,820 --> 00:43:14,150  
computer know-how to telescopes moving

1095  
00:43:12,349 --> 00:43:15,889  
as when the computer is moving it's a I

1096  
00:43:14,150 --> 00:43:17,630  
need to move with the telescope 90

1097  
00:43:15,889 --> 00:43:19,819  
degrees this way how does it know what

1098  
00:43:17,630 --> 00:43:22,309  
90 degrees that way it looks at the

1099  
00:43:19,820 --> 00:43:25,580  
gyros but the gyros aren't the first way

1100  
00:43:22,309 --> 00:43:28,730  
we point telescope the information from

1101  
00:43:25,579 --> 00:43:32,389  
the gyros now arrows are extremely

1102  
00:43:28,730 --> 00:43:33,769  
accurate over small distances they can

1103  
00:43:32,389 --> 00:43:35,389  
actually hold the telescope they are

1104  
00:43:33,769 --> 00:43:37,489  
actually primary will help the whole

1105  
00:43:35,389 --> 00:43:40,039  
telescope but if you did a big slew

1106  
00:43:37,489 --> 00:43:41,719  
build up this little bit of error in and

1107  
00:43:40,039 --> 00:43:44,539  
builds up and so we have all these other

1108  
00:43:41,719 --> 00:43:47,569  
instruments that allow us to bind to the

1109  
00:43:44,539 --> 00:43:49,699  
pointing afterwards um but gyros without

1110  
00:43:47,570 --> 00:43:53,330  
gyros you can't point the telescope oh

1111  
00:43:49,699 --> 00:43:56,889  
now we have six of them had various lots

1112

00:43:53,329 --> 00:43:59,869  
of them Gail on different years um

1113  
00:43:56,889 --> 00:44:01,759  
actually science and for many many years

1114  
00:43:59,869 --> 00:44:03,349  
we actually did science on two of them

1115  
00:44:01,760 --> 00:44:05,000  
and we actually have what's known to

1116  
00:44:03,349 --> 00:44:08,630  
gyro and we actually figured out a way

1117  
00:44:05,000 --> 00:44:11,090  
we only need one gyro good it's because

1118  
00:44:08,630 --> 00:44:13,220  
of these other instruments one gyro if

1119  
00:44:11,090 --> 00:44:15,680  
you can get yourself onto the fine

1120  
00:44:13,219 --> 00:44:18,619  
guidance sensors you can do science and

1121  
00:44:15,679 --> 00:44:20,239  
we need one gyro to get there it takes a

1122  
00:44:18,619 --> 00:44:23,000  
little bit longer sometimes but only

1123  
00:44:20,239 --> 00:44:24,349  
need one to actually do science and so

1124  
00:44:23,000 --> 00:44:26,090  
that that's why we're thinking we're

1125  
00:44:24,349 --> 00:44:27,980  
pretty good off still I think it's a

1126  
00:44:26,090 --> 00:44:29,180

good point to put up that pickle diagram

1127

00:44:27,980 --> 00:44:31,940  
you were talking about can you

1128

00:44:29,179 --> 00:44:34,818  
can you put that up for Scott when you

1129

00:44:31,940 --> 00:44:36,409  
get chance this is a picture Oh pickle

1130

00:44:34,818 --> 00:44:37,880  
by the way something completely

1131

00:44:36,409 --> 00:44:39,858  
different now you're thinking obvious

1132

00:44:37,880 --> 00:44:41,960  
call pickle no hubble hubble needs

1133

00:44:39,858 --> 00:44:45,940  
pickles I mean as you know what are they

1134

00:44:41,960 --> 00:44:49,670  
sweet you know are they ill I've got her

1135

00:44:45,940 --> 00:44:51,980  
here we go so this is an image of the

1136

00:44:49,670 --> 00:44:52,789  
well i'll let you describe it Bob Mike

1137

00:44:51,980 --> 00:44:55,099  
why don't you tell us what we're looking

1138

00:44:52,789 --> 00:44:57,019  
at okay this is for like if you were in

1139

00:44:55,099 --> 00:45:00,260  
the back end of Hubble sort of looking

1140

00:44:57,019 --> 00:45:02,329  
out this is how Hubble sees the sky what



1141  
00:45:00,260 --> 00:45:03,770  
what you sort of see you know you see a

1142  
00:45:02,329 --> 00:45:05,869  
stars in the background there there's

1143  
00:45:03,769 --> 00:45:08,449  
active galaxies in the middle um and you

1144  
00:45:05,869 --> 00:45:10,700  
see outlines of the big outline is the

1145  
00:45:08,449 --> 00:45:13,429  
telescope that's the higher area of sky

1146  
00:45:10,699 --> 00:45:15,500  
the telescope could ever see the little

1147  
00:45:13,429 --> 00:45:17,239  
thing directly in the center that's sort

1148  
00:45:15,500 --> 00:45:19,789  
of what the wide field camera is see on

1149  
00:45:17,239 --> 00:45:21,348  
the other little circles to decide those

1150  
00:45:19,789 --> 00:45:23,300  
are the other instruments those are part

1151  
00:45:21,349 --> 00:45:25,670  
of the sky that they can see those big

1152  
00:45:23,300 --> 00:45:28,369  
parks on the edge those are what we call

1153  
00:45:25,670 --> 00:45:31,550  
the pickles because it looked like bent

1154  
00:45:28,369 --> 00:45:33,289  
pickles um know about that my guess

1155  
00:45:31,550 --> 00:45:36,559  
that's pretty fast pretty big stretch

1156  
00:45:33,289 --> 00:45:37,789  
but go ahead I think it was created by

1157  
00:45:36,559 --> 00:45:39,769  
some software engineers who were

1158  
00:45:37,789 --> 00:45:43,039  
defining the name well that explains it

1159  
00:45:39,769 --> 00:45:46,909  
that explains it ok that's the software

1160  
00:45:43,039 --> 00:45:49,699  
engineer yeah you don't want to trust us

1161  
00:45:46,909 --> 00:45:51,739  
as far as you can throw us know so

1162  
00:45:49,699 --> 00:45:53,598  
that's what fine guidance sensors can

1163  
00:45:51,739 --> 00:45:55,578  
see so each one of those a ones fine

1164  
00:45:53,599 --> 00:45:57,950  
guidance sensor one one's a fine

1165  
00:45:55,579 --> 00:45:59,510  
guidance sensor to do 13 and you notice

1166  
00:45:57,949 --> 00:46:01,699  
that there start there would be sparse

1167  
00:45:59,510 --> 00:46:03,920  
sitting there into what we do is we

1168  
00:46:01,699 --> 00:46:06,259  
actually these fine guidance sensors go

1169

00:46:03,920 --> 00:46:08,088  
out they can move anywhere they're kind

1170  
00:46:06,260 --> 00:46:10,579  
of weird instruments we can move

1171  
00:46:08,088 --> 00:46:12,469  
anywhere around in that little arc where

1172  
00:46:10,579 --> 00:46:14,030  
that big in that pickle and much of you

1173  
00:46:12,469 --> 00:46:15,769  
don't want me to say to turn anywhere in

1174  
00:46:14,030 --> 00:46:18,109  
that pickle we can actually go and find

1175  
00:46:15,769 --> 00:46:22,219  
a star there and call what we say we

1176  
00:46:18,108 --> 00:46:24,798  
lock onto it so like in his image if you

1177  
00:46:22,219 --> 00:46:27,048  
wanted to observe that galaxies pick one

1178  
00:46:24,798 --> 00:46:28,670  
of the stars the pickle on the right and

1179  
00:46:27,048 --> 00:46:30,619  
one of the stars in the pickle on left

1180  
00:46:28,670 --> 00:46:33,260  
and you tell your fine guidance sensors

1181  
00:46:30,619 --> 00:46:36,619  
go out there and find these stars lock

1182  
00:46:33,260 --> 00:46:39,230  
on to them in Holmby exactly perfectly

1183  
00:46:36,619 --> 00:46:41,599

still so that decides instrument can get

1184  
00:46:39,230 --> 00:46:42,490  
its name those momentum wheels right

1185  
00:46:41,599 --> 00:46:43,780  
those that we talked

1186  
00:46:42,489 --> 00:46:46,239  
about earlier they keep this pointed

1187  
00:46:43,780 --> 00:46:49,330  
straight or is that just move yeah okay

1188  
00:46:46,239 --> 00:46:53,199  
well well no they will move I did they

1189  
00:46:49,329 --> 00:46:54,699  
also yeah they will move it you'll find

1190  
00:46:53,199 --> 00:46:56,289  
you too because you I realize we're

1191  
00:46:54,699 --> 00:46:58,118  
spinning around that 18,000 miles an

1192  
00:46:56,289 --> 00:47:00,639  
hour trying to point something out space

1193  
00:46:58,119 --> 00:47:03,550  
we've got you know we're moving we have

1194  
00:47:00,639 --> 00:47:05,170  
to move these things in and how accurate

1195  
00:47:03,550 --> 00:47:07,930  
doesn't do that I mean does it can you

1196  
00:47:05,170 --> 00:47:10,659  
keep the stars within a pixel are moving

1197  
00:47:07,929 --> 00:47:13,118  
keep stars within six milliseconds then

1198  
00:47:10,659 --> 00:47:15,129  
less than 6 million a few milli arcs and

1199  
00:47:13,119 --> 00:47:18,100  
so point zero zero one arc seconds if if

1200  
00:47:15,130 --> 00:47:21,160  
that takes go yeah that's pretty darn

1201  
00:47:18,099 --> 00:47:23,170  
accurate all right good and it has to do

1202  
00:47:21,159 --> 00:47:25,299  
that while orbiting the earth yeah well

1203  
00:47:23,170 --> 00:47:27,490  
this is 18,000 miles an hour that's

1204  
00:47:25,300 --> 00:47:29,590  
right I mean essentially it's like we're

1205  
00:47:27,489 --> 00:47:31,209  
looking at a dime a dime at the top of

1206  
00:47:29,590 --> 00:47:33,910  
the Empire State Building and we can

1207  
00:47:31,210 --> 00:47:35,920  
hold Hubble pointed at that time ice

1208  
00:47:33,909 --> 00:47:37,179  
very nice I like this picture because it

1209  
00:47:35,920 --> 00:47:38,980  
shows all of the seems like there's a

1210  
00:47:37,179 --> 00:47:40,509  
lot of wasted space so what do you think

1211  
00:47:38,980 --> 00:47:43,869  
about this Scott you have any comments

1212  
00:47:40,510 --> 00:47:46,300  
on this week the what are some of these

1213  
00:47:43,869 --> 00:47:48,460  
other circles that that Mike alluded to

1214  
00:47:46,300 --> 00:47:50,440  
well the image that we've got up on the

1215  
00:47:48,460 --> 00:47:51,720  
screen now this is actually at the

1216  
00:47:50,440 --> 00:47:54,760  
instrument complement we had before

1217  
00:47:51,719 --> 00:47:56,799  
servicing mission three be all right I

1218  
00:47:54,760 --> 00:47:58,660  
just saw this boops one that you've got

1219  
00:47:56,800 --> 00:48:00,880  
in the center there is the the old wide

1220  
00:47:58,659 --> 00:48:03,039  
field planetary camera 2 which was

1221  
00:48:00,880 --> 00:48:06,519  
actually a conveyor a shin of for ccds

1222  
00:48:03,039 --> 00:48:08,440  
okay well it has that shape the if the

1223  
00:48:06,519 --> 00:48:10,050  
two circles just to the above and to the

1224  
00:48:08,440 --> 00:48:13,240  
left of that of the faint object camera

1225  
00:48:10,050 --> 00:48:14,920  
the circle and the inscribed squares

1226

00:48:13,239 --> 00:48:16,868  
those are actually the three nick moss

1227  
00:48:14,920 --> 00:48:18,579  
cameras that we have the infrared

1228  
00:48:16,869 --> 00:48:21,400  
instrument and those are still on board

1229  
00:48:18,579 --> 00:48:23,230  
and then the circle with the square and

1230  
00:48:21,400 --> 00:48:26,289  
then the X kind of inscribed in it

1231  
00:48:23,230 --> 00:48:29,170  
that's the disc field of view so that's

1232  
00:48:26,289 --> 00:48:31,090  
our imaging spectrograph okay on if you

1233  
00:48:29,170 --> 00:48:32,409  
want to go to the next I think what are

1234  
00:48:31,090 --> 00:48:36,010  
the next images that we've gotten that

1235  
00:48:32,409 --> 00:48:38,108  
package there should be an upgraded view

1236  
00:48:36,010 --> 00:48:40,750  
of this field of view projection it's

1237  
00:48:38,108 --> 00:48:44,349  
not on the sky but that show yep the one

1238  
00:48:40,750 --> 00:48:46,480  
back one yeah there you go okay get over

1239  
00:48:44,349 --> 00:48:48,789  
there it gives you the the upgraded

1240  
00:48:46,480 --> 00:48:51,280

fields of view with with ACS installed

1241  
00:48:48,789 --> 00:48:52,659  
that replaced an optic camera and then

1242  
00:48:51,280 --> 00:48:54,190  
you there you cease tests and then

1243  
00:48:52,659 --> 00:48:55,868  
capture cosmic origins spectrograph

1244  
00:48:54,190 --> 00:48:59,259  
which replaced

1245  
00:48:55,869 --> 00:49:01,358  
costar which was our optical pointing

1246  
00:48:59,259 --> 00:49:02,619  
correction by instrument so which is why

1247  
00:49:01,358 --> 00:49:04,509  
you didn't see anything in the bottom

1248  
00:49:02,619 --> 00:49:06,220  
left-hand corner of that that image add

1249  
00:49:04,509 --> 00:49:08,170  
up before and then you could see the

1250  
00:49:06,219 --> 00:49:09,639  
Nick cameras there Bradford Nick moss

1251  
00:49:08,170 --> 00:49:11,230  
and then of course in the center we have

1252  
00:49:09,639 --> 00:49:14,379  
wide field camera 3 now instead of would

1253  
00:49:11,230 --> 00:49:18,099  
do are those fine guidance sensors all

1254  
00:49:14,380 --> 00:49:20,380  
these see CDs okay there are actually



1255  
00:49:18,099 --> 00:49:22,390  
interferometers um which they did

1256  
00:49:20,380 --> 00:49:25,900  
they're actually amazing instruments um

1257  
00:49:22,389 --> 00:49:27,159  
because um air do the little Michelson

1258  
00:49:25,900 --> 00:49:30,369  
interferometer ziff you know what those

1259  
00:49:27,159 --> 00:49:32,018  
are yeah actually um have thinner bunch

1260  
00:49:30,369 --> 00:49:34,769  
of mirrors in them that'd slit the light

1261  
00:49:32,018 --> 00:49:37,689  
and recombine it and allow them to

1262  
00:49:34,768 --> 00:49:41,409  
extremely accurately grab on to preach

1263  
00:49:37,690 --> 00:49:42,849  
sources um but they actually be used as

1264  
00:49:41,409 --> 00:49:44,828  
science instruments we always like to

1265  
00:49:42,849 --> 00:49:46,390  
say you know Scott will say well I have

1266  
00:49:44,829 --> 00:49:48,369  
all these signs systems and I say well

1267  
00:49:46,389 --> 00:49:50,440  
I've got three science instruments here

1268  
00:49:48,369 --> 00:49:52,869  
because each fine guidance sensors can

1269  
00:49:50,440 --> 00:49:55,088  
actually use to do science in there's

1270  
00:49:52,869 --> 00:49:57,970  
what's known as the spirometry science

1271  
00:49:55,088 --> 00:49:59,828  
that public does and as the measurement

1272  
00:49:57,969 --> 00:50:01,598  
of positions in the sky right astrometry

1273  
00:49:59,829 --> 00:50:04,660  
you can measure in fires find positions

1274  
00:50:01,599 --> 00:50:07,269  
on the day turn extremely sensitive to

1275  
00:50:04,659 --> 00:50:09,278  
because they can i detect these

1276  
00:50:07,268 --> 00:50:11,738  
positions to hold the telescope to

1277  
00:50:09,278 --> 00:50:13,838  
within like story arc second they

1278  
00:50:11,739 --> 00:50:16,929  
actually can really find a fine double

1279  
00:50:13,838 --> 00:50:18,909  
stars on really well any stars of you

1280  
00:50:16,929 --> 00:50:20,469  
from the ground that people say oh it's

1281  
00:50:18,909 --> 00:50:21,788  
only once or it's one star Hubble will

1282  
00:50:20,469 --> 00:50:24,639  
actually say no no it's actually two

1283

00:50:21,789 --> 00:50:26,170  
stars you can actually measure their

1284  
00:50:24,639 --> 00:50:28,629  
separation and measure some of their

1285  
00:50:26,170 --> 00:50:31,329  
properties you'll do actually really

1286  
00:50:28,630 --> 00:50:33,369  
really high accuracy precision between

1287  
00:50:31,329 --> 00:50:34,869  
one star star the next star in the next

1288  
00:50:33,369 --> 00:50:36,970  
stars it's doing this drama tree

1289  
00:50:34,869 --> 00:50:38,380  
observations so they were just a while

1290  
00:50:36,969 --> 00:50:41,169  
back called the Hubble guide star

1291  
00:50:38,380 --> 00:50:43,180  
catalogue was that made in using that or

1292  
00:50:41,170 --> 00:50:46,659  
was that something else i'm thinking of

1293  
00:50:43,179 --> 00:50:48,399  
that's actually made I mean people when

1294  
00:50:46,659 --> 00:50:50,739  
I said well we were gonna go back you

1295  
00:50:48,400 --> 00:50:52,838  
know well there's that star there how do

1296  
00:50:50,739 --> 00:50:54,460  
we know exactly where that star is the

1297  
00:50:52,838 --> 00:50:57,429

Hubble guides our catalog is actually

1298

00:50:54,460 --> 00:50:59,798

catalog of many many hundreds of

1299

00:50:57,429 --> 00:51:01,358

thousands of stars in very accurate

1300

00:50:59,798 --> 00:51:03,670

positions because we need to know

1301

00:51:01,358 --> 00:51:05,318

exactly where those stars are to be

1302

00:51:03,670 --> 00:51:07,809

able to tell those stars is where to go to

1303

00:51:05,318 --> 00:51:09,489

find them so double star catalogue

1304

00:51:07,809 --> 00:51:11,110

is the star Oh

1305

00:51:09,489 --> 00:51:12,309

I thought yeah okay I was wondering if

1306

00:51:11,110 --> 00:51:14,829

it was related but it sounds like it's

1307

00:51:12,309 --> 00:51:15,880

not so okay I want to get to work

1308

00:51:14,829 --> 00:51:17,440

running out of time and I want to get

1309

00:51:15,880 --> 00:51:20,230

some comments here I have one from

1310

00:51:17,440 --> 00:51:22,300

Daniel no star on the Q&A app he is

1311

00:51:20,230 --> 00:51:25,119

asking do you think a private company

1312  
00:51:22,300 --> 00:51:27,039  
like SpaceX might take over the

1313  
00:51:25,119 --> 00:51:29,590  
maintenance and control of Hubble once

1314  
00:51:27,039 --> 00:51:31,900  
NASA converts over to JWST and perhaps

1315  
00:51:29,590 --> 00:51:34,240  
set up a crowdfunding system like slew

1316  
00:51:31,900 --> 00:51:37,809  
for anyone to point Hubble sure would be

1317  
00:51:34,239 --> 00:51:38,979  
cool it's a great idea uh Carol is that

1318  
00:51:37,809 --> 00:51:45,070  
something you'd want to comment on maybe

1319  
00:51:38,980 --> 00:51:48,730  
you're sure um so just for all you fans

1320  
00:51:45,070 --> 00:51:50,860  
of SpaceX and Elon Musk Elon Musk has

1321  
00:51:48,730 --> 00:51:54,280  
actually received quite a bit of NASA

1322  
00:51:50,860 --> 00:51:56,349  
funding to get his little enterprise off

1323  
00:51:54,280 --> 00:51:58,390  
the ground as we say so he's not

1324  
00:51:56,349 --> 00:52:02,860  
completely independent of NASA number

1325  
00:51:58,389 --> 00:52:06,879  
one and number two this kind of

1326  
00:52:02,860 --> 00:52:10,240  
exploration is and and use of scientific

1327  
00:52:06,880 --> 00:52:12,579  
instruments is really something that

1328  
00:52:10,239 --> 00:52:14,919  
requires a national effort and a

1329  
00:52:12,579 --> 00:52:16,659  
national will and so like a lot of the

1330  
00:52:14,920 --> 00:52:18,430  
ground-based telescopes are funded

1331  
00:52:16,659 --> 00:52:20,259  
through the National Science Foundation

1332  
00:52:18,429 --> 00:52:23,559  
because it's very hard for private

1333  
00:52:20,260 --> 00:52:25,540  
institutions to afford such facilities

1334  
00:52:23,559 --> 00:52:27,608  
now there are a few cases in the old

1335  
00:52:25,539 --> 00:52:30,460  
days of ground-based observatories that

1336  
00:52:27,608 --> 00:52:32,529  
were very capable that were privately

1337  
00:52:30,460 --> 00:52:34,769  
funded by people who had a lot of money

1338  
00:52:32,530 --> 00:52:37,720  
but in when we start talking about

1339  
00:52:34,769 --> 00:52:40,329  
sending rockets into space and then

1340

00:52:37,719 --> 00:52:42,489  
putting astronomical instruments on them

1341  
00:52:40,329 --> 00:52:45,069  
it's very difficult so maybe sometime

1342  
00:52:42,489 --> 00:52:47,889  
downstream it might be possible to

1343  
00:52:45,070 --> 00:52:51,609  
privatize right now NASA is really the

1344  
00:52:47,889 --> 00:52:54,069  
only name of the game and note you know

1345  
00:52:51,608 --> 00:52:56,799  
the science part of NASA is not for

1346  
00:52:54,070 --> 00:53:00,309  
profit and in fact we we give away all

1347  
00:52:56,800 --> 00:53:03,850  
of our data so to then start talking

1348  
00:53:00,309 --> 00:53:06,130  
about commercial space and then applying

1349  
00:53:03,849 --> 00:53:08,409  
that to scientific research is really

1350  
00:53:06,130 --> 00:53:10,539  
scary for people like me because that

1351  
00:53:08,409 --> 00:53:13,059  
means that the costs are what going to

1352  
00:53:10,539 --> 00:53:16,239  
go way up and it's not going to really

1353  
00:53:13,059 --> 00:53:18,969  
be possible for many of us to to do the

1354  
00:53:16,239 --> 00:53:20,439

science unless it's federally funded

1355

00:53:18,969 --> 00:53:22,839

we have this arrangement with the

1356

00:53:20,440 --> 00:53:25,360

European Space Agency so it's two very

1357

00:53:22,840 --> 00:53:27,370

large agencies putting together their

1358

00:53:25,360 --> 00:53:29,079

resources and expertise so that

1359

00:53:27,369 --> 00:53:33,789

scientists can do the research sorry

1360

00:53:29,079 --> 00:53:36,069

it's an interesting idea but it does

1361

00:53:33,789 --> 00:53:38,199

require significant resources and

1362

00:53:36,070 --> 00:53:40,450

expertise to to keep these things

1363

00:53:38,199 --> 00:53:42,789

running and you're only you're seeing

1364

00:53:40,449 --> 00:53:45,519

three of great experts on mobile and

1365

00:53:42,789 --> 00:53:47,170

there are many more right yeah so it's

1366

00:53:45,519 --> 00:53:50,500

easy so it's a very expensive endeavor

1367

00:53:47,170 --> 00:53:52,269

good what good point there if Tony I

1368

00:53:50,500 --> 00:53:55,480

think there's definitely going to be



1369  
00:53:52,269 --> 00:53:57,969  
good overlap between JWST and Hubble so

1370  
00:53:55,480 --> 00:54:00,190  
it's not like once jwst is on orbit

1371  
00:53:57,969 --> 00:54:02,019  
Hubble's just gonna get turned off okay

1372  
00:54:00,190 --> 00:54:03,610  
hold that thought oh that's not hold

1373  
00:54:02,019 --> 00:54:07,119  
that thought there Morgan because brooke

1374  
00:54:03,610 --> 00:54:09,070  
van der be a Q&A app is it yeah we get

1375  
00:54:07,119 --> 00:54:11,259  
this almost every time how long are we

1376  
00:54:09,070 --> 00:54:18,010  
going to keep using Hubble why would it

1377  
00:54:11,260 --> 00:54:20,260  
stop being usable I continue please stop

1378  
00:54:18,010 --> 00:54:21,910  
right at least until 2020 and like I

1379  
00:54:20,260 --> 00:54:24,970  
said we're really hoping to get a few

1380  
00:54:21,909 --> 00:54:27,759  
years of overlap between Hubble and jwst

1381  
00:54:24,969 --> 00:54:29,709  
we can both telescopes can be observing

1382  
00:54:27,760 --> 00:54:32,890  
the same thing and get data from the

1383  
00:54:29,710 --> 00:54:34,119  
different instruments and I you know my

1384  
00:54:32,889 --> 00:54:36,219  
instinct is that we're going to be able

1385  
00:54:34,119 --> 00:54:38,949  
to operate longer than 20 20 and

1386  
00:54:36,219 --> 00:54:42,969  
certainly as instruments dyers the gyros

1387  
00:54:38,949 --> 00:54:45,129  
die um the capabilities might be lower

1388  
00:54:42,969 --> 00:54:47,019  
than they are right now and but we have

1389  
00:54:45,130 --> 00:54:49,690  
a lot of contingency built-in we have a

1390  
00:54:47,019 --> 00:54:51,880  
lot of engineers working on all sorts of

1391  
00:54:49,690 --> 00:54:54,309  
life extension projects to keep Hubble

1392  
00:54:51,880 --> 00:54:56,110  
going just as long as we possibly can so

1393  
00:54:54,309 --> 00:54:58,179  
what about the second part of that

1394  
00:54:56,110 --> 00:54:59,769  
question why would it stop being usable

1395  
00:54:58,179 --> 00:55:03,399  
what are some of the things that would

1396  
00:54:59,769 --> 00:55:05,650  
make it no not not a thing we can use

1397

00:55:03,400 --> 00:55:07,990  
anymore certainly like Mike said we have

1398  
00:55:05,650 --> 00:55:12,130  
science modes that can operate with 10

1399  
00:55:07,989 --> 00:55:15,069  
um so the gyros are 11 and if all of the

1400  
00:55:12,130 --> 00:55:17,050  
instruments end up having we've had some

1401  
00:55:15,070 --> 00:55:19,300  
power issues on the instruments

1402  
00:55:17,050 --> 00:55:22,000  
historically so if the instruments just

1403  
00:55:19,300 --> 00:55:25,000  
stop not being able to literally not get

1404  
00:55:22,000 --> 00:55:27,010  
power Mike we gave you one of the

1405  
00:55:25,000 --> 00:55:29,170  
doomsday scenarios of we go into a

1406  
00:55:27,010 --> 00:55:31,150  
regular safe mode we close the door so

1407  
00:55:29,170 --> 00:55:32,200  
there's lots of different things that

1408  
00:55:31,150 --> 00:55:33,849  
could go wrong

1409  
00:55:32,199 --> 00:55:36,639  
but we have multiple layers of

1410  
00:55:33,849 --> 00:55:39,400  
redundancy built in so we need lots of

1411  
00:55:36,639 --> 00:55:40,569

problems Dalton well that leads me I'm

1412

00:55:39,400 --> 00:55:41,710

sorry to be rushing but I'm running out

1413

00:55:40,570 --> 00:55:43,300

of time i'll make sure i get some of

1414

00:55:41,710 --> 00:55:45,670

these that leads me to Tony Lynch's

1415

00:55:43,300 --> 00:55:47,740

question which is how do you this is

1416

00:55:45,670 --> 00:55:50,200

another limiting factor on Hubble how do

1417

00:55:47,739 --> 00:55:52,750

you keep Hubble in its actual altitude

1418

00:55:50,199 --> 00:55:55,659

in his orbital altitude how do we keep

1419

00:55:52,750 --> 00:55:58,570

it up there what do we do go it's a

1420

00:55:55,659 --> 00:56:01,000

quite it's just sitting up there it in

1421

00:55:58,570 --> 00:56:03,250

and it's actually slowly falling down I

1422

00:56:01,000 --> 00:56:05,858

mean the trouble is this thing has very

1423

00:56:03,250 --> 00:56:07,960

big wings on it and these things I mean

1424

00:56:05,858 --> 00:56:09,909

even though we're at yo 340 miles above

1425

00:56:07,960 --> 00:56:12,130

the atmosphere we get atmospheric drag

1426  
00:56:09,909 --> 00:56:14,618  
we are slowly coming down and there's

1427  
00:56:12,130 --> 00:56:17,650  
nothing we can do about that I mean you

1428  
00:56:14,619 --> 00:56:19,960  
know you that is the most life limiting

1429  
00:56:17,650 --> 00:56:21,760  
thing I mean what it will do or 'but and

1430  
00:56:19,960 --> 00:56:23,500  
so but that's out you know this

1431  
00:56:21,760 --> 00:56:25,690  
estimates now are pushing that out you

1432  
00:56:23,500 --> 00:56:28,630  
know 2035 something like that we come

1433  
00:56:25,690 --> 00:56:29,769  
down by ourselves right so and I think

1434  
00:56:28,630 --> 00:56:32,260  
the limit the outer limit on that

1435  
00:56:29,769 --> 00:56:36,579  
somewhere around the middle mid-2020s

1436  
00:56:32,260 --> 00:56:38,140  
where that might be a real problem so so

1437  
00:56:36,579 --> 00:56:42,280  
yeah so that that's another limiting

1438  
00:56:38,139 --> 00:56:43,838  
issue so here is let me just respond to

1439  
00:56:42,280 --> 00:56:45,369  
this comment shungo for is asking is

1440  
00:56:43,838 --> 00:56:47,380  
there any way to rewatch this once it's

1441  
00:56:45,369 --> 00:56:49,240  
over yes this will be archived on our

1442  
00:56:47,380 --> 00:56:51,160  
youtube channel hubble slight channel

1443  
00:56:49,239 --> 00:56:52,838  
which if you haven't subscribed you are

1444  
00:56:51,159 --> 00:56:55,659  
wrong you need to go over to youtube and

1445  
00:56:52,838 --> 00:56:58,019  
subscribe to our channel yeah I don't

1446  
00:56:55,659 --> 00:57:00,429  
feel how do you feel about that Tony

1447  
00:56:58,019 --> 00:57:01,900  
I'll subscribe that way you'll also be

1448  
00:57:00,429 --> 00:57:04,509  
notified of any future hangouts on air

1449  
00:57:01,900 --> 00:57:06,940  
and also wanted a shout out to we just

1450  
00:57:04,510 --> 00:57:09,640  
broke four million followers and Google+

1451  
00:57:06,940 --> 00:57:11,079  
so thank you all in Google+ and make

1452  
00:57:09,639 --> 00:57:13,629  
sure to follow us over at Twitter we're

1453  
00:57:11,079 --> 00:57:15,700  
at Hubble telescope yes thank you for

1454

00:57:13,630 --> 00:57:18,130  
that Michael job in one final comment

1455  
00:57:15,699 --> 00:57:21,578  
and then so you don't torque with the

1456  
00:57:18,130 --> 00:57:24,940  
CMG's you don't torque on the CMG's with

1457  
00:57:21,579 --> 00:57:29,800  
actuators to move it CMG's what are

1458  
00:57:24,940 --> 00:57:31,869  
those i'm not sure but but no to move it

1459  
00:57:29,800 --> 00:57:34,240  
all because spin the wheels yeah you

1460  
00:57:31,869 --> 00:57:39,940  
just spin the wheels alligators cool

1461  
00:57:34,239 --> 00:57:41,348  
mini gremlins and Nnanji yeah i'm not

1462  
00:57:39,940 --> 00:57:43,358  
question what those are Michael but

1463  
00:57:41,349 --> 00:57:44,710  
thanks for that and so yeah there's the

1464  
00:57:43,358 --> 00:57:45,759  
momentum wheels that are there solely

1465  
00:57:44,710 --> 00:57:47,619  
responsible for moving

1466  
00:57:45,760 --> 00:57:48,670  
I I forgetting anything Scott that I

1467  
00:57:47,619 --> 00:57:51,460  
haven't looked at the queue at the

1468  
00:57:48,670 --> 00:57:54,730

Hubble of the YouTube nope at the

1469

00:57:51,460 --> 00:57:56,980

YouTube I'm thinking the only thing here

1470

00:57:54,730 --> 00:57:58,809

Twitter actually has been great and a

1471

00:57:56,980 --> 00:58:01,000

lot of our questions has been and thank

1472

00:57:58,809 --> 00:58:04,719

what I need though you has been greater

1473

00:58:01,000 --> 00:58:07,840

on Twitter um la let's see here there's

1474

00:58:04,719 --> 00:58:10,649

more of comments you know so for you

1475

00:58:07,840 --> 00:58:12,850

guys for our amazing guests lots of

1476

00:58:10,650 --> 00:58:15,099

thankful comments and actually

1477

00:58:12,849 --> 00:58:18,400

understanding how Hubble works so this

1478

00:58:15,099 --> 00:58:19,869

one is from da roc caelius Hubble is a

1479

00:58:18,400 --> 00:58:21,430

beautiful series of instruments this

1480

00:58:19,869 --> 00:58:24,099

video is helping me to understand the

1481

00:58:21,429 --> 00:58:26,069

fascinating simplicity and complexity in

1482

00:58:24,099 --> 00:58:30,369

the structure of the telescope thank you



1483  
00:58:26,070 --> 00:58:33,280  
which also know that yes and I think

1484  
00:58:30,369 --> 00:58:37,210  
this is a good question maybe in general

1485  
00:58:33,280 --> 00:58:40,680  
this from Chris Marshall here it says if

1486  
00:58:37,210 --> 00:58:42,940  
there was see here if there was a

1487  
00:58:40,679 --> 00:58:46,029  
spacecraft available the service Hubble

1488  
00:58:42,940 --> 00:58:47,769  
again what changes would you make is

1489  
00:58:46,030 --> 00:58:52,120  
there anything you guys would would

1490  
00:58:47,769 --> 00:58:54,210  
change I'd get a new key number I've

1491  
00:58:52,119 --> 00:58:58,329  
been to a pentium class or something i

1492  
00:58:54,210 --> 00:59:00,730  
don't look not broken yeah that's a good

1493  
00:58:58,329 --> 00:59:03,369  
philosophy of those problems instruments

1494  
00:59:00,730 --> 00:59:04,840  
i mean the the ability to change of

1495  
00:59:03,369 --> 00:59:06,609  
science which means is really what has

1496  
00:59:04,840 --> 00:59:08,050  
given Hubble the long life in the

1497  
00:59:06,610 --> 00:59:11,260  
ability if you put a new science

1498  
00:59:08,050 --> 00:59:13,150  
instrument up there the whole new yep

1499  
00:59:11,260 --> 00:59:15,400  
that's what happened so if you could all

1500  
00:59:13,150 --> 00:59:17,349  
one thing up on Hubble even a say you

1501  
00:59:15,400 --> 00:59:19,090  
had lost half your gyros in one wheel

1502  
00:59:17,349 --> 00:59:20,409  
you would put a science instrument up

1503  
00:59:19,090 --> 00:59:23,019  
there because it's going to give you

1504  
00:59:20,409 --> 00:59:25,359  
more science um yeah and I would say

1505  
00:59:23,019 --> 00:59:26,920  
that if we were face well if we had an

1506  
00:59:25,360 --> 00:59:30,280  
opportunity to do that and we were

1507  
00:59:26,920 --> 00:59:31,960  
pretty confident that wife ocala 3 was

1508  
00:59:30,280 --> 00:59:33,970  
going to continue operation i think the

1509  
00:59:31,960 --> 00:59:37,960  
science community would like then maybe

1510  
00:59:33,969 --> 00:59:40,659  
to expand the UV capability because this

1511

00:59:37,960 --> 00:59:42,460  
is the last telescope for a very long

1512  
00:59:40,659 --> 00:59:45,609  
time that we'll be able to look in the

1513  
00:59:42,460 --> 00:59:47,740  
ultraviolet so that we're going to lose

1514  
00:59:45,610 --> 00:59:49,900  
that capability when we use Hubble and

1515  
00:59:47,739 --> 00:59:51,669  
in fact we have noticed that the number

1516  
00:59:49,900 --> 00:59:55,119  
of there's a whole campaign but the

1517  
00:59:51,670 --> 00:59:58,360  
number of proposals that have gone in

1518  
00:59:55,119 --> 00:59:59,230  
have emphasized some of the ultraviolet

1519  
00:59:58,360 --> 01:00:00,820  
capability

1520  
00:59:59,230 --> 01:00:03,099  
but the great thing is to have the wide

1521  
01:00:00,820 --> 01:00:05,769  
field camera there not only with the you

1522  
01:00:03,099 --> 01:00:07,829  
biz but but the infrared capability as

1523  
01:00:05,769 --> 01:00:10,179  
well so it's it's all of that together

1524  
01:00:07,829 --> 01:00:11,739  
so we have to think as a science

1525  
01:00:10,179 --> 01:00:15,129

community what really is the highest

1526

01:00:11,739 --> 01:00:17,679

priority so I guess Elena looked it up

1527

01:00:15,130 --> 01:00:20,440

and said CMG is control moment gyroscope

1528

01:00:17,679 --> 01:00:22,839

so I guess we just didn't hold it oh you

1529

01:00:20,440 --> 01:00:26,320

know yeah no I guess that's what that

1530

01:00:22,840 --> 01:00:27,579

CMG is okay well I think that's all of

1531

01:00:26,320 --> 01:00:29,920

it I think that will conclude this

1532

01:00:27,579 --> 01:00:31,029

week's this week's hanging out I want to

1533

01:00:29,920 --> 01:00:32,070

thank everybody for watch I want to

1534

01:00:31,030 --> 01:00:34,930

thank our guests you guys were awesome

1535

01:00:32,070 --> 01:00:36,309

so thank you all this was a lot of fun

1536

01:00:34,929 --> 01:00:37,329

I've been dying to learn about the nuts

1537

01:00:36,309 --> 01:00:39,579

and bolts of the Hubble Space Telescope

1538

01:00:37,329 --> 01:00:41,108

and how its operated so thank you all

1539

01:00:39,579 --> 01:00:45,309

thank you all for taking the time out to

1540  
01:00:41,108 --> 01:00:49,480  
join us from Goddard and Carol next week

1541  
01:00:45,309 --> 01:00:52,779  
all it says is a bill 2744 Z equals 10

1542  
01:00:49,480 --> 01:00:54,969  
that's that's a frontier fields frontier

1543  
01:00:52,780 --> 01:00:59,290  
fields is that a discovery of a very

1544  
01:00:54,969 --> 01:01:01,179  
very distant galaxies using not only the

1545  
01:00:59,289 --> 01:01:02,949  
standard techniques of measuring its

1546  
01:01:01,179 --> 01:01:06,549  
color because we can't measure its

1547  
01:01:02,949 --> 01:01:09,699  
spectrum but it's also studying the lens

1548  
01:01:06,550 --> 01:01:11,800  
model and that this object was found by

1549  
01:01:09,699 --> 01:01:15,519  
examining the lens mom so we'll be able

1550  
01:01:11,800 --> 01:01:16,930  
to really talk about okay we did these

1551  
01:01:15,519 --> 01:01:18,969  
clusters we know their gravitational

1552  
01:01:16,929 --> 01:01:20,649  
lenses now how do you model that and

1553  
01:01:18,969 --> 01:01:23,079  
what can you learn so it could all be

1554  
01:01:20,650 --> 01:01:26,950  
pretty cool I also tune in to see what Z

1555  
01:01:23,079 --> 01:01:32,170  
equals 10 mins so we means it really far

1556  
01:01:26,949 --> 01:01:33,730  
away that really far away we'll get a

1557  
01:01:32,170 --> 01:01:36,400  
frontier fields update next week on

1558  
01:01:33,730 --> 01:01:38,530  
Thursday three o'clock eastern time so

1559  
01:01:36,400 --> 01:01:42,510  
we hope you guys a little tune in thank

1560  
01:01:38,530 --> 01:01:47,970  
you all for watching and as always keep

1561  
01:01:42,510 --> 01:01:47,970  
up thanks everyone thank you