
SILICON VALLEY
AMES RESEARCH CENTER

1
00:00:00,000 --> 00:00:09,010
eight seven six five four three two

2
00:00:28,540 --> 00:00:22,530
[Music]

3
00:00:31,330 --> 00:00:28,550
what's up everybody you're watching NASA

4
00:00:33,850 --> 00:00:31,340
in Silicon Valley live for December 6

5
00:00:35,500 --> 00:00:33,860
I'm your host Cassandra bell and if you

6
00:00:37,210 --> 00:00:35,510
didn't know this is NASA and Silicon

7
00:00:38,860 --> 00:00:37,220
Valley live a conversational talk show

8
00:00:40,630 --> 00:00:38,870
talk show out of NASA Ames Research

9
00:00:43,210 --> 00:00:40,640
Center with the various scientists

10
00:00:45,000 --> 00:00:43,220
engineers and researchers and all-around

11
00:00:47,500 --> 00:00:45,010
cool things that you need to know about

12
00:00:50,350 --> 00:00:47,510
I'm here with my co-host Abbie Taber

13
00:00:53,320 --> 00:00:50,360

hey Sandra hey everybody welcome back

14
00:00:55,030 --> 00:00:53,330
thanks for joining us again if you like

15
00:00:57,880 --> 00:00:55,040
that nerdy NASA news we are

16
00:01:00,279 --> 00:00:57,890
simultaneously live on twitch YouTube

17
00:01:02,619 --> 00:01:00,289
and Facebook but if you want to join us

18
00:01:04,299 --> 00:01:02,629
in the chat and ask our guests questions

19
00:01:07,510 --> 00:01:04,309
you gotta join us on Twitch so that is

20
00:01:09,400 --> 00:01:07,520
twitch.tv slash NASA and if you can't

21
00:01:11,560 --> 00:01:09,410
catch us live no big deal we'll have the

22
00:01:14,050 --> 00:01:11,570
video on demand later including on NASA

23
00:01:15,999 --> 00:01:14,060
TV and if you want to listen to the

24
00:01:19,359 --> 00:01:16,009
audio only version you can catch us on

25
00:01:21,310 --> 00:01:19,369
your favorite podcast service so today

26
00:01:24,219 --> 00:01:21,320
I'm very happy to introduce you to our

27
00:01:26,469 --> 00:01:24,229
special guests Andrew and Jim can you

28
00:01:28,540 --> 00:01:26,479
tell us your full name and just a little

29
00:01:30,219 --> 00:01:28,550
bit about what you do here sure my name

30
00:01:32,679 --> 00:01:30,229
is Andrew Hilton and I'm research

31
00:01:34,899 --> 00:01:32,689
scientists here at NASA Ames and I study

32
00:01:37,840 --> 00:01:34,909
evolve stars so stars nearing the end of

33
00:01:40,690 --> 00:01:37,850
their lifetime interesting cool and I'm

34
00:01:43,450 --> 00:01:40,700
Jim divisor I'm a scientist here at Ames

35
00:01:45,969 --> 00:01:43,460
as well my main field of research is how

36
00:01:47,649 --> 00:01:45,979
stars form and I also work on

37
00:01:49,510 --> 00:01:47,659
astronomical instrumentation so these

38
00:01:50,770 --> 00:01:49,520

are the cameras and instruments that we

39
00:01:52,870 --> 00:01:50,780
put at the back end of the telescope

40
00:01:55,210 --> 00:01:52,880
that collects the light that takes the

41
00:01:57,670 --> 00:01:55,220
image or studies the object in space

42
00:02:01,179 --> 00:01:57,680
that we want to observe okay that's

43
00:02:02,980 --> 00:02:01,189
pretty essential for astronomy right so

44
00:02:05,139 --> 00:02:02,990
today we're here to talk about airborne

45
00:02:06,520 --> 00:02:05,149
astronomy so can you tell us a little

46
00:02:08,199 --> 00:02:06,530
bit about what that means airborne

47
00:02:10,569 --> 00:02:08,209
astronomy yeah so when you think about

48
00:02:13,090 --> 00:02:10,579
astronomy you might think about the dome

49
00:02:14,860 --> 00:02:13,100
on the top of a mountain in a isolated

50
00:02:17,259 --> 00:02:14,870
mountain range somewhere or you might

51
00:02:18,819 --> 00:02:17,269
think of a satellite in space but one of

52
00:02:20,740 --> 00:02:18,829
the other places you can do astronomy is

53
00:02:22,690 --> 00:02:20,750
from the atmosphere and that can be from

54
00:02:24,370 --> 00:02:22,700
a balloon or from a sounding rocket but

55
00:02:27,520 --> 00:02:24,380
what we're gonna concentrate on talking

56
00:02:29,229 --> 00:02:27,530
about today is astronomy from planes so

57
00:02:32,140 --> 00:02:29,239
putting a telescope on a plane to

58
00:02:33,759 --> 00:02:32,150
observe space okay that's clearly

59
00:02:35,400 --> 00:02:33,769
awesome telescope on a plane but why

60
00:02:37,010 --> 00:02:35,410
would you do that what's the advantage

61
00:02:40,040 --> 00:02:37,020
there number two

62
00:02:41,930 --> 00:02:40,050
just having telescope on a plane you

63
00:02:43,520 --> 00:02:41,940

could imagine that not all astronomical

64
00:02:45,230 --> 00:02:43,530
events happen at the same place on the

65
00:02:46,610 --> 00:02:45,240
surface of the earth and so sometimes

66
00:02:48,260 --> 00:02:46,620
you might need to take your Observatory

67
00:02:49,790 --> 00:02:48,270
to where that events going to occur and

68
00:02:52,160 --> 00:02:49,800
of course the plains of mobile platforms

69
00:02:54,020 --> 00:02:52,170
so you can go anywhere you want and so

70
00:02:56,300 --> 00:02:54,030
that's one reason also you have people

71
00:02:57,950 --> 00:02:56,310
onboard so if you have problems with

72
00:02:59,090 --> 00:02:57,960
your instruments during a flight rather

73
00:03:00,740 --> 00:02:59,100
than being stuck in space where you

74
00:03:02,360 --> 00:03:00,750
can't access them you're right there and

75
00:03:04,100 --> 00:03:02,370
so you can work on it the plane comes

76
00:03:05,570 --> 00:03:04,110
home every night and so you can make

77
00:03:08,240 --> 00:03:05,580
changes to the instrumentation you can

78
00:03:10,160 --> 00:03:08,250
make repairs as they're needed and then

79
00:03:12,140 --> 00:03:10,170
in addition since you're flying on a

80
00:03:14,570 --> 00:03:12,150
plane you can get up into the atmosphere

81
00:03:15,500 --> 00:03:14,580
where you can start to see a mission

82
00:03:16,730 --> 00:03:15,510
that you wouldn't otherwise be able to

83
00:03:19,010 --> 00:03:16,740
see from the ground you start to see

84
00:03:20,360 --> 00:03:19,020
wavelengths of light that are impossible

85
00:03:22,040 --> 00:03:20,370
to detect on it from a ground-based

86
00:03:23,780 --> 00:03:22,050
observatory okay tell us more about that

87
00:03:26,000 --> 00:03:23,790
what is a wavelength of light that we're

88
00:03:28,880 --> 00:03:26,010

not gonna see down here so for example

89
00:03:30,320 --> 00:03:28,890
our eyes are sensitive to optical light

90
00:03:31,460 --> 00:03:30,330
so the visual portion of the spectrum

91
00:03:33,860 --> 00:03:31,470
which is actually just a very small

92
00:03:35,680 --> 00:03:33,870
fraction of the total spectrum of light

93
00:03:38,660 --> 00:03:35,690
like the rainbow like the rainbow yeah

94
00:03:40,970 --> 00:03:38,670
very very narrow portion of all the

95
00:03:43,970 --> 00:03:40,980
electromagnetic radiation spectrum and

96
00:03:45,770 --> 00:03:43,980
so if you're wanting to observe in the

97
00:03:47,480 --> 00:03:45,780
infrared portion of the spectrum which

98
00:03:49,040 --> 00:03:47,490
is a wavelength just a little bit longer

99
00:03:50,360 --> 00:03:49,050
than visual you're not going to be able

100
00:03:51,650 --> 00:03:50,370
to see that from the ground because the

101
00:03:54,290 --> 00:03:51,660
atmosphere absorbs most of them

102
00:03:56,510 --> 00:03:54,300
okay so infrared is like remote controls

103
00:03:57,890 --> 00:03:56,520
right like yeah the TV that's how that

104
00:03:59,390 --> 00:03:57,900
works to change the channel that's

105
00:04:01,430 --> 00:03:59,400
that's right and so your eye can't see

106
00:04:02,780 --> 00:04:01,440
it right but you clearly see that it's

107
00:04:05,900 --> 00:04:02,790
affecting your television right right

108
00:04:07,250 --> 00:04:05,910
and that's infrared radiation and then

109
00:04:09,350 --> 00:04:07,260
that's what we're you know looking at

110
00:04:12,140 --> 00:04:09,360
that's what you're looking at light we

111
00:04:17,710 --> 00:04:12,150
can't see whether I think we have an

112
00:04:25,850 --> 00:04:22,909
Andrew and Jim and so here this is the

113
00:04:27,440 --> 00:04:25,860

emission from warm objects right and so

114
00:04:29,840 --> 00:04:27,450
if you're looking at this display here

115
00:04:31,460 --> 00:04:29,850
anything that's dark is cool for the

116
00:04:34,550 --> 00:04:31,470
most part although Jim might talk about

117
00:04:37,550 --> 00:04:34,560
that anything is bright is warm and the

118
00:04:39,290 --> 00:04:37,560
exception so yeah you see my forehead my

119
00:04:40,970 --> 00:04:39,300
mouths are pretty hot because they're

120
00:04:44,360 --> 00:04:40,980
the sort of the brighter yellow colors

121
00:04:46,280 --> 00:04:44,370
my nose is cold it's darker my my

122
00:04:49,010 --> 00:04:46,290
glasses look very dark but that's not

123
00:04:49,940 --> 00:04:49,020
because it's cold because the infrared

124
00:04:52,280 --> 00:04:49,950
light can't actually

125
00:04:54,500 --> 00:04:52,290
go through my glasses if I take off my

126
00:04:56,120 --> 00:04:54,510
glasses you can see my eyes there

127
00:04:57,950 --> 00:04:56,130
they're pretty hot but I put my glasses

128
00:05:01,040 --> 00:04:57,960
back on and then the infrared light

129
00:05:14,980 --> 00:05:01,050
can't penetrate through that okay didn't

130
00:05:20,690 --> 00:05:18,890
I have a question from the chat from

131
00:05:22,160 --> 00:05:20,700
bandit Sierra and why is it important to

132
00:05:23,540 --> 00:05:22,170
use an infrared telescope for Space

133
00:05:25,100 --> 00:05:23,550
Exploration and what do you hope to

134
00:05:27,680 --> 00:05:25,110
learn from this so like why why would

135
00:05:30,890 --> 00:05:27,690
you look at this kind of light right so

136
00:05:32,210 --> 00:05:30,900
as Andrew said the optical light that we

137
00:05:34,160 --> 00:05:32,220
see with our eyes there are only a very

138
00:05:37,490 --> 00:05:34,170

small part of the entire electromagnetic

139
00:05:38,960 --> 00:05:37,500
spectrum so in order to understand

140
00:05:40,640 --> 00:05:38,970
what's going on in space we want to look

141
00:05:44,150 --> 00:05:40,650
at other wavelengths to see what other

142
00:05:46,010 --> 00:05:44,160
wavelengths these objects emit at now it

143
00:05:47,780 --> 00:05:46,020
turns out that stars the surface of

144
00:05:50,390 --> 00:05:47,790
stars give off light that we see with

145
00:05:51,860 --> 00:05:50,400
our eyes and most of things that other

146
00:05:53,930 --> 00:05:51,870
things that we see are because that

147
00:05:56,000 --> 00:05:53,940
light is reflected off those objects to

148
00:05:58,790 --> 00:05:56,010
us so we can see them but the great part

149
00:06:00,500 --> 00:05:58,800
about infrared is all objects have heat

150
00:06:02,270 --> 00:06:00,510
and that's what the infrared traces and

151
00:06:04,730 --> 00:06:02,280
so all objects give off infrared light

152
00:06:06,410 --> 00:06:04,740
in fact a majority of the light in the

153
00:06:09,160 --> 00:06:06,420
universe is given off at the infrared

154
00:06:11,510 --> 00:06:09,170
wavelengths so it allows us to observe

155
00:06:13,670 --> 00:06:11,520
almost every astronomical object in

156
00:06:16,580 --> 00:06:13,680
space at a very interesting wavelength

157
00:06:18,350 --> 00:06:16,590
that we can't see with our eyes so you

158
00:06:20,060 --> 00:06:18,360
said we can see things in infrared that

159
00:06:22,520 --> 00:06:20,070
we can't see in visible light I think we

160
00:06:26,750 --> 00:06:22,530
have a picture of visible and infrared

161
00:06:29,210 --> 00:06:26,760
light sort of compare compare right so

162
00:06:32,060 --> 00:06:29,220
here we have an image of the sombrero

163
00:06:35,330 --> 00:06:32,070

galaxy and you'll notice that there's a

164
00:06:36,800 --> 00:06:35,340
halo of what are isolated stars mostly

165
00:06:38,990 --> 00:06:36,810
isolated stars but then around the waist

166
00:06:41,720 --> 00:06:39,000
of the galaxy there are these dark lanes

167
00:06:45,500 --> 00:06:41,730
and those dark lanes are lanes of gas

168
00:06:47,030 --> 00:06:45,510
and and dust and they're dark because

169
00:06:48,980 --> 00:06:47,040
they're absorbing a lot of that visual

170
00:06:50,270 --> 00:06:48,990
light the portion of the rainbow

171
00:06:51,920 --> 00:06:50,280
spectrum their eyes can see they're

172
00:06:56,240 --> 00:06:51,930
absorbing that material so if we go to

173
00:06:58,070 --> 00:06:56,250
the next infrared same galaxy but now

174
00:07:01,040 --> 00:06:58,080
you'll notice that what was dark in the

175
00:07:03,180 --> 00:07:01,050
last image is now illuminated because

176
00:07:04,590 --> 00:07:03,190
it's emitting the infrared light so it's

177
00:07:06,120 --> 00:07:04,600
in the optical but it's admitting in the

178
00:07:08,130 --> 00:07:06,130
infrared and you don't see the stars and

179
00:07:10,080 --> 00:07:08,140
you don't see the stars as well okay so

180
00:07:13,650 --> 00:07:10,090
that pink is the dust glowing and that's

181
00:07:15,630 --> 00:07:13,660
the dust glowing that's right the other

182
00:07:18,900 --> 00:07:15,640
advantage about working the infrared is

183
00:07:21,330 --> 00:07:18,910
it has a penetrating power and what I

184
00:07:23,220 --> 00:07:21,340
mean by that is a lot of times in the

185
00:07:24,600 --> 00:07:23,230
center of galaxies or where stars are

186
00:07:27,120 --> 00:07:24,610
forming they're surrounded by a lot of

187
00:07:28,980 --> 00:07:27,130
gas and dust which makes it impossible

188
00:07:30,360 --> 00:07:28,990

for us to see what's going on and with

189
00:07:32,370 --> 00:07:30,370
or with our eyes or with optical

190
00:07:34,170 --> 00:07:32,380
wavelengths but the infrared light comes

191
00:07:37,080 --> 00:07:34,180
through so we can detect that and we can

192
00:07:39,510 --> 00:07:37,090
see how stars are forming so the analogy

193
00:07:42,210 --> 00:07:39,520
to that is firefighters when they go

194
00:07:43,710 --> 00:07:42,220
into a burning building there's a lot of

195
00:07:45,000 --> 00:07:43,720
smoke they might not be able to see the

196
00:07:48,120 --> 00:07:45,010
people they're trying to save if they

197
00:07:49,740 --> 00:07:48,130
don't have goggles which are IR goggles

198
00:07:51,150 --> 00:07:49,750
which it allows them to see through the

199
00:07:52,590 --> 00:07:51,160
smoke and see the heat signatures of the

200
00:07:54,390 --> 00:07:52,600
people the bodies of the people who

201
00:07:56,520 --> 00:07:54,400
they're trying to save so it's very

202
00:07:58,280 --> 00:07:56,530
similar it's a very similar technology

203
00:07:59,520 --> 00:07:58,290
and what we're doing in astronomy so

204
00:08:01,620 --> 00:07:59,530
cool

205
00:08:04,350 --> 00:08:01,630
that sounds like a very on-the-ground

206
00:08:06,780 --> 00:08:04,360
kind of used for infrared but why would

207
00:08:10,860 --> 00:08:06,790
we use airplanes to do infrared

208
00:08:13,200 --> 00:08:10,870
astronomy airplanes as I mentioned

209
00:08:17,130 --> 00:08:13,210
earlier allow us to get up higher into

210
00:08:18,720 --> 00:08:17,140
the atmosphere and infrared of absorbed

211
00:08:20,580 --> 00:08:18,730
in our atmosphere by water vapor and

212
00:08:23,010 --> 00:08:20,590
water vapor is very efficient at

213
00:08:24,240 --> 00:08:23,020

absorbing infrared radiation and so in

214
00:08:26,610 --> 00:08:24,250
our atmosphere it turns out the most

215
00:08:29,070 --> 00:08:26,620
that warf vapor is at the lower levels

216
00:08:30,630 --> 00:08:29,080
of the atmosphere and if you get as high

217
00:08:33,600 --> 00:08:30,640
as what we call the stratosphere it

218
00:08:34,980 --> 00:08:33,610
becomes very dry and so you can now see

219
00:08:37,830 --> 00:08:34,990
on the infrared it's now transparent

220
00:08:39,450 --> 00:08:37,840
where we're trying to observe okay once

221
00:08:41,070 --> 00:08:39,460
it gets to the stratosphere yeah okay so

222
00:08:42,810 --> 00:08:41,080
I think we have an illustration sort of

223
00:08:45,150 --> 00:08:42,820
show it what that is what what we mean

224
00:08:46,920 --> 00:08:45,160
by the stratosphere and maybe we're

225
00:08:48,540 --> 00:08:46,930
waiting oh here we go here we go so yeah

226
00:08:52,380 --> 00:08:48,550
you'll see there's two layers of the

227
00:08:54,329 --> 00:08:52,390
atmosphere here there's these rays of

228
00:08:56,010 --> 00:08:54,339
infrared light which are shown as red

229
00:08:57,450 --> 00:08:56,020
and you see as they come down through

230
00:08:59,190 --> 00:08:57,460
the stratosphere and into the lower

231
00:09:01,350 --> 00:08:59,200
atmosphere they start to become

232
00:09:02,250 --> 00:09:01,360
attenuated or drop off and you the light

233
00:09:04,200 --> 00:09:02,260
doesn't make it all the way to the

234
00:09:06,690 --> 00:09:04,210
ground however there's a plane there in

235
00:09:08,190 --> 00:09:06,700
the stratosphere where it's intercepting

236
00:09:09,870 --> 00:09:08,200
that infrared like so that could be the

237
00:09:11,550 --> 00:09:09,880
light from an astronomical object for

238
00:09:12,360 --> 00:09:11,560

instance and so that's the reason why we

239
00:09:14,160 --> 00:09:12,370
try to get up there into the

240
00:09:15,870 --> 00:09:14,170
stratosphere yeah a bunch of people want

241
00:09:17,939 --> 00:09:15,880
to know like resonator games

242
00:09:20,370 --> 00:09:17,949
and how high did these tools fly so

243
00:09:22,430 --> 00:09:20,380
what's the altitude for severe normal

244
00:09:25,249 --> 00:09:22,440
cruising altitude for when we're doing

245
00:09:28,590 --> 00:09:25,259
observations is anywhere between 39 and

246
00:09:29,610 --> 00:09:28,600
43,000 feet okay so that's is that what

247
00:09:30,900 --> 00:09:29,620
is that in relation to where a

248
00:09:33,600 --> 00:09:30,910
commercial plane would fly so a

249
00:09:35,550 --> 00:09:33,610
commercial plane flies about 35,000 feet

250
00:09:38,189 --> 00:09:35,560
but at that way at that height it gets

251
00:09:40,230 --> 00:09:38,199
us above 99% of the Earth's water vapor

252
00:09:44,759 --> 00:09:40,240
in the atmosphere so we wrap around 40

253
00:09:47,720 --> 00:09:44,769
around 40,000 yeah NASA's been putting

254
00:09:50,370 --> 00:09:47,730
telescopes on planes for quite a while

255
00:09:53,340 --> 00:09:50,380
and we have some models here to talk

256
00:09:55,439 --> 00:09:53,350
about all these telescopes I'm cleaning

257
00:09:59,430 --> 00:09:55,449
yeah I have an early example here this

258
00:10:02,220 --> 00:09:59,440
is the Learjet right right so this is

259
00:10:03,900 --> 00:10:02,230
the NASA's Learjet Observatory so this

260
00:10:07,139 --> 00:10:03,910
was one of the earliest airborne

261
00:10:09,689 --> 00:10:07,149
observatories in the infrared and it

262
00:10:11,639 --> 00:10:09,699
started flying in late 60s it had a

263
00:10:13,889 --> 00:10:11,649

telescope that was 12 inches in diameter

264
00:10:15,780 --> 00:10:13,899
on board and so that's a modest sized

265
00:10:18,780 --> 00:10:15,790
telescope yeah it's about that big in

266
00:10:20,009 --> 00:10:18,790
diameter about that long a lot of people

267
00:10:21,360 --> 00:10:20,019
who are amateur astronomers have

268
00:10:24,329 --> 00:10:21,370
telescopes of that size in their

269
00:10:26,249 --> 00:10:24,339
backyard but in this case it was one of

270
00:10:27,240 --> 00:10:26,259
the first infrared telescopes so we're

271
00:10:29,100 --> 00:10:27,250
looking at the infrared part of the

272
00:10:32,460 --> 00:10:29,110
spectrum so it didn't make a lot of

273
00:10:35,069 --> 00:10:32,470
discoveries and if you see here in the

274
00:10:36,900 --> 00:10:35,079
front the hole here it's not really a

275
00:10:38,790 --> 00:10:36,910
hole but that's the telescope sitting

276
00:10:41,040 --> 00:10:38,800
out the are pointing out the side of the

277
00:10:42,629 --> 00:10:41,050
plane and what can you mention some

278
00:10:45,480 --> 00:10:42,639
discoveries made from this Lear Jeff

279
00:10:47,189 --> 00:10:45,490
yeah so I think there were a lot of

280
00:10:48,689 --> 00:10:47,199
discoveries made because again it was

281
00:10:51,120 --> 00:10:48,699
one of the first infrared observatories

282
00:10:53,699 --> 00:10:51,130
but one of the interesting ones was it

283
00:10:55,860 --> 00:10:53,709
totally changed how we perceived or how

284
00:10:57,660 --> 00:10:55,870
we thought about Venus so prior to these

285
00:11:00,120 --> 00:10:57,670
observations a little bit prior to these

286
00:11:01,920 --> 00:11:00,130
observations we we knew that Venus had

287
00:11:02,910 --> 00:11:01,930
lots of clouds and its atmosphere we

288
00:11:04,079 --> 00:11:02,920

knew that it's about the size of the

289
00:11:06,569 --> 00:11:04,089
earth but it's a little bit closer to

290
00:11:08,970 --> 00:11:06,579
the Sun so a lot of people thought that

291
00:11:10,860 --> 00:11:08,980
well Venus is probably like this very

292
00:11:13,290 --> 00:11:10,870
lush tropical paradise lots of rain

293
00:11:16,530 --> 00:11:13,300
maybe even vegetation or plants on the

294
00:11:17,879 --> 00:11:16,540
surface and just before these learjet

295
00:11:20,040 --> 00:11:17,889
observations they found that there was

296
00:11:22,170 --> 00:11:20,050
no water in the clouds of Venus and the

297
00:11:23,910 --> 00:11:22,180
learjet actually determined that the

298
00:11:27,910 --> 00:11:23,920
major aerosol constituent of the

299
00:11:30,530 --> 00:11:27,920
atmosphere is sulfuric acid

300
00:11:33,320 --> 00:11:30,540
so now instead of a lush tropical

301
00:11:36,770 --> 00:11:33,330
paradise or picture of Venus is sort of

302
00:11:42,160 --> 00:11:36,780
a hellscape it's so hot on the surface

303
00:11:50,510 --> 00:11:46,700
okay cool finding from the learjet now

304
00:11:54,440 --> 00:11:50,520
let's fly in my second example here even

305
00:11:57,140 --> 00:11:54,450
the next airplane a new generation of

306
00:11:58,700 --> 00:11:57,150
airborne astronomy there what's this one

307
00:12:00,470 --> 00:11:58,710
so this is a model of the Kuiper

308
00:12:03,290 --> 00:12:00,480
airborne Observatory which was the next

309
00:12:06,470 --> 00:12:03,300
generation after the Learjet the Kuiper

310
00:12:08,510 --> 00:12:06,480
was a c-141 military cargo aircraft that

311
00:12:10,490 --> 00:12:08,520
was converted to house a telescope just

312
00:12:12,290 --> 00:12:10,500
like the Learjet you can see that the

313
00:12:16,040 --> 00:12:12,300

telescope is in front of the wing right

314
00:12:18,170 --> 00:12:16,050
there just behind the cabin it's quite a

315
00:12:20,060 --> 00:12:18,180
bit larger than the Learjet was right so

316
00:12:21,650 --> 00:12:20,070
before the Learjet had telescopes is

317
00:12:24,050 --> 00:12:21,660
only about 12 inches in diameter so

318
00:12:26,090 --> 00:12:24,060
about 1 foot it's about 36 inches so

319
00:12:27,950 --> 00:12:26,100
three feet about three times bigger and

320
00:12:30,560 --> 00:12:27,960
the aircraft of course is quite a bit

321
00:12:32,840 --> 00:12:30,570
bigger as well the Learjet had a

322
00:12:36,200 --> 00:12:32,850
passenger it's in space for about four

323
00:12:37,580 --> 00:12:36,210
people with pilots and here we even have

324
00:12:39,140 --> 00:12:37,590
an upgrade so you can have about 12

325
00:12:41,390 --> 00:12:39,150
people on board so it's still pretty

326
00:12:43,250 --> 00:12:41,400
pretty small but that's mostly because

327
00:12:44,780 --> 00:12:43,260
it's taken up the fuselage is taken up

328
00:12:46,910 --> 00:12:44,790
with a lot of equipment and computers

329
00:12:48,770 --> 00:12:46,920
and whatnot if this were just a

330
00:12:50,360 --> 00:12:48,780
passenger jet it would be about 150

331
00:12:52,990 --> 00:12:50,370
people are so on board

332
00:12:55,520 --> 00:12:53,000
compared to the Lear Jets what six

333
00:12:57,050 --> 00:12:55,530
things and I think we're a picture of

334
00:13:00,110 --> 00:12:57,060
what it was like inside slang you

335
00:13:00,830 --> 00:13:00,120
mentioned not having a lot of space yeah

336
00:13:02,270 --> 00:13:00,840
so here we go

337
00:13:04,010 --> 00:13:02,280
yes there it is so you can see that most

338
00:13:05,720 --> 00:13:04,020

of the fuselage is taken up with

339
00:13:07,760 --> 00:13:05,730
computing equipments and control

340
00:13:10,810 --> 00:13:07,770
equipment it looks kind of like

341
00:13:14,300 --> 00:13:10,820
something from an old missile silo

342
00:13:17,810 --> 00:13:14,310
inside RC 141 and what years did this

343
00:13:20,630 --> 00:13:17,820
fly for so it flew from about 1975 to

344
00:13:22,460 --> 00:13:20,640
about 1995 and it was very active during

345
00:13:24,620 --> 00:13:22,470
that time so it conducted a lot of

346
00:13:27,350 --> 00:13:24,630
research it flew for about seven 1/2

347
00:13:30,500 --> 00:13:27,360
hours at a time and it would fly two to

348
00:13:33,290 --> 00:13:30,510
three times a week again it made a lot

349
00:13:35,120 --> 00:13:33,300
of discoveries similar to the Learjet it

350
00:13:38,240 --> 00:13:35,130
was one of the first observatories that

351
00:13:43,850 --> 00:13:38,250
observed the atmosphere of Pluto

352
00:13:45,710 --> 00:13:43,860
so yeah not a planet and we're actually

353
00:13:53,269 --> 00:13:45,720
lucky today to have one of the Romney

354
00:13:54,920 --> 00:13:53,279
super villains 2006's tropical

355
00:13:58,100 --> 00:13:54,930
International Astronomical Union meeting

356
00:14:01,370 --> 00:13:58,110
where they decided to reclassify Pluto

357
00:14:03,590 --> 00:14:01,380
from a planet to a dwarf planet and one

358
00:14:05,269 --> 00:14:03,600
of the main sort of contentions are

359
00:14:06,590 --> 00:14:05,279
things that people think wasn't quite

360
00:14:07,430 --> 00:14:06,600
right about it was it was towards the

361
00:14:08,900 --> 00:14:07,440
end of the meeting and there weren't a

362
00:14:11,540 --> 00:14:08,910
lot of astronomers left there was only

363
00:14:12,980 --> 00:14:11,550

so a few hundreds of us from the couple

364
00:14:15,410 --> 00:14:12,990
of thousand that were there for the

365
00:14:18,740 --> 00:14:15,420
whole meeting but we had the vote and

366
00:14:20,960 --> 00:14:18,750
and Pluto was determined not to be a

367
00:14:43,870 --> 00:14:20,970
planet and I just want people to know

368
00:14:46,150 --> 00:14:43,880
that large majority of people planet and

369
00:14:48,590 --> 00:14:46,160
what else did the Kuiper Discoverer

370
00:14:50,509 --> 00:14:48,600
study lots of things you said well

371
00:14:52,850 --> 00:14:50,519
another one that people will find a very

372
00:14:55,490 --> 00:14:52,860
interesting is the discovery of rings

373
00:14:58,699 --> 00:14:55,500
around the planet Uranus was also done

374
00:15:01,280 --> 00:14:58,709
by by Kuiper so that's another popular

375
00:15:09,380 --> 00:15:01,290
one very cool that's just a pretty big

376
00:15:12,350 --> 00:15:09,390
discovery awesome should we move on this

377
00:15:17,889 --> 00:15:12,360
is no ordinary airborne Observatory it

378
00:15:23,060 --> 00:15:20,259
that's right that's right so this is

379
00:15:25,069 --> 00:15:23,070
Sophia this is the stratospheric

380
00:15:27,889 --> 00:15:25,079
Observatory for infrared astronomy and

381
00:15:31,750 --> 00:15:27,899
this is the mission that both Andrew and

382
00:15:35,030 --> 00:15:31,760
I work on and so we're now looking at a

383
00:15:38,389 --> 00:15:35,040
747 that's been heavily modified so that

384
00:15:39,710 --> 00:15:38,399
there is a much larger telescope in the

385
00:15:42,250 --> 00:15:39,720
back so the Learjet we were talking

386
00:15:44,449 --> 00:15:42,260
about a one-foot telescope in diameter

387
00:15:45,620 --> 00:15:44,459
Piper was a three-foot diameter now

388
00:15:48,350 --> 00:15:45,630

we're talking almost nine feet in

389
00:15:51,530 --> 00:15:48,360
diameter on this telescope here nine

390
00:15:57,090 --> 00:15:51,540
feet nine feet inside

391
00:15:58,410 --> 00:15:57,100
Wow yeah cool and how often does this

392
00:16:00,900 --> 00:15:58,420
fly this is so you said the world's

393
00:16:04,400 --> 00:16:00,910
largest observatory observatory

394
00:16:06,810 --> 00:16:04,410
it flies three to four times a week and

395
00:16:09,240 --> 00:16:06,820
10 hours on a flight so a little bit

396
00:16:10,800 --> 00:16:09,250
longer than the kuiper which was at 7

397
00:16:13,040 --> 00:16:10,810
half hours and Learjet only foot could

398
00:16:16,200 --> 00:16:13,050
fly for 4 3 hours so we have a lot more

399
00:16:19,050 --> 00:16:16,210
observations coming out of the Sofia

400
00:16:20,070 --> 00:16:19,060
than we did those two facilities yeah

401
00:16:22,080 --> 00:16:20,080
and you'll notice that here the

402
00:16:23,520 --> 00:16:22,090
telescope is behind the wing whereas in

403
00:16:25,350 --> 00:16:23,530
the other two models it was in front of

404
00:16:27,060 --> 00:16:25,360
the wing that's job makes it much easier

405
00:16:28,640 --> 00:16:27,070
for the pilots to access the rest rooms

406
00:16:30,930 --> 00:16:28,650
and fly it so that's a good thing

407
00:16:36,150 --> 00:16:30,940
there's there's a lot more space to move

408
00:16:38,250 --> 00:16:36,160
around so normally if you're on a 747

409
00:16:41,100 --> 00:16:38,260
passenger jet it can house almost 300

410
00:16:44,010 --> 00:16:41,110
people or so and so this is a market

411
00:16:47,520 --> 00:16:44,020
increase in size from the c-141 that was

412
00:16:49,530 --> 00:16:47,530
the kuiper and the telescope is in the

413
00:16:50,610 --> 00:16:49,540

rear as I mentioned and that's that hole

414
00:16:52,740 --> 00:16:50,620
just to give you a sense of perspective

415
00:16:54,930 --> 00:16:52,750
about the size of a normal garage door

416
00:17:03,480 --> 00:16:54,940
right so that's how large the hole in

417
00:17:05,460 --> 00:17:03,490
the cavity that's no window and so if

418
00:17:06,569 --> 00:17:05,470
you look carefully at the fuselage you

419
00:17:09,600 --> 00:17:06,579
might be able to make this out there's a

420
00:17:11,699 --> 00:17:09,610
little rise leading up to the opening

421
00:17:14,340 --> 00:17:11,709
and that rise it was very carefully

422
00:17:16,650 --> 00:17:14,350
engineered and tested here at Ames and

423
00:17:18,420 --> 00:17:16,660
our wind tunnels here at Ames to take

424
00:17:20,790 --> 00:17:18,430
the air and direct it over the cavity

425
00:17:22,860 --> 00:17:20,800
and it's a reunion to have it redirect

426
00:17:24,090 --> 00:17:22,870
to the back side so that there's no

427
00:17:25,439 --> 00:17:24,100
turbulence in the cavity or at least

428
00:17:27,270 --> 00:17:25,449
very little turbulence in the category

429
00:17:29,100 --> 00:17:27,280
right so it's very smooth airflow across

430
00:17:30,570 --> 00:17:29,110
that the pilots are surest they can't

431
00:17:32,130 --> 00:17:30,580
tell if it's open or closed it's it's

432
00:17:33,930 --> 00:17:32,140
almost seamless Wow

433
00:17:36,200 --> 00:17:33,940
and I think we video this door opening

434
00:17:41,720 --> 00:17:36,210
this garage door in the back of the 747

435
00:17:44,760 --> 00:17:41,730
yeah Sofia in all of its glory in flight

436
00:17:47,280 --> 00:17:44,770
sunset trip yeah and here's one of our

437
00:17:48,720 --> 00:17:47,290
test flights where we're opening the

438
00:17:50,670 --> 00:17:48,730

door for the first time so you can see

439
00:17:54,120 --> 00:17:50,680
the door slowly opening in the back

440
00:17:55,920 --> 00:17:54,130
there and eventually it'll open to about

441
00:17:59,340 --> 00:17:55,930
ten feet in size because it's a nine

442
00:18:00,450 --> 00:17:59,350
foot diameter telescope so and if you

443
00:18:02,710 --> 00:18:00,460
think that it looks like it's a little

444
00:18:05,159 --> 00:18:02,720
bit stubby for a 747 you're

445
00:18:07,210 --> 00:18:05,169
correct it is it's a it's actually a

446
00:18:09,310 --> 00:18:07,220
747sp so it's a special performance

447
00:18:12,310 --> 00:18:09,320
seven four seven okay they only made

448
00:18:14,770 --> 00:18:12,320
about forty of those but it's just a

449
00:18:16,960 --> 00:18:14,780
smaller shorter version but we're on

450
00:18:19,120 --> 00:18:16,970
board we're on board during these it's

451
00:18:21,220 --> 00:18:19,130
not like there being the telescope and

452
00:18:23,200 --> 00:18:21,230
the instruments are being remote work we

453
00:18:25,060 --> 00:18:23,210
are on board the plane at the time we

454
00:18:26,529 --> 00:18:25,070
are moving at all the people on board

455
00:18:28,360 --> 00:18:26,539
are moving the telescope the people on

456
00:18:30,310 --> 00:18:28,370
board are using the instruments and

457
00:18:32,890 --> 00:18:30,320
collecting the data reactive work

458
00:18:35,590 --> 00:18:32,900
environment yeah what does that like are

459
00:18:37,539 --> 00:18:35,600
you moving around or you fixed it your

460
00:18:39,100 --> 00:18:37,549
computer screens what is it like on

461
00:18:40,450 --> 00:18:39,110
board well we have different stations

462
00:18:42,370 --> 00:18:40,460
where different people do their work

463
00:18:44,200 --> 00:18:42,380

there is a station for the telescope

464
00:18:46,299 --> 00:18:44,210
operators who point the telescope to

465
00:18:47,770 --> 00:18:46,309
where we need it to go there's a station

466
00:18:50,230 --> 00:18:47,780
for the instrument operators these are

467
00:18:51,490 --> 00:18:50,240
the people who are looking at the data

468
00:18:52,690 --> 00:18:51,500
coming out of the cameras at the back

469
00:18:54,130 --> 00:18:52,700
end of the telescope so used to be

470
00:18:55,240 --> 00:18:54,140
pieces of the back of telescopes and

471
00:18:56,680 --> 00:18:55,250
everything's digital cameras or

472
00:18:59,500 --> 00:18:56,690
instruments that collect light and

473
00:19:01,600 --> 00:18:59,510
analyze light and then you have mission

474
00:19:03,340 --> 00:19:01,610
directors who are talking between the

475
00:19:06,310 --> 00:19:03,350
scientists on the flight deck and the

476
00:19:07,630 --> 00:19:06,320
pilots up in the cockpit to organize how

477
00:19:09,789 --> 00:19:07,640
things and the flight are going to go

478
00:19:12,490 --> 00:19:09,799
and of course you have the pods up up

479
00:19:15,070 --> 00:19:12,500
top because they they're on the second

480
00:19:16,450 --> 00:19:15,080
level on a 747 and of course there's

481
00:19:18,640 --> 00:19:16,460
still a lot of space on board and so

482
00:19:19,899 --> 00:19:18,650
there's plenty of room for investigators

483
00:19:21,310 --> 00:19:19,909
who are actually the people were

484
00:19:22,810 --> 00:19:21,320
conducting the observations for the

485
00:19:24,250 --> 00:19:22,820
people who have proposed the research

486
00:19:25,570 --> 00:19:24,260
they can come on board and see their

487
00:19:27,130 --> 00:19:25,580
data as that's coming in no other

488
00:19:28,720 --> 00:19:27,140

astronomers other astronomers from all

489
00:19:30,700 --> 00:19:28,730
over the world can come join so our crew

490
00:19:33,340 --> 00:19:30,710
including visitors are typically

491
00:19:35,260 --> 00:19:33,350
somewhere somewhere around 20 you know

492
00:19:37,210 --> 00:19:35,270
the kuiper could have you know maybe

493
00:19:38,710 --> 00:19:37,220
seven people on board and and the

494
00:19:42,760 --> 00:19:38,720
learjet can only have four people on

495
00:19:45,250 --> 00:19:42,770
board video showing a little bit about

496
00:19:48,640 --> 00:19:45,260
even pace ladies there's our second home

497
00:19:51,600 --> 00:19:48,650
yes so yeah what you're seeing here is

498
00:19:53,500 --> 00:19:51,610
that's the back of the mission directors

499
00:19:54,700 --> 00:19:53,510
computers I was talking about the

500
00:19:56,860 --> 00:19:54,710
mission directors stadium that's the

501
00:19:59,710 --> 00:19:56,870
science station there that's where the

502
00:20:01,960 --> 00:19:59,720
people who are looking at the that's

503
00:20:03,360 --> 00:20:01,970
where we would be we were watching and

504
00:20:05,470 --> 00:20:03,370
analyzing the data come in on the

505
00:20:07,000 --> 00:20:05,480
astronomical instruments if you're

506
00:20:10,899 --> 00:20:07,010
paying attention people were facing the

507
00:20:12,520 --> 00:20:10,909
telescope and so your your back is to

508
00:20:16,270 --> 00:20:12,530
the direction that you're flying or your

509
00:20:20,510 --> 00:20:18,799
okay and is that so everyone's facing

510
00:20:22,940 --> 00:20:20,520
the telescope we can watch and monitor

511
00:20:24,770 --> 00:20:22,950
what the telescope is doing cool I have

512
00:20:31,310 --> 00:20:24,780
an important question from venom plays

513
00:20:34,159 --> 00:20:31,320

777 are their in-flight meals what you

514
00:20:36,350 --> 00:20:34,169
bring onboard yourself we know we do

515
00:20:37,730 --> 00:20:36,360
have a galley which has microwave ovens

516
00:20:39,529 --> 00:20:37,740
we have a coffeemaker we have

517
00:20:40,700 --> 00:20:39,539
refrigerators now for years we didn't

518
00:20:41,990 --> 00:20:40,710
and it was there was a lot of

519
00:20:46,240 --> 00:20:42,000
celebration when we finally got a

520
00:21:03,830 --> 00:21:01,970
BYO snacks midnight but I mean we could

521
00:21:05,750 --> 00:21:03,840
actually observe infrared in the daytime

522
00:21:07,549 --> 00:21:05,760
as well but we use optical cameras to

523
00:21:08,570 --> 00:21:07,559
find where we are in the sky and so

524
00:21:09,250 --> 00:21:08,580
that's what you have to observe at night

525
00:21:12,380 --> 00:21:09,260
mm-hmm

526
00:21:15,789 --> 00:21:12,390
I'm getting a lot of questions how about

527
00:21:19,720 --> 00:21:15,799
we move on to our first segment

528
00:21:26,630 --> 00:21:24,460
[Music]

529
00:21:28,880 --> 00:21:26,640
alright you asked for it so here we go

530
00:21:30,409 --> 00:21:28,890
again rapid-fire questions is where we

531
00:21:33,680 --> 00:21:30,419
cover as many questions from the chat as

532
00:21:36,500 --> 00:21:33,690
we can so let's go quick questions quick

533
00:21:38,630 --> 00:21:36,510
answers and we'll hit as many as we can

534
00:21:40,310 --> 00:21:38,640
there was a good question well first of

535
00:21:43,640 --> 00:21:40,320
all what's the observing cadence for

536
00:21:45,320 --> 00:21:43,650
Sophia from core accretion so we

537
00:21:47,810 --> 00:21:45,330
typically observe three to four nights a

538
00:21:50,840 --> 00:21:47,820

week and then that will occur on this

539
00:21:52,070 --> 00:21:50,850
over span of two to three weeks and then

540
00:21:53,419 --> 00:21:52,080
we'll do an instrument swap put a new

541
00:21:54,830 --> 00:21:53,429
instrument on and do the same thing

542
00:21:55,940 --> 00:21:54,840
again and that happens pretty much here

543
00:21:58,640 --> 00:21:55,950
around cool

544
00:22:00,440 --> 00:21:58,650
okay space TV net is asking is the Sofia

545
00:22:02,630 --> 00:22:00,450
telescope designed more similar to a

546
00:22:04,549 --> 00:22:02,640
space telescope or a ground telescope

547
00:22:07,370 --> 00:22:04,559
yeah it's much more like a space-based

548
00:22:09,200 --> 00:22:07,380
telescope we actually point and maintain

549
00:22:11,720 --> 00:22:09,210
our pointing through gyros so just the

550
00:22:14,270 --> 00:22:11,730
way a space observatory works and so

551
00:22:15,950 --> 00:22:14,280
yeah when you're in flight there's

552
00:22:17,299 --> 00:22:15,960
turbulence the telescope looks like it's

553
00:22:19,549 --> 00:22:17,309
bouncing around it's not actually

554
00:22:21,380 --> 00:22:19,559
bouncing around it's actually stabilized

555
00:22:22,669 --> 00:22:21,390
inertially stabilized with respect to

556
00:22:24,680 --> 00:22:22,679
the stars that means it's not moving

557
00:22:26,210 --> 00:22:24,690
everything you're seeing is us bouncing

558
00:22:28,549 --> 00:22:26,220
around the telescope so it's much more

559
00:22:30,380 --> 00:22:28,559
like a space-based I'm not careful it

560
00:22:31,789 --> 00:22:30,390
can give you a sense of seasickness just

561
00:22:34,130 --> 00:22:31,799
trying to watch it because it moves

562
00:22:35,990 --> 00:22:34,140
around a lot yeah we're gonna see some

563
00:22:38,690 --> 00:22:36,000

of that later that's pretty cool

564
00:22:40,340 --> 00:22:38,700
why use a plane are there advantages as

565
00:22:41,750 --> 00:22:40,350
opposed to common satellites could you

566
00:22:44,799 --> 00:22:41,760
review that a little bit for 8-bit

567
00:22:47,899 --> 00:22:44,809
Pepper right so I mentioned easy access

568
00:22:50,180 --> 00:22:47,909
which is a really big one you know if

569
00:22:52,700 --> 00:22:50,190
you launch a satellite and something

570
00:22:55,070 --> 00:22:52,710
goes wrong either you're out of luck and

571
00:22:56,750 --> 00:22:55,080
it's just a lost mission or it's a very

572
00:22:58,730 --> 00:22:56,760
expensive process to go about fixing it

573
00:23:00,529 --> 00:22:58,740
right it takes a dedicated mission to

574
00:23:01,909 --> 00:23:00,539
fix it here we don't have that problem

575
00:23:04,340 --> 00:23:01,919
since we come home every night we can

576
00:23:06,500 --> 00:23:04,350
address any issues that might arise so

577
00:23:08,510 --> 00:23:06,510
that's one of the the big advantages of

578
00:23:10,070 --> 00:23:08,520
being on board a plane as opposed to a

579
00:23:13,010 --> 00:23:10,080
satellite because the one is we can

580
00:23:15,110 --> 00:23:13,020
upgrade the technology when you plan for

581
00:23:16,279 --> 00:23:15,120
a satellite mission by the time you

582
00:23:18,710 --> 00:23:16,289
actually launch the mission it's a

583
00:23:20,630 --> 00:23:18,720
couple decades old technology right we

584
00:23:22,220 --> 00:23:20,640
can we since we come home every night we

585
00:23:24,350 --> 00:23:22,230
can put the latest technology on board

586
00:23:26,659 --> 00:23:24,360
and try things out and maybe even be a

587
00:23:28,430 --> 00:23:26,669
pathfinder for technologies that are

588
00:23:29,750 --> 00:23:28,440

used on future satellite we've had some

589
00:23:32,720 --> 00:23:29,760
provoked gracious over the last few

590
00:23:34,310 --> 00:23:32,730
years that's correct yeah yeah bag of

591
00:23:35,380 --> 00:23:34,320
spaghetti is commenting that is pretty

592
00:23:38,140 --> 00:23:35,390
cool

593
00:23:40,330 --> 00:23:38,150
and furgus dickmas says this is an

594
00:23:45,940 --> 00:23:40,340
incredible piece of engineering it is

595
00:23:48,180 --> 00:23:45,950
it's just you wait why a bay door

596
00:23:52,210 --> 00:23:48,190
instead of a window from resonator games

597
00:23:55,150 --> 00:23:52,220
yeah so there's two reasons one since

598
00:23:56,890 --> 00:23:55,160
we're looking in the infrared we are

599
00:23:58,960 --> 00:23:56,900
looking at heat as we were talking about

600
00:24:01,090 --> 00:23:58,970
we want the telescope as cool as

601
00:24:02,730 --> 00:24:01,100
possible so up at the higher altitudes

602
00:24:05,380 --> 00:24:02,740
that were flying we can get you know

603
00:24:07,810 --> 00:24:05,390
minus 30 degrees Celsius so it gets very

604
00:24:09,970 --> 00:24:07,820
very cold and we want our telescope to

605
00:24:11,409 --> 00:24:09,980
be cold because that that gives us less

606
00:24:12,669 --> 00:24:11,419
background emission from the telescope

607
00:24:14,500 --> 00:24:12,679
so that's one reason why we what kind of

608
00:24:16,900 --> 00:24:14,510
want to open it's sort of passively

609
00:24:18,669 --> 00:24:16,910
cooled by the atmosphere but the other

610
00:24:21,159 --> 00:24:18,679
reason is there's very few materials

611
00:24:23,980 --> 00:24:21,169
that we can make a large window of this

612
00:24:25,900 --> 00:24:23,990
size out of that allows us to look at

613
00:24:27,940 --> 00:24:25,910

all of the wavelengths of infrared light

614
00:24:30,640 --> 00:24:27,950
that we're interested in looking at like

615
00:24:32,230 --> 00:24:30,650
I said my glasses earlier are made of

616
00:24:35,080 --> 00:24:32,240
material that block infrared light at

617
00:24:37,210 --> 00:24:35,090
the wavelength at that camera so our

618
00:24:39,070 --> 00:24:37,220
cameras look at a very broad range of

619
00:24:41,500 --> 00:24:39,080
wavelengths and it just isn't material

620
00:24:50,860 --> 00:24:41,510
available in this size that would be a

621
00:24:52,060 --> 00:24:50,870
garage-door sized sheet of diamond all

622
00:24:54,159 --> 00:24:52,070
right

623
00:24:56,820 --> 00:24:54,169
so many good ones are cosmic ray strikes

624
00:25:00,250 --> 00:24:56,830
an issue for sophia data core accretion

625
00:25:02,530 --> 00:25:00,260
for much of our data it's really not and

626
00:25:04,780 --> 00:25:02,540
even for our optical cameras where it is

627
00:25:07,419 --> 00:25:04,790
more of a problem if you're taking a lot

628
00:25:10,480 --> 00:25:07,429
of images is sequentially then it's easy

629
00:25:11,680 --> 00:25:10,490
to remove cosmic ray hits so most of the

630
00:25:12,940 --> 00:25:11,690
time it's not an issue even for our

631
00:25:14,500 --> 00:25:12,950
optical cameras we can deal with that if

632
00:25:16,630 --> 00:25:14,510
we need to our detectors aren't as

633
00:25:18,730 --> 00:25:16,640
sensitive to cosmic ray hits and because

634
00:25:20,950 --> 00:25:18,740
we co add data we take very short

635
00:25:22,930 --> 00:25:20,960
exposures and co add them it gets

636
00:25:26,799 --> 00:25:22,940
averaged out any cosmic rays get

637
00:25:30,400 --> 00:25:26,809
averaged out mm-hmm okay what's the

638
00:25:35,560 --> 00:25:30,410

distance that Sophia can see in terms of

639
00:25:36,880 --> 00:25:35,570
light-years basically from David well

640
00:25:39,220 --> 00:25:36,890
that's that's a tough one because it

641
00:25:43,120 --> 00:25:39,230
depends on how bright something is so we

642
00:25:44,409 --> 00:25:43,130
did recently observe the quasar or

643
00:25:46,750 --> 00:25:44,419
something like that that was that as a

644
00:25:48,860 --> 00:25:46,760
lens galaxy out so it was a very high as

645
00:25:51,649 --> 00:25:48,870
easy as six or something like that maybe

646
00:25:54,409 --> 00:25:51,659
remember that so what that means is is

647
00:25:58,340 --> 00:25:54,419
it's you know very close to the dawn of

648
00:26:00,169 --> 00:25:58,350
the of the universe so in terms of light

649
00:26:04,549 --> 00:26:00,179
years again it's all dependent on how

650
00:26:05,960 --> 00:26:04,559
bright the object is we were able to do

651
00:26:07,580 --> 00:26:05,970
it just because there was something in

652
00:26:12,740 --> 00:26:07,590
front of it that acted as a magnifying

653
00:26:14,419 --> 00:26:12,750
glass maybe this is related solar

654
00:26:15,799 --> 00:26:14,429
captains asking is Sofia going to be

655
00:26:17,090 --> 00:26:15,809
able to see further away than the

656
00:26:19,310 --> 00:26:17,100
observatory telescopes

657
00:26:25,299 --> 00:26:19,320
I think ground-based observatories I

658
00:26:29,470 --> 00:26:27,950
so something we can see things very far

659
00:26:31,909 --> 00:26:29,480
away as long as they're bright and

660
00:26:33,740 --> 00:26:31,919
mostly that's a function of the size of

661
00:26:36,440 --> 00:26:33,750
the telescope so the bigger you go the

662
00:26:39,080 --> 00:26:36,450
the easier it is to see faint objects

663
00:26:40,909 --> 00:26:39,090

which may be farther away yeah and most

664
00:26:44,120 --> 00:26:40,919
of the wavelengths that Sofia works at

665
00:26:46,700 --> 00:26:44,130
we are now the largest observatory that

666
00:26:47,870 --> 00:26:46,710
there is so there is is the most light

667
00:26:49,789 --> 00:26:47,880
collecting power that we can get out of

668
00:26:51,409 --> 00:26:49,799
any any facility is with our large

669
00:26:54,230 --> 00:26:51,419
telescope right and and there really is

670
00:26:57,139 --> 00:26:54,240
very little way to upgrade the size on

671
00:26:59,990 --> 00:26:57,149
an aircraft right because the fuselage

672
00:27:01,340 --> 00:27:00,000
of a 747 is about as big as it gets you

673
00:27:02,870 --> 00:27:01,350
can go a little bit larger but it's not

674
00:27:04,279 --> 00:27:02,880
going to actually increase the size of

675
00:27:05,779 --> 00:27:04,289
your telescope very much you can't get a

676
00:27:07,430 --> 00:27:05,789
bigger telescope on board you just

677
00:27:09,320 --> 00:27:07,440
squeeze in anything else all these

678
00:27:11,029 --> 00:27:09,330
upgrades from the early airborne

679
00:27:12,500 --> 00:27:11,039
Observatory so now the bigger plane was

680
00:27:15,889 --> 00:27:12,510
to get the bigger telescope that's right

681
00:27:17,450 --> 00:27:15,899
that's right yeah okay maybe one more

682
00:27:23,659 --> 00:27:17,460
because I've got a bunch of questions

683
00:27:27,590 --> 00:27:23,669
that are gonna come up in the next let

684
00:27:29,659 --> 00:27:27,600
me see is the data recorded during these

685
00:27:33,380 --> 00:27:29,669
missions available to citizen

686
00:27:36,860 --> 00:27:33,390
astronomers from questions so yeah we we

687
00:27:39,230 --> 00:27:36,870
do archive all the day that we have most

688
00:27:41,210 --> 00:27:39,240

of our data is from people who have

689
00:27:43,490 --> 00:27:41,220
proposed to use our facility and have

690
00:27:46,340 --> 00:27:43,500
gone through a selection process they

691
00:27:47,539 --> 00:27:46,350
have a proprietary year to look at it

692
00:27:49,940 --> 00:27:47,549
and do what they want with the data but

693
00:27:52,700 --> 00:27:49,950
then after that the data is is public

694
00:27:55,340 --> 00:27:52,710
you go to our data website and download

695
00:27:56,720 --> 00:27:55,350
it you just have to register your email

696
00:27:58,340 --> 00:27:56,730
that's it

697
00:28:00,760 --> 00:27:58,350
could use it we do also have a number of

698
00:28:03,530 --> 00:28:00,770
what we call directors time programs and

699
00:28:04,909 --> 00:28:03,540
those are data that we observe and then

700
00:28:06,740 --> 00:28:04,919
make it immediately available to the

701
00:28:08,900 --> 00:28:06,750
world so anybody can look at that data

702
00:28:12,560 --> 00:28:08,910
right now in fact just a few days after

703
00:28:16,360 --> 00:28:12,570
its it's been observed cool great

704
00:28:18,830 --> 00:28:16,370
questions yeah and there are lots more

705
00:28:21,350 --> 00:28:18,840
this is a reminder that you're watching

706
00:28:23,240 --> 00:28:21,360
NASA and Silicon Valley live and today

707
00:28:26,180 --> 00:28:23,250
we're talking about Sofia and airborne

708
00:28:30,169 --> 00:28:26,190
astronomy have questions put it in the

709
00:28:32,299 --> 00:28:30,179
chat and we will get to them and when we

710
00:28:39,230 --> 00:28:32,309
can but would we love your questions

711
00:28:41,810 --> 00:28:39,240
yeah we're saying goodbye and now we

712
00:28:46,070 --> 00:28:41,820
will shortly have with us our guests a

713
00:28:49,940 --> 00:28:46,080

Kim and Ken Kimberly and ago and Ken

714
00:29:02,450 --> 00:28:49,950
Bowers welcome thank you both for

715
00:29:03,770 --> 00:29:02,460
joining us Kim tell us a little bit

716
00:29:06,470 --> 00:29:03,780
about what you do here and introduce

717
00:29:09,590 --> 00:29:06,480
yourself my name is Ken Bauer and I'm an

718
00:29:12,380 --> 00:29:09,600
engineer here at NASA Ames and my job is

719
00:29:14,120 --> 00:29:12,390
easy to explain but hard to do I planned

720
00:29:17,810 --> 00:29:14,130
missions for Sofia the airborne

721
00:29:19,760 --> 00:29:17,820
observatory very good and Kimberly Anika

722
00:29:22,549 --> 00:29:19,770
Smith I'm a research astrophysicist here

723
00:29:23,810 --> 00:29:22,559
at NASA Ames and as a Astra for the

724
00:29:25,909 --> 00:29:23,820
system studying the phenomena of the

725
00:29:27,620 --> 00:29:25,919
universe and I also do a lot of design

726
00:29:27,919 --> 00:29:27,630
and evaluate missions to study the

727
00:29:30,380 --> 00:29:27,929
universe

728
00:29:31,909 --> 00:29:30,390
okay so a lot of people are using Sofia

729
00:29:33,650 --> 00:29:31,919
to do a lot of different science can you

730
00:29:35,960 --> 00:29:33,660
give us a little taste of what kinds of

731
00:29:38,360 --> 00:29:35,970
things you observe and study absolutely

732
00:29:40,460 --> 00:29:38,370
as Jim and Andrew were talking through

733
00:29:42,049 --> 00:29:40,470
this amazing the world's largest flying

734
00:29:44,690 --> 00:29:42,059
Observatory

735
00:29:47,090 --> 00:29:44,700
we have astronomers from all over the

736
00:29:49,190 --> 00:29:47,100
world applying for time to study the

737
00:29:51,590 --> 00:29:49,200
infrared universe and a lot of their

738
00:29:54,310 --> 00:29:51,600

science is all about our origins you

739
00:29:56,570 --> 00:29:54,320
know how do we get here science about

740
00:29:59,539 --> 00:29:56,580
what are the conditions under which

741
00:30:00,470 --> 00:29:59,549
stars can form the stellar nurseries how

742
00:30:04,039 --> 00:30:00,480
two planets form

743
00:30:06,380 --> 00:30:04,049
how do atoms ions molecules in the

744
00:30:09,409 --> 00:30:06,390
universe get into planetary systems and

745
00:30:10,490 --> 00:30:09,419
we study a variety of objects from

746
00:30:12,110 --> 00:30:10,500
nearby

747
00:30:15,350 --> 00:30:12,120
like comets and asteroids and planets

748
00:30:17,150 --> 00:30:15,360
our own solar system to star formation

749
00:30:19,250 --> 00:30:17,160
regions all over our own galaxy in the

750
00:30:21,050 --> 00:30:19,260
Milky Way their variety of shapes and

751
00:30:25,850 --> 00:30:21,060
sizes amazing how many astronomers

752
00:30:28,010 --> 00:30:25,860
wanted study dust dust is where you know

753
00:30:31,490 --> 00:30:28,020
large fraction of the light and the

754
00:30:32,990 --> 00:30:31,500
universe is irradiation with dust we

755
00:30:33,590 --> 00:30:33,000
also study other galaxies outside our

756
00:30:35,690 --> 00:30:33,600
own Milky Way

757
00:30:38,360 --> 00:30:35,700
even some of these lens galaxies that

758
00:30:40,190 --> 00:30:38,370
Andrew had talked about okay yeah so we

759
00:30:42,470 --> 00:30:40,200
talked a little bit about all these cool

760
00:30:44,150 --> 00:30:42,480
things that Sofia is looking at but can

761
00:30:46,550 --> 00:30:44,160
how you talk about planning these

762
00:30:48,290 --> 00:30:46,560
missions that goes into how we do that

763
00:30:50,540 --> 00:30:48,300

can you explain about that for us sure

764
00:30:52,010 --> 00:30:50,550
it starts more than a year before we fly

765
00:30:53,510 --> 00:30:52,020
a mission and that's when we ask people

766
00:30:55,130 --> 00:30:53,520
what do you want to look at so

767
00:30:57,590 --> 00:30:55,140
scientists all over the word all over

768
00:31:00,950 --> 00:30:57,600
the world propose observations that they

769
00:31:02,630 --> 00:31:00,960
want to make and then we take all of

770
00:31:04,850 --> 00:31:02,640
those and there's about five times as

771
00:31:06,830 --> 00:31:04,860
many proposed observations as we could

772
00:31:09,260 --> 00:31:06,840
possibly observe we put those in front

773
00:31:12,200 --> 00:31:09,270
of a panel of esteemed scientists and

774
00:31:14,000 --> 00:31:12,210
they rank them for merit and the list

775
00:31:16,370 --> 00:31:14,010
comes to me and I only get the top fifth

776
00:31:17,930 --> 00:31:16,380
and the names are taken off and my job

777
00:31:21,350 --> 00:31:17,940
is to try to schedule all of those

778
00:31:23,300 --> 00:31:21,360
observations it's a complicated jigsaw

779
00:31:25,490 --> 00:31:23,310
puzzle because the earth goes around the

780
00:31:27,650 --> 00:31:25,500
Sun and you see different stars at

781
00:31:29,510 --> 00:31:27,660
different nights and the earth is

782
00:31:31,700 --> 00:31:29,520
spinning as well so the stars are rising

783
00:31:32,810 --> 00:31:31,710
and setting and if you look at the

784
00:31:35,000 --> 00:31:32,820
airplane you'll notice that the

785
00:31:37,970 --> 00:31:35,010
telescope is always on the left side of

786
00:31:39,530 --> 00:31:37,980
the airplane so that means that if I

787
00:31:41,570 --> 00:31:39,540
want to look at a star in the north I'm

788
00:31:44,330 --> 00:31:41,580

going to fly the plane to the east if I

789
00:31:48,860 --> 00:31:44,340
want to eventually come home which we'd

790
00:31:51,320 --> 00:31:48,870
like to do I need to find a star in the

791
00:31:53,600 --> 00:31:51,330
south to observe at the right time of

792
00:31:56,120 --> 00:31:53,610
the night so it's a it's a big jigsaw

793
00:31:58,520 --> 00:31:56,130
puzzle and the pieces change every time

794
00:32:00,440 --> 00:31:58,530
you put one down because the Earth

795
00:32:01,340 --> 00:32:00,450
rotates and all the stars are now in a

796
00:32:04,250 --> 00:32:01,350
different location

797
00:32:05,960 --> 00:32:04,260
we'll be tuning our flight plans from 10

798
00:32:08,750 --> 00:32:05,970
weeks before we start flying a

799
00:32:11,560 --> 00:32:08,760
particular clump of them okay and we'll

800
00:32:14,360 --> 00:32:11,570
even be adjusting it the day of because

801
00:32:16,190 --> 00:32:14,370
most airplanes do care about wind but

802
00:32:17,810 --> 00:32:16,200
not that much because you just want to

803
00:32:19,970 --> 00:32:17,820
get someplace in an airplane so where

804
00:32:21,680 --> 00:32:19,980
the plane is going is fine if there's a

805
00:32:22,530 --> 00:32:21,690
crosswind you just lean into it a little

806
00:32:23,730 --> 00:32:22,540
bit and you

807
00:32:25,950 --> 00:32:23,740
there a moment later and it doesn't

808
00:32:27,960 --> 00:32:25,960
really matter we can't do that we have

809
00:32:29,430 --> 00:32:27,970
to point the plane so that the telescope

810
00:32:32,580 --> 00:32:29,440
is always looking in the right direction

811
00:32:34,800 --> 00:32:32,590
and if the wind needs to blow us it's

812
00:32:36,720 --> 00:32:34,810
going to blow us so part of the job of

813
00:32:38,580 --> 00:32:36,730

flight planner is to adapt to the wind

814
00:32:40,680 --> 00:32:38,590
and make a flight plan that will work

815
00:32:42,270 --> 00:32:40,690
given all of those conditions sometimes

816
00:32:43,800 --> 00:32:42,280
we bring the plane down to the southern

817
00:32:45,210 --> 00:32:43,810
hemisphere Shradha Murs want to look at

818
00:32:47,010 --> 00:32:45,220
the Celtic targets in the southern

819
00:32:48,600 --> 00:32:47,020
hemisphere as well so the plane moves to

820
00:32:51,510 --> 00:32:48,610
a different Airport and as flight

821
00:32:52,680 --> 00:32:51,520
operations out of there and still doing

822
00:32:55,290 --> 00:32:52,690
the flight plan still the same

823
00:32:57,840 --> 00:32:55,300
geometries you know so I mean she's

824
00:33:00,060 --> 00:32:57,850
changing from hemispheres but if you're

825
00:33:02,550 --> 00:33:00,070
flying from the same base night after

826
00:33:05,160 --> 00:33:02,560
night it's the same flight plan every

827
00:33:07,530 --> 00:33:05,170
night so it is never the same flight

828
00:33:09,180 --> 00:33:07,540
plan even if we wanted it to be it's

829
00:33:11,910 --> 00:33:09,190
never the same flight plan because the

830
00:33:13,530 --> 00:33:11,920
winds change a little bit and even if

831
00:33:15,720 --> 00:33:13,540
you just say I'll fly last night's

832
00:33:17,220 --> 00:33:15,730
flight plan over tonight well the earth

833
00:33:25,770 --> 00:33:17,230
has gone a little ways around the Sun

834
00:33:28,140 --> 00:33:25,780
and so that's crazy okay we're talking a

835
00:33:31,020 --> 00:33:28,150
lot about the plane moving all the time

836
00:33:33,540 --> 00:33:31,030
all these fibers I mean the wind is

837
00:33:34,950 --> 00:33:33,550
blowing it the stars are moving I've

838
00:33:37,410 --> 00:33:34,960

been on a plane I know there are times

839
00:33:39,360 --> 00:33:37,420
when I can't even stand up because the

840
00:33:41,340 --> 00:33:39,370
plane is shaking so much and there are a

841
00:33:44,760 --> 00:33:41,350
bunch of questions here from resonator

842
00:33:46,440 --> 00:33:44,770
games growled core accretion gamma 76

843
00:33:48,870 --> 00:33:46,450
everybody wants to know how do you

844
00:33:51,570 --> 00:33:48,880
stabilize the telescope so let's go to

845
00:33:53,240 --> 00:33:51,580
our next segment explain it like I'm

846
00:33:58,710 --> 00:33:53,250
five

847
00:34:03,490 --> 00:34:01,630
all right so grab your sippy cups folks

848
00:34:05,710 --> 00:34:03,500
explain it like I'm five is when we ask

849
00:34:07,570 --> 00:34:05,720
our NASA guests to explain a complex

850
00:34:09,430 --> 00:34:07,580
scientific concept and make it

851
00:34:12,190 --> 00:34:09,440
understandable for us kindergartners so

852
00:34:14,830 --> 00:34:12,200
take it away can explain how you keep

853
00:34:17,020 --> 00:34:14,840
the telescope's stable excuse me and

854
00:34:19,120 --> 00:34:17,030
focused on a target it's one of our most

855
00:34:20,860 --> 00:34:19,130
common questions if you've ever tried to

856
00:34:22,570 --> 00:34:20,870
look at Saturn with binoculars you know

857
00:34:24,220 --> 00:34:22,580
that the thing bounces all over the

858
00:34:25,540 --> 00:34:24,230
place and it's you that's moving you

859
00:34:27,790 --> 00:34:25,550
don't have to move much for something

860
00:34:30,399 --> 00:34:27,800
that's that far away to be very

861
00:34:33,100 --> 00:34:30,409
difficult to see so you want your

862
00:34:34,149 --> 00:34:33,110
telescope to be very stable and that's

863
00:34:35,830 --> 00:34:34,159

great when you're talking about a

864
00:34:37,060 --> 00:34:35,840
building on a mountaintop but it's not

865
00:34:40,540 --> 00:34:37,070
so great when you're talking about an

866
00:34:41,740 --> 00:34:40,550
aircraft you've been in aircrafts most

867
00:34:45,100 --> 00:34:41,750
have you been in them you know that they

868
00:34:48,040 --> 00:34:45,110
move and aircrafts tend to rock and roll

869
00:34:56,190 --> 00:34:48,050
a little bit as they steer around and

870
00:35:01,450 --> 00:34:56,200
they tend to go through vibration of

871
00:35:03,130 --> 00:35:01,460
larger scale and it is mounted inside a

872
00:35:04,870 --> 00:35:03,140
what's called a spherical bearing it's

873
00:35:06,910 --> 00:35:04,880
like a ball and socket joint like your

874
00:35:08,260 --> 00:35:06,920
shoulder is yeah so there's one sphere

875
00:35:10,780 --> 00:35:08,270
and type of another and that allows it

876
00:35:12,910 --> 00:35:10,790
to rotate freely and three different

877
00:35:16,750 --> 00:35:12,920
axes a little bit this way in this way

878
00:35:21,190 --> 00:35:16,760
and a lot this way while the telescope

879
00:35:22,690 --> 00:35:21,200
is flying it will be making changes

880
00:35:25,300 --> 00:35:22,700
because as the Earth rotates the stars

881
00:35:27,580 --> 00:35:25,310
appear to rise and set and so the

882
00:35:29,050 --> 00:35:27,590
telescope will be tracking along and if

883
00:35:31,600 --> 00:35:29,060
it gets out of range the plane just

884
00:35:33,730 --> 00:35:31,610
moves a little bit we actually use a

885
00:35:38,050 --> 00:35:33,740
plane to do some of the steering in this

886
00:35:40,120 --> 00:35:38,060
direction and when the plane goes

887
00:35:45,340 --> 00:35:40,130
through some turbulence the telescope

888
00:35:49,390 --> 00:35:45,350

can adapt to it and we can often watch

889
00:35:50,890 --> 00:35:49,400
this when I've been on the flight I can

890
00:35:54,730 --> 00:35:50,900
watch this telescope bouncing up and

891
00:35:55,990 --> 00:35:54,740
down it moves that much yes yeah it was

892
00:35:58,720 --> 00:35:56,000
quite a lot it will go up and down a

893
00:36:01,150 --> 00:35:58,730
couple of feet so how does the image

894
00:36:04,420 --> 00:36:01,160
quality the astounding thing is that it

895
00:36:07,060 --> 00:36:04,430
does not like the image quality I can be

896
00:36:08,350 --> 00:36:07,070
watching this thing go up and down

897
00:36:10,690 --> 00:36:08,360
this is moving up and down a foot or two

898
00:36:13,840 --> 00:36:10,700
at a time quite within a second or two

899
00:36:16,000 --> 00:36:13,850
it can go that far and yet I look out

900
00:36:18,400 --> 00:36:16,010
the the image that the cameras looking

901
00:36:19,660 --> 00:36:18,410
at and it's a completely still image it

902
00:36:21,610 --> 00:36:19,670
could have been a photograph it still

903
00:36:23,680 --> 00:36:21,620
shot I think they have a time-lapse

904
00:36:27,010 --> 00:36:23,690
video showing what it's like on a flight

905
00:36:29,020 --> 00:36:27,020
let's see so this is sped up I think 50

906
00:36:30,490 --> 00:36:29,030
times and as much as it looks jittery

907
00:36:32,230 --> 00:36:30,500
seeing it moving around all over the

908
00:36:33,970 --> 00:36:32,240
place this is actually a pretty stable

909
00:36:35,800 --> 00:36:33,980
flight as they go I don't I don't see

910
00:36:39,130 --> 00:36:35,810
really big motions when you see make a

911
00:36:41,560 --> 00:36:39,140
big rotation that like that is changing

912
00:36:43,420 --> 00:36:41,570
its target and the little motion just

913
00:36:45,910 --> 00:36:43,430

seeing or all the corrections for what

914
00:36:48,550 --> 00:36:45,920
the plane is doing in addition to these

915
00:36:50,410 --> 00:36:48,560
Corrections to sort of cancel out the

916
00:36:53,200 --> 00:36:50,420
hum the whole thing is sitting on a

917
00:36:56,740 --> 00:36:53,210
giant air cushion so I'm sitting inside

918
00:36:58,840 --> 00:36:56,750
a ring of inner tubes and there are

919
00:37:01,110 --> 00:36:58,850
other fancier devices that help cancel

920
00:37:03,670 --> 00:37:01,120
out those high-frequency hums

921
00:37:05,260 --> 00:37:03,680
interesting the science instrument is

922
00:37:08,080 --> 00:37:05,270
shown in the center there with the the

923
00:37:10,200 --> 00:37:08,090
bags of white which are the when the car

924
00:37:13,030 --> 00:37:10,210
jeans on border are changing to vapor

925
00:37:15,280 --> 00:37:13,040
and so that is just taking the spectra

926
00:37:17,140 --> 00:37:15,290
of the target and you've a there's an

927
00:37:18,460 --> 00:37:17,150
electronic track over to the right and

928
00:37:21,970 --> 00:37:18,470
the telescope structure is that blue

929
00:37:24,490 --> 00:37:21,980
structure it's moving quite rapidly in

930
00:37:26,530 --> 00:37:24,500
the sped up version all right when

931
00:37:28,270 --> 00:37:26,540
you're on board I mean you can feel the

932
00:37:30,250 --> 00:37:28,280
plane moving and you're seeing on the

933
00:37:31,690 --> 00:37:30,260
screen and the image is Rocksteady you

934
00:37:34,720 --> 00:37:31,700
just know the telescope has compensated

935
00:37:36,610 --> 00:37:34,730
some amazing German engineering the

936
00:37:37,720 --> 00:37:36,620
partner on our Sofia project is the

937
00:37:43,420 --> 00:37:37,730
German Aerospace Center and they

938
00:37:48,670 --> 00:37:43,430

delivered us one awesome telescope we

939
00:37:51,430 --> 00:37:48,680
have really good tools does the

940
00:37:55,810 --> 00:37:51,440
telescope have adaptive optics so does

941
00:37:58,720 --> 00:37:55,820
it have adaptive optics a bit there are

942
00:38:01,960 --> 00:37:58,730
some devices on the back and the

943
00:38:04,390 --> 00:38:01,970
secondary can do some motion it's kind

944
00:38:06,580 --> 00:38:04,400
of a technical answer okay so I won't

945
00:38:08,440 --> 00:38:06,590
get into deep question and we don't have

946
00:38:09,730 --> 00:38:08,450
we're not using a classical adaptive

947
00:38:11,650 --> 00:38:09,740
optics like ground-based telescopes

948
00:38:13,030 --> 00:38:11,660
where they use a sodium guide star or

949
00:38:15,460 --> 00:38:13,040
anything like that weird we don't do any

950
00:38:17,080 --> 00:38:15,470
of that okay most of most of our

951
00:38:18,170 --> 00:38:17,090
adaptive is about canceling vibration

952
00:38:21,260 --> 00:38:18,180
that's right

953
00:38:24,800 --> 00:38:21,270
his Majesty wants to know does it adjust

954
00:38:25,820 --> 00:38:24,810
by itself or some software well I don't

955
00:38:26,440 --> 00:38:25,830
think it's ever going to take care of

956
00:38:28,760 --> 00:38:26,450
itself

957
00:38:30,590 --> 00:38:28,770
there are gyroscopes and there's

958
00:38:32,480 --> 00:38:30,600
software in the loop so the gyroscopes

959
00:38:36,650 --> 00:38:32,490
remember what way up is and keep track

960
00:38:38,510 --> 00:38:36,660
of the make all the corrections for us

961
00:38:39,920 --> 00:38:38,520
but it's all software in the loop yes

962
00:38:41,510 --> 00:38:39,930
okay and we also have the visual

963
00:38:43,670 --> 00:38:41,520

centroid in with the images on the star

964
00:38:45,530 --> 00:38:43,680
itself we have three guide cameras of a

965
00:38:47,270 --> 00:38:45,540
large field of view medium field and

966
00:38:49,310 --> 00:38:47,280
fine field of view and you're constantly

967
00:38:51,500 --> 00:38:49,320
tracking multiple stars so you can take

968
00:38:52,970 --> 00:38:51,510
out rotations and stay on point the

969
00:38:55,040 --> 00:38:52,980
gyroscopes can try to keep you pointing

970
00:38:56,420 --> 00:38:55,050
to the same direction but the same you

971
00:38:58,430 --> 00:38:56,430
don't want to be pointed in the same

972
00:39:01,280 --> 00:38:58,440
direction you want to follow the star as

973
00:39:03,140 --> 00:39:01,290
the star moves right everything I have a

974
00:39:05,120 --> 00:39:03,150
message for trooper Nick's we're live

975
00:39:09,890 --> 00:39:05,130
have a question for our guests write it

976
00:39:12,710 --> 00:39:09,900
in the chat gosh there's so many

977
00:39:15,680 --> 00:39:12,720
questions some kuro would like to know

978
00:39:18,620 --> 00:39:15,690
what does it mean that you typically fly

979
00:39:20,570 --> 00:39:18,630
north south so typically if you've

980
00:39:22,760 --> 00:39:20,580
looked at some of our flight paths I

981
00:39:24,830 --> 00:39:22,770
think you say if you want if you want to

982
00:39:28,760 --> 00:39:24,840
look south you have to fly okay so the

983
00:39:30,350 --> 00:39:28,770
the airplane flies towards its nose but

984
00:39:34,220 --> 00:39:30,360
the telescope only looks out the left

985
00:39:36,800 --> 00:39:34,230
side of the aircraft so if I am flying

986
00:39:39,050 --> 00:39:36,810
north then the telescope will be looking

987
00:39:41,690 --> 00:39:39,060
to the west so I'm looking at some

988
00:39:43,700 --> 00:39:41,700

target some star that is setting in the

989
00:39:45,440 --> 00:39:43,710
West and if I'm flying south and the

990
00:39:46,850 --> 00:39:45,450
telescope is looking to the east so I'm

991
00:39:49,190 --> 00:39:46,860
looking at something that's rising in

992
00:39:51,380 --> 00:39:49,200
the east and I those have to be balanced

993
00:39:53,510 --> 00:39:51,390
out we need to end up flying the exact

994
00:39:56,240 --> 00:39:53,520
same amount of time north as south as

995
00:39:58,340 --> 00:39:56,250
east as west mm-hmm so Ken's often

996
00:39:59,510 --> 00:39:58,350
trying to find targets that you know the

997
00:40:01,340 --> 00:39:59,520
astronomers want but those that are

998
00:40:04,190 --> 00:40:01,350
rising and those that are setting yes

999
00:40:05,720 --> 00:40:04,200
okay it turns out that in the south is a

1000
00:40:07,220 --> 00:40:05,730
lot more things that astronomers want to

1001
00:40:16,610 --> 00:40:07,230
look at in the north so I spend a lot of

1002
00:40:17,960 --> 00:40:16,620
time Nathan my I think is asking if

1003
00:40:18,470 --> 00:40:17,970
Sophie ever looks back at the earth in

1004
00:40:20,150 --> 00:40:18,480
infrared

1005
00:40:21,680 --> 00:40:20,160
you'd have to fly at an angle facing the

1006
00:40:24,710 --> 00:40:21,690
camera so he earth so we realize that

1007
00:40:26,990 --> 00:40:24,720
with very simple answer that no

1008
00:40:29,990 --> 00:40:27,000
we can only actually look not even at

1009
00:40:33,200 --> 00:40:30,000
the horizon only 20 degrees up to 60

1010
00:40:34,670 --> 00:40:33,210
degrees above the horizon and if we were

1011
00:40:35,900 --> 00:40:34,680
to Bank the telescope like that I think

1012
00:40:41,059 --> 00:40:35,910
all the passengers would be very

1013
00:40:43,579 --> 00:40:41,069

uncomfortable well we have so many great

1014
00:40:45,680 --> 00:40:43,589
questions yeah live but we are going to

1015
00:40:47,720 --> 00:40:45,690
run at a time if we don't move talk a

1016
00:40:49,970 --> 00:40:47,730
little bit about some of the object

1017
00:40:52,660 --> 00:40:49,980
that's Sofia studies and that's what

1018
00:40:55,130 --> 00:40:52,670
people want to know about as well so

1019
00:40:57,050 --> 00:40:55,140
Kimberly I've flown on a few flights

1020
00:41:01,640 --> 00:40:57,060
with you okay get these models out of

1021
00:41:03,620 --> 00:41:01,650
the way yes with you we've been looking

1022
00:41:05,809 --> 00:41:03,630
at black holes so you tell us a little

1023
00:41:07,370 --> 00:41:05,819
bit about Sofia's black hole observation

1024
00:41:09,829 --> 00:41:07,380
black holes yeah one of many different

1025
00:41:14,329 --> 00:41:09,839
type of top targets at Sofia so black

1026
00:41:16,460 --> 00:41:14,339
hole is an object whose gravity is so

1027
00:41:21,109 --> 00:41:16,470
strong that no it not even light can

1028
00:41:24,079 --> 00:41:21,119
escape and there's actually quite a few

1029
00:41:25,670 --> 00:41:24,089
black holes in our in our Milky Way but

1030
00:41:27,859 --> 00:41:25,680
they're hard to find you know they're

1031
00:41:29,780 --> 00:41:27,869
hard to define the signatures in fact

1032
00:41:31,400 --> 00:41:29,790
they're one out of every thousand stars

1033
00:41:35,690 --> 00:41:31,410
may eventually go through a black hole

1034
00:41:37,370 --> 00:41:35,700
phase in our Milky Way and you can sort

1035
00:41:40,220 --> 00:41:37,380
of get a sense of it's very massive just

1036
00:41:42,950 --> 00:41:40,230
imagine our Sun but 10 times the mass of

1037
00:41:45,859 --> 00:41:42,960
our Sun concentrated in an area like New

1038
00:41:48,109 --> 00:41:45,869

York City yes

1039
00:41:49,430 --> 00:41:48,119
size and black hole would be wow there's

1040
00:41:50,900 --> 00:41:49,440
even bigger ones out there they're

1041
00:41:52,370 --> 00:41:50,910
called supermassive black holes and

1042
00:41:54,650 --> 00:41:52,380
these are the ones that have millions or

1043
00:41:56,780 --> 00:41:54,660
billions of solar masses and the center

1044
00:41:57,440 --> 00:41:56,790
of our Milky Way has a supermassive

1045
00:41:59,540 --> 00:41:57,450
black hole

1046
00:42:09,020 --> 00:41:59,550
it's our galaxy that's the Milky Way's

1047
00:42:11,420 --> 00:42:09,030
our galaxy and and and also there are

1048
00:42:14,180 --> 00:42:11,430
lots of galaxies outside the Milky Way

1049
00:42:17,030 --> 00:42:14,190
that we the astronomers close in the

1050
00:42:18,920 --> 00:42:17,040
term active galaxies and it's because if

1051
00:42:21,740 --> 00:42:18,930
you were to add up all the light from

1052
00:42:23,569 --> 00:42:21,750
the stars they're brighter than what the

1053
00:42:25,160 --> 00:42:23,579
stars themselves would get give off no

1054
00:42:27,710 --> 00:42:25,170
and they're also emitting at all

1055
00:42:30,440 --> 00:42:27,720
different wavelengths x-ray gamma rays

1056
00:42:33,140 --> 00:42:30,450
radio infrared visible isn't actively

1057
00:42:34,819 --> 00:42:33,150
all the way and all telescopes are

1058
00:42:38,000 --> 00:42:34,829
looking at this and then we you know

1059
00:42:38,640 --> 00:42:38,010
with these active galaxies you know

1060
00:42:40,650 --> 00:42:38,650
Sophie has been

1061
00:42:43,350 --> 00:42:40,660
can get a few of them and like which

1062
00:42:47,280 --> 00:42:43,360
ones we recently looked at Cigna say

1063
00:42:48,780 --> 00:42:47,290

which is it's a one of the brightest

1064
00:42:51,450 --> 00:42:48,790
radio galaxies' was discovered

1065
00:42:54,240 --> 00:42:51,460
regionally in the radio it's about 600

1066
00:42:55,920 --> 00:42:54,250
million light years away and it is

1067
00:43:00,210 --> 00:42:55,930
understood to have a supermassive black

1068
00:43:03,360 --> 00:43:00,220
hole that's about 2 billion solar masses

1069
00:43:05,580 --> 00:43:03,370
Oh two billion two billion suns so our

1070
00:43:07,920 --> 00:43:05,590
galaxy has four million this was got

1071
00:43:10,460 --> 00:43:07,930
about 2 billion super super massive and

1072
00:43:13,200 --> 00:43:10,470
it's eating very actively now yeah what

1073
00:43:14,670 --> 00:43:13,210
why is it so bright it's because all the

1074
00:43:16,020 --> 00:43:14,680
material may be falling into the black

1075
00:43:18,450 --> 00:43:16,030
hole and emitting at all these different

1076
00:43:20,160 --> 00:43:18,460
wavelengths so there's a model try to

1077
00:43:21,690 --> 00:43:20,170
explain what a black hole at active

1078
00:43:24,450 --> 00:43:21,700
galaxies with a supermassive black hole

1079
00:43:26,460 --> 00:43:24,460
looks like and it has this dusty ring

1080
00:43:28,830 --> 00:43:26,470
which is the material for which is

1081
00:43:33,480 --> 00:43:28,840
feeding that central part of the black

1082
00:43:35,250 --> 00:43:33,490
we have an illustration of what artists

1083
00:43:38,130 --> 00:43:35,260
representation of Cygnus a and what's

1084
00:43:40,410 --> 00:43:38,140
striking about it is it's got this dusty

1085
00:43:43,010 --> 00:43:40,420
ring you sort of see this grayish

1086
00:43:45,750 --> 00:43:43,020
material and these Jets that are

1087
00:43:48,510 --> 00:43:45,760
emitting from the center perpendicular

1088
00:43:50,580 --> 00:43:48,520

right angles to the ring and if you're a

1089
00:43:52,230 --> 00:43:50,590
clever eye is looking at it you can see

1090
00:43:53,910 --> 00:43:52,240
sort of looks like tinsel since we're in

1091
00:43:57,110 --> 00:43:53,920
the Christmas season it's a little

1092
00:43:59,790 --> 00:43:57,120
surrounding the ring all around that

1093
00:44:02,580 --> 00:43:59,800
deposition of magnetic fields so Sofia

1094
00:44:06,000 --> 00:44:02,590
made observations of the orientation of

1095
00:44:08,640 --> 00:44:06,010
magnetic fields around Cygnus a and on

1096
00:44:10,860 --> 00:44:08,650
hypothesis is is it confining the dust

1097
00:44:14,040 --> 00:44:10,870
and therefore providing unlimited food

1098
00:44:16,830 --> 00:44:14,050
supply for this supermassive black hole

1099
00:44:19,320 --> 00:44:16,840
also the magnetic fields could be some

1100
00:44:21,240 --> 00:44:19,330
way to channel the energy like warping

1101
00:44:24,020 --> 00:44:21,250
space and time and turning into a coil

1102
00:44:26,370 --> 00:44:24,030
and then we being the source of those

1103
00:44:28,410 --> 00:44:26,380
relativistic Jets coming out because

1104
00:44:31,650 --> 00:44:28,420
Sofia is gonna be studying a lot more of

1105
00:44:33,180 --> 00:44:31,660
these galaxies with without Jets to see

1106
00:44:34,620 --> 00:44:33,190
whether you know what's the strength of

1107
00:44:36,660 --> 00:44:34,630
their magnetic field looking for a

1108
00:44:39,120 --> 00:44:36,670
magnetic field that's excited very cool

1109
00:44:41,610 --> 00:44:39,130
so black holes are one of my favorite

1110
00:44:43,290 --> 00:44:41,620
things but I know you want to talk about

1111
00:44:44,490 --> 00:44:43,300
some of your favorite things you tell us

1112
00:44:46,320 --> 00:44:44,500
about some other things that's a few

1113
00:44:49,320 --> 00:44:46,330

studies what might be one of your

1114
00:44:51,930 --> 00:44:49,330
particular favorites I'll tell you about

1115
00:44:52,859 --> 00:44:51,940
one of the big challenges that I have in

1116
00:44:55,499 --> 00:44:52,869
planning

1117
00:44:57,539 --> 00:44:55,509
is an event called an occultation an

1118
00:44:59,160 --> 00:44:57,549
occultation is the general case of an

1119
00:45:00,870 --> 00:44:59,170
eclipse so if you've seen a solar

1120
00:45:02,579 --> 00:45:00,880
eclipse or a lunar eclipse it's only

1121
00:45:05,130 --> 00:45:02,589
called in Eclipse if the earth the Sun

1122
00:45:07,170 --> 00:45:05,140
and the moon line up together if it's

1123
00:45:09,749 --> 00:45:07,180
three other objects like a star and a

1124
00:45:11,809 --> 00:45:09,759
planet and your eye that's called an

1125
00:45:14,489 --> 00:45:11,819
occultation so it's a general case and

1126
00:45:16,200 --> 00:45:14,499
if you participated in last year's

1127
00:45:23,779 --> 00:45:16,210
Eclipse across America

1128
00:45:29,759 --> 00:45:27,470
all across the country missed us and

1129
00:45:33,059 --> 00:45:29,769
sometimes you have to be where the

1130
00:45:34,650 --> 00:45:33,069
action is and the shadow of the moon is

1131
00:45:39,120 --> 00:45:34,660
just a small spot compared to the earth

1132
00:45:40,739 --> 00:45:39,130
so we didn't get to see it here by most

1133
00:45:42,359 --> 00:45:40,749
observations that I make it's just a

1134
00:45:44,220 --> 00:45:42,369
question of saying is the star up can I

1135
00:45:46,589 --> 00:45:44,230
point out it but in the case of

1136
00:45:48,660 --> 00:45:46,599
occultation I have to be at exactly the

1137
00:45:50,910 --> 00:45:48,670
right spot on the earth to observe it as

1138
00:45:53,940 --> 00:45:50,920

well like in the path of totality yep in

1139
00:45:56,220 --> 00:45:53,950
the path of totality totality the size

1140
00:45:57,720 --> 00:45:56,230
of the shadow is equivalent to the size

1141
00:45:59,249 --> 00:45:57,730
of the object you're looking at so a

1142
00:46:02,309 --> 00:45:59,259
bigger object will cast a bigger shadow

1143
00:46:12,359 --> 00:46:02,319
a smaller object will have a the biggest

1144
00:46:14,519 --> 00:46:12,369
object if looked at is Pluto look like

1145
00:46:16,049 --> 00:46:14,529
so we're flying along you can see the

1146
00:46:17,609 --> 00:46:16,059
planet and it's just now moving in front

1147
00:46:20,190 --> 00:46:17,619
of a bright star there it goes and the

1148
00:46:21,839 --> 00:46:20,200
shadows cast upon the earth Sofia is

1149
00:46:23,880 --> 00:46:21,849
flying through the shadow and there's a

1150
00:46:26,220 --> 00:46:23,890
bright flash so that was the moment

1151
00:46:28,470 --> 00:46:26,230
where the star and the planet and the

1152
00:46:30,660 --> 00:46:28,480
shadow on the earth were all exactly

1153
00:46:33,269 --> 00:46:30,670
lined up and we want to try to hit that

1154
00:46:35,579 --> 00:46:33,279
that central flash it's called and that

1155
00:46:37,950 --> 00:46:35,589
can be really tricky to try to hit even

1156
00:46:41,220 --> 00:46:37,960
given the shadows size of Pluto about

1157
00:46:44,370 --> 00:46:41,230
the size of Australia this central flash

1158
00:46:45,569 --> 00:46:44,380
goes by really quickly really you said

1159
00:46:48,059 --> 00:46:45,579
it's about the size of Australia how

1160
00:46:50,819 --> 00:46:48,069
long does that do you have to study that

1161
00:46:52,950 --> 00:46:50,829
was less than 2 minutes but not a 1

1162
00:46:55,050 --> 00:46:52,960
minute and a half 1990 second

1163
00:46:57,820 --> 00:46:55,060

[Music]

1164
00:46:59,440 --> 00:46:57,830
about 50 miles or you'll miss the

1165
00:47:01,480 --> 00:46:59,450
central flash entirely and we like to

1166
00:47:03,280 --> 00:47:01,490
try to be within five miles and we're

1167
00:47:05,140 --> 00:47:03,290
moving at five or six hundred miles per

1168
00:47:07,720 --> 00:47:05,150
hour at the same time and the shadows

1169
00:47:10,120 --> 00:47:07,730
moving about 50 or 60,000 miles per hour

1170
00:47:15,220 --> 00:47:10,130
so we're we're definitely not shadow

1171
00:47:18,910 --> 00:47:15,230
chasers to be there when it gets there

1172
00:47:20,560 --> 00:47:18,920
yes when you study objects like this

1173
00:47:22,570 --> 00:47:20,570
what did you learn about Pluto you can

1174
00:47:24,640 --> 00:47:22,580
learn about its size because when you

1175
00:47:27,610 --> 00:47:24,650
cross the dish ad we get the the size of

1176
00:47:30,160 --> 00:47:27,620
the object you can also learn about its

1177
00:47:32,380 --> 00:47:30,170
atmosphere depending upon how the light

1178
00:47:34,720 --> 00:47:32,390
curve changed this the stimming in the

1179
00:47:37,180 --> 00:47:34,730
light and you can also learn about the

1180
00:47:39,220 --> 00:47:37,190
environment Uranus

1181
00:47:42,220 --> 00:47:39,230
its rings were discovered by the cuiprit

1182
00:47:44,410 --> 00:47:42,230
Creek airborne Observatory in

1183
00:47:46,300 --> 00:47:44,420
measurement because it was an unexpected

1184
00:47:48,070 --> 00:47:46,310
result and again they look they found

1185
00:47:50,260 --> 00:47:48,080
rings around a body so applications say

1186
00:47:52,570 --> 00:47:50,270
about a size information about the

1187
00:47:54,640 --> 00:47:52,580
atmosphere and whether there's rings or

1188
00:47:56,740 --> 00:47:54,650

other satellites around the object

1189
00:47:58,450 --> 00:47:56,750
amazingly Pluto for being so far and

1190
00:48:00,970 --> 00:47:58,460
cold has also got a dynamic atmosphere

1191
00:48:02,260 --> 00:48:00,980
it's changing over time it's and that

1192
00:48:09,340 --> 00:48:02,270
has been confirmed by many occupations

1193
00:48:11,440 --> 00:48:09,350
over the several decades you talked

1194
00:48:13,420 --> 00:48:11,450
about searching for rings and for areas

1195
00:48:15,940 --> 00:48:13,430
around this what other objects have we

1196
00:48:19,440 --> 00:48:15,950
done that have you looked at search for

1197
00:48:22,150 --> 00:48:19,450
rings Bart with Sofia the summer of 2017

1198
00:48:24,430 --> 00:48:22,160
we studied a quip about object called

1199
00:48:25,660 --> 00:48:24,440
2014 mu 69 and for the audience

1200
00:48:27,460 --> 00:48:25,670
reference I think we have an

1201
00:48:32,140 --> 00:48:27,470
illustration of what the Kuiper belt is

1202
00:48:33,970 --> 00:48:32,150
yeah this region in the solar system out

1203
00:48:37,230 --> 00:48:33,980
beyond the orbit of Neptune yeah do we

1204
00:48:39,430 --> 00:48:37,240
have that image of the Kuiper belt Dave

1205
00:48:41,380 --> 00:48:39,440
sometimes it's not to be confused with

1206
00:48:43,030 --> 00:48:41,390
the asteroid belt right yeah so this is

1207
00:48:45,610 --> 00:48:43,040
a region in the solar system beyond the

1208
00:48:47,860 --> 00:48:45,620
orbit of Neptune and Pluto is a frequent

1209
00:48:50,740 --> 00:48:47,870
visitor of that well after its 250 year

1210
00:48:54,990 --> 00:48:50,750
your orbit the king of the Kuiper belt

1211
00:49:00,580 --> 00:48:55,000
the most famous one and a billion miles

1212
00:49:05,170 --> 00:49:00,590
beyond Pluto is mu 69 or 2014 mu 69 a

1213
00:49:07,450 --> 00:49:05,180

very small rocky body okay and what was

1214
00:49:09,490 --> 00:49:07,460
to feel looking forth so we didn't we

1215
00:49:11,320 --> 00:49:09,500
an occultation presented its opportunity

1216
00:49:12,820 --> 00:49:11,330
presented itself and this is an object

1217
00:49:14,290 --> 00:49:12,830
discovered by Hubble but we didn't know

1218
00:49:16,450 --> 00:49:14,300
anything about its size so we wanted to

1219
00:49:18,760 --> 00:49:16,460
catch the occultation it's a small

1220
00:49:20,890 --> 00:49:18,770
object it's anticipated like Pluto was

1221
00:49:22,540 --> 00:49:20,900
gonna be like a 90 second event mm-hmm

1222
00:49:29,220 --> 00:49:22,550
this one was gonna be less than two

1223
00:49:34,330 --> 00:49:31,600
Pluto crossing the earth was like the

1224
00:49:37,000 --> 00:49:34,340
size of Australia or the size of Western

1225
00:49:40,090 --> 00:49:37,010
us from say the Mississippi Pacific the

1226
00:49:42,280 --> 00:49:40,100
size of this 20 50 mile type object

1227
00:49:45,550 --> 00:49:42,290
would be the size of Dallas the city of

1228
00:49:47,620 --> 00:49:45,560
Dallas heinie and we're still at these

1229
00:49:48,850 --> 00:49:47,630
same speeds we're traveling this fast

1230
00:49:51,670 --> 00:49:48,860
and the shadows still traveling that's

1231
00:49:56,290 --> 00:49:51,680
super fast fifty thousand miles an hour

1232
00:49:58,180 --> 00:49:56,300
don't blink so we had a very fast camera

1233
00:50:00,280 --> 00:49:58,190
on board just like the same frame Lee

1234
00:50:02,200 --> 00:50:00,290
you get at a movie theater 20 frames per

1235
00:50:04,360 --> 00:50:02,210
second okay for something to take one or

1236
00:50:08,340 --> 00:50:04,370
two seconds would take several several

1237
00:50:10,810 --> 00:50:08,350
measurements like 10 or 15 images okay

1238
00:50:13,600 --> 00:50:10,820

the event happened we actually caught a

1239
00:50:16,570 --> 00:50:13,610
bit of it of the annotation and two of

1240
00:50:18,610 --> 00:50:16,580
our frames wonderful and we were also

1241
00:50:20,740 --> 00:50:18,620
interested in the environment around it

1242
00:50:22,270 --> 00:50:20,750
do these objects have rings or other

1243
00:50:24,400 --> 00:50:22,280
satellites Oh because when you get that

1244
00:50:25,750 --> 00:50:24,410
small the calculations predict there

1245
00:50:27,460 --> 00:50:25,760
you're in these swarms of different

1246
00:50:32,980 --> 00:50:27,470
types of lots of bodies so there could

1247
00:50:35,380 --> 00:50:32,990
have been about why we were searching

1248
00:50:38,470 --> 00:50:35,390
for debris um what other mission was

1249
00:50:42,400 --> 00:50:38,480
interesting that that was necessary for

1250
00:50:44,200 --> 00:50:42,410
aizen's mission NASA flew by Pluto we

1251
00:50:48,760 --> 00:50:44,210
have an animation of new horizons come

1252
00:50:52,110 --> 00:50:48,770
past Pluto Dave can you really grand

1253
00:50:54,340 --> 00:50:52,120
piano size nuclear-powered spacecraft

1254
00:50:57,250 --> 00:50:54,350
flying by Pluto and there's an artist

1255
00:51:00,100 --> 00:50:57,260
representation of Pluto the flyby was in

1256
00:51:02,530 --> 00:51:00,110
July of 2015 and in the distance there

1257
00:51:04,510 --> 00:51:02,540
is Pluto's moon Saturn and so it was a

1258
00:51:06,540 --> 00:51:04,520
sorry Sharon and there is a flyby of

1259
00:51:09,220 --> 00:51:06,550
Pluto there and the spacecraft is

1260
00:51:11,620 --> 00:51:09,230
continuing to to exit the solar system

1261
00:51:15,880 --> 00:51:11,630
is taking lots of pictures of Pluto and

1262
00:51:20,200 --> 00:51:15,890
Charon and when it you know it's wasn't

1263
00:51:21,330 --> 00:51:20,210

slowing down and so really fast and yeah

1264
00:51:26,090 --> 00:51:21,340
some escaped reject

1265
00:51:28,440 --> 00:51:26,100
and its next target is 2014 mu 69

1266
00:51:30,360 --> 00:51:28,450
measurement with Sophia was to look for

1267
00:51:31,830 --> 00:51:30,370
the environment to help inform the

1268
00:51:34,620 --> 00:51:31,840
flight planners because this is a year

1269
00:51:35,910 --> 00:51:34,630
and a half out from their flyby flybys

1270
00:51:40,380 --> 00:51:35,920
in January first

1271
00:51:42,300 --> 00:51:40,390
coming up yeah so we helped the flight

1272
00:51:44,310 --> 00:51:42,310
planner teams for New Horizons you know

1273
00:51:45,840 --> 00:51:44,320
get an early glimpse of the environment

1274
00:51:51,000 --> 00:51:45,850
around their next target all right

1275
00:51:52,410 --> 00:51:51,010
Sherman it's pretty clean and chunky

1276
00:51:54,270 --> 00:51:52,420
they would have had to stay far away

1277
00:51:56,910 --> 00:51:54,280
well it'll be exciting to watch New

1278
00:51:59,100 --> 00:51:56,920
Horizons flyby so you want to ring in

1279
00:52:01,080 --> 00:51:59,110
the New Year with NASA New Horizons and

1280
00:52:03,990 --> 00:52:01,090
learn all about this piano sized

1281
00:52:06,780 --> 00:52:04,000
spacecraft visit nasa.gov slash New

1282
00:52:08,880 --> 00:52:06,790
Horizons yeah and as a quick reminder

1283
00:52:10,380 --> 00:52:08,890
for everybody watching this is NASA and

1284
00:52:11,550 --> 00:52:10,390
Silicon Valley live and today we're

1285
00:52:14,700 --> 00:52:11,560
talking about the world's largest

1286
00:52:16,590 --> 00:52:14,710
airborne Observatory Sofia we're gonna

1287
00:52:18,330 --> 00:52:16,600
have time for another round of questions

1288
00:52:20,760 --> 00:52:18,340

so leave your questions in the chat and

1289
00:52:23,010 --> 00:52:20,770
we'll try to get as many as we can you

1290
00:52:24,750 --> 00:52:23,020
guys up for a few more questions

1291
00:52:27,960 --> 00:52:24,760
all right Cassandra do you want to like

1292
00:52:29,760 --> 00:52:27,970
switch back and forth sure I see sneaky

1293
00:52:32,520 --> 00:52:29,770
Rhino one wants to know how long does

1294
00:52:34,230 --> 00:52:32,530
Sofia stay in the air and does it refuel

1295
00:52:36,630 --> 00:52:34,240
how long does it stay in the air

1296
00:52:38,610 --> 00:52:36,640
typically it's a 10-hour mission so from

1297
00:52:41,670 --> 00:52:38,620
wheels up to wheels down is about 10

1298
00:52:43,650 --> 00:52:41,680
hours and that's a pretty long flight if

1299
00:52:45,840 --> 00:52:43,660
I were flying it as a passenger I'd be

1300
00:52:48,090 --> 00:52:45,850
uncomfortable but I get to get up and

1301
00:52:51,270 --> 00:52:48,100
walk around it does get cold and it does

1302
00:52:53,130 --> 00:52:51,280
get loud on board without all sorts of

1303
00:52:54,510 --> 00:52:53,140
passengers and seats all over the place

1304
00:52:55,950 --> 00:52:54,520
the rumble of the plane is pretty loud

1305
00:52:58,800 --> 00:52:55,960
so we actually wear hearing protection

1306
00:53:01,170 --> 00:52:58,810
most of the time that we're there

1307
00:53:04,230 --> 00:53:01,180
does it refuel so in-flight refueling no

1308
00:53:05,640 --> 00:53:04,240
it does not we land the plane and refuel

1309
00:53:11,810 --> 00:53:05,650
it but astronomers would love that

1310
00:53:16,740 --> 00:53:15,090
observe at night and so even if we were

1311
00:53:19,260 --> 00:53:16,750
to do it try to do a 20-hour flight we

1312
00:53:21,030 --> 00:53:19,270
don't have 20 hours on certain

1313
00:53:24,990 --> 00:53:21,040

wavelengths see and we can be observing

1314
00:53:27,330 --> 00:53:25,000
it longer Webb yes okay we need to does

1315
00:53:28,890 --> 00:53:27,340
the plane have to fly without lights to

1316
00:53:30,510 --> 00:53:28,900
not interfere the telescope I suppose

1317
00:53:33,360 --> 00:53:30,520
and does this cause issues with flight

1318
00:53:34,330 --> 00:53:33,370
laws nail file one asks so that's not an

1319
00:53:37,090 --> 00:53:34,340
issue

1320
00:53:39,130 --> 00:53:37,100
we we turn off the lights in the that

1321
00:53:41,590 --> 00:53:39,140
are shining on the telescope itself but

1322
00:53:44,110 --> 00:53:41,600
other than that we turn them off so the

1323
00:53:46,180 --> 00:53:44,120
logo light that's the light on the plane

1324
00:53:49,240 --> 00:53:46,190
that shines on the plane itself which is

1325
00:53:50,140 --> 00:53:49,250
off as well but the blinking lights the

1326
00:53:51,760 --> 00:53:50,150
red and the green

1327
00:53:53,260 --> 00:53:51,770
they're on they're on the whole time

1328
00:53:55,300 --> 00:53:53,270
because you're following all FAA rules

1329
00:53:56,680 --> 00:53:55,310
and they're emitting in the visible and

1330
00:53:58,900 --> 00:53:56,690
you remember our telescope looks in the

1331
00:54:01,030 --> 00:53:58,910
infrared exactly so and it doesn't

1332
00:54:02,560 --> 00:54:01,040
interfere at all with our our cameras or

1333
00:54:05,920 --> 00:54:02,570
our guide cameras that work in the

1334
00:54:11,800 --> 00:54:05,930
visible so we do follow all the FAA

1335
00:54:14,320 --> 00:54:11,810
rules particle 73 wants to know are

1336
00:54:19,510 --> 00:54:14,330
there multiple Sofia in operation no

1337
00:54:21,730 --> 00:54:19,520
just one and space V net would like to

1338
00:54:24,010 --> 00:54:21,740

know who was the genius that first had

1339
00:54:26,380 --> 00:54:24,020
the idea of an airborne Observatory oh I

1340
00:54:28,720 --> 00:54:26,390
don't know the answer to that yeah I

1341
00:54:31,810 --> 00:54:28,730
mean there was earlier we learned about

1342
00:54:33,630 --> 00:54:31,820
the the Learjet in the 1960s but even

1343
00:54:35,500 --> 00:54:33,640
prior to that you know there was a

1344
00:54:37,870 --> 00:54:35,510
smaller jet that was put up and they

1345
00:54:39,370 --> 00:54:37,880
just stuck a camera outside the window

1346
00:54:40,900 --> 00:54:39,380
and just to see what you can measure

1347
00:54:42,880 --> 00:54:40,910
because you knew about this property

1348
00:54:44,710 --> 00:54:42,890
that the atmosphere was blocking the

1349
00:54:46,450 --> 00:54:44,720
infrared and when the first infra

1350
00:54:48,970 --> 00:54:46,460
detectors were being discovered were

1351
00:54:50,860 --> 00:54:48,980
being made one they took it up and they

1352
00:54:52,930 --> 00:54:50,870
realized that we are missing a lot of

1353
00:54:58,690 --> 00:54:52,940
the universe up there the answer is the

1354
00:55:01,870 --> 00:54:58,700
cool people at NASA it's doing that for

1355
00:55:04,660 --> 00:55:01,880
a long time could Sofia be used to

1356
00:55:08,200 --> 00:55:04,670
observe a comet and its tail absolutely

1357
00:55:13,030 --> 00:55:08,210
and it has oh yeah several times we have

1358
00:55:14,290 --> 00:55:13,040
one coming up yeah yeah comment that's

1359
00:55:18,010 --> 00:55:14,300
gonna make its perihelion around

1360
00:55:20,230 --> 00:55:18,020
December 16th or so Oh

1361
00:55:21,970 --> 00:55:20,240
closest to the Sun so when a comet gets

1362
00:55:23,230 --> 00:55:21,980
closer to the Sun it gets more active

1363
00:55:25,360 --> 00:55:23,240

and you can see a lot more of its

1364
00:55:26,830 --> 00:55:25,370
activities and so in the end Fred we're

1365
00:55:29,620 --> 00:55:26,840
looking at we can look at the study the

1366
00:55:31,060 --> 00:55:29,630
the gas and also the dust and the ice so

1367
00:55:33,640 --> 00:55:31,070
we can look at water because the carbon

1368
00:55:35,230 --> 00:55:33,650
dioxide we can look at methane we can

1369
00:55:37,210 --> 00:55:35,240
look at any of the constituents and also

1370
00:55:39,400 --> 00:55:37,220
the temperature so we do a lot of common

1371
00:55:41,320 --> 00:55:39,410
studies ok yeah whenever a comet comes

1372
00:55:43,360 --> 00:55:41,330
around it gets scheduled we even have

1373
00:55:45,550 --> 00:55:43,370
open observations if a comet were meters

1374
00:55:47,390 --> 00:55:45,560
to be discovered it would it would get

1375
00:55:49,970 --> 00:55:47,400
bumped up into Q to be observed

1376
00:55:52,849 --> 00:55:49,980
hey Fred Birkhoff is asking what is

1377
00:55:54,079 --> 00:55:52,859
space made out of that seems like a

1378
00:56:00,620 --> 00:55:54,089
simple question but that's actually

1379
00:56:05,239 --> 00:56:00,630
that's a use the term space gas and dust

1380
00:56:06,710 --> 00:56:05,249
yes gas gases atoms they are molecules

1381
00:56:08,569 --> 00:56:06,720
when you have more than one atom you

1382
00:56:11,029 --> 00:56:08,579
have ions which are when you remove an

1383
00:56:13,999 --> 00:56:11,039
electron or you know a neutron and you

1384
00:56:16,549 --> 00:56:14,009
charge it and then dust two solid

1385
00:56:18,019 --> 00:56:16,559
particles and in some astronomers like

1386
00:56:19,970 --> 00:56:18,029
to call dust anything that's heavier

1387
00:56:22,789 --> 00:56:19,980
than helium so sometimes carbon oxygen

1388
00:56:25,190 --> 00:56:22,799

nitrogen if there's a lot of it is a

1389
00:56:27,109 --> 00:56:25,200
solid call a dust consider the dust okay

1390
00:56:32,390 --> 00:56:27,119
planets are giant aggregates of dust

1391
00:56:41,480 --> 00:56:32,400
yeah and then there's the gap between

1392
00:56:44,029 --> 00:56:41,490
the gas and the dust - mm-hmm about in

1393
00:56:45,859 --> 00:56:44,039
our last minute or so what Sophia is

1394
00:56:47,120 --> 00:56:45,869
looking at going forward you mentioned

1395
00:56:49,519 --> 00:56:47,130
this comet

1396
00:56:52,670 --> 00:56:49,529
maybe what they're looking at this week

1397
00:56:54,289 --> 00:56:52,680
this week so let me I can tell you what

1398
00:56:56,839 --> 00:56:54,299
we're looking at tonight today so we're

1399
00:57:01,150 --> 00:56:56,849
taking off in about two hours time so

1400
00:57:03,079 --> 00:57:01,160
6:40 p.m. on Pacific time 9:40 Eastern

1401
00:57:05,239 --> 00:57:03,089
240 in the morning if you're at

1402
00:57:07,220 --> 00:57:05,249
Greenwich Mean Time and it'll be flying

1403
00:57:09,620 --> 00:57:07,230
about for ten hours and will fly out of

1404
00:57:11,749 --> 00:57:09,630
Southern California fly up to Manitoba

1405
00:57:15,380 --> 00:57:11,759
then across to Vancouver and back down

1406
00:57:18,710 --> 00:57:15,390
to Southern California and then in that

1407
00:57:20,329 --> 00:57:18,720
time we will observe three different

1408
00:57:21,739 --> 00:57:20,339
stars at various stages of their life

1409
00:57:25,880 --> 00:57:21,749
we're going to look at one that has

1410
00:57:28,789 --> 00:57:25,890
newborn inside of a cloud we're going to

1411
00:57:31,249 --> 00:57:28,799
look at a taut Erling spewing planet and

1412
00:57:33,430 --> 00:57:31,259
an aging lost its hair already bald

1413
00:57:34,579 --> 00:57:33,440

planet and finally in a great view of

1414
00:57:36,019 --> 00:57:34,589
m51

1415
00:57:37,460 --> 00:57:36,029
a galaxy that's like the Milky Way but

1416
00:57:39,859 --> 00:57:37,470
close enough we can get details and its

1417
00:57:41,930 --> 00:57:39,869
face on and you can use your favorite

1418
00:57:44,870 --> 00:57:41,940
flight tracking program and our tail

1419
00:57:48,530 --> 00:57:44,880
sign is the NASA seven four seven

1420
00:57:51,230 --> 00:57:48,540
just in two hours yeah yeah okay awesome

1421
00:57:53,060 --> 00:57:51,240
well thank you both for joining us we're

1422
00:57:54,860 --> 00:57:53,070
just about out of time thank you for

1423
00:57:56,750 --> 00:57:54,870
watching for all your questions in the

1424
00:57:58,610 --> 00:57:56,760
chat this has been NASA in Silicon

1425
00:58:00,950 --> 00:57:58,620
Valley live the conversational talk show

1426
00:58:02,360 --> 00:58:00,960
out of NASA Ames Research Center with

1427
00:58:04,420 --> 00:58:02,370
the various scientists engineers and

1428
00:58:07,070 --> 00:58:04,430
researchers and all-around cool people

1429
00:58:09,680 --> 00:58:07,080
where we talk about all that nerdy NASA

1430
00:58:11,750 --> 00:58:09,690
news you need to know about if you like

1431
00:58:14,930 --> 00:58:11,760
that we're simultaneously live on twitch

1432
00:58:16,760 --> 00:58:14,940
YouTube and Facebook and NASA TV as well

1433
00:58:19,010 --> 00:58:16,770
and if you can't catch us live don't

1434
00:58:21,500 --> 00:58:19,020
worry we will being video on demand

1435
00:58:24,910 --> 00:58:21,510
after the fact and you can also catch us

1436
00:58:31,960 --> 00:58:24,920
on podcast services on the audio version

1437
00:58:36,680 --> 00:58:34,490
thank you to everybody in the chat who

1438
00:58:38,930 --> 00:58:36,690

joined us and we'll be back on Thursday

1439
00:58:41,570 --> 00:58:38,940
December 20th for a special holiday

1440
00:58:43,880 --> 00:58:41,580
unboxing episode so be sure to join us