

1  
00:00:01,310 --> 00:00:10,679  
let me know when you see alive Hubble

2  
00:00:07,440 --> 00:00:14,099  
hang out and help hello everybody and

3  
00:00:10,679 --> 00:00:16,079  
welcome to the 225th meeting of the

4  
00:00:14,099 --> 00:00:17,399  
american astronomical society my name is

5  
00:00:16,079 --> 00:00:19,409  
Tony Darnell I work at the Space

6  
00:00:17,399 --> 00:00:21,209  
Telescope Science Institute and we are

7  
00:00:19,410 --> 00:00:23,490  
here at the northrop grumman booth in

8  
00:00:21,210 --> 00:00:26,189  
the exhibit hall to talk about a really

9  
00:00:23,489 --> 00:00:29,098  
cool project called star shape and with

10  
00:00:26,189 --> 00:00:30,839  
me as I again after a long time is my

11  
00:00:29,099 --> 00:00:32,159  
old friend Alberto continent this

12  
00:00:30,839 --> 00:00:33,299  
awkward thing going with the microphone

13  
00:00:32,159 --> 00:00:34,889  
I'm going to have to give it back and

14  
00:00:33,299 --> 00:00:36,929  
forth to him in a min i'm going to let

15  
00:00:34,890 --> 00:00:38,730  
him speak to us but first interact with

16  
00:00:36,929 --> 00:00:42,179  
us send us questions talk to us on

17  
00:00:38,729 --> 00:00:43,679  
Twitter Facebook and G+ as well as the

18  
00:00:42,179 --> 00:00:45,689  
YouTube page from which this is being

19  
00:00:43,679 --> 00:00:47,399  
broadcast this is on our Hubble site

20  
00:00:45,689 --> 00:00:49,468  
channel we're looking at your comments

21  
00:00:47,399 --> 00:00:51,539  
if you use the hashtag Hubble hang out

22  
00:00:49,469 --> 00:00:54,920  
we will see that on Twitter and I've got

23  
00:00:51,539 --> 00:00:57,329  
lots of people looking up for those of

24  
00:00:54,920 --> 00:00:59,670  
tweets from you as well as the comments

25  
00:00:57,329 --> 00:01:01,289  
on g+ and facebook so ask us questions

26  
00:00:59,670 --> 00:01:02,579  
about starshade we're gonna you don't

27  
00:01:01,289 --> 00:01:04,228  
know what it is we're going to find out

28  
00:01:02,579 --> 00:01:05,129  
so I got I got people here from Northrop

29

00:01:04,228 --> 00:01:08,159  
Grumman to tell us but before I

30  
00:01:05,129 --> 00:01:10,680  
introduce them Alberto it's good to see

31  
00:01:08,159 --> 00:01:12,930  
you again after do this which is a lock

32  
00:01:10,680 --> 00:01:15,030  
what is it I have to wait to respond to

33  
00:01:12,930 --> 00:01:16,110  
you it's good to see you again we

34  
00:01:15,030 --> 00:01:19,079  
haven't be we haven't seen each other

35  
00:01:16,109 --> 00:01:20,700  
for quite some time actually here and so

36  
00:01:19,079 --> 00:01:23,548  
this is actually routine for us so we

37  
00:01:20,700 --> 00:01:24,630  
should do this often the old days so

38  
00:01:23,549 --> 00:01:25,830  
we're going to do this I wanted to

39  
00:01:24,629 --> 00:01:28,019  
mention we can do this throughout the

40  
00:01:25,829 --> 00:01:29,879  
week so you're going to do it half and

41  
00:01:28,019 --> 00:01:31,679  
half at the North three booths and half

42  
00:01:29,879 --> 00:01:32,908  
at the space let's go booth which is

43  
00:01:31,680 --> 00:01:34,409

fantastic so we're going to talk about

44

00:01:32,909 --> 00:01:36,180

lots of topic start is just the

45

00:01:34,409 --> 00:01:37,530

first one we have great people here for

46

00:01:36,180 --> 00:01:40,590

a new program to tell you exactly what

47

00:01:37,530 --> 00:01:43,710

they are and well they leave it up to

48

00:01:40,590 --> 00:01:45,240

you let's let's get it on so I'm glad so

49

00:01:43,709 --> 00:01:46,379

you tell people what you're doing a

50

00:01:45,239 --> 00:01:47,969

northrop though i don't think people

51

00:01:46,379 --> 00:01:50,129

know what you do you left this institute

52

00:01:47,969 --> 00:01:51,868

to do what are you doing now little

53

00:01:50,129 --> 00:01:54,000

strange title i'm an innovation manager

54

00:01:51,868 --> 00:01:55,560

for civil air and spaces so i work in

55

00:01:54,000 --> 00:01:58,349

the business development organization so

56

00:01:55,560 --> 00:01:59,640

i have in my portfolio things like jwst

57

00:01:58,349 --> 00:02:01,379

which I support I can continue to

58  
00:01:59,640 --> 00:02:03,329  
support but also things like we're going

59  
00:02:01,379 --> 00:02:05,339  
to talk about today star shades and

60  
00:02:03,328 --> 00:02:07,139  
maybe next generation flagship so it's a

61  
00:02:05,340 --> 00:02:10,259  
very very trusting job very very hectic

62  
00:02:07,140 --> 00:02:12,689  
and it's love it yeah well we miss you

63  
00:02:10,258 --> 00:02:13,719  
at the Institute that's for sure so okay

64  
00:02:12,689 --> 00:02:15,789  
let's get to let's get to the

65  
00:02:13,719 --> 00:02:17,259  
just get to the me oh one more thing if

66  
00:02:15,789 --> 00:02:18,849  
you want to keep track of where we're

67  
00:02:17,259 --> 00:02:20,349  
going on what what hangouts are coming

68  
00:02:18,849 --> 00:02:22,000  
next the best way to do that is to

69  
00:02:20,349 --> 00:02:24,549  
follow our Facebook page Hubble

70  
00:02:22,000 --> 00:02:27,969  
telescope also follow Hubble NASA Hubble

71  
00:02:24,550 --> 00:02:29,920  
he'll be tweeting on that as well as I'd

72  
00:02:27,969 --> 00:02:30,969  
be posting the events on google+ so

73  
00:02:29,919 --> 00:02:32,859  
that's how you're going to know which

74  
00:02:30,969 --> 00:02:34,240  
hangouts are coming up next all the ones

75  
00:02:32,860 --> 00:02:35,710  
for today are already posted we have a

76  
00:02:34,240 --> 00:02:38,290  
whole nother slew of them planned

77  
00:02:35,710 --> 00:02:39,700  
tomorrow so ok let me get to our guests

78  
00:02:38,289 --> 00:02:41,620  
I have with me an astronomer from

79  
00:02:39,699 --> 00:02:44,530  
Northrop Grumman his his name's Ron

80  
00:02:41,620 --> 00:02:46,629  
politian I had to look at your I'm so bad

81  
00:02:44,530 --> 00:02:47,800  
at names he is an astronomer at Northrop

82  
00:02:46,629 --> 00:02:49,930  
Grumman welcome so I tell us a little

83  
00:02:47,800 --> 00:02:52,030  
about what you're doing I'm the science

84  
00:02:49,930 --> 00:02:54,280  
manager for Northrop Grumman and with

85  
00:02:52,030 --> 00:02:55,930  
regard to star shades I've been there

86

00:02:54,280 --> 00:02:57,580  
since the beginning when about 10 years

87  
00:02:55,930 --> 00:02:59,620  
ago when the concept first came into

88  
00:02:57,580 --> 00:03:01,630  
being we did some stuff with the

89  
00:02:59,620 --> 00:03:03,700  
university of colorado and what resulted

90  
00:03:01,629 --> 00:03:05,949  
from that was this concept of a star

91  
00:03:03,699 --> 00:03:07,419  
shade awesome and also with me and Steve

92  
00:03:05,949 --> 00:03:09,579  
Warrick he's an engineer building the

93  
00:03:07,419 --> 00:03:10,750  
thing I see hey how you doing tell us a

94  
00:03:09,580 --> 00:03:12,040  
little about what what you're doing so

95  
00:03:10,750 --> 00:03:14,469  
most of what we're doing at the moment

96  
00:03:12,039 --> 00:03:17,500  
is testing the optics of the starshade

97  
00:03:14,469 --> 00:03:19,780  
seeing how the starshade does what it's

98  
00:03:17,500 --> 00:03:21,430  
supposed to do which is to block out the

99  
00:03:19,780 --> 00:03:24,610  
light of a star so that we can see the

100  
00:03:21,430 --> 00:03:26,620

light from a planet an exoplanet well

101

00:03:24,610 --> 00:03:27,760

welcome to both of you from to our to

102

00:03:26,620 --> 00:03:28,659

our Hubble hang on I appreciate this

103

00:03:27,759 --> 00:03:31,090

even though we're talking about

104

00:03:28,659 --> 00:03:33,039

starshade it is it is in fact the hub

105

00:03:31,090 --> 00:03:34,150

will hang out so so Ron let me get back

106

00:03:33,039 --> 00:03:35,949

to you a little bit tell us tell

107

00:03:34,150 --> 00:03:37,629

everybody what this thing is what are

108

00:03:35,949 --> 00:03:39,399

you doing what is starshade and what are

109

00:03:37,629 --> 00:03:42,039

you hoping to accomplish with it only

110

00:03:39,400 --> 00:03:43,560

the big issue with seeing exoplanets

111

00:03:42,039 --> 00:03:46,419

these are planets that are round stars

112

00:03:43,560 --> 00:03:47,949

outside the solar system planets are

113

00:03:46,419 --> 00:03:49,719

very faint stars very bright so

114

00:03:47,949 --> 00:03:51,699

astronomers have been struggling for a



115  
00:03:49,719 --> 00:03:53,680  
long time with how to suppress that

116  
00:03:51,699 --> 00:03:56,409  
starlight and then see the planets

117  
00:03:53,680 --> 00:03:58,239  
around it about 10 years ago we came up

118  
00:03:56,409 --> 00:03:59,139  
with this concept for something that's

119  
00:03:58,239 --> 00:04:01,360  
very different from the traditional

120  
00:03:59,139 --> 00:04:04,539  
approach which is to build an instrument

121  
00:04:01,360 --> 00:04:06,430  
and put it inside the telescope and get

122  
00:04:04,539 --> 00:04:08,439  
rid of the Starlight through some sort

123  
00:04:06,430 --> 00:04:10,590  
of internal thing this is a device

124  
00:04:08,439 --> 00:04:13,780  
that's fairly large but it flies outside

125  
00:04:10,590 --> 00:04:17,199  
the telescope and it blocks the light

126  
00:04:13,780 --> 00:04:18,910  
from entering the telescope and allows

127  
00:04:17,199 --> 00:04:20,680  
the planet to come through unencumbered

128  
00:04:18,910 --> 00:04:22,630  
so it's sort of like putting your thumb

129

00:04:20,680 --> 00:04:24,230

in front of a bright light to block out

130

00:04:22,629 --> 00:04:26,089

the light so you can see what around it

131

00:04:24,230 --> 00:04:30,890

so yes like that and so this is just a

132

00:04:26,089 --> 00:04:34,399

very special unusually shaped thumb I'll

133

00:04:30,889 --> 00:04:36,379

say looks like a daisy with petals and

134

00:04:34,399 --> 00:04:39,199

such and that's a mathematical design

135

00:04:36,379 --> 00:04:41,420

that allows this this spot that it

136

00:04:39,199 --> 00:04:43,430

creates to be very very deep and very

137

00:04:41,420 --> 00:04:45,170

dark and so think of it as a traveling

138

00:04:43,430 --> 00:04:46,340

dark spot okay well that's a really

139

00:04:45,170 --> 00:04:47,900

interesting concept I mean a lot of

140

00:04:46,339 --> 00:04:50,629

times I know what you're saying about

141

00:04:47,899 --> 00:04:52,279

sometimes they have telescope tubes or

142

00:04:50,629 --> 00:04:54,379

optical assemblies we'll put something

143

00:04:52,279 --> 00:04:56,329  
called in a culture in the light path to

144  
00:04:54,379 --> 00:04:58,100  
kind of block out just a little disk

145  
00:04:56,329 --> 00:04:59,810  
usually it's a cone shape or something

146  
00:04:58,100 --> 00:05:01,810  
like that it just sort of blocks out the

147  
00:04:59,810 --> 00:05:04,220  
bright spot of this the bright star

148  
00:05:01,810 --> 00:05:05,420  
solar telescopes have these all over the

149  
00:05:04,220 --> 00:05:07,040  
place to block out the disk of the Sun

150  
00:05:05,420 --> 00:05:10,520  
so they can see the limb and also the

151  
00:05:07,040 --> 00:05:12,439  
solar corona so the stars because is it

152  
00:05:10,519 --> 00:05:14,629  
because the stars are so far away that

153  
00:05:12,439 --> 00:05:17,899  
the planets are I mean you can still

154  
00:05:14,629 --> 00:05:19,579  
resolve even at say dozens of

155  
00:05:17,899 --> 00:05:20,659  
light-years planets that might be an

156  
00:05:19,579 --> 00:05:23,029  
orbit around a star with the light

157  
00:05:20,660 --> 00:05:24,770

blocked yes I mean the big issue and it

158

00:05:23,029 --> 00:05:28,939

is a hard thing to do it's basically

159

00:05:24,769 --> 00:05:31,129

like trying to image a firefly a few

160

00:05:28,939 --> 00:05:34,730

centimeters from a searchlight so it is

161

00:05:31,129 --> 00:05:36,439

a very very difficult thing to do but

162

00:05:34,730 --> 00:05:38,390

yes with a large enough telescope and

163

00:05:36,439 --> 00:05:40,009

with something that could block out this

164

00:05:38,389 --> 00:05:42,349

light the plants are going to be

165

00:05:40,009 --> 00:05:43,879

observable so Steve let me get you in on

166

00:05:42,350 --> 00:05:46,280

this so have we started building it yet

167

00:05:43,879 --> 00:05:48,319

and no way it not the space version at

168

00:05:46,279 --> 00:05:50,419

least we've been we've been doing some

169

00:05:48,319 --> 00:05:53,269

testing on the ground and what we're

170

00:05:50,420 --> 00:05:55,189

doing there is we're taking a light

171

00:05:53,269 --> 00:05:56,569

source out to the desert we got a nice

172  
00:05:55,189 --> 00:05:58,850  
picture here there's a light source

173  
00:05:56,569 --> 00:06:04,129  
overruns head over there telescope in

174  
00:05:58,850 --> 00:06:05,480  
here and what we're doing is is is we're

175  
00:06:04,129 --> 00:06:08,480  
using this bright light source to

176  
00:06:05,480 --> 00:06:10,009  
simulate a a star and we've got some

177  
00:06:08,480 --> 00:06:12,200  
other little light sources that simulate

178  
00:06:10,009 --> 00:06:14,959  
in the planet we put a star shade which

179  
00:06:12,199 --> 00:06:17,149  
is you know about that big a one-percent

180  
00:06:14,959 --> 00:06:19,909  
scale starshade something like that in

181  
00:06:17,149 --> 00:06:22,250  
between the bright source and the and

182  
00:06:19,910 --> 00:06:24,020  
the telescope and and we're checking our

183  
00:06:22,250 --> 00:06:26,360  
imaging with that and we're showing that

184  
00:06:24,019 --> 00:06:29,149  
the computer models that we have for how

185  
00:06:26,360 --> 00:06:31,670  
the optics we'll work our are very

186  
00:06:29,149 --> 00:06:33,109  
similar to what we're able to collect

187  
00:06:31,670 --> 00:06:36,050  
the images we were able to collect in

188  
00:06:33,110 --> 00:06:37,370  
the desert ok so so we've got a

189  
00:06:36,050 --> 00:06:40,490  
proof-of-concept essentially

190  
00:06:37,370 --> 00:06:42,470  
already built yes absolutely so and one

191  
00:06:40,490 --> 00:06:44,120  
of the things with the sausage was as

192  
00:06:42,470 --> 00:06:46,760  
Ron mentioned the the very specific

193  
00:06:44,120 --> 00:06:49,399  
shape of it and we're trying to suppress

194  
00:06:46,759 --> 00:06:51,289  
the Starlight to 10 to the 10 and that's

195  
00:06:49,399 --> 00:06:53,179  
a really difficult number ten to the six

196  
00:06:51,290 --> 00:06:55,729  
would be relatively easy 10 to the 10

197  
00:06:53,180 --> 00:06:57,800  
gets really quite hard so there's a lot

198  
00:06:55,728 --> 00:06:59,990  
of questions about whether the model is

199  
00:06:57,800 --> 00:07:02,389  
is going to be accurate the optical

200

00:06:59,990 --> 00:07:04,250  
model is accurate at that level so and

201  
00:07:02,389 --> 00:07:06,800  
there's some possible different shapes

202  
00:07:04,250 --> 00:07:08,269  
you can use there's the issue of when

203  
00:07:06,800 --> 00:07:10,639  
you build this thing and you fly it in

204  
00:07:08,269 --> 00:07:12,769  
space can you control the shape to the

205  
00:07:10,639 --> 00:07:14,180  
the accuracy you need so we've been

206  
00:07:12,769 --> 00:07:15,680  
doing some testing with what happens

207  
00:07:14,180 --> 00:07:18,168  
when the the shape isn't quite perfect

208  
00:07:15,680 --> 00:07:20,629  
and and you start distorting the shape

209  
00:07:18,168 --> 00:07:22,668  
does that affect the results are you're

210  
00:07:20,629 --> 00:07:24,379  
going to be able to get so you tested

211  
00:07:22,668 --> 00:07:25,788  
this on the ground and you said it works

212  
00:07:24,379 --> 00:07:28,279  
were you able to see anything and you

213  
00:07:25,788 --> 00:07:29,719  
pee on any planet so when we're testing

214  
00:07:28,279 --> 00:07:33,649

on the ground we're looking at these

215

00:07:29,720 --> 00:07:36,830

LEDs and so what we were simulating a

216

00:07:33,649 --> 00:07:40,279

system it's not it's not it's not a it's

217

00:07:36,829 --> 00:07:41,930

not quite the right scale for what you

218

00:07:40,279 --> 00:07:43,250

would be looking at yeah I misunderstood

219

00:07:41,930 --> 00:07:45,228

what you said about the test day okay

220

00:07:43,250 --> 00:07:47,959

your door you were using LEDs to do that

221

00:07:45,228 --> 00:07:50,180

not actual stars correct yeah yeah so

222

00:07:47,959 --> 00:07:52,909

okay so I didn't hear that part

223

00:07:50,180 --> 00:07:55,129

certainly we saw the LEDs like we

224

00:07:52,910 --> 00:07:57,110

expected to see them so the whole point

225

00:07:55,129 --> 00:07:58,310

here is because this is a new concept

226

00:07:57,110 --> 00:08:00,080

this is something that hasn't been

227

00:07:58,310 --> 00:08:02,120

around for generations it's something

228

00:08:00,079 --> 00:08:04,219

that really came into being on two



229  
00:08:02,120 --> 00:08:06,709  
thousand four and five there's a lot of

230  
00:08:04,220 --> 00:08:09,410  
basic understanding that we need until

231  
00:08:06,709 --> 00:08:11,439  
these tests in the desert that Steve

232  
00:08:09,410 --> 00:08:14,630  
talked about are essential to start

233  
00:08:11,439 --> 00:08:16,219  
saying if we model this this is what we

234  
00:08:14,629 --> 00:08:17,990  
think we should see and then we go out

235  
00:08:16,220 --> 00:08:19,520  
and empirically see is this what we see

236  
00:08:17,990 --> 00:08:21,259  
and then through those sorts of things

237  
00:08:19,519 --> 00:08:24,109  
like Steve said with putting in

238  
00:08:21,259 --> 00:08:25,879  
artificial distortions if I can put in a

239  
00:08:24,110 --> 00:08:27,830  
distortion and predict what I'm going to

240  
00:08:25,879 --> 00:08:29,598  
see then obviously I know more about

241  
00:08:27,829 --> 00:08:31,250  
this and if I put in something I get

242  
00:08:29,598 --> 00:08:33,319  
something completely different and so

243  
00:08:31,250 --> 00:08:35,599  
this is a very methodical process to go

244  
00:08:33,320 --> 00:08:38,479  
through and understand this optic

245  
00:08:35,599 --> 00:08:40,370  
because it is an optic and how performs

246  
00:08:38,479 --> 00:08:42,349  
what are the things that are tight

247  
00:08:40,370 --> 00:08:44,389  
tolerances what are the things that are

248  
00:08:42,349 --> 00:08:46,670  
not very much oh and here we go this is

249  
00:08:44,389 --> 00:08:49,159  
this is we have a model thank you this

250  
00:08:46,669 --> 00:08:51,439  
is what they look like in general

251  
00:08:49,159 --> 00:08:53,629  
as I was going to just reiterate one

252  
00:08:51,440 --> 00:08:55,339  
thing as Steve will show you in a second

253  
00:08:53,629 --> 00:08:57,019  
describe the starshade I want to go back

254  
00:08:55,339 --> 00:08:58,670  
to what the size of the problem really

255  
00:08:57,019 --> 00:09:00,519  
is what are we trying to do right you're

256  
00:08:58,669 --> 00:09:04,250  
trying to find an earth-like planet

257

00:09:00,519 --> 00:09:06,078  
around a star okay and the planet is 10

258  
00:09:04,250 --> 00:09:08,509  
billion times fainter than the parent

259  
00:09:06,078 --> 00:09:11,778  
star so you're putting your your thumb

260  
00:09:08,509 --> 00:09:13,370  
up there on top of it so in virtually on

261  
00:09:11,778 --> 00:09:15,470  
top of its of the very little separation

262  
00:09:13,370 --> 00:09:17,480  
so that's the heart of problem and so

263  
00:09:15,470 --> 00:09:20,629  
the shape is actually very meaningful so

264  
00:09:17,480 --> 00:09:22,129  
I'm gonna it's very pretty I like it

265  
00:09:20,629 --> 00:09:23,810  
yeah but it's all black you need to add

266  
00:09:22,129 --> 00:09:27,470  
colors and maybe a little smiley face on

267  
00:09:23,809 --> 00:09:28,399  
there and that'll be all right tell us a

268  
00:09:27,470 --> 00:09:30,709  
little bit more about what you hold out

269  
00:09:28,399 --> 00:09:32,720  
okay so what I'm holding here is in one

270  
00:09:30,708 --> 00:09:34,250  
of the samples that we we test in the

271  
00:09:32,720 --> 00:09:36,920

desert and and and as I mentioned

272

00:09:34,250 --> 00:09:38,958  
earlier this shape is is critical to

273

00:09:36,919 --> 00:09:41,778  
reach in that kind of suppression that

274

00:09:38,958 --> 00:09:44,778  
we were looking for and we also have

275

00:09:41,778 --> 00:09:45,948  
just as shown how it worked tested with

276

00:09:44,778 --> 00:09:48,110  
a dish because it's about the same size

277

00:09:45,948 --> 00:09:50,179  
but for completely circular and what we

278

00:09:48,110 --> 00:09:53,028  
see with the disc is that you get as we

279

00:09:50,179 --> 00:09:55,609  
expected a bright ring of diffracted

280

00:09:53,028 --> 00:09:57,799  
light from the from the main LED coming

281

00:09:55,610 --> 00:09:59,269  
around there and that's just natural

282

00:09:57,799 --> 00:10:00,318  
behavior of light going through anything

283

00:09:59,269 --> 00:10:01,879  
what tell us a little bit about a

284

00:10:00,318 --> 00:10:04,610  
fraction so different' is the way that

285

00:10:01,879 --> 00:10:06,740  
land light bends around or in fact any

286  
00:10:04,610 --> 00:10:08,240  
wave then bends around the surface in

287  
00:10:06,740 --> 00:10:11,419  
this case we're talking about light and

288  
00:10:08,240 --> 00:10:12,919  
when we've got a surface that is is at

289  
00:10:11,419 --> 00:10:15,078  
right angles to the light beam then it

290  
00:10:12,919 --> 00:10:16,610  
will bend around it what's going on here

291  
00:10:15,078 --> 00:10:19,008  
is we're getting that same diffraction

292  
00:10:16,610 --> 00:10:22,370  
but with this this petal shape we're

293  
00:10:19,009 --> 00:10:24,079  
canceling out the diffraction rings so

294  
00:10:22,370 --> 00:10:27,230  
that we wind up with a much a little

295  
00:10:24,078 --> 00:10:28,909  
lower so that we can sit where we get

296  
00:10:27,230 --> 00:10:31,579  
we're canceling out the diffraction from

297  
00:10:28,909 --> 00:10:33,528  
different radii along a pebble so that

298  
00:10:31,578 --> 00:10:35,539  
we get a much darker spot than we would

299  
00:10:33,528 --> 00:10:37,009  
with just a disc that was out in front

300  
00:10:35,539 --> 00:10:38,299  
of so it was just one of the beauties of

301  
00:10:37,009 --> 00:10:40,839  
science that it turned out to be the

302  
00:10:38,299 --> 00:10:43,609  
shape it did that that's exactly right

303  
00:10:40,839 --> 00:10:44,630  
okay so triangle shape yeah so the

304  
00:10:43,610 --> 00:10:45,709  
differentially she's talking about if

305  
00:10:44,629 --> 00:10:47,659  
you ever look at a star through a

306  
00:10:45,708 --> 00:10:50,028  
telescope and the secondary mirror

307  
00:10:47,659 --> 00:10:51,318  
sometimes you can see little rings that

308  
00:10:50,028 --> 00:10:52,399  
they come around and that's what they're

309  
00:10:51,318 --> 00:10:54,558  
talking about canceling it now and that

310  
00:10:52,399 --> 00:10:56,539  
can prevent you from seeing really close

311  
00:10:54,558 --> 00:10:58,188  
planets right near the star so you want

312  
00:10:56,539 --> 00:11:00,889  
to get rid of that as much as you can so

313  
00:10:58,188 --> 00:11:03,289  
run why space can we do this on the

314

00:11:00,889 --> 00:11:05,360  
ground I mean the problem will start

315  
00:11:03,289 --> 00:11:07,429  
is that while it's a very efficient way

316  
00:11:05,360 --> 00:11:10,399  
to operate it's a very large baseline

317  
00:11:07,429 --> 00:11:11,659  
and so even in our desert test what do

318  
00:11:10,399 --> 00:11:14,539  
you mean long long baseline I the

319  
00:11:11,659 --> 00:11:17,899  
distance between other telescope and the

320  
00:11:14,539 --> 00:11:20,208  
starshade has to be very large compared

321  
00:11:17,899 --> 00:11:22,190  
to the size of either so for example in

322  
00:11:20,208 --> 00:11:24,198  
the desert it's a couple of kilometers

323  
00:11:22,190 --> 00:11:26,120  
different distance between the starshade

324  
00:11:24,198 --> 00:11:27,588  
and the camera so this was sitting a

325  
00:11:26,120 --> 00:11:29,209  
couple of kilometers away from the

326  
00:11:27,589 --> 00:11:30,589  
telescope you were testing right and so

327  
00:11:29,208 --> 00:11:32,119  
in space because we're dealing with

328  
00:11:30,589 --> 00:11:34,970

bigger telescopes and bigger things

329

00:11:32,120 --> 00:11:38,179

you're talking about a 30 to 60 meter

330

00:11:34,970 --> 00:11:40,250

diameter starshade tens of thousands of

331

00:11:38,179 --> 00:11:42,198

kilometers in front of a telescope so

332

00:11:40,250 --> 00:11:44,659

it's a very long arm that is holding

333

00:11:42,198 --> 00:11:46,669

that thumb and so they're they're

334

00:11:44,659 --> 00:11:49,789

independent they're they're traveling

335

00:11:46,669 --> 00:11:51,439

together so its formation flying but one

336

00:11:49,789 --> 00:11:53,509

that's relatively straightforward and

337

00:11:51,440 --> 00:11:56,269

that's what allows us to have the really

338

00:11:53,509 --> 00:11:59,060

small spot so we can cover the star but

339

00:11:56,269 --> 00:12:01,009

not cover the planet ok so we haven't

340

00:11:59,059 --> 00:12:03,078

you've tested it but we haven't actually

341

00:12:01,009 --> 00:12:05,778

started building this yet correct known

342

00:12:03,078 --> 00:12:08,299

as a space mission no I mean it's pretty



343  
00:12:05,778 --> 00:12:10,870  
critical that we know exactly how this

344  
00:12:08,299 --> 00:12:14,448  
works before we go spending you know

345  
00:12:10,870 --> 00:12:16,610  
government money so this is but we have

346  
00:12:14,448 --> 00:12:18,528  
begun testing components because in

347  
00:12:16,610 --> 00:12:21,440  
parallel to the desert test with their

348  
00:12:18,528 --> 00:12:23,179  
testing the optics are we and people at

349  
00:12:21,440 --> 00:12:25,339  
JPL and other people in community are

350  
00:12:23,179 --> 00:12:27,138  
testing other aspects of this how would

351  
00:12:25,339 --> 00:12:29,360  
we build it how would we deploy it what

352  
00:12:27,139 --> 00:12:31,639  
materials should be involved so those

353  
00:12:29,360 --> 00:12:33,230  
are going on in parallel they're not at

354  
00:12:31,639 --> 00:12:36,440  
the level right now where we would be

355  
00:12:33,230 --> 00:12:38,000  
using space equivalent hardware but it's

356  
00:12:36,440 --> 00:12:41,690  
the first stages like with the optical

357  
00:12:38,000 --> 00:12:43,549  
testing of testing how in some number of

358  
00:12:41,690 --> 00:12:45,920  
years will we actually build this to fly

359  
00:12:43,549 --> 00:12:48,889  
in space I wanted to go back to what

360  
00:12:45,919 --> 00:12:52,068  
something that Rhonda said which is not

361  
00:12:48,889 --> 00:12:56,060  
only the distance between here is

362  
00:12:52,068 --> 00:12:57,919  
telephone that's right that's right so

363  
00:12:56,059 --> 00:12:59,299  
not only the distance between the

364  
00:12:57,919 --> 00:13:01,129  
telescope in the starshade has to be

365  
00:12:59,299 --> 00:13:02,328  
over 10,000 you know thousands of

366  
00:13:01,129 --> 00:13:04,068  
kilometers to ten thousands of

367  
00:13:02,328 --> 00:13:05,750  
kilometers but I should they shape the

368  
00:13:04,068 --> 00:13:07,338  
size of the starshade is also relevant

369  
00:13:05,750 --> 00:13:09,110  
you know so you know this is not these

370  
00:13:07,339 --> 00:13:11,810  
are not this is a clear model it's very

371

00:13:09,110 --> 00:13:14,449  
small so maybe you know both you and Stu

372  
00:13:11,809 --> 00:13:16,009  
can tell give us an idea of how big you

373  
00:13:14,448 --> 00:13:17,189  
know with the task of B it was sorry

374  
00:13:16,009 --> 00:13:20,159  
with the starshade have to

375  
00:13:17,190 --> 00:13:22,590  
in order to act as this famous thumb

376  
00:13:20,159 --> 00:13:24,269  
yeah and also this is this is kind of

377  
00:13:22,590 --> 00:13:25,620  
solid material you're not going to make

378  
00:13:24,269 --> 00:13:28,889  
it out of solid material I don't think

379  
00:13:25,620 --> 00:13:30,830  
either right so now i'm at the right now

380  
00:13:28,889 --> 00:13:33,990  
we're looking at is something that is a

381  
00:13:30,830 --> 00:13:35,820  
membrane suspended between some sort of

382  
00:13:33,990 --> 00:13:36,840  
structure but that's part of what we're

383  
00:13:35,820 --> 00:13:38,960  
looking at is how we would go about

384  
00:13:36,840 --> 00:13:41,670  
doing this anything like the jwst

385  
00:13:38,960 --> 00:13:42,810

essentials something very similar be sun

386

00:13:41,669 --> 00:13:44,459

shield and what are the one of the

387

00:13:42,809 --> 00:13:45,719

interesting aspects of this is that one

388

00:13:44,460 --> 00:13:47,759

of the cast we will be doing over the

389

00:13:45,720 --> 00:13:49,830

next couple years is if i have a

390

00:13:47,759 --> 00:13:51,000

membrane it's really light and therefore

391

00:13:49,830 --> 00:13:54,570

this thing doesn't have to weigh as much

392

00:13:51,000 --> 00:13:57,179

but um how transparent is it because

393

00:13:54,570 --> 00:13:58,770

even though you know if i look at a

394

00:13:57,179 --> 00:14:01,469

piece of mylar or whatever they would

395

00:13:58,769 --> 00:14:03,779

use it seems opaque as scheme said we're

396

00:14:01,470 --> 00:14:06,779

talking about one part in 10 to the 10

397

00:14:03,779 --> 00:14:08,339

billion oh no we need to make sure that

398

00:14:06,779 --> 00:14:09,689

it's actually opaque to that level so

399

00:14:08,340 --> 00:14:15,660

there's lots of interesting tests are

400  
00:14:09,690 --> 00:14:16,860  
going on okay so um Alberto I ok so so

401  
00:14:15,659 --> 00:14:17,759  
let's go back to the size of this so

402  
00:14:16,860 --> 00:14:19,740  
tell us a little about how big these

403  
00:14:17,759 --> 00:14:21,750  
things going to be so in the space

404  
00:14:19,740 --> 00:14:24,299  
application we've looked at everything

405  
00:14:21,750 --> 00:14:26,370  
from 30 metres up to about 80 meters and

406  
00:14:24,299 --> 00:14:27,919  
it depends very much on the telescope

407  
00:14:26,370 --> 00:14:30,149  
that you're working with the other

408  
00:14:27,919 --> 00:14:31,469  
obvious problem that you've got is there

409  
00:14:30,149 --> 00:14:33,240  
aren't many photons coming from the

410  
00:14:31,470 --> 00:14:35,550  
planets that we're trying to observe so

411  
00:14:33,240 --> 00:14:37,230  
you really want to get a large

412  
00:14:35,549 --> 00:14:38,789  
collecting area you make the telescope

413  
00:14:37,230 --> 00:14:41,129  
larger than the starshade has to be

414  
00:14:38,789 --> 00:14:43,769  
larger to be able to give the dark spot

415  
00:14:41,129 --> 00:14:48,389  
that surrounds the entire optics of your

416  
00:14:43,769 --> 00:14:51,179  
telescope so there's lots of discussion

417  
00:14:48,389 --> 00:14:52,500  
here / over the last weekend and I'm

418  
00:14:51,179 --> 00:14:55,139  
sure there will be further discussion

419  
00:14:52,500 --> 00:14:56,909  
about the next generation telescope the

420  
00:14:55,139 --> 00:14:58,470  
next next generation tal scale the one

421  
00:14:56,909 --> 00:15:01,439  
after James Webb and how big that will

422  
00:14:58,470 --> 00:15:03,089  
be if you've got a 8 meter optic or 10

423  
00:15:01,440 --> 00:15:06,240  
millimeter optic then the starshade

424  
00:15:03,089 --> 00:15:09,060  
should be around 80 meters diameter to

425  
00:15:06,240 --> 00:15:10,320  
be 80 meters 10 spot yeah we're going to

426  
00:15:09,059 --> 00:15:12,000  
have a hangout on the future of space

427  
00:15:10,320 --> 00:15:13,230  
telescopes to later this week I think so

428

00:15:12,000 --> 00:15:15,899  
we'll how about we'll talk about that as

429  
00:15:13,230 --> 00:15:18,389  
well so does the telescope have to be

430  
00:15:15,899 --> 00:15:19,289  
built to your building the starshade now

431  
00:15:18,389 --> 00:15:20,970  
you're gonna be able to build in

432  
00:15:19,289 --> 00:15:22,740  
different sizes depending on you said

433  
00:15:20,970 --> 00:15:24,269  
the telescope that is used with but if I

434  
00:15:22,740 --> 00:15:26,009  
want to use a star shade on my telescope

435  
00:15:24,269 --> 00:15:27,629  
do I have to design my telescope to

436  
00:15:26,009 --> 00:15:29,490  
specifically be compatible with this is

437  
00:15:27,629 --> 00:15:30,379  
a require for example a certain field of

438  
00:15:29,490 --> 00:15:32,419  
view

439  
00:15:30,379 --> 00:15:35,600  
no really no I mean it will work with

440  
00:15:32,419 --> 00:15:36,709  
practically any generic Space Telescope

441  
00:15:35,600 --> 00:15:39,320  
because you know there's lots of those

442  
00:15:36,710 --> 00:15:41,210

lying around but I'm gonna launch a CA

443

00:15:39,320 --> 00:15:44,210

that's what I'm gonna do you see a dura

444

00:15:41,210 --> 00:15:46,280

lx200 yeah yeah so it should work with

445

00:15:44,210 --> 00:15:48,740

practically any space telescope the only

446

00:15:46,279 --> 00:15:50,059

caveat to that is you need to know where

447

00:15:48,740 --> 00:15:51,500

the two things are you need to know

448

00:15:50,059 --> 00:15:53,599

where your star shape you've got to line

449

00:15:51,500 --> 00:15:55,009

them up yeah you're gonna line them up

450

00:15:53,600 --> 00:15:56,210

you're gonna know where your / it

451

00:15:55,009 --> 00:15:58,730

spacecraft is you're going to know where

452

00:15:56,210 --> 00:16:01,220

your telescope is so it's it the benefit

453

00:15:58,730 --> 00:16:03,080

is having a beacon on on your telescope

454

00:16:01,220 --> 00:16:04,879

so that you can you can detect where you

455

00:16:03,080 --> 00:16:05,960

are relative to each other oh that's an

456

00:16:04,879 --> 00:16:08,779

interesting point so how would that work



457  
00:16:05,960 --> 00:16:10,790  
Ronnie you got okay aspect of this is

458  
00:16:08,779 --> 00:16:12,980  
that um as I said this is a traveling

459  
00:16:10,789 --> 00:16:15,529  
bare spot that dark spot has a diameter

460  
00:16:12,980 --> 00:16:17,570  
so you also have to match your telescope

461  
00:16:15,529 --> 00:16:19,250  
that it needs to sit inside the dark

462  
00:16:17,570 --> 00:16:21,920  
spot we aren't really care where in the

463  
00:16:19,250 --> 00:16:24,710  
dark spot but if I have a dark spot that

464  
00:16:21,919 --> 00:16:26,120  
is let's say five meters across and I

465  
00:16:24,710 --> 00:16:27,710  
have a 10-meter telescope that's not

466  
00:16:26,120 --> 00:16:28,789  
going to help so I do got to keep these

467  
00:16:27,710 --> 00:16:30,320  
things in mind when I build my tell

468  
00:16:28,789 --> 00:16:33,049  
that's the only thing that it does

469  
00:16:30,320 --> 00:16:35,180  
require is that the telescope has to fit

470  
00:16:33,049 --> 00:16:37,969  
inside of our spot okay and adjust this

471  
00:16:35,179 --> 00:16:39,889  
to be the size that it's needed so if

472  
00:16:37,970 --> 00:16:41,750  
you have a four meter telescope I can

473  
00:16:39,889 --> 00:16:43,939  
give you a five or six meters shadow or

474  
00:16:41,750 --> 00:16:45,620  
if you have a 10 meter one I can give

475  
00:16:43,940 --> 00:16:48,470  
you a bigger one but that's that's where

476  
00:16:45,620 --> 00:16:49,879  
the scaling size comes in okay so you

477  
00:16:48,470 --> 00:16:51,920  
said it's a movable dark spot how do I

478  
00:16:49,879 --> 00:16:54,200  
move this thing it operates with

479  
00:16:51,919 --> 00:16:56,689  
propulsion more likely than not electric

480  
00:16:54,200 --> 00:17:00,710  
propulsion and I move it around the side

481  
00:16:56,690 --> 00:17:03,260  
to align services yeah like what like

482  
00:17:00,710 --> 00:17:06,559  
Rosetta right there well I Rosetta or

483  
00:17:03,259 --> 00:17:08,269  
dawn and must rely so those sorts of

484  
00:17:06,559 --> 00:17:10,009  
things so existing technology so you got

485

00:17:08,269 --> 00:17:12,289  
to be patient to point this thing right

486  
00:17:10,009 --> 00:17:13,099  
i mean if you want to you want to end

487  
00:17:12,289 --> 00:17:14,838  
you're going to have to somehow

488  
00:17:13,099 --> 00:17:15,948  
coordinate that with your telescope it's

489  
00:17:14,838 --> 00:17:18,980  
going to have to all be linked together

490  
00:17:15,949 --> 00:17:21,259  
you're going to have to write and and

491  
00:17:18,980 --> 00:17:22,490  
you're going to need to be I want to now

492  
00:17:21,259 --> 00:17:24,949  
and look over here this part of this guy

493  
00:17:22,490 --> 00:17:26,509  
is going to take a while right and we

494  
00:17:24,949 --> 00:17:28,820  
look at essentially for traveling

495  
00:17:26,509 --> 00:17:30,230  
salesman problem is that we have a bunch

496  
00:17:28,819 --> 00:17:32,720  
of stars on sky that we want to look at

497  
00:17:30,230 --> 00:17:35,390  
and we can go from one to the next in

498  
00:17:32,720 --> 00:17:36,920  
some plan and then therefore optimize

499  
00:17:35,390 --> 00:17:38,750

the time the nice thing about starshade

500

00:17:36,920 --> 00:17:40,880

since it doesn't require any special

501

00:17:38,750 --> 00:17:41,839

anything on the telescope that in

502

00:17:40,880 --> 00:17:43,190

between those

503

00:17:41,839 --> 00:17:45,558

listening the telescope can be doing

504

00:17:43,190 --> 00:17:47,330

other astrophysics so it's not one of

505

00:17:45,558 --> 00:17:50,028

these things where I'm dedicated to do

506

00:17:47,329 --> 00:17:53,480

this the throughput of the starshade is

507

00:17:50,028 --> 00:17:55,970

very high so when I do finally align I

508

00:17:53,480 --> 00:17:57,860

can get my data very quickly and then

509

00:17:55,970 --> 00:18:01,220

how that move on to the next one and so

510

00:17:57,859 --> 00:18:04,399

it becomes basically how energetic of an

511

00:18:01,220 --> 00:18:06,140

ion propulsion system you have and how

512

00:18:04,400 --> 00:18:08,480

far you are away and sort of stuff but

513

00:18:06,140 --> 00:18:09,919

what very doable and very much within

514  
00:18:08,480 --> 00:18:12,110  
giving you the right number of stars

515  
00:18:09,919 --> 00:18:13,788  
people would want to survey and that's

516  
00:18:12,109 --> 00:18:14,778  
awesome so see I don't know if this is

517  
00:18:13,788 --> 00:18:16,519  
your expertise enough I'd like to ask

518  
00:18:14,778 --> 00:18:17,808  
you a bit more about this ion drive key

519  
00:18:16,519 --> 00:18:21,230  
tell us what they're like how they work

520  
00:18:17,808 --> 00:18:24,829  
and so not my area of expertise but and

521  
00:18:21,230 --> 00:18:26,750  
you you are basically driving xenon gas

522  
00:18:24,829 --> 00:18:28,548  
out of the back of the thrusters and on

523  
00:18:26,750 --> 00:18:31,640  
Zenon depending on where which side is

524  
00:18:28,548 --> 00:18:35,960  
Atlantic Zenon Zenon Zenon alcoholism

525  
00:18:31,640 --> 00:18:37,460  
and and and that's you using electric

526  
00:18:35,960 --> 00:18:39,470  
propulsion to do that so you're

527  
00:18:37,460 --> 00:18:43,308  
basically charging the particles and

528  
00:18:39,470 --> 00:18:46,038  
using the charge between two plates to

529  
00:18:43,308 --> 00:18:48,470  
pull the the Zen on out the back of the

530  
00:18:46,038 --> 00:18:49,849  
thruster so is that the limiting factor

531  
00:18:48,470 --> 00:18:51,620  
of the lifetime of the starshade is how

532  
00:18:49,849 --> 00:18:54,969  
much gas you put in it that would

533  
00:18:51,619 --> 00:18:57,139  
definitely be part of it and it they

534  
00:18:54,970 --> 00:19:00,169  
because you were only able to look at

535  
00:18:57,140 --> 00:19:01,850  
planets and you've got a limit of how

536  
00:19:00,169 --> 00:19:03,288  
close you can look to the start because

537  
00:19:01,849 --> 00:19:05,178  
you know that's the size of the dark

538  
00:19:03,288 --> 00:19:07,129  
spot and we're talking of the order of

539  
00:19:05,179 --> 00:19:08,990  
100 milli arcseconds something like that

540  
00:19:07,130 --> 00:19:10,909  
maybe 60 milliseconds something like

541  
00:19:08,990 --> 00:19:13,730  
that so what that means is when you're

542

00:19:10,909 --> 00:19:15,710  
looking for habitable zones you're only

543  
00:19:13,730 --> 00:19:18,649  
able to look at the nearest 200 or so

544  
00:19:15,710 --> 00:19:19,970  
stars may be 500 stars because once you

545  
00:19:18,648 --> 00:19:22,668  
start looking at stars that are further

546  
00:19:19,970 --> 00:19:24,230  
away than that then then the annular

547  
00:19:22,669 --> 00:19:27,350  
separation between the habitable zone

548  
00:19:24,230 --> 00:19:30,769  
and the and the and the star starts to

549  
00:19:27,349 --> 00:19:32,928  
be too small so yes it does have a

550  
00:19:30,769 --> 00:19:35,389  
lifetime at that lifetime is is based on

551  
00:19:32,929 --> 00:19:37,070  
fuel but your point would be that to

552  
00:19:35,390 --> 00:19:39,288  
design a mission that can in its

553  
00:19:37,069 --> 00:19:41,389  
lifetime get round the stars that that

554  
00:19:39,288 --> 00:19:44,869  
you give you the best chance of finding

555  
00:19:41,390 --> 00:19:46,880  
you know a earth-like planet in you know

556  
00:19:44,869 --> 00:19:50,538

in our neighborhood ok he said habitable

557

00:19:46,880 --> 00:19:52,500

zone hey how little zone this is what

558

00:19:50,538 --> 00:19:56,069

has become sort of the

559

00:19:52,500 --> 00:19:58,410

standard measure and it's it's consider

560

00:19:56,069 --> 00:20:00,839

we believe that water is essential for

561

00:19:58,410 --> 00:20:03,060

life so the habitable zone is basically

562

00:20:00,839 --> 00:20:05,039

the area around a star where liquid

563

00:20:03,059 --> 00:20:07,649

water can exist on the surface of a

564

00:20:05,039 --> 00:20:10,109

planet so if you go too close to the Sun

565

00:20:07,650 --> 00:20:12,060

it gets real hot you evaporate all your

566

00:20:10,109 --> 00:20:13,979

water so you get things like a Mercury

567

00:20:12,059 --> 00:20:16,649

and Venus if you go too far from the Sun

568

00:20:13,980 --> 00:20:18,809

you get ice freezing of water freezing

569

00:20:16,650 --> 00:20:20,759

out and you get Mars and then Jupiter

570

00:20:18,809 --> 00:20:23,399

and beyond so there is a narrow region



571  
00:20:20,759 --> 00:20:24,930  
around every star in which the

572  
00:20:23,400 --> 00:20:26,580  
temperature is just right so it's also

573  
00:20:24,930 --> 00:20:29,070  
called the Goldilocks zone where it's

574  
00:20:26,579 --> 00:20:31,049  
not unfortunately it's not too cold it's

575  
00:20:29,069 --> 00:20:32,609  
just right and so that's what people are

576  
00:20:31,049 --> 00:20:34,019  
looking for yes and we've talked at

577  
00:20:32,609 --> 00:20:35,609  
length about why liquid water is

578  
00:20:34,019 --> 00:20:37,049  
important you may not think it's all

579  
00:20:35,609 --> 00:20:38,819  
that big a deal but liquid water is

580  
00:20:37,049 --> 00:20:40,409  
where we start because we know at least

581  
00:20:38,819 --> 00:20:43,109  
in the one spot where we know there is

582  
00:20:40,410 --> 00:20:44,490  
life it is vital so he looks may as well

583  
00:20:43,109 --> 00:20:46,169  
look for what we know works so that's

584  
00:20:44,490 --> 00:20:47,759  
why liquid liquid water has been so

585  
00:20:46,170 --> 00:20:49,440  
important in our search for life ishan

586  
00:20:47,759 --> 00:20:54,660  
says he's got some social media stuff

587  
00:20:49,440 --> 00:21:01,019  
going to tell us Daniel and Sato of

588  
00:20:54,660 --> 00:21:03,540  
Google+ wants to know how do you get the

589  
00:21:01,019 --> 00:21:04,559  
starshade and the telescope to orbit in

590  
00:21:03,539 --> 00:21:06,930  
sync when they're thousands of

591  
00:21:04,559 --> 00:21:09,299  
kilometers apart who wants that one and

592  
00:21:06,930 --> 00:21:11,850  
great question and you can't do that

593  
00:21:09,299 --> 00:21:13,950  
around us so your your your options are

594  
00:21:11,849 --> 00:21:16,349  
that you go to l2 which is where the

595  
00:21:13,950 --> 00:21:18,480  
James Webb Space Telescope is going a

596  
00:21:16,349 --> 00:21:20,639  
lot of other things it seems yeah and a

597  
00:21:18,480 --> 00:21:24,720  
lot of other things so then it so L 2

598  
00:21:20,640 --> 00:21:27,180  
that is a gravitational saddle that is

599

00:21:24,720 --> 00:21:29,339  
in line with the the Sun and the earth

600  
00:21:27,180 --> 00:21:31,980  
and it's about a million miles beyond

601  
00:21:29,339 --> 00:21:33,839  
the Earth from the Sun and the gravity

602  
00:21:31,980 --> 00:21:37,259  
area there is pretty flat and so you

603  
00:21:33,839 --> 00:21:39,149  
your gravity difference between what's

604  
00:21:37,259 --> 00:21:41,430  
affecting the starshade spacecraft and

605  
00:21:39,150 --> 00:21:44,190  
your telescope spacecraft is very minor

606  
00:21:41,430 --> 00:21:46,380  
so you don't need that much fuel to hold

607  
00:21:44,190 --> 00:21:48,120  
the position between the two there's

608  
00:21:46,380 --> 00:21:49,770  
other options as well earth trailing

609  
00:21:48,119 --> 00:21:52,319  
orbits or if leading orbits would also

610  
00:21:49,769 --> 00:21:53,460  
give you a way of doing that really good

611  
00:21:52,319 --> 00:21:54,720  
question I was going to ask him myself

612  
00:21:53,460 --> 00:21:57,090  
but you got to it you got another winner

613  
00:21:54,720 --> 00:21:58,350

is that it for now okay so keep keep on

614

00:21:57,089 --> 00:22:02,909

coming guys we're monitoring we got it

615

00:21:58,349 --> 00:22:05,909

we got you covered so I guess I get so

616

00:22:02,910 --> 00:22:06,320

the but we're in the planning stages now

617

00:22:05,910 --> 00:22:08,600

is

618

00:22:06,319 --> 00:22:10,308

they're some kind of and a presumably

619

00:22:08,599 --> 00:22:12,558

Northrop Grumman is building this thing

620

00:22:10,308 --> 00:22:14,089

for space at some point is there

621

00:22:12,558 --> 00:22:17,200

anything we're waiting on to get make

622

00:22:14,089 --> 00:22:20,298

further progress on this or is it is it

623

00:22:17,200 --> 00:22:22,190

I guess it's what what's what are we

624

00:22:20,298 --> 00:22:24,740

ready to move to the next phase we are

625

00:22:22,190 --> 00:22:27,019

moving to the next phase so the desert

626

00:22:24,740 --> 00:22:29,138

tests that we are in the process of

627

00:22:27,019 --> 00:22:32,179

doing and they're still more to do are

628  
00:22:29,138 --> 00:22:33,859  
establishing the optical properties so

629  
00:22:32,179 --> 00:22:35,120  
it's under we're understanding now what

630  
00:22:33,859 --> 00:22:37,668  
our tolerances are we're getting

631  
00:22:35,119 --> 00:22:39,979  
empirical measures of theoretical

632  
00:22:37,669 --> 00:22:41,960  
calculations so we're combining that so

633  
00:22:39,980 --> 00:22:44,120  
we understand how it works would it

634  
00:22:41,960 --> 00:22:45,500  
what's needed to make it work what kind

635  
00:22:44,119 --> 00:22:47,028  
of tolerances we need on the thing that

636  
00:22:45,500 --> 00:22:48,528  
we're going to build as i said in

637  
00:22:47,028 --> 00:22:50,480  
parallel we're also trying to look at

638  
00:22:48,528 --> 00:22:52,940  
how we would deploy this how we would

639  
00:22:50,480 --> 00:22:54,558  
fit this into a fairing so all those are

640  
00:22:52,940 --> 00:22:56,960  
starting to converge and so over the

641  
00:22:54,558 --> 00:23:00,319  
next few years we will learn more about

642  
00:22:56,960 --> 00:23:01,730  
this our understanding will grow and at

643  
00:23:00,319 --> 00:23:04,009  
some point hopefully within a couple of

644  
00:23:01,730 --> 00:23:06,528  
years we will be ready to do some sort

645  
00:23:04,009 --> 00:23:10,419  
of demo test or something of that nature

646  
00:23:06,528 --> 00:23:13,009  
to go to the next stage so this is a

647  
00:23:10,419 --> 00:23:15,230  
broad reach project right now because

648  
00:23:13,009 --> 00:23:17,480  
we're looking at how it works optically

649  
00:23:15,230 --> 00:23:19,339  
how it works mechanically what are some

650  
00:23:17,480 --> 00:23:21,589  
of the issues as for the question from

651  
00:23:19,339 --> 00:23:23,569  
there what orbits we should go into what

652  
00:23:21,589 --> 00:23:25,730  
those constraints put on things so all

653  
00:23:23,569 --> 00:23:27,408  
those things need to be looked at and so

654  
00:23:25,730 --> 00:23:28,970  
it's a lot of work to do but it's coming

655  
00:23:27,409 --> 00:23:30,379  
together very nicely and we would hope

656

00:23:28,970 --> 00:23:33,288  
in a few years to be ready to start

657  
00:23:30,378 --> 00:23:35,750  
looking at a space-based at least test

658  
00:23:33,288 --> 00:23:37,190  
if not the demo okay so in a couple

659  
00:23:35,750 --> 00:23:38,450  
years we might be testing anybody want

660  
00:23:37,190 --> 00:23:40,850  
to prognosticate when this thing is

661  
00:23:38,450 --> 00:23:43,960  
going to be in norway in orbit come on

662  
00:23:40,849 --> 00:23:46,219  
that's really up to NASA and the

663  
00:23:43,960 --> 00:23:47,990  
halliwell what's this is your good

664  
00:23:46,220 --> 00:23:49,850  
support for NASA on this project yes

665  
00:23:47,990 --> 00:23:51,950  
very good and so nASA has been very

666  
00:23:49,849 --> 00:23:54,378  
helpful from the very early days on

667  
00:23:51,950 --> 00:23:56,929  
NASA's been involved in the discussion

668  
00:23:54,378 --> 00:23:59,148  
are the some of the demonstrations of

669  
00:23:56,929 --> 00:24:01,879  
how the deployment works were done at

670  
00:23:59,148 --> 00:24:04,219

JPL with Norfolk support stuff so NASA

671

00:24:01,878 --> 00:24:06,500

is very key to this very important and

672

00:24:04,220 --> 00:24:08,329

supplied both great intellectual

673

00:24:06,500 --> 00:24:09,740

property but also the resources and the

674

00:24:08,329 --> 00:24:12,230

facilities to do some of the stuff the

675

00:24:09,740 --> 00:24:14,028

the starshade itself doesn't seem like

676

00:24:12,230 --> 00:24:15,409

it's that expensive to make I mean

677

00:24:14,028 --> 00:24:16,788

compared to some of the other things

678

00:24:15,409 --> 00:24:18,830

that go up into space this might be a

679

00:24:16,788 --> 00:24:19,398

pretty economical thing to build right

680

00:24:18,829 --> 00:24:20,898

well

681

00:24:19,398 --> 00:24:22,368

a lot of that depends on what we find

682

00:24:20,898 --> 00:24:24,439

over the next few years I mean we are

683

00:24:22,368 --> 00:24:26,358

looking at tolerances and other sorts of

684

00:24:24,440 --> 00:24:28,729

things we hope it will be very



685  
00:24:26,358 --> 00:24:30,798  
affordable at this stage it's probably a

686  
00:24:28,729 --> 00:24:32,450  
little early to say absolutely but you

687  
00:24:30,798 --> 00:24:34,429  
know yes indeed well we think this is a

688  
00:24:32,450 --> 00:24:36,769  
very good way to go forward we think

689  
00:24:34,429 --> 00:24:38,629  
this may be one of the better ways to

690  
00:24:36,769 --> 00:24:42,378  
find out if there's life outside the

691  
00:24:38,628 --> 00:24:43,939  
solar system no oh okay he took the

692  
00:24:42,378 --> 00:24:46,009  
words out of your mouth did he okay cool

693  
00:24:43,940 --> 00:24:47,659  
well I'd say to me what worries me are

694  
00:24:46,009 --> 00:24:49,639  
the space telescopes themselves I don't

695  
00:24:47,659 --> 00:24:51,649  
know of a lot other than say W first and

696  
00:24:49,638 --> 00:24:52,908  
maybe something else down the road we

697  
00:24:51,648 --> 00:24:54,439  
got to start now thinking about the

698  
00:24:52,909 --> 00:24:56,479  
you're building star shades but we got

699  
00:24:54,440 --> 00:24:57,919  
telescopes to build to use these things

700  
00:24:56,479 --> 00:24:59,899  
that kind of worries me a little bit i'm

701  
00:24:57,919 --> 00:25:01,549  
not sure i guess the one other aspect of

702  
00:24:59,898 --> 00:25:03,228  
this than the other big advantage of a

703  
00:25:01,548 --> 00:25:05,898  
star shade is since it's a an

704  
00:25:03,229 --> 00:25:07,909  
independent operator it's an external

705  
00:25:05,898 --> 00:25:09,048  
occult for an external coronagraph it

706  
00:25:07,909 --> 00:25:11,539  
can actually operate with multiple

707  
00:25:09,048 --> 00:25:13,700  
telescopes so if we had three or four

708  
00:25:11,538 --> 00:25:15,440  
telescopes at I2 right now in principle

709  
00:25:13,700 --> 00:25:18,588  
we could operate a star shape with each

710  
00:25:15,440 --> 00:25:20,629  
one so you know one could look at using

711  
00:25:18,588 --> 00:25:22,278  
telescope number one to do one thing and

712  
00:25:20,628 --> 00:25:24,108  
tell us what number two to do nothing we

713

00:25:22,278 --> 00:25:26,659  
just need to then move the starshade in

714  
00:25:24,108 --> 00:25:31,189  
line with Ulster well what about jada

715  
00:25:26,659 --> 00:25:33,289  
beastie certainly one good in principle

716  
00:25:31,190 --> 00:25:36,019  
do that as Steve said I mean the one big

717  
00:25:33,288 --> 00:25:38,088  
issue with this is the easiest way to

718  
00:25:36,019 --> 00:25:39,858  
align the choose to put a beacon on on

719  
00:25:38,088 --> 00:25:42,079  
the telescope so I know where the

720  
00:25:39,858 --> 00:25:43,489  
telescope is or if I'm a star shade and

721  
00:25:42,079 --> 00:25:45,528  
it's the telescope knows what the

722  
00:25:43,489 --> 00:25:46,969  
starshade is that both those there then

723  
00:25:45,528 --> 00:25:48,648  
it becomes really easy right now there's

724  
00:25:46,969 --> 00:25:51,009  
no beach in on Jane flow Alberta you

725  
00:25:48,648 --> 00:25:53,178  
need to add that as a feature on JWST

726  
00:25:51,009 --> 00:25:54,378  
yeah that would be interesting feature I

727  
00:25:53,179 --> 00:25:57,109

don't think is in the plan but it will

728

00:25:54,378 --> 00:26:00,678

be an interesting feature so but we want

729

00:25:57,108 --> 00:26:01,848

to see I mean it's generally we look at

730

00:26:00,679 --> 00:26:03,259

yeah but remember this is a piece was

731

00:26:01,848 --> 00:26:05,298

built to look at spectra for exoplanets

732

00:26:03,259 --> 00:26:06,528

rye and so I think it's a kind of

733

00:26:05,298 --> 00:26:08,179

different kind of absorbing right that

734

00:26:06,528 --> 00:26:09,950

you want to do in terms of in terms of

735

00:26:08,179 --> 00:26:12,048

what you want to get out right and sorry

736

00:26:09,950 --> 00:26:14,149

I talks is not going to look at you know

737

00:26:12,048 --> 00:26:15,888

I don't generously denial resolution to

738

00:26:14,148 --> 00:26:16,939

look at earth-sized planets rice you're

739

00:26:15,888 --> 00:26:18,949

going to look at hot Jupiters for

740

00:26:16,940 --> 00:26:20,909

example right so ishan do you have

741

00:26:18,950 --> 00:26:26,909

anything for me

742  
00:26:20,909 --> 00:26:29,099  
golf addict 75 youtube how small of a

743  
00:26:26,909 --> 00:26:31,859  
planet will be able to image who wants

744  
00:26:29,098 --> 00:26:33,989  
that one and the issue is that's

745  
00:26:31,858 --> 00:26:35,548  
depending on how big of a telescope as

746  
00:26:33,989 --> 00:26:37,950  
the resolving power of the telescope

747  
00:26:35,548 --> 00:26:41,158  
primary and how I'm these planets are

748  
00:26:37,950 --> 00:26:42,720  
faint so but with a big telescope and a

749  
00:26:41,159 --> 00:26:44,429  
suitable starshade one should be able to

750  
00:26:42,720 --> 00:26:47,399  
image earth or smaller planets so

751  
00:26:44,429 --> 00:26:49,048  
earth-sized are smaller and but you are

752  
00:26:47,398 --> 00:26:51,418  
limited by how close you can get correct

753  
00:26:49,048 --> 00:26:54,148  
a pen that's correct so yeah if you

754  
00:26:51,419 --> 00:26:56,788  
there's a in a working angle 65 million

755  
00:26:54,148 --> 00:26:58,768  
seconds probably about right and so and

756  
00:26:56,788 --> 00:27:01,319  
then it depends your Goldilocks zone

757  
00:26:58,769 --> 00:27:03,028  
depends on the brightness of the star

758  
00:27:01,319 --> 00:27:05,368  
you know the type of star you're looking

759  
00:27:03,028 --> 00:27:07,950  
at so I certainly on some of them like

760  
00:27:05,368 --> 00:27:10,829  
the M Dwarfs that area may be too far in

761  
00:27:07,950 --> 00:27:13,229  
for a star shade to to be able to work

762  
00:27:10,829 --> 00:27:15,720  
but stars that are like our own star

763  
00:27:13,229 --> 00:27:17,399  
then then yeah absolutely there's 200

764  
00:27:15,720 --> 00:27:20,700  
plus targets that we could go after with

765  
00:27:17,398 --> 00:27:22,378  
this okay i just want and you know that

766  
00:27:20,700 --> 00:27:23,788  
there's a lot of interest from NASA from

767  
00:27:22,378 --> 00:27:26,009  
lots of other folks to actually look at

768  
00:27:23,788 --> 00:27:27,808  
planet that size right the have water in

769  
00:27:26,009 --> 00:27:29,429  
the Goldilocks zone so i think is not a

770

00:27:27,808 --> 00:27:31,408  
surprising answer that we want to aim

771  
00:27:29,429 --> 00:27:32,548  
you know for a 10 to 12 meter telescope

772  
00:27:31,409 --> 00:27:34,200  
for example in the future of the

773  
00:27:32,548 --> 00:27:37,648  
jeddah-based e to those kind of planets

774  
00:27:34,200 --> 00:27:39,509  
right anything else you Sean okay so I

775  
00:27:37,648 --> 00:27:40,648  
want to get to a little bit about so I'm

776  
00:27:39,509 --> 00:27:41,669  
gonna go that's a little bit about

777  
00:27:40,648 --> 00:27:43,018  
starshade I want to thank you guys for

778  
00:27:41,669 --> 00:27:43,919  
giving us an update on that but I want

779  
00:27:43,019 --> 00:27:46,108  
to talk a little bit about Northrop

780  
00:27:43,919 --> 00:27:47,369  
Grumman and why you guys are doing this

781  
00:27:46,108 --> 00:27:49,888  
and we were talking to him last night

782  
00:27:47,368 --> 00:27:51,839  
Ron about how early career scientists

783  
00:27:49,888 --> 00:27:54,748  
when they're coming out of graduate

784  
00:27:51,839 --> 00:27:55,589

school and maybe going into postdoc we

785

00:27:54,749 --> 00:27:57,778

were talking about how what how

786

00:27:55,589 --> 00:27:59,398

competitive that is but actually there's

787

00:27:57,778 --> 00:28:01,169

other career paths you've both chosen

788

00:27:59,398 --> 00:28:02,848

industry or at least you're working at

789

00:28:01,169 --> 00:28:04,169

northrop grumman can you talk a little

790

00:28:02,848 --> 00:28:06,028

bit about the opportunities that might

791

00:28:04,169 --> 00:28:07,320

be available to younger people and I'm

792

00:28:06,028 --> 00:28:10,378

gonna let Steve go first in an ID code

793

00:28:07,319 --> 00:28:11,788

are you okay I mean just maybe the ideas

794

00:28:10,378 --> 00:28:14,038

i think to let people know that is it

795

00:28:11,788 --> 00:28:17,098

not always about academia no absolutely

796

00:28:14,038 --> 00:28:19,499

not and our our team the team that said

797

00:28:17,098 --> 00:28:23,189

that works for wrong I believe we've got

798

00:28:19,499 --> 00:28:26,788

what four for astronomy PhDs on the team



799  
00:28:23,190 --> 00:28:28,879  
and Alberto's one right you got an abuse

800  
00:28:26,788 --> 00:28:31,849  
running they all you got on their team

801  
00:28:28,878 --> 00:28:33,859  
that was revoked right

802  
00:28:31,849 --> 00:28:36,048  
yeah so I mean that doesn't mean you're

803  
00:28:33,859 --> 00:28:38,659  
necessarily doing astronomy you're doing

804  
00:28:36,048 --> 00:28:40,668  
engineering or interface to to a

805  
00:28:38,660 --> 00:28:42,320  
customer like James Webb obviously the

806  
00:28:40,669 --> 00:28:44,840  
for James Webb there are hundreds of

807  
00:28:42,319 --> 00:28:46,639  
scientists who are the customers for the

808  
00:28:44,839 --> 00:28:48,859  
James Webb Space Telescope so and

809  
00:28:46,640 --> 00:28:50,780  
something that that astronomers working

810  
00:28:48,859 --> 00:28:52,788  
at Northrop Grumman have done is is be

811  
00:28:50,779 --> 00:28:55,160  
the interface to those people speak the

812  
00:28:52,788 --> 00:28:56,450  
science language and learn a little bit

813  
00:28:55,160 --> 00:28:59,120  
of engineering and speak to the

814  
00:28:56,450 --> 00:29:01,548  
engineers to and be that bridge so that

815  
00:28:59,119 --> 00:29:04,369  
that us as engineers can understand

816  
00:29:01,548 --> 00:29:06,429  
properly what we're trying to do so how

817  
00:29:04,369 --> 00:29:10,069  
would it compare do you think Ron with

818  
00:29:06,429 --> 00:29:12,288  
with academia versus working in a

819  
00:29:10,069 --> 00:29:13,970  
company well it turns out i can give you

820  
00:29:12,288 --> 00:29:16,519  
a unique perspective on that I ask you

821  
00:29:13,970 --> 00:29:19,130  
that ah the first third of my career I

822  
00:29:16,519 --> 00:29:22,190  
was an academic you know doing basic

823  
00:29:19,130 --> 00:29:23,720  
research publishing papers I then joined

824  
00:29:22,190 --> 00:29:25,279  
NASA and in the middle third of my

825  
00:29:23,720 --> 00:29:26,120  
career I was a NASA civil servant

826  
00:29:25,279 --> 00:29:29,658  
working at the Goddard Space Flight

827

00:29:26,119 --> 00:29:31,279  
Center and then I got a call one day

828  
00:29:29,659 --> 00:29:33,230  
from someone saying you ever think of

829  
00:29:31,279 --> 00:29:34,788  
working in industry and so the last

830  
00:29:33,230 --> 00:29:36,919  
third of my career is now in industry

831  
00:29:34,788 --> 00:29:39,319  
and so I think one of the things that

832  
00:29:36,919 --> 00:29:43,730  
that I think star shades illustrates is

833  
00:29:39,319 --> 00:29:45,168  
the ability of comp i combined science

834  
00:29:43,730 --> 00:29:47,029  
and engineering team to sell the

835  
00:29:45,169 --> 00:29:50,330  
problems one of the things that we went

836  
00:29:47,029 --> 00:29:52,579  
from over 10 years we went from

837  
00:29:50,329 --> 00:29:55,308  
literally the laughable fringe the first

838  
00:29:52,579 --> 00:29:56,720  
time we presented this paper on star

839  
00:29:55,308 --> 00:29:58,730  
shades we were actually laughed at

840  
00:29:56,720 --> 00:30:00,288  
because this is a chuckle to now one of

841  
00:29:58,730 --> 00:30:01,849

the baseline architectures and the

842

00:30:00,288 --> 00:30:04,369

reason we were able to do that in such a

843

00:30:01,849 --> 00:30:06,349

short amount of time is we had a really

844

00:30:04,369 --> 00:30:08,658

nice integrated science and engineering

845

00:30:06,349 --> 00:30:10,279

team scientists contribute to scientists

846

00:30:08,659 --> 00:30:12,260

the engineers pretty contribute the

847

00:30:10,279 --> 00:30:14,269

engineering and that combination of

848

00:30:12,259 --> 00:30:15,980

those two disciplines really allowed us

849

00:30:14,269 --> 00:30:18,139

to solve problems far faster than

850

00:30:15,980 --> 00:30:20,870

anybody ever thought we would solve so

851

00:30:18,140 --> 00:30:23,240

that's really the key I think to success

852

00:30:20,869 --> 00:30:26,418

four star shades is the ability of an

853

00:30:23,240 --> 00:30:28,609

industry government and academia team

854

00:30:26,419 --> 00:30:30,080

working together arm and arm to go

855

00:30:28,609 --> 00:30:32,149

forward and that's really been

856  
00:30:30,079 --> 00:30:34,009  
beneficial on really got us through a

857  
00:30:32,150 --> 00:30:35,450  
lot of problems very quickly okay so

858  
00:30:34,009 --> 00:30:36,710  
Alberto you're in that Club to how about

859  
00:30:35,450 --> 00:30:39,590  
you give us comments on that I

860  
00:30:36,710 --> 00:30:41,150  
completely agree with but what both well

861  
00:30:39,589 --> 00:30:43,399  
these guys actually said because it's

862  
00:30:41,150 --> 00:30:44,269  
it's absolutely true so I just came from

863  
00:30:43,400 --> 00:30:46,548  
a panel

864  
00:30:44,269 --> 00:30:48,229  
call Korea's one on one when I gave my

865  
00:30:46,548 --> 00:30:49,908  
perspective about exactly about this way

866  
00:30:48,229 --> 00:30:52,879  
and so exactly along the lines of what

867  
00:30:49,909 --> 00:30:54,889  
well Ion and Ron and Steve actually said

868  
00:30:52,878 --> 00:30:57,428  
but one other thing i want to add is

869  
00:30:54,888 --> 00:30:59,928  
also that sometimes that they need for

870  
00:30:57,429 --> 00:31:01,429  
talking to engineers in the language

871  
00:30:59,929 --> 00:31:02,749  
they can understand it translate those

872  
00:31:01,429 --> 00:31:04,459  
requirements are from science for

873  
00:31:02,749 --> 00:31:05,838  
example into engineer requirements

874  
00:31:04,459 --> 00:31:07,459  
something that really is some time is

875  
00:31:05,838 --> 00:31:08,928  
missing so if you don't have that your

876  
00:31:07,459 --> 00:31:10,879  
project would not really go very well

877  
00:31:08,929 --> 00:31:13,459  
and so people like like Steve you know

878  
00:31:10,878 --> 00:31:15,228  
people like like like Ron are those

879  
00:31:13,459 --> 00:31:16,879  
they're mediators if you will a

880  
00:31:15,229 --> 00:31:18,109  
translator right they translate some

881  
00:31:16,878 --> 00:31:19,428  
requirements are come from us to visit

882  
00:31:18,108 --> 00:31:21,078  
what is the science that you want to

883  
00:31:19,429 --> 00:31:22,759  
implement so this is how you actually

884

00:31:21,078 --> 00:31:24,648  
build this and then they argue for a

885  
00:31:22,759 --> 00:31:25,639  
while and then it compromised and

886  
00:31:24,648 --> 00:31:28,458  
actually that's part of the team and

887  
00:31:25,638 --> 00:31:30,888  
successful team actually is a team that

888  
00:31:28,459 --> 00:31:31,999  
can draw from the sensor comments

889  
00:31:30,888 --> 00:31:33,498  
understand how you implement those

890  
00:31:31,999 --> 00:31:35,389  
requirements while pushing the

891  
00:31:33,499 --> 00:31:37,098  
engineering at the limit you know we do

892  
00:31:35,388 --> 00:31:38,718  
this every level jeddah-based e but it's

893  
00:31:37,098 --> 00:31:40,398  
a it's a very successful thing that we

894  
00:31:38,719 --> 00:31:43,159  
do and i think actually there's a is a

895  
00:31:40,398 --> 00:31:45,528  
great partnership that has to be had you

896  
00:31:43,159 --> 00:31:47,389  
know in in between industry academia and

897  
00:31:45,528 --> 00:31:49,098  
an engineering just because of this yeah

898  
00:31:47,388 --> 00:31:50,269

i just want to make that point because i

899

00:31:49,098 --> 00:31:52,038

know a lot of people think there's

900

00:31:50,269 --> 00:31:53,569

really only one path in science an

901

00:31:52,038 --> 00:31:55,038

astronomy they did you know that you go

902

00:31:53,569 --> 00:31:56,388

to graduate are your undergrad degree

903

00:31:55,038 --> 00:31:58,128

you get a graduate degree you get your

904

00:31:56,388 --> 00:31:59,508

post off you do the postdoc work and

905

00:31:58,128 --> 00:32:01,009

then you hopefully get a job as a

906

00:31:59,509 --> 00:32:03,798

tenured professor at some point but that

907

00:32:01,009 --> 00:32:05,179

is a highly competitive and a difficult

908

00:32:03,798 --> 00:32:06,769

way to go and it's not also the only way

909

00:32:05,179 --> 00:32:08,869

to go yeah and that's the point i really

910

00:32:06,769 --> 00:32:11,899

wanted to make the other aspect of that

911

00:32:08,868 --> 00:32:13,428

is um in academia when I was there there

912

00:32:11,898 --> 00:32:15,708

were some very compelling problems I'm



913  
00:32:13,429 --> 00:32:18,409  
really stimulating mentally stimulating

914  
00:32:15,709 --> 00:32:20,538  
intellectually you know worthwhile

915  
00:32:18,409 --> 00:32:21,979  
things that i did when i joined the

916  
00:32:20,538 --> 00:32:23,898  
government there are also things there

917  
00:32:21,979 --> 00:32:25,578  
and now in industry there's also equally

918  
00:32:23,898 --> 00:32:27,348  
no equal number of compelling things to

919  
00:32:25,578 --> 00:32:29,450  
do so so the real thing is you want to

920  
00:32:27,348 --> 00:32:31,479  
work on something where you have the

921  
00:32:29,450 --> 00:32:34,069  
ability to contribute where you have

922  
00:32:31,479 --> 00:32:36,348  
some contribution to something important

923  
00:32:34,069 --> 00:32:37,848  
and at least from my career i was able

924  
00:32:36,348 --> 00:32:39,739  
to do that as an academic i was able to

925  
00:32:37,848 --> 00:32:42,678  
do that as a civil servant and able to

926  
00:32:39,739 --> 00:32:43,848  
do that as a member of industry i just

927  
00:32:42,679 --> 00:32:45,379  
want to add one thing which is the

928  
00:32:43,848 --> 00:32:46,759  
reason why people are like they say

929  
00:32:45,378 --> 00:32:48,588  
astronomers for example a companies like

930  
00:32:46,759 --> 00:32:50,569  
a northrop grumman is because their

931  
00:32:48,588 --> 00:32:52,158  
skills are in problem solving they've

932  
00:32:50,569 --> 00:32:53,450  
been given a problem that no one else

933  
00:32:52,159 --> 00:32:55,159  
has seen before and they can actually

934  
00:32:53,450 --> 00:32:56,509  
walk it through right it's the same

935  
00:32:55,159 --> 00:32:57,650  
thing for engineers that right engineers

936  
00:32:56,509 --> 00:32:59,360  
i can solve you know

937  
00:32:57,650 --> 00:33:01,160  
it's all very very very hard problems

938  
00:32:59,359 --> 00:33:03,199  
and they're hard not because of the

939  
00:33:01,160 --> 00:33:05,269  
specialty there you know which the

940  
00:33:03,200 --> 00:33:06,410  
thesis with you know the idea that my

941

00:33:05,269 --> 00:33:08,150  
thesis in you know a numerical

942  
00:33:06,410 --> 00:33:10,250  
simulations you know what maybe it's not

943  
00:33:08,150 --> 00:33:12,470  
gonna be very useful but we have a way

944  
00:33:10,250 --> 00:33:14,690  
to approach problems that is not common

945  
00:33:12,470 --> 00:33:16,250  
and that's actually what's worth you

946  
00:33:14,690 --> 00:33:17,600  
know money and and and works to a

947  
00:33:16,250 --> 00:33:19,190  
company what's also why a lot of

948  
00:33:17,599 --> 00:33:21,230  
physicists go into finance to I mean

949  
00:33:19,190 --> 00:33:22,460  
they solve problems using they're using

950  
00:33:21,230 --> 00:33:27,620  
their skill set you Sean do you have

951  
00:33:22,460 --> 00:33:31,970  
another one to n Ram samurai two

952  
00:33:27,619 --> 00:33:37,099  
questions on YouTube how long can the

953  
00:33:31,970 --> 00:33:38,360  
starshade be kept in space and can you

954  
00:33:37,099 --> 00:33:39,679  
get all good we didn't we didn't cover

955  
00:33:38,359 --> 00:33:40,939

that a good one and can you give us a

956

00:33:39,680 --> 00:33:42,799

good a simple explanation of how you

957

00:33:40,940 --> 00:33:46,730

unfurl atlas what was the first one

958

00:33:42,799 --> 00:33:49,909

again i forgot how long his face is

959

00:33:46,730 --> 00:33:51,710

saying space he wants that so how long

960

00:33:49,910 --> 00:33:54,470

it stays in space p only driven by the

961

00:33:51,710 --> 00:33:55,970

the fuel the thrusters the size of the

962

00:33:54,470 --> 00:33:58,279

tank that you're able to take with you

963

00:33:55,970 --> 00:34:00,589

we would expect to make a mission that

964

00:33:58,279 --> 00:34:02,990

was five years or maybe a little longer

965

00:34:00,589 --> 00:34:04,459

than that that would be designed mission

966

00:34:02,990 --> 00:34:06,650

right we talked about a little bit with

967

00:34:04,460 --> 00:34:10,849

with the gas for their for the electrons

968

00:34:06,650 --> 00:34:11,840

right unfurling it okay so and there

969

00:34:10,849 --> 00:34:14,119

were a couple of ways we can do this

970  
00:34:11,840 --> 00:34:15,890  
obviously i'm feeling is a critical

971  
00:34:14,119 --> 00:34:18,139  
problem you're talking about making

972  
00:34:15,889 --> 00:34:20,658  
something in space that is 50 60 70

973  
00:34:18,139 --> 00:34:22,699  
meters across and rocking for rocket

974  
00:34:20,659 --> 00:34:25,010  
ferrin's at the moment though are five

975  
00:34:22,699 --> 00:34:27,678  
meters across or if you use the space

976  
00:34:25,010 --> 00:34:29,659  
you know the SLS rocket there may be a

977  
00:34:27,679 --> 00:34:31,789  
little larger so you need to win full

978  
00:34:29,659 --> 00:34:33,789  
the the starshade when you get on orbit

979  
00:34:31,789 --> 00:34:36,648  
a couple of ways of doing that we got

980  
00:34:33,789 --> 00:34:40,029  
some technology that was used for and

981  
00:34:36,648 --> 00:34:43,460  
still is used for unfolding

982  
00:34:40,030 --> 00:34:45,109  
antennas mesh antennas in space and that

983  
00:34:43,460 --> 00:34:50,480  
kind of its called a perimeter truss

984  
00:34:45,108 --> 00:34:53,509  
design and it expands with a ring of of

985  
00:34:50,480 --> 00:34:55,668  
struts around the edge so all the struts

986  
00:34:53,510 --> 00:34:56,899  
are wrapped up in 2 into 1 cor and as

987  
00:34:55,668 --> 00:34:59,629  
you drive them out of these struts

988  
00:34:56,898 --> 00:35:02,029  
expand out into a ring that forms the

989  
00:34:59,630 --> 00:35:04,190  
center of a star shade deployable design

990  
00:35:02,030 --> 00:35:06,859  
then then what we have is the pedals

991  
00:35:04,190 --> 00:35:09,050  
attach the edge of that perimeter trust

992  
00:35:06,858 --> 00:35:11,630  
that our star vertical and as they as

993  
00:35:09,050 --> 00:35:14,450  
the trust pushes out they rotate to to

994  
00:35:11,630 --> 00:35:17,119  
be flat so that's that's probably the

995  
00:35:14,449 --> 00:35:19,759  
easiest way to describe a deployment at

996  
00:35:17,119 --> 00:35:21,769  
the moment and presumably that would

997  
00:35:19,760 --> 00:35:24,320  
take a long time alright if you look on

998

00:35:21,769 --> 00:35:26,989  
youtube and look for star shades and

999  
00:35:24,320 --> 00:35:30,109  
deployment you will see a about a third

1000  
00:35:26,989 --> 00:35:33,799  
scale demonstration that was done last

1001  
00:35:30,108 --> 00:35:36,199  
year I think and so you should be able

1002  
00:35:33,800 --> 00:35:38,450  
to watch it it's on a number of YouTube

1003  
00:35:36,199 --> 00:35:40,219  
sites so just look for starshade

1004  
00:35:38,449 --> 00:35:42,529  
deployment on YouTube and you'll find a

1005  
00:35:40,219 --> 00:35:43,879  
demo you'll find a video I'm glad you

1006  
00:35:42,530 --> 00:35:45,170  
mentioned that thing and the next thing

1007  
00:35:43,880 --> 00:35:47,088  
you can actually see there's actually a

1008  
00:35:45,170 --> 00:35:48,650  
video of a deployment of JPL put

1009  
00:35:47,088 --> 00:35:50,269  
together i think the full you know

1010  
00:35:48,650 --> 00:35:51,470  
address rendition but it's actually nice

1011  
00:35:50,269 --> 00:35:57,380  
it gives you an idea of a Hollywood

1012  
00:35:51,469 --> 00:35:59,389

unfurl you know a artist simulation and

1013

00:35:57,380 --> 00:36:02,420

some real demonstrations this gets back

1014

00:35:59,389 --> 00:36:04,670

to your earlier comment about moving

1015

00:36:02,420 --> 00:36:06,440

forward this now has gotten to the point

1016

00:36:04,670 --> 00:36:07,970

where we have a little bit of hardware

1017

00:36:06,440 --> 00:36:09,769

being demonstrated and we're moving

1018

00:36:07,969 --> 00:36:11,929

forward and parallel with the desert us

1019

00:36:09,769 --> 00:36:13,909

awesome so yeah well unfortunately folks

1020

00:36:11,929 --> 00:36:14,838

this is not a hangout on air like we're

1021

00:36:13,909 --> 00:36:16,309

used to doing we don't have the

1022

00:36:14,838 --> 00:36:18,078

technology to share our screens here

1023

00:36:16,309 --> 00:36:20,529

we're just streaming live from one one

1024

00:36:18,079 --> 00:36:23,119

spot so definitely go to youtube and

1025

00:36:20,530 --> 00:36:24,349

look up starshade and all kinds of

1026

00:36:23,119 --> 00:36:25,670

animations will come up and you'll be



1027  
00:36:24,349 --> 00:36:27,410  
able to see this deployment I'm glad we

1028  
00:36:25,670 --> 00:36:32,409  
brought that up you have anything else I

1029  
00:36:27,409 --> 00:36:32,409  
Sean ok another one Kristy

1030  
00:36:35,989 --> 00:36:43,798  
you know what I think he should just

1031  
00:36:38,039 --> 00:36:45,719  
read it we've heard that NASA is the key

1032  
00:36:43,798 --> 00:36:47,429  
to the starshade moving forward what is

1033  
00:36:45,719 --> 00:36:54,298  
Northrop Grumman role in development of

1034  
00:36:47,429 --> 00:36:56,669  
the starshade um we are an aerospace

1035  
00:36:54,298 --> 00:37:00,358  
industry so we have built demonstrations

1036  
00:36:56,670 --> 00:37:03,930  
of some of the hardware we are looking

1037  
00:37:00,358 --> 00:37:06,259  
at the engineering aspects of this to go

1038  
00:37:03,929 --> 00:37:10,889  
forward as I said this is an integrated

1039  
00:37:06,259 --> 00:37:12,688  
Northrop NASA academic team so it's kind

1040  
00:37:10,889 --> 00:37:14,489  
of hard to draw a dividing line as to

1041  
00:37:12,688 --> 00:37:16,558  
what NASA is doing and what we're doing

1042  
00:37:14,489 --> 00:37:19,139  
and what academia are doing we're all in

1043  
00:37:16,559 --> 00:37:22,019  
this as an integrated team and everybody

1044  
00:37:19,139 --> 00:37:24,629  
has contributed some aspect of both the

1045  
00:37:22,018 --> 00:37:26,129  
optimal performance the deployment and

1046  
00:37:24,630 --> 00:37:28,140  
this sort of stuff so it's not

1047  
00:37:26,130 --> 00:37:32,519  
partitioned in that similar way we are a

1048  
00:37:28,139 --> 00:37:33,838  
single team so elberta you in it I just

1049  
00:37:32,518 --> 00:37:35,818  
want to add you know part of a core

1050  
00:37:33,838 --> 00:37:36,778  
mission is to enhance discovery right so

1051  
00:37:35,818 --> 00:37:38,308  
that's how we do it we do it with

1052  
00:37:36,778 --> 00:37:40,349  
jeddah-based a for example we do it in

1053  
00:37:38,309 --> 00:37:42,199  
many areas of science and starshade it

1054  
00:37:40,349 --> 00:37:44,369  
just will be another example how we

1055

00:37:42,199 --> 00:37:46,409  
fulfill that promise you know they'll

1056  
00:37:44,369 --> 00:37:48,749  
find an exoplanet for example in the

1057  
00:37:46,409 --> 00:37:53,938  
future all right is there anything else

1058  
00:37:48,748 --> 00:37:56,129  
you saw Mary becker on youtube wants to

1059  
00:37:53,938 --> 00:37:59,578  
know starshade will work four stars out

1060  
00:37:56,130 --> 00:38:03,989  
to what distance from us to what

1061  
00:37:59,579 --> 00:38:07,289  
distance from us Oh somewhat of a fuzzy

1062  
00:38:03,989 --> 00:38:08,699  
question is on the damage yeah I mean

1063  
00:38:07,289 --> 00:38:11,640  
you know it basically is how big which

1064  
00:38:08,699 --> 00:38:14,278  
all soaped you want to go for um when

1065  
00:38:11,639 --> 00:38:15,808  
you get much beyond about a about a

1066  
00:38:14,278 --> 00:38:18,659  
hundred parsecs it gets really really

1067  
00:38:15,809 --> 00:38:21,059  
tough the habitable zone just becomes

1068  
00:38:18,659 --> 00:38:22,629  
really close for all stars and so

1069  
00:38:21,059 --> 00:38:26,259

something within

1070

00:38:22,630 --> 00:38:27,460

um you know 20 to 50 light-years is

1071

00:38:26,259 --> 00:38:29,730

probably going to be fairly straight

1072

00:38:27,460 --> 00:38:33,809

forward over the next decade or two

1073

00:38:29,730 --> 00:38:36,039

beyond that it's a lot sent to depend on

1074

00:38:33,809 --> 00:38:37,990

how big of a telescope you want to build

1075

00:38:36,039 --> 00:38:40,000

and how big of a starter you want to put

1076

00:38:37,989 --> 00:38:42,818

with it okay awesome but will sample

1077

00:38:40,000 --> 00:38:45,759

enough space to have a high probability

1078

00:38:42,818 --> 00:38:48,429

of saying does life exist outside

1079

00:38:45,759 --> 00:38:51,548

sources there you go so that's a good

1080

00:38:48,429 --> 00:38:53,288

question um so I guess way is that

1081

00:38:51,548 --> 00:38:54,849

everything there each other okay I guess

1082

00:38:53,289 --> 00:38:56,079

we'll go ahead and let you guys have one

1083

00:38:54,849 --> 00:38:58,150

when I address something that we haven't

1084  
00:38:56,079 --> 00:38:59,318  
talked about I guess we'll sort of will

1085  
00:38:58,150 --> 00:39:00,639  
sort of close it there yeah I've worked

1086  
00:38:59,318 --> 00:39:02,079  
out you have anything you wanna add ok

1087  
00:39:00,639 --> 00:39:04,118  
all right folks well that's it for our

1088  
00:39:02,079 --> 00:39:07,630  
first hangout from the double-a s the

1089  
00:39:04,119 --> 00:39:10,900  
225 I'll be joining me come back what

1090  
00:39:07,630 --> 00:39:13,088  
time is it in about an hour about about

1091  
00:39:10,900 --> 00:39:15,130  
about another little over an hour I'll

1092  
00:39:13,088 --> 00:39:19,088  
be setting up at three-thirty pacific

1093  
00:39:15,130 --> 00:39:20,940  
standard time to talk about the 25th

1094  
00:39:19,088 --> 00:39:23,349  
anniversary Hubble 25th anniversary

1095  
00:39:20,940 --> 00:39:25,119  
image release it's coming out in about

1096  
00:39:23,349 --> 00:39:26,230  
five minutes so we'll have carol

1097  
00:39:25,119 --> 00:39:28,059  
christian zolta bay and a few other

1098  
00:39:26,230 --> 00:39:31,269  
people at the Institute to talk about

1099  
00:39:28,059 --> 00:39:33,278  
that image we hope you'll you will also

1100  
00:39:31,268 --> 00:39:35,078  
leave us comments and questions and on

1101  
00:39:33,278 --> 00:39:37,239  
behalf of the folks here at northrop

1102  
00:39:35,079 --> 00:39:40,298  
grumman Steve and Enron and Alberto

1103  
00:39:37,239 --> 00:39:42,778  
thank you all for watching and as always

1104  
00:39:40,298 --> 00:39:42,778  
keep