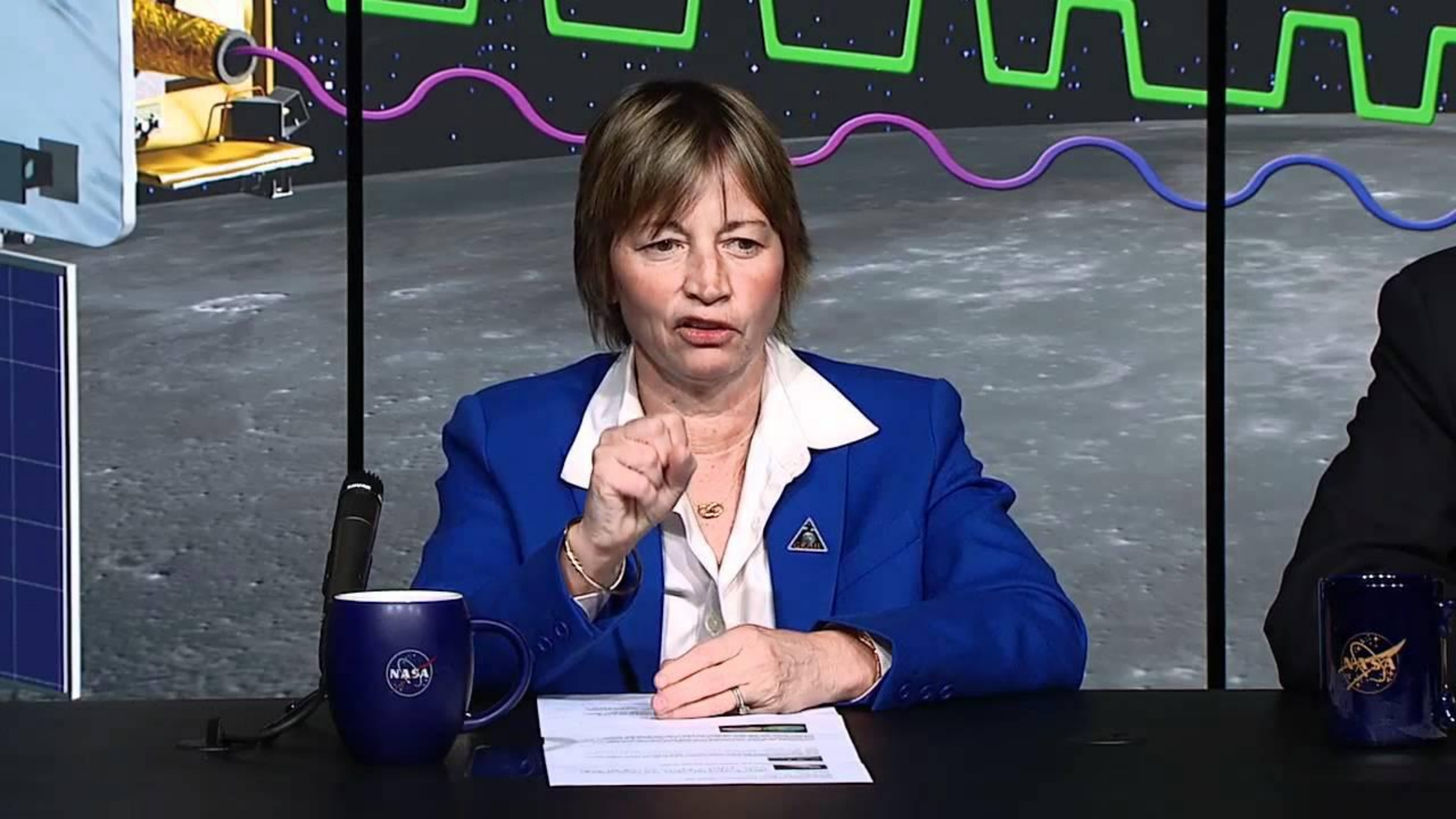
NASA
NASA

1
00:00:09,500 --> 00:00:07,880
good good morning my name is Duane Brown

2
00:00:12,620 --> 00:00:09,510
with the office of communications and

3
00:00:14,780 --> 00:00:12,630
welcome to NASA headquarters today you

4
00:00:17,300 --> 00:00:14,790
will hear about the upcoming launch of

5
00:00:20,170 --> 00:00:17,310
NASA's Gravity Recovery and interior

6
00:00:22,250 --> 00:00:20,180
laboratory otherwise known as Grail

7
00:00:24,170 --> 00:00:22,260
right now all systems are go for

8
00:00:25,790 --> 00:00:24,180
September launch and today you will hear

9
00:00:29,630 --> 00:00:25,800
the incredible details and science

10
00:00:33,110 --> 00:00:29,640
expected the visuals and information are

11
00:00:36,049 --> 00:00:33,120
available on the internet at wws a govt

12
00:00:37,819 --> 00:00:36,059
/ grill will have brief presentations

13
00:00:39,080 --> 00:00:37,829

from my speakers then open it up for

14
00:00:41,569 --> 00:00:39,090
questions starting here NASA

15
00:00:43,940 --> 00:00:41,579
headquarters on NASA centers in the

16
00:00:45,400 --> 00:00:43,950
phone lines before we get started let me

17
00:00:50,840 --> 00:00:45,410
introduce you to today's participants

18
00:00:52,510 --> 00:00:50,850
first up Jim Green director Planetary

19
00:00:58,040 --> 00:00:52,520
Science Division NASA headquarters

20
00:01:00,740 --> 00:00:58,050
Washington Maria Zuber grail principal

21
00:01:06,859 --> 00:01:00,750
investigator Massachusetts Institute of

22
00:01:09,100 --> 00:01:06,869
Technology Cambridge David layman grail

23
00:01:12,340 --> 00:01:09,110
project manager NASA's Jet Propulsion

24
00:01:16,160 --> 00:01:12,350
Laboratory in Pasadena California and

25
00:01:18,710 --> 00:01:16,170
Lisa Hubbard teacher and residents Sally

26
00:01:21,800 --> 00:01:18,720
Ride science San Diego and with that

27
00:01:24,289 --> 00:01:21,810
I'll turn it over to Jim thank you very

28
00:01:26,660 --> 00:01:24,299
much doing with this press conference

29
00:01:28,940 --> 00:01:26,670
we're beginning the launch campaign of

30
00:01:32,990 --> 00:01:28,950
the Grail mission the Grail mission is a

31
00:01:37,609 --> 00:01:33,000
discovery mission for which we initiated

32
00:01:40,310 --> 00:01:37,619
the discovery program in 1992 and since

33
00:01:44,090 --> 00:01:40,320
that time we've had ten launches of

34
00:01:46,969 --> 00:01:44,100
discovery spacecraft of various reaches

35
00:01:50,270 --> 00:01:46,979
of the solar system the program has been

36
00:01:53,420 --> 00:01:50,280
designed to have frequent access to

37
00:01:56,030 --> 00:01:53,430
space for planetary scientists it's run

38
00:01:58,789 --> 00:01:56,040

in a principal investigator mode and a

39
00:02:03,679 --> 00:01:58,799
science team supporting the mission and

40
00:02:05,569 --> 00:02:03,689
data analysis now to date the program is

41
00:02:08,180 --> 00:02:05,579
done an enormous number of discoveries

42
00:02:11,059 --> 00:02:08,190
and it and that is continuing on even

43
00:02:13,550 --> 00:02:11,069
today the last year alone we've had two

44
00:02:17,510 --> 00:02:13,560
of our discover

45
00:02:19,850 --> 00:02:17,520
three missions fly by comets we've had

46
00:02:22,850 --> 00:02:19,860
the messenger spacecraft get in orbit

47
00:02:25,040 --> 00:02:22,860
around our first planet Mercury we've

48
00:02:27,380 --> 00:02:25,050
had the Dawn spacecraft get in orbit

49
00:02:29,870 --> 00:02:27,390
around an enormous asteroid called Vesta

50
00:02:32,479 --> 00:02:29,880
and in fact most recently we have

51
00:02:35,300 --> 00:02:32,489
selected three discovery missions for

52
00:02:39,380 --> 00:02:35,310
further study and about this time next

53
00:02:41,449 --> 00:02:39,390
year will select one for flight the

54
00:02:44,620 --> 00:02:41,459
program we're talking about today the

55
00:02:48,440 --> 00:02:44,630
Grail mission is part of our discovery

56
00:02:51,110 --> 00:02:48,450
program will be launched on September 8

57
00:02:53,960 --> 00:02:51,120
this when the window begins and I'm

58
00:02:57,620 --> 00:02:53,970
delighted that our first principal

59
00:03:01,100 --> 00:02:57,630
investigator woman Maria Zuber is at the

60
00:03:04,789 --> 00:03:01,110
helm on that mission one of the stories

61
00:03:09,050 --> 00:03:04,799
I want to tell it at this point is when

62
00:03:10,360 --> 00:03:09,060
Grail was selected in December 2007 and

63
00:03:14,210 --> 00:03:10,370

we were preparing for the announcement

64
00:03:17,030 --> 00:03:14,220
both Marie and I were at the scientific

65
00:03:19,670 --> 00:03:17,040
meeting in California and I had the

66
00:03:21,259 --> 00:03:19,680
opportunity and the pleasure to go up to

67
00:03:23,479 --> 00:03:21,269
Maria and let her know that her mission

68
00:03:26,569 --> 00:03:23,489
was selected and of course she was

69
00:03:28,940 --> 00:03:26,579
incredibly excited about it and we both

70
00:03:31,490 --> 00:03:28,950
enjoyed the moment but all of a sudden

71
00:03:34,160 --> 00:03:31,500
she got very serious and she looked at

72
00:03:36,920 --> 00:03:34,170
me and she said I'm going to promise you

73
00:03:40,400 --> 00:03:36,930
right now that this mission will come on

74
00:03:42,680 --> 00:03:40,410
budget and on schedule three and a half

75
00:03:45,170 --> 00:03:42,690
years later we're now ready for the

76
00:03:47,720 --> 00:03:45,180
launch of Grail and I'm here to tell you

77
00:03:51,080 --> 00:03:47,730
that is exactly what Maria has done and

78
00:03:53,800 --> 00:03:51,090
so with that let me introduce Maria

79
00:03:57,710 --> 00:03:53,810
Zuber principal investigator on Grail

80
00:03:59,720 --> 00:03:57,720
great thank you very much Jim we could

81
00:04:02,030 --> 00:03:59,730
start with the first graphic please I am

82
00:04:05,150 --> 00:04:02,040
so delighted to be here today to tell

83
00:04:07,809 --> 00:04:05,160
you about the Grail mission the first

84
00:04:09,710 --> 00:04:07,819
image shows just an absolutely beautiful

85
00:04:13,400 --> 00:04:09,720
image that was taken by the galileo

86
00:04:16,009 --> 00:04:13,410
spacecraft while it was on route to the

87
00:04:19,039 --> 00:04:16,019
planet Jupiter and if you think about

88
00:04:21,710 --> 00:04:19,049

looking at the moon nearly every human

89
00:04:24,770 --> 00:04:21,720
who's ever lived has looked up at the

90
00:04:27,110 --> 00:04:24,780
moon and admired it the moon has played

91
00:04:29,689 --> 00:04:27,120
a really central role

92
00:04:32,140 --> 00:04:29,699
in the human imagination and the human

93
00:04:36,020 --> 00:04:32,150
psyche could have the next slide please

94
00:04:38,960 --> 00:04:36,030
so much so that when humans reached out

95
00:04:43,670 --> 00:04:38,970
and landed on the moon it really became

96
00:04:47,780 --> 00:04:43,680
a defining event for civilization since

97
00:04:50,750 --> 00:04:47,790
the dawn of the Space Age in 1959 there

98
00:04:55,010 --> 00:04:50,760
have been 109 missions that have

99
00:04:57,469 --> 00:04:55,020
targeted the moon 12 humans have walked

100
00:05:02,090 --> 00:04:57,479
on the surface of the Moon we've brought

101
00:05:04,700 --> 00:05:02,100
back 842 pounds of rocks and soil that

102
00:05:06,350 --> 00:05:04,710
are still being analyzed today I won't

103
00:05:10,150 --> 00:05:06,360
even call it a national treasure it's a

104
00:05:13,340 --> 00:05:10,160
world treasure those samples as we speak

105
00:05:16,129 --> 00:05:13,350
there are three spacecraft that are

106
00:05:20,650 --> 00:05:16,139
orbiting the moon and collecting science

107
00:05:23,779 --> 00:05:20,660
observations given all of this activity

108
00:05:27,800 --> 00:05:23,789
do we know everything that we'd like to

109
00:05:30,710 --> 00:05:27,810
know about the moon in short the answer

110
00:05:32,450 --> 00:05:30,720
is no so let's talk about some

111
00:05:35,240 --> 00:05:32,460
fundamental things that we know and

112
00:05:37,550 --> 00:05:35,250
don't know about the moon if I could

113
00:05:42,700 --> 00:05:37,560

have the next slide please so the moon

114
00:05:45,650 --> 00:05:42,710
is the nearest most accessible old

115
00:05:50,629 --> 00:05:45,660
planetary rocky terrestrial planetary

116
00:05:52,460 --> 00:05:50,639
body we believe that the moon formed by

117
00:05:54,170 --> 00:05:52,470
an impact of a mars-sized body into

118
00:05:56,689 --> 00:05:54,180
Earth and the moon accreted out of the

119
00:05:59,300 --> 00:05:56,699
material that was thrown off into a disk

120
00:06:01,150 --> 00:05:59,310
but that's a theory we continue to test

121
00:06:04,370 --> 00:06:01,160
that theory we don't know for sure

122
00:06:07,430 --> 00:06:04,380
surprises emerge even now about the

123
00:06:09,290 --> 00:06:07,440
accretion process of the moon trying to

124
00:06:13,159 --> 00:06:09,300
understand how the moon formed and how

125
00:06:14,510 --> 00:06:13,169
it evolved over its history is one of

126
00:06:16,460 --> 00:06:14,520
the things we're trying to address with

127
00:06:18,350 --> 00:06:16,470
the Grail mission but also to try to

128
00:06:20,570 --> 00:06:18,360
understand how the moon is an example of

129
00:06:22,850 --> 00:06:20,580
how to rest real planets in general have

130
00:06:25,070 --> 00:06:22,860
formed so if you look at this picture of

131
00:06:27,770 --> 00:06:25,080
the new moon another beautiful picture

132
00:06:30,740 --> 00:06:27,780
this is a wide-angle cam wide wide angle

133
00:06:32,629 --> 00:06:30,750
camera image of the lunar near side on

134
00:06:35,270 --> 00:06:32,639
the left that's the side of the moon

135
00:06:37,880 --> 00:06:35,280
that we see from Earth and the far side

136
00:06:40,410 --> 00:06:37,890
on the right these images were taken by

137
00:06:42,780 --> 00:06:40,420
the Lunar Reconnaissance Orbiter

138
00:06:45,630 --> 00:06:42,790

it's currently taking observations right

139
00:06:47,100 --> 00:06:45,640
now of the moon you see that the near

140
00:06:49,260 --> 00:06:47,110
side and the far side of the Moon are

141
00:06:51,390 --> 00:06:49,270
very different and you would think

142
00:06:52,650 --> 00:06:51,400
having sent many missions to the moon we

143
00:06:54,480 --> 00:06:52,660
would understand the difference between

144
00:06:58,800 --> 00:06:54,490
the near side and the far side but in

145
00:07:01,170 --> 00:06:58,810
fact we don't the near side shows a lot

146
00:07:04,560 --> 00:07:01,180
of dark areas that consist of lava flows

147
00:07:07,050 --> 00:07:04,570
that flooded large impact basins which

148
00:07:08,550 --> 00:07:07,060
are on the near side of the moon but

149
00:07:10,500 --> 00:07:08,560
this didn't occur on the far side of the

150
00:07:13,110 --> 00:07:10,510
Moon for a long time we thought well

151
00:07:14,360 --> 00:07:13,120
there was all this magma that was deep

152
00:07:16,830 --> 00:07:14,370
beneath the surface of the Moon and

153
00:07:18,840 --> 00:07:16,840
because elevations on the near side of

154
00:07:21,360 --> 00:07:18,850
the moon were lower it rose up and we

155
00:07:24,480 --> 00:07:21,370
just see it or as that isn't the case on

156
00:07:28,170 --> 00:07:24,490
the far side but if we go to the next

157
00:07:30,750 --> 00:07:28,180
chart this is an elevation map taken

158
00:07:32,130 --> 00:07:30,760
from the laser altimeter on the Lunar

159
00:07:34,410 --> 00:07:32,140
Reconnaissance Orbiter that is still

160
00:07:37,890 --> 00:07:34,420
collecting images around the moon right

161
00:07:42,000 --> 00:07:37,900
now this elevation map is color coded

162
00:07:44,940 --> 00:07:42,010
here whites and reds are high and blues

163
00:07:47,310 --> 00:07:44,950

and purples are low and and you see you

164
00:07:49,230 --> 00:07:47,320
get quite a different story that begs

165
00:07:51,870 --> 00:07:49,240
the question of well maybe this idea of

166
00:07:53,070 --> 00:07:51,880
the magma being many places on both the

167
00:07:55,980 --> 00:07:53,080
near side and the far side of the Moon

168
00:07:57,960 --> 00:07:55,990
is incorrect because on the far side of

169
00:08:00,390 --> 00:07:57,970
the Moon on the right-hand side there

170
00:08:03,360 --> 00:08:00,400
you see in the deep purple down towards

171
00:08:06,330 --> 00:08:03,370
the bottom the largest impact basin on

172
00:08:09,510 --> 00:08:06,340
the moon the impactor that formed this

173
00:08:12,020 --> 00:08:09,520
basin excavated deeper into the moon

174
00:08:17,550 --> 00:08:12,030
than any of the basins on the near side

175
00:08:18,720 --> 00:08:17,560
but no magma flooded in it so clearly we

176
00:08:21,540 --> 00:08:18,730
don't understand what was happening

177
00:08:24,540 --> 00:08:21,550
inside the moon on just the basis of the

178
00:08:27,930 --> 00:08:24,550
near side and the far side let's focus

179
00:08:29,610 --> 00:08:27,940
now on the white area on the far side of

180
00:08:33,090 --> 00:08:29,620
the Moon on the right those Highland

181
00:08:35,520 --> 00:08:33,100
regions okay just a few weeks ago in the

182
00:08:38,340 --> 00:08:35,530
journal Nature an article was published

183
00:08:41,760 --> 00:08:38,350
that suggested that those far side

184
00:08:44,760 --> 00:08:41,770
Highlands actually occurred due to a

185
00:08:46,920 --> 00:08:44,770
second moon that might have formed after

186
00:08:49,560 --> 00:08:46,930
the moon-forming collision that we think

187
00:08:52,400 --> 00:08:49,570
happened this moon would have been in

188
00:08:54,860 --> 00:08:52,410

the same orbit as our moon

189
00:08:56,660 --> 00:08:54,870
and ever so slowly it would have come

190
00:08:58,490 --> 00:08:56,670
towards and coalesced with the moon and

191
00:09:01,699 --> 00:08:58,500
essentially bumped it and collided and

192
00:09:03,769 --> 00:09:01,709
it added more more material to the moon

193
00:09:05,809 --> 00:09:03,779
than it excavated and so it actually

194
00:09:10,309 --> 00:09:05,819
produced a mountainous region rather

195
00:09:13,160 --> 00:09:10,319
than a whole the hypothesis that this

196
00:09:17,150 --> 00:09:13,170
occurred it's actually when I saw the

197
00:09:19,910 --> 00:09:17,160
paper I thought it was outlandish but as

198
00:09:21,379 --> 00:09:19,920
I read the paper I realized that the

199
00:09:24,110 --> 00:09:21,389
simulations that were done were very

200
00:09:26,689 --> 00:09:24,120
very well thought out and and they made

201
00:09:29,569 --> 00:09:26,699
specific testable predictions that could

202
00:09:32,240 --> 00:09:29,579
be addressed by studying data that will

203
00:09:35,809 --> 00:09:32,250
be obtained with Grail the next hand

204
00:09:38,329 --> 00:09:35,819
slide the next slide please okay so

205
00:09:40,850 --> 00:09:38,339
Grail is a mission that will study the

206
00:09:43,100 --> 00:09:40,860
inside of the moon from crust decor and

207
00:09:45,639 --> 00:09:43,110
it will use the information that we gain

208
00:09:47,990 --> 00:09:45,649
on the inside of the moon along with

209
00:09:51,470 --> 00:09:48,000
information that is gained and being

210
00:09:52,970 --> 00:09:51,480
gained from other spacecraft that have

211
00:09:56,329 --> 00:09:52,980
looked at the surface of the Moon and

212
00:09:58,460 --> 00:09:56,339
from the continued analysis of the lunar

213
00:10:00,740 --> 00:09:58,470

samples and we're going to show a video

214
00:10:04,340 --> 00:10:00,750
next that's going to show you how we

215
00:10:07,370 --> 00:10:04,350
make these these measurements so here

216
00:10:10,340 --> 00:10:07,380
the two rail spacecraft are in orbit

217
00:10:12,530 --> 00:10:10,350
around the moon they're lined up with

218
00:10:16,360 --> 00:10:12,540
each other the two spacecraft are about

219
00:10:19,220 --> 00:10:16,370
55 kilometers above the lunar surface

220
00:10:22,160 --> 00:10:19,230
the distance between them varies on a

221
00:10:24,800 --> 00:10:22,170
large scale between 60 and about 225

222
00:10:26,600 --> 00:10:24,810
kilometers so we can sample at different

223
00:10:28,639 --> 00:10:26,610
depths in the moon and these two

224
00:10:31,009 --> 00:10:28,649
spacecraft will essentially chase each

225
00:10:33,439 --> 00:10:31,019
other around in a polar orbit as the

226
00:10:35,689 --> 00:10:33,449
moon rotates slowly underneath them and

227
00:10:38,569 --> 00:10:35,699
the basic measurement is that you can

228
00:10:40,759 --> 00:10:38,579
see here as there is a mass on the

229
00:10:43,210 --> 00:10:40,769
surface or in the subsurface the lead

230
00:10:46,220 --> 00:10:43,220
spacecraft will accelerate and speed up

231
00:10:47,929 --> 00:10:46,230
in response to that mass and cause the

232
00:10:51,230 --> 00:10:47,939
distance between the two to increase and

233
00:10:53,780 --> 00:10:51,240
then as the second spacecraft then comes

234
00:10:55,549 --> 00:10:53,790
over this greater mass it will speed up

235
00:10:57,920 --> 00:10:55,559
and get closer to the first spacecraft

236
00:11:01,429 --> 00:10:57,930
so we're essentially taking the distance

237
00:11:03,590 --> 00:11:01,439
between two points and and watching how

238
00:11:05,759 --> 00:11:03,600

that distance changes and this is a

239
00:11:08,189 --> 00:11:05,769
fundamental measurement that you

240
00:11:10,259 --> 00:11:08,199
school children learn in middle school

241
00:11:12,689 --> 00:11:10,269
or even elementary school when they

242
00:11:13,859 --> 00:11:12,699
first take geometry but the fact of the

243
00:11:16,619 --> 00:11:13,869
matter is that we have to make this

244
00:11:18,239 --> 00:11:16,629
measurement extremely well we measure

245
00:11:20,729 --> 00:11:18,249
the velocity change between the two

246
00:11:24,210 --> 00:11:20,739
spacecraft to a couple of fractions

247
00:11:27,479 --> 00:11:24,220
about tenths of a micron per second okay

248
00:11:29,699 --> 00:11:27,489
it's an extremely extremely accurate

249
00:11:31,049 --> 00:11:29,709
measurement that has to be made so if

250
00:11:32,519 --> 00:11:31,059
you're out there and you're learning how

251
00:11:34,499 --> 00:11:32,529
to measure the change between the

252
00:11:36,660 --> 00:11:34,509
distance between two points learn how to

253
00:11:37,889 --> 00:11:36,670
do it well because when you grow up you

254
00:11:41,009 --> 00:11:37,899
might be able to do a mission to the

255
00:11:43,109 --> 00:11:41,019
moon and so I'll pass things over now to

256
00:11:44,160 --> 00:11:43,119
our project manager gave layman who'll

257
00:11:47,489 --> 00:11:44,170
tell you how we're going to get there

258
00:11:49,019 --> 00:11:47,499
okay Maria described how we're going to

259
00:11:50,309 --> 00:11:49,029
do the science of the moon and now i'm

260
00:11:52,619 --> 00:11:50,319
going to talk about how we're going to

261
00:11:55,829 --> 00:11:52,629
get there and so back when the Grail was

262
00:11:57,479 --> 00:11:55,839
selected in December 2007 we formed a

263
00:12:00,150 --> 00:11:57,489

number of different teams to implement

264
00:12:01,949 --> 00:12:00,160
the mission at JPL this is where we do

265
00:12:04,109 --> 00:12:01,959
the project management and also the

266
00:12:06,629 --> 00:12:04,119
instrument was built for the grill

267
00:12:08,699 --> 00:12:06,639
mission then lockheed martin in denver

268
00:12:11,280 --> 00:12:08,709
colorado is where the spacecraft was

269
00:12:13,109 --> 00:12:11,290
built and then United Launch Alliance is

270
00:12:15,600 --> 00:12:13,119
where the the launch vehicle was built

271
00:12:17,999 --> 00:12:15,610
and so we've been working since then and

272
00:12:20,460 --> 00:12:18,009
in May tooth of this year that's when we

273
00:12:23,669 --> 00:12:20,470
ship the spacecraft to Florida and

274
00:12:25,980 --> 00:12:23,679
you'll see a next graphic place this is

275
00:12:27,929 --> 00:12:25,990
the an image of the spacecraft it's two

276
00:12:30,210 --> 00:12:27,939
days old and it shows the two spacecraft

277
00:12:32,340 --> 00:12:30,220
on top of the second stage of the launch

278
00:12:36,179 --> 00:12:32,350
vehicle and behind that you'll see this

279
00:12:39,840 --> 00:12:36,189
is the the fairing enveloping the

280
00:12:41,879 --> 00:12:39,850
spacecraft and we've since put on the

281
00:12:43,799 --> 00:12:41,889
the other half of the fairing and we did

282
00:12:46,259 --> 00:12:43,809
that in preparations because we were

283
00:12:48,869 --> 00:12:46,269
concerned about Hurricane Irene so the

284
00:12:51,960 --> 00:12:48,879
spacecraft was all all buttoned up and

285
00:12:54,629 --> 00:12:51,970
secure if in case we had a problem with

286
00:12:56,669 --> 00:12:54,639
with Irene so over the next 13 days

287
00:12:58,679 --> 00:12:56,679
while we're preparing for the launch a

288
00:13:01,559 --> 00:12:58,689

lot of work is going on the final

289
00:13:04,679 --> 00:13:01,569
preparations the main thing left to do

290
00:13:06,989 --> 00:13:04,689
is to fuel the second stage and and then

291
00:13:09,299 --> 00:13:06,999
we'll be ready to go and in the next

292
00:13:12,119 --> 00:13:09,309
graphic I want to show you what we will

293
00:13:15,929 --> 00:13:12,129
see ansan September 8th this is the

294
00:13:18,990 --> 00:13:15,939
launch of the the Grail spacecraft from

295
00:13:22,500 --> 00:13:19,000
the Delta two rocket from

296
00:13:24,180 --> 00:13:22,510
Cape Canaveral and after this first

297
00:13:25,590 --> 00:13:24,190
stage is spent then we go to the second

298
00:13:29,610 --> 00:13:25,600
stage of the launch vehicle and here we

299
00:13:32,580 --> 00:13:29,620
show the the second stage preparing to

300
00:13:35,580 --> 00:13:32,590
deploy the two spacecraft and then we

301
00:13:38,010 --> 00:13:35,590
first we deploy a Grail a and then eight

302
00:13:40,620 --> 00:13:38,020
minutes later we deploy Grail be and

303
00:13:44,220 --> 00:13:40,630
then the two spacecraft are on the way

304
00:13:46,140 --> 00:13:44,230
to the moon what will happen next is a

305
00:13:48,300 --> 00:13:46,150
series of maneuvers we do a total of

306
00:13:50,010 --> 00:13:48,310
thirty-three maneuvers on the weight of

307
00:13:52,590 --> 00:13:50,020
the moon to give them the proper orbit

308
00:13:55,290 --> 00:13:52,600
and in the next graphic I want to show

309
00:13:58,260 --> 00:13:55,300
you the trajectory as we go through on

310
00:14:00,510 --> 00:13:58,270
September eighth we have a that's the

311
00:14:02,160 --> 00:14:00,520
opening the launch period and we can

312
00:14:04,110 --> 00:14:02,170
launch any day after that for four to

313
00:14:06,480 --> 00:14:04,120

two days and on your left you'll see the

314
00:14:08,580 --> 00:14:06,490
trajectory to the moon if we launched on

315
00:14:11,070 --> 00:14:08,590
the first day of the launch period and

316
00:14:13,440 --> 00:14:11,080
then the in the center there's a graphic

317
00:14:15,540 --> 00:14:13,450
showing how the spacecraft will get to

318
00:14:18,960 --> 00:14:15,550
the moon if we launch at the end of the

319
00:14:22,440 --> 00:14:18,970
launch period and so this is a busy time

320
00:14:24,540 --> 00:14:22,450
for this for the team preparing to get

321
00:14:26,970 --> 00:14:24,550
ready to get ready for lunar orbit

322
00:14:29,250 --> 00:14:26,980
insertion and then the next graphic will

323
00:14:30,990 --> 00:14:29,260
show this lunar orbit insertion and this

324
00:14:33,300 --> 00:14:31,000
will happen on grail ale happens on New

325
00:14:36,630 --> 00:14:33,310
Year's Eve and on grill be new year's

326
00:14:39,600 --> 00:14:36,640
day and it's a 38 minute burn to get

327
00:14:42,390 --> 00:14:39,610
into these orbits and the orbit period

328
00:14:44,370 --> 00:14:42,400
is about 11 and a half hours and so over

329
00:14:47,370 --> 00:14:44,380
this period we do a series of maneuvers

330
00:14:49,650 --> 00:14:47,380
to circulate the orbit eventually we

331
00:14:52,320 --> 00:14:49,660
want to get into an orbit about 55

332
00:14:54,510 --> 00:14:52,330
kilometers above the moon and it's

333
00:14:55,650 --> 00:14:54,520
highly circular orbit and this is a

334
00:14:58,050 --> 00:14:55,660
period where we go through the

335
00:15:00,150 --> 00:14:58,060
transition to science formation and this

336
00:15:04,560 --> 00:15:00,160
is where we have to get the orbits very

337
00:15:06,240 --> 00:15:04,570
precisely position so that we can carry

338
00:15:08,880 --> 00:15:06,250

out the science phase of the mission and

339
00:15:11,480 --> 00:15:08,890
then in the next graphic will give you a

340
00:15:14,820 --> 00:15:11,490
understanding of the the data that we

341
00:15:18,000 --> 00:15:14,830
collect in order to return to science we

342
00:15:20,400 --> 00:15:18,010
have a k-band ranging system that

343
00:15:21,930 --> 00:15:20,410
exchanges ranging data between the two

344
00:15:24,780 --> 00:15:21,940
spacecraft and then we also have another

345
00:15:26,910 --> 00:15:24,790
signal at s band that that exchanges the

346
00:15:28,949 --> 00:15:26,920
clock information and that all this data

347
00:15:31,110 --> 00:15:28,959
is down like from each spacecraft a test

348
00:15:31,890 --> 00:15:31,120
ban is where we send the science data

349
00:15:34,080 --> 00:15:31,900
and the hell

350
00:15:37,940 --> 00:15:34,090
than status data and then we also have a

351
00:15:40,890 --> 00:15:37,950
radio science beacon that returns

352
00:15:43,410 --> 00:15:40,900
navigation information for for the

353
00:15:45,180 --> 00:15:43,420
scientist so that summarizes how we're

354
00:15:47,370 --> 00:15:45,190
going to get to the moon and let me turn

355
00:15:49,890 --> 00:15:47,380
it over to Lisa Hubbard to talk about

356
00:15:52,920 --> 00:15:49,900
the education house path of the mission

357
00:15:55,290 --> 00:15:52,930
great good morning I'm happy to be here

358
00:15:57,210 --> 00:15:55,300
to have the opportunity to tell you

359
00:16:00,030 --> 00:15:57,220
about the education and public outreach

360
00:16:03,090 --> 00:16:00,040
component of the Grail mission which is

361
00:16:05,580 --> 00:16:03,100
called moon Kim it's led by dr. Sally

362
00:16:09,060 --> 00:16:05,590
Ride America's first woman in space and

363
00:16:10,860 --> 00:16:09,070

her team at Sally Ride science a unique

364
00:16:13,320 --> 00:16:10,870
think about this is it's the first

365
00:16:15,000 --> 00:16:13,330
NASA's first planetary mission to

366
00:16:17,160 --> 00:16:15,010
include instruments that are fully

367
00:16:20,040 --> 00:16:17,170
dedicated to education and public

368
00:16:22,940 --> 00:16:20,050
outreach we intend to tap into the

369
00:16:26,750 --> 00:16:22,950
excitement of science and technology

370
00:16:29,220 --> 00:16:26,760
using the context of lunar exploration

371
00:16:32,070 --> 00:16:29,230
while Grail is performing its

372
00:16:34,470 --> 00:16:32,080
gravitational experiments moon cam will

373
00:16:39,720 --> 00:16:34,480
serve as eyes on the moon for Earth

374
00:16:42,360 --> 00:16:39,730
students give me a slide please and how

375
00:16:45,480 --> 00:16:42,370
they will do that is through the use of

376
00:16:48,360 --> 00:16:45,490
these cameras each spacecraft has four

377
00:16:50,970 --> 00:16:48,370
cameras on board there are two that are

378
00:16:53,130 --> 00:16:50,980
looking for and aft at a 60-degree angle

379
00:16:54,810 --> 00:16:53,140
and there are two that are pointed

380
00:16:58,080 --> 00:16:54,820
straight down to the surface of the moon

381
00:17:00,120 --> 00:16:58,090
using different powered lenses this

382
00:17:02,100 --> 00:17:00,130
program is available at no cost to

383
00:17:04,890 --> 00:17:02,110
schools and students are going to be

384
00:17:05,880 --> 00:17:04,900
able to take their very own photos this

385
00:17:08,010 --> 00:17:05,890
is what's going to make the difference

386
00:17:09,810 --> 00:17:08,020
we know there are lots of images of the

387
00:17:13,020 --> 00:17:09,820
moon out there but this gives students

388
00:17:14,579 --> 00:17:13,030

their own ownership of that once the

389
00:17:17,130 --> 00:17:14,589
satellites are in orbit around the moon

390
00:17:18,270 --> 00:17:17,140
the cameras will be activated and this

391
00:17:21,510 --> 00:17:18,280
part of the mission will last

392
00:17:23,640 --> 00:17:21,520
approximately 80 days the missions

393
00:17:26,520 --> 00:17:23,650
operations center which would be similar

394
00:17:28,590 --> 00:17:26,530
to Mission Control in Houston is located

395
00:17:31,650 --> 00:17:28,600
at the University of California San

396
00:17:33,360 --> 00:17:31,660
Diego there we have you we have

397
00:17:35,160 --> 00:17:33,370
undergraduate students who have been

398
00:17:36,780 --> 00:17:35,170
involved in the planning they're

399
00:17:39,270 --> 00:17:36,790
involved in the operations of the

400
00:17:41,610 --> 00:17:39,280
mission and during the mission they will

401
00:17:46,370 --> 00:17:41,620
serve as the link to middle school

402
00:17:53,490 --> 00:17:48,419
students are going to be able to access

403
00:17:55,860 --> 00:17:53,500
our website slide please to help them

404
00:17:57,779 --> 00:17:55,870
plan and target the area of the moon

405
00:18:00,000 --> 00:17:57,789
that they want to explore further

406
00:18:03,299 --> 00:18:00,010
they'll be able to look at the latitude

407
00:18:06,659 --> 00:18:03,309
the longitude which orbit and camera

408
00:18:10,620 --> 00:18:06,669
will be available for those images next

409
00:18:13,169 --> 00:18:10,630
slide this website will also be very

410
00:18:15,600 --> 00:18:13,179
interactive there will be images of the

411
00:18:18,120 --> 00:18:15,610
moon that they can rotate they can zoom

412
00:18:21,539 --> 00:18:18,130
in on them they will be able to view the

413
00:18:24,779 --> 00:18:21,549

exact orbital tract of the spacecraft

414
00:18:26,430 --> 00:18:24,789
and they can click on that and that will

415
00:18:29,430 --> 00:18:26,440
also give them information about the

416
00:18:31,320 --> 00:18:29,440
latitude and longitude once they decide

417
00:18:34,680 --> 00:18:31,330
which area they want to explore further

418
00:18:36,990 --> 00:18:34,690
they will send that request to the

419
00:18:40,049 --> 00:18:37,000
Mission Operations Center in San Diego

420
00:18:42,029 --> 00:18:40,059
and once the images are taken they'll be

421
00:18:45,149 --> 00:18:42,039
downloaded to a gallery which will be

422
00:18:47,279 --> 00:18:45,159
open to the general public there will be

423
00:18:49,950 --> 00:18:47,289
different ways that those images can be

424
00:18:52,680 --> 00:18:49,960
categorized as they begin to build on

425
00:18:54,810 --> 00:18:52,690
themselves students will be able to go

426
00:18:57,240 --> 00:18:54,820
there and access the image that they

427
00:18:59,639 --> 00:18:57,250
personally took they'll also be able to

428
00:19:02,970 --> 00:18:59,649
look at other images from other students

429
00:19:05,250 --> 00:19:02,980
and it will help them further their own

430
00:19:07,769 --> 00:19:05,260
research by looking at other images

431
00:19:11,100 --> 00:19:07,779
they'll be able to annotate those images

432
00:19:13,289 --> 00:19:11,110
and you never know what a student will

433
00:19:16,230 --> 00:19:13,299
be inspired to do with those pictures

434
00:19:19,560 --> 00:19:16,240
that are their very own it might be an

435
00:19:21,480 --> 00:19:19,570
artist or a poet or maybe something even

436
00:19:23,070 --> 00:19:21,490
in music which is something that we

437
00:19:27,360 --> 00:19:23,080
generally don't think about when we're

438
00:19:32,789 --> 00:19:27,370

thinking about science and technology so

439
00:19:35,399 --> 00:19:32,799
um both before during and after the

440
00:19:39,029 --> 00:19:35,409
mission Sally Ride science is providing

441
00:19:42,419 --> 00:19:39,039
training and support for teachers we are

442
00:19:45,690 --> 00:19:42,429
linking them in workshops with lunar

443
00:19:47,430 --> 00:19:45,700
scientists and experts in the field we

444
00:19:49,080 --> 00:19:47,440
are also providing them with hands-on

445
00:19:51,000 --> 00:19:49,090
activities they can use in their

446
00:19:53,070 --> 00:19:51,010
classrooms that they're already bringing

447
00:19:55,529 --> 00:19:53,080
back to their classrooms in preparation

448
00:19:57,520 --> 00:19:55,539
we have over 500 teachers that are

449
00:19:59,800 --> 00:19:57,530
already registered

450
00:20:01,930 --> 00:19:59,810
on our moon cam website and we encourage

451
00:20:03,760 --> 00:20:01,940
teachers to go there and register

452
00:20:05,440 --> 00:20:03,770
because we will be helping them get

453
00:20:08,590 --> 00:20:05,450
prepared for ways that they can use

454
00:20:10,540 --> 00:20:08,600
these images as they relate to standards

455
00:20:13,950 --> 00:20:10,550
that they have to use and meet in their

456
00:20:16,710 --> 00:20:13,960
classrooms it's really exciting that

457
00:20:19,870 --> 00:20:16,720
students are going to be able to do this

458
00:20:22,810 --> 00:20:19,880
where NASA is just a great vehicle for

459
00:20:25,630 --> 00:20:22,820
inspiring students in careers that

460
00:20:28,150 --> 00:20:25,640
involve science and technology kids have

461
00:20:30,010 --> 00:20:28,160
a natural interest in space even my

462
00:20:32,020 --> 00:20:30,020
four-year-old nephew calls me and ask me

463
00:20:35,110 --> 00:20:32,030

questions about the moon so he's

464
00:20:36,970 --> 00:20:35,120
starting early we also you know like we

465
00:20:39,000 --> 00:20:36,980
said we are going to be engaging middle

466
00:20:41,500 --> 00:20:39,010
school students and we'll be engaging

467
00:20:43,690 --> 00:20:41,510
undergraduate students many of those

468
00:20:46,180 --> 00:20:43,700
students have actually gone on to work

469
00:20:49,690 --> 00:20:46,190
for NASA by working in our mission

470
00:20:51,940 --> 00:20:49,700
operation center so we hope that this

471
00:20:54,100 --> 00:20:51,950
will encourage students in those in

472
00:20:56,740 --> 00:20:54,110
those fields and they'll be very excited

473
00:20:58,570 --> 00:20:56,750
about being part of real world science

474
00:21:03,910 --> 00:20:58,580
and they will actually be scientists

475
00:21:08,470 --> 00:21:03,920
themselves if you go to our website wwm

476
00:21:10,690 --> 00:21:08,480
on cam UCSD edu that is where you'll

477
00:21:13,360 --> 00:21:10,700
find all the information about the site

478
00:21:15,100 --> 00:21:13,370
we would ask you to tell other educators

479
00:21:17,770 --> 00:21:15,110
about it and encourage them to come and

480
00:21:19,570 --> 00:21:17,780
register and I think it pretty much

481
00:21:21,610 --> 00:21:19,580
everything that you need to know you can

482
00:21:24,310 --> 00:21:21,620
find there and we would encourage you to

483
00:21:26,860 --> 00:21:24,320
go check it out look at the website and

484
00:21:30,610 --> 00:21:26,870
see what's there and get more involved

485
00:21:31,690 --> 00:21:30,620
thanks okay thank you and now we're

486
00:21:34,120 --> 00:21:31,700
going to transition into the

487
00:21:36,610 --> 00:21:34,130
question-and-answer phase we're going to

488
00:21:38,710 --> 00:21:36,620

start here NASA headquarters air can

489
00:21:41,020 --> 00:21:38,720
then I have some questions that were

490
00:21:42,610 --> 00:21:41,030
sent in to me by some of the media that

491
00:21:44,500 --> 00:21:42,620
are watching this program across the

492
00:21:47,140 --> 00:21:44,510
country and then we'll go to the phone

493
00:21:49,330 --> 00:21:47,150
lines so Eric don't you start us off

494
00:21:51,970 --> 00:21:49,340
sure thanks doing Eric hang with nature

495
00:21:54,670 --> 00:21:51,980
magazine if my questions for Maria Maria

496
00:21:58,780 --> 00:21:54,680
can you explain a in more detail how

497
00:22:01,030 --> 00:21:58,790
Grail could possibly explain this this

498
00:22:04,810 --> 00:22:01,040
dichotomy between the the near side and

499
00:22:07,390 --> 00:22:04,820
the far side sure happy to learn okay so

500
00:22:10,510 --> 00:22:07,400
um so we believe that there was melting

501
00:22:13,660 --> 00:22:10,520
deep inside the moon and

502
00:22:16,780 --> 00:22:13,670
and it could be that there is a mega

503
00:22:19,870 --> 00:22:16,790
plume or was a mega plume in the moon in

504
00:22:22,270 --> 00:22:19,880
its far history and in fact the lunar

505
00:22:25,360 --> 00:22:22,280
prospector mission showed that there

506
00:22:27,370 --> 00:22:25,370
were high concentrations of elements

507
00:22:31,030 --> 00:22:27,380
such as thori and potassium that were

508
00:22:34,410 --> 00:22:31,040
heat producing elements but the actually

509
00:22:37,840 --> 00:22:34,420
the lunar prospector spectral data only

510
00:22:40,030 --> 00:22:37,850
penetrated about a meter deep beneath

511
00:22:44,050 --> 00:22:40,040
the surface of the moon so we actually

512
00:22:46,390 --> 00:22:44,060
don't have an idea of what the anything

513
00:22:50,260 --> 00:22:46,400

related to the composition of the moon

514
00:22:52,660 --> 00:22:50,270
beneath that and and Braille we'll be

515
00:22:54,610 --> 00:22:52,670
looking at this in you know many more

516
00:22:58,150 --> 00:22:54,620
orders of magnitude in terms of higher

517
00:23:02,350 --> 00:22:58,160
resolution so because of the fact that

518
00:23:06,040 --> 00:23:02,360
we will we will do orders of magnitude

519
00:23:08,470 --> 00:23:06,050
better in terms of our sensitivity as

520
00:23:13,420 --> 00:23:08,480
well as our spatial resolution and what

521
00:23:14,890 --> 00:23:13,430
I like to say sometimes is that when you

522
00:23:17,830 --> 00:23:14,900
can make a measurement better than has

523
00:23:19,510 --> 00:23:17,840
been made before by a factor of two you

524
00:23:21,820 --> 00:23:19,520
make very interesting discoveries but

525
00:23:24,790 --> 00:23:21,830
when you can measure things orders of

526
00:23:27,040 --> 00:23:24,800
magnitude better they can really be

527
00:23:29,200 --> 00:23:27,050
paradigm changing and this is this is

528
00:23:32,380 --> 00:23:29,210
what we're expecting so will essentially

529
00:23:34,690 --> 00:23:32,390
be able to look taking into account our

530
00:23:36,760 --> 00:23:34,700
understanding of the bulk composition of

531
00:23:38,760 --> 00:23:36,770
the moon on the basis of the Apollo

532
00:23:42,520 --> 00:23:38,770
samples and surface spectral data in

533
00:23:43,990 --> 00:23:42,530
comparison with our sensitivity looking

534
00:23:47,590 --> 00:23:44,000
at gravity and what that telling us

535
00:23:49,210 --> 00:23:47,600
about the mass distribution radially we

536
00:23:51,910 --> 00:23:49,220
will be able to look at how melting

537
00:23:55,990 --> 00:23:51,920
occurred within the moon and actually

538
00:23:57,340 --> 00:23:56,000

what the source materials were that

539
00:24:00,880 --> 00:23:57,350
produced melts that occurred to the

540
00:24:03,490 --> 00:24:00,890
surface okay before we go to the phone

541
00:24:06,070 --> 00:24:03,500
line I do have a couple questions from

542
00:24:10,300 --> 00:24:06,080
the west coast and the first question is

543
00:24:12,130 --> 00:24:10,310
for you Maria question goes it took the

544
00:24:14,290 --> 00:24:12,140
Apollo a few days to get to the moon why

545
00:24:16,660 --> 00:24:14,300
does Grail take approximately three and

546
00:24:18,790 --> 00:24:16,670
a half months to ride there well we

547
00:24:22,210 --> 00:24:18,800
that's a that's a good question the

548
00:24:23,800 --> 00:24:22,220
we're using a low energy trajectory that

549
00:24:28,090 --> 00:24:23,810
uses the earth

550
00:24:31,210 --> 00:24:28,100
Lagrange point and we originally did

551
00:24:33,580 --> 00:24:31,220
that to save fuel ok so the Apollo

552
00:24:36,160 --> 00:24:33,590
astronauts we wanted to send them to the

553
00:24:38,470 --> 00:24:36,170
moon get them on the moon and get them

554
00:24:41,650 --> 00:24:38,480
home safely ok and we wanted to do that

555
00:24:44,380 --> 00:24:41,660
as expeditiously as possible but if you

556
00:24:46,840 --> 00:24:44,390
think about it if you go barreling

557
00:24:50,050 --> 00:24:46,850
towards the moon you've got to hit the

558
00:24:52,510 --> 00:24:50,060
brakes big time to slow down enough for

559
00:24:55,110 --> 00:24:52,520
lunar gravity to capture you into orbit

560
00:24:58,540 --> 00:24:55,120
ok that means you need a big fuel tank

561
00:25:03,430 --> 00:24:58,550
loss of fuel maybe two rockets for the

562
00:25:05,440 --> 00:25:03,440
two spacecraft okay we had we teamed

563
00:25:07,570 --> 00:25:05,450

with Lockheed Martin who had a very

564
00:25:09,700 --> 00:25:07,580
flexible spacecraft that was actually a

565
00:25:13,540 --> 00:25:09,710
Department of Defense spacecraft that

566
00:25:16,300 --> 00:25:13,550
they got permission to adapt and and it

567
00:25:18,790 --> 00:25:16,310
was a small spacecraft and we used

568
00:25:20,320 --> 00:25:18,800
wanted to use a small fuel tank in order

569
00:25:22,690 --> 00:25:20,330
to do that so by using the small

570
00:25:25,360 --> 00:25:22,700
spacecraft and using the low energy

571
00:25:28,120 --> 00:25:25,370
trajectory it made sense to take this

572
00:25:30,100 --> 00:25:28,130
longer three and a half month trip to

573
00:25:32,520 --> 00:25:30,110
the moon but it turned out that after we

574
00:25:35,110 --> 00:25:32,530
got into it and started studying it

575
00:25:37,450 --> 00:25:35,120
there were a lot of other advantages of

576
00:25:39,340 --> 00:25:37,460
taking a slow trip to the moon so first

577
00:25:41,880 --> 00:25:39,350
of all we're able to put those two

578
00:25:44,440 --> 00:25:41,890
spacecraft into lunar orbit a day apart

579
00:25:48,250 --> 00:25:44,450
so that we're not doing two critical

580
00:25:51,220 --> 00:25:48,260
orbit insertion maneuvers in one day we

581
00:25:55,120 --> 00:25:51,230
were able to get to the moon on the same

582
00:25:58,030 --> 00:25:55,130
day no matter what day in this 42 day

583
00:26:00,340 --> 00:25:58,040
long window that we launched and that

584
00:26:02,050 --> 00:26:00,350
allowed us to completely d couple the

585
00:26:03,460 --> 00:26:02,060
operations during cruise from the

586
00:26:05,590 --> 00:26:03,470
operations around the moon which

587
00:26:07,180 --> 00:26:05,600
actually greatly simplified our mission

588
00:26:10,060 --> 00:26:07,190

operations and one of the things that

589
00:26:12,880 --> 00:26:10,070
helped us control costs another thing

590
00:26:15,310 --> 00:26:12,890
that happens is it teaches Argives our

591
00:26:18,100 --> 00:26:15,320
operations team time to learn how to

592
00:26:20,380 --> 00:26:18,110
operate the spacecraft and it allows the

593
00:26:23,140 --> 00:26:20,390
spacecraft 2d gas so the spacecraft

594
00:26:25,870 --> 00:26:23,150
within its structure actually has gases

595
00:26:28,570 --> 00:26:25,880
that come out and because even though

596
00:26:30,550 --> 00:26:28,580
it's very very tiny amounts it's still

597
00:26:33,040 --> 00:26:30,560
an acceleration acceleration has the

598
00:26:34,720 --> 00:26:33,050
same units of gravity so spacecraft

599
00:26:36,610 --> 00:26:34,730
degassing is actually an error source

600
00:26:37,400 --> 00:26:36,620
for us and we have to actually worry

601
00:26:40,370 --> 00:26:37,410
about error

602
00:26:43,190 --> 00:26:40,380
sources down at the level of spacecraft

603
00:26:46,310 --> 00:26:43,200
degassing because we need to make the

604
00:26:48,050 --> 00:26:46,320
measurement as precisely as we do thanks

605
00:26:49,760 --> 00:26:48,060
Maria we're going to do one more

606
00:26:50,720 --> 00:26:49,770
question i received from the west coast

607
00:26:52,610 --> 00:26:50,730
and then we're going to head down to

608
00:26:55,130 --> 00:26:52,620
kennedy and i think i'm going to ask you

609
00:27:00,490 --> 00:26:55,140
guys to get your crystal ball across the

610
00:27:03,440 --> 00:27:00,500
ball out this is question is what legacy

611
00:27:05,630 --> 00:27:03,450
would you want Grail to have and/or its

612
00:27:07,250 --> 00:27:05,640
impact if future generations if you

613
00:27:08,870 --> 00:27:07,260

could see in the future so Jim let's

614
00:27:11,330 --> 00:27:08,880
just go down the line and individual

615
00:27:14,570 --> 00:27:11,340
comments on that starting with you well

616
00:27:16,550 --> 00:27:14,580
of course as a discovery mission it's

617
00:27:18,050 --> 00:27:16,560
really doing some pioneering science and

618
00:27:21,080 --> 00:27:18,060
that's what that program is all about

619
00:27:23,270 --> 00:27:21,090
swell focused it has an important

620
00:27:26,840 --> 00:27:23,280
objective that objective is to really

621
00:27:30,230 --> 00:27:26,850
understand the evolution and the origin

622
00:27:33,140 --> 00:27:30,240
of the of the earth-moon system we have

623
00:27:34,490 --> 00:27:33,150
a number of theories and and Grail will

624
00:27:36,020 --> 00:27:34,500
set us on the right track of

625
00:27:38,030 --> 00:27:36,030
understanding that now that may have

626
00:27:42,560 --> 00:27:38,040
application in other parts of our solar

627
00:27:45,680 --> 00:27:42,570
system so so its legacy then is indeed

628
00:27:49,310 --> 00:27:45,690
applicable to to looking at looking at

629
00:27:54,350 --> 00:27:49,320
this into the future okay can I say two

630
00:27:58,520 --> 00:27:54,360
things okay so one is the first is when

631
00:28:03,590 --> 00:27:58,530
I do an experiment I like to rewrite the

632
00:28:08,780 --> 00:28:03,600
textbooks okay and and so I think a lot

633
00:28:10,850 --> 00:28:08,790
of us for very good reason believe in

634
00:28:12,080 --> 00:28:10,860
the impact origin of the moon and then

635
00:28:16,040 --> 00:28:12,090
the cooling off of the moon and the

636
00:28:17,810 --> 00:28:16,050
evolution I am predicting that we're

637
00:28:20,390 --> 00:28:17,820
going to find something and I don't know

638
00:28:22,430 --> 00:28:20,400

what it is that is really really going

639
00:28:24,740 --> 00:28:22,440
to surprise us and turn our

640
00:28:26,750 --> 00:28:24,750
understanding of how the moon and other

641
00:28:30,350 --> 00:28:26,760
terrestrial planets formed on its ear

642
00:28:32,960 --> 00:28:30,360
okay so that's that's my scientific

643
00:28:37,160 --> 00:28:32,970
thing the but there's also a

644
00:28:39,980 --> 00:28:37,170
technological legacy here so Grail is

645
00:28:42,560 --> 00:28:39,990
the moon version of the extremely

646
00:28:45,530 --> 00:28:42,570
successful earth science grace mission

647
00:28:48,110 --> 00:28:45,540
that is mapping the earth right now and

648
00:28:50,540 --> 00:28:48,120
we were able to take the grace

649
00:28:54,020 --> 00:28:50,550
instrumentation and and

650
00:28:57,950 --> 00:28:54,030
adapted for orbit around the moon and as

651
00:29:00,650 --> 00:28:57,960
you heard from dave here it's very

652
00:29:03,230 --> 00:29:00,660
important to get precise timing of these

653
00:29:05,810 --> 00:29:03,240
two spacecraft and on for grace grace

654
00:29:08,030 --> 00:29:05,820
does its timing using GPS but we didn't

655
00:29:09,710 --> 00:29:08,040
have GPS at the moon and so we had to

656
00:29:11,900 --> 00:29:09,720
figure out a way to do clock

657
00:29:14,480 --> 00:29:11,910
calibrations and now that we've

658
00:29:17,570 --> 00:29:14,490
demonstrated the way that we can do

659
00:29:20,090 --> 00:29:17,580
precise timing this really opens up the

660
00:29:22,610 --> 00:29:20,100
possibility of taking a concept like

661
00:29:26,510 --> 00:29:22,620
this and doing it another around another

662
00:29:28,640 --> 00:29:26,520
planet say imagine mapping currents in

663
00:29:31,460 --> 00:29:28,650

the ocean beneath Europa using a concept

664
00:29:33,770 --> 00:29:31,470
like this but beyond this particular

665
00:29:36,230 --> 00:29:33,780
concept going to any other planet where

666
00:29:39,590 --> 00:29:36,240
you would like to do closely coordinated

667
00:29:42,680 --> 00:29:39,600
timed observations we've now figured out

668
00:29:45,320 --> 00:29:42,690
a way to do this so i think in hope that

669
00:29:49,970 --> 00:29:45,330
the legacies will be both scientific and

670
00:29:52,880 --> 00:29:49,980
technological i think for me the the big

671
00:29:55,520 --> 00:29:52,890
challenge of Grail is actually get into

672
00:29:56,930 --> 00:29:55,530
getting into the science orbit and so we

673
00:29:59,000 --> 00:29:56,940
call that the transfer to science

674
00:30:01,010 --> 00:29:59,010
formation phase and it's a very complex

675
00:30:03,380 --> 00:30:01,020
phase for us in the mission where we

676
00:30:05,660 --> 00:30:03,390
have to get the two spacecraft very

677
00:30:08,360 --> 00:30:05,670
tightly coordinated one around the other

678
00:30:10,940 --> 00:30:08,370
our navigators are quarter million miles

679
00:30:12,500 --> 00:30:10,950
away from the moon trying to trying to

680
00:30:15,950 --> 00:30:12,510
orchestrate these two spacecraft into

681
00:30:19,690 --> 00:30:15,960
very very precise orbits and I'm retired

682
00:30:22,070 --> 00:30:19,700
Navy Reserve Officer and to me it's like

683
00:30:23,750 --> 00:30:22,080
the blue angels at the moon and so

684
00:30:26,840 --> 00:30:23,760
that's our big challenge and and we're

685
00:30:28,640 --> 00:30:26,850
really looking forward to doing it well

686
00:30:30,860 --> 00:30:28,650
I can only speak the moon cam but I

687
00:30:34,610 --> 00:30:30,870
think that is going to impact students

688
00:30:36,410 --> 00:30:34,620

in an emotional way as well while the

689
00:30:38,270 --> 00:30:36,420
moon is our nearest neighbor there's

690
00:30:40,310 --> 00:30:38,280
still so many things that our students

691
00:30:42,680 --> 00:30:40,320
don't understand it may be the first

692
00:30:46,870 --> 00:30:42,690
time our students realize that the dark

693
00:30:50,660 --> 00:30:46,880
side isn't the same as the the far side

694
00:30:52,850 --> 00:30:50,670
and I think once they begin to look at

695
00:30:54,380 --> 00:30:52,860
detailed images when they go out in

696
00:30:56,060 --> 00:30:54,390
their backyard and look at the moon

697
00:30:58,900 --> 00:30:56,070
they're gonna look at it in a whole new

698
00:31:01,010 --> 00:30:58,910
way and I think that's priceless

699
00:31:02,690 --> 00:31:01,020
excellent thank you okay now we're going

700
00:31:04,340 --> 00:31:02,700
to head down south where the spacecraft

701
00:31:06,529 --> 00:31:04,350
is

702
00:31:08,000 --> 00:31:06,539
getting made ready for launch and we're

703
00:31:11,180 --> 00:31:08,010
going to go to the Kennedy Space Center

704
00:31:17,810 --> 00:31:11,190
there for a question or two Kennedy how

705
00:31:19,250 --> 00:31:17,820
do you read here you find this is Marcia

706
00:31:22,010 --> 00:31:19,260
Dunn of the associated press with

707
00:31:25,549 --> 00:31:22,020
actually three questions if I might for

708
00:31:27,409 --> 00:31:25,559
dr. Zubrin you could you give me some

709
00:31:30,380 --> 00:31:27,419
sort of a reference point you were

710
00:31:32,060 --> 00:31:30,390
mentioning the precise measurements that

711
00:31:34,100 --> 00:31:32,070
will be taken between the two orbiting

712
00:31:36,140 --> 00:31:34,110
craft think you mentioned tenth of a

713
00:31:38,419 --> 00:31:36,150

micron per second that's hard for me to

714
00:31:40,370 --> 00:31:38,429
imagine could you put that in some

715
00:31:42,560 --> 00:31:40,380
simple terms that I could explain to my

716
00:31:50,120 --> 00:31:42,570
readers sure it's about half the size of

717
00:31:53,450 --> 00:31:50,130
a red blood cell I'm sorry could you

718
00:32:01,310 --> 00:31:53,460
repeat that a tenth of a micron is about

719
00:32:03,169 --> 00:32:01,320
half the size of a red blood cell I'm

720
00:32:06,799 --> 00:32:03,179
sorry you're breaking up a cop okay you

721
00:32:11,980 --> 00:32:06,809
try one more time ask the size of a red

722
00:32:16,310 --> 00:32:11,990
blood cell is a tenth of a micron okay

723
00:32:19,159 --> 00:32:16,320
got that thing second question probably

724
00:32:21,350 --> 00:32:19,169
for you or maybe dr. green as well are

725
00:32:24,200 --> 00:32:21,360
there any implications from your your

726
00:32:26,810 --> 00:32:24,210
results that you anticipate that might

727
00:32:29,390 --> 00:32:26,820
be able to benefit future human

728
00:32:33,460 --> 00:32:29,400
explorers astronauts who may one day one

729
00:32:36,860 --> 00:32:33,470
to live on the moon yes I'll answer that

730
00:32:40,039 --> 00:32:36,870
Grail was selected in our discovery

731
00:32:44,510 --> 00:32:40,049
program from purely scientific reasons

732
00:32:46,520 --> 00:32:44,520
it and it has important implications for

733
00:32:48,560 --> 00:32:46,530
the origin and evolution of our solar

734
00:32:51,440 --> 00:32:48,570
system as as we've discussed today and

735
00:32:54,289 --> 00:32:51,450
of course that data will always be

736
00:32:56,360 --> 00:32:54,299
available we'll be developing models

737
00:32:58,789 --> 00:32:56,370
will be putting that in the archive and

738
00:33:01,430 --> 00:32:58,799

it will be available for future

739
00:33:03,169 --> 00:33:01,440
generations and future missions which

740
00:33:06,289 --> 00:33:03,179
would include potentially human

741
00:33:08,590 --> 00:33:06,299
exploration missions to the moon so how

742
00:33:11,570 --> 00:33:08,600
they use that will be dependent upon

743
00:33:13,760 --> 00:33:11,580
their decisions and what they want to do

744
00:33:17,960 --> 00:33:13,770
relative to well landing and exploring

745
00:33:19,640 --> 00:33:17,970
the moon further yeah if I could just

746
00:33:23,630 --> 00:33:19,650
add to that so this this will be the

747
00:33:26,120 --> 00:33:23,640
highest resolution gravity field for any

748
00:33:28,640 --> 00:33:26,130
planet including earth okay on earth on

749
00:33:30,260 --> 00:33:28,650
earth you can't get down low enough to

750
00:33:32,450 --> 00:33:30,270
make the kind of measurements that we're

751
00:33:34,820 --> 00:33:32,460
making because of the atmospheric drag

752
00:33:36,590 --> 00:33:34,830
and actually atmospheric drag is another

753
00:33:38,360 --> 00:33:36,600
force that needs to be contend with

754
00:33:40,580 --> 00:33:38,370
because it has the same units of gravity

755
00:33:44,980 --> 00:33:40,590
you can't very difficult to separate

756
00:33:49,960 --> 00:33:44,990
that out so you can't map that low so so

757
00:33:53,150 --> 00:33:49,970
the ability to do precise targeting of

758
00:33:55,730 --> 00:33:53,160
observations by humans or by future

759
00:33:58,160 --> 00:33:55,740
robotic explorers is going to be really

760
00:34:06,110 --> 00:33:58,170
unprecedented after this gravitational

761
00:34:08,690 --> 00:34:06,120
field is produced Jeremy thank you and

762
00:34:11,150 --> 00:34:08,700
my final question probably for dr. green

763
00:34:14,050 --> 00:34:11,160

or maybe dr. grow as well there was

764
00:34:17,750 --> 00:34:14,060
immense attention on the Juno mission

765
00:34:18,860 --> 00:34:17,760
recently given the end of the shuttle

766
00:34:22,460 --> 00:34:18,870
program and I'm wondering do you

767
00:34:25,070 --> 00:34:22,470
anticipate a more interest than usual

768
00:34:28,340 --> 00:34:25,080
more attention more eyes on the lunch of

769
00:34:30,830 --> 00:34:28,350
grilled coming on the heels of Juno in

770
00:34:33,080 --> 00:34:30,840
the end of the shuttle program well I

771
00:34:37,070 --> 00:34:33,090
certainly hope so in the sense that our

772
00:34:40,160 --> 00:34:37,080
planetary program that nASA has that the

773
00:34:43,330 --> 00:34:40,170
this country pays for is really

774
00:34:49,030 --> 00:34:43,340
unbelievable in terms of its ability to

775
00:34:51,650 --> 00:34:49,040
to enthuse our students and and engage

776
00:34:55,190 --> 00:34:51,660
the scientific community of the world

777
00:34:57,850 --> 00:34:55,200
and I'm just delighted that the country

778
00:35:00,170 --> 00:34:57,860
is responding by now beginning to look

779
00:35:03,590 --> 00:35:00,180
going down to Kennedy and being able to

780
00:35:06,470 --> 00:35:03,600
observe the launches from Kennedy of our

781
00:35:08,660 --> 00:35:06,480
of our robotic spacecraft Juno you

782
00:35:11,360 --> 00:35:08,670
mentioned was the first robotic

783
00:35:15,440 --> 00:35:11,370
spacecraft launched after the shuttle at

784
00:35:18,110 --> 00:35:15,450
Grail is the second and we we certainly

785
00:35:21,650 --> 00:35:18,120
are anticipating a large crowd attending

786
00:35:23,930 --> 00:35:21,660
the Grail launch on when the window

787
00:35:25,850 --> 00:35:23,940
opens on September 8 so we're just

788
00:35:30,890 --> 00:35:25,860

delighted by the way the country is

789
00:35:38,430 --> 00:35:34,349
thank you Jim let's go to the phone line

790
00:35:40,380 --> 00:35:38,440
and we have on the phone and I catch

791
00:35:47,609 --> 00:35:40,390
them from the Harvard School of

792
00:35:49,469 --> 00:35:47,619
Journalism Anna hello hi thank you I

793
00:35:51,259 --> 00:35:49,479
wondered if both dr. Gruber and miss

794
00:35:54,569 --> 00:35:51,269
Hubbard could address this question I

795
00:35:57,089 --> 00:35:54,579
see that you can register for the moon's

796
00:35:58,769 --> 00:35:57,099
camp if you are abroad if you're a

797
00:36:01,380 --> 00:35:58,779
teacher abroad and for the young

798
00:36:03,749 --> 00:36:01,390
students worldwide and I wondered if you

799
00:36:06,180 --> 00:36:03,759
could speak to why it's important to

800
00:36:08,849 --> 00:36:06,190
reach out to teachers and their young

801
00:36:11,039 --> 00:36:08,859
students worldwide while at the same

802
00:36:18,749 --> 00:36:11,049
time reaching out to American students

803
00:36:21,029 --> 00:36:18,759
why are we reaching out abroad well we

804
00:36:23,130 --> 00:36:21,039
have a similar program called earthcam

805
00:36:27,479 --> 00:36:23,140
that we have always had students

806
00:36:29,910 --> 00:36:27,489
worldwide that have participated in I

807
00:36:32,130 --> 00:36:29,920
think the International Space Station is

808
00:36:34,440 --> 00:36:32,140
a perfect example also of why it's

809
00:36:42,059 --> 00:36:34,450
important that we are all working

810
00:36:44,579 --> 00:36:42,069
together yeah I i think i think the moon

811
00:36:48,959 --> 00:36:44,589
should be for everybody everybody looks

812
00:36:52,650 --> 00:36:48,969
up and sees the moon and and I I think

813
00:36:55,160 --> 00:36:52,660

that I think that the more that brings

814
00:37:00,930 --> 00:36:55,170
us together as opposed to draws us apart

815
00:37:08,969 --> 00:37:00,940
is good for everybody okay we want to go

816
00:37:10,890 --> 00:37:08,979
now to Irene Irene are you there join

817
00:37:12,450 --> 00:37:10,900
yes I was wondering if someone might

818
00:37:13,799 --> 00:37:12,460
just discuss a little bit more detail

819
00:37:16,559 --> 00:37:13,809
about how you're able to make that

820
00:37:18,870 --> 00:37:16,569
precise of the measurement and also if

821
00:37:21,209 --> 00:37:18,880
there's any relation to that new

822
00:37:23,519 --> 00:37:21,219
technology demo mission that was just

823
00:37:27,059 --> 00:37:23,529
announced to fly an atomic clock a deep

824
00:37:30,660 --> 00:37:27,069
space at on a talk Thanks alright so

825
00:37:32,219 --> 00:37:30,670
i'll i'll talk about the things that we

826
00:37:36,059 --> 00:37:32,229
have to do to make the measurement at

827
00:37:39,120 --> 00:37:36,069
that level so we we have a radio system

828
00:37:42,029 --> 00:37:39,130
that is at a very high frequency so that

829
00:37:43,200 --> 00:37:42,039
that's a good start to make a relative

830
00:37:46,560 --> 00:37:43,210
measurement

831
00:37:48,420 --> 00:37:46,570
but we have to make incredible

832
00:37:50,160 --> 00:37:48,430
corrections to be able to figure out

833
00:37:52,380 --> 00:37:50,170
where the two spacecraft are and what

834
00:37:55,680 --> 00:37:52,390
the relative timing of the of the two

835
00:37:59,339 --> 00:37:55,690
spacecraft are so are actually our

836
00:38:02,609 --> 00:37:59,349
biggest source of error in the

837
00:38:05,070 --> 00:38:02,619
measurement is the pressure of sunlight

838
00:38:09,030 --> 00:38:05,080

on the solar panels which we have to

839
00:38:12,630 --> 00:38:09,040
calculate and correct for we have to

840
00:38:15,240 --> 00:38:12,640
take into account the masses of all the

841
00:38:18,660 --> 00:38:15,250
planets in the solar system we have to

842
00:38:21,480 --> 00:38:18,670
take into account corrections due to

843
00:38:25,140 --> 00:38:21,490
general relativity which is a very very

844
00:38:28,620 --> 00:38:25,150
small force we have to make corrections

845
00:38:32,099 --> 00:38:28,630
for the weather at the sites where we

846
00:38:34,410 --> 00:38:32,109
have tracking stations on earth so

847
00:38:39,480 --> 00:38:34,420
making corrections for things like the

848
00:38:42,599 --> 00:38:39,490
ionosphere and and we even correct for

849
00:38:47,700 --> 00:38:42,609
the tectonic drift of the plates that

850
00:38:49,320 --> 00:38:47,710
the radio tracking antennas are on so so

851
00:38:54,480 --> 00:38:49,330
to be able to make a measurement that

852
00:38:56,880 --> 00:38:54,490
precise is is just an absolutely it's a

853
00:38:59,820 --> 00:38:56,890
it really takes an extraordinary amount

854
00:39:03,240 --> 00:38:59,830
of work so obviously Grail is a mission

855
00:39:05,790 --> 00:39:03,250
where you won't be able to log on to the

856
00:39:07,760 --> 00:39:05,800
website every day and see a brand-new

857
00:39:11,339 --> 00:39:07,770
gravitational result because of the

858
00:39:14,970 --> 00:39:11,349
immense amount of processing that goes

859
00:39:19,070 --> 00:39:14,980
on with this mission so but when we

860
00:39:22,950 --> 00:39:19,080
produce the products it'll really be

861
00:39:25,620 --> 00:39:22,960
spectacular I think and not just to the

862
00:39:28,589 --> 00:39:25,630
clarification hours Irene Klotz who

863
00:39:30,960 --> 00:39:28,599

writes varieties and discover and other

864
00:39:32,970 --> 00:39:30,970
publications so Thank You Irene the next

865
00:39:41,640 --> 00:39:32,980
question is from mike wall from space

866
00:39:44,040 --> 00:39:41,650
com Mike oh yeah hi um this is this is a

867
00:39:45,480 --> 00:39:44,050
question about the launch I guess and

868
00:39:47,430 --> 00:39:45,490
what what you guys have had to do to

869
00:39:49,980 --> 00:39:47,440
prepare could you just speak speak

870
00:39:52,470 --> 00:39:49,990
briefly about what the big storm has

871
00:39:53,970 --> 00:39:52,480
kind of done to your preparations if

872
00:39:55,930 --> 00:39:53,980
it's affected them at all and if you're

873
00:39:58,300 --> 00:39:55,940
anticipating any other kind of

874
00:40:00,460 --> 00:39:58,310
from from Hurricane Irene all right when

875
00:40:04,120 --> 00:40:00,470
we we heard about I first heard about

876
00:40:06,220 --> 00:40:04,130
Irene about last Sunday and we quickly

877
00:40:08,500 --> 00:40:06,230
decided we have to get ready for this

878
00:40:12,210 --> 00:40:08,510
and so what we did is we moved up our

879
00:40:14,680 --> 00:40:12,220
schedule a couple days and we actually

880
00:40:16,600 --> 00:40:14,690
put the fairing on this on there on the

881
00:40:19,930 --> 00:40:16,610
launch vehicle a few days ahead of

882
00:40:22,900 --> 00:40:19,940
schedule on tuesday in order to prepare

883
00:40:26,080 --> 00:40:22,910
for this and so and then we instituted

884
00:40:29,020 --> 00:40:26,090
our hurricane plan and made all kinds of

885
00:40:30,640 --> 00:40:29,030
preparations and it's looked looking

886
00:40:32,320 --> 00:40:30,650
like that we're going to be okay and it

887
00:40:38,260 --> 00:40:32,330
will have no impact on on the grill

888
00:40:40,270 --> 00:40:38,270

mission are our colleagues at ula who

889
00:40:43,990 --> 00:40:40,280
are taking care of the launch vehicle

890
00:40:47,320 --> 00:40:44,000
and down at KSC have just they added

891
00:40:49,000 --> 00:40:47,330
extra shifts in the work to get all this

892
00:40:51,520 --> 00:40:49,010
done to make sure that they could secure

893
00:40:55,210 --> 00:40:51,530
the spacecraft and so so we've had

894
00:40:58,990 --> 00:40:55,220
really amazing help from from KSC and

895
00:41:02,230 --> 00:40:59,000
ula on this to really to really get this

896
00:41:04,840 --> 00:41:02,240
i feel i feel very comfortable that the

897
00:41:06,400 --> 00:41:04,850
the spacecraft are going to be safe

898
00:41:08,320 --> 00:41:06,410
during the storm I worry more about

899
00:41:10,990 --> 00:41:08,330
whether I'm going to be able to get from

900
00:41:13,500 --> 00:41:11,000
Boston down to Cape Canaveral early next

901
00:41:16,930 --> 00:41:13,510
week when I'm supposed to be down there

902
00:41:19,870 --> 00:41:16,940
well thank you and that's going to do it

903
00:41:22,780 --> 00:41:19,880
for us today it all systems I currently

904
00:41:26,020 --> 00:41:22,790
go for launch in September again go to

905
00:41:27,790 --> 00:41:26,030
ww is a gov / grail for the latest

906
00:41:30,790 --> 00:41:27,800
developments and information on the

907
00:41:32,320 --> 00:41:30,800
science thank you for joining us and we