CHELYABINSK EVENT

February 15, 2013
1613 citizens injured
~$30 million damages

1
00:00:05,670 --> 00:00:03,350
good evening and welcome to nasa's

2
00:00:08,310 --> 00:00:05,680
asteroid initiative idea synthesis

3
00:00:10,470 --> 00:00:08,320
workshop we're broadcasting live on nasa

4
00:00:13,030 --> 00:00:10,480
tv from the lunar and planetary

5
00:00:14,709 --> 00:00:13,040
institute in houston texas

6
00:00:17,349 --> 00:00:14,719
over the next couple of days we'll be

7
00:00:18,710 --> 00:00:17,359
talking about the 96 ideas that were

8
00:00:21,670 --> 00:00:18,720
selected from

9
00:00:23,429 --> 00:00:21,680
more more than 400 responses to nasa's

10
00:00:26,150 --> 00:00:23,439
asteroid initiative

11
00:00:27,189 --> 00:00:26,160
request for information released back in

12
00:00:29,589 --> 00:00:27,199
june

13
00:00:34,549 --> 00:00:29,599

for those of you tuning in online we

14
00:00:40,150 --> 00:00:37,510
chat rooms set up and the workshop

15
00:00:42,709 --> 00:00:40,160
hashtag is nasa asteroid

16
00:00:44,389 --> 00:00:42,719
and we'll have hashtags for each topic

17
00:00:46,549 --> 00:00:44,399
session

18
00:00:48,549 --> 00:00:46,559
we ask that you actively participate and

19
00:00:50,869 --> 00:00:48,559
keep the conversation going

20
00:00:53,750 --> 00:00:50,879
all the virtual participation options

21
00:00:55,270 --> 00:00:53,760
are available at nasa.gov

22
00:00:57,670 --> 00:00:55,280
asteroid workshop

23
00:01:00,229 --> 00:00:57,680
and now it is my pleasure to introduce

24
00:01:05,509 --> 00:01:00,239
dr stephen mackwell he's the director of

25
00:01:09,030 --> 00:01:06,710
thank you

26
00:01:11,190 --> 00:01:09,040
it's a great pleasure to welcome

27
00:01:13,830 --> 00:01:11,200
everybody back it's only been what 51

28
00:01:16,070 --> 00:01:13,840
days for many of you um

29
00:01:18,710 --> 00:01:16,080
for those of you who are here

30
00:01:20,870 --> 00:01:18,720
it just before october began uh welcome

31
00:01:22,630 --> 00:01:20,880
back uh we put on some rather cooler

32
00:01:24,630 --> 00:01:22,640
weather for you which

33
00:01:25,670 --> 00:01:24,640
is nice it's pretty time of year in

34
00:01:27,749 --> 00:01:25,680
houston

35
00:01:30,149 --> 00:01:27,759
the um

36
00:01:32,390 --> 00:01:30,159
the meeting that that we started 50 days

37
00:01:34,550 --> 00:01:32,400
ago was um was a very interesting

38
00:01:36,149 --> 00:01:34,560

exciting meeting i think it was uh it

39
00:01:39,190 --> 00:01:36,159
was great um

40
00:01:42,389 --> 00:01:39,200
turn out of people great flux of ideas

41
00:01:43,830 --> 00:01:42,399
it was a great beginning to this meeting

42
00:01:45,590 --> 00:01:43,840
and i think um

43
00:01:47,749 --> 00:01:45,600
you know we really do have a uh the

44
00:01:49,749 --> 00:01:47,759
stage set for a very exciting couple of

45
00:01:51,590 --> 00:01:49,759
days here and i'm looking forward to

46
00:01:53,109 --> 00:01:51,600
hearing the presentations and seeing

47
00:01:55,270 --> 00:01:53,119
what we can do here in the next couple

48
00:01:57,590 --> 00:01:55,280
of days but it's um obviously it's a

49
00:01:59,030 --> 00:01:57,600
very important and vibrant topic and one

50
00:02:02,230 --> 00:01:59,040
with a lot of opportunities going

51
00:02:05,190 --> 00:02:02,240
forward so welcome again um

52
00:02:07,109 --> 00:02:05,200
i would suggest that um that

53
00:02:08,630 --> 00:02:07,119
tomorrow at the end of the sessions i

54
00:02:11,029 --> 00:02:08,640
guess the session kind of ends up

55
00:02:12,630 --> 00:02:11,039
sometime around 5 30 or something like

56
00:02:14,790 --> 00:02:12,640
that tomorrow or the two sessions going

57
00:02:16,390 --> 00:02:14,800
to end up around then tomorrow evening

58
00:02:19,510 --> 00:02:16,400
and this is purely coincidence we didn't

59
00:02:21,030 --> 00:02:19,520
do this but tomorrow evening um

60
00:02:23,270 --> 00:02:21,040
david crank one of the scientists here

61
00:02:25,750 --> 00:02:23,280
at the lpi is giving a presentation at

62
00:02:28,710 --> 00:02:25,760
um 7 30 it's a public presentation on

63
00:02:30,470 --> 00:02:28,720

the 2003 taliban air burst

64
00:02:32,550 --> 00:02:30,480
and the hazards of near-earth asteroid

65
00:02:35,110 --> 00:02:32,560
impacts and that's going to be on in

66
00:02:38,229 --> 00:02:35,120
this room tomorrow evening at 7 30. it's

67
00:02:39,830 --> 00:02:38,239
a public public kind of presentation so

68
00:02:41,750 --> 00:02:39,840
the the level is going to be pitched

69
00:02:43,589 --> 00:02:41,760
fairly broadly um david is a good

70
00:02:45,030 --> 00:02:43,599
speaker so um so it should be pretty

71
00:02:46,550 --> 00:02:45,040
good and afterwards there'll be

72
00:02:49,270 --> 00:02:46,560
refreshments out in the great room here

73
00:02:50,949 --> 00:02:49,280
so everybody of course is welcome to

74
00:02:53,110 --> 00:02:50,959
disappear quickly for dinner and come

75
00:02:55,670 --> 00:02:53,120
back for that if you wish um

76
00:02:57,589 --> 00:02:55,680
discontinuing the theme of asteroids law

77
00:03:00,229 --> 00:02:57,599
one final thing i have to do and it's a

78
00:03:02,710 --> 00:03:00,239
requirement that i do here is that

79
00:03:04,710 --> 00:03:02,720
for those of you who've heard it before

80
00:03:05,910 --> 00:03:04,720
if a fire alarm goes off

81
00:03:07,589 --> 00:03:05,920
leave

82
00:03:09,670 --> 00:03:07,599
okay

83
00:03:11,110 --> 00:03:09,680
we have fire exits at the back i'll tell

84
00:03:12,949 --> 00:03:11,120
you if the fire alarm goes off you will

85
00:03:15,350 --> 00:03:12,959
know the fire alarm went off

86
00:03:17,430 --> 00:03:15,360
um we actually had alarm go off the last

87
00:03:20,309 --> 00:03:17,440
time when we started that wasn't the

88
00:03:22,070 --> 00:03:20,319

fire alarm that was the quiet one

89
00:03:23,830 --> 00:03:22,080
the real fire alarm will have you out of

90
00:03:25,190 --> 00:03:23,840
the building very quickly the easiest

91
00:03:26,869 --> 00:03:25,200
way to go is out through the doors here

92
00:03:28,869 --> 00:03:26,879
and back out through the foyer and out

93
00:03:30,390 --> 00:03:28,879
into the parking lot

94
00:03:31,750 --> 00:03:30,400
there are also fire escapes at the back

95
00:03:33,270 --> 00:03:31,760
here

96
00:03:34,630 --> 00:03:33,280
the only other thing i have to mention

97
00:03:36,309 --> 00:03:34,640
you probably all know this already

98
00:03:37,509 --> 00:03:36,319
because most of you have been already

99
00:03:40,149 --> 00:03:37,519
bathrooms

100
00:03:42,070 --> 00:03:40,159
down the corridor over there

101
00:03:43,830 --> 00:03:42,080
down that hallway you'll find bathrooms

102
00:03:45,750 --> 00:03:43,840
there's also bathrooms couple of

103
00:03:47,430 --> 00:03:45,760
bathrooms just in the back here so i

104
00:03:48,390 --> 00:03:47,440
know everybody online really needed to

105
00:03:50,390 --> 00:03:48,400
know that

106
00:03:51,589 --> 00:03:50,400
so with that thank you very much and

107
00:03:53,990 --> 00:03:51,599
i'll pass it

108
00:03:59,270 --> 00:03:55,110
thank you

109
00:04:02,149 --> 00:03:59,280
next up we have michelle gates from the

110
00:04:04,070 --> 00:04:02,159
human exploration admissions operation

111
00:04:05,830 --> 00:04:04,080
directorate at nasa headquarters

112
00:04:10,630 --> 00:04:05,840
michelle is going to give us a brief

113
00:04:15,429 --> 00:04:12,470

hi welcome back

114
00:04:17,830 --> 00:04:15,439
it's very unfortunate that we were

115
00:04:19,270 --> 00:04:17,840
so abruptly cut off the last time we all

116
00:04:21,509 --> 00:04:19,280
met

117
00:04:23,670 --> 00:04:21,519
but we're very excited to continue with

118
00:04:26,950 --> 00:04:23,680
what was very important to us

119
00:04:28,710 --> 00:04:26,960
as well as many of our stakeholders

120
00:04:29,990 --> 00:04:28,720
and so what i thought i'd do today is

121
00:04:32,150 --> 00:04:30,000
just give

122
00:04:34,230 --> 00:04:32,160
a couple chart overview of some of the

123
00:04:35,670 --> 00:04:34,240
stuff we talked about last time in the

124
00:04:37,830 --> 00:04:35,680
plenary session

125
00:04:40,550 --> 00:04:37,840
and then briefly review the objectives

126
00:04:43,350 --> 00:04:40,560
of the workshop as well as the charge to

127
00:04:48,230 --> 00:04:43,360
the session chairs for the closing

128
00:04:52,790 --> 00:04:49,909
so you'll remember that there are two

129
00:04:55,030 --> 00:04:52,800
aspects of the asteroid initiative

130
00:04:59,110 --> 00:04:55,040
one is the grand challenge jason kessler

131
00:05:00,550 --> 00:04:59,120
and jen costetic who are here i believe

132
00:05:02,310 --> 00:05:00,560
are going to be leading that i think

133
00:05:04,390 --> 00:05:02,320
there's three sessions in this workshop

134
00:05:06,469 --> 00:05:04,400
on the grin challenge

135
00:05:07,990 --> 00:05:06,479
which includes

136
00:05:10,550 --> 00:05:08,000
the cert

137
00:05:12,390 --> 00:05:10,560
next slide finding all asteroid threats

138
00:05:13,590 --> 00:05:12,400

to human populations and knowing what to

139
00:05:15,590 --> 00:05:13,600
do about them

140
00:05:17,749 --> 00:05:15,600
so i know jason and jen are very much

141
00:05:20,150 --> 00:05:17,759
looking forward to getting started in

142
00:05:22,070 --> 00:05:20,160
this workshop with finishing up what was

143
00:05:24,950 --> 00:05:22,080
important to them in their planning that

144
00:05:26,550 --> 00:05:24,960
we started in october the other aspect

145
00:05:29,110 --> 00:05:26,560
of the initiative as you know is the

146
00:05:31,510 --> 00:05:29,120
asteroid redirect mission there are

147
00:05:34,070 --> 00:05:31,520
elements that are unique to each and

148
00:05:36,629 --> 00:05:34,080
there are elements that are

149
00:05:41,029 --> 00:05:36,639
common and leveraged for both so they're

150
00:05:44,710 --> 00:05:42,790
you may recall this slide as well which

151
00:05:46,790 --> 00:05:44,720
talks about the near-term strategy for

152
00:05:49,110 --> 00:05:46,800
the asteroid redirect mission

153
00:05:50,469 --> 00:05:49,120
which includes leveraging ongoing

154
00:05:54,469 --> 00:05:50,479
activities

155
00:05:56,870 --> 00:05:54,479
in the science mission directorate which

156
00:05:57,990 --> 00:05:56,880
we have called the identify segment of

157
00:05:59,430 --> 00:05:58,000
the mission

158
00:06:01,510 --> 00:05:59,440
which includes

159
00:06:04,390 --> 00:06:01,520
studies and trades right now as well as

160
00:06:06,629 --> 00:06:04,400
upgrades and observation assets that

161
00:06:09,670 --> 00:06:06,639
lindley johnson will be talking to you

162
00:06:11,830 --> 00:06:09,680
about a little bit later this evening

163
00:06:14,629 --> 00:06:11,840

in the redirect

164
00:06:16,469 --> 00:06:14,639
mission segment

165
00:06:18,309 --> 00:06:16,479
there is a reference mission that is

166
00:06:20,469 --> 00:06:18,319
currently being studied as well as an

167
00:06:22,629 --> 00:06:20,479
alternate mission and we're looking

168
00:06:24,870 --> 00:06:22,639
forward to your ideas hearing those in

169
00:06:26,950 --> 00:06:24,880
this meeting as well as

170
00:06:29,110 --> 00:06:26,960
your thoughts and inputs in the

171
00:06:31,350 --> 00:06:29,120
synthesis session

172
00:06:33,830 --> 00:06:31,360
the last segment is the redirect crude

173
00:06:35,270 --> 00:06:33,840
mission which includes

174
00:06:38,150 --> 00:06:35,280
leveraging the activities that the

175
00:06:40,790 --> 00:06:38,160
agency has going on right now the orion

176
00:06:41,830 --> 00:06:40,800
and sls vehicles and how we can use

177
00:06:42,710 --> 00:06:41,840
those

178
00:06:44,550 --> 00:06:42,720
uh

179
00:06:46,230 --> 00:06:44,560
beyond the moon to accomplish this

180
00:06:49,110 --> 00:06:46,240
compelling mission steve stitch is going

181
00:06:51,990 --> 00:06:49,120
to be speaking after me in detail about

182
00:06:54,230 --> 00:06:52,000
that and sharing some updates as well

183
00:06:56,550 --> 00:06:54,240
we have evolved our thinking on the

184
00:06:58,309 --> 00:06:56,560
mission objectives and we have listened

185
00:07:00,230 --> 00:06:58,319
to the feedback that we have received to

186
00:07:01,670 --> 00:07:00,240
date

187
00:07:03,749 --> 00:07:01,680
so i wanted to share with you today this

188
00:07:06,070 --> 00:07:03,759

is actually the first time that i think

189
00:07:07,909 --> 00:07:06,080
we've talked broadly about this

190
00:07:09,510 --> 00:07:07,919
but the primary objectives that we're

191
00:07:13,189 --> 00:07:09,520
currently planning

192
00:07:15,189 --> 00:07:13,199
to and doing analysis against are human

193
00:07:17,749 --> 00:07:15,199
exploration in the mid-2020s to an

194
00:07:19,909 --> 00:07:17,759
asteroid that prepares for future

195
00:07:21,830 --> 00:07:19,919
exploration activities

196
00:07:24,309 --> 00:07:21,840
technology demonstration of advanced

197
00:07:26,870 --> 00:07:24,319
solar electric propulsion and enhanced

198
00:07:29,350 --> 00:07:26,880
detection and observation of near earth

199
00:07:31,510 --> 00:07:29,360
asteroids for planetary defense those

200
00:07:33,270 --> 00:07:31,520
are the three main areas that we're

201
00:07:35,430 --> 00:07:33,280
looking at as the primary objectives of

202
00:07:37,589 --> 00:07:35,440
the mission there are many secondary

203
00:07:40,070 --> 00:07:37,599
benefits and objectives

204
00:07:43,110 --> 00:07:40,080
as you have heard previously and that we

205
00:07:45,670 --> 00:07:43,120
have talked about broadly at length as

206
00:07:47,589 --> 00:07:45,680
this initiative is so broad and that

207
00:07:49,830 --> 00:07:47,599
includes asteroid deflection

208
00:07:53,350 --> 00:07:49,840
demonstration or proof of concept which

209
00:07:55,270 --> 00:07:53,360
is another aspect of planetary defense

210
00:07:56,790 --> 00:07:55,280
linley johnson again here i'm going to

211
00:07:58,469 --> 00:07:56,800
talk about that

212
00:08:00,150 --> 00:07:58,479
science benefits international

213
00:08:01,830 --> 00:08:00,160

partnership opportunities commercial

214
00:08:03,510 --> 00:08:01,840
partnership opportunities

215
00:08:06,469 --> 00:08:03,520
excuse me opportunities and that

216
00:08:08,309 --> 00:08:06,479
includes for example in situ resource

217
00:08:09,909 --> 00:08:08,319
utilization

218
00:08:10,830 --> 00:08:09,919
there's also some ground rules that

219
00:08:13,670 --> 00:08:10,840
we've been

220
00:08:16,309 --> 00:08:13,680
taking in our analysis as

221
00:08:18,550 --> 00:08:16,319
boundaries including affordability

222
00:08:22,550 --> 00:08:18,560
manageable risk tolerance and technical

223
00:08:26,710 --> 00:08:25,029
we currently have three internal mission

224
00:08:28,390 --> 00:08:26,720
studies going on

225
00:08:29,510 --> 00:08:28,400
one is the reference robotic mission

226
00:08:31,670 --> 00:08:29,520
concept

227
00:08:34,469 --> 00:08:31,680
which again is to redirect a small

228
00:08:36,310 --> 00:08:34,479
near-earth asteroid to a stable orbit in

229
00:08:39,029 --> 00:08:36,320
the lunar vicinity and potentially

230
00:08:40,389 --> 00:08:39,039
demonstrate asteroid deflection

231
00:08:42,709 --> 00:08:40,399
the studies being led by the jet

232
00:08:43,990 --> 00:08:42,719
propulsion lab it's nasa wide and

233
00:08:45,430 --> 00:08:44,000
there's significant involvement in

234
00:08:46,310 --> 00:08:45,440
partnership with the glenn research

235
00:08:47,670 --> 00:08:46,320
center

236
00:08:49,110 --> 00:08:47,680
in that study

237
00:08:50,230 --> 00:08:49,120
we're also looking at an alternate

238
00:08:51,990 --> 00:08:50,240

concept

239
00:08:54,310 --> 00:08:52,000
to redirect a small

240
00:08:57,110 --> 00:08:54,320
mass from a larger asteroid and

241
00:08:59,670 --> 00:08:57,120
potentially demonstrate

242
00:09:01,350 --> 00:08:59,680
potentially hazardous asteroid size

243
00:09:03,269 --> 00:09:01,360
deflection

244
00:09:05,670 --> 00:09:03,279
the study this study is being led by

245
00:09:07,350 --> 00:09:05,680
langley research center it also includes

246
00:09:09,110 --> 00:09:07,360
many of the same members as a previous

247
00:09:11,030 --> 00:09:09,120
study and so we're looking forward to

248
00:09:13,590 --> 00:09:11,040
how both of those turn out as well as

249
00:09:15,750 --> 00:09:13,600
evolve with the ideas in this workshop

250
00:09:18,630 --> 00:09:15,760
the crude mission is being looked at by

251
00:09:19,910 --> 00:09:18,640
the johnson space center and again steve

252
00:09:20,829 --> 00:09:19,920
we'll talk to you more about that when

253
00:09:23,670 --> 00:09:20,839
he comes

254
00:09:25,350 --> 00:09:23,680
up this slide is just a brief summary of

255
00:09:27,670 --> 00:09:25,360
our current status which has evolved

256
00:09:30,150 --> 00:09:27,680
since the last first day of the workshop

257
00:09:31,990 --> 00:09:30,160
that we had previously

258
00:09:34,230 --> 00:09:32,000
we have charted a robotic concept

259
00:09:36,310 --> 00:09:34,240
integration team that team is being led

260
00:09:37,509 --> 00:09:36,320
by jim ryder from the marshall space

261
00:09:39,829 --> 00:09:37,519
flight center who's sitting over there

262
00:09:42,550 --> 00:09:39,839
just raised his hand he's also the chair

263
00:09:47,750 --> 00:09:44,550

redirect session

264
00:09:51,430 --> 00:09:49,509
consistent with our guidance our

265
00:09:52,949 --> 00:09:51,440
acquisition strategy foundation is to

266
00:09:54,470 --> 00:09:52,959
leverage ongoing work and you all are

267
00:09:56,630 --> 00:09:54,480
well aware of that

268
00:09:58,630 --> 00:09:56,640
we we do want to pursue partnerships and

269
00:10:00,470 --> 00:09:58,640
participatory engagement this

270
00:10:02,710 --> 00:10:00,480
workshop is a part of that and we have

271
00:10:04,630 --> 00:10:02,720
some internal status briefings scheduled

272
00:10:07,509 --> 00:10:04,640
and are planning an industry day for the

273
00:10:09,430 --> 00:10:07,519
spring of next year in which we'll stick

274
00:10:12,069 --> 00:10:09,440
will share our status

275
00:10:14,069 --> 00:10:12,079
as a result of near-term decisions

276
00:10:16,949 --> 00:10:14,079
including this meeting

277
00:10:18,470 --> 00:10:16,959
planned updates to fy14 plans as well as

278
00:10:20,230 --> 00:10:18,480
communicate our

279
00:10:22,630 --> 00:10:20,240
plan in the 15

280
00:10:24,870 --> 00:10:22,640
nasa budget

281
00:10:27,430 --> 00:10:24,880
we did want to emphasize this time that

282
00:10:29,910 --> 00:10:27,440
we believe this activity does advance

283
00:10:31,910 --> 00:10:29,920
existing policy goals there's a list

284
00:10:33,750 --> 00:10:31,920
that you can read at your leisure or

285
00:10:37,030 --> 00:10:33,760
we'd be happy to talk about there are

286
00:10:39,430 --> 00:10:37,040
several areas of bipartisan part

287
00:10:43,509 --> 00:10:39,440
of bipartisan policy

288
00:10:45,269 --> 00:10:43,519

that this initiative is responsive to

289
00:10:46,630 --> 00:10:45,279
chris moore we'll talk to you more this

290
00:10:49,269 --> 00:10:46,640
evening about

291
00:10:50,630 --> 00:10:49,279
a summary of the rfi results

292
00:10:53,430 --> 00:10:50,640
as well as

293
00:10:55,670 --> 00:10:53,440
the review process

294
00:10:56,949 --> 00:10:55,680
and here's the core why we're here at

295
00:10:59,110 --> 00:10:56,959
this meeting

296
00:11:00,949 --> 00:10:59,120
is to hear what you have to say

297
00:11:03,030 --> 00:11:00,959
we want to examine and foster a broad

298
00:11:05,430 --> 00:11:03,040
discussion on the ideas coming forth in

299
00:11:07,750 --> 00:11:05,440
this meeting as well as discuss debate

300
00:11:11,030 --> 00:11:07,760
and synthesize a set of findings that we

301
00:11:13,110 --> 00:11:11,040
can take back and use within nasa

302
00:11:15,190 --> 00:11:13,120
our nasa personnel will serve as leads

303
00:11:17,670 --> 00:11:15,200
in our discussions but we ask for your

304
00:11:20,470 --> 00:11:17,680
active participation you'll see in the

305
00:11:23,030 --> 00:11:20,480
workshop sessions the cdm the seating is

306
00:11:25,670 --> 00:11:23,040
auditory and styled but that is just due

307
00:11:27,829 --> 00:11:25,680
to space limitation please have open

308
00:11:30,150 --> 00:11:27,839
discussion please feel free to speak up

309
00:11:31,750 --> 00:11:30,160
we have already read the rfis we really

310
00:11:33,590 --> 00:11:31,760
want to hear what you have to say and

311
00:11:34,630 --> 00:11:33,600
what you think including the folks

312
00:11:36,550 --> 00:11:34,640
online

313
00:11:39,350 --> 00:11:36,560

there's chat rooms there's twitter we've

314
00:11:41,030 --> 00:11:39,360
got facilitators and moderators who are

315
00:11:44,069 --> 00:11:41,040
available in the sessions to help with

316
00:11:48,949 --> 00:11:46,150
and so friday morning we'll be hearing

317
00:11:51,829 --> 00:11:48,959
the synthesis results of each session

318
00:11:53,190 --> 00:11:51,839
presented to us by the session chairs

319
00:11:55,350 --> 00:11:53,200
they've been given a request for

320
00:11:58,310 --> 00:11:55,360
specific areas to bring out of the

321
00:12:00,150 --> 00:11:58,320
session discussions and present to us

322
00:12:01,350 --> 00:12:00,160
this is a summary chart here but chris

323
00:12:03,030 --> 00:12:01,360
moore is actually going to talk to you a

324
00:12:04,710 --> 00:12:03,040
little bit more about this when he gets

325
00:12:07,750 --> 00:12:04,720
up

326
00:12:11,190 --> 00:12:09,269
thank you michelle

327
00:12:13,829 --> 00:12:11,200
next we're going to hear from steve

328
00:12:16,389 --> 00:12:13,839
stitch he's the deputy director at

329
00:12:18,790 --> 00:12:16,399
johnson space center here in houston and

330
00:12:21,030 --> 00:12:18,800
as michelle stated he's going to talk

331
00:12:23,190 --> 00:12:21,040
about the asteroid redirect mission with

332
00:12:25,190 --> 00:12:23,200
the focus on current activities related

333
00:12:27,269 --> 00:12:25,200
to the crew portion

334
00:12:28,870 --> 00:12:27,279
thanks thanks wendy before i get started

335
00:12:31,269 --> 00:12:28,880
i'd like to thank dr maxwell and lunar

336
00:12:33,190 --> 00:12:31,279
planetary institute for uh for hosting

337
00:12:35,430 --> 00:12:33,200
us again here i think uh they have

338
00:12:36,710 --> 00:12:35,440

treated this very well we're not like

339
00:12:39,430 --> 00:12:36,720
in-laws or something that won't leave

340
00:12:41,269 --> 00:12:39,440
but but thanks very much for hosting us

341
00:12:43,030 --> 00:12:41,279
again and also on behalf of the johnson

342
00:12:44,870 --> 00:12:43,040
space center eleanor children kirk

343
00:12:45,829 --> 00:12:44,880
sherman the center director and deputy

344
00:12:47,430 --> 00:12:45,839
center director i'd like to welcome

345
00:12:49,190 --> 00:12:47,440
everybody here to the

346
00:12:50,550 --> 00:12:49,200
ashford workshop

347
00:12:52,550 --> 00:12:50,560
i'm going to try to talk a little bit

348
00:12:54,790 --> 00:12:52,560
tonight uh about what we've been doing

349
00:12:56,790 --> 00:12:54,800
relative to the mission and also sort of

350
00:12:58,710 --> 00:12:56,800
frame it in the context of

351
00:13:00,389 --> 00:12:58,720
the capability driven framework and how

352
00:13:02,069 --> 00:13:00,399
what we're doing with this first

353
00:13:03,990 --> 00:13:02,079
exploration mission

354
00:13:05,350 --> 00:13:04,000
uh as one mission in a series of

355
00:13:07,269 --> 00:13:05,360
missions we're trying to take

356
00:13:08,230 --> 00:13:07,279
capabilities that we're building

357
00:13:13,990 --> 00:13:08,240
across

358
00:13:15,990 --> 00:13:14,000
mission directorate and pull those

359
00:13:17,829 --> 00:13:16,000
together into a single mission

360
00:13:20,389 --> 00:13:17,839
if you look at this image

361
00:13:21,910 --> 00:13:20,399
this is a pretty bold uh mission

362
00:13:25,350 --> 00:13:21,920
if you think about this time frame in

363
00:13:26,790 --> 00:13:25,360

the in the early 2020s some 50 years

364
00:13:29,509 --> 00:13:26,800
after we would have flown the apollo

365
00:13:30,790 --> 00:13:29,519
missions we will send two crew members

366
00:13:32,310 --> 00:13:30,800
further into deep space and they've ever

367
00:13:33,190 --> 00:13:32,320
traveled before

368
00:13:34,790 --> 00:13:33,200
to

369
00:13:36,870 --> 00:13:34,800
obtain some samples from an asteroid

370
00:13:39,110 --> 00:13:36,880
that we've moved there using a robotic

371
00:13:40,230 --> 00:13:39,120
spacecraft so it's a very ambitious

372
00:13:42,069 --> 00:13:40,240
mission as a former shuttle flight

373
00:13:43,110 --> 00:13:42,079
director i think about this mission

374
00:13:45,110 --> 00:13:43,120
and i think

375
00:13:47,670 --> 00:13:45,120
wow it'd be great to be on console for

376
00:13:51,829 --> 00:13:50,389
so within hilo we're really operating on

377
00:13:54,790 --> 00:13:51,839
six principles in terms of putting

378
00:13:56,710 --> 00:13:54,800
together our exploration plan we need to

379
00:13:58,310 --> 00:13:56,720
execute our missions within a

380
00:14:00,949 --> 00:13:58,320
sustainable budget

381
00:14:03,189 --> 00:14:00,959
uh we realize uh the situation relative

382
00:14:05,350 --> 00:14:03,199
to the budget and so we have to keep

383
00:14:08,629 --> 00:14:05,360
that in mind as we build our missions

384
00:14:11,030 --> 00:14:08,639
we're trying to take high trl high uh

385
00:14:13,189 --> 00:14:11,040
very mature technologies that are ready

386
00:14:16,069 --> 00:14:13,199
to be infused into a mission and bring

387
00:14:17,350 --> 00:14:16,079
those together into a compelling mission

388
00:14:20,150 --> 00:14:17,360

we're also looking for near-term

389
00:14:21,990 --> 00:14:20,160
opportunities uh to to fly in space to

390
00:14:24,310 --> 00:14:22,000
push forward in deep space

391
00:14:26,629 --> 00:14:24,320
uh relative to to eventual goal of

392
00:14:28,870 --> 00:14:26,639
sending humans to mars in the 2030s and

393
00:14:30,790 --> 00:14:28,880
then we also look for opportunities to

394
00:14:32,949 --> 00:14:30,800
to bring our commercial partnerships

395
00:14:35,509 --> 00:14:32,959
along and commercial business to further

396
00:14:37,110 --> 00:14:35,519
enhance that industry as well we've had

397
00:14:38,790 --> 00:14:37,120
great partnerships uh on the

398
00:14:40,550 --> 00:14:38,800
international space station with

399
00:14:42,069 --> 00:14:40,560
commercial cargo and so we see this as

400
00:14:43,910 --> 00:14:42,079
another avenue that's very important as

401
00:14:45,910 --> 00:14:43,920
we build our strategy and then we're

402
00:14:47,509 --> 00:14:45,920
looking to put together uh

403
00:14:49,829 --> 00:14:47,519
infrastructure in space that's that's

404
00:14:51,269 --> 00:14:49,839
used for a long time that can't be kind

405
00:14:53,269 --> 00:14:51,279
of a single purpose mission but it needs

406
00:14:54,389 --> 00:14:53,279
to kind of feed forward to deep space

407
00:14:55,829 --> 00:14:54,399
exploration

408
00:14:57,430 --> 00:14:55,839
and then again we want to work strongly

409
00:14:58,629 --> 00:14:57,440
with our international partners and

410
00:15:00,470 --> 00:14:58,639
leverage the partnerships that we have

411
00:15:01,990 --> 00:15:00,480
on the international space station today

412
00:15:04,629 --> 00:15:02,000
and also our commercial partnerships as

413
00:15:07,189 --> 00:15:04,639

we move forward

414
00:15:09,189 --> 00:15:07,199
so our overall purpose is to move to

415
00:15:10,550 --> 00:15:09,199
move forward from the left part of the

416
00:15:13,430 --> 00:15:10,560
slide where

417
00:15:14,550 --> 00:15:13,440
today uh in the shuttle program and then

418
00:15:17,189 --> 00:15:14,560
in the international space station

419
00:15:19,670 --> 00:15:17,199
program we've been operating uh very

420
00:15:21,110 --> 00:15:19,680
well and doing a lot of great research

421
00:15:23,030 --> 00:15:21,120
and exploration on the international

422
00:15:24,949 --> 00:15:23,040
space station but we're very much in

423
00:15:27,509 --> 00:15:24,959
what we would call an earth-reliant

424
00:15:30,310 --> 00:15:27,519
centric model where we're very dependent

425
00:15:31,910 --> 00:15:30,320
on resupply from the earth we need to

426
00:15:33,509 --> 00:15:31,920
move to that final destination which is

427
00:15:36,069 --> 00:15:33,519
mars on the right-hand portion of the

428
00:15:37,910 --> 00:15:36,079
slide which is earth independent where

429
00:15:39,030 --> 00:15:37,920
we need to be much more on our own in

430
00:15:40,710 --> 00:15:39,040
terms of

431
00:15:41,590 --> 00:15:40,720
not having that supply chain from the

432
00:15:43,110 --> 00:15:41,600
earth

433
00:15:44,389 --> 00:15:43,120
and the way we're going to do this is

434
00:15:45,910 --> 00:15:44,399
we're going to move into this proving

435
00:15:48,710 --> 00:15:45,920
ground which in the middle of the slide

436
00:15:50,470 --> 00:15:48,720
you can see the moon and cislunar space

437
00:15:52,069 --> 00:15:50,480
and you can see the slide that shows the

438
00:15:53,749 --> 00:15:52,079

orion dock to

439
00:15:55,590 --> 00:15:53,759
the asteroid redirect vehicle and and

440
00:15:57,430 --> 00:15:55,600
how we would move into that area to

441
00:15:59,030 --> 00:15:57,440
begin to buy down the risk

442
00:16:01,189 --> 00:15:59,040
if you think about today on the

443
00:16:03,509 --> 00:16:01,199
international space station uh the crew

444
00:16:04,550 --> 00:16:03,519
is a mere one or two days from returning

445
00:16:05,990 --> 00:16:04,560
to earth

446
00:16:07,590 --> 00:16:06,000
um and in fact if there were an

447
00:16:09,430 --> 00:16:07,600
emergency they can be back to the earth

448
00:16:11,350 --> 00:16:09,440
within hours as we move into system of

449
00:16:14,150 --> 00:16:11,360
space those transit times are in the

450
00:16:15,749 --> 00:16:14,160
order of depending on the time chosen

451
00:16:18,069 --> 00:16:15,759
somewhere on the order of six to twelve

452
00:16:19,749 --> 00:16:18,079
days to return back to the earth and if

453
00:16:21,509 --> 00:16:19,759
you think about mars those transit times

454
00:16:23,590 --> 00:16:21,519
are on the order of six to nine months

455
00:16:25,430 --> 00:16:23,600
so we're kind of moving out you know if

456
00:16:27,350 --> 00:16:25,440
you look at it in terms of a sailing

457
00:16:29,189 --> 00:16:27,360
ship we're moving into that deep waters

458
00:16:32,550 --> 00:16:29,199
much more slowly as we evolve our

459
00:16:36,710 --> 00:16:34,150
it all starts with the international

460
00:16:38,470 --> 00:16:36,720
space station of course today is the

461
00:16:39,990 --> 00:16:38,480
15th anniversary of the first element

462
00:16:41,509 --> 00:16:40,000
launch which was zarya

463
00:16:43,829 --> 00:16:41,519

if you think about where we started 15

464
00:16:46,870 --> 00:16:43,839
years ago it was incredible we only had

465
00:16:48,069 --> 00:16:46,880
44 000 pounds of hardware in space today

466
00:16:49,990 --> 00:16:48,079
we have an international space station

467
00:16:52,150 --> 00:16:50,000
that's uh that's a little less than a

468
00:16:54,069 --> 00:16:52,160
million pounds of hardware and today the

469
00:16:56,310 --> 00:16:54,079
things we're doing on space station feed

470
00:16:58,470 --> 00:16:56,320
directly toward exploration uh we're

471
00:17:00,310 --> 00:16:58,480
testing human health and performance uh

472
00:17:01,990 --> 00:17:00,320
we're embarking on longer and longer

473
00:17:03,590 --> 00:17:02,000
crew durations we're trying to

474
00:17:05,429 --> 00:17:03,600
understand how the human body performs

475
00:17:08,230 --> 00:17:05,439
in space in terms of

476
00:17:10,470 --> 00:17:08,240
cardiac performance bone loss

477
00:17:12,870 --> 00:17:10,480
how to sustain the human body in space

478
00:17:14,309 --> 00:17:12,880
eventually in 2015 we'll fly a one year

479
00:17:15,750 --> 00:17:14,319
duration which is kind of building up

480
00:17:17,909 --> 00:17:15,760
with two crew members

481
00:17:19,590 --> 00:17:17,919
building up toward mars we're also using

482
00:17:21,829 --> 00:17:19,600
the space station as a habitability

483
00:17:24,470 --> 00:17:21,839
logistics testbed of how we would work

484
00:17:27,510 --> 00:17:24,480
those kinds of things for uh for moving

485
00:17:29,590 --> 00:17:27,520
on to to mars and then it's a technology

486
00:17:31,270 --> 00:17:29,600
testbed where we're testing things like

487
00:17:32,950 --> 00:17:31,280
a docking technology

488
00:17:34,549 --> 00:17:32,960

how do we do closed-loop life support

489
00:17:36,870 --> 00:17:34,559
better to sustain a crew all the way to

490
00:17:38,070 --> 00:17:36,880
mars those systems are in their infancy

491
00:17:40,310 --> 00:17:38,080
and they're working well in the space

492
00:17:41,830 --> 00:17:40,320
station and we need to use those systems

493
00:17:44,310 --> 00:17:41,840
to improve those systems on the space

494
00:17:45,990 --> 00:17:44,320
station to build forward

495
00:17:47,909 --> 00:17:46,000
also we can look at how well hardware

496
00:17:50,310 --> 00:17:47,919
performs in space for long durations the

497
00:17:52,150 --> 00:17:50,320
zarya element and the node uh have been

498
00:17:53,270 --> 00:17:52,160
in space for 15 years and so we can

499
00:17:54,710 --> 00:17:53,280
understand the performance of those

500
00:17:56,870 --> 00:17:54,720
systems as well

501
00:17:58,549 --> 00:17:56,880
and then of course uh today we're in the

502
00:18:00,070 --> 00:17:58,559
process of turning leo over to a

503
00:18:02,230 --> 00:18:00,080
commercial endeavors through commercial

504
00:18:04,070 --> 00:18:02,240
cargo and commercial crew programs

505
00:18:05,909 --> 00:18:04,080
and in fact this week on tuesday we

506
00:18:07,830 --> 00:18:05,919
released the request for proposals for

507
00:18:09,669 --> 00:18:07,840
the commercial crew next phase of the

508
00:18:13,430 --> 00:18:09,679
contract so we're moving moving out in

509
00:18:17,350 --> 00:18:14,390
now

510
00:18:19,830 --> 00:18:17,360
our programs today in exploration are

511
00:18:22,150 --> 00:18:19,840
not just about paper designs not just

512
00:18:24,630 --> 00:18:22,160
about analysis and documentation but

513
00:18:26,150 --> 00:18:24,640

we're really moving into a phase where

514
00:18:28,390 --> 00:18:26,160
you can see our hardware beginning to

515
00:18:29,830 --> 00:18:28,400
take shape you can see the next launch

516
00:18:32,070 --> 00:18:29,840
vehicle beginning to take shape and the

517
00:18:33,350 --> 00:18:32,080
orion spacecraft as well

518
00:18:35,350 --> 00:18:33,360
in this slide if you look at the upper

519
00:18:36,390 --> 00:18:35,360
left you can see we've had already three

520
00:18:38,390 --> 00:18:36,400
successful

521
00:18:39,990 --> 00:18:38,400
round tests of the space launch system

522
00:18:41,750 --> 00:18:40,000
development motors these are derivatives

523
00:18:43,110 --> 00:18:41,760
of the shuttle motors so again we're

524
00:18:45,430 --> 00:18:43,120
taking capabilities we've had in the

525
00:18:47,270 --> 00:18:45,440
past and building them up into the space

526
00:18:48,549 --> 00:18:47,280
launch system we've got on the upper

527
00:18:50,070 --> 00:18:48,559
right hand you've got the core stage

528
00:18:51,990 --> 00:18:50,080
computers being installed and ready for

529
00:18:53,270 --> 00:18:52,000
testing and very soon

530
00:18:57,190 --> 00:18:53,280
on the uh

531
00:18:58,789 --> 00:18:57,200
test bed the the flight test bed uh in

532
00:19:00,870 --> 00:18:58,799
the marshall space flight center at the

533
00:19:03,830 --> 00:19:00,880
michoud assembly facility in the bottom

534
00:19:05,270 --> 00:19:03,840
left we're doing friction stir welds

535
00:19:06,710 --> 00:19:05,280
on the barrel section

536
00:19:07,990 --> 00:19:06,720
the tank is derived from shuttle

537
00:19:09,990 --> 00:19:08,000
technology but we're using modern

538
00:19:12,630 --> 00:19:10,000

manufacturing and then we're about to

539
00:19:14,710 --> 00:19:12,640
get very soon back into rs 25 which is a

540
00:19:16,549 --> 00:19:14,720
derivative of the shuttle main engine

541
00:19:17,750 --> 00:19:16,559
testing on the test stands at stennis

542
00:19:19,510 --> 00:19:17,760
space center

543
00:19:22,310 --> 00:19:19,520
uh the inlet conditions are slightly

544
00:19:23,750 --> 00:19:22,320
different for uh for the sls rocket so

545
00:19:26,549 --> 00:19:23,760
the space launch system is going to be a

546
00:19:28,870 --> 00:19:26,559
very versatile launch vehicle it really

547
00:19:32,230 --> 00:19:28,880
is the key to enabling missions in deep

548
00:19:34,230 --> 00:19:32,240
space it will lift up to 25 metric tons

549
00:19:35,750 --> 00:19:34,240
to the cis lunar environment

550
00:19:37,190 --> 00:19:35,760
to the dro environment which i'll talk

551
00:19:39,270 --> 00:19:37,200
about a little longer and then it's up

552
00:19:40,630 --> 00:19:39,280
to 70 metric tons to low earth orbit

553
00:19:44,070 --> 00:19:40,640
with initial capability which is

554
00:19:46,070 --> 00:19:44,080
available to up to 130 metric tons

555
00:19:48,310 --> 00:19:46,080
when we turn to the crew vehicle orion

556
00:19:49,510 --> 00:19:48,320
is beginning to take shape as well and

557
00:19:52,390 --> 00:19:49,520
and i'll talk a little bit more about

558
00:19:54,789 --> 00:19:52,400
how orion will be very beneficial for

559
00:19:56,789 --> 00:19:54,799
this asteroid redirect mission uh we had

560
00:19:58,470 --> 00:19:56,799
a very very big milestone recently at

561
00:20:00,630 --> 00:19:58,480
the kennedy space center

562
00:20:02,549 --> 00:20:00,640
where we've done power on testing in the

563
00:20:05,029 --> 00:20:02,559

upper left hand corner

564
00:20:06,470 --> 00:20:05,039
of the slide for for the orion

565
00:20:07,990 --> 00:20:06,480
exploration flight test one

566
00:20:09,430 --> 00:20:08,000
configuration

567
00:20:11,750 --> 00:20:09,440
we're bringing those systems online

568
00:20:12,549 --> 00:20:11,760
we're powering them up exchanging data

569
00:20:13,990 --> 00:20:12,559
and

570
00:20:15,669 --> 00:20:14,000
letting the computers commit send

571
00:20:17,430 --> 00:20:15,679
commands out to the various uh

572
00:20:18,789 --> 00:20:17,440
propulsion elements and various other

573
00:20:20,390 --> 00:20:18,799
pieces of the vehicle so it's a very

574
00:20:22,950 --> 00:20:20,400
important milestone

575
00:20:24,549 --> 00:20:22,960
we've done nine parachute drop tests for

576
00:20:25,669 --> 00:20:24,559
orion to date

577
00:20:27,029 --> 00:20:25,679
and we've done a variety of

578
00:20:28,870 --> 00:20:27,039
configurations

579
00:20:31,590 --> 00:20:28,880
with here you see the the three chute

580
00:20:34,230 --> 00:20:31,600
cluster we've done one parachute out

581
00:20:35,909 --> 00:20:34,240
we've done a single drug shoot we've

582
00:20:37,430 --> 00:20:35,919
done a variety of tests to stress the

583
00:20:39,029 --> 00:20:37,440
envelope of this system

584
00:20:40,470 --> 00:20:39,039
and so far the performance has been very

585
00:20:42,230 --> 00:20:40,480
well we've been sharing this data with

586
00:20:43,990 --> 00:20:42,240
uh with our commercial

587
00:20:45,669 --> 00:20:44,000
crew partners they're using some of the

588
00:20:48,310 --> 00:20:45,679

same technology so

589
00:20:50,070 --> 00:20:48,320
again we're making great progress there

590
00:20:52,470 --> 00:20:50,080
on the upper right we've done water

591
00:20:54,390 --> 00:20:52,480
landing tests with the vehicle to

592
00:20:55,830 --> 00:20:54,400
understand how it performs and floats in

593
00:20:57,590 --> 00:20:55,840
the water environment

594
00:20:59,990 --> 00:20:57,600
at the bottom left you can see the the

595
00:21:02,390 --> 00:21:00,000
heat shield which is up at textron

596
00:21:05,270 --> 00:21:02,400
near boston and it's uh it's finalizing

597
00:21:06,870 --> 00:21:05,280
its uh preparation for being shipped to

598
00:21:08,549 --> 00:21:06,880
the kennedy space center

599
00:21:09,430 --> 00:21:08,559
later this month

600
00:21:10,710 --> 00:21:09,440
we've

601
00:21:12,470 --> 00:21:10,720
put together the back shelf for the

602
00:21:14,310 --> 00:21:12,480
exploration flight test one unit in the

603
00:21:15,590 --> 00:21:14,320
bottom uh on the bottom row in the

604
00:21:17,750 --> 00:21:15,600
middle slide

605
00:21:20,870 --> 00:21:17,760
and that's progressing well and then

606
00:21:22,390 --> 00:21:20,880
recently at it uh at sunnyvale we've

607
00:21:24,230 --> 00:21:22,400
done the fairing step test these

608
00:21:25,430 --> 00:21:24,240
fairings are on the service module and

609
00:21:27,830 --> 00:21:25,440
actually help carry the load those

610
00:21:29,270 --> 00:21:27,840
separate during powered flight very

611
00:21:32,230 --> 00:21:29,280
important for those to perform well and

612
00:21:34,070 --> 00:21:32,240
we've completed that test

613
00:21:35,510 --> 00:21:34,080

this is all moving toward exploration

614
00:21:38,070 --> 00:21:35,520
flight test 1

615
00:21:40,149 --> 00:21:38,080
in 2014 so this is real hard work coming

616
00:21:41,830 --> 00:21:40,159
together which would be the first test

617
00:21:42,950 --> 00:21:41,840
of the orion heat shield in the actual

618
00:21:45,350 --> 00:21:42,960
environment

619
00:21:47,909 --> 00:21:45,360
we'll get up to to about

620
00:21:50,630 --> 00:21:47,919
60 to 70 percent of the cis lunar

621
00:21:52,070 --> 00:21:50,640
uh speed required for entry uh it does

622
00:21:54,230 --> 00:21:52,080
two revs around the earth we'll also get

623
00:21:56,710 --> 00:21:54,240
a little test of the uh

624
00:21:58,149 --> 00:21:56,720
on the delta iv heavy the upper stage is

625
00:21:59,590 --> 00:21:58,159
very has a lot of common components to

626
00:22:01,110 --> 00:21:59,600
what we're going to use for

627
00:22:02,549 --> 00:22:01,120
future exploration missions so we'll get

628
00:22:04,630 --> 00:22:02,559
a great test of that

629
00:22:06,870 --> 00:22:04,640
the hardware is coming together and the

630
00:22:08,789 --> 00:22:06,880
vehicle will be ready in the springtime

631
00:22:11,750 --> 00:22:08,799
so this is a real mission real hardware

632
00:22:13,430 --> 00:22:11,760
moving forward in exploration

633
00:22:16,070 --> 00:22:13,440
this leads us to uh

634
00:22:18,310 --> 00:22:16,080
em1 in the 2017 time frame and this is

635
00:22:19,909 --> 00:22:18,320
the first integrated test of the uh of

636
00:22:22,149 --> 00:22:19,919
the space launch system with the orion

637
00:22:23,669 --> 00:22:22,159
vehicle we've recently changed the

638
00:22:25,029 --> 00:22:23,679

mission we've baselined this distance

639
00:22:27,270 --> 00:22:25,039
retrograde orbit which you can see on

640
00:22:28,630 --> 00:22:27,280
the right hand part of the slide

641
00:22:30,950 --> 00:22:28,640
that's the kind of orbit we're going to

642
00:22:35,430 --> 00:22:30,960
need for this asteroid redirect mission

643
00:22:37,430 --> 00:22:35,440
and so we see this test flight uncrewed

644
00:22:38,870 --> 00:22:37,440
using the trajectory simulating the

645
00:22:41,590 --> 00:22:38,880
trajectory and the distant retrograde

646
00:22:43,350 --> 00:22:41,600
orbit is very beneficial we can learn

647
00:22:44,710 --> 00:22:43,360
how to target all the burns the

648
00:22:45,669 --> 00:22:44,720
navigation required for each of the

649
00:22:47,830 --> 00:22:45,679
burns

650
00:22:49,270 --> 00:22:47,840
it'll be a good dry run from a mission

651
00:22:51,190 --> 00:22:49,280
perspective

652
00:22:52,950 --> 00:22:51,200
for the asteroid redirect mission so

653
00:22:55,350 --> 00:22:52,960
this is a recent change and very

654
00:22:56,549 --> 00:22:55,360
important

655
00:22:59,350 --> 00:22:56,559
now as we move into the asteroid

656
00:23:01,110 --> 00:22:59,360
redirect mission um

657
00:23:02,149 --> 00:23:01,120
you can see the mission uses the uh the

658
00:23:05,029 --> 00:23:02,159
sls

659
00:23:07,029 --> 00:23:05,039
and orion vehicles so orion heads out to

660
00:23:08,630 --> 00:23:07,039
the distant retrograde orbit which is a

661
00:23:10,870 --> 00:23:08,640
great uh

662
00:23:12,230 --> 00:23:10,880
orbit about the moon that we found that

663
00:23:14,149 --> 00:23:12,240

it's it's called retrograde because it

664
00:23:15,990 --> 00:23:14,159
kind of travels in the opposite

665
00:23:18,470 --> 00:23:16,000
direction of the the moon's orbit but

666
00:23:19,909 --> 00:23:18,480
it's a very balanced uh place to be it's

667
00:23:21,750 --> 00:23:19,919
a good place for us to bring the

668
00:23:24,470 --> 00:23:21,760
asteroid to and also we can get there

669
00:23:26,390 --> 00:23:24,480
with orion we'll uh dock to

670
00:23:27,909 --> 00:23:26,400
to the robotic spacecraft with orion and

671
00:23:29,270 --> 00:23:27,919
then we'll perform

672
00:23:30,789 --> 00:23:29,280
two evas and we'll talk a little bit

673
00:23:32,710 --> 00:23:30,799
more about that in detail and then of

674
00:23:34,390 --> 00:23:32,720
course the main objective is to get get

675
00:23:37,990 --> 00:23:34,400
a sample from the asteroid and then

676
00:23:42,310 --> 00:23:39,750
so uh

677
00:23:43,590 --> 00:23:42,320
this will try to build upon some of the

678
00:23:44,950 --> 00:23:43,600
capabilities we have in development so

679
00:23:47,510 --> 00:23:44,960
i've talked about the space launch

680
00:23:48,950 --> 00:23:47,520
system i've talked about orion

681
00:23:51,190 --> 00:23:48,960
what we're doing with the rendezvous

682
00:23:52,870 --> 00:23:51,200
introductory work is we're building upon

683
00:23:54,149 --> 00:23:52,880
capabilities that we've had on previous

684
00:23:55,909 --> 00:23:54,159
programs

685
00:23:58,310 --> 00:23:55,919
here you can see on the right-hand part

686
00:24:00,549 --> 00:23:58,320
of the slide what the trajectory looks

687
00:24:03,110 --> 00:24:00,559
like it takes about nine days to get out

688
00:24:04,549 --> 00:24:03,120

for this particular launch launch date

689
00:24:08,070 --> 00:24:04,559
to the distant retrograde orbit where

690
00:24:10,230 --> 00:24:08,080
the asteroid robotic spacecraft will be

691
00:24:12,230 --> 00:24:10,240
we use a lunar gravity assist on the on

692
00:24:13,510 --> 00:24:12,240
the way out which we've taken that trick

693
00:24:15,909 --> 00:24:13,520
from many of our

694
00:24:17,510 --> 00:24:15,919
scientific missions that have used that

695
00:24:19,510 --> 00:24:17,520
and it slingshots us into this distant

696
00:24:21,350 --> 00:24:19,520
retrograde orbit we'll spend about five

697
00:24:22,789 --> 00:24:21,360
days there doing a couple spacewalks and

698
00:24:24,070 --> 00:24:22,799
then we'll return

699
00:24:26,230 --> 00:24:24,080
the return flight time for this

700
00:24:27,750 --> 00:24:26,240
particular launch date is about 11 days

701
00:24:29,350 --> 00:24:27,760
and again we'll use a flyby of the moon

702
00:24:31,750 --> 00:24:29,360
on the way back it'll be a spectacular

703
00:24:33,430 --> 00:24:31,760
view of the moon flying by at about

704
00:24:35,430 --> 00:24:33,440
100 kilometers

705
00:24:36,789 --> 00:24:35,440
on the left-hand side you can see we're

706
00:24:38,149 --> 00:24:36,799
trying to leverage a lot of the work

707
00:24:40,230 --> 00:24:38,159
that we've done

708
00:24:41,830 --> 00:24:40,240
from the space shuttle program toward

709
00:24:44,070 --> 00:24:41,840
the very end of the shuttle program we

710
00:24:46,230 --> 00:24:44,080
flew a variety of sensors on board the

711
00:24:49,029 --> 00:24:46,240
shuttle in parallel with the system we

712
00:24:50,549 --> 00:24:49,039
use to to do the approach to station to

713
00:24:52,230 --> 00:24:50,559

test their performance

714
00:24:54,710 --> 00:24:52,240
we're utilizing some of those sensor

715
00:24:56,710 --> 00:24:54,720
systems for for both the robotic vehicle

716
00:24:58,070 --> 00:24:56,720
we're looking at commonality between

717
00:25:00,230 --> 00:24:58,080
that sensor system for the robotic

718
00:25:01,830 --> 00:25:00,240
vehicle and orion so we're leveraging

719
00:25:03,110 --> 00:25:01,840
that technology there's a lot of synergy

720
00:25:04,549 --> 00:25:03,120
between those two

721
00:25:06,870 --> 00:25:04,559
and then we're continuing to work and

722
00:25:08,310 --> 00:25:06,880
refine how that system performs uh

723
00:25:10,149 --> 00:25:08,320
relative to trajectory and we've done

724
00:25:11,669 --> 00:25:10,159
testing with those sensors so this

725
00:25:13,830 --> 00:25:11,679
builds on real sensors that have flown

726
00:25:15,430 --> 00:25:13,840
in space

727
00:25:17,190 --> 00:25:15,440
in terms of the docking system so this

728
00:25:18,789 --> 00:25:17,200
is another thing if you think about the

729
00:25:20,710 --> 00:25:18,799
rendezvous sensors and trajectory that

730
00:25:21,909 --> 00:25:20,720
feeds forward to exploration

731
00:25:22,950 --> 00:25:21,919
all the destinations are going to

732
00:25:24,549 --> 00:25:22,960
require

733
00:25:26,710 --> 00:25:24,559
an approach to another

734
00:25:28,310 --> 00:25:26,720
object in space the docking system is

735
00:25:29,750 --> 00:25:28,320
the same way we're leveraging a lot of

736
00:25:31,430 --> 00:25:29,760
the work that we're doing today on the

737
00:25:32,950 --> 00:25:31,440
international space station

738
00:25:35,110 --> 00:25:32,960

it's kind of a two-phased approach where

739
00:25:36,630 --> 00:25:35,120
we're using this international docking

740
00:25:37,990 --> 00:25:36,640
system standard

741
00:25:40,870 --> 00:25:38,000
on the international space station

742
00:25:43,029 --> 00:25:40,880
that's completed a pdr recently and the

743
00:25:44,710 --> 00:25:43,039
september preliminary design review in

744
00:25:47,190 --> 00:25:44,720
the september time frame they're working

745
00:25:49,269 --> 00:25:47,200
toward a critical design review

746
00:25:51,110 --> 00:25:49,279
uh next summer and then the delivery of

747
00:25:54,070 --> 00:25:51,120
hardware in the 2015

748
00:25:55,269 --> 00:25:54,080
2016 time frame that you can see on the

749
00:25:57,510 --> 00:25:55,279
upper right there's a couple of

750
00:25:59,909 --> 00:25:57,520
locations that are going to be utilized

751
00:26:01,909 --> 00:25:59,919
on the international space station

752
00:26:04,149 --> 00:26:01,919
to allow the commercial crew vehicles to

753
00:26:05,190 --> 00:26:04,159
dock we're taking that same hardware and

754
00:26:07,029 --> 00:26:05,200
we're feeding that forward to the

755
00:26:08,789 --> 00:26:07,039
asteroid redirect mission on the left

756
00:26:10,630 --> 00:26:08,799
hand side you can see the active docking

757
00:26:12,230 --> 00:26:10,640
mechanism extended that'll go on the

758
00:26:13,590 --> 00:26:12,240
orion spacecraft

759
00:26:15,510 --> 00:26:13,600
in kind of in the center of the slide

760
00:26:17,750 --> 00:26:15,520
there's the passive mechanism that goes

761
00:26:20,470 --> 00:26:17,760
on the robotic spacecraft

762
00:26:22,070 --> 00:26:20,480
so it's a phase two approach for the

763
00:26:25,110 --> 00:26:22,080

docking system so we're feeding that

764
00:26:26,710 --> 00:26:25,120
forward to space station if you look uh

765
00:26:28,710 --> 00:26:26,720
at the way we're going to transport this

766
00:26:31,110 --> 00:26:28,720
to the international space station we're

767
00:26:33,110 --> 00:26:31,120
going to use the dragon cargo vehicle to

768
00:26:34,630 --> 00:26:33,120
bring it up so we're combining our

769
00:26:36,630 --> 00:26:34,640
commercial crew program international

770
00:26:38,149 --> 00:26:36,640
space station and exploration together

771
00:26:39,430 --> 00:26:38,159
to put together the docking system which

772
00:26:41,830 --> 00:26:39,440
then feeds forward to the rest of

773
00:26:43,909 --> 00:26:41,840
exploration

774
00:26:46,470 --> 00:26:43,919
now i'll talk a little bit about eva

775
00:26:46,480 --> 00:26:50,390
our eba development

776
00:26:55,350 --> 00:26:51,669
and this is a very important part of the

777
00:26:57,430 --> 00:26:55,360
mission so we have a video we'll show

778
00:26:58,549 --> 00:26:57,440
and uh this shows the crew coming out of

779
00:27:00,470 --> 00:26:58,559
the orion

780
00:27:01,830 --> 00:27:00,480
spacecraft orion will be served as the

781
00:27:03,750 --> 00:27:01,840
airlock for the asteroid redirect

782
00:27:05,430 --> 00:27:03,760
mission based on our concept they'll use

783
00:27:07,909 --> 00:27:05,440
some very simple poles to traverse

784
00:27:10,710 --> 00:27:07,919
across to the robotic spacecraft

785
00:27:12,470 --> 00:27:10,720
and it looks very simple in the video

786
00:27:14,230 --> 00:27:12,480
and animation

787
00:27:15,830 --> 00:27:14,240
but we've spent a lot of time already in

788
00:27:18,149 --> 00:27:15,840

our neutral buoyancy

789
00:27:19,269 --> 00:27:18,159
laboratory here in houston simulating

790
00:27:20,710 --> 00:27:19,279
these very

791
00:27:22,630 --> 00:27:20,720
very techniques you can see a crew

792
00:27:24,710 --> 00:27:22,640
member a practicing egress from the

793
00:27:27,909 --> 00:27:24,720
orion hatch in our modified aces which

794
00:27:29,190 --> 00:27:27,919
is a little bit like a gemini spacesuit

795
00:27:31,350 --> 00:27:29,200
and now

796
00:27:32,950 --> 00:27:31,360
you can see the next phase of the eva

797
00:27:35,750 --> 00:27:32,960
would be to traverse across the

798
00:27:37,230 --> 00:27:35,760
spacecraft here you can see rex walheim

799
00:27:39,830 --> 00:27:37,240
a mission specialist that flew on

800
00:27:41,750 --> 00:27:39,840
sts-135 traversing across a set of

801
00:27:42,870 --> 00:27:41,760
handrails

802
00:27:44,389 --> 00:27:42,880
that

803
00:27:46,070 --> 00:27:44,399
it's actually space station hardware in

804
00:27:47,510 --> 00:27:46,080
the neutral buoyancy lab but he's

805
00:27:49,830 --> 00:27:47,520
practicing that same technique to

806
00:27:51,110 --> 00:27:49,840
understand the suit performance you can

807
00:27:52,389 --> 00:27:51,120
see a lot of the hardware on the suit is

808
00:27:53,510 --> 00:27:52,399
derivative from shuttle and space

809
00:27:55,990 --> 00:27:53,520
station

810
00:27:57,510 --> 00:27:56,000
and the suit is a derivative from

811
00:27:59,830 --> 00:27:57,520
the shuttle

812
00:28:01,190 --> 00:27:59,840
entry suit

813
00:28:03,350 --> 00:28:01,200

and now you can see

814
00:28:05,430 --> 00:28:03,360
this again is rex trying to see what

815
00:28:07,110 --> 00:28:05,440
kind of tasks he can work on here he is

816
00:28:08,710 --> 00:28:07,120
in the neutral buoyancy lab

817
00:28:09,750 --> 00:28:08,720
using something called a portable foot

818
00:28:11,669 --> 00:28:09,760
restraint

819
00:28:13,269 --> 00:28:11,679
and he's installing it in a socket which

820
00:28:14,789 --> 00:28:13,279
he would typically do and these are the

821
00:28:17,350 --> 00:28:14,799
kind of tasks we might need to do on the

822
00:28:19,029 --> 00:28:17,360
asteroid so again we're in the neutral

823
00:28:20,710 --> 00:28:19,039
buoyancy lab trying to understand

824
00:28:24,070 --> 00:28:20,720
performance of this suit

825
00:28:26,630 --> 00:28:24,080
and the suit is a very important early

826
00:28:27,830 --> 00:28:26,640
part of the mission

827
00:28:29,430 --> 00:28:27,840
here you can see one of the next tasks

828
00:28:30,549 --> 00:28:29,440
would be to set up the crew member in

829
00:28:32,230 --> 00:28:30,559
position

830
00:28:34,070 --> 00:28:32,240
to extract the samples and here you can

831
00:28:35,430 --> 00:28:34,080
see a rex walheim again

832
00:28:37,029 --> 00:28:35,440
in the nbl

833
00:28:39,110 --> 00:28:37,039
managing his tether

834
00:28:42,310 --> 00:28:39,120
and practicing traversing across a

835
00:28:44,149 --> 00:28:42,320
simulated part of the asteroid

836
00:28:46,310 --> 00:28:44,159
and so we've completed a total of eight

837
00:28:47,830 --> 00:28:46,320
tests in the in neutral buoyancy lab

838
00:28:49,750 --> 00:28:47,840

already in the suit

839
00:28:51,190 --> 00:28:49,760
and we have about six more planned for

840
00:28:53,430 --> 00:28:51,200
next year next year we'll move into a

841
00:28:55,750 --> 00:28:53,440
little bit higher fidelity phase

842
00:28:57,590 --> 00:28:55,760
we'll upgrade the suit try to improve

843
00:28:59,269 --> 00:28:57,600
the performance of the suit

844
00:29:02,310 --> 00:28:59,279
in september we did two

845
00:29:03,669 --> 00:29:02,320
two four hour runs to try to

846
00:29:05,510 --> 00:29:03,679
prove out the duration that we might

847
00:29:07,350 --> 00:29:05,520
need for the mission

848
00:29:08,549 --> 00:29:07,360
here you can see the crew members uh

849
00:29:10,630 --> 00:29:08,559
doing some photography and then it's

850
00:29:12,870 --> 00:29:10,640
starting to extract the samples

851
00:29:13,990 --> 00:29:12,880
these are notional videos and here you

852
00:29:16,149 --> 00:29:14,000
can see

853
00:29:19,269 --> 00:29:16,159
uh rex in the nbl

854
00:29:20,870 --> 00:29:19,279
working doing some pretty delicate tasks

855
00:29:22,870 --> 00:29:20,880
we've got the the same gloves on the

856
00:29:24,710 --> 00:29:22,880
suit that we use uh on space station

857
00:29:28,630 --> 00:29:24,720
today and so we've made that change to

858
00:29:29,430 --> 00:29:28,640
the suit so again real progress this

859
00:29:35,269 --> 00:29:29,440
year

860
00:29:37,110 --> 00:29:35,279
and here you can see uh rex in the nbl

861
00:29:38,950 --> 00:29:37,120
going after another sample and putting

862
00:29:40,789 --> 00:29:38,960
it in a bag and you can see it's

863
00:29:42,950 --> 00:29:40,799

tethered just like we would execute in

864
00:29:43,830 --> 00:29:42,960
the real asteroid redirect mission so

865
00:29:50,549 --> 00:29:43,840
again

866
00:29:55,110 --> 00:29:53,190
now we'll talk a little bit about

867
00:29:58,630 --> 00:29:55,120
the primary life support system that

868
00:30:00,310 --> 00:29:58,640
enables this this technology

869
00:30:01,909 --> 00:30:00,320
we have an advanced exploration system

870
00:30:04,230 --> 00:30:01,919
project that's looking at an advanced

871
00:30:06,149 --> 00:30:04,240
spacesuit life support system

872
00:30:08,549 --> 00:30:06,159
they've been working for several years a

873
00:30:10,470 --> 00:30:08,559
lot this past fiscal year they completed

874
00:30:12,870 --> 00:30:10,480
a prototype of that system

875
00:30:15,350 --> 00:30:12,880
and uh it's in testing here at the

876
00:30:17,110 --> 00:30:15,360
johnson space center we've got uh if you

877
00:30:19,430 --> 00:30:17,120
look in the upper right you can see uh

878
00:30:21,430 --> 00:30:19,440
what looks like a crew member next to

879
00:30:22,630 --> 00:30:21,440
the the plus which is in the two

880
00:30:24,230 --> 00:30:22,640
brackets

881
00:30:25,669 --> 00:30:24,240
on the upper right we've got this

882
00:30:27,510 --> 00:30:25,679
metabolic simulator and we're into

883
00:30:29,110 --> 00:30:27,520
testing already

884
00:30:30,710 --> 00:30:29,120
on this place and this plus feeds

885
00:30:32,549 --> 00:30:30,720
forward very well this primary life

886
00:30:35,029 --> 00:30:32,559
support system feeds well

887
00:30:36,470 --> 00:30:35,039
for both on mars and

888
00:30:37,990 --> 00:30:36,480

and other missions

889
00:30:39,909 --> 00:30:38,000
and then at the bottom right you can see

890
00:30:42,789 --> 00:30:39,919
the kind of modifications that we need

891
00:30:43,590 --> 00:30:42,799
to perform to make the modified

892
00:30:49,190 --> 00:30:43,600
uh

893
00:30:51,350 --> 00:30:49,200
for this mission helmet lights backpack

894
00:30:52,950 --> 00:30:51,360
cameras display module we're already

895
00:30:54,549 --> 00:30:52,960
working on the design for where we would

896
00:30:57,110 --> 00:30:54,559
put those things how we've interfaced

897
00:30:58,070 --> 00:30:57,120
into the suit so that work is ongoing

898
00:30:59,430 --> 00:30:58,080
today

899
00:31:01,350 --> 00:30:59,440
so again in terms of suit we're

900
00:31:02,710 --> 00:31:01,360
leveraging technology that we're working

901
00:31:03,990 --> 00:31:02,720
on today

902
00:31:06,149 --> 00:31:04,000
trying to integrate that into the

903
00:31:09,029 --> 00:31:06,159
mission and then looking how that feeds

904
00:31:11,669 --> 00:31:09,039
forward toward exploration

905
00:31:13,269 --> 00:31:11,679
and then the same thing with uh with our

906
00:31:15,830 --> 00:31:13,279
high powered solar electric propulsion

907
00:31:17,350 --> 00:31:15,840
system that enables the the asteroid to

908
00:31:19,430 --> 00:31:17,360
be brought back to the distant

909
00:31:20,950 --> 00:31:19,440
retrograde orbit

910
00:31:23,750 --> 00:31:20,960
today that system would be on the order

911
00:31:25,830 --> 00:31:23,760
of 40 to 50 kilowatts using three

912
00:31:28,310 --> 00:31:25,840
13 kilowatt thrusters

913
00:31:30,950 --> 00:31:28,320

that then feeds forward to uh to

914
00:31:32,389 --> 00:31:30,960
exploration into the 90 to 100 kilowatt

915
00:31:34,549 --> 00:31:32,399
with the same kind of thrusters and then

916
00:31:36,389 --> 00:31:34,559
that evolves to what we would need for

917
00:31:38,310 --> 00:31:36,399
cargo delivery to mars for example in

918
00:31:41,830 --> 00:31:38,320
the upper right which is on the order of

919
00:31:43,830 --> 00:31:41,840
250 kilowatts using a little bit higher

920
00:31:45,110 --> 00:31:43,840
power thrusters and in the bottom you

921
00:31:46,389 --> 00:31:45,120
can see that we're currently under our

922
00:31:48,710 --> 00:31:46,399
space technology mission directorate

923
00:31:50,789 --> 00:31:48,720
working on solar array technology

924
00:31:53,029 --> 00:31:50,799
that's real funded work within within

925
00:31:55,350 --> 00:31:53,039
the agency and also thrusters and power

926
00:31:57,750 --> 00:31:55,360
processing units so here we're taking a

927
00:31:59,830 --> 00:31:57,760
capability that we're working on in the

928
00:32:01,830 --> 00:31:59,840
space technology mission directorate and

929
00:32:05,509 --> 00:32:01,840
infusing that into this asteroid mission

930
00:32:10,149 --> 00:32:07,430
and then finally how does this

931
00:32:11,269 --> 00:32:10,159
mission feed forward to mars

932
00:32:13,029 --> 00:32:11,279
this chart

933
00:32:15,990 --> 00:32:13,039
across the top shows the different kinds

934
00:32:17,990 --> 00:32:16,000
of missions the current mission on iss

935
00:32:20,070 --> 00:32:18,000
the asteroid redirect mission and then

936
00:32:21,830 --> 00:32:20,080
longer stays in deep space and we're

937
00:32:23,750 --> 00:32:21,840
working our way out to mars on the upper

938
00:32:25,669 --> 00:32:23,760

right

939
00:32:27,350 --> 00:32:25,679
you can see that each of these things

940
00:32:29,750 --> 00:32:27,360
that we're doing sort of building in a

941
00:32:31,750 --> 00:32:29,760
stair-step fashion to get us further

942
00:32:33,110 --> 00:32:31,760
into space and then build capabilities

943
00:32:35,669 --> 00:32:33,120
for the next mission

944
00:32:37,669 --> 00:32:35,679
so again we're trying to slowly work our

945
00:32:39,750 --> 00:32:37,679
way into the solar system

946
00:32:41,669 --> 00:32:39,760
and use this mission as the start at the

947
00:32:43,269 --> 00:32:41,679
bottom you can see iss provides the deep

948
00:32:45,590 --> 00:32:43,279
space habitat

949
00:32:47,750 --> 00:32:45,600
life support and autonomous assembly

950
00:32:49,669 --> 00:32:47,760
that we've been working on that feeds

951
00:32:50,789 --> 00:32:49,679
forward to all the different mars

952
00:32:53,110 --> 00:32:50,799
missions

953
00:32:55,350 --> 00:32:53,120
for uh for the asteroid mission we add

954
00:32:57,190 --> 00:32:55,360
those pieces of the

955
00:32:59,669 --> 00:32:57,200
space launch system to get heavy lift

956
00:33:02,149 --> 00:32:59,679
which we need to get cargo beyond

957
00:33:03,750 --> 00:33:02,159
uh the earth's gravity gravity field we

958
00:33:06,549 --> 00:33:03,760
get the orion high speed entry

959
00:33:08,630 --> 00:33:06,559
capability we get exploration eva and

960
00:33:10,870 --> 00:33:08,640
then we get this solar propulsion

961
00:33:11,750 --> 00:33:10,880
capability which enables exploration

962
00:33:13,669 --> 00:33:11,760
and then

963
00:33:15,669 --> 00:33:13,679

someday we continue to work on the other

964
00:33:18,549 --> 00:33:15,679
pieces at the top to build these

965
00:33:19,990 --> 00:33:18,559
stepping stones to mars

966
00:33:21,830 --> 00:33:20,000
and finally

967
00:33:24,389 --> 00:33:21,840
how does this enable exploration you can

968
00:33:26,549 --> 00:33:24,399
see on the right-hand side three

969
00:33:29,029 --> 00:33:26,559
different kind of visions of how this

970
00:33:30,149 --> 00:33:29,039
feeds forward the upper right slide

971
00:33:32,710 --> 00:33:30,159
shows

972
00:33:34,870 --> 00:33:32,720
continued utilization of the asteroid

973
00:33:36,549 --> 00:33:34,880
in the distant retrograde orbit with

974
00:33:39,350 --> 00:33:36,559
what we call an exploration augmentation

975
00:33:41,990 --> 00:33:39,360
module concept it could be provided by

976
00:33:44,389 --> 00:33:42,000
an international partner or commercial

977
00:33:45,909 --> 00:33:44,399
or nasa provided but it would extend the

978
00:33:46,870 --> 00:33:45,919
state time in the distant retrograde

979
00:33:48,789 --> 00:33:46,880
orbit

980
00:33:50,310 --> 00:33:48,799
you can see

981
00:33:52,870 --> 00:33:50,320
our international partners in particular

982
00:33:54,230 --> 00:33:52,880
are very interested in lunar missions

983
00:33:55,590 --> 00:33:54,240
and you can see in the middle slide on

984
00:33:57,909 --> 00:33:55,600
the right how that then would feed

985
00:33:59,909 --> 00:33:57,919
forward to a potential low lunar orbit

986
00:34:01,269 --> 00:33:59,919
kind of campaign and then at the bottom

987
00:34:02,470 --> 00:34:01,279
you can see how this feeds forward a

988
00:34:04,389 --> 00:34:02,480

deep space

989
00:34:06,230 --> 00:34:04,399
so again i won't read through these but

990
00:34:08,310 --> 00:34:06,240
you can see how this builds the systems

991
00:34:10,869 --> 00:34:08,320
we need for exploration on this first

992
00:34:12,790 --> 00:34:10,879
exploration mission we get orion in sls

993
00:34:13,909 --> 00:34:12,800
we get solar electric propulsion

994
00:34:15,430 --> 00:34:13,919
and then

995
00:34:17,030 --> 00:34:15,440
we get deep space capabilities like

996
00:34:19,190 --> 00:34:17,040
rendezvous and docking and eva which

997
00:34:21,190 --> 00:34:19,200
then feed forward so that's a little bit

998
00:34:23,270 --> 00:34:21,200
about what we've been doing uh here at

999
00:34:25,829 --> 00:34:23,280
the johnson space center we look forward

1000
00:34:29,909 --> 00:34:25,839
to the session tomorrow at 1 30 to uh to

1001
00:34:29,919 --> 00:34:33,030
thank you steve

1002
00:34:38,389 --> 00:34:35,669
next up we have brian wilcox he's from

1003
00:34:40,470 --> 00:34:38,399
nasa's jet propulsion laboratory and

1004
00:34:43,990 --> 00:34:40,480
he's going to discuss the latest work in

1005
00:34:47,349 --> 00:34:44,000
the asteroid redirect mission um the

1006
00:34:49,669 --> 00:34:47,359
capture system design and analysis

1007
00:34:51,669 --> 00:34:49,679
good evening um for the next few minutes

1008
00:34:53,669 --> 00:34:51,679
i want to talk to you about the capture

1009
00:34:55,349 --> 00:34:53,679
mechanism and process uh envision for

1010
00:34:58,550 --> 00:34:55,359
the so-called reference mission that

1011
00:35:00,310 --> 00:34:58,560
michelle described earlier and um and

1012
00:35:03,109 --> 00:35:00,320
this uh if

1013
00:35:05,829 --> 00:35:03,119

if people on the web can see my laser

1014
00:35:07,990 --> 00:35:05,839
pointer uh basically it describes the uh

1015
00:35:09,430 --> 00:35:08,000
the bag going over the asteroid which

1016
00:35:11,190 --> 00:35:09,440
you've seen in the animation that was

1017
00:35:12,710 --> 00:35:11,200
released in this during the summer i'm

1018
00:35:14,550 --> 00:35:12,720
not going to replay that animation it's

1019
00:35:18,470 --> 00:35:14,560
a great uh it's a great animation done

1020
00:35:21,589 --> 00:35:20,150
but i'm going to talk about the details

1021
00:35:23,270 --> 00:35:21,599
of that

1022
00:35:25,270 --> 00:35:23,280
process

1023
00:35:32,870 --> 00:35:25,280
the

1024
00:35:34,150 --> 00:35:32,880
reference mission is that

1025
00:35:35,750 --> 00:35:34,160
it's the thing that really hasn't been

1026
00:35:37,910 --> 00:35:35,760
done and it's a thing that strikes many

1027
00:35:38,950 --> 00:35:37,920
people is quite sporty

1028
00:35:41,829 --> 00:35:38,960
and so

1029
00:35:44,150 --> 00:35:41,839
uh you know we need to pay attention to

1030
00:35:46,550 --> 00:35:44,160
uh the possibilities of what we might

1031
00:35:47,990 --> 00:35:46,560
confront when we get there uh first

1032
00:35:50,310 --> 00:35:48,000
thing we don't know a lot about these

1033
00:35:51,990 --> 00:35:50,320
asteroids many of them are probably

1034
00:35:54,150 --> 00:35:52,000
rocks uh that is

1035
00:35:55,990 --> 00:35:54,160
uh the ones that you know turn out to be

1036
00:35:56,870 --> 00:35:56,000
meteorites when they hit the ground

1037
00:35:59,109 --> 00:35:56,880
because they made it through the

1038
00:36:00,470 --> 00:35:59,119

atmosphere are the more competent ones

1039
00:36:01,910 --> 00:36:00,480
there's lots of reasons however to

1040
00:36:04,470 --> 00:36:01,920
believe that the

1041
00:36:06,390 --> 00:36:04,480
meteors that enter the atmosphere that

1042
00:36:07,910 --> 00:36:06,400
many of fragments don't make it to the

1043
00:36:10,310 --> 00:36:07,920
ground is because that they're not very

1044
00:36:12,550 --> 00:36:10,320
competent and so they could be in the

1045
00:36:15,349 --> 00:36:12,560
form of dirt clods and we do see

1046
00:36:17,270 --> 00:36:15,359
uh pieces of asteroidal material uh that

1047
00:36:19,829 --> 00:36:17,280
do make it to the ground that that have

1048
00:36:21,510 --> 00:36:19,839
much the consistency of dirt clods uh

1049
00:36:22,550 --> 00:36:21,520
and then there are also quite possibly

1050
00:36:24,470 --> 00:36:22,560
just

1051
00:36:26,710 --> 00:36:24,480
grains of sand that are bonded together

1052
00:36:29,190 --> 00:36:26,720
by molecular forces that are

1053
00:36:31,430 --> 00:36:29,200
extremely weak and where the slightest

1054
00:36:32,710 --> 00:36:31,440
touch would uh would break up the the

1055
00:36:35,190 --> 00:36:32,720
object so

1056
00:36:37,990 --> 00:36:35,200
that led us to focus on the bag

1057
00:36:39,510 --> 00:36:38,000
because not only did we want to confine

1058
00:36:40,630 --> 00:36:39,520
the whole asteroid and bring the whole

1059
00:36:42,470 --> 00:36:40,640
thing back

1060
00:36:44,790 --> 00:36:42,480
but we also wanted to protect our solar

1061
00:36:45,910 --> 00:36:44,800
arrays and our optical surfaces and our

1062
00:36:48,550 --> 00:36:45,920
radiators

1063
00:36:50,470 --> 00:36:48,560

from contamination so all the ideas that

1064
00:36:55,030 --> 00:36:50,480
you might imagine you know harpoons and

1065
00:36:59,190 --> 00:36:57,109
that aspect of the

1066
00:37:01,430 --> 00:36:59,200
of the problem that that it could well

1067
00:37:05,270 --> 00:37:01,440
be one of these rubble piles uh you know

1068
00:37:10,310 --> 00:37:08,550
the other aspect of it is the spin state

1069
00:37:13,990 --> 00:37:10,320
certainly many of them do spin very

1070
00:37:16,950 --> 00:37:14,000
slowly hours you know rotation period

1071
00:37:20,470 --> 00:37:18,870
many of them do tumble and the smaller

1072
00:37:23,109 --> 00:37:20,480
they are the more likely they are to

1073
00:37:25,030 --> 00:37:23,119
tumble because the time to relax to a

1074
00:37:27,030 --> 00:37:25,040
principal access spin

1075
00:37:28,630 --> 00:37:27,040
is long compared to the time between

1076
00:37:30,550 --> 00:37:28,640
collisions in fact long compared to the

1077
00:37:34,310 --> 00:37:30,560
age of the solar system so for these

1078
00:37:37,270 --> 00:37:34,320
small objects we would expect them to

1079
00:37:39,430 --> 00:37:37,280
in many cases be tumbling um and the one

1080
00:37:42,150 --> 00:37:39,440
that gives us real pause are the ones

1081
00:37:44,870 --> 00:37:42,160
that are uh spinning fast and tumbling

1082
00:37:47,270 --> 00:37:44,880
the ones that are in excess of one rpm

1083
00:37:51,510 --> 00:37:47,280
um and tumbling and and you'll see in a

1084
00:37:52,310 --> 00:37:51,520
few minutes why that uh why that is

1085
00:37:56,470 --> 00:37:52,320
the

1086
00:37:59,430 --> 00:37:56,480
distribution of spin states has been uh

1087
00:38:00,950 --> 00:37:59,440
mapped this uh this is maybe a year old

1088
00:38:03,270 --> 00:38:00,960

i think there are a few more objects

1089
00:38:05,670 --> 00:38:03,280
that have been identified

1090
00:38:07,510 --> 00:38:05,680
but you know most of the larger objects

1091
00:38:09,510 --> 00:38:07,520
here we have absolute magnitude which is

1092
00:38:11,430 --> 00:38:09,520
basically an astronomer's way of uh

1093
00:38:14,069 --> 00:38:11,440
saying how big it is

1094
00:38:15,589 --> 00:38:14,079
and in the box we have the range of

1095
00:38:18,790 --> 00:38:15,599
interest to us which is about five to

1096
00:38:20,870 --> 00:38:18,800
ten meters in diameter

1097
00:38:22,550 --> 00:38:20,880
the bigger objects tend to be clustered

1098
00:38:24,470 --> 00:38:22,560
just below the so-called spin barrier

1099
00:38:26,150 --> 00:38:24,480
rubble pile limit where the gravity is

1100
00:38:28,470 --> 00:38:26,160
equal to the centrifugal force at the

1101
00:38:30,790 --> 00:38:28,480
equator and that is

1102
00:38:32,470 --> 00:38:30,800
one of the things that leads people to

1103
00:38:34,069 --> 00:38:32,480
believe the fact that there's so many

1104
00:38:36,470 --> 00:38:34,079
clustered right up to that limit and

1105
00:38:39,750 --> 00:38:36,480
very few beyond it that there are many

1106
00:38:41,750 --> 00:38:39,760
of these objects are very weak

1107
00:38:43,349 --> 00:38:41,760
but as you get uh

1108
00:38:45,990 --> 00:38:43,359
smaller and smaller

1109
00:38:47,109 --> 00:38:46,000
that spin barrier no longer appears to

1110
00:38:50,150 --> 00:38:47,119
be a

1111
00:38:51,910 --> 00:38:50,160
major constraint and and you do see

1112
00:38:54,150 --> 00:38:51,920
objects spinning faster and at the one

1113
00:38:56,310 --> 00:38:54,160

rpm you know you see a few objects have

1114
00:38:58,230 --> 00:38:56,320
been discovered that are faster than one

1115
00:39:00,790 --> 00:38:58,240
rpm but many of them most of the

1116
00:39:02,870 --> 00:39:00,800
population of interest to us uh is

1117
00:39:04,150 --> 00:39:02,880
spinning slower than that so one thing

1118
00:39:05,510 --> 00:39:04,160
we could do is we could just say well

1119
00:39:06,870 --> 00:39:05,520
we're not going to go after any fast

1120
00:39:08,390 --> 00:39:06,880
spinners but

1121
00:39:11,109 --> 00:39:08,400
it's incumbent upon

1122
00:39:12,630 --> 00:39:11,119
the team to evaluate whether indeed you

1123
00:39:14,630 --> 00:39:12,640
know we have to make that constraint

1124
00:39:15,990 --> 00:39:14,640
because we'd like to i know if we find a

1125
00:39:17,670 --> 00:39:16,000
great a great

1126
00:39:19,910 --> 00:39:17,680
target that just happens to be spinning

1127
00:39:22,790 --> 00:39:19,920
fast we'd like to be able to go after it

1128
00:39:24,470 --> 00:39:22,800
uh the current thinking of the bag is to

1129
00:39:26,630 --> 00:39:24,480
have

1130
00:39:29,670 --> 00:39:26,640
these pie shaped wedges

1131
00:39:30,870 --> 00:39:29,680
that we can inflate interior to the bag

1132
00:39:33,270 --> 00:39:30,880
and thereby

1133
00:39:35,270 --> 00:39:33,280
grab the surface of the asteroid if it

1134
00:39:37,190 --> 00:39:35,280
is spinning rapidly

1135
00:39:39,510 --> 00:39:37,200
we could grab that

1136
00:39:41,190 --> 00:39:39,520
that surface quickly

1137
00:39:46,550 --> 00:39:41,200
and

1138
00:39:48,710 --> 00:39:46,560

comparable to the the the yield strength

1139
00:39:50,630 --> 00:39:48,720
the uh tensile strength of the

1140
00:39:53,829 --> 00:39:50,640
of the asteroid you know a fraction of a

1141
00:39:55,829 --> 00:39:53,839
psi and yet over the huge you know area

1142
00:39:58,230 --> 00:39:55,839
surface areas that we're talking about

1143
00:40:00,310 --> 00:39:58,240
to many tens of square meters

1144
00:40:01,829 --> 00:40:00,320
we would have

1145
00:40:03,670 --> 00:40:01,839
the the

1146
00:40:06,550 --> 00:40:03,680
forces that we need to despin and

1147
00:40:09,109 --> 00:40:06,560
detumble those objects so we have an

1148
00:40:11,990 --> 00:40:09,119
inflatable exoskeleton that deploys the

1149
00:40:13,670 --> 00:40:12,000
bag and then we get the asteroid into

1150
00:40:15,430 --> 00:40:13,680
the bag and then

1151
00:40:17,829 --> 00:40:15,440
if it's a fast spinner we would deploy

1152
00:40:19,510 --> 00:40:17,839
those bags to quickly capture it so if

1153
00:40:21,190 --> 00:40:19,520
it's a slow spinner we would bring it

1154
00:40:23,990 --> 00:40:21,200
into the bag

1155
00:40:26,230 --> 00:40:24,000
but then just use cinch winches to to

1156
00:40:28,390 --> 00:40:26,240
pull the bag closed so

1157
00:40:30,550 --> 00:40:28,400
these winches very much like fishing

1158
00:40:32,630 --> 00:40:30,560
reel winches that basically have a slip

1159
00:40:34,710 --> 00:40:32,640
clutch so that if the fish wants to run

1160
00:40:36,630 --> 00:40:34,720
it it can run because after all you have

1161
00:40:38,150 --> 00:40:36,640
a thousand ton object

1162
00:40:41,829 --> 00:40:38,160
and if it wants to do something it's

1163
00:40:43,670 --> 00:40:41,839

gonna do it um so so you basically have

1164
00:40:46,790 --> 00:40:43,680
these slip uh these winches with slip

1165
00:40:49,270 --> 00:40:46,800
clutches that uh you can gradually close

1166
00:40:52,470 --> 00:40:49,280
the bag over it as the air has bled out

1167
00:40:54,470 --> 00:40:52,480
of the system as the gas is vented

1168
00:40:55,829 --> 00:40:54,480
and you don't need to deploy you know if

1169
00:40:58,710 --> 00:40:55,839
it's a slow spinner you don't really

1170
00:41:00,790 --> 00:40:58,720
need to deploy these interior bags but

1171
00:41:03,589 --> 00:41:00,800
if it's a fast spinner

1172
00:41:06,630 --> 00:41:03,599
then the feeling is you would

1173
00:41:08,790 --> 00:41:06,640
deploy these wedge-shaped bags

1174
00:41:10,309 --> 00:41:08,800
in a very rapid

1175
00:41:12,790 --> 00:41:10,319
time

1176
00:41:15,430 --> 00:41:12,800
in vacuum of course these bags deploy

1177
00:41:17,430 --> 00:41:15,440
very rapidly

1178
00:41:18,390 --> 00:41:17,440
because they're not limited by the

1179
00:41:20,630 --> 00:41:18,400
gas

1180
00:41:23,109 --> 00:41:20,640
pressure uh on the front face

1181
00:41:25,670 --> 00:41:23,119
and uh and so these uh we have convinced

1182
00:41:27,430 --> 00:41:25,680
ourselves that with a sufficient number

1183
00:41:29,829 --> 00:41:27,440
we're showing six and we believe that

1184
00:41:32,150 --> 00:41:29,839
six is probably a good number uh as well

1185
00:41:34,069 --> 00:41:32,160
as interior shear panels we can make

1186
00:41:36,069 --> 00:41:34,079
this as stiff as we needed to make it in

1187
00:41:39,030 --> 00:41:36,079
order to get the right the right

1188
00:41:43,349 --> 00:41:41,510

for the system so here's an animation a

1189
00:41:45,109 --> 00:41:43,359
dynamic simulation of it and we're

1190
00:41:46,950 --> 00:41:45,119
showing here where the spacecraft is

1191
00:41:49,109 --> 00:41:46,960
lined up on the angular momentum vector

1192
00:41:51,510 --> 00:41:49,119
of the asteroid but it is not a simple

1193
00:41:55,109 --> 00:41:51,520
spinner it's a tumbling asteroid and so

1194
00:41:55,910 --> 00:41:55,119
the instantaneous spin axis shown in red

1195
00:41:58,550 --> 00:41:55,920
is

1196
00:42:00,790 --> 00:41:58,560
kind of wanders around the angular

1197
00:42:02,790 --> 00:42:00,800
momentum vector that is constant and so

1198
00:42:05,510 --> 00:42:02,800
what you see from the spacecraft you see

1199
00:42:07,990 --> 00:42:05,520
a continuous rotation here however we

1200
00:42:11,190 --> 00:42:08,000
have lined up the spacecraft's spin

1201
00:42:14,950 --> 00:42:11,200
around a future axis that we know the

1202
00:42:17,349 --> 00:42:14,960
angular the the spin velocity will reach

1203
00:42:19,750 --> 00:42:17,359
and so when the timer gets to 30 seconds

1204
00:42:21,510 --> 00:42:19,760
it will be perfectly lined up

1205
00:42:23,990 --> 00:42:21,520
spinning the spacecraft will be spinning

1206
00:42:26,950 --> 00:42:24,000
at the exact same speed as the

1207
00:42:29,349 --> 00:42:26,960
as the asteroid so with that approach

1208
00:42:31,990 --> 00:42:29,359
we're able to um

1209
00:42:35,430 --> 00:42:32,000
get zero relative motion at the instant

1210
00:42:39,510 --> 00:42:35,440
that we grab and so here again at uh at

1211
00:42:41,030 --> 00:42:39,520
30 seconds uh the spacecraft motion the

1212
00:42:43,829 --> 00:42:41,040
asteroid motion relative to the

1213
00:42:47,349 --> 00:42:43,839

spacecraft will be zero at the moment of

1214
00:42:49,990 --> 00:42:47,359
capture and uh and so um you know we're

1215
00:42:51,750 --> 00:42:50,000
just now coming up on the point where

1216
00:42:54,150 --> 00:42:51,760
there's no relative motion we trigger

1217
00:42:57,270 --> 00:42:54,160
the bags and we capture the object and

1218
00:43:00,390 --> 00:42:57,280
then we go for a ride and the spacecraft

1219
00:43:01,829 --> 00:43:00,400
as you see you know starts to move in a

1220
00:43:05,030 --> 00:43:01,839
significant way

1221
00:43:07,510 --> 00:43:05,040
uh off both in rotation and and uh

1222
00:43:09,990 --> 00:43:07,520
translation and it uh this is this is a

1223
00:43:12,390 --> 00:43:10,000
typical case where it rotates out along

1224
00:43:14,790 --> 00:43:12,400
the equator the belt line of the

1225
00:43:17,270 --> 00:43:14,800
asteroid and that's a good thing for us

1226
00:43:19,430 --> 00:43:17,280
because that means the reaction control

1227
00:43:21,670 --> 00:43:19,440
system thrusters on the end of the

1228
00:43:24,550 --> 00:43:21,680
spacecraft have a nice long lever arm

1229
00:43:26,550 --> 00:43:24,560
with which to de-spin and de-tumble this

1230
00:43:28,550 --> 00:43:26,560
object now it only takes a relatively

1231
00:43:31,190 --> 00:43:28,560
few newtons of force

1232
00:43:33,670 --> 00:43:31,200
over a period of hours to def

1233
00:43:35,750 --> 00:43:33,680
de-spin and de-tumble an object even a

1234
00:43:37,109 --> 00:43:35,760
thousand tons spinning at two rpm or

1235
00:43:38,790 --> 00:43:37,119
more

1236
00:43:41,030 --> 00:43:38,800
but the

1237
00:43:42,630 --> 00:43:41,040
the key thing is that you need a long

1238
00:43:44,950 --> 00:43:42,640

lever arm if you're going to be

1239
00:43:46,710 --> 00:43:44,960
efficient in your use of

1240
00:43:48,870 --> 00:43:46,720
a propellant now here in the lower

1241
00:43:50,870 --> 00:43:48,880
corner you see the so-called solar array

1242
00:43:53,030 --> 00:43:50,880
deployment actuator torque which is the

1243
00:43:56,309 --> 00:43:53,040
key thing that is going to break on the

1244
00:43:59,270 --> 00:43:56,319
spacecraft is the joint where the solar

1245
00:44:00,470 --> 00:43:59,280
wings you know hang off the spacecraft

1246
00:44:03,190 --> 00:44:00,480
and so

1247
00:44:05,109 --> 00:44:03,200
when you accelerate the spacecraft if

1248
00:44:07,589 --> 00:44:05,119
there's too much torque on that

1249
00:44:10,390 --> 00:44:07,599
deployment actuator the solar arrays

1250
00:44:12,230 --> 00:44:10,400
break off and that's a bad day so

1251
00:44:14,630 --> 00:44:12,240
that is the most sensitive part of the

1252
00:44:17,750 --> 00:44:14,640
spacecraft and that is the thing about

1253
00:44:20,550 --> 00:44:17,760
the spacecraft that is uh is most in

1254
00:44:23,190 --> 00:44:20,560
need of protection uh with our uh

1255
00:44:26,309 --> 00:44:23,200
approach to uh grabbing

1256
00:44:28,790 --> 00:44:26,319
uh grabbing the uh

1257
00:44:31,190 --> 00:44:28,800
the asteroid so we have done a uh monte

1258
00:44:34,870 --> 00:44:31,200
carlo simulation so we simulated about

1259
00:44:37,270 --> 00:44:34,880
45 500 different cases

1260
00:44:39,030 --> 00:44:37,280
uh with a wide variety of spin rates and

1261
00:44:41,349 --> 00:44:39,040
shapes and and

1262
00:44:43,349 --> 00:44:41,359
angles between the angular momentum

1263
00:44:47,109 --> 00:44:43,359

vector and the principal axes

1264
00:44:49,990 --> 00:44:47,119
and um and of course it's the it's the

1265
00:44:52,710 --> 00:44:50,000
uh flapping motion of the solar array

1266
00:44:55,190 --> 00:44:52,720
around what we call the y-axis here that

1267
00:44:57,270 --> 00:44:55,200
is the the greatest concern because that

1268
00:44:59,109 --> 00:44:57,280
when you when you yank on the spacecraft

1269
00:45:01,349 --> 00:44:59,119
with the thousand-ton rock

1270
00:45:04,550 --> 00:45:01,359
um that's the thing that's the mode that

1271
00:45:05,349 --> 00:45:04,560
it's going to see the largest uh torque

1272
00:45:07,910 --> 00:45:05,359
so

1273
00:45:10,390 --> 00:45:07,920
as you see here we've plotted the uh the

1274
00:45:13,190 --> 00:45:10,400
torque about all three axes but the it's

1275
00:45:16,309 --> 00:45:13,200
the torque around that that y-axis that

1276
00:45:19,190 --> 00:45:16,319
is in every case the the largest and as

1277
00:45:21,430 --> 00:45:19,200
we go out to 2 rpm

1278
00:45:22,870 --> 00:45:21,440
we see that we

1279
00:45:25,510 --> 00:45:22,880
have

1280
00:45:27,589 --> 00:45:25,520
a reasonable amount because the vendors

1281
00:45:30,950 --> 00:45:27,599
for the solar array deployment actuators

1282
00:45:32,390 --> 00:45:30,960
have told us that with essentially no

1283
00:45:33,870 --> 00:45:32,400
special effort

1284
00:45:36,390 --> 00:45:33,880
they can achieve

1285
00:45:37,829 --> 00:45:36,400
1765 newton meters of

1286
00:45:39,030 --> 00:45:37,839
of torque

1287
00:45:42,390 --> 00:45:39,040
as their

1288
00:45:44,870 --> 00:45:42,400

design limit and so you see here that

1289
00:45:47,349 --> 00:45:44,880
even in the case of two rpm we're below

1290
00:45:49,589 --> 00:45:47,359
that and here we have tuned the

1291
00:45:51,750 --> 00:45:49,599
stiffness of the bags the pressure in

1292
00:45:53,910 --> 00:45:51,760
the bags and then and the number of

1293
00:45:55,750 --> 00:45:53,920
shear panels and so on in order to make

1294
00:45:57,990 --> 00:45:55,760
the bag have the right elastic

1295
00:46:01,510 --> 00:45:58,000
properties the spring dampering

1296
00:46:04,630 --> 00:46:01,520
spring and damping properties so that it

1297
00:46:07,030 --> 00:46:04,640
achieves this performance and working

1298
00:46:09,190 --> 00:46:07,040
with our inflatable people uh you know

1299
00:46:11,589 --> 00:46:09,200
that have done the airbags on pathfinder

1300
00:46:13,990 --> 00:46:11,599
and myrrh and and the the new low

1301
00:46:15,190 --> 00:46:14,000
density decelerator

1302
00:46:17,589 --> 00:46:15,200
that

1303
00:46:19,910 --> 00:46:17,599
those people tell us they can achieve

1304
00:46:20,950 --> 00:46:19,920
these levels of stiffness and and

1305
00:46:22,550 --> 00:46:20,960
damping

1306
00:46:26,309 --> 00:46:22,560
in the

1307
00:46:31,349 --> 00:46:28,710
we have built a test bed and that test

1308
00:46:33,750 --> 00:46:31,359
bed allows us it's a one-fifth scale so

1309
00:46:35,910 --> 00:46:33,760
we have a two meter asteroid which is

1310
00:46:37,910 --> 00:46:35,920
actually a piece of styrofoam covered in

1311
00:46:40,069 --> 00:46:37,920
rhino bed liner which is what you spray

1312
00:46:43,270 --> 00:46:40,079
the back of your truck your pickup truck

1313
00:46:45,910 --> 00:46:43,280

with to protect it but it looks like

1314
00:46:48,470 --> 00:46:45,920
much like an asteroid and we have a bag

1315
00:46:51,510 --> 00:46:48,480
and we have uh it's lined with vectrans

1316
00:46:54,470 --> 00:46:51,520
uh which is a fabric that we got

1317
00:46:56,150 --> 00:46:54,480
actually left over from the last airbag

1318
00:46:58,790 --> 00:46:56,160
system which was the mars exploration

1319
00:47:00,470 --> 00:46:58,800
rovers um they had a whole bunch of

1320
00:47:02,790 --> 00:47:00,480
fabric left over so we managed to get

1321
00:47:04,870 --> 00:47:02,800
that from them uh and then we got an

1322
00:47:06,870 --> 00:47:04,880
inflatable structure from a company that

1323
00:47:08,470 --> 00:47:06,880
makes bounce houses for uh children's

1324
00:47:11,030 --> 00:47:08,480
birthday parties and they said trevor

1325
00:47:13,270 --> 00:47:11,040
we'll build you with that and no problem

1326
00:47:16,150 --> 00:47:13,280
so we built this inflatable exoskeleton

1327
00:47:18,470 --> 00:47:16,160
and then we put the our the the rock

1328
00:47:20,630 --> 00:47:18,480
on the end of an eight degree of freedom

1329
00:47:23,750 --> 00:47:20,640
robot arm that has a forced torque

1330
00:47:26,470 --> 00:47:23,760
sensor at the point of attachment

1331
00:47:27,109 --> 00:47:26,480
between the last degree of freedom and

1332
00:47:34,150 --> 00:47:27,119
the

1333
00:47:36,150 --> 00:47:34,160
over it basically it has this little

1334
00:47:38,549 --> 00:47:36,160
spike that goes up into the center of

1335
00:47:40,950 --> 00:47:38,559
the asteroid and then there's a spin

1336
00:47:43,910 --> 00:47:40,960
axis so that we can spin it continuously

1337
00:47:46,150 --> 00:47:43,920
about one axis and then we can move it

1338
00:47:49,270 --> 00:47:46,160

in a cyclic way about all the other axes

1339
00:47:51,589 --> 00:47:49,280
and thereby simulate tumbling motion

1340
00:47:53,829 --> 00:47:51,599
we measure the forces and torques on

1341
00:47:55,030 --> 00:47:53,839
that spike at the point of attachment

1342
00:47:57,190 --> 00:47:55,040
and thereby

1343
00:48:00,069 --> 00:47:57,200
measure the forces that are applied by

1344
00:48:01,109 --> 00:48:00,079
the bag to the asteroid after accounting

1345
00:48:03,510 --> 00:48:01,119
for the ground you know the

1346
00:48:05,670 --> 00:48:03,520
gravitational forces on the asteroid and

1347
00:48:07,510 --> 00:48:05,680
so that allows us to

1348
00:48:09,670 --> 00:48:07,520
to uh to

1349
00:48:11,190 --> 00:48:09,680
to evolve the spin physics in a

1350
00:48:13,670 --> 00:48:11,200
realistic way

1351
00:48:16,150 --> 00:48:13,680
so that we can

1352
00:48:17,750 --> 00:48:16,160
basically just apply you know newton's

1353
00:48:19,589 --> 00:48:17,760
law that says the time rate of change of

1354
00:48:21,589 --> 00:48:19,599
angular momentum is the applied torque

1355
00:48:23,270 --> 00:48:21,599
we measure the applied torque

1356
00:48:25,670 --> 00:48:23,280
we know what the angular momentum of the

1357
00:48:27,750 --> 00:48:25,680
asteroid is so we can say what the

1358
00:48:30,390 --> 00:48:27,760
future you know what the next spin state

1359
00:48:32,069 --> 00:48:30,400
is in every instant of time

1360
00:48:33,990 --> 00:48:32,079
and this will allow us to answer

1361
00:48:36,150 --> 00:48:34,000
questions that you could never get out

1362
00:48:38,549 --> 00:48:36,160
of a computer simulation like

1363
00:48:39,990 --> 00:48:38,559

does the fabric snag on the rock excuse

1364
00:48:41,829 --> 00:48:40,000
me

1365
00:48:43,910 --> 00:48:41,839
so we're going to put little matterhorn

1366
00:48:46,069 --> 00:48:43,920
rocks on the surface of our asteroid and

1367
00:48:48,710 --> 00:48:46,079
see if we can get the get the fabric to

1368
00:48:51,030 --> 00:48:48,720
snag and what does that do when one side

1369
00:48:51,829 --> 00:48:51,040
of the rock snags on it and

1370
00:48:54,069 --> 00:48:51,839
and

1371
00:48:55,910 --> 00:48:54,079
you know the other side is slipping

1372
00:48:57,190 --> 00:48:55,920
we can answer questions like do the

1373
00:48:59,829 --> 00:48:57,200
cinch course

1374
00:49:01,750 --> 00:48:59,839
cords of the cinch winches do they slide

1375
00:49:04,390 --> 00:49:01,760
freely over the surface of the bag or

1376
00:49:06,470 --> 00:49:04,400
does the bag bunch up in one spot and

1377
00:49:08,390 --> 00:49:06,480
limit the motion of the cinch cord so

1378
00:49:09,589 --> 00:49:08,400
that the cinch cords don't

1379
00:49:11,670 --> 00:49:09,599
completely

1380
00:49:14,790 --> 00:49:11,680
close the whole bag but they get bound

1381
00:49:16,790 --> 00:49:14,800
up and and the bag stops closing

1382
00:49:18,790 --> 00:49:16,800
prematurely those kinds of questions you

1383
00:49:20,790 --> 00:49:18,800
could never answer

1384
00:49:23,430 --> 00:49:20,800
with any with any confidence in a

1385
00:49:25,109 --> 00:49:23,440
computer simulation

1386
00:49:27,190 --> 00:49:25,119
and so with that i think i'm done thank

1387
00:49:31,109 --> 00:49:27,200
you

1388
00:49:36,870 --> 00:49:34,069

okay next up we have lynley johnson he's

1389
00:49:39,190 --> 00:49:36,880
the near earth objects program executive

1390
00:49:41,030 --> 00:49:39,200
in planetary science division at nasa

1391
00:49:43,270 --> 00:49:41,040
headquarters he'll share with us a

1392
00:49:45,030 --> 00:49:43,280
little bit about nasa's observation

1393
00:49:46,710 --> 00:49:45,040
campaign

1394
00:49:48,630 --> 00:49:46,720
well thank you very much it's nice to be

1395
00:49:49,510 --> 00:49:48,640
here this time i wasn't able to join you

1396
00:49:52,230 --> 00:49:49,520
in

1397
00:49:53,270 --> 00:49:52,240
the first part of this workshop so it's

1398
00:49:55,910 --> 00:49:53,280
nice of

1399
00:49:59,109 --> 00:49:55,920
everybody to delayed this for me to be

1400
00:50:02,390 --> 00:49:59,119
able to join you for the continuation

1401
00:50:04,710 --> 00:50:02,400
uh so um talk to you tonight about

1402
00:50:05,589 --> 00:50:04,720
our new earth object observation program

1403
00:50:09,910 --> 00:50:05,599
and

1404
00:50:10,950 --> 00:50:09,920
enhancements to it to be able to find

1405
00:50:12,549 --> 00:50:10,960
the

1406
00:50:15,109 --> 00:50:12,559
right candidate

1407
00:50:17,030 --> 00:50:15,119
for this redirect mission

1408
00:50:18,549 --> 00:50:17,040
you've heard about the grand challenge

1409
00:50:20,150 --> 00:50:18,559
already

1410
00:50:21,190 --> 00:50:20,160
we actually started working this grand

1411
00:50:22,950 --> 00:50:21,200
challenge

1412
00:50:24,790 --> 00:50:22,960
about a year ago even though it wasn't

1413
00:50:27,030 --> 00:50:24,800

announced until

1414
00:50:29,430 --> 00:50:27,040
june of last year

1415
00:50:34,710 --> 00:50:32,390
the reason why it's very important to

1416
00:50:35,670 --> 00:50:34,720
all of us earth residents

1417
00:50:38,470 --> 00:50:35,680
was

1418
00:50:41,430 --> 00:50:38,480
made evident to us almost on cue

1419
00:50:44,630 --> 00:50:41,440
in february of this year with the uh

1420
00:50:48,870 --> 00:50:44,640
cellubinsk event uh in russia

1421
00:50:51,589 --> 00:50:48,880
where a relatively small asteroid on the

1422
00:50:53,670 --> 00:50:51,599
latest analysis showed it to be about 19

1423
00:50:55,270 --> 00:50:53,680
meters in size

1424
00:50:58,870 --> 00:50:55,280
exploded entered the atmosphere and

1425
00:51:01,589 --> 00:50:58,880
exploded over the city of chelyabinsk

1426
00:51:06,150 --> 00:51:01,599
detonating with energy of

1427
00:51:07,510 --> 00:51:06,160
something over 500 kilotons of tnt

1428
00:51:09,270 --> 00:51:07,520
so

1429
00:51:11,990 --> 00:51:09,280
object that small

1430
00:51:14,470 --> 00:51:12,000
uh releasing that uh that much energy is

1431
00:51:15,990 --> 00:51:14,480
uh uh quite a

1432
00:51:18,309 --> 00:51:16,000
uh site

1433
00:51:21,270 --> 00:51:18,319
and uh it was captured uh of course this

1434
00:51:23,670 --> 00:51:21,280
is probably gonna be the best studied uh

1435
00:51:24,710 --> 00:51:23,680
asteroid entry

1436
00:51:26,950 --> 00:51:24,720
ever

1437
00:51:29,270 --> 00:51:26,960
the meter

1438
00:51:31,030 --> 00:51:29,280

meter and

1439
00:51:32,870 --> 00:51:31,040
asteroid scientists have gotten spoiled

1440
00:51:34,710 --> 00:51:32,880
by all the data they got from the dash

1441
00:51:37,750 --> 00:51:34,720
cams of the russians

1442
00:51:40,870 --> 00:51:37,760
but um but it did uh

1443
00:51:42,630 --> 00:51:40,880
uh cause a significant emergency uh for

1444
00:51:43,910 --> 00:51:42,640
the russian population there in

1445
00:51:47,270 --> 00:51:43,920
chelyabinsk

1446
00:51:49,430 --> 00:51:47,280
and over um sixteen hundred citizens uh

1447
00:51:52,390 --> 00:51:49,440
being injured by the broken glass that

1448
00:51:53,910 --> 00:51:52,400
was caused by the blast wave

1449
00:51:55,510 --> 00:51:53,920
from this object even though it

1450
00:51:57,109 --> 00:51:55,520
detonated

1451
00:51:59,990 --> 00:51:57,119
some 20

1452
00:52:02,710 --> 00:52:00,000
kilometers up in the atmosphere

1453
00:52:04,390 --> 00:52:02,720
the shock wave hit the town a few

1454
00:52:06,790 --> 00:52:04,400
minutes later while everybody was

1455
00:52:07,990 --> 00:52:06,800
looking out the window staring at this

1456
00:52:12,309 --> 00:52:08,000
uh

1457
00:52:14,549 --> 00:52:12,319
displayed across the sky and did some 30

1458
00:52:16,309 --> 00:52:14,559
million dollars of damage a few broken

1459
00:52:17,910 --> 00:52:16,319
windows but if you think of the

1460
00:52:21,270 --> 00:52:17,920
temperatures in

1461
00:52:22,710 --> 00:52:21,280
western siberia in february

1462
00:52:25,270 --> 00:52:22,720
it was a bit of an emergency on their

1463
00:52:27,030 --> 00:52:25,280

part to get the windows fixed to be able

1464
00:52:30,309 --> 00:52:27,040
to keep their buildings heated

1465
00:52:33,670 --> 00:52:30,319
so even though it was a fairly small

1466
00:52:35,910 --> 00:52:33,680
event as uh planetary impacts go

1467
00:52:38,790 --> 00:52:35,920
uh it uh still

1468
00:52:41,270 --> 00:52:38,800
caught everybody's attention

1469
00:52:43,430 --> 00:52:41,280
so the grand challenge as uh

1470
00:52:45,430 --> 00:52:43,440
michelle described earlier as one part

1471
00:52:47,190 --> 00:52:45,440
of the agency's overall asteroid

1472
00:52:49,190 --> 00:52:47,200
initiative the other part being the

1473
00:52:50,390 --> 00:52:49,200
asteroid redirect

1474
00:52:51,750 --> 00:52:50,400
mission

1475
00:52:54,710 --> 00:52:51,760
and

1476
00:52:56,710 --> 00:52:54,720
what has been described here

1477
00:52:58,870 --> 00:52:56,720
this evening it's kind of interesting we

1478
00:53:00,309 --> 00:52:58,880
began with the vision of what we want to

1479
00:53:02,630 --> 00:53:00,319
get to and now we're showing you how

1480
00:53:05,589 --> 00:53:02,640
we're going to get there

1481
00:53:08,150 --> 00:53:05,599
but the uh near earth object observation

1482
00:53:09,349 --> 00:53:08,160
program sits right in the middle of both

1483
00:53:10,230 --> 00:53:09,359
these uh

1484
00:53:12,230 --> 00:53:10,240
initia

1485
00:53:14,950 --> 00:53:12,240
both these endeavors

1486
00:53:16,549 --> 00:53:14,960
and we need to enhance the capabilities

1487
00:53:18,630 --> 00:53:16,559
that we currently have with the

1488
00:53:20,630 --> 00:53:18,640

observation program to to accomplish

1489
00:53:22,790 --> 00:53:20,640
these things

1490
00:53:26,710 --> 00:53:22,800
we are seeing increases in a program it

1491
00:53:30,150 --> 00:53:26,720
was increased to 12 million in fy12

1492
00:53:32,790 --> 00:53:30,160
before the redirect mission was even

1493
00:53:34,710 --> 00:53:32,800
announced and uh we were looking at

1494
00:53:35,750 --> 00:53:34,720
another doubling of funding for the neo

1495
00:53:38,150 --> 00:53:35,760
program

1496
00:53:39,750 --> 00:53:38,160
uh because it's uh it's the first step

1497
00:53:41,670 --> 00:53:39,760
in this

1498
00:53:42,950 --> 00:53:41,680
redirect mission endeavor and that is to

1499
00:53:44,630 --> 00:53:42,960
identify

1500
00:53:47,430 --> 00:53:44,640
uh the asteroid that

1501
00:53:48,309 --> 00:53:47,440
we are going to collect and uh and bring

1502
00:53:50,150 --> 00:53:48,319
back

1503
00:53:52,630 --> 00:53:50,160
uh to the lunar orbit

1504
00:53:54,870 --> 00:53:52,640
that's been tasked to the existing near

1505
00:53:57,589 --> 00:53:54,880
earth object observation program which

1506
00:53:58,870 --> 00:53:57,599
i and a few other dedicated individuals

1507
00:54:01,510 --> 00:53:58,880
around the country

1508
00:54:05,349 --> 00:54:02,390
but

1509
00:54:09,589 --> 00:54:05,359
it's already an international effort

1510
00:54:12,230 --> 00:54:09,599
to identify and find the asteroids

1511
00:54:14,150 --> 00:54:12,240
that are hazardous to the earth it's

1512
00:54:15,670 --> 00:54:14,160
been a subject

1513
00:54:17,750 --> 00:54:15,680

from the committee of peaceful uses of

1514
00:54:19,910 --> 00:54:17,760
outer space of the u.n

1515
00:54:21,430 --> 00:54:19,920
office of outer space affairs

1516
00:54:24,069 --> 00:54:21,440
for a number of years now i've

1517
00:54:25,589 --> 00:54:24,079
participated in an ineo working group

1518
00:54:26,470 --> 00:54:25,599
with that committee

1519
00:54:27,349 --> 00:54:26,480
and

1520
00:54:30,069 --> 00:54:27,359
to

1521
00:54:32,390 --> 00:54:30,079
work the process uh by which

1522
00:54:35,030 --> 00:54:32,400
the member states would work together

1523
00:54:37,349 --> 00:54:35,040
to both identify a hazardous threat to

1524
00:54:39,670 --> 00:54:37,359
the earth and then figure out what we

1525
00:54:42,789 --> 00:54:39,680
would do about it

1526
00:54:44,710 --> 00:54:42,799
the committee uh and how the uh

1527
00:54:46,549 --> 00:54:44,720
the un operates has been somewhat

1528
00:54:49,109 --> 00:54:46,559
misunderstood the committee on peaceful

1529
00:54:50,710 --> 00:54:49,119
users of outer space provides a forum

1530
00:54:52,789 --> 00:54:50,720
for the member states to get together to

1531
00:54:54,230 --> 00:54:52,799
talk about how do we cooperate

1532
00:54:55,670 --> 00:54:54,240
collaborate and

1533
00:54:56,950 --> 00:54:55,680
explore

1534
00:54:59,270 --> 00:54:56,960
and make

1535
00:55:01,990 --> 00:54:59,280
use of space

1536
00:55:04,630 --> 00:55:02,000
for the betterment of mankind

1537
00:55:07,030 --> 00:55:04,640
so it's it's the ideal form for

1538
00:55:09,190 --> 00:55:07,040

the space capable nations to get

1539
00:55:12,230 --> 00:55:09,200
together and talk about how would we

1540
00:55:13,430 --> 00:55:12,240
would deal with a impact threat from

1541
00:55:14,390 --> 00:55:13,440
space

1542
00:55:15,349 --> 00:55:14,400
and

1543
00:55:24,470 --> 00:55:15,359
the

1544
00:55:26,150 --> 00:55:24,480
council for approval of our

1545
00:55:28,069 --> 00:55:26,160
recommendations

1546
00:55:29,510 --> 00:55:28,079
uh of how the

1547
00:55:31,190 --> 00:55:29,520
member states would work together an

1548
00:55:33,430 --> 00:55:31,200
international asteroid warning network

1549
00:55:35,670 --> 00:55:33,440
would be set up which is an enhancement

1550
00:55:38,390 --> 00:55:35,680
of of our existing network which we've

1551
00:55:39,190 --> 00:55:38,400
been running for some 15 years now

1552
00:55:41,349 --> 00:55:39,200
and

1553
00:55:43,750 --> 00:55:41,359
a forum for the space agencies to get

1554
00:55:48,309 --> 00:55:43,760
together and talk about mitigation uh or

1555
00:55:51,349 --> 00:55:48,319
deflection capabilities uh to divert a

1556
00:55:53,270 --> 00:55:51,359
hazardous asteroid off an earth impact

1557
00:55:55,190 --> 00:55:53,280
would be the space missions planning and

1558
00:55:57,430 --> 00:55:55,200
advisory group over on the

1559
00:55:58,150 --> 00:55:57,440
on the lower right there

1560
00:55:59,910 --> 00:55:58,160
we

1561
00:56:01,510 --> 00:55:59,920
would

1562
00:56:03,670 --> 00:56:01,520
get

1563
00:56:05,670 --> 00:56:03,680

have this form on a regular basis before

1564
00:56:07,109 --> 00:56:05,680
a threat was ever identified so that we

1565
00:56:09,829 --> 00:56:07,119
could talk about

1566
00:56:13,670 --> 00:56:09,839
what capabilities we would bring to bear

1567
00:56:15,670 --> 00:56:13,680
to deal with that threat once it was

1568
00:56:17,990 --> 00:56:15,680
discovered

1569
00:56:20,230 --> 00:56:18,000
and once a credible threat is

1570
00:56:24,069 --> 00:56:20,240
uh found then the member states would

1571
00:56:28,950 --> 00:56:26,150
bring the plan together that would then

1572
00:56:30,789 --> 00:56:28,960
be taken into the international forum uh

1573
00:56:32,789 --> 00:56:30,799
informed with the committee on peaceful

1574
00:56:34,630 --> 00:56:32,799
uses of outer space who might set up an

1575
00:56:36,630 --> 00:56:34,640
ad hoc mitigation planning advisory

1576
00:56:37,670 --> 00:56:36,640
group to work within the international

1577
00:56:40,069 --> 00:56:37,680
forum

1578
00:56:42,230 --> 00:56:40,079
to keep everybody

1579
00:56:43,829 --> 00:56:42,240
informed and working together and advise

1580
00:56:46,150 --> 00:56:43,839
any of the nations that might be

1581
00:56:48,109 --> 00:56:46,160
affected by such an impact which

1582
00:56:50,870 --> 00:56:48,119
could be a large number it wouldn't

1583
00:56:53,190 --> 00:56:50,880
necessarily be any one nation

1584
00:56:55,109 --> 00:56:53,200
about what the space capable

1585
00:56:56,309 --> 00:56:55,119
member states are doing

1586
00:56:59,589 --> 00:56:56,319
to

1587
00:57:00,710 --> 00:56:59,599
avert uh that threat and and so that is

1588
00:57:03,670 --> 00:57:00,720

uh

1589
00:57:05,910 --> 00:57:03,680
what has been going on in the u.n um

1590
00:57:07,430 --> 00:57:05,920
uh uh forms

1591
00:57:09,910 --> 00:57:07,440
under the committee on peaceful uses of

1592
00:57:12,069 --> 00:57:09,920
outer space uh there's no approval of a

1593
00:57:14,230 --> 00:57:12,079
mission or authorization of a mission by

1594
00:57:17,670 --> 00:57:14,240
the united nations it is work that is

1595
00:57:18,789 --> 00:57:17,680
done by the space capable member states

1596
00:57:21,190 --> 00:57:18,799
with

1597
00:57:23,190 --> 00:57:21,200
the sanction of that process

1598
00:57:24,789 --> 00:57:23,200
and how it works together by the

1599
00:57:28,710 --> 00:57:24,799
international

1600
00:57:38,309 --> 00:57:29,910
so back to

1601
00:57:38,319 --> 00:57:42,710
let's go back here

1602
00:57:45,670 --> 00:57:44,470
yeah i have a toronto direction

1603
00:57:49,430 --> 00:57:45,680
okay so

1604
00:57:51,109 --> 00:57:49,440
back to uh the existing uh program that

1605
00:57:54,470 --> 00:57:51,119
uh that the united states has

1606
00:57:57,910 --> 00:57:54,480
participated in uh and actually been the

1607
00:58:02,630 --> 00:57:57,920
leading force for 15 years now

1608
00:58:07,829 --> 00:58:04,710
nasa committing to the house committee

1609
00:58:10,470 --> 00:58:07,839
on science that we would find

1610
00:58:11,510 --> 00:58:10,480
at least 50 percent of the

1611
00:58:13,910 --> 00:58:11,520
large

1612
00:58:15,349 --> 00:58:13,920
near-earth objects those one kilometer

1613
00:58:17,349 --> 00:58:15,359

and larger in size if the earth were to

1614
00:58:21,030 --> 00:58:17,359
get hit by one of those that would be

1615
00:58:23,430 --> 00:58:21,040
a three-segment bad day for all of us

1616
00:58:25,430 --> 00:58:23,440
uh and originally the uh program

1617
00:58:27,750 --> 00:58:25,440
averaged about four million uh dollars a

1618
00:58:29,829 --> 00:58:27,760
year uh through most of the last decade

1619
00:58:31,670 --> 00:58:29,839
uh but we reached that goal of finding

1620
00:58:34,150 --> 00:58:31,680
uh over ninety percent of the one

1621
00:58:37,270 --> 00:58:34,160
kilometer and larger near-earth objects

1622
00:58:38,309 --> 00:58:37,280
uh in um 2010.

1623
00:58:41,829 --> 00:58:38,319
however

1624
00:58:43,910 --> 00:58:41,839
in the meantime as we studied

1625
00:58:45,190 --> 00:58:43,920
what size object could still do

1626
00:58:47,670 --> 00:58:45,200
significant damage to the earth's

1627
00:58:48,470 --> 00:58:47,680
surface in two or three studies that we

1628
00:58:50,789 --> 00:58:48,480
did

1629
00:58:52,309 --> 00:58:50,799
almost a decade ago now

1630
00:58:54,870 --> 00:58:52,319
we found that we really got to find them

1631
00:58:57,750 --> 00:58:54,880
to a smaller size than that to

1632
00:58:58,630 --> 00:58:57,760
significantly reduce the risk

1633
00:59:00,390 --> 00:58:58,640
of

1634
00:59:02,390 --> 00:59:00,400
casualties

1635
00:59:05,030 --> 00:59:02,400
in an unwarned impact

1636
00:59:08,230 --> 00:59:05,040
down to at least the 100 meter size

1637
00:59:09,990 --> 00:59:08,240
because even 100 meter size object could

1638
00:59:11,510 --> 00:59:10,000

wipe out

1639
00:59:12,549 --> 00:59:11,520
a large

1640
00:59:14,870 --> 00:59:12,559
region

1641
00:59:17,990 --> 00:59:14,880
certainly larger than a city if it were

1642
00:59:21,910 --> 00:59:18,000
to hit the earth in the wrong place

1643
00:59:24,789 --> 00:59:21,920
so the goal post removed in 2005

1644
00:59:26,150 --> 00:59:24,799
for us to find a 100 meter class

1645
00:59:27,670 --> 00:59:26,160
this is the language out of the

1646
00:59:32,870 --> 00:59:27,680
authorization act

1647
00:59:34,789 --> 00:59:32,880
uh 140 meters in in size in order to

1648
00:59:36,870 --> 00:59:34,799
have a complete assessment of the rest

1649
00:59:37,750 --> 00:59:36,880
of the risk of near-earth objects to the

1650
00:59:40,150 --> 00:59:37,760
earth

1651
00:59:41,589 --> 00:59:40,160
and the goal of the survey would be to

1652
00:59:44,549 --> 00:59:41,599
find 90

1653
00:59:46,630 --> 00:59:44,559
of those objects down to a 100 meter

1654
00:59:51,470 --> 00:59:46,640
class within 15 years

1655
00:59:57,670 --> 00:59:55,349
2005 that would be by 2020.

1656
01:00:00,630 --> 00:59:57,680
we've got a ways to go

1657
01:00:02,630 --> 01:00:00,640
to be able to achieve that goal so our

1658
01:00:03,829 --> 01:00:02,640
but our current program is objective is

1659
01:00:05,349 --> 01:00:03,839
to do that

1660
01:00:07,190 --> 01:00:05,359
as soon as possible

1661
01:00:09,589 --> 01:00:07,200
uh probably won't be able to achieve it

1662
01:00:12,150 --> 01:00:09,599
by 2020 at the current at the current

1663
01:00:15,430 --> 01:00:12,160

rate and the current capabilities but

1664
01:00:16,230 --> 01:00:15,440
now starting in last year and uh this

1665
01:00:17,910 --> 01:00:16,240
year

1666
01:00:19,109 --> 01:00:17,920
the program is working with 20 million

1667
01:00:21,270 --> 01:00:19,119
dollars a year

1668
01:00:24,230 --> 01:00:21,280
and but this program also detects even

1669
01:00:26,309 --> 01:00:24,240
smaller uh size objects down to the size

1670
01:00:28,150 --> 01:00:26,319
that we were talking about here a 7 to

1671
01:00:29,750 --> 01:00:28,160
10 meter size object or even smaller

1672
01:00:32,950 --> 01:00:29,760
we've actually found

1673
01:00:35,349 --> 01:00:32,960
uh one or two meter objects as they pass

1674
01:00:36,789 --> 01:00:35,359
through the earth moon system

1675
01:00:38,630 --> 01:00:36,799
so we're able to detect those small

1676
01:00:40,069 --> 01:00:38,640
objects uh as they approach the earth

1677
01:00:42,390 --> 01:00:40,079
and those are exactly the type of

1678
01:00:44,309 --> 01:00:42,400
objects that we are looking for

1679
01:00:47,109 --> 01:00:44,319
for this asteroid redirect mission there

1680
01:00:48,710 --> 01:00:47,119
are objects uh that are asteroids that

1681
01:00:50,710 --> 01:00:48,720
are in orbits that are very

1682
01:00:52,150 --> 01:00:50,720
uh near earth's orbit

1683
01:00:55,589 --> 01:00:52,160
so that's what makes them easy to bring

1684
01:00:58,470 --> 01:00:55,599
back so it all kind of works together

1685
01:01:01,750 --> 01:00:58,480
current observation program

1686
01:01:02,789 --> 01:01:01,760
first of all we have two main

1687
01:01:04,630 --> 01:01:02,799
data

1688
01:01:05,430 --> 01:01:04,640

analysis and processing center the first

1689
01:01:07,030 --> 01:01:05,440
one

1690
01:01:08,630 --> 01:01:07,040
is the minor planet center the minor

1691
01:01:10,150 --> 01:01:08,640
planet center has been in operation for

1692
01:01:12,390 --> 01:01:10,160
decades

1693
01:01:14,069 --> 01:01:12,400
it is the international astronomical

1694
01:01:15,670 --> 01:01:14,079
union sanctioned

1695
01:01:16,870 --> 01:01:15,680
core

1696
01:01:19,670 --> 01:01:16,880
center

1697
01:01:22,470 --> 01:01:19,680
for obtaining observations from

1698
01:01:24,390 --> 01:01:22,480
observatories around the world on all

1699
01:01:25,510 --> 01:01:24,400
the small bodies in the in the solar

1700
01:01:26,309 --> 01:01:25,520
system

1701
01:01:28,950 --> 01:01:26,319
so

1702
01:01:29,829 --> 01:01:28,960
it's been existence for decades and

1703
01:01:32,630 --> 01:01:29,839
it

1704
01:01:33,910 --> 01:01:32,640
is an integral part of nasa's neo

1705
01:01:36,069 --> 01:01:33,920
program now

1706
01:01:37,109 --> 01:01:36,079
and that it does special processing on

1707
01:01:39,910 --> 01:01:37,119
objects

1708
01:01:41,990 --> 01:01:39,920
that are found to be in these uh

1709
01:01:43,270 --> 01:01:42,000
orbits near the earth's orbit

1710
01:01:45,430 --> 01:01:43,280
and gives us the initial orbit

1711
01:01:47,589 --> 01:01:45,440
determination and alerts our systems

1712
01:01:50,470 --> 01:01:47,599
when there's an object of interest to us

1713
01:01:52,549 --> 01:01:50,480

one that could be a potential hazard to

1714
01:01:54,549 --> 01:01:52,559
impact in the earth

1715
01:01:56,870 --> 01:01:54,559
that information is then relayed to the

1716
01:01:58,710 --> 01:01:56,880
neo program office out at the jeff

1717
01:02:00,870 --> 01:01:58,720
propulsion laboratory

1718
01:02:02,789 --> 01:02:00,880
who helps nasa headquarters first of all

1719
01:02:03,990 --> 01:02:02,799
with the program coordination

1720
01:02:06,630 --> 01:02:04,000
they do the precision orbit

1721
01:02:08,390 --> 01:02:06,640
determination

1722
01:02:10,630 --> 01:02:08,400
with all the observations that do come

1723
01:02:13,029 --> 01:02:10,640
in i mean this is a group

1724
01:02:15,029 --> 01:02:13,039
of orbital analyst

1725
01:02:16,470 --> 01:02:15,039
astrodynamicists

1726
01:02:17,270 --> 01:02:16,480
that

1727
01:02:19,430 --> 01:02:17,280
do

1728
01:02:21,190 --> 01:02:19,440
the navigation for spacecraft that we

1729
01:02:23,750 --> 01:02:21,200
have throughout the solar system they

1730
01:02:25,349 --> 01:02:23,760
put the cassini space for wrath

1731
01:02:27,029 --> 01:02:25,359
through the rings of saturn

1732
01:02:28,390 --> 01:02:27,039
for goodness sake so i think they kind

1733
01:02:31,589 --> 01:02:28,400
of know what they're doing

1734
01:02:35,990 --> 01:02:32,950
so they do

1735
01:02:37,109 --> 01:02:36,000
the precise orbit determination project

1736
01:02:38,789 --> 01:02:37,119
forward

1737
01:02:40,390 --> 01:02:38,799
where these asteroids that we've

1738
01:02:43,349 --> 01:02:40,400

discovered are going to be in the future

1739
01:02:45,109 --> 01:02:43,359
with the observations that are obtained

1740
01:02:47,029 --> 01:02:45,119
and

1741
01:02:49,270 --> 01:02:47,039
determine if there is any probability of

1742
01:02:52,150 --> 01:02:49,280
impact for that object not only the

1743
01:02:54,230 --> 01:02:52,160
earth by the way but all of the other

1744
01:02:55,829 --> 01:02:54,240
planets and large moons in the solar

1745
01:02:57,109 --> 01:02:55,839
system

1746
01:02:59,430 --> 01:02:57,119
they

1747
01:03:02,789 --> 01:03:00,870
predict whether an object is going to be

1748
01:03:05,349 --> 01:03:02,799
an impact

1749
01:03:07,829 --> 01:03:05,359
hazard to the to mars which would be a

1750
01:03:10,789 --> 01:03:07,839
very interesting planetary experiment to

1751
01:03:14,309 --> 01:03:12,069
so

1752
01:03:16,630 --> 01:03:14,319
those are our main processing nodes then

1753
01:03:18,789 --> 01:03:16,640
we have currently these are the

1754
01:03:19,670 --> 01:03:18,799
ground-based telescopes along the bottom

1755
01:03:22,710 --> 01:03:19,680
here

1756
01:03:25,029 --> 01:03:22,720
that do the major uh contributions uh to

1757
01:03:25,829 --> 01:03:25,039
search and detection and tracking

1758
01:03:28,309 --> 01:03:25,839
of

1759
01:03:29,670 --> 01:03:28,319
near-earth asteroids linear has been

1760
01:03:33,029 --> 01:03:29,680
with us since the beginning of the

1761
01:03:33,750 --> 01:03:33,039
program in 98 catalina sky survey had

1762
01:03:36,470 --> 01:03:33,760
been

1763
01:03:38,470 --> 01:03:36,480

is our most productive program

1764
01:03:39,990 --> 01:03:38,480
came along about

1765
01:03:42,789 --> 01:03:40,000
10 years ago

1766
01:03:44,630 --> 01:03:42,799
and bringing up the capability and finds

1767
01:03:47,750 --> 01:03:44,640
almost uh 60

1768
01:03:48,630 --> 01:03:47,760
of the uh near earth asteroids uh these

1769
01:03:50,870 --> 01:03:48,640
days

1770
01:03:53,670 --> 01:03:50,880
pan stars the university y is has been

1771
01:03:54,870 --> 01:03:53,680
coming online with a 1.8 meter uh

1772
01:03:57,109 --> 01:03:54,880
telescope

1773
01:03:58,789 --> 01:03:57,119
uh and is uh coming up on the on the

1774
01:04:01,510 --> 01:03:58,799
step uh and

1775
01:04:04,390 --> 01:04:01,520
uh once uh we're able to go to a larger

1776
01:04:05,349 --> 01:04:04,400
percentage of the of their uh time on

1777
01:04:07,190 --> 01:04:05,359
the sky

1778
01:04:08,630 --> 01:04:07,200
for asteroid search they will be the

1779
01:04:10,390 --> 01:04:08,640
most uh

1780
01:04:12,870 --> 01:04:10,400
capable uh system

1781
01:04:14,309 --> 01:04:12,880
and then we've had the uh

1782
01:04:16,309 --> 01:04:14,319
uh

1783
01:04:17,349 --> 01:04:16,319
one space-based capability that we've

1784
01:04:20,309 --> 01:04:17,359
been uh

1785
01:04:23,349 --> 01:04:20,319
making use of it was actually uh the

1786
01:04:26,549 --> 01:04:23,359
wide field infrared survey explorer

1787
01:04:28,870 --> 01:04:26,559
was to do a science mission of of the

1788
01:04:31,109 --> 01:04:28,880

astrophysics science mission of

1789
01:04:32,549 --> 01:04:31,119
mapping the infrared background of the

1790
01:04:35,029 --> 01:04:32,559
of the sky

1791
01:04:36,789 --> 01:04:35,039
uh to uh great detail and preparation

1792
01:04:38,710 --> 01:04:36,799
for the james webb

1793
01:04:41,190 --> 01:04:38,720
space telescope

1794
01:04:43,510 --> 01:04:41,200
so it does that by uh

1795
01:04:46,789 --> 01:04:43,520
uh continuously imaging the sky and

1796
01:04:48,470 --> 01:04:46,799
taking multiple images uh up to uh about

1797
01:04:52,309 --> 01:04:48,480
15 images

1798
01:04:54,549 --> 01:04:52,319
uh over the course of of a day

1799
01:04:55,829 --> 01:04:54,559
of the same area of the sky

1800
01:04:58,630 --> 01:04:55,839
and then

1801
01:05:00,069 --> 01:04:58,640
over the course of a year

1802
01:05:01,990 --> 01:05:00,079
it will image

1803
01:05:04,470 --> 01:05:02,000
the entire sky twice

1804
01:05:05,829 --> 01:05:04,480
well we quickly realized that

1805
01:05:07,190 --> 01:05:05,839
that this

1806
01:05:08,870 --> 01:05:07,200
instrument

1807
01:05:11,430 --> 01:05:08,880
even though it

1808
01:05:12,390 --> 01:05:11,440
does it slowly

1809
01:05:17,510 --> 01:05:12,400
then

1810
01:05:21,750 --> 01:05:19,910
is a very good asteroid detector because

1811
01:05:23,430 --> 01:05:21,760
you can take all those images that it

1812
01:05:24,950 --> 01:05:23,440
collects

1813
01:05:27,190 --> 01:05:24,960

hundreds of thousands of images of the

1814
01:05:29,270 --> 01:05:27,200
sky and compare them one to the other

1815
01:05:33,109 --> 01:05:29,280
and see what moves and the things that

1816
01:05:33,829 --> 01:05:33,119
moves are are are usually asteroids

1817
01:05:36,390 --> 01:05:33,839
so

1818
01:05:40,390 --> 01:05:36,400
as it was in its main uh prime mission

1819
01:05:43,910 --> 01:05:40,400
in in 2010 uh started operations in 2010

1820
01:05:47,589 --> 01:05:45,510
enhanced its ground processing

1821
01:05:50,069 --> 01:05:47,599
capability to make an asteroid hunter

1822
01:05:51,150 --> 01:05:50,079
out of it and over the course of that

1823
01:05:54,069 --> 01:05:51,160
year

1824
01:05:55,829 --> 01:05:54,079
129 near earth asteroids were found by

1825
01:05:58,309 --> 01:05:55,839
this system

1826
01:06:01,190 --> 01:05:58,319
independently and it also took

1827
01:06:03,270 --> 01:06:01,200
observations of several thousand

1828
01:06:05,750 --> 01:06:03,280
already known

1829
01:06:07,829 --> 01:06:05,760
asteroids both near earth asteroids and

1830
01:06:10,630 --> 01:06:07,839
in the main belt so it's become one of

1831
01:06:14,470 --> 01:06:10,640
the biggest databases there is right now

1832
01:06:15,510 --> 01:06:14,480
on asteroids in the solar system

1833
01:06:22,150 --> 01:06:15,520
it

1834
01:06:23,990 --> 01:06:22,160
more months

1835
01:06:27,430 --> 01:06:24,000
as an asteroid hunter but then it was

1836
01:06:32,950 --> 01:06:29,829
in the hopes of future use

1837
01:06:34,470 --> 01:06:32,960
with the grand challenge coming on board

1838
01:06:36,549 --> 01:06:34,480

and our need

1839
01:06:38,870 --> 01:06:36,559
to make the most use of any capability

1840
01:06:42,069 --> 01:06:38,880
we could to find asteroids

1841
01:06:46,150 --> 01:06:42,079
we've reactivated wise in a as a

1842
01:06:48,470 --> 01:06:46,160
dedicated asteroid hunter uh it was uh

1843
01:06:49,910 --> 01:06:48,480
woken up and uh

1844
01:06:56,710 --> 01:06:49,920
uh

1845
01:06:58,630 --> 01:06:56,720
its optics are cooling down

1846
01:07:00,950 --> 01:06:58,640
uh for it to begin imaging here within

1847
01:07:02,710 --> 01:07:00,960
the next uh within the next month and

1848
01:07:04,150 --> 01:07:02,720
we'll operate this spacecraft for as

1849
01:07:06,069 --> 01:07:04,160
long as it uh

1850
01:07:06,950 --> 01:07:06,079
will last

1851
01:07:09,349 --> 01:07:06,960
and

1852
01:07:11,670 --> 01:07:09,359
be in a in the right kind of an orbit

1853
01:07:15,029 --> 01:07:11,680
for about three years we hope

1854
01:07:17,109 --> 01:07:15,039
we'll be able to operate it

1855
01:07:19,589 --> 01:07:17,119
currently our sky coverage with those

1856
01:07:21,510 --> 01:07:19,599
systems that we talk about over the

1857
01:07:22,870 --> 01:07:21,520
course of a month looks like looks like

1858
01:07:23,990 --> 01:07:22,880
this

1859
01:07:25,910 --> 01:07:24,000
we

1860
01:07:27,670 --> 01:07:25,920
can't

1861
01:07:30,069 --> 01:07:27,680
from from the ground

1862
01:07:31,990 --> 01:07:30,079
we can't really search for these very

1863
01:07:34,549 --> 01:07:32,000

dim objects in the full of the moon so

1864
01:07:36,549 --> 01:07:34,559
we lose about a week or so of time every

1865
01:07:39,270 --> 01:07:36,559
month

1866
01:07:44,710 --> 01:07:39,280
current system

1867
01:07:47,029 --> 01:07:44,720
most of the accessible sky now you see

1868
01:07:49,829 --> 01:07:47,039
here that

1869
01:07:52,789 --> 01:07:49,839
we're well covered in the northern uh

1870
01:07:54,630 --> 01:07:52,799
latitudes hemisphere we lack search

1871
01:07:57,589 --> 01:07:54,640
capability in the south which would it

1872
01:08:00,630 --> 01:07:57,599
would be nice to have a more capable

1873
01:08:02,230 --> 01:08:00,640
search capability in the south so but

1874
01:08:04,230 --> 01:08:02,240
these are these are how these systems

1875
01:08:07,190 --> 01:08:04,240
operate they basically tile the sky you

1876
01:08:09,670 --> 01:08:07,200
know starting uh one section of the sky

1877
01:08:11,670 --> 01:08:09,680
image it for about uh for a few seconds

1878
01:08:13,510 --> 01:08:11,680
and then move on to the next tile and

1879
01:08:16,229 --> 01:08:13,520
across the sky and then they will come

1880
01:08:19,349 --> 01:08:16,239
back 30 minutes to an hour later image

1881
01:08:20,630 --> 01:08:19,359
that same uh part of the sky

1882
01:08:22,390 --> 01:08:20,640
bring all that

1883
01:08:24,550 --> 01:08:22,400
data into their computer processing and

1884
01:08:27,189 --> 01:08:24,560
compare one image to another to see what

1885
01:08:32,789 --> 01:08:29,590
so this is uh

1886
01:08:34,870 --> 01:08:32,799
the actual discovery uh imagery

1887
01:08:36,229 --> 01:08:34,880
of of an asteroid

1888
01:08:38,390 --> 01:08:36,239

and

1889
01:08:41,749 --> 01:08:38,400
you can see it move from one image to

1890
01:08:44,390 --> 01:08:41,759
another there's about 30 minutes or so

1891
01:08:46,390 --> 01:08:44,400
between those those images

1892
01:08:48,070 --> 01:08:46,400
and we look for what moves across the

1893
01:08:50,950 --> 01:08:48,080
sky

1894
01:08:53,510 --> 01:08:50,960
and did you see it

1895
01:08:57,669 --> 01:08:53,520
this is the discovery imagery of uh

1896
01:09:01,829 --> 01:08:57,679
asteroid uh 2013 mz5 which was the 100th

1897
01:09:04,470 --> 01:09:01,839
uh nearest object that we have found

1898
01:09:08,070 --> 01:09:04,480
in the course of our program

1899
01:09:11,430 --> 01:09:08,080
i was found by panstarrs uh back in uh

1900
01:09:13,749 --> 01:09:11,440
uh june of of this year

1901
01:09:15,110 --> 01:09:13,759
and you see it's uh

1902
01:09:18,309 --> 01:09:15,120
from uh

1903
01:09:21,030 --> 01:09:18,319
each uh 30 30 minute sequences move it

1904
01:09:24,709 --> 01:09:21,040
move across

1905
01:09:27,110 --> 01:09:24,719
current observing network is worldwide

1906
01:09:29,349 --> 01:09:27,120
this shows uh observatories from around

1907
01:09:31,269 --> 01:09:29,359
the world that contributed observations

1908
01:09:33,669 --> 01:09:31,279
to our network

1909
01:09:36,870 --> 01:09:33,679
in in 2012 some

1910
01:09:38,149 --> 01:09:36,880
observatories from some 46 countries

1911
01:09:40,630 --> 01:09:38,159
some of them

1912
01:09:43,349 --> 01:09:40,640
quite professional observatories uh a

1913
01:09:45,189 --> 01:09:43,359

lot of uh observations once we found an

1914
01:09:46,870 --> 01:09:45,199
object for follow-up tracking actually

1915
01:09:48,550 --> 01:09:46,880
come in from amateurs very capable

1916
01:09:51,030 --> 01:09:48,560
amateurs were certainly the larger

1917
01:09:53,349 --> 01:09:51,040
asteroids when we get down to 100 meters

1918
01:09:55,669 --> 01:09:53,359
or so in size it's it's uh

1919
01:09:58,950 --> 01:09:55,679
it's really beyond the uh capabilities

1920
01:10:00,790 --> 01:09:58,960
of of uh even uh sophisticated amateur

1921
01:10:03,030 --> 01:10:00,800
but we've got some semi-pros out there

1922
01:10:05,350 --> 01:10:03,040
too that

1923
01:10:07,830 --> 01:10:05,360
even though they may not get paid for it

1924
01:10:09,030 --> 01:10:07,840
they have very capable equipment

1925
01:10:11,350 --> 01:10:09,040
and

1926
01:10:12,310 --> 01:10:11,360
a very dedicated

1927
01:10:14,310 --> 01:10:12,320
hobby

1928
01:10:16,470 --> 01:10:14,320
for some of these and

1929
01:10:18,550 --> 01:10:16,480
some of them make significant fines like

1930
01:10:20,709 --> 01:10:18,560
for instance uh comet ison which we're

1931
01:10:23,110 --> 01:10:20,719
hearing all about right now it's

1932
01:10:25,590 --> 01:10:23,120
if it survives a perihelion passage uh

1933
01:10:27,990 --> 01:10:25,600
by the sun here in a week

1934
01:10:31,110 --> 01:10:28,000
uh should be a quite spectacular object

1935
01:10:33,669 --> 01:10:31,120
in our skies in in december and uh

1936
01:10:35,750 --> 01:10:33,679
january that was found by a team hunting

1937
01:10:38,790 --> 01:10:35,760
for asteroids and comets

1938
01:10:40,229 --> 01:10:38,800

uh uh in russia

1939
01:10:42,550 --> 01:10:40,239
and um

1940
01:10:46,550 --> 01:10:42,560
so they uh they make significant

1941
01:10:48,310 --> 01:10:46,560
contributions to the effort still

1942
01:10:51,030 --> 01:10:48,320
currently uh

1943
01:10:53,430 --> 01:10:51,040
this is our population uh

1944
01:10:56,790 --> 01:10:53,440
curve accumulation curve from when the

1945
01:11:00,310 --> 01:10:56,800
program started in 1998 through

1946
01:11:02,149 --> 01:11:00,320
this month right now we have 10 450 new

1947
01:11:04,630 --> 01:11:02,159
earth objects in our catalog that

1948
01:11:06,070 --> 01:11:04,640
includes 94 comets by the way and that's

1949
01:11:07,510 --> 01:11:06,080
why we call them objects versus

1950
01:11:09,110 --> 01:11:07,520
asteroids because some of them are

1951
01:11:09,950 --> 01:11:09,120
comets

1952
01:11:14,630 --> 01:11:09,960
and

1953
01:11:19,430 --> 01:11:17,030
larger than a kilometer in size but you

1954
01:11:20,470 --> 01:11:19,440
see that the discovery curve is tapered

1955
01:11:22,550 --> 01:11:20,480
off

1956
01:11:24,149 --> 01:11:22,560
so that means we've

1957
01:11:27,910 --> 01:11:24,159
found the larger part of the population

1958
01:11:30,229 --> 01:11:27,920
of large objects our completion

1959
01:11:32,950 --> 01:11:30,239
percentages based upon our population

1960
01:11:34,950 --> 01:11:32,960
models 96 percent are those kilometers

1961
01:11:37,350 --> 01:11:34,960
and larger

1962
01:11:40,709 --> 01:11:37,360
60 percent in this bin but as we get

1963
01:11:42,950 --> 01:11:40,719

down to 100 meters and smaller we have a

1964
01:11:45,430 --> 01:11:42,960
significant

1965
01:11:47,110 --> 01:11:45,440
number of objects to find

1966
01:11:49,030 --> 01:11:47,120
and really need

1967
01:11:51,590 --> 01:11:49,040
more enhanced capability to be able to

1968
01:11:55,350 --> 01:11:53,590
our understanding of the population is

1969
01:11:59,990 --> 01:11:55,360
based upon the modeling that's been done

1970
01:12:04,149 --> 01:12:02,229
the time it's been found and and the

1971
01:12:06,630 --> 01:12:04,159
volume of sky that's been found in you

1972
01:12:08,870 --> 01:12:06,640
can do statistical models on what the

1973
01:12:09,830 --> 01:12:08,880
overall population is

1974
01:12:12,870 --> 01:12:09,840
um

1975
01:12:14,709 --> 01:12:12,880
this uh graph is uh

1976
01:12:16,149 --> 01:12:14,719
this is a graph for the program that has

1977
01:12:18,390 --> 01:12:16,159
everything on it uh down along the

1978
01:12:20,310 --> 01:12:18,400
bottom here is uh

1979
01:12:21,830 --> 01:12:20,320
absolute magnitude the brightness of the

1980
01:12:25,030 --> 01:12:21,840
detected object

1981
01:12:26,149 --> 01:12:25,040
roughly compared to its size

1982
01:12:27,990 --> 01:12:26,159
assuming

1983
01:12:29,750 --> 01:12:28,000
average reflectivity

1984
01:12:32,550 --> 01:12:29,760
the earth's atmosphere

1985
01:12:34,870 --> 01:12:32,560
would protect us from any objects

1986
01:12:38,630 --> 01:12:34,880
below about 30 meters in size although

1987
01:12:44,070 --> 01:12:41,430
which would have been here on the curve

1988
01:12:45,910 --> 01:12:44,080

you know caused us to learn a few things

1989
01:12:48,070 --> 01:12:45,920
about what we maybe need to worry about

1990
01:12:50,709 --> 01:12:48,080
about smaller objects

1991
01:12:52,709 --> 01:12:50,719
tunguska back in 1908 which is the most

1992
01:12:56,070 --> 01:12:52,719
significant event prior to that

1993
01:12:58,149 --> 01:12:56,080
uh was about about 50 meters the kt

1994
01:13:00,630 --> 01:12:58,159
impactor uh this is the one that killed

1995
01:13:02,390 --> 01:13:00,640
the dinosaurs back 65 million years ago

1996
01:13:07,750 --> 01:13:02,400
and thankfully we only get an impact

1997
01:13:10,630 --> 01:13:08,550
so

1998
01:13:12,390 --> 01:13:10,640
one kilometer size objects as we said we

1999
01:13:13,750 --> 01:13:12,400
have about a thousand of them

2000
01:13:16,070 --> 01:13:13,760
to find

2001
01:13:18,709 --> 01:13:16,080
and uh we're well up on that curve we go

2002
01:13:19,590 --> 01:13:18,719
down to 100 meter class there's some 20

2003
01:13:21,510 --> 01:13:19,600
000

2004
01:13:25,030 --> 01:13:21,520
objects out there to be found

2005
01:13:26,709 --> 01:13:25,040
uh 50 meters 250 000. if we get down

2006
01:13:27,910 --> 01:13:26,719
though to the size that we're talking

2007
01:13:30,070 --> 01:13:27,920
about here

2008
01:13:32,229 --> 01:13:30,080
7 to 10 meters in size

2009
01:13:34,310 --> 01:13:32,239
we're talking about millions of objects

2010
01:13:35,910 --> 01:13:34,320
out there that could be classified as

2011
01:13:37,910 --> 01:13:35,920
near-earth objects

2012
01:13:39,110 --> 01:13:37,920
but those that would really be

2013
01:13:39,990 --> 01:13:39,120

acceptable

2014
01:13:42,070 --> 01:13:40,000
uh

2015
01:13:43,750 --> 01:13:42,080
for such a retrieval mission are in the

2016
01:13:46,630 --> 01:13:43,760
right kind of near-earth objects or

2017
01:13:47,590 --> 01:13:46,640
maybe on the order of a few thousand

2018
01:13:51,510 --> 01:13:47,600
we have

2019
01:13:54,310 --> 01:13:51,520
found 370 so far that fit in that size

2020
01:13:56,149 --> 01:13:54,320
range however not in the orbit that

2021
01:13:58,630 --> 01:13:56,159
could be retrievable

2022
01:14:00,630 --> 01:13:58,640
by this system there's only about 14

2023
01:14:02,790 --> 01:14:00,640
objects that we know of

2024
01:14:04,390 --> 01:14:02,800
right now that are in that type of orbit

2025
01:14:06,790 --> 01:14:04,400
and we are

2026
01:14:09,030 --> 01:14:06,800
campaign is attempting to find more more

2027
01:14:11,110 --> 01:14:09,040
data on them

2028
01:14:13,750 --> 01:14:11,120
enhancements that we're doing

2029
01:14:16,310 --> 01:14:13,760
to build up our capability we're working

2030
01:14:17,990 --> 01:14:16,320
with the department of defense and

2031
01:14:20,229 --> 01:14:18,000
and darpa and their new space

2032
01:14:22,070 --> 01:14:20,239
surveillance telescope so that it has uh

2033
01:14:24,950 --> 01:14:22,080
neo detection capabilities so they can

2034
01:14:27,030 --> 01:14:24,960
do that as a secondary mission

2035
01:14:29,830 --> 01:14:27,040
enhancing uh the capabilities of

2036
01:14:31,669 --> 01:14:29,840
pan-starrs pan-starrs one getting more

2037
01:14:34,470 --> 01:14:31,679
time on the system

2038
01:14:38,709 --> 01:14:34,480

so that is able to dedicate more

2039
01:14:40,070 --> 01:14:38,719
of its telescope time to search and also

2040
01:14:42,229 --> 01:14:40,080
helping the university of hawaii

2041
01:14:44,390 --> 01:14:42,239
complete the second pan-star system so

2042
01:14:45,590 --> 01:14:44,400
we have a second aperture that can that

2043
01:14:48,470 --> 01:14:45,600
can be used

2044
01:14:49,990 --> 01:14:48,480
also we have a new uh capability that's

2045
01:14:52,470 --> 01:14:50,000
in development

2046
01:14:54,550 --> 01:14:52,480
called atlas

2047
01:14:57,990 --> 01:14:54,560
it is making use of smaller aperture

2048
01:14:59,750 --> 01:14:58,000
telescopes but using very sophisticated

2049
01:15:01,430 --> 01:14:59,760
cameras and

2050
01:15:03,669 --> 01:15:01,440
software processing

2051
01:15:05,590 --> 01:15:03,679
to more rapidly cover the night sky so

2052
01:15:07,510 --> 01:15:05,600
they would be able to

2053
01:15:10,310 --> 01:15:07,520
with a couple of these systems

2054
01:15:11,430 --> 01:15:10,320
be able to cover the entire night sky

2055
01:15:15,590 --> 01:15:11,440
each

2056
01:15:18,790 --> 01:15:15,600
it won't go as deep

2057
01:15:20,149 --> 01:15:18,800
in other words to see dim

2058
01:15:22,470 --> 01:15:20,159
large objects

2059
01:15:25,270 --> 01:15:22,480
far away that are very dim but would

2060
01:15:26,630 --> 01:15:25,280
find any object that was close to earth

2061
01:15:29,430 --> 01:15:26,640
down to

2062
01:15:33,189 --> 01:15:29,440
this size of 10 meters or so

2063
01:15:34,870 --> 01:15:33,199

that will come online in 2015.

2064
01:15:36,870 --> 01:15:34,880
with these enhanced capabilities we

2065
01:15:39,669 --> 01:15:36,880
expect the discovery rate

2066
01:15:42,550 --> 01:15:39,679
of armed candidates to be increased we

2067
01:15:44,229 --> 01:15:42,560
find about two a year now that meet the

2068
01:15:45,990 --> 01:15:44,239
criteria

2069
01:15:48,550 --> 01:15:46,000
that

2070
01:15:50,070 --> 01:15:48,560
is needed for this retrieval mission we

2071
01:15:52,630 --> 01:15:50,080
think the capability with these

2072
01:15:54,709 --> 01:15:52,640
enhancements uh our studies show the

2073
01:15:56,950 --> 01:15:54,719
capability would will be increased at

2074
01:15:59,669 --> 01:15:56,960
least five per year so over the three or

2075
01:16:02,870 --> 01:15:59,679
four years we have until uh

2076
01:16:04,550 --> 01:16:02,880
the the launch of such a system

2077
01:16:05,350 --> 01:16:04,560
we should be able to find at least 15

2078
01:16:10,790 --> 01:16:05,360
more

2079
01:16:15,350 --> 01:16:13,030
another important aspect as brian went

2080
01:16:17,189 --> 01:16:15,360
into is being able to characterize these

2081
01:16:18,229 --> 01:16:17,199
new earth objects

2082
01:16:20,229 --> 01:16:18,239
and the

2083
01:16:22,310 --> 01:16:20,239
we used a number of techniques so

2084
01:16:24,149 --> 01:16:22,320
whatever is able to observe the objects

2085
01:16:26,310 --> 01:16:24,159
to do that radar is an important

2086
01:16:30,070 --> 01:16:26,320
capability but we also use a lot of

2087
01:16:33,590 --> 01:16:32,550
to understand more about the size and

2088
01:16:36,310 --> 01:16:33,600

mass

2089
01:16:38,149 --> 01:16:36,320
of these objects if

2090
01:16:40,709 --> 01:16:38,159
there can be a significant difference in

2091
01:16:42,950 --> 01:16:40,719
the size that you don't know until we do

2092
01:16:47,030 --> 01:16:42,960
this more enhanced characterization it

2093
01:16:52,390 --> 01:16:49,750
and so be outside of the capabilities of

2094
01:16:55,030 --> 01:16:52,400
the retrieval spacecraft or it might be

2095
01:16:57,030 --> 01:16:55,040
a very small but bright object and so it

2096
01:16:59,830 --> 01:16:57,040
would meet the size

2097
01:17:01,910 --> 01:16:59,840
that the arm could retrieve so final uh

2098
01:17:03,350 --> 01:17:01,920
selection of the target will depend

2099
01:17:05,510 --> 01:17:03,360
largely upon

2100
01:17:07,750 --> 01:17:05,520
our ability to characterize it

2101
01:17:09,510 --> 01:17:07,760
and the upper bound

2102
01:17:10,630 --> 01:17:09,520
may be

2103
01:17:11,910 --> 01:17:10,640
us

2104
01:17:13,590 --> 01:17:11,920
we have to work with what the upper

2105
01:17:15,910 --> 01:17:13,600
bounds might be

2106
01:17:17,270 --> 01:17:15,920
to be within the capability of the

2107
01:17:20,149 --> 01:17:17,280
retrieval mission

2108
01:17:23,030 --> 01:17:20,159
radar as i said is one of our most

2109
01:17:24,470 --> 01:17:23,040
important capabilities to do this

2110
01:17:25,510 --> 01:17:24,480
and we should be able

2111
01:17:27,590 --> 01:17:25,520
to

2112
01:17:29,189 --> 01:17:27,600
now rapidly get the radar on these

2113
01:17:30,870 --> 01:17:29,199

objects as they are discovered in the

2114
01:17:32,070 --> 01:17:30,880
past a small object we really didn't

2115
01:17:33,750 --> 01:17:32,080
care about it

2116
01:17:36,149 --> 01:17:33,760
we let it go by

2117
01:17:37,990 --> 01:17:36,159
but now that we are interested in in

2118
01:17:40,149 --> 01:17:38,000
seeing these things

2119
01:17:42,790 --> 01:17:40,159
for the retrieval mission we'll bring

2120
01:17:44,470 --> 01:17:42,800
those radars on as rapidly as we can

2121
01:17:46,229 --> 01:17:44,480
after the object is discovered we have

2122
01:17:48,070 --> 01:17:46,239
to discover the object optically you

2123
01:17:49,590 --> 01:17:48,080
can't do it with radar

2124
01:17:51,830 --> 01:17:49,600
you don't just don't get the signal

2125
01:17:54,149 --> 01:17:51,840
noise return but once it's discovered

2126
01:17:56,149 --> 01:17:54,159
optically then the radar the two

2127
01:17:57,110 --> 01:17:56,159
planetary radars can be brought up on it

2128
01:17:58,550 --> 01:17:57,120
to

2129
01:17:59,990 --> 01:17:58,560
more fully characterize it and that

2130
01:18:02,070 --> 01:18:00,000
would be the best way to be able to

2131
01:18:04,149 --> 01:18:02,080
characterize those things

2132
01:18:06,229 --> 01:18:04,159
so our characterization enhancements

2133
01:18:08,390 --> 01:18:06,239
first of all the radar getting as much

2134
01:18:10,630 --> 01:18:08,400
time on those as we can and also

2135
01:18:12,149 --> 01:18:10,640
streamlining the rapid response

2136
01:18:14,790 --> 01:18:12,159
to get

2137
01:18:17,350 --> 01:18:14,800
observations on an object as as soon as

2138
01:18:19,990 --> 01:18:17,360

it's discovered also in increasing our

2139
01:18:22,870 --> 01:18:20,000
capabilities with the nasa's infrared

2140
01:18:25,430 --> 01:18:22,880
telescope facility uh monacai and hawaii

2141
01:18:27,189 --> 01:18:25,440
both in rapid responses as the same with

2142
01:18:28,709 --> 01:18:27,199
the radars but also improving the

2143
01:18:30,709 --> 01:18:28,719
instrumentation that's available for

2144
01:18:32,310 --> 01:18:30,719
characterization

2145
01:18:35,750 --> 01:18:32,320
and then as i mentioned we've already

2146
01:18:38,229 --> 01:18:35,760
reactivated wise as i said wise

2147
01:18:41,110 --> 01:18:38,239
is important as a discovery tool but

2148
01:18:43,510 --> 01:18:41,120
it's also very important in that for

2149
01:18:47,030 --> 01:18:43,520
characterization in that it operates in

2150
01:18:50,070 --> 01:18:47,040
the ir bands and with two ir bands you

2151
01:18:54,709 --> 01:18:52,630
precise determination of its size

2152
01:18:57,110 --> 01:18:54,719
estimate of its size and you cannot then

2153
01:18:59,350 --> 01:18:57,120
you can optically

2154
01:19:03,590 --> 01:18:59,360
bound it within about 20 percent versus

2155
01:19:05,270 --> 01:19:03,600
maybe 200 percent uh with just optical

2156
01:19:08,630 --> 01:19:05,280
observations

2157
01:19:11,270 --> 01:19:08,640
uh so these capabilities uh will uh add

2158
01:19:12,149 --> 01:19:11,280
to our capability to find not only

2159
01:19:17,030 --> 01:19:12,159
uh

2160
01:19:19,270 --> 01:19:17,040
improve our capability to find a

2161
01:19:20,950 --> 01:19:19,280
hazardous asteroids which is what we've

2162
01:19:24,550 --> 01:19:20,960
been in the business for for a long time

2163
01:19:29,590 --> 01:19:26,390

rapid response after discovery of the

2164
01:19:31,750 --> 01:19:29,600
object is is is key and so these objects

2165
01:19:33,270 --> 01:19:31,760
that we find now that we're undertaking

2166
01:19:34,630 --> 01:19:33,280
this mission these objects that we find

2167
01:19:36,310 --> 01:19:34,640
in the future

2168
01:19:37,910 --> 01:19:36,320
will have better characterization of

2169
01:19:40,790 --> 01:19:37,920
those objects

2170
01:19:42,470 --> 01:19:40,800
than we did previous to this time

2171
01:19:44,550 --> 01:19:42,480
because we just weren't

2172
01:19:46,070 --> 01:19:44,560
focused on the small objects because we

2173
01:19:47,910 --> 01:19:46,080
they're not seen as a hazard to the

2174
01:19:49,510 --> 01:19:47,920
earth

2175
01:19:50,470 --> 01:19:49,520
we'll bring

2176
01:19:55,030 --> 01:19:50,480
all the

2177
01:19:57,669 --> 01:19:55,040
assets that we can to bear on this uh

2178
01:20:00,229 --> 01:19:57,679
mission in the next two or three years

2179
01:20:02,149 --> 01:20:00,239
and work with both interagency and

2180
01:20:03,350 --> 01:20:02,159
international entities on this

2181
01:20:04,550 --> 01:20:03,360
capability

2182
01:20:07,669 --> 01:20:04,560
and so

2183
01:20:08,629 --> 01:20:07,679
uh with this increase in neos

2184
01:20:10,790 --> 01:20:08,639
both

2185
01:20:12,790 --> 01:20:10,800
as a hazard to impact to the earth and

2186
01:20:14,950 --> 01:20:12,800
the opportunity that they pose

2187
01:20:17,350 --> 01:20:14,960
for not only exploration but potentially

2188
01:20:19,830 --> 01:20:17,360

future resource utilization this is a

2189
01:20:22,149 --> 01:20:19,840
big uh mission area now for for our

2190
01:20:24,870 --> 01:20:22,159
planetary sciences

2191
01:20:27,189 --> 01:20:24,880
not only for nasa but uh around the

2192
01:20:28,229 --> 01:20:27,199
world in in the planetary science

2193
01:20:32,070 --> 01:20:28,239
community

2194
01:20:32,080 --> 01:20:35,110
you lindley

2195
01:20:39,990 --> 01:20:37,030
our final presenter tonight is chris

2196
01:20:42,149 --> 01:20:40,000
moore chris moore is the deputy deputy

2197
01:20:44,390 --> 01:20:42,159
director of the advanced exploration

2198
01:20:46,870 --> 01:20:44,400
systems in the human exploration and

2199
01:20:49,830 --> 01:20:46,880
operations mission directorate at nasa

2200
01:20:51,750 --> 01:20:49,840
headquarters chris led the rfi selection

2201
01:20:55,669 --> 01:20:51,760
process and he's going to give us a

2202
01:20:59,350 --> 01:20:57,350
good evening

2203
01:21:02,310 --> 01:20:59,360
as wendy said i'm going to talk about

2204
01:21:05,669 --> 01:21:02,320
the rfi process and explain why we're

2205
01:21:10,629 --> 01:21:08,149
so when we first started this asteroid

2206
01:21:12,830 --> 01:21:10,639
initiative we realized we'd never done

2207
01:21:16,950 --> 01:21:12,840
anything quite like this

2208
01:21:20,229 --> 01:21:16,960
before so we knew that we had to get

2209
01:21:21,350 --> 01:21:20,239
the best and most innovative ideas to

2210
01:21:22,709 --> 01:21:21,360
help us

2211
01:21:24,629 --> 01:21:22,719
plan

2212
01:21:26,310 --> 01:21:24,639
the missions and the flight systems

2213
01:21:28,950 --> 01:21:26,320

development

2214
01:21:31,030 --> 01:21:28,960
we also realized that

2215
01:21:33,510 --> 01:21:31,040
defending our planet against the threat

2216
01:21:36,070 --> 01:21:33,520
of asteroid collisions

2217
01:21:38,470 --> 01:21:36,080
really involves everybody on the planet

2218
01:21:41,350 --> 01:21:38,480
everybody's got a stake in it

2219
01:21:42,950 --> 01:21:41,360
so we wanted to involve as many people

2220
01:21:45,990 --> 01:21:42,960
as possible

2221
01:21:47,669 --> 01:21:46,000
so we cast the net widely for ideas we

2222
01:21:49,750 --> 01:21:47,679
released an rfi

2223
01:21:53,110 --> 01:21:49,760
in june

2224
01:21:55,750 --> 01:21:53,120
and we requested information in

2225
01:21:56,390 --> 01:21:55,760
six main areas

2226
01:22:00,070 --> 01:21:56,400
and

2227
01:22:03,270 --> 01:22:00,080
the rfi was open to everyone

2228
01:22:05,270 --> 01:22:03,280
individuals companies universities

2229
01:22:07,990 --> 01:22:05,280
other government agencies international

2230
01:22:13,750 --> 01:22:11,590
we did receive 402 responses and

2231
01:22:16,310 --> 01:22:13,760
we went through a process

2232
01:22:18,950 --> 01:22:16,320
of evaluation to select

2233
01:22:20,470 --> 01:22:18,960
the most promising and interesting

2234
01:22:22,870 --> 01:22:20,480
proposals to discuss here at the

2235
01:22:25,030 --> 01:22:22,880
workshop

2236
01:22:28,790 --> 01:22:25,040
here's a breakdown of the

2237
01:22:32,070 --> 01:22:28,800
responses by type of organization and

2238
01:22:33,430 --> 01:22:32,080

we had about 40 percent from the general

2239
01:22:36,629 --> 01:22:33,440
public

2240
01:22:38,709 --> 01:22:36,639
which was really gratifying

2241
01:22:40,149 --> 01:22:38,719
we had people who would sit down in

2242
01:22:40,870 --> 01:22:40,159
front of their computer in the evening

2243
01:22:42,950 --> 01:22:40,880
and

2244
01:22:46,149 --> 01:22:42,960
type a few lines

2245
01:22:47,270 --> 01:22:46,159
describing the idea that they had and so

2246
01:22:49,270 --> 01:22:47,280
we really

2247
01:22:50,709 --> 01:22:49,280
captured the interest of the general

2248
01:22:51,750 --> 01:22:50,719
public

2249
01:22:53,750 --> 01:22:51,760
the other

2250
01:22:58,629 --> 01:22:53,760
large segment was from

2251
01:23:03,030 --> 01:23:01,510
stimulating new

2252
01:23:05,270 --> 01:23:03,040
markets and

2253
01:23:07,189 --> 01:23:05,280
asteroid resources and

2254
01:23:08,870 --> 01:23:07,199
new technologies

2255
01:23:09,830 --> 01:23:08,880
and we had

2256
01:23:11,669 --> 01:23:09,840
about

2257
01:23:13,830 --> 01:23:11,679
10 percent from

2258
01:23:16,149 --> 01:23:13,840
larger corporations

2259
01:23:18,830 --> 01:23:16,159
the rest from nasa centers

2260
01:23:18,840 --> 01:23:24,070
some observatories and universities

2261
01:23:29,590 --> 01:23:26,550
here's a breakdown by the

2262
01:23:31,270 --> 01:23:29,600
six areas and

2263
01:23:33,510 --> 01:23:31,280

the workshop is

2264
01:23:35,430 --> 01:23:33,520
structured around these areas which were

2265
01:23:37,830 --> 01:23:35,440
in the rfi

2266
01:23:39,830 --> 01:23:37,840
but the

2267
01:23:42,149 --> 01:23:39,840
area with the most

2268
01:23:45,110 --> 01:23:42,159
responses was the asteroid and

2269
01:23:47,189 --> 01:23:45,120
deflection demonstrations

2270
01:23:50,550 --> 01:23:47,199
followed

2271
01:23:53,110 --> 01:23:50,560
closely by asteroid observation

2272
01:24:00,629 --> 01:23:53,120
and the one with the fewest responses

2273
01:24:05,430 --> 01:24:02,950
we also got responses from all over the

2274
01:24:07,270 --> 01:24:05,440
world from 16

2275
01:24:08,629 --> 01:24:07,280
different countries there was a lot of

2276
01:24:11,830 --> 01:24:08,639
interest in

2277
01:24:13,350 --> 01:24:11,840
europe and from the uk

2278
01:24:15,030 --> 01:24:13,360
but we got

2279
01:24:19,510 --> 01:24:15,040
responses from

2280
01:24:23,430 --> 01:24:21,830
finland so it was really

2281
01:24:29,350 --> 01:24:23,440
great to see that

2282
01:24:34,310 --> 01:24:33,189
these are the criteria we use to

2283
01:24:35,510 --> 01:24:34,320
decide

2284
01:24:37,910 --> 01:24:35,520
which

2285
01:24:39,350 --> 01:24:37,920
ideas would be presented here at the

2286
01:24:42,070 --> 01:24:39,360
workshop

2287
01:24:43,750 --> 01:24:42,080
we had a team of nasa reviewers who read

2288
01:24:46,310 --> 01:24:43,760

all the proposals

2289
01:24:48,709 --> 01:24:46,320
and we tried to assess them

2290
01:24:51,270 --> 01:24:48,719
relative to these four factors

2291
01:24:54,550 --> 01:24:51,280
the first factor was how relevant was it

2292
01:24:57,510 --> 01:24:54,560
to the objectives of the rfi

2293
01:24:59,350 --> 01:24:57,520
did it address one of the six main areas

2294
01:25:02,470 --> 01:24:59,360
and did it

2295
01:25:03,910 --> 01:25:02,480
demonstrate a clear understanding

2296
01:25:05,669 --> 01:25:03,920
of these areas

2297
01:25:07,830 --> 01:25:05,679
the second factor was

2298
01:25:10,870 --> 01:25:07,840
how much impact

2299
01:25:12,629 --> 01:25:10,880
would the idea have on ensuring michigan

2300
01:25:13,910 --> 01:25:12,639
success or

2301
01:25:16,470 --> 01:25:13,920
accelerating

2302
01:25:18,790 --> 01:25:16,480
asteroid observations

2303
01:25:21,189 --> 01:25:18,800
reducing risk or improving performance

2304
01:25:23,590 --> 01:25:21,199
of the system was a really innovative

2305
01:25:25,030 --> 01:25:23,600
idea and

2306
01:25:26,629 --> 01:25:25,040
most

2307
01:25:28,870 --> 01:25:26,639
importantly was it feasible was it

2308
01:25:29,830 --> 01:25:28,880
something that we could incorporate into

2309
01:25:31,030 --> 01:25:29,840
our

2310
01:25:34,229 --> 01:25:31,040
plans

2311
01:25:37,590 --> 01:25:34,239
the third factor was maturity um

2312
01:25:39,669 --> 01:25:37,600
some of the ideas we got were really

2313
01:25:41,669 --> 01:25:39,679

great ideas but they were

2314
01:25:43,350 --> 01:25:41,679
way out ideas that

2315
01:25:47,270 --> 01:25:43,360
require a lot of

2316
01:25:49,669 --> 01:25:47,280
development so we had to

2317
01:25:53,030 --> 01:25:49,679
decide if

2318
01:25:54,950 --> 01:25:53,040
it was feasible that these new

2319
01:25:56,629 --> 01:25:54,960
technologies could be matured in a

2320
01:26:00,070 --> 01:25:56,639
reasonable time frame

2321
01:26:01,430 --> 01:26:00,080
to incorporate into our mission plans

2322
01:26:03,830 --> 01:26:01,440
and

2323
01:26:06,629 --> 01:26:03,840
the fourth factor was affordability

2324
01:26:09,590 --> 01:26:06,639
can the concept

2325
01:26:12,870 --> 01:26:09,600
significantly improved the

2326
01:26:14,390 --> 01:26:12,880
affordability and

2327
01:26:17,590 --> 01:26:14,400
we also

2328
01:26:20,470 --> 01:26:17,600
tried to involve as many people

2329
01:26:22,470 --> 01:26:20,480
that we hadn't talked to before

2330
01:26:24,149 --> 01:26:22,480
we didn't want to talk to the usual

2331
01:26:25,910 --> 01:26:24,159
suspects because

2332
01:26:28,550 --> 01:26:25,920
we know what's going on in the

2333
01:26:30,709 --> 01:26:28,560
neo-observation program and so he wanted

2334
01:26:33,669 --> 01:26:30,719
to get ideas from

2335
01:26:37,590 --> 01:26:33,679
outside the usual sphere

2336
01:26:39,669 --> 01:26:37,600
so that's how we arrived at the 96

2337
01:26:41,430 --> 01:26:39,679
briefings that you'll hear

2338
01:26:44,070 --> 01:26:41,440

and

2339
01:26:45,990 --> 01:26:44,080
the abstracts of all these responses are

2340
01:26:51,110 --> 01:26:46,000
archived on the web so you can download

2341
01:26:54,149 --> 01:26:52,790
so what do we want to get out of this

2342
01:26:56,310 --> 01:26:54,159
workshop

2343
01:26:59,030 --> 01:26:56,320
we've asked the

2344
01:27:00,550 --> 01:26:59,040
leads for each of the

2345
01:27:02,550 --> 01:27:00,560
groups

2346
01:27:06,390 --> 01:27:02,560
to

2347
01:27:08,149 --> 01:27:06,400
summarize the most promising ideas and

2348
01:27:09,590 --> 01:27:08,159
describe any

2349
01:27:11,910 --> 01:27:09,600
technology development that may be

2350
01:27:13,270 --> 01:27:11,920
needed to mature these ideas to the

2351
01:27:14,790 --> 01:27:13,280
point where they can be incorporated

2352
01:27:18,229 --> 01:27:14,800
into designs

2353
01:27:19,590 --> 01:27:18,239
are there any relationships or linkages

2354
01:27:21,910 --> 01:27:19,600
that could help with

2355
01:27:24,950 --> 01:27:21,920
system or mission integration

2356
01:27:26,870 --> 01:27:24,960
and we really don't want this to be just

2357
01:27:28,709 --> 01:27:26,880
a bunch of presentations

2358
01:27:32,790 --> 01:27:28,719
we want to encourage

2359
01:27:35,430 --> 01:27:32,800
discussion that's why we're here and

2360
01:27:36,790 --> 01:27:35,440
we'd like you to come up with

2361
01:27:40,149 --> 01:27:36,800
findings and

2362
01:27:42,629 --> 01:27:40,159
recommendations on how to use all these

2363
01:27:43,830 --> 01:27:42,639

great ideas so we have a wealth of data

2364
01:27:45,110 --> 01:27:43,840
and

2365
01:27:46,870 --> 01:27:45,120
we're just

2366
01:27:49,110 --> 01:27:46,880
trying to

2367
01:27:50,870 --> 01:27:49,120
synthesize all these

2368
01:27:53,430 --> 01:27:50,880
ideas into

2369
01:27:54,629 --> 01:27:53,440
products that we can actually use in

2370
01:27:58,709 --> 01:27:54,639
planning

2371
01:28:03,430 --> 01:28:00,950
so

2372
01:28:06,149 --> 01:28:03,440
i think that

2373
01:28:08,149 --> 01:28:06,159
we can reflect on

2374
01:28:11,510 --> 01:28:08,159
the importance of this

2375
01:28:13,430 --> 01:28:11,520
asteroid initiative in history

2376
01:28:16,310 --> 01:28:13,440
if we're successful with the redirect

2377
01:28:18,550 --> 01:28:16,320
mission for the first time we'll be

2378
01:28:20,229 --> 01:28:18,560
rearranging the solar system to bring

2379
01:28:22,550 --> 01:28:20,239
humanity greater

2380
01:28:25,270 --> 01:28:22,560
prosperity and security

2381
01:28:26,470 --> 01:28:25,280
greater prosperity by using asteroid

2382
01:28:28,709 --> 01:28:26,480
resources

2383
01:28:31,110 --> 01:28:28,719
on greater security by

2384
01:28:33,430 --> 01:28:31,120
protecting our planet from

2385
01:28:35,270 --> 01:28:33,440
the threat of asteroid

2386
01:28:36,709 --> 01:28:35,280
collisions

2387
01:28:40,149 --> 01:28:36,719
and this is pretty incredible if you

2388
01:28:42,790 --> 01:28:40,159

really stop and think about it

2389
01:28:43,830 --> 01:28:42,800
the solar system's been in existence

2390
01:28:46,310 --> 01:28:43,840
about

2391
01:28:48,470 --> 01:28:46,320
four and a half billion years and

2392
01:28:49,590 --> 01:28:48,480
the planets and asteroids and the comets

2393
01:28:51,030 --> 01:28:49,600
have been

2394
01:28:52,629 --> 01:28:51,040
circling the sun

2395
01:28:55,430 --> 01:28:52,639
all that time

2396
01:28:57,510 --> 01:28:55,440
moving under the influence of gravity

2397
01:28:59,430 --> 01:28:57,520
but not really perturbed by anything

2398
01:29:00,470 --> 01:28:59,440
that happens on earth

2399
01:29:07,030 --> 01:29:00,480
and

2400
01:29:08,550 --> 01:29:07,040
we have the capability to shape the

2401
01:29:10,629 --> 01:29:08,560
solar system

2402
01:29:12,950 --> 01:29:10,639
for our own purposes

2403
01:29:15,189 --> 01:29:12,960
so we tend to get excited about all the

2404
01:29:16,629 --> 01:29:15,199
science and the engineering and the

2405
01:29:18,709 --> 01:29:16,639
technology

2406
01:29:21,750 --> 01:29:18,719
that goes into this mission but

2407
01:29:26,229 --> 01:29:21,760
let's also reflect on how it

2408
01:29:29,189 --> 01:29:26,239
conveys the human spirit to explore

2409
01:29:31,350 --> 01:29:29,199
so all of you are helping us take the

2410
01:29:32,950 --> 01:29:31,360
first steps in this

2411
01:29:35,110 --> 01:29:32,960
great endeavor

2412
01:29:38,790 --> 01:29:35,120
by being here and

2413
01:29:42,149 --> 01:29:40,790

we do appreciate and

2414
01:29:45,350 --> 01:29:42,159
value

2415
01:29:47,590 --> 01:29:45,360
your inputs and the time you've devoted

2416
01:29:48,550 --> 01:29:47,600
to this workshop so we look forward to a

2417
01:29:50,550 --> 01:29:48,560
lot of

2418
01:29:51,750 --> 01:29:50,560
great discussions

2419
01:29:54,709 --> 01:29:51,760
and

2420
01:29:56,629 --> 01:29:54,719
we're really excited to see this program

2421
01:29:57,910 --> 01:29:56,639
get started

2422
01:29:59,910 --> 01:29:57,920
so

2423
01:30:01,510 --> 01:29:59,920
that's the last presentation for this

2424
01:30:03,669 --> 01:30:01,520
evening we're going to open it up for

2425
01:30:06,310 --> 01:30:03,679
questions now and i'll turn it back to

2426
01:30:09,910 --> 01:30:06,320
wendy thank you chris um and thanks to

2427
01:30:15,430 --> 01:30:13,350
we're um running short on time so uh we

2428
01:30:21,030 --> 01:30:15,440
probably only have time for one or two

2429
01:30:23,990 --> 01:30:21,910
hi

2430
01:30:26,550 --> 01:30:24,000
i had a question for

2431
01:30:28,950 --> 01:30:26,560
um lindley johnson i guess are there any

2432
01:30:30,790 --> 01:30:28,960
plans to actually extend assets and deep

2433
01:30:33,830 --> 01:30:30,800
into the southern hemisphere

2434
01:30:35,669 --> 01:30:33,840
uh chile or south africa or even that

2435
01:30:38,310 --> 01:30:35,679
matter the south pole

2436
01:30:39,270 --> 01:30:38,320
i mean it seems like it's a missing

2437
01:30:42,229 --> 01:30:39,280
gap

2438
01:30:46,709 --> 01:30:45,110

well um over the course of time it it's

2439
01:30:49,110 --> 01:30:46,719
not so important

2440
01:30:51,510 --> 01:30:49,120
that we're not searching from

2441
01:30:52,550 --> 01:30:51,520
the southern hemisphere

2442
01:30:54,950 --> 01:30:52,560
because

2443
01:30:57,270 --> 01:30:54,960
we hope to discover these objects you

2444
01:30:59,990 --> 01:30:57,280
know many years before they might be an

2445
01:31:02,709 --> 01:31:00,000
impactor but

2446
01:31:04,629 --> 01:31:02,719
that aside it would be good for uh some

2447
01:31:05,830 --> 01:31:04,639
of the southern hemisphere countries to

2448
01:31:06,950 --> 01:31:05,840
to join

2449
01:31:10,310 --> 01:31:06,960
the effort

2450
01:31:12,390 --> 01:31:10,320
and uh you know add capability both for

2451
01:31:13,189 --> 01:31:12,400
shirts and tracking

2452
01:31:18,629 --> 01:31:13,199
of

2453
01:31:18,639 --> 01:31:28,310
we have one over there

2454
01:31:33,750 --> 01:31:31,910
what happens uh after the workshop

2455
01:31:36,310 --> 01:31:33,760
what happens to the material how does it

2456
01:31:37,910 --> 01:31:36,320
get fed into uh headquarters planning

2457
01:31:40,870 --> 01:31:37,920
and so forth

2458
01:31:43,350 --> 01:31:40,880
for uh actual mission

2459
01:31:45,830 --> 01:31:43,360
so there's actually two routes that are

2460
01:31:49,830 --> 01:31:45,840
currently

2461
01:31:52,070 --> 01:31:49,840
planned no pun intended the first is the

2462
01:31:55,189 --> 01:31:52,080
leads for the study efforts that were

2463
01:31:56,550 --> 01:31:55,199

discussed are present and here have been

2464
01:31:59,990 --> 01:31:56,560
asked to

2465
01:32:02,149 --> 01:32:00,000
listen and incorporate any of their

2466
01:32:04,709 --> 01:32:02,159
any of the highly

2467
01:32:07,350 --> 01:32:04,719
rated ideas in the synthesis friday

2468
01:32:09,590 --> 01:32:07,360
afternoon into their studies the second

2469
01:32:11,830 --> 01:32:09,600
is that the robotic concept integration

2470
01:32:15,750 --> 01:32:11,840
team that has been chartered and is

2471
01:32:17,830 --> 01:32:15,760
being led by jim ryder at marshall

2472
01:32:21,270 --> 01:32:17,840
has been asked to

2473
01:32:23,030 --> 01:32:21,280
perform a figures of merit assessment

2474
01:32:25,110 --> 01:32:23,040
including ideas that come out of this

2475
01:32:29,030 --> 01:32:25,120
workshop

2476
01:32:31,270 --> 01:32:29,040
so that we're ensuring that we've got a

2477
01:32:32,470 --> 01:32:31,280
quantitative analysis

2478
01:32:34,870 --> 01:32:32,480
of

2479
01:32:37,189 --> 01:32:34,880
an integrated system and a mission

2480
01:32:39,110 --> 01:32:37,199
concept that brings brings the best and

2481
01:32:40,950 --> 01:32:39,120
brightest forward

2482
01:32:42,950 --> 01:32:40,960
i would also say that

2483
01:32:45,030 --> 01:32:42,960
the robotic concept integration team has

2484
01:32:49,270 --> 01:32:45,040
been asked to make recommendations on

2485
01:32:53,030 --> 01:32:49,280
any future activities that we might

2486
01:32:57,189 --> 01:32:53,040
offer as a follow-on to this rfi to gain

2487
01:32:59,910 --> 01:32:57,199
more analysis in specific areas that

2488
01:33:02,149 --> 01:32:59,920

fit into the results of the farm

2489
01:33:03,750 --> 01:33:02,159
analysis i'm not sure if that's

2490
01:33:06,470 --> 01:33:03,760
clear enough but

2491
01:33:08,470 --> 01:33:06,480
in our industry day we will announce any

2492
01:33:10,149 --> 01:33:08,480
changes in our plans

2493
01:33:12,390 --> 01:33:10,159
as a result of the robotic concept

2494
01:33:17,990 --> 01:33:12,400
integration team as well as the internal

2495
01:33:21,189 --> 01:33:19,510
thank you

2496
01:33:23,189 --> 01:33:21,199
and i also believe that we have a

2497
01:33:24,950 --> 01:33:23,199
question online

2498
01:33:26,790 --> 01:33:24,960
there's been lots of discussion online

2499
01:33:29,030 --> 01:33:26,800
and a few questions on twitter about

2500
01:33:31,270 --> 01:33:29,040
mission schedule and cost michelle could

2501
01:33:33,030 --> 01:33:31,280
you summarize that asteroid redirect

2502
01:33:36,070 --> 01:33:33,040
mission timeline and briefly address the

2503
01:33:41,510 --> 01:33:38,070
is it possible to bring my slides back

2504
01:33:43,030 --> 01:33:41,520
up there's a slide um

2505
01:33:45,189 --> 01:33:43,040
four

2506
01:33:47,669 --> 01:33:45,199
which just re-articulates the alignment

2507
01:33:49,270 --> 01:33:47,679
strategy that's been discussed

2508
01:33:51,430 --> 01:33:49,280
since robert lightfoot our associate

2509
01:33:55,750 --> 01:33:51,440
administrator first

2510
01:34:01,750 --> 01:33:57,350
sorry

2511
01:34:07,270 --> 01:34:04,870
so this chart actually if you watch the

2512
01:34:10,149 --> 01:34:07,280
versions as we continue with our concept

2513
01:34:12,070 --> 01:34:10,159

development it evolves over time

2514
01:34:14,229 --> 01:34:12,080
you can see the um

2515
01:34:17,830 --> 01:34:14,239
addition of the neo-wise activation in

2516
01:34:20,310 --> 01:34:17,840
this version as well as the

2517
01:34:23,270 --> 01:34:20,320
anticipated

2518
01:34:26,070 --> 01:34:23,280
enabling of a robotic mission launch in

2519
01:34:27,750 --> 01:34:26,080
2018 which includes the solar electric

2520
01:34:30,790 --> 01:34:27,760
propulsion demo

2521
01:34:34,390 --> 01:34:30,800
and uh the crude e-m1 mission of sls and

2522
01:34:36,709 --> 01:34:34,400
orion so the basic strategy is to

2523
01:34:39,270 --> 01:34:36,719
leverage ongoing activities inside the

2524
01:34:40,470 --> 01:34:39,280
organization inside nasa

2525
01:34:43,990 --> 01:34:40,480
with

2526
01:34:46,310 --> 01:34:44,000
key strategic investments in other areas

2527
01:34:47,990 --> 01:34:46,320
to enable this strategy to occur so i

2528
01:34:50,310 --> 01:34:48,000
would say

2529
01:34:52,950 --> 01:34:50,320
that our current studies are looking at

2530
01:34:55,910 --> 01:34:52,960
technical and programmatic feasibility

2531
01:34:58,310 --> 01:34:55,920
these timelines will change as we gain

2532
01:35:02,229 --> 01:34:58,320
more data including on targets like

2533
01:35:04,950 --> 01:35:02,239
lynley johnson suggested or presented

2534
01:35:07,669 --> 01:35:04,960
his observation asset

2535
01:35:10,070 --> 01:35:07,679
plans that are being put in place

2536
01:35:11,830 --> 01:35:10,080
and as this timeline

2537
01:35:15,030 --> 01:35:11,840
matures and we gain a better

2538
01:35:16,950 --> 01:35:15,040

understanding of

2539
01:35:18,950 --> 01:35:16,960
technical and programmatic feasibility

2540
01:35:20,790 --> 01:35:18,960
combined

2541
01:35:23,510 --> 01:35:20,800
we'll have we'll have better answers to

2542
01:35:27,430 --> 01:35:25,189
thanks again michelle

2543
01:35:29,109 --> 01:35:27,440
okay so we're out of time but there have

2544
01:35:31,109 --> 01:35:29,119
been some great conversations going

2545
01:35:33,990 --> 01:35:31,119
online and we want to try to keep that

2546
01:35:35,430 --> 01:35:34,000
going so we want to remind everyone that

2547
01:35:38,229 --> 01:35:35,440
the hashtag

2548
01:35:41,030 --> 01:35:38,239
nasa asteroid and that we will have chat

2549
01:35:42,470 --> 01:35:41,040
rooms and hashtags for each session

2550
01:35:44,629 --> 01:35:42,480
and so

2551
01:35:47,350 --> 01:35:44,639
keep the conversation going and this

2552
01:35:49,510 --> 01:35:47,360
concludes our plenary session

2553
01:35:51,669 --> 01:35:49,520
and we look forward to having everyone