1
00:00:06,630 --> 00:00:02,470
fire its engines and bid farewell to

2
00:00:11,430 --> 00:00:09,110
hello everyone today is a big day at

3
00:00:13,910 --> 00:00:11,440
nasa after two and a half years of space

4
00:00:16,470 --> 00:00:13,920
operations near asteroid bennu nasa's

5
00:00:18,310 --> 00:00:16,480
first asteroid return mission osiris-rex

6
00:00:20,310 --> 00:00:18,320
is ready to bid far well to this

7
00:00:22,310 --> 00:00:20,320
fascinating rocky object

8
00:00:23,990 --> 00:00:22,320
i'm your host joy ung and i'm joining

9
00:00:26,390 --> 00:00:24,000
you from nasa's goddard space flight

10
00:00:27,990 --> 00:00:26,400
center in greenbelt maryland we're about

11
00:00:30,310 --> 00:00:28,000
20 minutes away from witnessing the

12
00:00:32,389 --> 00:00:30,320
exact moment our cyrus rex begins its

13
00:00:34,150 --> 00:00:32,399

journey back to earth and starts a new

14
00:00:36,150 --> 00:00:34,160
phase in its mission

15
00:00:38,069 --> 00:00:36,160
this mission will well this journey will

16
00:00:40,150 --> 00:00:38,079
take more than two years and will be the

17
00:00:41,670 --> 00:00:40,160
largest sample return since the apollo

18
00:00:43,270 --> 00:00:41,680
astronauts brought back rocks from the

19
00:00:45,750 --> 00:00:43,280
moon in the 70s

20
00:00:47,750 --> 00:00:45,760
so this is really exciting in today's

21
00:00:49,670 --> 00:00:47,760
show we have a great lineup we're going

22
00:00:51,189 --> 00:00:49,680
to take you inside lockheed martin's

23
00:00:54,310 --> 00:00:51,199
mission support area in littleton

24
00:00:55,990 --> 00:00:54,320
colorado as we depart asteroid bennu

25
00:00:58,709 --> 00:00:56,000
we're going to show you the last images

26
00:01:00,869 --> 00:00:58,719
of bennu taken by osiris-rex and explain

27
00:01:03,029 --> 00:01:00,879
why the mission chose to make one final

28
00:01:04,630 --> 00:01:03,039
encounter with the asteroid

29
00:01:07,030 --> 00:01:04,640
and helping us tell those stories will

30
00:01:08,469 --> 00:01:07,040
be the current osiris-rex team this is a

31
00:01:09,830 --> 00:01:08,479
really special moment for the team

32
00:01:11,429 --> 00:01:09,840
because they've been working together

33
00:01:12,950 --> 00:01:11,439
for many years and they're about to

34
00:01:16,310 --> 00:01:12,960
finish their stint on the mission as the

35
00:01:17,830 --> 00:01:16,320
spacecraft heads into its new phase

36
00:01:19,990 --> 00:01:17,840
so if you have questions for any of the

37
00:01:21,590 --> 00:01:20,000
team head to nasa's solar system

38
00:01:23,590 --> 00:01:21,600

instagram to pop your questions and our

39
00:01:25,590 --> 00:01:23,600
stories you can also track their mission

40
00:01:28,149 --> 00:01:25,600
by following nasa solar system on

41
00:01:31,749 --> 00:01:28,159
twitter facebook and instagram or by

42
00:01:34,390 --> 00:01:31,759
following the hashtag tu bennu and back

43
00:01:37,350 --> 00:01:34,400
so there's a team watching close rex's

44
00:01:38,950 --> 00:01:37,360
every move as it orbits asteroid bennu

45
00:01:40,789 --> 00:01:38,960
they're based at lockheed martin space

46
00:01:43,270 --> 00:01:40,799
in littleton colorado

47
00:01:45,109 --> 00:01:43,280
this is where osiris-rex was built and

48
00:01:47,670 --> 00:01:45,119
where mission controllers receive its

49
00:01:49,030 --> 00:01:47,680
data and can tell how it's doing so

50
00:01:51,270 --> 00:01:49,040
let's check in with them now to get an

51
00:01:54,710 --> 00:01:51,280
update on today's big event

52
00:01:57,270 --> 00:01:54,720
hi lauren how's it going

53
00:01:59,109 --> 00:01:57,280
we're doing great here joy i'm lauren

54
00:02:01,190 --> 00:01:59,119
duna and we're here in the lockheed

55
00:02:03,350 --> 00:02:01,200
martin mission support area outside of

56
00:02:05,510 --> 00:02:03,360
denver colorado where a team of

57
00:02:08,389 --> 00:02:05,520
engineers is flying osiris-rex right

58
00:02:10,949 --> 00:02:08,399
beside us with me today is osiris-rex's

59
00:02:12,390 --> 00:02:10,959
propulsion lead carrie parish

60
00:02:13,670 --> 00:02:12,400
carrie can you tell myself and our

61
00:02:14,790 --> 00:02:13,680
viewers what's going to be happening

62
00:02:16,790 --> 00:02:14,800
here today

63
00:02:19,070 --> 00:02:16,800

sure so today we're going to be using

64
00:02:22,309 --> 00:02:19,080
our largest engines in order to change

65
00:02:24,070 --> 00:02:22,319
osiris-rex's velocity relative to bennu

66
00:02:25,270 --> 00:02:24,080
and get it started on its journey back

67
00:02:27,350 --> 00:02:25,280
to earth

68
00:02:29,510 --> 00:02:27,360
now today's activity is similar to

69
00:02:31,910 --> 00:02:29,520
maneuvers that we've executed at bennu

70
00:02:33,589 --> 00:02:31,920
over the last two and a half years the

71
00:02:35,430 --> 00:02:33,599
main difference though is that we're

72
00:02:37,589 --> 00:02:35,440
going to fire our thrusters for a much

73
00:02:39,430 --> 00:02:37,599
longer duration in order to really kick

74
00:02:41,030 --> 00:02:39,440
up the momentum of the spacecraft back

75
00:02:43,430 --> 00:02:41,040
towards earth

76
00:02:45,110 --> 00:02:43,440
so this will be osiris-rex's longest

77
00:02:47,350 --> 00:02:45,120
engine burn since it's been at the

78
00:02:49,430 --> 00:02:47,360
asteroid venue about how long will the

79
00:02:51,990 --> 00:02:49,440
departure process take today

80
00:02:53,990 --> 00:02:52,000
well the maneuver itself lasts for about

81
00:02:56,390 --> 00:02:54,000
seven minutes but our team has been

82
00:02:58,869 --> 00:02:56,400
working for the last several weeks to

83
00:03:00,949 --> 00:02:58,879
optimize the magnitude of the burn and

84
00:03:02,790 --> 00:03:00,959
the direction the spacecraft is facing

85
00:03:05,509 --> 00:03:02,800
when the thrusters fire

86
00:03:07,190 --> 00:03:05,519
our main engine maneuver sequence which

87
00:03:09,350 --> 00:03:07,200
is responsible for executing all the

88
00:03:10,550 --> 00:03:09,360

commands on board was started about an

89
00:03:12,949 --> 00:03:10,560
hour ago

90
00:03:14,470 --> 00:03:12,959
that is so exciting well i know i can't

91
00:03:16,390 --> 00:03:14,480
wait for what happens here in just a

92
00:03:18,390 --> 00:03:16,400
little while thank you so much for

93
00:03:21,270 --> 00:03:18,400
joining us today carrie and good luck to

94
00:03:24,070 --> 00:03:21,280
you and the team thank you lauren

95
00:03:25,830 --> 00:03:24,080
so after today's engine burn osiris-rex

96
00:03:27,910 --> 00:03:25,840
doesn't exactly have a straight path

97
00:03:29,990 --> 00:03:27,920
back to earth the spacecraft will

98
00:03:32,229 --> 00:03:30,000
actually have to surf using some pretty

99
00:03:33,270 --> 00:03:32,239
cool orbital mechanics to propel itself

100
00:03:35,110 --> 00:03:33,280
home

101
00:03:37,830 --> 00:03:35,120
joining us now to talk about that is

102
00:03:39,910 --> 00:03:37,840
mike moreau osiris-rex's deputy project

103
00:03:41,110 --> 00:03:39,920
manager at nasa's goddard space flight

104
00:03:43,030 --> 00:03:41,120
center

105
00:03:45,030 --> 00:03:43,040
mike how are you doing today great

106
00:03:46,789 --> 00:03:45,040
lauren i'm really excited to be here

107
00:03:48,550 --> 00:03:46,799
with our lockheed martin and kinetics

108
00:03:50,710 --> 00:03:48,560
team members to get the spacecraft

109
00:03:52,710 --> 00:03:50,720
headed towards home well we're very

110
00:03:53,589 --> 00:03:52,720
excited to have you and very excited for

111
00:03:55,750 --> 00:03:53,599
today

112
00:03:57,990 --> 00:03:55,760
so fast forwarding a little bit after

113
00:03:59,830 --> 00:03:58,000

osiris-rex heads back to earth how will

114
00:04:00,949 --> 00:03:59,840
the sample return capsule actually get

115
00:04:03,830 --> 00:04:00,959
back to earth

116
00:04:05,509 --> 00:04:03,840
well that's a good question so um

117
00:04:08,869 --> 00:04:05,519
benny was in an orbit that's very much

118
00:04:11,110 --> 00:04:08,879
like the earth's orbit about the sun

119
00:04:13,030 --> 00:04:11,120
you know but right now bennu is actually

120
00:04:15,429 --> 00:04:13,040
on the opposite side of the solar system

121
00:04:17,509 --> 00:04:15,439
from us so following the maneuver today

122
00:04:19,749 --> 00:04:17,519
the spacecraft will be moving rapidly

123
00:04:22,230 --> 00:04:19,759
away from bennu but it will still take

124
00:04:24,870 --> 00:04:22,240
almost two years or two full orbits

125
00:04:27,990 --> 00:04:24,880
about the sun for osiris-rex uh to catch

126
00:04:29,830 --> 00:04:28,000
up with the earth so after that journey

127
00:04:32,230 --> 00:04:29,840
the sample return capsule will be

128
00:04:35,350 --> 00:04:32,240
jettisoned from the spacecraft uh in

129
00:04:37,510 --> 00:04:35,360
september of 2023 just four hours before

130
00:04:40,310 --> 00:04:37,520
atmospheric entry and the satellite

131
00:04:43,749 --> 00:04:40,320
osiris-rex will perform its own maneuver

132
00:04:45,670 --> 00:04:43,759
to divert and fly safely past the earth

133
00:04:47,590 --> 00:04:45,680
well i know i can't wait to see what the

134
00:04:50,390 --> 00:04:47,600
spacecraft brings back to us in its

135
00:04:51,909 --> 00:04:50,400
sample return capsule so reflecting back

136
00:04:54,870 --> 00:04:51,919
a little bit on what the mission has

137
00:04:57,430 --> 00:04:54,880
done to date so osiris-rex launched in

138
00:05:00,629 --> 00:04:57,440

september of 2016 and arrived at the new

139
00:05:02,550 --> 00:05:00,639
in december of 2018 but after it arrived

140
00:05:05,430 --> 00:05:02,560
it didn't just stay in orbit like most

141
00:05:07,590 --> 00:05:05,440
planetary missions why was that

142
00:05:09,590 --> 00:05:07,600
well the short answer lauren is that

143
00:05:11,990 --> 00:05:09,600
benue's gravity is much weaker than that

144
00:05:13,830 --> 00:05:12,000
of a planet like mars or jupiter so

145
00:05:16,870 --> 00:05:13,840
flying in the vicinity of bennu is more

146
00:05:18,710 --> 00:05:16,880
like a dance it takes only tiny nudges

147
00:05:20,469 --> 00:05:18,720
to send osiris-rex

148
00:05:22,950 --> 00:05:20,479
changing direction to execute the next

149
00:05:25,430 --> 00:05:22,960
flyby or to capture into orbit or

150
00:05:27,510 --> 00:05:25,440
whatever the next dance move is

151
00:05:29,590 --> 00:05:27,520
so osiris-rex is still attracted by

152
00:05:31,990 --> 00:05:29,600
bennu's gravity but that force is so

153
00:05:34,150 --> 00:05:32,000
small that the spacecraft is also pushed

154
00:05:36,310 --> 00:05:34,160
around by the sun's radiation pressure

155
00:05:37,909 --> 00:05:36,320
on the solar arrays and from tiny

156
00:05:40,070 --> 00:05:37,919
accelerations from heating and cooling

157
00:05:41,510 --> 00:05:40,080
from surfaces of the spacecraft

158
00:05:43,990 --> 00:05:41,520
so that's what makes bennu so

159
00:05:46,150 --> 00:05:44,000
challenging is the the precise modeling

160
00:05:48,310 --> 00:05:46,160
that has to happen in order to do this

161
00:05:50,710 --> 00:05:48,320
dance around venue absolutely that

162
00:05:52,550 --> 00:05:50,720
sounds super complex and it sounds like

163
00:05:54,310 --> 00:05:52,560

it's actually not that easy to fly in

164
00:05:56,469 --> 00:05:54,320
low gravity no it's required a

165
00:05:58,790 --> 00:05:56,479
monumental amount of effort by our

166
00:06:00,230 --> 00:05:58,800
operations and navigation team members

167
00:06:01,270 --> 00:06:00,240
some of which are sitting in the room

168
00:06:04,150 --> 00:06:01,280
here today

169
00:06:06,469 --> 00:06:04,160
absolutely so i know we actually have a

170
00:06:08,950 --> 00:06:06,479
video out there of the complex web that

171
00:06:10,870 --> 00:06:08,960
osiris-rex made around bennu can you

172
00:06:12,950 --> 00:06:10,880
talk us through that yeah that's right

173
00:06:15,029 --> 00:06:12,960
it's called the web around bennu and uh

174
00:06:16,870 --> 00:06:15,039
it maps out every trajectory arc in

175
00:06:18,469 --> 00:06:16,880
orbit performed by osiris-rex since

176
00:06:20,950 --> 00:06:18,479
2018.

177
00:06:22,950 --> 00:06:20,960
one of our cyrus first arrived it made a

178
00:06:25,430 --> 00:06:22,960
series of flybys over bennu from about

179
00:06:27,909 --> 00:06:25,440
five miles away then it captured into an

180
00:06:29,990 --> 00:06:27,919
orbit at the end of 2018

181
00:06:31,590 --> 00:06:30,000
just a mile above the surface and this

182
00:06:33,990 --> 00:06:31,600
pattern of leaving orbit conducting

183
00:06:35,510 --> 00:06:34,000
flybys and returning was repeated

184
00:06:37,350 --> 00:06:35,520
through subsequent mission phases each

185
00:06:39,670 --> 00:06:37,360
time getting closer to bennu to observe

186
00:06:41,749 --> 00:06:39,680
in greater and greater detail

187
00:06:43,590 --> 00:06:41,759
so in 2020 we began conducting

188
00:06:45,749 --> 00:06:43,600

rehearsals and we had the same pattern

189
00:06:46,950 --> 00:06:45,759
of getting back into orbit after each

190
00:06:49,510 --> 00:06:46,960
activity

191
00:06:51,749 --> 00:06:49,520
then after the successful tag in 2020 in

192
00:06:53,830 --> 00:06:51,759
october we drifted almost 2 000

193
00:06:55,270 --> 00:06:53,840
kilometers away from bennu

194
00:06:56,870 --> 00:06:55,280
but at the very end of the animation you

195
00:06:59,909 --> 00:06:56,880
can see that we came back for one last

196
00:07:01,830 --> 00:06:59,919
flyby on april 7th to see how we

197
00:07:04,309 --> 00:07:01,840
disturbed the tag site

198
00:07:06,629 --> 00:07:04,319
from the sample collection event

199
00:07:08,390 --> 00:07:06,639
wow so i know that really looks like a

200
00:07:10,469 --> 00:07:08,400
tangled web indeed

201
00:07:12,230 --> 00:07:10,479
and so did the team learn anything from

202
00:07:13,830 --> 00:07:12,240
doing all these very precise maneuvers

203
00:07:16,550 --> 00:07:13,840
around the asteroid that we could apply

204
00:07:17,909 --> 00:07:16,560
to future missions yes absolutely every

205
00:07:19,430 --> 00:07:17,919
kink in this trajectory means the

206
00:07:21,749 --> 00:07:19,440
spacecraft performed an extremely

207
00:07:24,230 --> 00:07:21,759
precise maneuver changing its velocity

208
00:07:26,230 --> 00:07:24,240
by two to twenty centimeters per second

209
00:07:28,629 --> 00:07:26,240
so each of those results in a huge

210
00:07:30,230 --> 00:07:28,639
effort by the team here in the room so

211
00:07:31,510 --> 00:07:30,240
on the next small body mission i believe

212
00:07:34,469 --> 00:07:31,520
we'll be able to use some of the

213
00:07:36,550 --> 00:07:34,479

autonomy and onboard smarts that made

214
00:07:39,189 --> 00:07:36,560
our tag event so successful to ease the

215
00:07:41,670 --> 00:07:39,199
burden on the team members over the two

216
00:07:43,270 --> 00:07:41,680
years of operations that we did

217
00:07:44,790 --> 00:07:43,280
that is so exciting and again it's

218
00:07:46,230 --> 00:07:44,800
always great to have a mission like this

219
00:07:47,830 --> 00:07:46,240
but even more important that we learn

220
00:07:49,749 --> 00:07:47,840
things to take forward

221
00:07:51,270 --> 00:07:49,759
mike thank you so much for joining us

222
00:07:52,629 --> 00:07:51,280
today we're so glad you're here and i

223
00:07:56,790 --> 00:07:52,639
know we'll see you back a little bit

224
00:08:01,110 --> 00:07:59,189
so as we wait for cyrus rex to begin its

225
00:08:03,110 --> 00:08:01,120
journey back to earth let's take a brief

226
00:08:05,589 --> 00:08:03,120
look at its most challenging event at

227
00:08:07,749 --> 00:08:05,599
bennu the moment it slowly descended to

228
00:08:11,320 --> 00:08:07,759
the surface and reached out its arm to

229
00:08:11,330 --> 00:09:09,829
[Music]

230
00:09:14,070 --> 00:09:12,150
wow that is such an exciting moment i

231
00:09:15,829 --> 00:09:14,080
just love seeing that footage you can

232
00:09:17,829 --> 00:09:15,839
see just how much loose material is

233
00:09:19,190 --> 00:09:17,839
flying around in those images taken by

234
00:09:21,269 --> 00:09:19,200
the spacecraft

235
00:09:23,110 --> 00:09:21,279
tag was a huge success for the mission

236
00:09:25,910 --> 00:09:23,120
osiris-rex collected a substantial

237
00:09:28,550 --> 00:09:25,920
amount of rock and dust but that success

238
00:09:30,710 --> 00:09:28,560

created another hiccup a little while

239
00:09:33,030 --> 00:09:30,720
ago we asked ryan olds the guidance

240
00:09:35,269 --> 00:09:33,040
navigation and control team lead what

241
00:09:37,670 --> 00:09:35,279
happened after tag let's hear what he

242
00:09:39,590 --> 00:09:37,680
had to say

243
00:09:41,829 --> 00:09:39,600
the tag moment itself we had no way to

244
00:09:44,949 --> 00:09:41,839
really know for sure how much was in the

245
00:09:47,030 --> 00:09:44,959
sample head seeing those first pictures

246
00:09:49,590 --> 00:09:47,040
me personally i went from absolute

247
00:09:51,590 --> 00:09:49,600
excitement to just being stunned

248
00:09:54,070 --> 00:09:51,600
initially we saw we had a ton of

249
00:09:55,910 --> 00:09:54,080
material in the sample head but the more

250
00:09:57,750 --> 00:09:55,920
and more images we started to see the

251
00:09:59,430 --> 00:09:57,760
more we started to pause and say wait a

252
00:10:01,110 --> 00:09:59,440
minute we're starting to lose some of

253
00:10:02,870 --> 00:10:01,120
the samples so we had to look through a

254
00:10:04,870 --> 00:10:02,880
lot of these images to determine what

255
00:10:06,949 --> 00:10:04,880
was going on how much sample we had if

256
00:10:08,790 --> 00:10:06,959
there was any risk to stowage because

257
00:10:10,870 --> 00:10:08,800
there are some possibilities of the

258
00:10:12,630 --> 00:10:10,880
material getting in the way and blocking

259
00:10:13,670 --> 00:10:12,640
the sampling mechanism from stowing

260
00:10:15,269 --> 00:10:13,680
properly

261
00:10:16,949 --> 00:10:15,279
we started to realize hey we might have

262
00:10:19,430 --> 00:10:16,959
to make some changes here to be

263
00:10:22,069 --> 00:10:19,440

successful so in order to know that the

264
00:10:24,550 --> 00:10:22,079
sample was stored safely we relied a lot

265
00:10:27,110 --> 00:10:24,560
on images from our stocam camera which

266
00:10:29,430 --> 00:10:27,120
took pictures of the capsule and the

267
00:10:31,350 --> 00:10:29,440
sample head getting sewed into it it was

268
00:10:33,350 --> 00:10:31,360
a very challenging process we had not

269
00:10:35,110 --> 00:10:33,360
practiced that procedure since before

270
00:10:37,750 --> 00:10:35,120
launch when the spacecraft was in the

271
00:10:39,590 --> 00:10:37,760
high bay to go through that process um

272
00:10:41,829 --> 00:10:39,600
taking all the images as we carefully

273
00:10:44,150 --> 00:10:41,839
moved sample head into the capsule was

274
00:10:50,230 --> 00:10:44,160
extremely exciting extremely challenging

275
00:10:54,069 --> 00:10:52,150
that was a precarious moment for the

276
00:10:56,710 --> 00:10:54,079
mission after all of the hard work that

277
00:10:59,030 --> 00:10:56,720
went into tagging bennu osiris-rex was

278
00:11:00,150 --> 00:10:59,040
almost a victim of its own success

279
00:11:02,230 --> 00:11:00,160
but to tell us more about how the

280
00:11:04,389 --> 00:11:02,240
mission adapted to the rough surface of

281
00:11:06,069 --> 00:11:04,399
bennu we have the osiris-rex principal

282
00:11:09,350 --> 00:11:06,079
investigator from the university of

283
00:11:11,030 --> 00:11:09,360
arizona dante loretta hi dante how are

284
00:11:12,870 --> 00:11:11,040
you

285
00:11:15,190 --> 00:11:12,880
i'm very excited joey this is a great

286
00:11:17,430 --> 00:11:15,200
day for the mission

287
00:11:19,590 --> 00:11:17,440
so we just saw a cyrus rex create a lot

288
00:11:21,750 --> 00:11:19,600

of turbulence on the on bennu during its

289
00:11:25,350 --> 00:11:21,760
sample grab what did the flying debris

290
00:11:27,190 --> 00:11:25,360
reveal about the asteroids rough surface

291
00:11:28,630 --> 00:11:27,200
uh one of the biggest uncertainties when

292
00:11:30,389 --> 00:11:28,640
we were designing the mission was what

293
00:11:32,710 --> 00:11:30,399
was going to happen when the spacecraft

294
00:11:34,550 --> 00:11:32,720
made contact with bennu and we had

295
00:11:36,790 --> 00:11:34,560
predictions ranging from a fraction of

296
00:11:38,949 --> 00:11:36,800
an inch to three feet deep that that arm

297
00:11:41,430 --> 00:11:38,959
would sink we were much more on that

298
00:11:43,750 --> 00:11:41,440
ladder of perspective the spacecraft was

299
00:11:45,670 --> 00:11:43,760
uh penetrated deeply into the asteroid

300
00:11:48,069 --> 00:11:45,680
surface and the surface responded almost

301
00:11:50,310 --> 00:11:48,079
like a fluid i like to compare it to one

302
00:11:52,150 --> 00:11:50,320
of those ball pits at a kid's playground

303
00:11:54,069 --> 00:11:52,160
so we learned that the surfaces of these

304
00:11:56,949 --> 00:11:54,079
rubble pile asteroids are very loosely

305
00:11:59,350 --> 00:11:56,959
consolidated

306
00:12:03,750 --> 00:11:59,360
well that was a really dramatic maneuver

307
00:12:06,069 --> 00:12:03,760
so why do we need an asteroid sample

308
00:12:08,389 --> 00:12:06,079
asteroids are the geologic remnants from

309
00:12:09,990 --> 00:12:08,399
the dawn of the solar system we want to

310
00:12:12,550 --> 00:12:10,000
understand how did earth become a

311
00:12:15,269 --> 00:12:12,560
habitable planet how were the seeds of

312
00:12:17,350 --> 00:12:15,279
life those prebiotic organic materials

313
00:12:19,350 --> 00:12:17,360

delivered to earth that trigger the

314
00:12:22,150 --> 00:12:19,360
origin of life and evolution as we know

315
00:12:24,069 --> 00:12:22,160
it so we have to go back to the rocks

316
00:12:26,150 --> 00:12:24,079
that date from that time of solar system

317
00:12:29,110 --> 00:12:26,160
history and that is where you find the

318
00:12:32,470 --> 00:12:31,110
well i'm so excited that the sample is

319
00:12:35,910 --> 00:12:32,480
finally coming back

320
00:12:38,069 --> 00:12:35,920
so after tag on april 7th 2021

321
00:12:40,550 --> 00:12:38,079
osiris-rex made its final flyover of

322
00:12:42,389 --> 00:12:40,560
bennu why did you send osiris-rex back

323
00:12:44,389 --> 00:12:42,399
to survey bennu after collecting the

324
00:12:46,310 --> 00:12:44,399
sample

325
00:12:48,230 --> 00:12:46,320
well we've all seen that amazing footage

326
00:12:50,389 --> 00:12:48,240
of the day that osiris-rex contacted

327
00:12:52,389 --> 00:12:50,399
bennu and sent that to debris flying

328
00:12:54,470 --> 00:12:52,399
everywhere and everybody wanted to know

329
00:12:56,069 --> 00:12:54,480
what did the surface look like the good

330
00:12:57,670 --> 00:12:56,079
news was after we checked out the

331
00:12:59,829 --> 00:12:57,680
spacecraft everything looked really

332
00:13:01,829 --> 00:12:59,839
healthy with no sign of any degradation

333
00:13:04,069 --> 00:13:01,839
whatsoever from the tag event

334
00:13:06,629 --> 00:13:04,079
the flight dynamics team also did their

335
00:13:08,710 --> 00:13:06,639
calculations and said today may 10th was

336
00:13:10,629 --> 00:13:08,720
the best time to leave the asteroid to

337
00:13:12,710 --> 00:13:10,639
conserve fuel on the spacecraft so we

338
00:13:14,389 --> 00:13:12,720

had a healthy spacecraft and we had time

339
00:13:17,110 --> 00:13:14,399
i told the team we have to go back and

340
00:13:20,230 --> 00:13:17,120
get those final images

341
00:13:22,230 --> 00:13:20,240
and so on what did you learn

342
00:13:24,069 --> 00:13:22,240
uh well we definitely left our mark on

343
00:13:26,150 --> 00:13:24,079
the asteroid we're seeing a pretty large

344
00:13:28,790 --> 00:13:26,160
crater extensive amounts of material was

345
00:13:30,870 --> 00:13:28,800
mobilized and so it really helps us

346
00:13:32,629 --> 00:13:30,880
understand the nature of the asteroid

347
00:13:36,150 --> 00:13:32,639
surface and gives us some insight into

348
00:13:40,629 --> 00:13:38,389
great thank you and so um thank you so

349
00:13:43,829 --> 00:13:40,639
much for joining us dante so we're about

350
00:13:48,069 --> 00:13:43,839
to um head to the

351
00:13:49,030 --> 00:13:48,079
mission support area so

352
00:13:50,949 --> 00:13:49,040
um

353
00:13:55,590 --> 00:13:50,959
let's go back to the lockheed martin to

354
00:14:00,069 --> 00:13:58,230
thanks joy we are just about two minutes

355
00:14:02,710 --> 00:14:00,079
away here from the initiation of the

356
00:14:05,350 --> 00:14:02,720
departure burn and with me i've got jody

357
00:14:07,189 --> 00:14:05,360
zareski who is osiris-rex's systems lead

358
00:14:09,030 --> 00:14:07,199
here at lockheed martin

359
00:14:10,470 --> 00:14:09,040
dodie what are we moments away from

360
00:14:12,230 --> 00:14:10,480
happening right now

361
00:14:13,829 --> 00:14:12,240
so right now the team is awaiting ground

362
00:14:21,910 --> 00:14:13,839
confirmation that the burn has started

363
00:14:25,350 --> 00:14:23,430

so i'm not sure if you all could hear

364
00:14:27,269 --> 00:14:25,360
that but we just heard the one minute

365
00:14:29,509 --> 00:14:27,279
countdown has started to the initiation

366
00:14:31,509 --> 00:14:29,519
of osiris-rex's engine burn

367
00:14:34,590 --> 00:14:31,519
while we're waiting for that to hit jody

368
00:14:37,670 --> 00:14:34,600
one question for you so osiris-rex is

369
00:14:39,350 --> 00:14:37,680
291 million miles away what is the

370
00:14:40,230 --> 00:14:39,360
communications delay like during that

371
00:14:45,509 --> 00:14:40,240
time

372
00:14:47,110 --> 00:14:45,519
about 15 minutes and 56 seconds gotcha

373
00:14:49,189 --> 00:14:47,120
so did the team upload the commands to

374
00:14:50,710 --> 00:14:49,199
the spacecraft prior to today we did all

375
00:14:52,389 --> 00:14:50,720
the products necessary to execute

376
00:14:55,110 --> 00:14:52,399
today's maneuver were sent this past

377
00:14:56,790 --> 00:14:55,120
friday that is super exciting well we'll

378
00:15:24,870 --> 00:14:56,800
go quiet here and listen to the room as

379
00:15:28,870 --> 00:15:26,870
dirty what have we just heard

380
00:15:30,790 --> 00:15:28,880
oh we just heard that uh

381
00:15:34,550 --> 00:15:30,800
settling burn has started

382
00:15:36,310 --> 00:15:34,560
that is super exciting

383
00:15:38,150 --> 00:15:36,320
so while we're kind of waiting as the

384
00:15:40,389 --> 00:15:38,160
team waits and watches the spacecraft

385
00:15:42,710 --> 00:15:40,399
here

386
00:15:45,110 --> 00:15:42,720
can you tell me a little bit about um

387
00:15:46,150 --> 00:15:45,120
what your role is on this mission all

388
00:15:48,069 --> 00:15:46,160

stations

389
00:15:51,110 --> 00:15:48,079
navigating has received received

390
00:15:52,949 --> 00:15:51,120
confirmation of settling start

391
00:15:55,509 --> 00:15:52,959
so that was the confirmation of

392
00:15:57,110 --> 00:15:55,519
osiris-rex's engine burn start there's a

393
00:15:58,870 --> 00:15:57,120
lot of excitement here in the room today

394
00:15:59,990 --> 00:15:58,880
we're super excited for this moment to

395
00:16:02,629 --> 00:16:00,000
happen

396
00:16:04,550 --> 00:16:02,639
jody how are you feeling right now oh i

397
00:16:05,829 --> 00:16:04,560
am so excited i really wish motley crue

398
00:16:07,189 --> 00:16:05,839
was here so we could rock out to home

399
00:16:09,670 --> 00:16:07,199
sweet home because we were bringing that

400
00:16:11,590 --> 00:16:09,680
sample back absolutely innovation has

401
00:16:12,870 --> 00:16:11,600
received confirmation of main engine

402
00:16:14,069 --> 00:16:12,880
turn start

403
00:16:16,310 --> 00:16:14,079
yes

404
00:16:21,430 --> 00:16:16,320
all good news here at lockheed martin

405
00:16:24,550 --> 00:16:23,189
that's lauren

406
00:16:26,790 --> 00:16:24,560
so while we're waiting for the

407
00:16:28,550 --> 00:16:26,800
completion of the engine burn let's take

408
00:16:43,110 --> 00:16:28,560
a quick look ahead at what will happen

409
00:16:48,550 --> 00:16:45,430
after departing from bennu osiris-rex

410
00:16:50,389 --> 00:16:48,560
will return to earth in late 2023

411
00:16:52,069 --> 00:16:50,399
four hours prior to arrival the

412
00:16:54,230 --> 00:16:52,079
spacecraft will release the sample

413
00:16:56,470 --> 00:16:54,240

return capsule then deflect away from

414
00:16:58,629 --> 00:16:56,480
earth to its final orbit as its piece of

415
00:17:00,389 --> 00:16:58,639
bennu comes home

416
00:17:02,389 --> 00:17:00,399
the capsule will enter the atmosphere

417
00:17:04,549 --> 00:17:02,399
over the night side of earth streaking

418
00:17:08,630 --> 00:17:04,559
towards the central california coastline

419
00:17:13,189 --> 00:17:10,470
west of the great salt lake at an

420
00:17:15,189 --> 00:17:13,199
altitude of approximately 33 kilometers

421
00:17:17,669 --> 00:17:15,199
the capsule will initiate its parachute

422
00:17:19,350 --> 00:17:17,679
sequence stabilizing and slowing its

423
00:17:21,189 --> 00:17:19,360
descent

424
00:17:23,029 --> 00:17:21,199
upon landing in the utah desert the

425
00:17:24,789 --> 00:17:23,039
sample will be recovered carefully

426
00:17:27,029 --> 00:17:24,799
removed from the capsule and taken to

427
00:17:29,190 --> 00:17:27,039
the osiris-rex curation facility at

428
00:17:30,549 --> 00:17:29,200
nasa's johnson space center in houston

429
00:17:32,470 --> 00:17:30,559
texas

430
00:17:34,710 --> 00:17:32,480
this pristine material from the early

431
00:17:37,190 --> 00:17:34,720
solar system will be studied for decades

432
00:17:39,669 --> 00:17:37,200
to come providing clues to the formation

433
00:17:41,430 --> 00:17:39,679
of the planets to the evolution of earth

434
00:17:49,830 --> 00:17:41,440
into the ingredients that were present

435
00:17:53,830 --> 00:17:51,909
welcome back my name is joy ung and i'm

436
00:17:55,830 --> 00:17:53,840
talking to you from nasa's goddard space

437
00:17:57,909 --> 00:17:55,840
flight center in greenback maryland if

438
00:17:59,990 --> 00:17:57,919

you're just joining us osiris-rex has

439
00:18:02,310 --> 00:18:00,000
fired its thrusters and begun the

440
00:18:03,590 --> 00:18:02,320
departure maneuver from asteroid bennu

441
00:18:05,510 --> 00:18:03,600
we're going to send you back now to

442
00:18:11,830 --> 00:18:05,520
lockheed martin to watch the rest of the

443
00:18:16,150 --> 00:18:13,909
thanks joy we're back here at lockheed

444
00:18:18,950 --> 00:18:16,160
martin and joining me again is mike

445
00:18:21,510 --> 00:18:18,960
moreau the nasa deputy project manager

446
00:18:23,110 --> 00:18:21,520
for osiris-rex now we're awaiting the

447
00:18:25,830 --> 00:18:23,120
announcement for 50

448
00:18:27,909 --> 00:18:25,840
uh completion of the burn for departure

449
00:18:29,830 --> 00:18:27,919
mike how are you feeling right now i'm

450
00:18:31,750 --> 00:18:29,840
feeling really great lauren uh we've got

451
00:18:33,830 --> 00:18:31,760
good news we're seeing on our displays

452
00:18:36,230 --> 00:18:33,840
that the burn is executing we're seeing

453
00:18:37,830 --> 00:18:36,240
these doppler points uh propagate on the

454
00:18:39,270 --> 00:18:37,840
plot which tells us we're making

455
00:18:41,110 --> 00:18:39,280
progress towards the burn and i think

456
00:18:42,470 --> 00:18:41,120
we're a couple minutes away

457
00:18:44,950 --> 00:18:42,480
from that midpoint

458
00:18:47,029 --> 00:18:44,960
well that is just fantastic to hear so

459
00:18:48,789 --> 00:18:47,039
while we're waiting for that midpoint

460
00:18:50,789 --> 00:18:48,799
let me ask you do you think this is a

461
00:18:51,750 --> 00:18:50,799
mission that we could have done 30 years

462
00:18:54,390 --> 00:18:51,760
ago

463
00:18:57,669 --> 00:18:54,400

uh no way um we're really pushing the

464
00:18:59,990 --> 00:18:57,679
envelope with our 21st century

465
00:19:02,630 --> 00:19:00,000
navigation and operations capabilities

466
00:19:05,270 --> 00:19:02,640
to fly a mission like osiris-rex

467
00:19:07,669 --> 00:19:05,280
just a couple of examples the navigation

468
00:19:09,909 --> 00:19:07,679
the maps for landmark navigation that we

469
00:19:12,870 --> 00:19:09,919
used on the mission required exchanging

470
00:19:14,870 --> 00:19:12,880
gigabytes of of data and these large

471
00:19:16,710 --> 00:19:14,880
files containing topographic maps of

472
00:19:19,190 --> 00:19:16,720
bennu which would have been a challenge

473
00:19:22,230 --> 00:19:19,200
with yesterday's computer systems also

474
00:19:23,830 --> 00:19:22,240
another example included 50 of the adm

475
00:19:25,990 --> 00:19:23,840
okay that's the call you were looking

476
00:19:27,590 --> 00:19:26,000
for we're halfway done the burn so we're

477
00:19:29,669 --> 00:19:27,600
about uh halfway through the seven

478
00:19:31,750 --> 00:19:29,679
minute main engine burn so

479
00:19:34,230 --> 00:19:31,760
that's very good news uh just to finish

480
00:19:35,750 --> 00:19:34,240
what i was saying um so

481
00:19:37,669 --> 00:19:35,760
the other example i was going to make is

482
00:19:39,750 --> 00:19:37,679
the nft system for those of you that

483
00:19:42,310 --> 00:19:39,760
followed the sample collection event we

484
00:19:44,070 --> 00:19:42,320
had an onboard system called nft that

485
00:19:45,990 --> 00:19:44,080
was used to navigate the spacecraft to

486
00:19:47,750 --> 00:19:46,000
the surface the lockheed martin team

487
00:19:50,710 --> 00:19:47,760
that developed nft had to do a lot of

488
00:19:52,710 --> 00:19:50,720

work to get that software which was

489
00:19:54,549 --> 00:19:52,720
running processes that we normally do on

490
00:19:56,230 --> 00:19:54,559
the ground in our computers here to get

491
00:19:58,870 --> 00:19:56,240
that to fit in the capability of the

492
00:20:01,110 --> 00:19:58,880
onboard processor on the spacecraft

493
00:20:02,630 --> 00:20:01,120
so so that's just a couple of examples

494
00:20:05,029 --> 00:20:02,640
uh but there are many things like that

495
00:20:07,029 --> 00:20:05,039
where we really had to push the envelope

496
00:20:09,510 --> 00:20:07,039
of our capabilities to to fly this

497
00:20:11,350 --> 00:20:09,520
mission and fly so close uh to bending

498
00:20:13,110 --> 00:20:11,360
and ultimately touch the surface

499
00:20:15,029 --> 00:20:13,120
absolutely especially something like

500
00:20:16,950 --> 00:20:15,039
that natural feature tracking where

501
00:20:18,549 --> 00:20:16,960
you're doing such proximity operations

502
00:20:21,110 --> 00:20:18,559
to an object that you really need that

503
00:20:22,950 --> 00:20:21,120
that real time data and that real time

504
00:20:24,070 --> 00:20:22,960
ability for the spacecraft to maneuver

505
00:20:26,630 --> 00:20:24,080
itself

506
00:20:28,870 --> 00:20:26,640
so i want to reflect back really briefly

507
00:20:30,789 --> 00:20:28,880
new year's eve 2018 i know there's a

508
00:20:33,270 --> 00:20:30,799
picture out there of you and the whole

509
00:20:36,070 --> 00:20:33,280
team here all dressed up in formal wear

510
00:20:37,990 --> 00:20:36,080
to go to work why did you guys do that

511
00:20:39,990 --> 00:20:38,000
okay well we mentioned earlier that's a

512
00:20:42,710 --> 00:20:40,000
great picture it's a great memory for

513
00:20:45,110 --> 00:20:42,720

the team i mentioned earlier that we had

514
00:20:47,909 --> 00:20:45,120
our first insertion into orbit december

515
00:20:49,909 --> 00:20:47,919
31st of 2018 and that was an event that

516
00:20:51,270 --> 00:20:49,919
was a big milestone on the project it

517
00:20:53,510 --> 00:20:51,280
was the first time we'd ever been that

518
00:20:56,149 --> 00:20:53,520
close to bennu and we were worried that

519
00:20:57,669 --> 00:20:56,159
we might be surprised by something new

520
00:20:59,590 --> 00:20:57,679
so we figured if we had to do this big

521
00:21:01,029 --> 00:20:59,600
event on new year's eve we might as well

522
00:21:02,470 --> 00:21:01,039
get dressed up and

523
00:21:03,590 --> 00:21:02,480
celebrate in the process and it was a

524
00:21:05,350 --> 00:21:03,600
lot of fun

525
00:21:06,950 --> 00:21:05,360
this picture actually was taken about an

526
00:21:09,350 --> 00:21:06,960
hour after we confirmed we were

527
00:21:11,750 --> 00:21:09,360
successfully in orbit uh we went outside

528
00:21:13,750 --> 00:21:11,760
it was about 10 degrees and snowing

529
00:21:16,549 --> 00:21:13,760
but we toasted our success

530
00:21:19,510 --> 00:21:16,559
with sparkling apple cider while uh

531
00:21:21,669 --> 00:21:19,520
it just happened to be a midnight gmt uh

532
00:21:23,350 --> 00:21:21,679
about that time when we did that so it's

533
00:21:25,029 --> 00:21:23,360
a great memory and it really just gives

534
00:21:27,270 --> 00:21:25,039
you an example the team has worked so

535
00:21:29,590 --> 00:21:27,280
hard over the past two years to

536
00:21:32,630 --> 00:21:29,600
accomplish this exploration of venue

537
00:21:34,070 --> 00:21:32,640
really sacrificing a lot and uh and but

538
00:21:36,789 --> 00:21:34,080

they knew how to have fun too and it was

539
00:21:38,470 --> 00:21:36,799
a really great team so that is such a

540
00:21:40,470 --> 00:21:38,480
cool memory and i'm sure not a lot of

541
00:21:43,029 --> 00:21:40,480
people can say that that is super

542
00:21:45,190 --> 00:21:43,039
exciting mike about how far out are we

543
00:21:47,510 --> 00:21:45,200
now from the completion of the departure

544
00:21:49,430 --> 00:21:47,520
burn um so we're getting uh close now i

545
00:21:51,669 --> 00:21:49,440
would say from the plot we're probably a

546
00:21:54,310 --> 00:21:51,679
minute or a minute and a half uh from

547
00:21:56,630 --> 00:21:54,320
the final call out so let's listen

548
00:21:59,029 --> 00:21:56,640
uh for that to happen

549
00:22:00,630 --> 00:21:59,039
absolutely so we're going to give a

550
00:22:02,950 --> 00:22:00,640
listen into the room now as we're

551
00:22:47,190 --> 00:22:02,960
waiting for osiris-rex's engine burn to

552
00:22:51,510 --> 00:22:49,029
all stations

553
00:22:54,549 --> 00:22:51,520
the avian burn is completed

554
00:22:57,040 --> 00:22:54,559
we have a nominal adm burn and we're

555
00:23:01,350 --> 00:22:57,050
bringing the samples home

556
00:23:05,830 --> 00:23:01,360
[Applause]

557
00:23:09,190 --> 00:23:07,830
mike how are you feeling right now after

558
00:23:11,430 --> 00:23:09,200
all the time that you've spent on this

559
00:23:13,909 --> 00:23:11,440
mission um well i'm very very excited

560
00:23:15,430 --> 00:23:13,919
i'm thankful that this event is over i

561
00:23:17,750 --> 00:23:15,440
mean we've done maneuvers like this many

562
00:23:19,430 --> 00:23:17,760
many times so we had confidence that

563
00:23:21,110 --> 00:23:19,440

would go well but now we know the

564
00:23:23,669 --> 00:23:21,120
spacecraft's coming home or the

565
00:23:25,510 --> 00:23:23,679
culmination of all of our hard work

566
00:23:26,870 --> 00:23:25,520
so it's really exciting to be here it's

567
00:23:28,950 --> 00:23:26,880
also a little

568
00:23:31,190 --> 00:23:28,960
sad to be leaving bennu

569
00:23:33,510 --> 00:23:31,200
but that's what we need to do to bring

570
00:23:35,190 --> 00:23:33,520
the sample home absolutely well i am

571
00:23:37,110 --> 00:23:35,200
super lucky to be here witnessing this

572
00:23:41,350 --> 00:23:37,120
moment i know we've also got program

573
00:23:42,950 --> 00:23:41,360
manager sandy friend here as well sandy

574
00:23:44,390 --> 00:23:42,960
after someone such as yourself i know

575
00:23:46,470 --> 00:23:44,400
you and mike have been on the mission

576
00:23:48,470 --> 00:23:46,480
for such a long time what does this feel

577
00:23:50,710 --> 00:23:48,480
like to you right now yes this is really

578
00:23:53,029 --> 00:23:50,720
kind of bittersweet we've spent over two

579
00:23:54,149 --> 00:23:53,039
years at asteroid bennu really getting

580
00:23:55,750 --> 00:23:54,159
to know it

581
00:23:58,149 --> 00:23:55,760
but the prime goal of this mission is to

582
00:24:00,149 --> 00:23:58,159
bring that sample home so we set out we

583
00:24:01,990 --> 00:24:00,159
did what we were supposed to do at venue

584
00:24:03,830 --> 00:24:02,000
we've got those samples in hand and it's

585
00:24:05,909 --> 00:24:03,840
time to bring them back so i'm really

586
00:24:07,510 --> 00:24:05,919
excited for this next phase

587
00:24:09,110 --> 00:24:07,520
and to see what the scientists learn

588
00:24:10,630 --> 00:24:09,120

once they have these samples in hand

589
00:24:12,310 --> 00:24:10,640
here back on earth

590
00:24:14,789 --> 00:24:12,320
definitely understand that bittersweet

591
00:24:16,549 --> 00:24:14,799
feeling i can't even imagine you know

592
00:24:18,549 --> 00:24:16,559
how you must feel and and how excited

593
00:24:20,310 --> 00:24:18,559
you must be but thank you so much for

594
00:24:22,230 --> 00:24:20,320
being here with us today sandy and

595
00:24:25,029 --> 00:24:22,240
congratulations again to you and mike

596
00:24:26,950 --> 00:24:25,039
and the entire osiris-rex mission team

597
00:24:29,010 --> 00:24:26,960
joy we'll send it back to you for some

598
00:24:38,710 --> 00:24:29,020
questions from our other team members

599
00:24:44,070 --> 00:24:41,990
so joining us now is dr laurie glaze who

600
00:24:46,549 --> 00:24:44,080
is the director of nasa's planetary

601
00:24:49,190 --> 00:24:46,559
science division from nasa headquarters

602
00:24:53,110 --> 00:24:49,200
hi lori how are you doing

603
00:24:54,789 --> 00:24:53,120
i'm doing just fantastic thank you

604
00:24:56,789 --> 00:24:54,799
i want to say congratulations to the

605
00:25:00,710 --> 00:24:56,799
whole team that was incredible nicely

606
00:25:02,230 --> 00:25:00,720
done nicely done as always

607
00:25:03,990 --> 00:25:02,240
so what has mata learned from

608
00:25:07,190 --> 00:25:04,000
osiris-rex's success that will be

609
00:25:10,789 --> 00:25:08,549
it's a really good question and you

610
00:25:13,190 --> 00:25:10,799
heard mike speak just a little earlier

611
00:25:14,950 --> 00:25:13,200
about the importance of for example the

612
00:25:16,630 --> 00:25:14,960
autonomous operations that were

613
00:25:18,870 --> 00:25:16,640

demonstrated by the osiris-rex

614
00:25:20,789 --> 00:25:18,880
spacecraft and the operations team that

615
00:25:22,390 --> 00:25:20,799
will help inform future small bodies

616
00:25:24,470 --> 00:25:22,400
missions but there are a variety of

617
00:25:25,750 --> 00:25:24,480
other things we've learned as well

618
00:25:27,669 --> 00:25:25,760
for example

619
00:25:29,669 --> 00:25:27,679
you know most of our planetary missions

620
00:25:31,909 --> 00:25:29,679
take their observations from a distance

621
00:25:34,390 --> 00:25:31,919
using remote sensing instruments to help

622
00:25:37,430 --> 00:25:34,400
us understand the composition of those

623
00:25:39,990 --> 00:25:37,440
planetary surfaces but it's really rare

624
00:25:41,909 --> 00:25:40,000
that we're actually able to

625
00:25:43,909 --> 00:25:41,919
collect a sample and bring it back to

626
00:25:46,310 --> 00:25:43,919
earth that we can then use as ground

627
00:25:48,470 --> 00:25:46,320
truth to help us calibrate those remote

628
00:25:49,990 --> 00:25:48,480
sensing observations

629
00:25:52,390 --> 00:25:50,000
so this we have a really unique

630
00:25:54,390 --> 00:25:52,400
opportunity here to use the samples that

631
00:25:56,630 --> 00:25:54,400
we've collected to help us interpret

632
00:25:58,470 --> 00:25:56,640
those remote sensing observations and

633
00:26:00,390 --> 00:25:58,480
then on future missions when we're

634
00:26:03,029 --> 00:26:00,400
taking remote sensing observations we'll

635
00:26:05,029 --> 00:26:03,039
be able to to better uh better interpret

636
00:26:05,830 --> 00:26:05,039
those and better uh

637
00:26:08,070 --> 00:26:05,840
make

638
00:26:11,830 --> 00:26:08,080

conclusions about what the surfaces of

639
00:26:13,909 --> 00:26:11,840
other bodies look like or what they are

640
00:26:16,710 --> 00:26:13,919
so what's next for nasa's small body

641
00:26:19,430 --> 00:26:16,720
missions after osiris-rex

642
00:26:21,830 --> 00:26:19,440
another great question so small bodies

643
00:26:24,310 --> 00:26:21,840
are incredibly fascinating and there are

644
00:26:27,029 --> 00:26:24,320
of course many many small bodies across

645
00:26:28,710 --> 00:26:27,039
our entire solar system and we find them

646
00:26:30,070 --> 00:26:28,720
in different locations and and the

647
00:26:31,909 --> 00:26:30,080
asteroids we find in each of those

648
00:26:34,390 --> 00:26:31,919
locations can tell us little bits or

649
00:26:36,149 --> 00:26:34,400
different parts of that story about how

650
00:26:38,630 --> 00:26:36,159
our solar system formed and how it

651
00:26:40,870 --> 00:26:38,640
evolved over time and so the next

652
00:26:43,350 --> 00:26:40,880
mission that we have ready to go that's

653
00:26:45,750 --> 00:26:43,360
going to launch in october of this year

654
00:26:48,390 --> 00:26:45,760
is called lucy and the lucy mission is

655
00:26:50,549 --> 00:26:48,400
going to go to study a family of special

656
00:26:52,230 --> 00:26:50,559
asteroids that are trapped in jupiter's

657
00:26:54,390 --> 00:26:52,240
orbit and it's actually going to visit

658
00:26:56,470 --> 00:26:54,400
seven different asteroids uh that are

659
00:26:59,190 --> 00:26:56,480
called trojan asteroids in that jupiter

660
00:27:01,190 --> 00:26:59,200
orbit uh to help us up understand uh the

661
00:27:04,390 --> 00:27:01,200
formation of those giant planets and how

662
00:27:06,070 --> 00:27:04,400
their their history uh impacted the uh

663
00:27:09,190 --> 00:27:06,080

the formation of those those different

664
00:27:11,350 --> 00:27:09,200
uh asteroids and and uh trojan asteroids

665
00:27:13,269 --> 00:27:11,360
found in that orbit and then the next

666
00:27:15,430 --> 00:27:13,279
mission after lucy uh that we're going

667
00:27:17,669 --> 00:27:15,440
to launch is called the double asteroid

668
00:27:19,430 --> 00:27:17,679
redirection test or dart and that

669
00:27:21,990 --> 00:27:19,440
mission is going to launch in november

670
00:27:24,630 --> 00:27:22,000
so just a month after the lucy launch

671
00:27:27,590 --> 00:27:24,640
we'll be launching uh dart and dart is

672
00:27:29,750 --> 00:27:27,600
our first mission in uh in our planetary

673
00:27:32,950 --> 00:27:29,760
defense line and so it has a really

674
00:27:35,830 --> 00:27:32,960
important purpose to demonstrate a new

675
00:27:38,070 --> 00:27:35,840
capability a a test a technique called

676
00:27:40,549 --> 00:27:38,080
the kinetic impactor technique where

677
00:27:43,029 --> 00:27:40,559
we're going to show just how well we can

678
00:27:45,669 --> 00:27:43,039
change the orbit of a very very small

679
00:27:49,029 --> 00:27:45,679
asteroid by impacting the spacecraft

680
00:27:50,470 --> 00:27:49,039
into the small moon of the asteroid

681
00:27:52,070 --> 00:27:50,480
ditty most in the small moon is called

682
00:27:53,750 --> 00:27:52,080
dimorphous and we're going to impact

683
00:27:56,070 --> 00:27:53,760
that spacecraft in there see just how

684
00:27:58,789 --> 00:27:56,080
well or how much we can change its orbit

685
00:28:01,669 --> 00:27:58,799
around the larger asteroid and then we

686
00:28:03,909 --> 00:28:01,679
have a another mission coming up in 2022

687
00:28:06,149 --> 00:28:03,919
called psyche that's going to launch in

688
00:28:08,470 --> 00:28:06,159

the summer of 22. uh that mission is

689
00:28:09,269 --> 00:28:08,480
going to visit a special asteroid called

690
00:28:10,950 --> 00:28:09,279
um

691
00:28:13,990 --> 00:28:10,960
16 psyche

692
00:28:15,909 --> 00:28:14,000
that is uh appears to be a very metallic

693
00:28:18,230 --> 00:28:15,919
asteroid a very unusual asteroid that

694
00:28:21,909 --> 00:28:18,240
could potentially be uh

695
00:28:23,669 --> 00:28:21,919
at the core of an early uh planetoid so

696
00:28:25,669 --> 00:28:23,679
we're really excited about that mission

697
00:28:27,430 --> 00:28:25,679
as well we're going we're all set to

698
00:28:29,669 --> 00:28:27,440
learn lots of great information about

699
00:28:31,750 --> 00:28:29,679
the small bodies that inhabit our solar

700
00:28:33,269 --> 00:28:31,760
system

701
00:28:35,830 --> 00:28:33,279
we have a busy and exciting few years

702
00:28:38,389 --> 00:28:35,840
ahead of us thank you so much lori

703
00:28:39,909 --> 00:28:38,399
it's my pleasure thank you

704
00:28:43,269 --> 00:28:39,919
now i'd like to bring back a cyrus rex

705
00:28:48,389 --> 00:28:46,630
dante how are you feeling

706
00:28:50,870 --> 00:28:48,399
uh i'm actually a little more emotional

707
00:28:52,710 --> 00:28:50,880
than i expected to be right now uh we

708
00:28:54,630 --> 00:28:52,720
knew this maneuver was coming up but to

709
00:28:56,470 --> 00:28:54,640
see that doppler plot and to know that

710
00:28:58,710 --> 00:28:56,480
those engines fired

711
00:29:00,789 --> 00:28:58,720
uh it's just an amazing sense of pride

712
00:29:02,389 --> 00:29:00,799
and accomplishment i couldn't be more

713
00:29:04,710 --> 00:29:02,399

excited for what this team has

714
00:29:06,389 --> 00:29:04,720
accomplished at moments like these i

715
00:29:08,789 --> 00:29:06,399
always think about the spacecraft and

716
00:29:11,190 --> 00:29:08,799
just imagine it 200 million miles or

717
00:29:13,350 --> 00:29:11,200
more away from us doing everything that

718
00:29:15,510 --> 00:29:13,360
we're asking you to do and today we're

719
00:29:17,669 --> 00:29:15,520
asking it to fire those engines it's now

720
00:29:21,110 --> 00:29:17,679
moving away over 600 miles an hour from

721
00:29:25,510 --> 00:29:23,669
i'm so excited for you so osiris-rex has

722
00:29:27,510 --> 00:29:25,520
collected a lot of data over the past

723
00:29:29,750 --> 00:29:27,520
two and a half years as the principal

724
00:29:31,430 --> 00:29:29,760
investigator what are you most excited

725
00:29:35,830 --> 00:29:31,440
about

726
00:29:38,070 --> 00:29:35,840
return and we picked bennu for a very

727
00:29:40,149 --> 00:29:38,080
special reason we believed from our

728
00:29:42,549 --> 00:29:40,159
astronomical telescopic data that it was

729
00:29:44,549 --> 00:29:42,559
rich in carbon primarily in the form of

730
00:29:47,269 --> 00:29:44,559
organic molecules and that it contained

731
00:29:48,630 --> 00:29:47,279
abundant water locked up inside minerals

732
00:29:50,549 --> 00:29:48,640
called clays

733
00:29:53,110 --> 00:29:50,559
so for me the most exciting results were

734
00:29:55,510 --> 00:29:53,120
when we got the spectrometer data down

735
00:29:57,510 --> 00:29:55,520
and first we saw that clear signature of

736
00:29:59,990 --> 00:29:57,520
water all over the surface of bennu it's

737
00:30:01,669 --> 00:30:00,000
a very wet hydrated rock and then a

738
00:30:04,149 --> 00:30:01,679

little later on in the mission we got

739
00:30:06,389 --> 00:30:04,159
the signal there was abundant carbon and

740
00:30:08,310 --> 00:30:06,399
it was everywhere on the surface we

741
00:30:09,750 --> 00:30:08,320
picked a great sample site nightingale

742
00:30:11,190 --> 00:30:09,760
which we think is going to give us wide

743
00:30:13,909 --> 00:30:11,200
representation of the different rock

744
00:30:15,510 --> 00:30:13,919
types on the asteroid so everything i

745
00:30:17,990 --> 00:30:15,520
hope that this mission would deliver in

746
00:30:20,549 --> 00:30:18,000
terms of the sample bennu has given us

747
00:30:22,149 --> 00:30:20,559
so we've done our job we got the sample

748
00:30:23,990 --> 00:30:22,159
now we fired our thrusters and we're on

749
00:30:27,190 --> 00:30:24,000
our way home it's time to look forward

750
00:30:29,830 --> 00:30:27,200
to what i call the ground game

751
00:30:31,269 --> 00:30:29,840
well huge congratulations again and most

752
00:30:32,870 --> 00:30:31,279
of the people on this team have been

753
00:30:34,230 --> 00:30:32,880
together for a long time and have

754
00:30:35,909 --> 00:30:34,240
performed flawlessly throughout the

755
00:30:39,190 --> 00:30:35,919
mission so what do you think has made

756
00:30:41,430 --> 00:30:39,200
this team so successful

757
00:30:43,029 --> 00:30:41,440
well building this team culture was one

758
00:30:45,430 --> 00:30:43,039
of the biggest jobs of our of the

759
00:30:46,870 --> 00:30:45,440
leadership group and we knew right away

760
00:30:48,630 --> 00:30:46,880
you're bringing together people from an

761
00:30:50,630 --> 00:30:48,640
academic institution from an industry

762
00:30:52,149 --> 00:30:50,640
partner from a government agency and

763
00:30:54,630 --> 00:30:52,159

there's different backgrounds different

764
00:30:56,549 --> 00:30:54,640
cultures and different motivations

765
00:30:58,549 --> 00:30:56,559
but we very quickly came together we

766
00:31:01,430 --> 00:30:58,559
were not university of arizona lockheed

767
00:31:03,509 --> 00:31:01,440
martin and nasa we were osiris-rex we

768
00:31:05,669 --> 00:31:03,519
had a mission that mission was to build

769
00:31:07,909 --> 00:31:05,679
an amazing spacecraft

770
00:31:09,669 --> 00:31:07,919
literally do some world record setting

771
00:31:12,070 --> 00:31:09,679
astro dynamic maneuvers around the

772
00:31:14,389 --> 00:31:12,080
asteroid and collect that sample so that

773
00:31:16,230 --> 00:31:14,399
common sense of purpose and that unity

774
00:31:18,710 --> 00:31:16,240
is what made this team work so well

775
00:31:20,870 --> 00:31:18,720
together

776
00:31:23,990 --> 00:31:20,880
thank you dante and congratulations to

777
00:31:25,190 --> 00:31:24,000
you and the entire asuras rex team

778
00:31:27,430 --> 00:31:25,200
thank you so

779
00:31:29,190 --> 00:31:27,440
welcome back and my name is joyang and

780
00:31:30,549 --> 00:31:29,200
i'm talking to you from nasa's goddard

781
00:31:32,470 --> 00:31:30,559
space flight center in greenback

782
00:31:35,190 --> 00:31:32,480
maryland if you just joined us

783
00:31:37,750 --> 00:31:35,200
osiris-rex has officially left asteroid

784
00:31:39,830 --> 00:31:37,760
bennu and it's on its way back to earth

785
00:31:42,149 --> 00:31:39,840
so the osiris-rex mission is not over

786
00:31:44,070 --> 00:31:42,159
though it enters a new exciting phase

787
00:31:45,750 --> 00:31:44,080
delivering the bounty of asteroid sample

788
00:31:47,590 --> 00:31:45,760

back to earth so we're going to be

789
00:31:50,310 --> 00:31:47,600
talking to two people who cannot wait to

790
00:31:52,470 --> 00:31:50,320
get their hands on that sample we have

791
00:31:55,029 --> 00:31:52,480
nicole lunning from nasa's johnson space

792
00:31:57,110 --> 00:31:55,039
center in texas and jason dwerkin from

793
00:31:59,669 --> 00:31:57,120
nasa's goddard space flight center in

794
00:32:03,990 --> 00:32:02,310
hi nicole jason thank you for joining us

795
00:32:05,590 --> 00:32:04,000
so this is a really exciting time for

796
00:32:07,830 --> 00:32:05,600
you both because your work is just

797
00:32:10,310 --> 00:32:07,840
beginning

798
00:32:11,509 --> 00:32:10,320
absolutely it's uh it's a thrilling time

799
00:32:14,950 --> 00:32:11,519
um

800
00:32:17,590 --> 00:32:14,960
uh i've been working uh cyrus rex uh to

801
00:32:19,750 --> 00:32:17,600
get get a sample back from an asteroid

802
00:32:22,149 --> 00:32:19,760
since my daughter was in diapers and now

803
00:32:23,990 --> 00:32:22,159
she's graduating from from high school

804
00:32:26,070 --> 00:32:24,000
it's uh i i can't wait to get that

805
00:32:30,630 --> 00:32:26,080
sample back and and

806
00:32:34,389 --> 00:32:32,549
and i'm newer to the mission than jason

807
00:32:35,990 --> 00:32:34,399
but i'm looking forward to years of

808
00:32:37,909 --> 00:32:36,000
being part of the team that curates and

809
00:32:40,630 --> 00:32:37,919
takes care of this sample once it

810
00:32:42,630 --> 00:32:40,640
returns to earth

811
00:32:44,710 --> 00:32:42,640
so nicole can you walk us through what

812
00:32:46,310 --> 00:32:44,720
happens after the samples are recovered

813
00:32:48,070 --> 00:32:46,320

in the utah desert

814
00:32:49,990 --> 00:32:48,080
how does the sample get secured and sent

815
00:32:52,310 --> 00:32:50,000
to the lab at nasa's johnson space

816
00:32:54,470 --> 00:32:52,320
center

817
00:32:56,070 --> 00:32:54,480
so after the sample return capsule is

818
00:32:58,389 --> 00:32:56,080
recovered it will actually be taken to a

819
00:33:01,190 --> 00:32:58,399
portable clean lab we'll set up in utah

820
00:33:03,350 --> 00:33:01,200
for us sort of preliminary disassembly

821
00:33:05,669 --> 00:33:03,360
where the part of the sample returned

822
00:33:07,909 --> 00:33:05,679
capsule that contains um the bennu

823
00:33:10,549 --> 00:33:07,919
material will actually be packaged then

824
00:33:12,710 --> 00:33:10,559
into a travel box that will keep it in a

825
00:33:14,310 --> 00:33:12,720
nitrogen atmosphere to protect it from

826
00:33:16,630 --> 00:33:14,320
contamination from earth's atmosphere

827
00:33:18,389 --> 00:33:16,640
that will be flown on a plane to our lab

828
00:33:20,710 --> 00:33:18,399
at johnson space center that we're

829
00:33:22,710 --> 00:33:20,720
currently building and there have been

830
00:33:24,470 --> 00:33:22,720
careful documentation processes of

831
00:33:26,070 --> 00:33:24,480
building it as well as choosing

832
00:33:28,149 --> 00:33:26,080
materials to limit

833
00:33:31,509 --> 00:33:28,159
very much what the asteroid material

834
00:33:33,750 --> 00:33:31,519
will be exposed to to really protect it

835
00:33:35,750 --> 00:33:33,760
that is quite the journey so in that

836
00:33:37,509 --> 00:33:35,760
same vein jason can you tell us a little

837
00:33:41,029 --> 00:33:37,519
bit about how you and the team will keep

838
00:33:42,389 --> 00:33:41,039

that sample in pristine condition

839
00:33:44,389 --> 00:33:42,399
right so as

840
00:33:46,470 --> 00:33:44,399
as nicole was saying we have a limited

841
00:33:48,549 --> 00:33:46,480
number of material stuff the sample can

842
00:33:50,149 --> 00:33:48,559
be exposed to this was actually planned

843
00:33:52,789 --> 00:33:50,159
out well before we ever started building

844
00:33:55,269 --> 00:33:52,799
a spacecraft on the very very early days

845
00:33:58,310 --> 00:33:55,279
we came up with with strategies to keep

846
00:33:59,190 --> 00:33:58,320
the sample clean and to document

847
00:34:01,350 --> 00:33:59,200
both

848
00:34:03,430 --> 00:34:01,360
in paper but also in chemical

849
00:34:04,870 --> 00:34:03,440
documentation of what the sample has

850
00:34:09,270 --> 00:34:04,880
been exposed to so that when it comes

851
00:34:11,669 --> 00:34:09,280
back we can compare uh the the witnesses

852
00:34:13,669 --> 00:34:11,679
uh the chemical witnesses of the sample

853
00:34:16,230 --> 00:34:13,679
uh with with what we actually get back

854
00:34:17,829 --> 00:34:16,240
and understand uh

855
00:34:20,550 --> 00:34:17,839
with the same what tells us about the

856
00:34:22,790 --> 00:34:20,560
solar system

857
00:34:25,109 --> 00:34:22,800
and jason you've had such a long career

858
00:34:28,389 --> 00:34:25,119
analyzing samples what excites you most

859
00:34:30,629 --> 00:34:28,399
about receiving this sample

860
00:34:33,750 --> 00:34:30,639
so i'm an organic animal chemist so i'm

861
00:34:38,389 --> 00:34:36,149
among our over 50 different hypotheses

862
00:34:39,430 --> 00:34:38,399
testing looking at things involved in

863
00:34:41,750 --> 00:34:39,440

the uh

864
00:34:43,990 --> 00:34:41,760
organic compounds that lead to life like

865
00:34:45,430 --> 00:34:44,000
the left and right hand amino acids and

866
00:34:47,909 --> 00:34:45,440
those sorts of things

867
00:34:51,750 --> 00:34:47,919
in the sample but the part that excites

868
00:34:53,589 --> 00:34:51,760
me the most is that 75 of the sample we

869
00:34:54,790 --> 00:34:53,599
bring back is archived for future

870
00:34:57,670 --> 00:34:54,800
generations

871
00:35:00,630 --> 00:34:57,680
so scientists perhaps not even born yet

872
00:35:02,470 --> 00:35:00,640
will use techniques we can't imagine

873
00:35:06,230 --> 00:35:02,480
to ask questions we don't know how to

874
00:35:09,270 --> 00:35:06,240
phrase yet and so this is a decades-long

875
00:35:12,310 --> 00:35:09,280
uh legacy that assassin rex brings to to

876
00:35:15,829 --> 00:35:13,990
well i'm so thrilled for you both thank

877
00:35:18,950 --> 00:35:15,839
you so much for joining us and huge

878
00:35:19,670 --> 00:35:18,960
congratulations again

879
00:35:21,589 --> 00:35:19,680
so

880
00:35:23,910 --> 00:35:21,599
there we have it osiris-rex has

881
00:35:24,710 --> 00:35:23,920
officially left bennu and is cruising

882
00:35:25,990 --> 00:35:24,720
home

883
00:35:28,310 --> 00:35:26,000
you can keep up to date with this

884
00:35:30,870 --> 00:35:28,320
amazing mission by following nasa solar

885
00:35:33,190 --> 00:35:30,880
system on twitter facebook and instagram

886
00:35:34,069 --> 00:35:33,200
or by following the hashtag twobenu and

887
00:35:35,990 --> 00:35:34,079
back

888
00:35:37,910 --> 00:35:36,000

we're now about to close the show with a

889
00:35:40,630 --> 00:35:37,920
look back at the best moments of the

890
00:35:43,190 --> 00:35:40,640
osiris-rex mission at belu thank you so

891
00:35:45,750 --> 00:35:43,200
much for joining us

892
00:35:48,310 --> 00:35:45,760
on october 20th 2020

893
00:35:51,190 --> 00:35:48,320
nasa's osiris-rex basement collected a

894
00:35:54,130 --> 00:35:51,200
sample from asteroid bennu

895
00:36:02,230 --> 00:35:54,140
navigation

896
00:36:10,230 --> 00:36:04,790
all stations this is rx systems on rx

897
00:36:17,670 --> 00:36:14,390
position uncertainty is 0.5 meters

898
00:36:22,589 --> 00:36:17,680
predicted tag lateral offset is 1.7

899
00:36:26,710 --> 00:36:24,550
osiris-rex's sampling mechanism

900
00:36:28,710 --> 00:36:26,720
penetrated venues regularly and fired

901
00:36:30,470 --> 00:36:28,720
its nitrogen gas bottle to stir up

902
00:36:34,230 --> 00:36:30,480
sample material for collection in the

903
00:36:39,349 --> 00:36:37,270
at 6 08 pm eastern the team on earth

904
00:36:41,430 --> 00:36:39,359
received confirmation of a successful

905
00:36:44,230 --> 00:36:41,440
touchdown

906
00:36:46,870 --> 00:36:44,240
rex has descended below the 5 meter mark

907
00:36:48,810 --> 00:36:46,880
the hazard map is go for tag

908
00:36:50,140 --> 00:36:48,820
and we have touchdowns

909
00:37:03,349 --> 00:36:50,150
[Applause]

910
00:37:05,670 --> 00:37:03,359
after spending approximately six seconds

911
00:37:07,829 --> 00:37:05,680
at the surface osiris-rex fired its

912
00:37:11,510 --> 00:37:07,839
thrusters and backed away from sample

913
00:37:16,390 --> 00:37:13,910

images taken a few days later by the sam

914
00:37:18,790 --> 00:37:16,400
cam camera showed rocks and dust

915
00:37:20,150 --> 00:37:18,800
escaping the sampler head

916
00:37:22,550 --> 00:37:20,160
the team believed it collected a

917
00:37:24,470 --> 00:37:22,560
sufficient sample and decided to seal

918
00:37:27,910 --> 00:37:24,480
the tax amp to preserve the remaining

919
00:37:32,390 --> 00:37:30,230
the spacecraft made one more flyover of

920
00:37:34,630 --> 00:37:32,400
bennu and saw just how big a market left

921
00:37:36,230 --> 00:37:34,640
on the asteroid surface the tag event

922
00:37:39,430 --> 00:37:36,240
sent boulders flying across

923
00:37:44,950 --> 00:37:41,910
osiris-rex completed its last flyover of

924
00:37:46,310 --> 00:37:44,960
bennu at around 6am eastern on april 7

925
00:37:48,230 --> 00:37:46,320
2021

926
00:37:52,790 --> 00:37:48,240
and slowly began drifting away from the

927
00:37:57,190 --> 00:37:54,710
on may 10th 2021

928
00:38:03,350 --> 00:37:57,200
osiris-rex fired his thrusters and began

929
00:38:03,360 --> 00:38:12,069
[Music]

930
00:38:16,230 --> 00:38:14,390
as osiris-rex approaches earth it will

931
00:38:20,150 --> 00:38:16,240
jettison the sample return capsule that

932
00:38:24,710 --> 00:38:22,230
the src will then travel through earth's

933
00:38:26,950 --> 00:38:24,720
atmosphere

934
00:38:29,589 --> 00:38:26,960
and land under parachutes at the utah

935
00:38:36,310 --> 00:38:29,599
test and training range on september 24

936
00:38:40,390 --> 00:38:38,390
once recovered the capsule will be

937
00:38:42,710 --> 00:38:40,400
transported to the curation facility at

938
00:38:44,310 --> 00:38:42,720

nasa's johnson space center where the

939
00:38:46,870 --> 00:38:44,320
sample will be removed for distribution

940
00:38:48,470 --> 00:38:46,880
to laboratories worldwide

941
00:38:50,870 --> 00:38:48,480
enabling scientists to study the

942
00:38:58,390 --> 00:38:50,880
formation of our solar system and earth

943
00:39:06,150 --> 00:39:01,589
in december 2018 after traveling for two

944
00:39:08,870 --> 00:39:06,160
years 101 days in over 1.2 billion miles

945
00:39:12,470 --> 00:39:08,880
nasa's osiris-rex spacecraft arrived at

946
00:39:14,790 --> 00:39:12,480
its target near-earth asteroid bennu

947
00:39:16,790 --> 00:39:14,800
osiris-rex is the first mission to

948
00:39:19,270 --> 00:39:16,800
explore this primitive remnant from the

949
00:39:21,589 --> 00:39:19,280
origins of the solar system designed to

950
00:39:23,430 --> 00:39:21,599
study the asteroid and return a sample

951
00:39:26,390 --> 00:39:23,440
to earth

952
00:39:28,790 --> 00:39:26,400
bennu is a dark diminutive world roughly

953
00:39:30,630 --> 00:39:28,800
the height of a skyscraper and now the

954
00:39:31,990 --> 00:39:30,640
smallest body to be orbited by a

955
00:39:34,230 --> 00:39:32,000
spacecraft

956
00:39:36,870 --> 00:39:34,240
prior to arrival it was known to have

957
00:39:39,510 --> 00:39:36,880
low thermal inertia a characteristic of

958
00:39:42,310 --> 00:39:39,520
fine-grained materials like sand

959
00:39:44,150 --> 00:39:42,320
an infrared spectrometer on osiris-rex

960
00:39:46,390 --> 00:39:44,160
confirmed this property leading

961
00:39:47,990 --> 00:39:46,400
scientists to expect a predominantly

962
00:39:50,150 --> 00:39:48,000
smooth surface

963
00:39:52,470 --> 00:39:50,160

but the first close-up views of bennu

964
00:39:54,310 --> 00:39:52,480
delivered a major surprise

965
00:39:56,390 --> 00:39:54,320
in exquisite detail the mission's

966
00:39:59,270 --> 00:39:56,400
cameras revealed an unrelenting

967
00:40:01,030 --> 00:39:59,280
rockscape dominated by boulders

968
00:40:04,069 --> 00:40:01,040
by combining these images from

969
00:40:06,390 --> 00:40:04,079
osiris-rex with its laser altimetry data

970
00:40:07,910 --> 00:40:06,400
we can take a tour of bennu's remarkable

971
00:40:10,630 --> 00:40:07,920
terrain

972
00:40:12,550 --> 00:40:10,640
the first stop is simmering saxon

973
00:40:15,190 --> 00:40:12,560
this prominent boulder defines the

974
00:40:17,910 --> 00:40:15,200
asteroids prime meridian and serves as

975
00:40:20,309 --> 00:40:17,920
the basis of its coordinate system

976
00:40:22,390 --> 00:40:20,319
in persian mythology the simrac is a

977
00:40:25,270 --> 00:40:22,400
large and benevolent bird and the

978
00:40:27,190 --> 00:40:25,280
possessor of all knowledge saxon is

979
00:40:29,430 --> 00:40:27,200
latin for stone

980
00:40:32,470 --> 00:40:29,440
to the northeast lies the largest

981
00:40:35,190 --> 00:40:32,480
boulder on venue measuring over 300 feet

982
00:40:37,270 --> 00:40:35,200
in length rock saxon is a colossus

983
00:40:40,230 --> 00:40:37,280
longer than a football field

984
00:40:42,550 --> 00:40:40,240
it is also rich in a type of iron oxide

985
00:40:45,030 --> 00:40:42,560
called magnetite which was used by

986
00:40:46,309 --> 00:40:45,040
mariners as an early form of magnetic

987
00:40:48,950 --> 00:40:46,319
compass

988
00:40:51,270 --> 00:40:48,960

in arab folklore the rock is an enormous

989
00:40:53,990 --> 00:40:51,280
bird of prey that can clasp elephants in

990
00:40:57,430 --> 00:40:54,000
its talons as well as stranded sailors

991
00:40:59,750 --> 00:40:57,440
like the hero sinbad

992
00:41:03,030 --> 00:40:59,760
continuing northeast over the equatorial

993
00:41:04,790 --> 00:41:03,040
ridge we arrive at gargoyle saxon

994
00:41:07,109 --> 00:41:04,800
this striking boulder is among the

995
00:41:08,790 --> 00:41:07,119
darkest on venue though it clutches a

996
00:41:11,030 --> 00:41:08,800
much brighter rock that is about the

997
00:41:13,270 --> 00:41:11,040
size of a person

998
00:41:15,430 --> 00:41:13,280
in medieval legend gargoyles are

999
00:41:17,670 --> 00:41:15,440
dragon-like winged monsters that can

1000
00:41:20,390 --> 00:41:17,680
breathe fire and that guard cathedrals

1001
00:41:22,790 --> 00:41:20,400
from evil spirits

1002
00:41:23,829 --> 00:41:22,800
our next destination takes us far to the

1003
00:41:25,829 --> 00:41:23,839
east

1004
00:41:28,309 --> 00:41:25,839
at the northern end of a small crater

1005
00:41:30,790 --> 00:41:28,319
lies acipity saxon a comparatively

1006
00:41:32,230 --> 00:41:30,800
bright boulder measuring about 33 feet

1007
00:41:34,790 --> 00:41:32,240
in diameter

1008
00:41:36,870 --> 00:41:34,800
oscipide saxon is located near one of

1009
00:41:39,750 --> 00:41:36,880
three sites where benue ejected small

1010
00:41:41,829 --> 00:41:39,760
particles into space in early 2019

1011
00:41:43,030 --> 00:41:41,839
displaying its dynamic and evolving

1012
00:41:45,589 --> 00:41:43,040
nature

1013
00:41:47,670 --> 00:41:45,599

in greek mythology oscipide is one of

1014
00:41:49,910 --> 00:41:47,680
the three harpies the half-maiden

1015
00:41:52,390 --> 00:41:49,920
half-bird personifications of storm

1016
00:41:57,030 --> 00:41:52,400
winds would carry evildoers away from

1017
00:42:02,630 --> 00:41:59,750
in the creation stories of ancient egypt

1018
00:42:04,550 --> 00:42:02,640
the universe began as a formless endless

1019
00:42:06,950 --> 00:42:04,560
expanse of water

1020
00:42:09,589 --> 00:42:06,960
from this primordial sea arose the

1021
00:42:12,150 --> 00:42:09,599
primordial mound ben ben

1022
00:42:14,630 --> 00:42:12,160
it was upon this rock that the god adam

1023
00:42:16,470 --> 00:42:14,640
settled in the form of the bennu bird

1024
00:42:17,910 --> 00:42:16,480
and sent forth the call that shaped

1025
00:42:20,069 --> 00:42:17,920
creation

1026
00:42:22,550 --> 00:42:20,079
the story of ben ben harkens to the

1027
00:42:24,309 --> 00:42:22,560
mounds of fertile silt that once emerged

1028
00:42:26,950 --> 00:42:24,319
from the receding flood waters of the

1029
00:42:29,430 --> 00:42:26,960
nile and it provides a fitting namesake

1030
00:42:32,630 --> 00:42:29,440
for the tallest boulder on bennu

1031
00:42:34,790 --> 00:42:32,640
protruding by over 70 feet benben saxon

1032
00:42:36,150 --> 00:42:34,800
is so tall that it was first detected

1033
00:42:38,390 --> 00:42:36,160
from earth

1034
00:42:40,550 --> 00:42:38,400
now we can appreciate this monumental

1035
00:42:44,150 --> 00:42:40,560
feature in detail using data from

1036
00:42:48,470 --> 00:42:46,550
the final stop on our tour is a cluster

1037
00:42:50,950 --> 00:42:48,480
of exceptionally bright boulders

1038
00:42:52,870 --> 00:42:50,960

scattered across the southern hemisphere

1039
00:42:55,670 --> 00:42:52,880
they bear the spectral fingerprint of

1040
00:42:58,390 --> 00:42:55,680
pyroxene a mineral found in igneous rock

1041
00:43:00,790 --> 00:42:58,400
that is unlikely to have formed on bennu

1042
00:43:02,950 --> 00:43:00,800
these boulders most likely originated on

1043
00:43:04,870 --> 00:43:02,960
the large asteroid vesta and were

1044
00:43:08,069 --> 00:43:04,880
delivered to bennu's parent body through

1045
00:43:10,630 --> 00:43:08,079
meteoroid impacts

1046
00:43:12,950 --> 00:43:10,640
although it is small in size asteroid

1047
00:43:15,750 --> 00:43:12,960
bennu has proved to be a fascinating

1048
00:43:18,230 --> 00:43:15,760
world abundant in geographic features

1049
00:43:20,870 --> 00:43:18,240
that have defied our expectations

1050
00:43:23,589 --> 00:43:20,880
thanks to osiris-rex we can now explore

1051
00:43:26,069 --> 00:43:23,599
bennu to uncover its composition its

1052
00:43:30,060 --> 00:43:26,079
evolution and its ancient memories from

1053
00:43:49,109 --> 00:43:30,070
the origins of the solar system

1054
00:43:52,550 --> 00:43:50,870
as we started to approach bennu from a

1055
00:43:54,630 --> 00:43:52,560
distance and it started to fill up the

1056
00:43:56,069 --> 00:43:54,640
camera field of view it looked exactly

1057
00:43:57,589 --> 00:43:56,079
like we thought it would with a few

1058
00:44:00,390 --> 00:43:57,599
boulders sticking out but as we got

1059
00:44:01,990 --> 00:44:00,400
closer we expected to see a very sandy

1060
00:44:04,390 --> 00:44:02,000
surface with maybe some few boulders

1061
00:44:06,390 --> 00:44:04,400
here and there and what we saw is

1062
00:44:08,710 --> 00:44:06,400
very little sand and we saw these

1063
00:44:11,910 --> 00:44:08,720

mountains we saw boulders we saw rocks

1064
00:44:13,990 --> 00:44:11,920
and we saw very few areas that had this

1065
00:44:21,190 --> 00:44:14,000
scenery surface that we were expecting

1066
00:44:25,349 --> 00:44:23,589
we have never done this before

1067
00:44:27,190 --> 00:44:25,359
we're actually going to collect a sample

1068
00:44:30,069 --> 00:44:27,200
and bring it back down to earth for

1069
00:44:32,150 --> 00:44:30,079
further examination by scientists

1070
00:44:33,589 --> 00:44:32,160
in order to achieve that objective the

1071
00:44:35,430 --> 00:44:33,599
osiris-rex spacecraft has been

1072
00:44:37,430 --> 00:44:35,440
navigating around bennu for about the

1073
00:44:40,470 --> 00:44:37,440
last two years studying it in great

1074
00:44:43,030 --> 00:44:40,480
detail and also overcoming a number of

1075
00:44:45,510 --> 00:44:43,040
challenges that bennu has presented we

1076
00:44:48,150 --> 00:44:45,520
were looking for locations on bennu that

1077
00:44:50,150 --> 00:44:48,160
were 50 meters in diameter relatively

1078
00:44:52,150 --> 00:44:50,160
flat and covered with fine grained

1079
00:44:54,309 --> 00:44:52,160
material and by fine grain material i

1080
00:44:56,150 --> 00:44:54,319
mean stuff that's the size of a dime or

1081
00:44:58,150 --> 00:44:56,160
smaller we realized that there were no

1082
00:44:59,829 --> 00:44:58,160
sites on bennu that even came close to

1083
00:45:01,750 --> 00:44:59,839
meeting this criteria everywhere we

1084
00:45:03,670 --> 00:45:01,760
looked was too small and covered with

1085
00:45:05,589 --> 00:45:03,680
boulders so we actually had to fly a

1086
00:45:08,150 --> 00:45:05,599
number of additional closed passes over

1087
00:45:11,510 --> 00:45:08,160
the asteroid and rethink our entire plan

1088
00:45:15,430 --> 00:45:13,349

after the additional observations of

1089
00:45:17,510 --> 00:45:15,440
bennu we had to down select to four

1090
00:45:19,829 --> 00:45:17,520
sites and then go back and survey those

1091
00:45:22,309 --> 00:45:19,839
sites even further to select the final

1092
00:45:24,309 --> 00:45:22,319
primary sample site my first impression

1093
00:45:26,470 --> 00:45:24,319
of nightingale is that's the last place

1094
00:45:29,030 --> 00:45:26,480
i wanted to go but as we started looking

1095
00:45:31,030 --> 00:45:29,040
at other sites we saw that one this is

1096
00:45:34,470 --> 00:45:31,040
probably one of the most sampleable

1097
00:45:36,150 --> 00:45:34,480
sites and two we were over performing in

1098
00:45:38,150 --> 00:45:36,160
our navigation capability and our

1099
00:45:39,750 --> 00:45:38,160
ability to contact

1100
00:45:41,589 --> 00:45:39,760
natural feature tracking works a lot

1101
00:45:44,230 --> 00:45:41,599
like the human mind in that we pick up

1102
00:45:45,829 --> 00:45:44,240
landmarks along the way as we descend we

1103
00:45:47,430 --> 00:45:45,839
look at features on the ground we

1104
00:45:49,430 --> 00:45:47,440
program the computer to recognize

1105
00:45:51,510 --> 00:45:49,440
certain features it takes a picture says

1106
00:45:53,190 --> 00:45:51,520
this feature is not where i expected it

1107
00:45:55,430 --> 00:45:53,200
to be it's a little bit off to the side

1108
00:45:57,109 --> 00:45:55,440
updates its position based on where it's

1109
00:45:59,990 --> 00:45:57,119
pointed and where that feature shows up

1110
00:46:03,349 --> 00:46:00,000
in the camera position

1111
00:46:04,710 --> 00:46:03,359
the tag event is our touch and go event

1112
00:46:06,950 --> 00:46:04,720
which is where we'll actually be

1113
00:46:08,470 --> 00:46:06,960

retrieving the sample from asteroid

1114
00:46:09,990 --> 00:46:08,480
bennu we start with a series of

1115
00:46:11,750 --> 00:46:10,000
maneuvers one of them being the

1116
00:46:13,910 --> 00:46:11,760
checkpoint burn which is where we'll

1117
00:46:16,550 --> 00:46:13,920
actually check our position velocity in

1118
00:46:18,630 --> 00:46:16,560
relation to the sample sites and then

1119
00:46:20,550 --> 00:46:18,640
the match point burn about 10 minutes

1120
00:46:22,470 --> 00:46:20,560
later we'll zero out our horizontal

1121
00:46:24,550 --> 00:46:22,480
velocity relative to the surface and

1122
00:46:26,710 --> 00:46:24,560
then about 10 minutes after that we make

1123
00:46:28,390 --> 00:46:26,720
contact with the tag sam fire the gas

1124
00:46:30,950 --> 00:46:28,400
bottle and then back away

1125
00:46:33,030 --> 00:46:30,960
and we hope to get at least 60 grams of

1126
00:46:35,109 --> 00:46:33,040
sample and then we'll be able to store

1127
00:46:36,309 --> 00:46:35,119
that and bring it back down to earth but

1128
00:46:37,910 --> 00:46:36,319
there are several things that could go

1129
00:46:39,750 --> 00:46:37,920
wrong and we also have to be prepared

1130
00:46:41,589 --> 00:46:39,760
that we won't be successful on our first

1131
00:46:44,069 --> 00:46:41,599
try at nightingale

1132
00:46:46,069 --> 00:46:44,079
we don't only get one shot at tag we

1133
00:46:47,430 --> 00:46:46,079
actually have three nitrogen bottles on

1134
00:46:49,750 --> 00:46:47,440
board the spacecraft so we can

1135
00:46:52,309 --> 00:46:49,760
potentially do three tag attempts if

1136
00:46:54,069 --> 00:46:52,319
needed we go through several what-if

1137
00:46:56,390 --> 00:46:54,079
scenarios and this is how we actually

1138
00:46:57,750 --> 00:46:56,400

prepare for a lot of our contingencies

1139
00:46:59,829 --> 00:46:57,760
so we've had to look all around the

1140
00:47:01,510 --> 00:46:59,839
surface and identify the rocks and

1141
00:47:03,910 --> 00:47:01,520
boulders that if the spacecraft were to

1142
00:47:05,349 --> 00:47:03,920
tip over up to 25 degrees

1143
00:47:07,910 --> 00:47:05,359
it could come into contact and be

1144
00:47:09,430 --> 00:47:07,920
damaged we had to develop a hazard map

1145
00:47:11,109 --> 00:47:09,440
which we program into the computer and

1146
00:47:13,349 --> 00:47:11,119
says if you're getting too close to

1147
00:47:15,190 --> 00:47:13,359
those hazards we'll do a wave off we'll

1148
00:47:17,109 --> 00:47:15,200
back away from the asteroid we'll come

1149
00:47:19,349 --> 00:47:17,119
back and do this another day everything

1150
00:47:21,589 --> 00:47:19,359
might work perfectly we come down we

1151
00:47:24,230 --> 00:47:21,599
touch the surface just where we want to

1152
00:47:27,910 --> 00:47:24,240
we fire the gas bottle but the area we

1153
00:47:30,549 --> 00:47:27,920
contact is covered in large rocks

1154
00:47:32,309 --> 00:47:30,559
those rocks would prevent any fine grain

1155
00:47:34,790 --> 00:47:32,319
material from being stirred up and

1156
00:47:37,109 --> 00:47:34,800
captured in the tag sand head

1157
00:47:38,630 --> 00:47:37,119
another similar scenario is if the tag

1158
00:47:40,790 --> 00:47:38,640
sam were to touch on the edge of a

1159
00:47:42,710 --> 00:47:40,800
boulder and become tipped up in that

1160
00:47:44,870 --> 00:47:42,720
case when the gas ball fires much of

1161
00:47:46,549 --> 00:47:44,880
that gas escapes out the side not

1162
00:47:48,630 --> 00:47:46,559
churning up the material that we want to

1163
00:47:50,470 --> 00:47:48,640

capture the day of tag is going to be

1164
00:47:52,790 --> 00:47:50,480
really exciting but the excitement for

1165
00:47:55,670 --> 00:47:52,800
our team doesn't end there we have to

1166
00:47:57,670 --> 00:47:55,680
verify that we have a proper sample

1167
00:47:59,109 --> 00:47:57,680
first we're going to image the tag sam

1168
00:48:00,309 --> 00:47:59,119
head by sticking in front of one of the

1169
00:48:01,910 --> 00:48:00,319
cameras then we're going to do a

1170
00:48:03,510 --> 00:48:01,920
maneuver called the sample mass

1171
00:48:05,589 --> 00:48:03,520
measurement in which we stick out the

1172
00:48:07,190 --> 00:48:05,599
arm and we spin the spacecraft in order

1173
00:48:08,790 --> 00:48:07,200
for us to decide if we've collected

1174
00:48:11,109 --> 00:48:08,800
enough mass to be able to stow the

1175
00:48:13,430 --> 00:48:11,119
sample and return home or if we have to

1176
00:48:14,630 --> 00:48:13,440
try again this is the culmination of a

1177
00:48:16,150 --> 00:48:14,640
lot of work it's probably one of the

1178
00:48:17,829 --> 00:48:16,160
most exciting missions that i've worked

1179
00:48:20,309 --> 00:48:17,839
on it is really exciting to know that

1180
00:48:22,150 --> 00:48:20,319
we're finally going to be able to touch

1181
00:48:30,230 --> 00:48:22,160
the surface of the asteroid and collect

1182
00:48:34,630 --> 00:48:33,030
after its discovery in 1999 our first

1183
00:48:37,030 --> 00:48:34,640
hints of what asteroid bennu looked like

1184
00:48:39,190 --> 00:48:37,040
came from the arecibo observatory

1185
00:48:41,190 --> 00:48:39,200
then as the osiris-rex spacecraft made

1186
00:48:43,589 --> 00:48:41,200
its way to bennu the asteroid grew in

1187
00:48:46,230 --> 00:48:43,599
detail from a few tiny pixels to a

1188
00:48:48,870 --> 00:48:46,240

surprisingly rugged world littered with