1
00:00:06,389 --> 00:00:04,710
as we started to approach bennu from a

2
00:00:08,470 --> 00:00:06,399
distance and it started to fill up the

3
00:00:09,910 --> 00:00:08,480
camera field of view it looked exactly

4
00:00:11,430 --> 00:00:09,920
like we thought it would with a few

5
00:00:14,230 --> 00:00:11,440
boulders sticking out but as we got

6
00:00:15,910 --> 00:00:14,240
closer we expected to see a very sandy

7
00:00:18,150 --> 00:00:15,920
surface with maybe a few boulders here

8
00:00:20,150 --> 00:00:18,160
and there and what we saw is

9
00:00:22,470 --> 00:00:20,160
very little sand and we saw these

10
00:00:25,670 --> 00:00:22,480
mountains we saw boulders we saw rocks

11
00:00:27,910 --> 00:00:25,680
and we saw very few areas that had this

12
00:00:34,950 --> 00:00:27,920
sandy surface that we were expecting and

13
00:00:39,110 --> 00:00:37,350

we have never done this before

14
00:00:40,950 --> 00:00:39,120
we're actually going to collect a sample

15
00:00:42,830 --> 00:00:40,960
and bring it back down to earth for

16
00:00:45,110 --> 00:00:42,840
further examination by

17
00:00:47,190 --> 00:00:45,120
scientists in order to achieve that

18
00:00:49,110 --> 00:00:47,200
objective the osiris-rex spacecraft has

19
00:00:51,189 --> 00:00:49,120
been navigating around bennu for about

20
00:00:54,229 --> 00:00:51,199
the last two years studying it in great

21
00:00:56,869 --> 00:00:54,239
detail and also overcoming a number of

22
00:00:59,270 --> 00:00:56,879
challenges that bennu has presented we

23
00:01:01,990 --> 00:00:59,280
were looking for locations on venue that

24
00:01:03,910 --> 00:01:02,000
were 50 meters in diameter relatively

25
00:01:05,910 --> 00:01:03,920
flat and covered with fine-grained

26
00:01:08,070 --> 00:01:05,920
material and by fine-grained material i

27
00:01:09,910 --> 00:01:08,080
mean stuff that's the size of a dime or

28
00:01:11,910 --> 00:01:09,920
smaller we realized that there were no

29
00:01:13,590 --> 00:01:11,920
sites on bennu that even came close to

30
00:01:15,510 --> 00:01:13,600
meeting this criteria everywhere we

31
00:01:17,510 --> 00:01:15,520
looked was too small and covered with

32
00:01:19,350 --> 00:01:17,520
boulders so we actually had to fly a

33
00:01:21,910 --> 00:01:19,360
number of additional close passes over

34
00:01:25,270 --> 00:01:21,920
the asteroid and rethink our entire plan

35
00:01:29,190 --> 00:01:27,109
after the additional observations of

36
00:01:31,270 --> 00:01:29,200
bennu we had to down select to four

37
00:01:33,590 --> 00:01:31,280
sites and then go back and survey those

38
00:01:36,069 --> 00:01:33,600

sites even further to select the final

39
00:01:38,069 --> 00:01:36,079
primary sample site my first impression

40
00:01:40,310 --> 00:01:38,079
of nightingale is that's the last place

41
00:01:42,789 --> 00:01:40,320
i wanted to go but as we started looking

42
00:01:44,789 --> 00:01:42,799
at other sites we saw that one this is

43
00:01:48,230 --> 00:01:44,799
probably one of the most sampleable

44
00:01:49,910 --> 00:01:48,240
sites and two we were over performing in

45
00:01:51,910 --> 00:01:49,920
our navigation capability and our

46
00:01:53,510 --> 00:01:51,920
ability to contact

47
00:01:55,350 --> 00:01:53,520
natural feature tracking works a lot

48
00:01:57,990 --> 00:01:55,360
like the human mind in that we pick up

49
00:01:59,590 --> 00:01:58,000
landmarks along the way as we descend we

50
00:02:01,190 --> 00:01:59,600
look at features on the ground we

51
00:02:03,190 --> 00:02:01,200
program the computer to recognize

52
00:02:05,270 --> 00:02:03,200
certain features it takes a picture says

53
00:02:06,950 --> 00:02:05,280
this feature is not where i expected it

54
00:02:09,190 --> 00:02:06,960
to be it's a little bit off to the side

55
00:02:10,869 --> 00:02:09,200
updates its position based on where it's

56
00:02:13,750 --> 00:02:10,879
pointed and where that feature shows up

57
00:02:17,110 --> 00:02:13,760
in the camera position

58
00:02:18,550 --> 00:02:17,120
the tag event is our touch and go event

59
00:02:20,790 --> 00:02:18,560
which is where we'll actually be

60
00:02:22,229 --> 00:02:20,800
retrieving the sample from asteroid

61
00:02:23,750 --> 00:02:22,239
bennu we start with a series of

62
00:02:25,510 --> 00:02:23,760
maneuvers one of them being the

63
00:02:27,670 --> 00:02:25,520

checkpoint burn which is where we'll

64
00:02:30,309 --> 00:02:27,680
actually check our position velocity in

65
00:02:32,390 --> 00:02:30,319
relation to the sample sites and then

66
00:02:34,309 --> 00:02:32,400
the match point burn about 10 minutes

67
00:02:36,229 --> 00:02:34,319
later we'll zero out our horizontal

68
00:02:38,309 --> 00:02:36,239
velocity relative to the surface and

69
00:02:40,470 --> 00:02:38,319
then about 10 minutes after that we make

70
00:02:43,030 --> 00:02:40,480
contact with the tag sam fire the gas

71
00:02:45,589 --> 00:02:43,040
bottle and then back away and we hope to

72
00:02:47,830 --> 00:02:45,599
get at least 60 grams of sample and then

73
00:02:49,430 --> 00:02:47,840
we'll be able to store that and bring it

74
00:02:50,869 --> 00:02:49,440
back down to earth but there are several

75
00:02:52,309 --> 00:02:50,879
things that could go wrong and we also

76
00:02:54,229 --> 00:02:52,319
have to be prepared that we won't be

77
00:02:55,350 --> 00:02:54,239
successful on our first try at

78
00:02:57,830 --> 00:02:55,360
nightingale

79
00:02:59,830 --> 00:02:57,840
we don't only get one shot at tag we

80
00:03:01,270 --> 00:02:59,840
actually have three nitrogen bottles on

81
00:03:03,509 --> 00:03:01,280
board the spacecraft so we can

82
00:03:06,070 --> 00:03:03,519
potentially do three tag attempts if

83
00:03:07,830 --> 00:03:06,080
needed we go through several what-if

84
00:03:10,149 --> 00:03:07,840
scenarios and this is how we actually

85
00:03:11,589 --> 00:03:10,159
prepare for a lot of our contingencies

86
00:03:13,589 --> 00:03:11,599
so we've had to look all around the

87
00:03:15,270 --> 00:03:13,599
surface and identify the rocks and

88
00:03:17,670 --> 00:03:15,280

boulders that if the spacecraft were to

89
00:03:19,110 --> 00:03:17,680
tip over up to 25 degrees

90
00:03:21,670 --> 00:03:19,120
it could come into contact and be

91
00:03:23,190 --> 00:03:21,680
damaged we had to develop a hazard map

92
00:03:24,869 --> 00:03:23,200
which we program into the computer and

93
00:03:27,110 --> 00:03:24,879
says if you're getting too close to

94
00:03:28,949 --> 00:03:27,120
those hazards we'll do a wave off we'll

95
00:03:30,869 --> 00:03:28,959
back away from the asteroid we'll come

96
00:03:33,110 --> 00:03:30,879
back and do this another day everything

97
00:03:35,350 --> 00:03:33,120
might work perfectly we come down we

98
00:03:37,990 --> 00:03:35,360
touch the surface just where we want to

99
00:03:41,670 --> 00:03:38,000
we fire the gas bottle but the area we

100
00:03:44,309 --> 00:03:41,680
contact is covered in large rocks

101
00:03:46,070 --> 00:03:44,319
those rocks would prevent any fine grain

102
00:03:48,550 --> 00:03:46,080
material from being stirred up and

103
00:03:50,869 --> 00:03:48,560
captured in the tag sam head

104
00:03:52,390 --> 00:03:50,879
another similar scenario is if the tag

105
00:03:54,550 --> 00:03:52,400
sam were to touch on the edge of a

106
00:03:56,470 --> 00:03:54,560
boulder and become tipped up in that

107
00:03:58,630 --> 00:03:56,480
case when the gas bottle fires much of

108
00:04:00,390 --> 00:03:58,640
that gas escapes out the side not

109
00:04:02,390 --> 00:04:00,400
churning up the material that we want to

110
00:04:04,229 --> 00:04:02,400
capture the day of tag is going to be

111
00:04:06,550 --> 00:04:04,239
really exciting but the excitement for

112
00:04:09,429 --> 00:04:06,560
our team doesn't end there we have to

113
00:04:11,429 --> 00:04:09,439

verify that we have a proper sample

114
00:04:12,869 --> 00:04:11,439
first we're going to image the tag sam

115
00:04:14,070 --> 00:04:12,879
head by sticking in front of one of the

116
00:04:15,670 --> 00:04:14,080
cameras then we're going to do a

117
00:04:17,270 --> 00:04:15,680
maneuver called the sample mass

118
00:04:19,430 --> 00:04:17,280
measurement in which we stick out the

119
00:04:20,949 --> 00:04:19,440
arm and we spin the spacecraft in order

120
00:04:22,550 --> 00:04:20,959
for us to decide if we've collected

121
00:04:24,870 --> 00:04:22,560
enough mass to be able to stow the

122
00:04:27,270 --> 00:04:24,880
sample and return home or if we have to

123
00:04:28,390 --> 00:04:27,280
try again this is the culmination of a

124
00:04:29,909 --> 00:04:28,400
lot of work it's probably one of the

125
00:04:31,590 --> 00:04:29,919
most exciting missions that i've worked

126
00:04:33,749 --> 00:04:31,600
on it is really exciting to know that

127
00:04:35,590 --> 00:04:33,759
we're finally going to be able to

128
00:04:37,350 --> 00:04:35,600
touch the surface of the asteroid and

129
00:04:41,300 --> 00:04:37,360
collect the sample to return back to