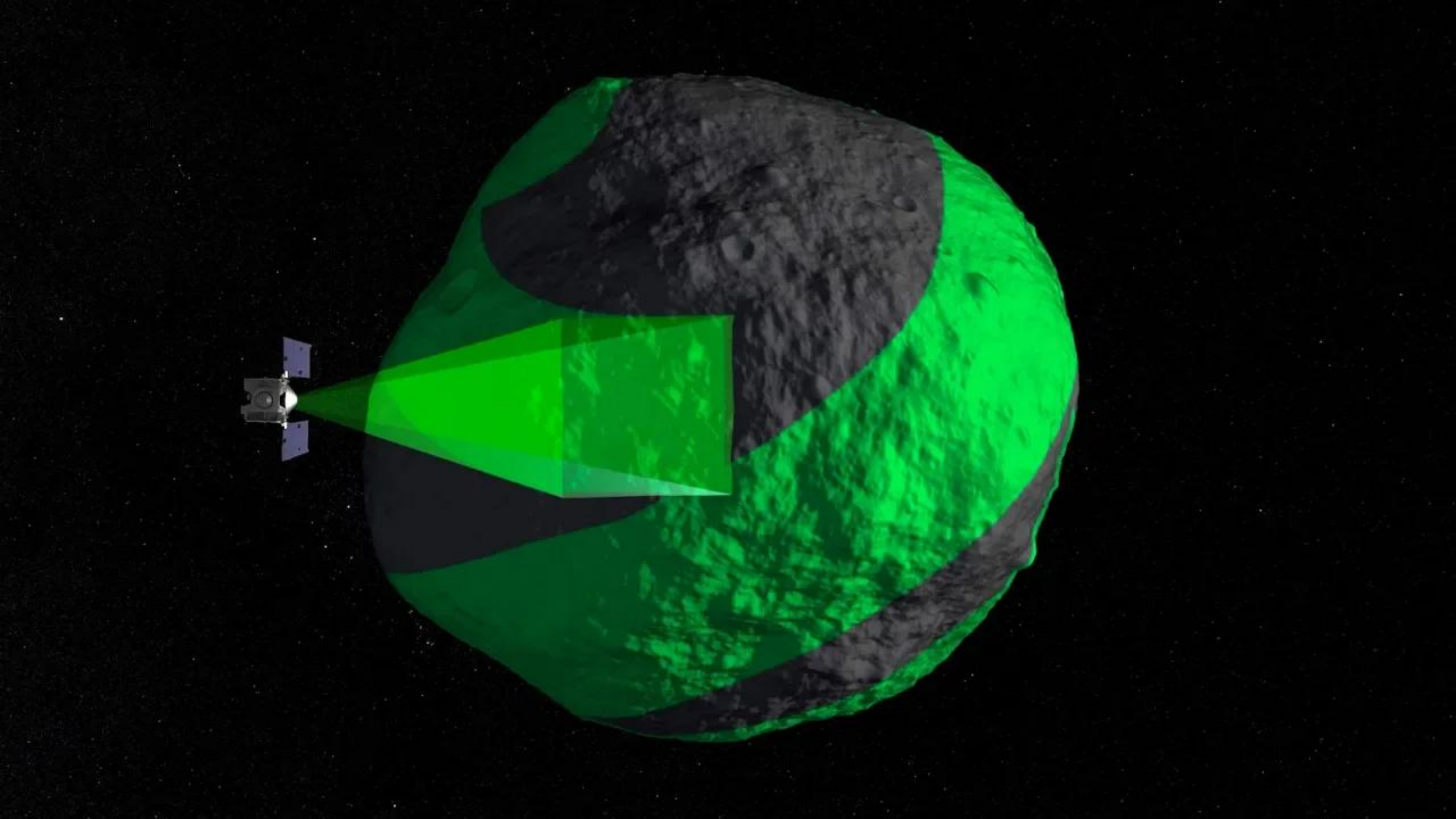

1
00:00:00,234 --> 00:00:01,902
[Music]

2
00:00:01,902 --> 00:00:05,372
OSIRIS-REx is a NASA
mission to explore near-Earth

3
00:00:05,372 --> 00:00:09,142
asteroid Bennu, a remnant from
the dawn of the solar system,

4
00:00:09,142 --> 00:00:12,412
and to return a
sample of Bennu to Earth.

5
00:00:12,412 --> 00:00:16,683
On September 8, 2016, OSIRIS-REx
began its journey to Bennu from

6
00:00:16,683 --> 00:00:19,286
Cape Canaveral, Florida
aboard an Atlas V rocket.

7
00:00:19,286 --> 00:00:23,524
It lifted off shortly before
sunset, climbing eastward over

8
00:00:23,524 --> 00:00:27,427
the Atlantic Ocean to traverse
the night side of Earth.

9
00:00:27,427 --> 00:00:30,964
One hour later, OSIRIS-REx
separated from its Centaur upper

10
00:00:30,964 --> 00:00:34,234
stage rocket and
drifted into space.

11

00:00:34,234 --> 00:00:37,571
It deployed its solar arrays to
catch the rising sun, and made a

12
00:00:37,571 --> 00:00:41,541
final pass over Australia before
embarking on its outbound cruise

13
00:00:41,541 --> 00:00:43,210
to Bennu.

14
00:00:43,210 --> 00:00:46,847
After a year in orbit around the
sun, OSIRIS-REx briefly returned

15
00:00:46,847 --> 00:00:50,751
to Earth in September
2017 for a gravity assist.

16
00:00:50,751 --> 00:00:54,554
The spacecraft passed within
18,000 kilometers of Antarctica,

17
00:00:54,554 --> 00:00:57,491
then turned its instrument deck
toward home to capture images

18
00:00:57,491 --> 00:01:00,027
and spectra of
Earth and the Moon.

19
00:01:00,027 --> 00:01:03,397
The gravity assist bent the
trajectory of OSIRIS-REx by six

20
00:01:03,397 --> 00:01:06,566
degrees, matching the orbital
tilt of Bennu, and sending the

21
00:01:06,566 --> 00:01:09,569

spacecraft on a path
to catch its target.

22
00:01:09,569 --> 00:01:14,107
In August 2018, OSIRIS-REx
began its Approach phase.

23
00:01:14,107 --> 00:01:17,177
Its long-range camera captured
the first visible-light images

24
00:01:17,177 --> 00:01:21,515
of Bennu as a single pixel
moving across a field of stars.

25
00:01:21,515 --> 00:01:25,319
Over the following months, Bennu
grew from a pixel into a world,

26
00:01:25,319 --> 00:01:29,256
with OSIRIS-REx revealing its
shape, rotation, and color for

27
00:01:29,256 --> 00:01:31,124
the first time.

28
00:01:31,124 --> 00:01:35,429
Now, after chasing its target
for over two years, OSIRIS-REx

29
00:01:35,429 --> 00:01:39,199
is arriving at asteroid Bennu.

30
00:01:39,199 --> 00:01:42,302
On December 3 it will fire
its thrusters to match Bennu's

31
00:01:42,302 --> 00:01:45,872
velocity and begin
its Preliminary Survey.

32
00:01:45,872 --> 00:01:49,343
OSIRIS-REx will pass high
above the equator and the poles,

33
00:01:49,343 --> 00:01:52,713
measuring Bennu's position and
mass, and refining its size,

34
00:01:52,713 --> 00:01:54,915
shape, and spin.

35
00:01:54,915 --> 00:01:58,018
On New Year's Eve, OSIRIS-REx
will venture close enough to

36
00:01:58,018 --> 00:02:02,222
Bennu to be captured into orbit
by its miniscule gravity, making

37
00:02:02,222 --> 00:02:06,693
it the smallest world ever to
be orbited by a spacecraft.

38
00:02:06,693 --> 00:02:10,297
In early 2019, OSIRIS-REx
will break orbit to conduct a

39
00:02:10,297 --> 00:02:11,565
Detailed Survey of Bennu.

40
00:02:11,565 --> 00:02:15,335
First, it will carry out a
mapping campaign called the

41
00:02:15,335 --> 00:02:17,270
Baseball Diamond.

42
00:02:17,270 --> 00:02:20,640

By observing Bennu at different
latitudes and times of day,

43
00:02:20,640 --> 00:02:24,645
OSIRIS-REx will capture stereo
images and identify large rocks

44
00:02:24,645 --> 00:02:28,281
on the surface that could pose
a hazard later in the mission.

45
00:02:28,281 --> 00:02:32,486
In its second mapping campaign,
OSIRIS-REx will observe Bennu

46
00:02:32,486 --> 00:02:34,855
from seven different
stations around its equator.

47
00:02:34,855 --> 00:02:38,692
At each station, it will take
measurements from pole-to-pole

48
00:02:38,692 --> 00:02:42,195
using its mapping camera,
laser altimeter, and two

49
00:02:42,195 --> 00:02:42,896
spectrometers.

50
00:02:42,896 --> 00:02:46,466
The combined data will provide
a detailed look at Bennu's

51
00:02:46,466 --> 00:02:48,568
geologic features
and its composition.

52
00:02:48,568 --> 00:02:51,838
This will improve landmark-based

navigation, and enable mission

53
00:02:51,838 --> 00:02:55,876
planners to begin looking for
places to collect a sample.

54
00:02:55,876 --> 00:02:58,545
Following the Detailed Survey,
OSIRIS-REx will once again enter

55
00:02:58,545 --> 00:03:00,047
orbit.

56
00:03:00,047 --> 00:03:03,417
At a radius of only one
kilometer, Orbital B will serve

57
00:03:03,417 --> 00:03:07,487
as the mission's safe home
orbit until sample collection.

58
00:03:07,487 --> 00:03:11,258
During this phase, OSIRIS-REx
will globally map Bennu.

59
00:03:11,258 --> 00:03:14,761
It will fly in a polar orbit as
the asteroid rotates beneath,

60
00:03:14,761 --> 00:03:17,831
enabling full
coverage of the surface.

61
00:03:17,831 --> 00:03:20,934
Orbital B's precession, or
wobble, will also be used to

62
00:03:20,934 --> 00:03:23,904
measure Bennu's gravity field,
along with the non-gravitational

63
00:03:23,904 --> 00:03:26,706
forces that are slowly
altering Bennu's trajectory.

64
00:03:29,342 --> 00:03:33,346
In mid-2019, OSIRIS-REx will
begin its Reconnaissance phase.

65
00:03:33,346 --> 00:03:37,317
It will break orbit and fly over
four candidate sample sites at

66
00:03:37,317 --> 00:03:41,188
225 meters, taking
high-resolution images.

67
00:03:41,188 --> 00:03:44,624
Flying at such close proximity
will reveal large pebbles that

68
00:03:44,624 --> 00:03:47,260
could pose a hazard
during sample collection.

69
00:03:47,260 --> 00:03:50,197
Mission planners will use this
information to select the two

70
00:03:50,197 --> 00:03:52,199
best sites for
additional inspection.

71
00:03:54,134 --> 00:03:58,405
At a range of 525 meters,
OSIRIS-REx will fly over the two

72
00:03:58,405 --> 00:04:01,174
final candidate sites,
spectrally mapping the surface

73
00:04:01,174 --> 00:04:03,510
to reveal its
chemical composition.

74
00:04:03,510 --> 00:04:06,079
This information will help
mission planners determine the

75
00:04:06,079 --> 00:04:09,015
most valuable site for
collecting the sample.

76
00:04:09,015 --> 00:04:12,419
Once the final site has been
selected, OSIRIS-REx will begin

77
00:04:12,419 --> 00:04:13,954
its rehearsal phase.

78
00:04:13,954 --> 00:04:16,556
Frist, it will practice
autonomous flight to a

79
00:04:16,556 --> 00:04:19,593
predetermined Check Point, where
it will start its descent during

80
00:04:19,593 --> 00:04:21,261
sample collection.

81
00:04:21,261 --> 00:04:25,265
Next, OSIRIS-REx will practice
flying to the Match Point.

82
00:04:25,265 --> 00:04:28,168
The spacecraft will lower to
within 30 meters of the surface

83

00:04:28,168 --> 00:04:31,571
to match Bennu's speed and
rotation, a necessity for safely

84
00:04:31,571 --> 00:04:33,507
touching the asteroid.

85
00:04:33,507 --> 00:04:37,477
Finally, in mid-2020, OSIRIS-REx
will be ready to collect a

86
00:04:37,477 --> 00:04:39,079
sample of Bennu.

87
00:04:39,079 --> 00:04:41,715
Before it descends to the
surface, the spacecraft will

88
00:04:41,715 --> 00:04:45,018
deploy its Touch-And-Go
Sample Acquisition-Mechanism, or

89
00:04:45,018 --> 00:04:48,855
TAGSAM, a new technology
invented for the mission.

90
00:04:48,855 --> 00:04:52,025
When it reaches the Check Point,
OSIRIS-REx will begin its final

91
00:04:52,025 --> 00:04:52,893
descent.

92
00:04:52,893 --> 00:04:56,530
It will pull back is solar
arrays for safety, and approach

93
00:04:56,530 --> 00:05:00,000
the surface at centimeters per
second, the walking pace of an

94
00:05:00,000 --> 00:05:01,067
insect.

95
00:05:01,067 --> 00:05:04,504
As the TAGSAM touches down, it
will blow high-pressure nitrogen

96
00:05:04,504 --> 00:05:07,340
gas into the soil,
stirring up loose material.

97
00:05:07,340 --> 00:05:11,178
A filter within the sample head
will trap rocks and dirt, while

98
00:05:11,178 --> 00:05:13,814
allowing the gas
to escape to space.

99
00:05:13,814 --> 00:05:17,150
Once the sample is collected,
OSIRIS-REx will fire its

100
00:05:17,150 --> 00:05:20,287
thrusters and back away from
Bennu, retreating to a safe

101
00:05:20,287 --> 00:05:22,289
distance with its
precious cargo.

102
00:05:25,692 --> 00:05:29,029
Following collection, OSIRIS-REx
will verify the status of the

103
00:05:29,029 --> 00:05:32,165
sample, using a
camera called SamCam.

104
00:05:32,165 --> 00:05:35,335
This visual inspection will
reveal whether any large debris

105
00:05:35,335 --> 00:05:38,338
is still attached to the sample
head, which could pose a hazard

106
00:05:38,338 --> 00:05:40,073
during stowage.

107
00:05:40,073 --> 00:05:43,810
Next, OSIRIS-REx will
verify the mass of the sample.

108
00:05:43,810 --> 00:05:47,714
It will fully extend its TAGSAM
arm and perform a spin maneuver,

109
00:05:47,714 --> 00:05:51,518
measuring the change in inertia
to determine the sample's mass.

110
00:05:51,518 --> 00:05:54,821
If at least 60 grams have been
collected, and the sample head

111
00:05:54,821 --> 00:05:57,958
is clear of hazardous debris,
mission planners will command

112
00:05:57,958 --> 00:06:00,160
the spacecraft to
stow the sample.

113
00:06:00,160 --> 00:06:03,363
StowCam will watch closely
as the sample head enters the

114

00:06:03,363 --> 00:06:06,466
return capsule and
is secured in place.

115
00:06:06,466 --> 00:06:10,203
OSIRIS-REx will then detach the
TAGSAM arm from the head, seal

116
00:06:10,203 --> 00:06:13,240
the sample return capsule, and
prepare for its journey back to

117
00:06:13,240 --> 00:06:15,242
Earth.

118
00:06:17,877 --> 00:06:21,881
After departing from Bennu in
early 2021, OSIRIS-REx will

119
00:06:21,881 --> 00:06:24,884
return to Earth in late 2023.

120
00:06:24,884 --> 00:06:28,021
Four hours prior to arrival,
the spacecraft will release the

121
00:06:28,021 --> 00:06:31,358
sample return capsule, then
deflect away from Earth to its

122
00:06:31,358 --> 00:06:35,028
final orbit, as its
piece of Bennu comes home.

123
00:06:35,028 --> 00:06:37,597
The capsule will enter the
atmosphere over the night side

124
00:06:37,597 --> 00:06:41,001
of Earth, streaking towards the

central California coastline at

125
00:06:41,001 --> 00:06:43,003
over 12 kilometers per second.

126
00:06:45,038 --> 00:06:48,642
West of the Great Salt Lake, at
an altitude of approximately 33

127
00:06:48,642 --> 00:06:52,312
kilometers, the capsule will
initiate its parachute sequence,

128
00:06:52,312 --> 00:06:55,715
stabilizing and
slowing its descent.

129
00:06:55,715 --> 00:06:58,985
Upon landing in the Utah desert,
the sample will be recovered,

130
00:06:58,985 --> 00:07:01,254
carefully removed from the
capsule, and taken to the

131
00:07:01,254 --> 00:07:05,425
OSIRIS-REx curation facility at
NASA's Johnson Space Center in

132
00:07:05,425 --> 00:07:06,926
Houston, Texas.

133
00:07:06,926 --> 00:07:09,896
This pristine material from
the early solar system will be

134
00:07:09,896 --> 00:07:13,466
studied for decades to come,
providing clues to the formation

135
00:07:13,466 --> 00:07:16,936
of the planets, to the evolution
of Earth, and to the ingredients

136
00:07:16,936 --> 00:07:18,872
that were present at
the origins of life.