



**CRAZY
ENGINEERING**

1
00:00:00,266 --> 00:00:01,434
[■]

2
00:00:01,468 --> 00:00:03,669
The Cassini Mission has been
exploring the Saturn system

3
00:00:03,702 --> 00:00:06,506
for nearly 13 years and has
rewritten the textbooks

4
00:00:06,539 --> 00:00:09,108
on the ringed planet
and its moons

5
00:00:09,141 --> 00:00:11,811
but the spacecraft is
pretty much out of fuel.

6
00:00:11,844 --> 00:00:14,080
Following NASA's planetary
protection guidelines,

7
00:00:14,113 --> 00:00:15,548
the mission will
end with Cassini

8
00:00:15,581 --> 00:00:17,917
plunging into
Saturn's atmosphere,

9
00:00:17,950 --> 00:00:19,185
but before
that happens,

10
00:00:19,218 --> 00:00:21,888
scientists and engineers have
planned an exciting Grand Finale

11

00:00:21,921 --> 00:00:24,757
that promises some of the most
amazing science and images

12
00:00:24,790 --> 00:00:26,059
of the whole mission.

13
00:00:26,092 --> 00:00:27,693
So, how are they going
to pull this off?

14
00:00:27,726 --> 00:00:29,295
Well, it really is going
to take a special kind

15
00:00:29,328 --> 00:00:31,297
of crazy engineering.

16
00:00:31,330 --> 00:00:35,168
[■]

17
00:00:39,705 --> 00:00:40,740
I am here
with Morgan,

18
00:00:40,773 --> 00:00:42,975
she's a scientist on
the Cassini Project.

19
00:00:43,008 --> 00:00:45,311
The Grand Finale, it's
going to be 22 orbits,

20
00:00:45,344 --> 00:00:47,447
about six months, what
do we hope to accomplish

21
00:00:47,480 --> 00:00:48,515
in that amount of time?

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00:00:48,548 --> 00:00:50,750

We hope to accomplish a
lot of incredible science,

23

00:00:50,783 --> 00:00:53,052

things that we have
never been able to do before

24

00:00:53,085 --> 00:00:54,387

with the Cassini Mission.

25

00:00:54,420 --> 00:00:56,956

We're going to go screaming
over the top of Saturn.

26

00:00:56,989 --> 00:00:59,992

We'll be able to study the
hexagon at Saturn's north pole

27

00:01:00,025 --> 00:01:01,861

in greater detail
than ever before.

28

00:01:01,894 --> 00:01:04,864

We're going to go shooting
between Saturn and its rings,

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00:01:04,897 --> 00:01:06,032

threading the needle,

30

00:01:06,065 --> 00:01:08,801

which means we'll be able to
taste the ring particles,

31

00:01:08,834 --> 00:01:11,170

be able to understand more about
what those are made of.

32

00:01:11,203 --> 00:01:13,840

We'll also be able to taste the atmosphere of Saturn.

33

00:01:13,873 --> 00:01:16,476

We're also going to get a better idea of the interior structure

34

00:01:16,509 --> 00:01:19,245

because we'll be getting closer to Saturn than we've ever been.

35

00:01:19,278 --> 00:01:21,848

And then, this will all culminate in Cassini's

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00:01:21,881 --> 00:01:24,250

final plunge into Saturn's atmosphere,

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00:01:24,283 --> 00:01:26,252

taking data for as long as possible

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00:01:26,285 --> 00:01:28,054

and transmitting that back to Earth.

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00:01:28,087 --> 00:01:29,989

To be able to do this engineering,

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00:01:30,022 --> 00:01:32,792

to thread that needle between Saturn and its rings,

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00:01:32,825 --> 00:01:33,926

is really challenging.

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00:01:33,959 --> 00:01:36,462

That requires something

called astrodynamics.

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00:01:36,495 --> 00:01:38,965

Okay, so what is
astrodynamics?

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00:01:38,998 --> 00:01:40,066

It's a form of
engineering.

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00:01:40,099 --> 00:01:42,401

But when we think about
engineering, typically,

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00:01:42,434 --> 00:01:44,604

we think about people who are
using physics and technology

47

00:01:44,637 --> 00:01:46,105

to build stuff.

48

00:01:46,138 --> 00:01:48,741

Astrodynamicists are
building flight paths

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00:01:48,774 --> 00:01:52,011

that will take our spacecraft
to get where they need to go.

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00:01:52,044 --> 00:01:54,080

Let's go talk to one of
the engineers who's pivotal

51

00:01:54,113 --> 00:01:57,550

in the design of the flight path
of the Cassini spacecraft.

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00:01:57,583 --> 00:01:58,417

Okay, this is Brent.

53

00:01:58,450 --> 00:02:00,820

He's our astrodynamacist
at JPL.

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00:02:00,853 --> 00:02:03,055

Brent, what makes
the Grand Finale

55

00:02:03,088 --> 00:02:05,458

particularly difficult
and challenging?

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00:02:05,491 --> 00:02:07,927

The Grand Finale
is a series of 22 orbits

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00:02:07,960 --> 00:02:10,563

where the periapsis, or the
closest point of the orbit,

58

00:02:10,596 --> 00:02:13,633

is actually in this gap between
the upper atmosphere of Saturn

59

00:02:13,666 --> 00:02:15,635

and the innermost part
of the main rings.

60

00:02:15,668 --> 00:02:16,936

What we've done is

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00:02:16,969 --> 00:02:18,404

we've designed this
trajectory such that

62

00:02:18,437 --> 00:02:21,040

utilizing one
last Titan gravity assist,

63

00:02:21,073 --> 00:02:24,677

we can jump the entire
ring system and place

64

00:02:24,710 --> 00:02:27,580

the spacecraft orbit inside
the very, very small gap

65

00:02:27,613 --> 00:02:29,882

that's only 2,000
kilometers wide.

66

00:02:29,915 --> 00:02:31,317

This concept of
gravity assist,

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00:02:31,350 --> 00:02:32,652

I think a lot of people
have heard of it

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00:02:32,685 --> 00:02:34,086

but maybe not completely
understand it.

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00:02:34,119 --> 00:02:36,522

What it essentially means
is you're harnessing

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00:02:36,555 --> 00:02:38,991

the gravity of a body that's
orbiting another body.

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00:02:39,024 --> 00:02:41,561

For Cassini, Titan, a
very massive moon,

72

00:02:41,594 --> 00:02:42,795

is orbiting Saturn.

73

00:02:42,828 --> 00:02:44,597

If Cassini is also
orbiting Saturn,

74

00:02:44,630 --> 00:02:46,666

I can fly very
close to Titan,

75

00:02:46,699 --> 00:02:50,336

depending if I fly in front of
or behind or above or below,

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00:02:50,736 --> 00:02:53,673

I can use that gravity
to bend my trajectory.

77

00:02:53,706 --> 00:02:54,874

We harness that power.

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00:02:54,907 --> 00:02:57,143

It's our engine. It's
our tour design engine.

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00:02:57,176 --> 00:02:59,579

As soon as we do that
last Titan flyby,

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00:02:59,612 --> 00:03:01,113

Cassini's fate is sealed.

81

00:03:01,146 --> 00:03:03,149

It is going to impact
Saturn no matter what.

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00:03:04,950 --> 00:03:06,519

So, some really
amazing science

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00:03:06,552 --> 00:03:08,821

before we take the
final plunge into Saturn.

84

00:03:08,854 --> 00:03:10,890

And let's remember
why we're doing that:

85

00:03:10,923 --> 00:03:13,459

Why are we flying
the spacecraft into the planet?

86

00:03:13,492 --> 00:03:15,428

It's to protect the
moons of Saturn.

87

00:03:15,461 --> 00:03:17,163

For example, Enceladus,

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00:03:17,196 --> 00:03:19,799

this great moon that has an
ocean underneath the surface.

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00:03:19,832 --> 00:03:22,835

It might just be a cozy little
place for microbes to live.

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00:03:22,868 --> 00:03:24,403

Now, if you look at
our spacecraft,

91

00:03:24,436 --> 00:03:25,805

we try to keep
it as clean as possible,

92

00:03:25,838 --> 00:03:27,607

but there's a real
chance we're bringing

93

00:03:27,640 --> 00:03:29,075

microbes from
Earth with us.

94

00:03:29,108 --> 00:03:30,509

There's no way
to avoid it.

95

00:03:30,542 --> 00:03:32,278

We want the moon as
pristine as possible

96

00:03:32,311 --> 00:03:34,513

for future missions to
go and exploring.

97

00:03:34,546 --> 00:03:35,815

So, for everyone
out there,

98

00:03:35,848 --> 00:03:37,650

follow the Grand
Finale of Cassini