1
00:00:10,620 --> 00:00:17,550
Understanding vast forces in space and how
they affect life here on Earth requires comprehending

2
00:00:17,590 --> 00:00:24,160
what's going on out there. NASA is planning
to launch four identical spacecraft that will

3
00:00:24,160 --> 00:00:29,519
orbit the Earth through the dynamic magnetic
system surrounding our planet, studying a

4
00:00:29,519 --> 00:00:33,339
little-understood phenomenon called magnetic
reconnection.

5
00:00:34,140 --> 00:00:40,560
Magnetic reconnection is unique to plasma,
that is, the mix of positively and negatively

6
00:00:40,570 --> 00:00:47,570
charged particles that make up stars, fill
space and account for an estimated 99 percent

7
00:00:47,570 --> 00:00:49,990
of the observable universe.

8
00:00:51,100 --> 00:00:58,820
On Oct. 28, 2003, and again the following
day, massive solar flares erupted on the sun,

9
00:00:58,820 --> 00:01:02,220
sending X-rays zooming through the solar system.

10
00:01:02,780 --> 00:01:06,000
Along with the flares, the sun expelled giant

11
00:01:06,000 --> 00:01:12,020
clouds of solar material, called coronal mass

ejections, or CMEs.

12
00:01:12,800 --> 00:01:14,300
The CMEs slammed into

13
00:01:14,310 --> 00:01:20,849
Earth's magnetic field pushed material and
energy in toward Earth. This created what's

14
00:01:20,849 --> 00:01:27,160
called a geomagnetic storm that can interrupt
the work of satellites we have come to depend on.

15
00:01:27,160 --> 00:01:31,750
"You can think of it as kind of like a magnetic
explosion. The reason this is important is

16
00:01:31,750 --> 00:01:38,060
because these explosions drive a lot of the
weather patterns that we see in the magnetosphere,

17
00:01:38,060 --> 00:01:40,480
so what space scientists like to refer to
as space weather.

18
00:01:41,349 --> 00:01:48,349
NASA's Magnetospheric Multiscale satellites,
or MMS, should help scientists understand

19
00:01:48,660 --> 00:01:51,450
and better predict space weather patterns.

20
00:01:51,450 --> 00:01:58,260
"The MMS mission is a mission consisting of
four spacecraft which will fly in close constellation

21
00:01:58,260 --> 00:02:00,660
to measure a process called magnetic reconnection."

22

00:02:00,660 --> 00:02:06,030
"We need to measure magnetic reconnection
in more than one location. Basically, how

23
00:02:06,030 --> 00:02:09,730
it varies in space, how it varies in all three
special dimensions."

24
00:02:11,640 --> 00:02:18,280
Scientists want to know exactly what conditions
-- what tipping points -- trigger magnetic

25
00:02:18,290 --> 00:02:24,900
reconnection events. Much of what we currently
know about the small-scale physics of magnetic

26
00:02:24,900 --> 00:02:30,900
reconnection comes from theoretical studies,
computer models and laboratory experiments.

27
00:02:31,900 --> 00:02:38,980
Better understanding requires observing magnetic
reconnection up close so MMS will make

28
00:02:38,990 --> 00:02:45,680
its measurements in Earth's magnetosphere,
an ideal natural laboratory in which reconnection

29
00:02:45,680 --> 00:02:49,710
can be observed under a wide range of conditions.

30
00:02:49,710 --> 00:02:56,120
But before MMS and its science team can begin
their studies, the satellites must be prepared

31
00:02:56,120 --> 00:02:57,950
for launch into orbit.

32
00:02:57,950 --> 00:03:03,520
"Once they arrived several things had to be

done: they had to be fueled, they had to be

33
00:03:03,560 --> 00:03:08,540
processed down here. And, remember, there
were four spacecraft, so it took four times

34
00:03:08,540 --> 00:03:09,500
the effort."

35
00:03:09,510 --> 00:03:16,590
NASA's Launch Services Program has extensive
experience preparing multiple probes for liftoff

36
00:03:16,590 --> 00:03:23,590
on a single rocket. In September 2011, the
GRAIL mission sent two spacecraft to

37
00:03:23,720 --> 00:03:29,960
the moon. More recently, the twin Radiation
Belt Storm Probe satellites were launched

38
00:03:29,960 --> 00:03:34,840
in 2013. But with MMS, there are four.

39
00:03:35,810 --> 00:03:42,390
Omar Baez is the MMS launch director for the
Launch Services Program at NASA's Kennedy

40
00:03:42,390 --> 00:03:43,990
Space Center in Florida.

41
00:03:45,320 --> 00:03:51,000
"Yeah, it would be simpler to do one spacecraft,
but we're here to do the difficult things

42
00:03:51,010 --> 00:03:54,270
and that's why this business is so interesting."

43
00:03:54,270 --> 00:04:01,270

As NASA's launch manager, Baez oversees integration
of the satellites with a familiar rocket the

44
00:04:01,490 --> 00:04:02,910
Atlas V.

45
00:04:02,910 --> 00:04:08,709
"The Launch Service Program contracts the
launch service to United Launch Alliance and

46
00:04:08,709 --> 00:04:14,150
this has been a team that has worked together
since the inception of the Launch Services

47
00:04:14,150 --> 00:04:22,210
Program here in 1998. We work very closely
with ULA from the very design of the mission

48
00:04:22,819 --> 00:04:28,680
from the contract of the mission through the
design through the integration and finally

49
00:04:28,680 --> 00:04:33,470
through the operations and buildup of the
launch vehicle and final launch."

50
00:04:33,470 --> 00:04:38,750
Once in orbit, the next challenge is deploying
all four MMS satellites.

51
00:04:39,260 --> 00:04:42,840
"To get them in orbit, in the right orbit
and the right place, is the most complicated

52
00:04:42,850 --> 00:04:49,130
flight design challenge our team has had.
Amazing amount of maneuvers we have to do

53
00:04:49,130 --> 00:04:54,940
with the Centaur upper stage to make sure

we release all four of the spacecraft at their

54
00:04:54,940 --> 00:05:00,410
right time in five-minute intervals between
release. So, if you can imagine, that first

55
00:05:00,410 --> 00:05:05,130
one pops off and then the second one five
minutes later, then the third one another

56
00:05:05,130 --> 00:05:06,320
five minutes and so on."

57
00:05:06,320 --> 00:05:12,300
After months of testing, the quartet of MMS
satellites will be ready to go to work.

58
00:05:12,300 --> 00:05:18,220
"Once they are commissioned after that six-month
time frame, they formation fly in a tetrahedron

59
00:05:18,220 --> 00:05:25,220
formation and they go around the Earth to
pick up these reconnection events we find

60
00:05:26,030 --> 00:05:31,030
on both sides of the Earth where the magnetosphere
of the sun, the sun's magnetic field and the

61
00:05:31,030 --> 00:05:37,530
Earth's magnetic field meet on the sun side
and on the tail side of the magneto tail of

62
00:05:37,530 --> 00:05:40,300
the Earth on the dark side of the Earth."

63
00:05:40,300 --> 00:05:45,050
As the spacecraft fly through such a site,
they will measure the magnetic and electric

64
00:05:45,050 --> 00:05:48,330
fields present, as well as the movement of
particles.

65
00:05:48,330 --> 00:05:52,220
"We need to understand both of those, if we
want to understand how the magnetosphere works.

66
00:05:52,220 --> 00:05:57,250
And we believe that both of those scenarios
are also very important for us for other applications,

67
00:05:57,250 --> 00:06:04,250
such as the sun, in the solar wind, in planetary
magnetospheres, and many astrophysical objects,

68
00:06:05,120 --> 00:06:06,690
as well as in the laboratory."

69
00:06:06,690 --> 00:06:12,370
During its first phase, MMS satellites will
travel through reconnection sites on the sun

70
00:06:12,370 --> 00:06:18,669
side of Earth. During the second phase of
its mission, MMS will observe reconnection

71
00:06:18,669 --> 00:06:24,919
on the night side where that connected field
flows around both sides of our planet to a

72
00:06:24,919 --> 00:06:26,720
second reconnection point.

73
00:06:26,720 --> 00:06:31,720
"On the day side, basically you have a situation
where the solar wind is just constantly running

74
00:06:31,720 --> 00:06:37,040

into Earth's magnetic field. And this is really
great for MMS, because we know at some point

75
00:06:37,040 --> 00:06:42,630
MMS is going to encounter this region. Our
hope is that since this process is always

76
00:06:42,630 --> 00:06:48,340
happening we are gonna get lucky and actually
fly right though the magnetic explosion as

77
00:06:48,340 --> 00:06:49,460
it is happening."

78
00:06:49,460 --> 00:06:53,460
"Now, on the night side, the situation is
a little bit different. So, what happens,

79
00:06:53,460 --> 00:06:58,340
you have a more gradual buildup of magnetic
energy in the tail, and these reconnection

80
00:06:58,340 --> 00:07:02,169
processes, these magnetic explosions, can
just sort of pop off randomly. We don't really

81
00:07:02,169 --> 00:07:05,460
know when it's going to happen or where it's
gonna happen."

82
00:07:05,460 --> 00:07:11,550
During the MMS mission, scientists will have
their first chance to watch magnetic reconnection

83
00:07:11,550 --> 00:07:18,160
right as it is occurring. By focusing on the
small-scale process, scientists may be able

84
00:07:18,160 --> 00:07:23,979
to open the door to understanding what happens

on larger scales throughout the universe.

85
00:07:23,979 --> 00:07:30,780
Of course, it also will teach us more about
giant geomagnetic storms, thus helping us

86
00:07:30,780 --> 00:07:32,699
safeguard our home planet.

87
00:07:32,699 --> 00:07:36,470
"We hope that is going to allow us to improve
our models so that we can put the right physics

88
00:07:36,470 --> 00:07:40,740
in it and actually make predictions about
where and when reconnection is going to happen,