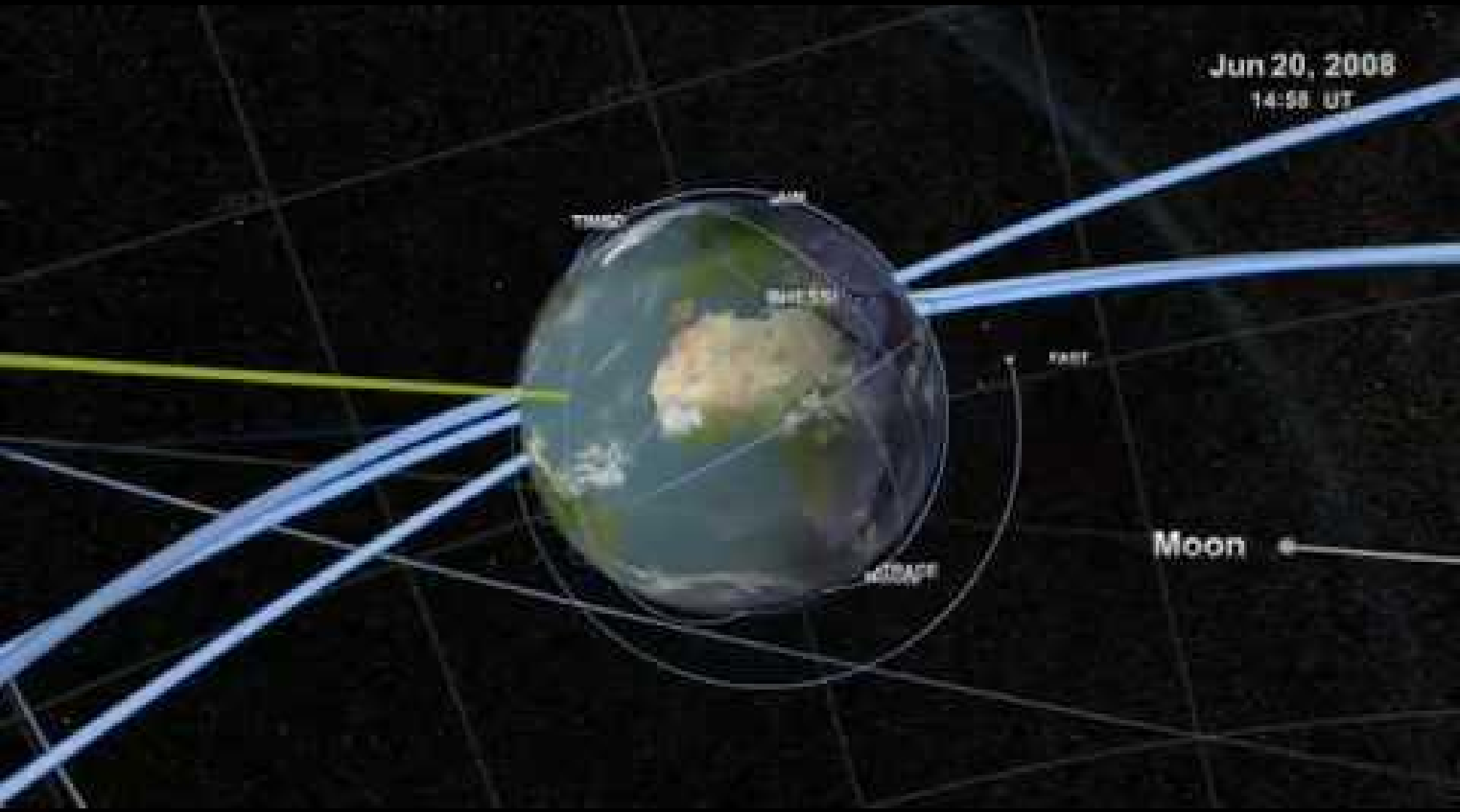
Jun 20, 2008
14:58 UT
Moon

1
00:00:13,430 --> 00:00:11,030
between the earth and the sun we tend to

2
00:00:15,110 --> 00:00:13,440
imagine empty space

3
00:00:18,390 --> 00:00:15,120
but every day

4
00:00:23,269 --> 00:00:18,400
every moment solar forces fill the void

5
00:00:28,070 --> 00:00:25,429
the grey mesh you see here is the

6
00:00:30,470 --> 00:00:28,080
magnetosphere it's effectively a bubble

7
00:00:33,430 --> 00:00:30,480
around the earth created by our planet's

8
00:00:35,910 --> 00:00:33,440
magnetic field squashed and elongated as

9
00:00:37,430 --> 00:00:35,920
intensely energized solar particles

10
00:00:39,990 --> 00:00:37,440
collide with it without the

11
00:00:40,869 --> 00:00:40,000
magnetosphere life on earth would likely

12
00:00:42,869 --> 00:00:40,879
cease

13
00:00:45,510 --> 00:00:42,879

naturally we want to know more about it

14
00:00:47,750 --> 00:00:45,520
so let's start close to home

15
00:00:50,069 --> 00:00:47,760
these near-earth satellites monitor

16
00:00:52,470 --> 00:00:50,079
solar activity interactions with our

17
00:00:54,150 --> 00:00:52,480
planet's atmosphere and other aspects of

18
00:00:55,830 --> 00:00:54,160
the sun's condition

19
00:00:58,389 --> 00:00:55,840
you'll notice how they orbit the earth

20
00:00:59,430 --> 00:00:58,399
quickly about once every 90 minutes or

21
00:01:01,910 --> 00:00:59,440
so

22
00:01:03,830 --> 00:01:01,920
remember this because the rate of times

23
00:01:06,550 --> 00:01:03,840
passage will change as we move through

24
00:01:08,789 --> 00:01:06,560
the solar system

25
00:01:10,469 --> 00:01:08,799
further away we see satellites measuring

26
00:01:12,710 --> 00:01:10,479
the three-dimensional boundaries of the

27
00:01:14,870 --> 00:01:12,720
magnetosphere as it interacts with the

28
00:01:17,270 --> 00:01:14,880
solar wind

29
00:01:19,109 --> 00:01:17,280
and let's be clear this is more than an

30
00:01:21,270 --> 00:01:19,119
academic exercise

31
00:01:23,670 --> 00:01:21,280
nasa's fleet of research satellites

32
00:01:26,149 --> 00:01:23,680
gathers vital information solar

33
00:01:27,910 --> 00:01:26,159
phenomena can jeopardize astronauts and

34
00:01:29,830 --> 00:01:27,920
provoke dramatic challenges to

35
00:01:32,789 --> 00:01:29,840
communications systems and the

36
00:01:35,749 --> 00:01:32,799
electrical grid on the ground

37
00:01:37,910 --> 00:01:35,759
time speeds up as we move out more space

38
00:01:40,069 --> 00:01:37,920

between objects means we have to travel

39
00:01:43,510 --> 00:01:40,079
greater distances and our tour of the

40
00:01:45,270 --> 00:01:43,520
heliosphere only lasts a few minutes

41
00:01:47,030 --> 00:01:45,280
while we're traveling take note of

42
00:01:48,069 --> 00:01:47,040
something you might not have considered

43
00:01:50,710 --> 00:01:48,079
before

44
00:01:53,270 --> 00:01:50,720
not all orbits look the same

45
00:01:54,630 --> 00:01:53,280
in close satellite paths essentially

46
00:01:57,030 --> 00:01:54,640
circle the earth

47
00:01:59,590 --> 00:01:57,040
but farther away we begin to encounter a

48
00:02:01,429 --> 00:01:59,600
wider variety of orbits designed for

49
00:02:03,350 --> 00:02:01,439
varying purposes

50
00:02:05,190 --> 00:02:03,360
the cluster vehicles are on a high

51
00:02:09,029 --> 00:02:05,200
elliptical flight path

52
00:02:11,270 --> 00:02:09,039
geotale makes a lazy loop all alone

53
00:02:13,589 --> 00:02:11,280
the two stereo satellites fly in

54
00:02:15,910 --> 00:02:13,599
relatively close formation but they

55
00:02:18,070 --> 00:02:15,920
won't stay that way for long

56
00:02:20,869 --> 00:02:18,080
i'll show you how in a moment but the

57
00:02:24,229 --> 00:02:20,879
point is navigation out here is harder

58
00:02:26,470 --> 00:02:24,239
than it looks a vehicle can't simply fly

59
00:02:29,830 --> 00:02:26,480
from place to place but for some

60
00:02:31,910 --> 00:02:29,840
missions like stereo precise position

61
00:02:32,869 --> 00:02:31,920
makes all the difference

62
00:02:35,350 --> 00:02:32,879
why

63
00:02:38,070 --> 00:02:35,360

the two stereo satellites will deliver

64
00:02:41,350 --> 00:02:38,080
3d pictures of the sun similar to the

65
00:02:43,190 --> 00:02:41,360
way your two eyes perceive 3d

66
00:02:45,190 --> 00:02:43,200
remember i said to keep an eye on

67
00:02:47,670 --> 00:02:45,200
stereo's flight path

68
00:02:49,589 --> 00:02:47,680
watch as one of the two stereo vehicles

69
00:02:50,550 --> 00:02:49,599
intercepts the moon's orbit a second

70
00:02:52,150 --> 00:02:50,560
time

71
00:02:53,750 --> 00:02:52,160
here it comes

72
00:02:55,990 --> 00:02:53,760
as they close the distance the

73
00:02:58,630 --> 00:02:56,000
spacecraft uses the moon's gravity to

74
00:03:00,869 --> 00:02:58,640
execute a cool maneuver like a roller

75
00:03:03,190 --> 00:03:00,879
coaster zooming up and into a corkscrew

76
00:03:04,869 --> 00:03:03,200
just after hitting a big drop

77
00:03:06,390 --> 00:03:04,879
now the vehicles are headed to their

78
00:03:08,470 --> 00:03:06,400
final orbits

79
00:03:11,190 --> 00:03:08,480
tight loops around the earth loose

80
00:03:13,910 --> 00:03:11,200
orbits out into space bank shots off the

81
00:03:16,710 --> 00:03:13,920
moon there are many ways to travel from

82
00:03:20,309 --> 00:03:16,720
place to place but sometimes travel is

83
00:03:22,470 --> 00:03:20,319
not the goal sometimes it pays to park

84
00:03:25,350 --> 00:03:22,480
welcome to a lagrange point

85
00:03:27,350 --> 00:03:25,360
this one l1 in space speak denotes a

86
00:03:29,589 --> 00:03:27,360
relative position between the earth and

87
00:03:32,550 --> 00:03:29,599
the sun where the gravitational pull of

88
00:03:35,589 --> 00:03:32,560

each object is in approximate balance

89
00:03:37,750 --> 00:03:35,599
these so-called halo orbits around l1

90
00:03:40,070 --> 00:03:37,760
make good places for hovering spacecraft

91
00:03:41,190 --> 00:03:40,080
to take observations of either the earth

92
00:03:42,949 --> 00:03:41,200
or sun

93
00:03:44,550 --> 00:03:42,959
we find a number of observatories

94
00:03:46,710 --> 00:03:44,560
patrolling out here

95
00:03:49,110 --> 00:03:46,720
including an extremely famous and

96
00:03:50,550 --> 00:03:49,120
extremely successful solar observatory

97
00:03:52,949 --> 00:03:50,560
called soho

98
00:03:55,509 --> 00:03:52,959
notice how l1 exists well in front of

99
00:03:58,149 --> 00:03:55,519
the magnetosphere this part of the solar

100
00:03:59,750 --> 00:03:58,159
system is fully bathed in the solar wind

101
00:04:01,190 --> 00:03:59,760
without the protection of earth's

102
00:04:03,429 --> 00:04:01,200
magnetic shield

103
00:04:05,589 --> 00:04:03,439
therefore it's extremely useful for

104
00:04:10,789 --> 00:04:05,599
studying solar activity without

105
00:04:16,069 --> 00:04:13,030
let's briefly revisit the area around

106
00:04:18,710 --> 00:04:16,079
the earth simulated time slows again as

107
00:04:20,870 --> 00:04:18,720
the distance between objects shrinks

108
00:04:23,030 --> 00:04:20,880
but as we once again approach our home

109
00:04:24,550 --> 00:04:23,040
you'll notice the calendar has advanced

110
00:04:26,629 --> 00:04:24,560
two years

111
00:04:29,270 --> 00:04:26,639
new satellites have entered the dance

112
00:04:31,030 --> 00:04:29,280
including the five themis vehicles

113
00:04:33,749 --> 00:04:31,040

the near-earth fleet of satellites

114
00:04:35,990 --> 00:04:33,759
swarms like bees around a hive some

115
00:04:37,990 --> 00:04:36,000
ranging out beyond the magnetosphere

116
00:04:40,310 --> 00:04:38,000
some well inside

117
00:04:42,870 --> 00:04:40,320
it's provocative to consider that all

118
00:04:46,150 --> 00:04:42,880
this activity takes place in space

119
00:04:49,110 --> 00:04:46,160
something we generally perceive as empty

120
00:04:51,590 --> 00:04:49,120
but what we find instead from light to

121
00:04:53,909 --> 00:04:51,600
charged particles to magnetic fields

122
00:04:55,830 --> 00:04:53,919
demonstrates a strange and wonderful

123
00:04:57,990 --> 00:04:55,840
solar vitality

124
00:04:59,830 --> 00:04:58,000
in fact there's a particular scientific

125
00:05:01,350 --> 00:04:59,840
discipline that describes the study of

126
00:05:03,990 --> 00:05:01,360
these things

127
00:05:06,310 --> 00:05:04,000
it's heliophysics from the greek word

128
00:05:08,830 --> 00:05:06,320
for sun combined with the word used to

129
00:05:11,350 --> 00:05:08,840
describe the study of matter and

130
00:05:13,749 --> 00:05:11,360
energy heliophysics studies how the

131
00:05:16,390 --> 00:05:13,759
sun's sphere of influence interacts with

132
00:05:19,350 --> 00:05:16,400
planets and the interstellar medium the

133
00:05:22,790 --> 00:05:19,360
barely tangible stuff that fills what we

134
00:05:25,029 --> 00:05:22,800
typically regard as empty space

135
00:05:26,790 --> 00:05:25,039
almost done but we've got to get moving

136
00:05:29,029 --> 00:05:26,800
if we're going to see the full extent of

137
00:05:31,510 --> 00:05:29,039
the sun's influence

138
00:05:34,469 --> 00:05:31,520

pulling way way back earth's

139
00:05:36,950 --> 00:05:34,479
magnetosphere effectively disappears

140
00:05:39,670 --> 00:05:36,960
almost all of our solar observing fleet

141
00:05:43,189 --> 00:05:39,680
shrinks like boats on the horizon

142
00:05:46,710 --> 00:05:43,199
almost but not all

143
00:05:49,749 --> 00:05:46,720
two legendary spacecraft voyager 1 and 2

144
00:05:51,830 --> 00:05:49,759
are out there still taking measurements

145
00:05:53,670 --> 00:05:51,840
notice the gravity assist bank shots and

146
00:05:57,110 --> 00:05:53,680
their flight paths

147
00:05:59,430 --> 00:05:57,120
launched in 1977 the voyager spacecraft

148
00:06:01,749 --> 00:05:59,440
are the most distant artifacts humanity

149
00:06:05,029 --> 00:06:01,759
has ever cast out into space

150
00:06:07,110 --> 00:06:05,039
time capsules from a small blue planet

151
00:06:09,430 --> 00:06:07,120
they are also the first human objects to

152
00:06:11,670 --> 00:06:09,440
encounter the sun's termination shock

153
00:06:13,430 --> 00:06:11,680
the area where the solar wind slows down

154
00:06:15,430 --> 00:06:13,440
enough to be affected by the flow of

155
00:06:17,110 --> 00:06:15,440
interstellar particles

156
00:06:18,790 --> 00:06:17,120
in a couple of decades one of the

157
00:06:21,189 --> 00:06:18,800
voyager crafts should pass the

158
00:06:23,749 --> 00:06:21,199
heliopause the zone where the sun's

159
00:06:25,270 --> 00:06:23,759
influence meets the interstellar medium

160
00:06:27,830 --> 00:06:25,280
years later it should encounter the

161
00:06:29,990 --> 00:06:27,840
so-called bow shock that's the wake in

162
00:06:31,830 --> 00:06:30,000
flowing interstellar particles as they

163
00:06:34,629 --> 00:06:31,840

move around the bubble of energy and

164
00:06:37,189 --> 00:06:34,639
particles emanating from our star

165
00:06:39,670 --> 00:06:37,199
our star the sun

166
00:06:41,029 --> 00:06:39,680
neither particularly large nor powerful

167
00:06:43,350 --> 00:06:41,039
as stars go

168
00:06:45,670 --> 00:06:43,360
stretches itself out further than even

169
00:06:47,909 --> 00:06:45,680
our most distant probes

170
00:06:50,309 --> 00:06:47,919
as we discover how to coexist with our

171
00:06:53,270 --> 00:06:50,319
own solar dynamo we stretch our