
TDM

1
00:00:00,000 --> 00:00:10,376
Music and sound effects.

2
00:00:14,639 --> 00:00:16,344
atomic clocks are central to

3
00:00:16,379 --> 00:00:18,296
deep space navigation it's

4
00:00:18,331 --> 00:00:19,480
just that those clocks are

5
00:00:19,515 --> 00:00:21,448
on the ground. And so an

6
00:00:21,483 --> 00:00:24,280
atomic clock generates a signal

7
00:00:24,315 --> 00:00:25,689
and it is sent through the

8
00:00:25,724 --> 00:00:27,864
antennae on the ground to a

9
00:00:27,899 --> 00:00:29,672
spacecraft in deep space. And

10
00:00:29,707 --> 00:00:31,769
that signal is turned around

11
00:00:31,804 --> 00:00:33,241
and received back at the

12
00:00:33,276 --> 00:00:34,728
transmitting. And with that

13
00:00:34,763 --> 00:00:37,064

transmission of the signal

14
00:00:37,099 --> 00:00:38,152
we can do measurements of that

15
00:00:38,187 --> 00:00:39,960
signal. You know how the

16
00:00:39,995 --> 00:00:41,593
doppler shift on the signal

17
00:00:41,628 --> 00:00:43,752
is how we can know how fast

18
00:00:43,787 --> 00:00:45,593
the spacecraft is moving and

19
00:00:45,628 --> 00:00:47,112
how long that signal takes

20
00:00:47,147 --> 00:00:48,792
is a measure of how far that

21
00:00:48,827 --> 00:00:51,064
spacecraft is. So the deep

22
00:00:51,099 --> 00:00:52,792
space atomic clock can change

23
00:00:52,827 --> 00:00:54,616
that paradigm. It can originate

24
00:00:54,651 --> 00:00:56,152
the signal at the earth

25
00:00:56,187 --> 00:00:57,480
and it can end at the

26
00:00:57,515 --> 00:00:59,368
spacecraft. Its good enough, that

27
00:00:59,403 --> 00:01:00,840
small clock that we are

28
00:01:00,875 --> 00:01:02,440
building is as stable and

29
00:01:02,475 --> 00:01:04,664
accurate as the ground clock

30
00:01:04,699 --> 00:01:07,465
that originated the signal. We

31
00:01:07,500 --> 00:01:08,985
get to utilize some of the

32
00:01:09,020 --> 00:01:10,455
efficiencies that the deep space

33
00:01:10,490 --> 00:01:11,736
tracking network has to

34
00:01:11,771 --> 00:01:13,368
offer today. The DSN supports

35
00:01:13,403 --> 00:01:16,072
more downlink than it does

36
00:01:16,107 --> 00:01:17,801
uplink and so at places

37
00:01:17,836 --> 00:01:19,640
like Mars where we have a

38
00:01:19,675 --> 00:01:21,096

number of spacecraft that are

39
00:01:21,131 --> 00:01:22,184
competing for two-way tracking

40
00:01:22,219 --> 00:01:23,801
time... you don't have to

41
00:01:23,836 --> 00:01:25,689
do that anymore. What does

42
00:01:25,724 --> 00:01:27,033
that do for us? well what we

43
00:01:27,068 --> 00:01:28,792
have found with a 2 times

44
00:01:28,827 --> 00:01:30,264
improvement in our tracking

45
00:01:30,299 --> 00:01:31,880
data for a Mars orbiter, the

46
00:01:31,915 --> 00:01:33,944
orbit information that we get

47
00:01:33,979 --> 00:01:35,608
is improved upon by a factor

48
00:01:35,643 --> 00:01:38,248
of five. One of the things

49
00:01:38,283 --> 00:01:39,656
we are envisioning at Mars

50
00:01:39,691 --> 00:01:42,457
is landing a pin-point lander,

51
00:01:42,492 --> 00:01:43,960
one that can land to a

52
00:01:43,995 --> 00:01:45,353
very precise location (beep

53
00:01:45,388 --> 00:01:46,855
sounds) on the surface of Mars.

54
00:01:46,890 --> 00:01:48,136
there's a lot of steps into

55
00:01:48,171 --> 00:01:49,464
making that happen. One of

56
00:01:49,499 --> 00:01:51,160
which is entering the top

57
00:01:51,195 --> 00:01:52,521
of the atmosphere and taking

58
00:01:52,556 --> 00:01:54,760
your entry state knowledge

59
00:01:54,795 --> 00:01:56,920
and onboard flying a

60
00:01:56,955 --> 00:01:58,361
trajectory with that entry state

61
00:01:58,396 --> 00:01:59,673
knowledge. We way in which we

62
00:01:59,708 --> 00:02:00,857
upload that navigation state

63
00:02:00,892 --> 00:02:02,329

today is that we do all the

64
00:02:02,364 --> 00:02:03,753
processing on the ground in about

65
00:02:03,788 --> 00:02:05,592
six or so hours and before

66
00:02:05,627 --> 00:02:07,992
entry we upload a final nav state

67
00:02:08,027 --> 00:02:09,880
to the vehicle. Well you can

68
00:02:09,915 --> 00:02:11,833
imagine after six hours of flight

69
00:02:11,868 --> 00:02:13,352
that solutions is little stale

70
00:02:13,387 --> 00:02:14,873
when you get to the top of the

71
00:02:14,908 --> 00:02:16,664
atmosphere. Well with DSAC with

72
00:02:16,699 --> 00:02:18,696
the measurement happening onboard

73
00:02:18,731 --> 00:02:20,839
you don't have to suffer that six

74
00:02:20,874 --> 00:02:22,776
hour delay. You can be computing

75
00:02:22,811 --> 00:02:24,472
onboard in real time. And what

76
00:02:24,507 --> 00:02:26,792
that does is where the six hour

77
00:02:26,827 --> 00:02:30,169
solution is in error by a few

78
00:02:30,204 --> 00:02:32,312
kilometers, this solution that's

79
00:02:32,347 --> 00:02:33,928
onboard is only off by a handful

80
00:02:33,963 --> 00:02:36,073
meters. that has a real benefit

81
00:02:36,108 --> 00:02:37,769
to decreasing the amount of

82
00:02:37,804 --> 00:02:39,848
propellant you have to carry to then

83
00:02:39,883 --> 00:02:41,816
later fly out the errors you had

84
00:02:41,851 --> 00:02:43,897
when you didn't know where you

85
00:02:43,932 --> 00:02:46,248
were at when you originally were

86
00:02:46,283 --> 00:02:47,176
at the top of the atmosphere.So

87
00:02:47,211 --> 00:02:48,440
that's gonna open up new ways,

88
00:02:48,475 --> 00:02:50,104

new science we are going to be

89
00:02:50,139 --> 00:02:51,336
able to do. In fact it's going

90
00:02:51,371 --> 00:02:52,568
to improve the gravity science

91
00:02:52,603 --> 00:02:54,280
we are going to be able to do

92
00:02:54,315 --> 00:02:55,993
at Mars today. An example of

93
00:02:56,028 --> 00:02:58,104
gravity science improvement that

94
00:02:58,139 --> 00:03:00,248
the clock enables further out is

95
00:03:00,283 --> 00:03:03,112
NASA is envisioning going to

96
00:03:03,147 --> 00:03:05,176
Europa; an moon around jupiter. And

97
00:03:05,211 --> 00:03:08,873
to be able to do the measurement,

98
00:03:08,908 --> 00:03:10,824
the gravity science measurement

99
00:03:10,859 --> 00:03:13,849
that NASA is planning. They're

100
00:03:13,884 --> 00:03:15,368
going to do it, one approach

101
00:03:15,403 --> 00:03:18,088
is a flyby mission. So they will

102
00:03:18,123 --> 00:03:19,896
fly by Europa with a four hour

103
00:03:19,931 --> 00:03:21,960
tracking pass, and then have a

104
00:03:21,995 --> 00:03:24,680
thirty day orbit around Europa,

105
00:03:24,715 --> 00:03:25,673
and then come back again for

106
00:03:25,708 --> 00:03:26,889
another flyby. And do a sequence

107
00:03:26,924 --> 00:03:29,753
of thirty or so of these flybys.

108
00:03:29,788 --> 00:03:32,072
Well if we have the atomic clock

109
00:03:32,107 --> 00:03:34,840
on a downlink signal from that

110
00:03:34,875 --> 00:03:36,408
flyby and it's received at the

111
00:03:36,443 --> 00:03:39,385
earth we can do it at Ka band.

112
00:03:39,420 --> 00:03:41,145
and the benefit of going to Ka

113
00:03:41,180 --> 00:03:43,048

band isn't so much that it has

114
00:03:43,083 --> 00:03:44,361
to deal with we can increase the

115
00:03:44,396 --> 00:03:46,473
bandwidth but what it does do

116
00:03:46,508 --> 00:03:48,887
is that it improves the accuracy

117
00:03:48,922 --> 00:03:50,248
of the measurement that we are

118
00:03:50,283 --> 00:03:51,528
taking, and it improves it by an

119
00:03:51,563 --> 00:03:52,920
order of magnitude and that is

120
00:03:52,955 --> 00:03:54,616
fundemental. Its that improvement

121
00:03:54,651 --> 00:03:57,864
in the data quality that will

122
00:03:57,899 --> 00:03:59,689
allow us to determine the gravity

123
00:03:59,724 --> 00:04:03,513
well enough. If decisions need

124
00:04:03,548 --> 00:04:05,400
to be made in real time, the