1
00:00:26,870 --> 00:00:24,870
this desolate landscape haleakala crater

2
00:00:28,230 --> 00:00:26,880
is located on the hawaiian island of

3
00:00:30,310 --> 00:00:28,240
maui

4
00:00:33,270 --> 00:00:30,320
it looks very similar to the distant

5
00:00:36,229 --> 00:00:33,280
pockmarked wastelands of the moon

6
00:00:38,470 --> 00:00:36,239
and it is here at the lower observatory

7
00:00:40,310 --> 00:00:38,480
that nasa and the university of hawaii

8
00:00:42,630 --> 00:00:40,320
are involved in work which helps us

9
00:00:45,430 --> 00:00:42,640
understand the geophysical science of

10
00:00:48,069 --> 00:00:45,440
the moon and the earth

11
00:00:50,790 --> 00:00:48,079
lure observatory situated at the ten

12
00:00:53,350 --> 00:00:50,800
thousand foot summit of mount haleakala

13
00:00:55,910 --> 00:00:53,360

uses laser technology to accurately

14
00:00:58,150 --> 00:00:55,920
range within one inch the two hundred

15
00:00:59,590 --> 00:00:58,160
forty thousand mile distance between the

16
00:01:01,990 --> 00:00:59,600
two bodies

17
00:01:03,910 --> 00:01:02,000
ranging or measuring distance is

18
00:01:06,310 --> 00:01:03,920
accomplished by clocking the time it

19
00:01:09,030 --> 00:01:06,320
takes bursts of laser light to leave the

20
00:01:11,590 --> 00:01:09,040
observatory hit one of four retro

21
00:01:12,870 --> 00:01:11,600
reflectors on the moon and return to the

22
00:01:14,870 --> 00:01:12,880
observatory

23
00:01:17,270 --> 00:01:14,880
by measuring the continually changing

24
00:01:19,590 --> 00:01:17,280
distance between the earth and moon we

25
00:01:22,710 --> 00:01:19,600
are able to unlock many details relating

26
00:01:24,789 --> 00:01:22,720
to the motions of both bodies

27
00:01:27,270 --> 00:01:24,799
analysis of day-to-day changes in the

28
00:01:29,270 --> 00:01:27,280
earth's motion help scientists better

29
00:01:30,870 --> 00:01:29,280
understand the earth's rotation

30
00:01:33,270 --> 00:01:30,880
continental drift

31
00:01:36,069 --> 00:01:33,280
weather phenomena such as the el nino

32
00:01:38,149 --> 00:01:36,079
effect and forces deep within the earth

33
00:01:39,670 --> 00:01:38,159
that set off earthquakes

34
00:01:41,830 --> 00:01:39,680
there are currently two other

35
00:01:44,230 --> 00:01:41,840
observatories located around the world

36
00:01:46,630 --> 00:01:44,240
which also participate in lunar laser

37
00:01:48,469 --> 00:01:46,640
ranging but as yet neither has achieved

38
00:01:49,830 --> 00:01:48,479

the level of precision of the lower

39
00:01:51,830 --> 00:01:49,840
facility

40
00:01:54,310 --> 00:01:51,840
much more will be learned in the future

41
00:01:56,630 --> 00:01:54,320
by interpreting data from many stations

42
00:01:58,870 --> 00:01:56,640
simultaneously

43
00:02:01,510 --> 00:01:58,880
the accuracy of ranging has come a long

44
00:02:03,030 --> 00:02:01,520
way since apollo astronauts armstrong

45
00:02:05,190 --> 00:02:03,040
and aldrin placed the first

46
00:02:07,030 --> 00:02:05,200
retroreflector on the moon

47
00:02:09,190 --> 00:02:07,040
a member of the technical staff at the

48
00:02:13,190 --> 00:02:09,200
jet propulsion laboratory working on

49
00:02:15,589 --> 00:02:13,200
lunar laser ranging is dr skip new hall

50
00:02:17,350 --> 00:02:15,599
the moon reflectors are composed of

51
00:02:18,630 --> 00:02:17,360
array of several dozen or perhaps a few

52
00:02:19,910 --> 00:02:18,640
hundred are these so-called corner

53
00:02:21,670 --> 00:02:19,920
reflectors

54
00:02:22,710 --> 00:02:21,680
and they have a nice feature

55
00:02:24,229 --> 00:02:22,720
that

56
00:02:25,270 --> 00:02:24,239
no matter what direction the light goes

57
00:02:27,430 --> 00:02:25,280
in from

58
00:02:29,910 --> 00:02:27,440
the it always returns out at exactly the

59
00:02:31,430 --> 00:02:29,920
same direction so when we shine a laser

60
00:02:33,830 --> 00:02:31,440
beam at the moon no matter how it's

61
00:02:37,509 --> 00:02:33,840
oriented locally the light comes right

62
00:02:39,990 --> 00:02:37,519
back out when the apollo

63
00:02:42,790 --> 00:02:40,000

astronauts first put the reflectives on

64
00:02:46,470 --> 00:02:42,800
the moon we got some returns back in

65
00:02:49,830 --> 00:02:46,480
early 1970 and late 1969

66
00:02:51,190 --> 00:02:49,840
the uncertainty in the return time was

67
00:02:53,910 --> 00:02:51,200
about

68
00:02:56,390 --> 00:02:53,920
equivalent of a distance of 150 to 200

69
00:02:58,630 --> 00:02:56,400
meters that's around 600 feet

70
00:03:01,270 --> 00:02:58,640
we have refined the time equipment the

71
00:03:03,509 --> 00:03:01,280
lasers and the other associated

72
00:03:04,630 --> 00:03:03,519
electronic equipment that supports this

73
00:03:06,309 --> 00:03:04,640
so now

74
00:03:08,149 --> 00:03:06,319
we have the uncertainties and distance

75
00:03:09,190 --> 00:03:08,159
are equal to about three quarters of an

76
00:03:11,670 --> 00:03:09,200
inch

77
00:03:14,070 --> 00:03:11,680
which is an amazing improvement

78
00:03:15,990 --> 00:03:14,080
the key to the lunar ranging operation

79
00:03:18,710 --> 00:03:16,000
is a laser that can be adjusted to

80
00:03:19,670 --> 00:03:18,720
create intense billion watt pulses of

81
00:03:23,190 --> 00:03:19,680
energy

82
00:03:25,350 --> 00:03:23,200
and back

83
00:03:27,990 --> 00:03:25,360
the light energy is channeled out of the

84
00:03:30,149 --> 00:03:28,000
observatory by this mirrored instrument

85
00:03:31,910 --> 00:03:30,159
which keeps the laser beam continually

86
00:03:34,390 --> 00:03:31,920
locked on target with the retro

87
00:03:36,149 --> 00:03:34,400
reflectors on the moon

88
00:03:38,550 --> 00:03:36,159

meanwhile in the observatory's main

89
00:03:41,110 --> 00:03:38,560
control room the receiving telescope

90
00:03:43,270 --> 00:03:41,120
which is composed of 80 lenses is

91
00:03:46,229 --> 00:03:43,280
adjusted to line up visually with the

92
00:03:47,910 --> 00:03:46,239
moon's apollo 15 retro reflector near

93
00:03:50,149 --> 00:03:47,920
hadley real

94
00:03:51,990 --> 00:03:50,159
the giant telescope acts as a collector

95
00:03:54,710 --> 00:03:52,000
for the particles of laser light that

96
00:03:56,229 --> 00:03:54,720
make the trip back to the observatory

97
00:03:58,309 --> 00:03:56,239
the time it takes for the light

98
00:04:01,190 --> 00:03:58,319
particles to reach the telescope is

99
00:04:03,350 --> 00:04:01,200
calculated and fed into data banks

100
00:04:05,670 --> 00:04:03,360
the information returned is analyzed

101
00:04:07,589 --> 00:04:05,680
regularly by a group of scientists at

102
00:04:09,429 --> 00:04:07,599
nasa's jet propulsion laboratory in

103
00:04:11,509 --> 00:04:09,439
pasadena california

104
00:04:14,390 --> 00:04:11,519
again dr skip newhall

105
00:04:18,150 --> 00:04:14,400
we have now a means of measuring

106
00:04:20,550 --> 00:04:18,160
earth and lunar phenomena geophysical

107
00:04:22,950 --> 00:04:20,560
body-oriented science phenomena that

108
00:04:24,469 --> 00:04:22,960
were not available by any means before

109
00:04:26,870 --> 00:04:24,479
this is the only way we can measure

110
00:04:28,790 --> 00:04:26,880
particularly connected with the moon

111
00:04:31,189 --> 00:04:28,800
lunar laser ranging

112
00:04:33,590 --> 00:04:31,199
helping scientists to learn more about