
SATURN
NEPTUNE
BEYOND THE PLANETS

1
00:00:01,001 --> 00:00:03,202
It's 1990 and we just got
the first images back

2
00:00:03,202 --> 00:00:04,303
from the Hubble Telescope.

3
00:00:04,303 --> 00:00:05,371
But, there's a big problem;

4
00:00:05,371 --> 00:00:07,207
the pictures are out of focus.

5
00:00:07,240 --> 00:00:08,608
How do you solve that?

6
00:00:08,608 --> 00:00:10,910
Well first of all, you're
gonna need one of these.

7
00:00:10,910 --> 00:00:13,179
That's the space shuttle
Endeavour and it was used

8
00:00:13,179 --> 00:00:15,848
in one of the greatest
engineering fixes in history.

9
00:00:15,848 --> 00:00:16,816
We'll talk all about that

10
00:00:16,850 --> 00:00:19,285
on this episode
of Crazy Engineering.

11
00:00:19,285 --> 00:00:27,393
[Music Open]

12

00:00:27,393 --> 00:00:29,662
The Hubble telescope is composed
of several different

13
00:00:29,662 --> 00:00:31,831
instruments, and outside of
those is something called the

14
00:00:31,864 --> 00:00:34,300
primary mirror, where all
the light bounces off of

15
00:00:34,300 --> 00:00:37,737
and goes into the instruments --
that's where the flaw was.

16
00:00:37,770 --> 00:00:41,540
So, the problem was something
called a spherical aberration.

17
00:00:41,540 --> 00:00:42,608
What exactly does that mean?

18
00:00:42,608 --> 00:00:45,678
It means the primary mirror
had the wrong shape.

19
00:00:45,678 --> 00:00:48,180
That is, it's a shallow
bowl, effectively,

20
00:00:48,214 --> 00:00:49,848
that brings light to a focus.

21
00:00:49,882 --> 00:00:51,184
It's a little too shallow.

22
00:00:51,217 --> 00:00:54,453
It rendered the telescope
fundamentally unfocusable.

23
00:00:54,453 --> 00:00:56,523
So, it was a little bit out of
tolerance in that primary mirror

24
00:00:56,556 --> 00:00:58,725
and it was effecting all the
instruments in Hubble?

25
00:00:58,758 --> 00:01:00,760
All five scientific instruments
on the Hubble

26
00:01:00,794 --> 00:01:03,896
depend on a sharp image.
That's the whole point.

27
00:01:03,930 --> 00:01:06,399
Meacham: So, Hubble is sitting
doctor's chair and

28
00:01:06,432 --> 00:01:08,134
it has the eye chart
in front of it

29
00:01:08,167 --> 00:01:09,668
and instead of the letter E
it sees the letter F.

30
00:01:09,702 --> 00:01:12,438
Trauger: Worse! What it sees
looks like a squashed spider.

31
00:01:12,472 --> 00:01:13,907
Meacham: But it's
way up in space,

32
00:01:13,940 --> 00:01:16,108
and you can't get it back here,
so how do you fix it?

33
00:01:16,141 --> 00:01:19,378
Well, if you're born with
eyeballs that don't quite work,

34
00:01:19,412 --> 00:01:21,180
you don't go and
buy new eyeballs,

35
00:01:21,214 --> 00:01:23,116
you buy a pair of glasses.

36
00:01:23,149 --> 00:01:24,350
And that's the approach
that we took.

37
00:01:24,350 --> 00:01:26,218
Meacham: The Wide Field
and Planetary Camera,

38
00:01:26,218 --> 00:01:27,186
known as WFPC,

39
00:01:27,219 --> 00:01:28,955
relied on light from
the primary mirror.

40
00:01:28,988 --> 00:01:31,624
Trauger: The light from
that primary mirror

41
00:01:31,657 --> 00:01:35,762
all comes down to a focus
inside our camera

42
00:01:35,762 --> 00:01:37,463
on a mirror that
looks just like this.

43

00:01:37,496 --> 00:01:40,432
And, this is now an opportunity
for us to correct the curvature,

44
00:01:40,466 --> 00:01:43,903
the shape of the primary
mirror right here.

45
00:01:43,936 --> 00:01:48,141
We simply put the same error in,
reversed, and correct it.

46
00:01:48,174 --> 00:01:51,610
The Hubble Telescope was
designed from the outset

47
00:01:51,644 --> 00:01:53,980
to be serviced every three
years by astronauts.

48
00:01:54,013 --> 00:01:56,615
[Astronaut talking]

49
00:01:56,615 --> 00:01:59,819
Trauger: The camera is designed
to be replaced in space.

50
00:01:59,852 --> 00:02:01,354
That's the one thing
that was really

51
00:02:01,387 --> 00:02:04,857
just waiting for us to
take advantage of.

52
00:02:04,890 --> 00:02:08,094
[Astronauts talking]

53
00:02:08,127 --> 00:02:10,496
So, what was the outcome?

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00:02:10,529 --> 00:02:12,598
Trauger: At the Space
Telescope Science Institute,

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00:02:12,631 --> 00:02:15,101
way down in the basement, there
were a bunch of us watching.

56
00:02:15,134 --> 00:02:18,237
And the first image, which
was a star, looked good.

57
00:02:18,270 --> 00:02:22,041
So, we knew right away that we
had a fix and everything that

58
00:02:22,074 --> 00:02:24,811
Hubble was suppose to do
was now going to happen.

59
00:02:24,844 --> 00:02:28,013
Meacham: I think I speak for
everyone when I just say thanks

60
00:02:28,047 --> 00:02:29,581
to you and your team
for all the hard work

61
00:02:29,615 --> 00:02:30,850
you put in fixing Hubble.

62
00:02:30,883 --> 00:02:32,852
Because now we have these
images really forever

63
00:02:32,885 --> 00:02:35,588
that we can appreciate.

64

00:02:35,588 --> 00:02:44,564
[Music]

65
00:02:44,564 --> 00:02:46,799
WFPC2 went on to become
the workhorse for the

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00:02:46,799 --> 00:02:49,335
Hubble telescope and it lasted
for more than 15 years.

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00:02:49,368 --> 00:02:50,736
Well, now you guys
can check it out

68
00:02:50,769 --> 00:02:53,572
at the National Air and Space
Museum in Washington D.C.,

69
00:02:53,606 --> 00:02:54,874
and we'll see all of you