

NASA'S INCREDIBLE DISCOVERY MACHINE:



THE STORY OF
THE HUBBLE SPACE TELESCOPE

1
00:00:00,000 --> 00:00:01,900



2
00:00:01,900 --> 00:00:04,500

-It has this direct window to the rest of the universe.

3
00:00:04,500 --> 00:00:06,100

There's nothing in between

4
00:00:06,100 --> 00:00:07,400

the rest of the universe and Hubble.

5
00:00:07,400 --> 00:00:09,900

I mean, there's not a single astronomer in the world

6
00:00:09,900 --> 00:00:12,000

whose life hasn't been touched by Hubble.

7
00:00:12,000 --> 00:00:13,900

-Hubble will be one of the great stories

8
00:00:13,900 --> 00:00:15,300

of all time.

9
00:00:15,300 --> 00:00:17,600

We will remember it with reverence,

10
00:00:17,600 --> 00:00:20,000

with the legacy, with the foundation.

11
00:00:20,000 --> 00:00:21,700

It gave us the optimism and the hope

12
00:00:21,700 --> 00:00:23,900

to reach for bigger things.

13
00:00:23,900 --> 00:00:26,700

-The world's most brilliant astronomers

14

00:00:26,700 --> 00:00:29,400

do miracles with this observatory,

15

00:00:29,400 --> 00:00:31,400

and it just keeps going on and on and on,

16

00:00:31,400 --> 00:00:33,600

and my jaw keeps dropping lower and lower

17

00:00:33,600 --> 00:00:35,300

with each new discovery.

18

00:00:35,300 --> 00:00:37,600

-Scientists around the world

19

00:00:37,600 --> 00:00:40,700

together with science enthusiasts, the public,

20

00:00:40,700 --> 00:00:43,400

science supporters came together to see.

21

00:00:43,400 --> 00:00:45,500

Here is an opportunity where,

22

00:00:45,500 --> 00:00:48,600

if we put our wits together and our support together,

23

00:00:48,600 --> 00:00:50,300

we can build a platform

24

00:00:50,300 --> 00:00:53,000

that opens new eyes to the universe.

25

00:00:53,000 --> 00:00:54,500

Let's go for it.

26

00:01:05,900 --> 00:01:09,000

-Earthbound telescopes, from Galileo's simple instrument

27

00:01:09,000 --> 00:01:11,300

to modern mountaintop observatories,

28

00:01:11,300 --> 00:01:13,000

are all hampered by the Earth's

29

00:01:13,000 --> 00:01:15,200

turbulent atmosphere.

30

00:01:15,200 --> 00:01:17,100

The best place for an observatory

31

00:01:17,100 --> 00:01:19,200

is in the heavens.

32

00:01:19,200 --> 00:01:20,800

Now, the Space Shuttle

33

00:01:20,800 --> 00:01:23,700

created by NASA, America's space agency,

34

00:01:23,700 --> 00:01:26,300

has the ability to put one there.

35

00:01:26,300 --> 00:01:28,700

-The periodic revisit of the shuttle

36

00:01:28,700 --> 00:01:30,900

will allow for the replacement of components

37

00:01:30,900 --> 00:01:33,200

and routine maintenance.

38

00:01:33,200 --> 00:01:36,700

This ability to service the telescope through human care

39

00:01:36,700 --> 00:01:38,400

will extend its life span

40

00:01:38,400 --> 00:01:41,100

up to 20 years.

41

00:01:41,100 --> 00:01:43,500

-Telescopes on brief rocket flights

42

00:01:43,500 --> 00:01:48,600

have brought us hints of entities we never knew existed,

43

00:01:48,600 --> 00:01:50,900

and balloon flights have lifted telescopes

44

00:01:50,900 --> 00:01:52,800

8 miles into the air

45

00:01:52,800 --> 00:01:54,700

to take some of the clearest photographs

46

00:01:54,700 --> 00:01:56,600

of the Sun ever obtained.

47

00:01:56,600 --> 00:01:59,500

-Another group of astronomers told a recent meeting

48

00:01:59,500 --> 00:02:03,900

of the American Rocket Society in San Diego, California,

49

00:02:03,900 --> 00:02:06,400

that they are designing a satellite that will

50

00:02:06,400 --> 00:02:10,600

carry a bank of telescopes into an orbit 500 miles,

51

00:02:10,600 --> 00:02:13,600

or 800 kilometers, high.

52

00:02:13,600 --> 00:02:17,900

By thus sending a telescope up above the Earth's atmosphere,

53

00:02:17,900 --> 00:02:21,100

they hope to pierce a blanketing ocean of air

54

00:02:21,100 --> 00:02:22,800

that has, for the most part,

55

00:02:22,800 --> 00:02:26,500

obscured man's detailed view of the universe.

56

00:02:44,500 --> 00:02:35,500

■■■

57

00:02:44,500 --> 00:02:48,700

-Well, astronomers have wanted for generations, actually,

58

00:02:48,700 --> 00:02:50,200

to get us a telescope

59

00:02:50,200 --> 00:02:52,100

above the atmosphere.

60

00:02:52,100 --> 00:02:56,700

The first reference I'm aware of is back in 1925,

61

00:02:56,700 --> 00:03:01,000

that it was suggested that we needed a telescope in space.

62

00:03:01,000 --> 00:03:04,700

I've read that one of the astronomers at Princeton --

63

00:03:04,700 --> 00:03:08,300

this was probably in the '30s or '40s --

64

00:03:08,300 --> 00:03:11,000

said that when he died,

65

00:03:11,000 --> 00:03:14,500

he wanted to go to heaven and take a telescope with him,

66

00:03:14,500 --> 00:03:17,300

and so when the possibly

67

00:03:17,300 --> 00:03:20,000

of a telescope in space opened up,

68

00:03:20,000 --> 00:03:22,600

astronomers jumped on the idea.

69

00:03:22,600 --> 00:03:26,600

-[Operatic singing]

70

00:03:57,700 --> 00:03:34,300

■■■

71

00:03:57,700 --> 00:03:59,200

-I certainly remember the very first time

72

00:03:59,200 --> 00:04:01,900

I went into the enormous clean room

73

00:04:01,900 --> 00:04:03,100

where Hubble was being built.

74

00:04:03,100 --> 00:04:06,700

I mean, it's 90 feet tall and 120 feet long

75

00:04:06,700 --> 00:04:10,100

and hyper-clean -- hyper-clean air.

76

00:04:10,100 --> 00:04:11,600

And the telescope just --

77

00:04:11,600 --> 00:04:13,900

I mean, it just looked like something Tiffany's had built.

78

00:04:13,900 --> 00:04:15,500

You sort of...

79

00:04:15,500 --> 00:04:17,300

were gonna look for the label somewhere

80

00:04:17,300 --> 00:04:18,700

that said, "Telescope by Tiffany's,"

81

00:04:18,700 --> 00:04:20,600

just glistening silver,

82

00:04:20,600 --> 00:04:24,900

fabulous, gorgeous piece of work -- huge.

83

00:04:24,900 --> 00:04:26,800

So, that's one real favorite memory.

84

00:04:26,800 --> 00:04:30,000

First sights always leave a deeper impression.

85

00:04:30,000 --> 00:04:31,400

-It was mind-boggling.

86

00:04:31,400 --> 00:04:34,000

I envisioned Hubble being big.

87

00:04:34,000 --> 00:04:37,000

I did not envision Hubble being huge,

88

00:04:37,000 --> 00:04:39,900

and Hubble was huge.

89
00:04:39,900 --> 00:04:42,000
Since I had already flown a shuttle mission,

90
00:04:42,000 --> 00:04:43,500
I knew how big the shuttle was,

91
00:04:43,500 --> 00:04:46,700
and I knew how big the shuttle's payload bay was.

92
00:04:46,700 --> 00:04:48,200
Hubble was too big,

93
00:04:48,200 --> 00:04:51,000
and, I mean, the first impression was,

94
00:04:51,000 --> 00:04:53,600
"How the hell are they gonna fit that in the payload bay?

95
00:04:53,600 --> 00:04:56,100
That is a monstrous payload."

96
00:04:56,100 --> 00:04:59,300
-What was happening in the context of science here?

97
00:04:59,300 --> 00:05:00,900
We were building an Earth-observing system

98
00:05:00,900 --> 00:05:02,200
to study our planet --

99
00:05:02,200 --> 00:05:04,700
very evocative, ozone holes being measured.

100
00:05:04,700 --> 00:05:06,100
Studying the Sun.

101

00:05:06,100 --> 00:05:08,000

We had had a couple of missions to Mars

102

00:05:08,000 --> 00:05:11,600

that showed us it's not the way we thought it was -- tough.

103

00:05:11,600 --> 00:05:13,700

Soviets had landed probes on Venus for about an hour.

104

00:05:13,700 --> 00:05:15,300

Pretty hellish.

105

00:05:15,300 --> 00:05:16,800

We had the Voyagers going out of the solar system,

106

00:05:16,800 --> 00:05:17,800

and that's it.

107

00:05:17,800 --> 00:05:19,500

That was our view --

108

00:05:19,500 --> 00:05:21,700

a few little points of light flying around,

109

00:05:21,700 --> 00:05:22,900

but they were narrow.

110

00:05:22,900 --> 00:05:24,700

Hubble was focused

111

00:05:24,700 --> 00:05:25,800

on the big picture,

112

00:05:25,800 --> 00:05:27,500

and the big picture is always fun.

113

00:05:27,500 --> 00:05:29,200

It has something for everyone.

114

00:05:29,200 --> 00:05:32,000

Some people call these great missions of exploration.

115

00:05:32,000 --> 00:05:33,100

They're kind of like

116

00:05:33,100 --> 00:05:36,400

the cathedrals of the 21st century,

117

00:05:36,400 --> 00:05:38,200

and in the Renaissance,

118

00:05:38,200 --> 00:05:40,300

people built cathedrals that were multigenerational.

119

00:05:40,300 --> 00:05:42,800

They were great architectural renderings

120

00:05:42,800 --> 00:05:44,000

that reached to the heavens.

121

00:05:44,000 --> 00:05:45,700

Now, we go to the heavens,

122

00:05:45,700 --> 00:05:47,900

and we follow the light.

123

00:05:47,900 --> 00:05:49,400

-I remember sitting

124

00:05:49,400 --> 00:05:51,500

around the dinner table the night before,

125

00:05:51,500 --> 00:05:55,400

and we had talked off and on about what was Hubble gonna --

126

00:05:55,400 --> 00:05:57,500

what was going to be the significance of Hubble,

127

00:05:57,500 --> 00:05:59,200

talking about what we thought

128

00:05:59,200 --> 00:06:00,900

Hubble's legacy was going to be and stuff.

129

00:06:00,900 --> 00:06:03,400

I mean, things you can't imagine.

130

00:06:03,400 --> 00:06:05,900

None of us could definitively say

131

00:06:05,900 --> 00:06:07,000

what we thought it was going to be,

132

00:06:07,000 --> 00:06:09,200

but all of us agreed Hubble was going to be

133

00:06:09,200 --> 00:06:11,700

something absolutely spectacular

134

00:06:11,700 --> 00:06:14,800

that was going to revolutionize

135

00:06:14,800 --> 00:06:16,700

the worlds of astronomy and astrophysics.

136

00:06:16,700 --> 00:06:21,400

We just didn't know how, and I think we underestimated

137

00:06:21,400 --> 00:06:24,600

the scientific and technological significance of Hubble,

138

00:06:24,600 --> 00:06:25,700

because it has dwarfed

139

00:06:25,700 --> 00:06:27,400

what any of us imagined

140

00:06:27,400 --> 00:06:28,800

it would ever do.

141

00:06:32,600 --> 00:06:35,500

-T-minus 13 seconds.

142

00:06:35,500 --> 00:06:36,600

-10. -T minus 10.

143

00:06:36,600 --> 00:06:38,300

Go for main engine start.

144

00:06:38,300 --> 00:06:40,200

We are go for main engine start.

145

00:06:40,200 --> 00:06:46,000

T-minus six, five, four, three, two, one,

146

00:06:46,000 --> 00:06:48,600

and lift off of the Space Shuttle Discovery

147

00:06:48,600 --> 00:06:50,400

with the Hubble Space Telescope,

148

00:06:50,400 --> 00:06:52,900

our window on the universe.

149

00:06:57,700 --> 00:06:59,400

-Discovery, Houston just wanted to let us know

150

00:06:59,400 --> 00:07:01,900

that the ground is currently configured

151
00:07:01,900 --> 00:07:04,400
for HST main bus activation.

152
00:07:04,400 --> 00:07:07,100
So, we're ready when you are.

153
00:07:07,100 --> 00:07:09,900
-Houston, Discovery.

154
00:07:09,900 --> 00:07:12,800
The transfer to internal power is complete.

155
00:07:12,800 --> 00:07:16,100
The umbilical is dead-faced, and we'll be standing by

156
00:07:16,100 --> 00:07:19,000
for your go for umbilical release.

157
00:07:21,700 --> 00:07:23,200
-Roger, Discovery.

158
00:07:25,900 --> 00:07:29,800
Discovery, you're go for umbilical disconnect.

159
00:07:29,800 --> 00:07:35,700
■■■

160
00:07:35,700 --> 00:07:38,000
-The Hubble deploy day did not go well.

161
00:07:38,000 --> 00:07:39,900
You know, in the end,

162
00:07:39,900 --> 00:07:41,600
we successfully deployed Hubble,

163
00:07:41,600 --> 00:07:44,700

and Hubble went on to greater things.

164

00:07:44,700 --> 00:07:47,600

Deploy day was long and arduous

165

00:07:47,600 --> 00:07:50,300

and nothing at all the way it was planned.

166

00:07:50,300 --> 00:07:53,000

From the moment Steve Hawley attached

167

00:07:53,000 --> 00:07:56,000

the RMS mechanical arm,

168

00:07:56,000 --> 00:07:57,400

things went wrong.

169

00:07:57,400 --> 00:07:59,500

Steve was supposed to be able to just pull out

170

00:07:59,500 --> 00:08:02,700

on the translational hand controller

171

00:08:02,700 --> 00:08:06,500

and have the arm lift Hubble straight out of the payload bay.

172

00:08:06,500 --> 00:08:07,700

That's not what happened.

173

00:08:07,700 --> 00:08:11,000

I mean, the Hubble's 25,000 pounds of mass.

174

00:08:11,000 --> 00:08:12,400

Granted, it's weightless in space,

175

00:08:12,400 --> 00:08:15,000

but it's still a 25,000-pound mass,

176

00:08:15,000 --> 00:08:16,400

and as he began to lift,

177

00:08:16,400 --> 00:08:19,300

it began to twist and turn,

178

00:08:19,300 --> 00:08:21,200

and we saw it immediately,

179

00:08:21,200 --> 00:08:22,900

and so I said, "Steve, stop.

180

00:08:22,900 --> 00:08:25,000

That's -- Something is not right."

181

00:08:25,000 --> 00:08:30,100

And so that necessitated Steve now going to a downgraded mode

182

00:08:30,100 --> 00:08:33,000

which was moving joint by joint,

183

00:08:33,000 --> 00:08:35,300

so for the next couple of hours,

184

00:08:35,300 --> 00:08:38,800

Steve Hawley literally had to lift a little bit,

185

00:08:38,800 --> 00:08:40,400

re-adjust a joint,

186

00:08:40,400 --> 00:08:42,600

get it straight again, lift a little bit,

187

00:08:42,600 --> 00:08:46,700

re-adjust a joint or roll it or do whatever was necessary

188

00:08:46,700 --> 00:08:52,000

to keep it as much in its orientation

189

00:08:52,000 --> 00:08:53,600

as it was in the bay as possible,

190

00:08:53,600 --> 00:08:55,700

but that took hours instead of minutes,

191

00:08:55,700 --> 00:08:57,000

the way it was supposed to work.

192

00:08:57,000 --> 00:08:59,600

-The thing about Hubble was, you know,

193

00:08:59,600 --> 00:09:01,800

we launched it cradled in the payload bay

194

00:09:01,800 --> 00:09:05,200

with electrical power umbilicals attached to the back,

195

00:09:05,200 --> 00:09:08,500

and once you pulled the plug on that umbilical,

196

00:09:08,500 --> 00:09:10,300

Hubble was on its batteries,

197

00:09:10,300 --> 00:09:11,800

and there was a fixed period of time,

198

00:09:11,800 --> 00:09:13,200

a maximum period of time

199

00:09:13,200 --> 00:09:15,400

that you could run it on its batteries

200

00:09:15,400 --> 00:09:18,200

without the solar rays being unfolded to sustain

201

00:09:18,200 --> 00:09:19,600

and recharge the batteries.

202

00:09:19,600 --> 00:09:21,100

If you got to the end of that time,

203

00:09:21,100 --> 00:09:22,900

the batteries would reach a point

204

00:09:22,900 --> 00:09:24,500

where they were not recoverable.

205

00:09:24,500 --> 00:09:26,500

So, that set a -- I forget now how long it was --

206

00:09:26,500 --> 00:09:28,500

something on the order of four hours.

207

00:09:28,500 --> 00:09:30,700

Well, if anything needs an EVA backup --

208

00:09:30,700 --> 00:09:32,200

And we could back up all that stuff.

209

00:09:32,200 --> 00:09:35,500

We could crank open the solar arrays.

210

00:09:35,500 --> 00:09:37,700

-And as the crew just confirmed there,

211

00:09:37,700 --> 00:09:40,200

we're seeing both blankets

212

00:09:40,200 --> 00:09:41,900

beginning to unfurl

213

00:09:41,900 --> 00:09:45,000

on the portside solar array.

214

00:09:45,000 --> 00:09:47,100



215

00:09:47,100 --> 00:09:50,400

-So far, we see good, smooth motion on both sides.

216

00:09:50,400 --> 00:09:53,100

-So the first solar array...

217

00:09:53,100 --> 00:09:55,500

you know, went out both sides, no problem.

218

00:09:55,500 --> 00:09:56,700

It took a few minutes.

219

00:09:56,700 --> 00:09:58,900

Everything was just like it should be.

220

00:09:58,900 --> 00:10:02,300

Second solar array, sent the command.

221

00:10:02,300 --> 00:10:06,300

It got about, I don't know, 16 inches and quit.

222

00:10:06,300 --> 00:10:07,600

-Houston, Discovery.

223

00:10:07,600 --> 00:10:09,000

It looks like motion's stopped

224

00:10:09,000 --> 00:10:13,300

with just about one panel showing.

225

00:10:13,300 --> 00:10:15,400

-And we see that, too, Loren.

226

00:10:15,400 --> 00:10:17,500

The DCE is off.

227

00:10:17,500 --> 00:10:19,000

-And as it turned out, of course,

228

00:10:19,000 --> 00:10:22,500

the second solar array did not unfurl correctly.

229

00:10:22,500 --> 00:10:24,000

It jammed partway out,

230

00:10:24,000 --> 00:10:26,900

and Bruce and I left the flight deck

231

00:10:26,900 --> 00:10:28,300

and dove down into the mid-deck

232

00:10:28,300 --> 00:10:29,700

with Charlie Bolden and suited up,

233

00:10:29,700 --> 00:10:31,700

and we were all buttoned up.

234

00:10:31,700 --> 00:10:33,100

The air lock was sealed.

235

00:10:33,100 --> 00:10:35,200

In fact, we had dumped half the air out of the air lock.

236

00:10:35,200 --> 00:10:40,300

We were about to get the go for EVA and proceed on outside.

237

00:10:40,300 --> 00:10:43,000

-The other thing I need an answer to is,

238

00:10:43,000 --> 00:10:45,800

if I can go ahead and commit to EVA

239

00:10:45,800 --> 00:10:48,900

with the thought of going out and cranking it out --

240

00:10:48,900 --> 00:10:50,800

if whatever they're about to do fails,

241

00:10:50,800 --> 00:10:53,400

but they want us to just press on to back them up.

242

00:10:53,400 --> 00:10:57,200

We need to get on with it.

243

00:10:57,200 --> 00:10:59,000

-I'll come back with answers.

244

00:10:59,000 --> 00:11:02,300

-I need answers now.

245

00:11:02,300 --> 00:11:04,100

-Planet fail. -Go ahead.

246

00:11:04,100 --> 00:11:06,400

-Yeah, I don't feel comfortable waiting until after 620.

247

00:11:06,400 --> 00:11:08,400

-I don't either. That's why I want the answers now.

248

00:11:08,400 --> 00:11:12,500

-Yeah, 620's my drop-dead time from adding up all the times.

249

00:11:12,500 --> 00:11:13,700

-Okay.

250

00:11:13,700 --> 00:11:16,500

I'm gonna have them press on. Alright.

251
00:11:16,500 --> 00:11:21,000
CAPCOM, tell the crew we want them to press on into EVA,

252
00:11:21,000 --> 00:11:23,300
and we'll stop them whenever we have to.

253
00:11:23,300 --> 00:11:26,200
So, quickly -- We've got four minutes on this pass.

254
00:11:26,200 --> 00:11:29,400

■■

255
00:11:29,400 --> 00:11:32,200
-Discovery, Houston.

256
00:11:32,200 --> 00:11:33,700
-Discovery. Go ahead.

257
00:11:35,800 --> 00:11:39,300
-Okay. With the panels that you've got out there right now,

258
00:11:39,300 --> 00:11:42,200
it's not satisfactory to stay overnight,

259
00:11:42,200 --> 00:11:45,400
so we're gonna have to move out on the EVA.

260
00:11:45,400 --> 00:11:48,300

■■

261
00:11:48,300 --> 00:11:49,800
-I was scared.

262
00:11:49,800 --> 00:11:54,800
I had never suited anybody who was gonna go out in space,

263
00:11:54,800 --> 00:11:58,700

and I knew that if I missed something --

264

00:11:58,700 --> 00:12:00,800

if I missed a glove, you know,

265

00:12:00,800 --> 00:12:02,500

if I didn't get it fastened right,

266

00:12:02,500 --> 00:12:06,100

or something on the helmet, they were going to die,

267

00:12:06,100 --> 00:12:07,700

and it was going to be my fault.

268

00:12:07,700 --> 00:12:10,600

So, even though these guys come out of combat

269

00:12:10,600 --> 00:12:11,900

and all other kinds of stuff,

270

00:12:11,900 --> 00:12:15,800

I was scared because I had never done this before,

271

00:12:15,800 --> 00:12:19,300

and so, you know, I knew my crew members were dependent on me,

272

00:12:19,300 --> 00:12:23,000

and we were getting ready to let them open the outer hatch

273

00:12:23,000 --> 00:12:25,000

when the ground said, "Hey, stop!"

274

00:12:25,000 --> 00:12:27,300

And we said, "Oh, okay."

275

00:12:27,300 --> 00:12:29,700

They said, "We got an idea."

276

00:12:29,700 --> 00:12:31,600

-We think there may be some problem

277

00:12:31,600 --> 00:12:34,800

with the tension-monitoring software.

278

00:12:34,800 --> 00:12:36,400

We've got the DCE back on.

279

00:12:36,400 --> 00:12:39,200

We're going to disable the tension monitoring

280

00:12:39,200 --> 00:12:44,300

and resend the proc to deploy the minus SDM.

281

00:12:44,300 --> 00:12:46,700

-Okay. Hit it.

282

00:12:46,700 --> 00:12:50,600

-And the irony -- This is the day of irony.

283

00:12:50,600 --> 00:12:55,700

Early in the morning when the solar array first stopped,

284

00:12:55,700 --> 00:12:57,800

Bruce came up with this crazy --

285

00:12:57,800 --> 00:13:00,000

Bruce McCandless said,

286

00:13:00,000 --> 00:13:02,200

"I don't think there's anything mechanically wrong.

287

00:13:02,200 --> 00:13:05,900

I think it's the tension-monitoring module,"

288

00:13:05,900 --> 00:13:09,400

and we all looked at Bruce and went, "The what?!"

289

00:13:09,400 --> 00:13:10,600

Everybody but Kathy.

290

00:13:10,600 --> 00:13:13,200

Kathy had heard of the tension-monitoring module,

291

00:13:13,200 --> 00:13:15,700

and so Bruce said, "Oh, it's this software module

292

00:13:15,700 --> 00:13:18,800

that we put in to protect the solar array.

293

00:13:18,800 --> 00:13:21,600

In case we got a mechanical jam or something,

294

00:13:21,600 --> 00:13:23,900

we didn't want to rip it and destroy the telescope,

295

00:13:23,900 --> 00:13:26,800

so we have this software module that would stop it

296

00:13:26,800 --> 00:13:29,300

until we could diagnose the problem and then correct it

297

00:13:29,300 --> 00:13:32,100

and then let it go out."

298

00:13:32,100 --> 00:13:33,700

This young man down here, at Goddard --

299

00:13:33,700 --> 00:13:36,100

and I say young man because, as I understand it,

300

00:13:36,100 --> 00:13:40,500

he was a very young flight controller on console --

301
00:13:40,500 --> 00:13:43,700
said, "Hey, I don't think we've got a mechanical problem.

302
00:13:43,700 --> 00:13:46,300
I really think it's the tension-monitoring module,

303
00:13:46,300 --> 00:13:50,400
and if you give me permission,

304
00:13:50,400 --> 00:13:52,700
I can no op the tension-monitoring module.

305
00:13:52,700 --> 00:13:53,800
I can turn it off."

306
00:13:53,800 --> 00:13:55,900
You know, "I'll make a one a zero,

307
00:13:55,900 --> 00:13:57,900
and I think everything will be okay."

308
00:13:57,900 --> 00:14:01,900
So, between Houston and Goddard and I think Bristol, England,

309
00:14:01,900 --> 00:14:03,500
and everywhere else in the world

310
00:14:03,500 --> 00:14:04,500
that had anything to do with Hubble,

311
00:14:04,500 --> 00:14:08,200
they meshed on this thing for hours,

312
00:14:08,200 --> 00:14:09,700
and they said, "Okay.

313
00:14:09,700 --> 00:14:11,600

Try to deploy it again,"

314

00:14:11,600 --> 00:14:14,100
and hit the deploy switch

315

00:14:14,100 --> 00:14:16,100
and...

316

00:14:16,100 --> 00:14:17,800
solar array went out.

317

00:14:17,800 --> 00:14:19,200
-It's fully deployed.

318

00:14:19,200 --> 00:14:22,700
The microswitches confirmed it.

319

00:14:22,700 --> 00:14:25,500
-Okay.

320

00:14:25,500 --> 00:14:27,800
-And for Bruce and Kathy, we'd like you to stop

321

00:14:27,800 --> 00:14:32,000
the air lock depress at five, please.

322

00:14:32,000 --> 00:14:33,400
-Rendezvous? -We're go.

323

00:14:33,400 --> 00:14:35,000
-Right-o, go.

324

00:14:35,000 --> 00:14:36,100
Eagle? -Go.

325

00:14:36,100 --> 00:14:38,300
-Decon? -Go.

326

00:14:38,300 --> 00:14:39,900

-Inco? -We're go.

327

00:14:39,900 --> 00:14:41,400

-FAO? -Go.

328

00:14:41,400 --> 00:14:42,600

-Max? -Go.

329

00:14:42,600 --> 00:14:44,300

-Peter S? -Go flight.

330

00:14:44,300 --> 00:14:45,600

-EVA? -We're go.

331

00:14:45,600 --> 00:14:47,900

-Sergeant, you're still go? -Go.

332

00:14:47,900 --> 00:14:50,400

-CAPCOM, we have a go for release.

333

00:14:50,400 --> 00:14:53,700

-Discovery, go for Hubble release.

334

00:14:53,700 --> 00:14:55,900

-Okay. We have a go for release,

335

00:14:55,900 --> 00:14:57,900

and we're gonna be a minute late.

336

00:14:57,900 --> 00:15:00,500

-Okay, Charlie.

337

00:15:00,500 --> 00:15:02,300

-And all Steve had to do was pull a trigger

338

00:15:02,300 --> 00:15:05,900

that opened the grapples

339

00:15:05,900 --> 00:15:08,600

that held the grapple fixture,

340

00:15:08,600 --> 00:15:10,100

and it was...

341

00:15:10,100 --> 00:15:11,800

I mean, it was breathtaking,

342

00:15:11,800 --> 00:15:16,000

and it was beautiful as it got farther and farther away,

343

00:15:16,000 --> 00:15:17,300

but it never went out of sight

344

00:15:17,300 --> 00:15:21,200

because it was so bright and shiny.

345

00:15:21,200 --> 00:15:24,700

-So, the irony of all of this is that after five years

346

00:15:24,700 --> 00:15:26,900

working together on the Hubble telescope --

347

00:15:26,900 --> 00:15:29,000

longer than any other person on the crew had worked

348

00:15:29,000 --> 00:15:30,500

on the Hubble telescope --

349

00:15:30,500 --> 00:15:32,000

the view that Bruce and I had

350

00:15:32,000 --> 00:15:33,600

at the time that Hubble was deployed

351
00:15:33,600 --> 00:15:37,600
was the blank white wall of the inside of the air lock.

352
00:15:37,600 --> 00:15:39,200
Never saw it.

353
00:15:39,200 --> 00:15:41,300
-Kathy has never forgiven me.

354
00:15:41,300 --> 00:15:44,100
She blames me for leaving her in the air lock,

355
00:15:44,100 --> 00:15:45,400
so, I mean, you know,

356
00:15:45,400 --> 00:15:46,800
a couple of hours later, I go down there.

357
00:15:46,800 --> 00:15:48,500
They got a lot of vacuum time

358
00:15:48,500 --> 00:15:50,700
but no space time, no space walk time,

359
00:15:50,700 --> 00:15:54,800
and so I repressurized the air lock, get them out,

360
00:15:54,800 --> 00:15:55,900
put them back on the wall,

361
00:15:55,900 --> 00:15:57,200
get them unsuited and everything,

362
00:15:57,200 --> 00:15:59,500
and they're just...

363
00:15:59,500 --> 00:16:01,900

But we had a lot of images for them.

364

00:16:01,900 --> 00:16:04,200

-Engineering things that have never been done

365

00:16:04,200 --> 00:16:06,100

sometimes have issues.

366

00:16:06,100 --> 00:16:08,900

Designing the preeminent

367

00:16:08,900 --> 00:16:10,500

viewpoint of the heavens,

368

00:16:10,500 --> 00:16:14,600

the Hubble Space Telescope, was not without, you know,

369

00:16:14,600 --> 00:16:18,500

sort of new inventions that were never done before.

370

00:16:18,500 --> 00:16:20,300

-The first images from Hubble

371

00:16:20,300 --> 00:16:22,200

were, frankly, a little disappointing.

372

00:16:22,200 --> 00:16:26,400

They were not as sharp and crisp as we had hoped.

373

00:16:26,400 --> 00:16:28,100

It turns out that the mirrors

374

00:16:28,100 --> 00:16:31,900

had a slightly misshapen form.

375

00:16:31,900 --> 00:16:33,300

-This special mirror,

376

00:16:33,300 --> 00:16:35,900

2.4 meters of specially ground glass

377

00:16:35,900 --> 00:16:38,400

designed to capture the light

378

00:16:38,400 --> 00:16:40,200

of the universe back in time,

379

00:16:40,200 --> 00:16:42,800

you know, billions of years,

380

00:16:42,800 --> 00:16:44,300

had an aberration

381

00:16:44,300 --> 00:16:46,300

the way my eyes have an aberration,

382

00:16:46,300 --> 00:16:49,600

and I wear glasses, and so there was an initial,

383

00:16:49,600 --> 00:16:51,100

"Oh, my goodness.

384

00:16:51,100 --> 00:16:53,800

What can we do?"

385

00:16:53,800 --> 00:16:58,000

This icon of exploration that took 50 years

386

00:16:58,000 --> 00:17:00,900

to think about to fly has a problem.

387

00:17:00,900 --> 00:17:04,000

-And I'm positive that if we all had written down

388

00:17:04,000 --> 00:17:07,900

the 100 most-likely problems with the Hubble Space Telescope,

389

00:17:07,900 --> 00:17:09,300

if everybody involved with Hubble

390

00:17:09,300 --> 00:17:11,500

had written down those top 100,

391

00:17:11,500 --> 00:17:12,700

not one of them --

392

00:17:12,700 --> 00:17:15,200

not one of them would have listed,

393

00:17:15,200 --> 00:17:17,600

"the mirror's the wrong shape."

394

00:17:17,600 --> 00:17:21,500

-We feel that we can characterize the problem,

395

00:17:21,500 --> 00:17:23,800

the spherical aberration problem, well enough

396

00:17:23,800 --> 00:17:26,800

that we can take advantage of an insurance policy

397

00:17:26,800 --> 00:17:28,800

that we haven't talked much about,

398

00:17:28,800 --> 00:17:30,200

and it hasn't been in the press much,

399

00:17:30,200 --> 00:17:32,000

and that is, we started a long time ago

400

00:17:32,000 --> 00:17:34,200

to plan a maintenance program.

401
00:17:34,200 --> 00:17:35,300
That is, every three years,

402
00:17:35,300 --> 00:17:37,600
we plan to go up with the Space Shuttle,

403
00:17:37,600 --> 00:17:40,900
change out instruments, change out things that broke --

404
00:17:40,900 --> 00:17:42,700
the the gyros or something might break.

405
00:17:42,700 --> 00:17:44,700
We have gyros in stock.

406
00:17:44,700 --> 00:17:47,600
In fact, we have, in stock, in storage,

407
00:17:47,600 --> 00:17:49,900
most of the critical components on space telescope.

408
00:17:49,900 --> 00:17:52,300
So we promised that we had a way to fix it,

409
00:17:52,300 --> 00:17:55,500
and we put a new camera in with corrective optics in it

410
00:17:55,500 --> 00:17:57,100
that would cure the optical problem.

411
00:17:57,100 --> 00:17:59,200
Right, as we talk now, we are building a second

412
00:17:59,200 --> 00:18:00,700
Wide Field Camera,

413
00:18:00,700 --> 00:18:03,100

and it's not too late to put a corrective optic --

414

00:18:03,100 --> 00:18:06,100

You can almost think of it, if you've got bad myopia,

415

00:18:06,100 --> 00:18:08,800

which you can say our telescope has now,

416

00:18:08,800 --> 00:18:10,100

and you put your glasses on,

417

00:18:10,100 --> 00:18:12,300

you can correct totally and get 20-20 vision.

418

00:18:12,300 --> 00:18:14,000

That's what we would do on the Wide Field Camera,

419

00:18:14,000 --> 00:18:15,200

the second Wide Field Camera.

420

00:18:15,200 --> 00:18:17,000

We would change one little mirror,

421

00:18:17,000 --> 00:18:18,800

relay mirror, in there,

422

00:18:18,800 --> 00:18:20,300

take out the aberration

423

00:18:20,300 --> 00:18:23,100

that the primary mirror causes --

424

00:18:23,100 --> 00:18:24,700

That is, if it's a positive aberration,

425

00:18:24,700 --> 00:18:27,800

we put in a negative aberration and basically cancel it out.

426

00:18:27,800 --> 00:18:30,200

We feel -- The analysis is only preliminary,

427

00:18:30,200 --> 00:18:33,700

but we're pretty optimistic that we can take out

428

00:18:33,700 --> 00:18:34,800

all the aberration

429

00:18:34,800 --> 00:18:36,600

with the second Wide Field Camera

430

00:18:36,600 --> 00:18:39,600

and get us back to the original specification.

431

00:18:39,600 --> 00:18:42,200

Nobody believed us, but we promised that we'd do it

432

00:18:42,200 --> 00:18:44,500

and would do it by December of '93.

433

00:18:44,500 --> 00:18:46,200

Let me conclude by saying,

434

00:18:46,200 --> 00:18:48,800

HST was and is a difficult challenge

435

00:18:48,800 --> 00:18:51,400

for a tremendous payoff.

436

00:18:51,400 --> 00:18:53,500

Hubble became...

437

00:18:53,500 --> 00:18:56,000

It was in the press all the time with the problems.

438

00:18:56,000 --> 00:18:58,600

It was a billion-dollar mistake.

439

00:18:58,600 --> 00:19:01,100

People in the press called it a technological disaster,

440

00:19:01,100 --> 00:19:02,600

a national disgrace.

441

00:19:02,600 --> 00:19:05,700

The late-night comedy hosts were making jokes about Hubble.

442

00:19:05,700 --> 00:19:08,300

-Well, have you been reading about the problems

443

00:19:08,300 --> 00:19:09,700

of the Hubble Telescope.

444

00:19:09,700 --> 00:19:10,800

The Hubble Space Telescope?

445

00:19:10,800 --> 00:19:12,700

-The Hubble Telescope... -The Hubble Telescope...

446

00:19:12,700 --> 00:19:13,900

The Hubble Telescope.

447

00:19:13,900 --> 00:19:16,500

-See, since there's no longer a Soviet threat,

448

00:19:16,500 --> 00:19:18,200

a lot of people feel we don't need the "Star Wars"

449

00:19:18,200 --> 00:19:19,300

defense system anymore.

450

00:19:19,300 --> 00:19:20,800

Hey, I think we should keep it, you know,

451
00:19:20,800 --> 00:19:22,600
if only they shoot down that Hubble spacecraft

452
00:19:22,600 --> 00:19:24,600
and put this thing out of its misery, huh?

453
00:19:24,600 --> 00:19:25,400
[Laughter]

454
00:19:25,400 --> 00:19:27,300
Boy, that's what I say.

455
00:19:27,300 --> 00:19:31,100
[Cheers and applause]

456
00:19:31,100 --> 00:19:32,600
-The teams at NASA,

457
00:19:32,600 --> 00:19:34,800
combinations with Johnson Space Center,

458
00:19:34,800 --> 00:19:37,400
Goddard Space Flight Center,

459
00:19:37,400 --> 00:19:40,000
great astronauts, the will of the people,

460
00:19:40,000 --> 00:19:42,000
great members of Congress who supported it,

461
00:19:42,000 --> 00:19:43,400
said, "Let's fix it.

462
00:19:43,400 --> 00:19:46,300
We fixed other things, you know, and they still work.

463
00:19:46,300 --> 00:19:48,300

Old cars still run.

464

00:19:48,300 --> 00:19:50,700

Let's make Hubble the better version."

465

00:19:50,700 --> 00:19:52,400

-We were all disappointed

466

00:19:52,400 --> 00:19:55,200

but all hopeful that something might be done

467

00:19:55,200 --> 00:19:59,000

to save this spectacular space observatory,

468

00:19:59,000 --> 00:20:00,500

and, in fact, something was done.

469

00:20:00,500 --> 00:20:03,600

We had already planned to be doing servicing missions

470

00:20:03,600 --> 00:20:05,500

on Hubble over the years,

471

00:20:05,500 --> 00:20:07,300

and so the first servicing mission

472

00:20:07,300 --> 00:20:09,600

to send astronauts back to Hubble

473

00:20:09,600 --> 00:20:12,200

was designed to repair

474

00:20:12,200 --> 00:20:14,900

this problem with Hubble.

475

00:20:14,900 --> 00:20:18,300

-And this big mirror really

476

00:20:18,300 --> 00:20:20,200

was the dominant driver.

477

00:20:20,200 --> 00:20:23,400

We worked very, very hard to develop,

478

00:20:23,400 --> 00:20:26,800

first of all, you know, how distorted was it?

479

00:20:26,800 --> 00:20:29,200

How mispolished was it?

480

00:20:29,200 --> 00:20:31,900

And then to find a company

481

00:20:31,900 --> 00:20:34,100

in the United States, preferably,

482

00:20:34,100 --> 00:20:37,400

that could polish corrective lenses

483

00:20:37,400 --> 00:20:39,500

that would take care of the problem.

484

00:20:39,500 --> 00:20:42,800

Those two challenges were really immense,

485

00:20:42,800 --> 00:20:46,400

and those challenges, when they finally got solved,

486

00:20:46,400 --> 00:20:48,600

led to something that was

487

00:20:48,600 --> 00:20:51,000

an extremely important payoff

488

00:20:51,000 --> 00:20:54,000

to the US and world citizenry.

489

00:20:54,000 --> 00:20:55,700

-To fly what you test

490

00:20:55,700 --> 00:20:58,200

and test what you fly would be easier

491

00:20:58,200 --> 00:21:00,500

if the telescope were back on Earth,

492

00:21:00,500 --> 00:21:03,500

but landing and relaunching

493

00:21:03,500 --> 00:21:05,500

could contaminate the telescope

494

00:21:05,500 --> 00:21:07,500

or damage it through vibration.

495

00:21:10,400 --> 00:21:12,500

NASA couldn't test the new corrective optics

496

00:21:12,500 --> 00:21:14,400

in the actual telescope,

497

00:21:14,400 --> 00:21:16,700

so to make sure the optics will work,

498

00:21:16,700 --> 00:21:20,300

the team had to determine the condition of Hubble in space

499

00:21:20,300 --> 00:21:24,100

and replicate that on the ground.

500

00:21:24,100 --> 00:21:26,900

One independent review panel used Hubble images

501
00:21:26,900 --> 00:21:30,500
to determine the precise shape of the flawed primary mirror

502
00:21:30,500 --> 00:21:33,900
and the prescription to fix it.

503
00:21:33,900 --> 00:21:38,700
Another team had to verify that the corrective optics will work.

504
00:21:38,700 --> 00:21:41,700
Teams had to test two optical packages,

505
00:21:41,700 --> 00:21:44,700
the replacement Wide Field Planetary Camera

506
00:21:44,700 --> 00:21:46,200
and the corrective optics

507
00:21:46,200 --> 00:21:49,700
for the other instruments, called COSTAR.

508
00:21:49,700 --> 00:21:52,600
Engineers built several independent analyzers

509
00:21:52,600 --> 00:21:54,500
to test that they had replicated

510
00:21:54,500 --> 00:21:57,600
what the Hubble Telescope does to light.

511
00:21:57,600 --> 00:22:00,700
For mechanical testing, engineers built a simulator

512
00:22:00,700 --> 00:22:02,500
at Goddard Space Flight Center

513
00:22:02,500 --> 00:22:04,600

using the same precision equipment

514

00:22:04,600 --> 00:22:06,700

that built Hubble originally.

515

00:22:06,700 --> 00:22:09,200

To replicate Hubble during electrical tests

516

00:22:09,200 --> 00:22:12,000

of the corrective-optics package and the new camera,

517

00:22:12,000 --> 00:22:13,800

an electrical test facility

518

00:22:13,800 --> 00:22:15,800

was built with the same schematics

519

00:22:15,800 --> 00:22:18,100

as the original telescope.

520

00:22:18,100 --> 00:22:21,400

Hardware has been thoroughly tested on the ground.

521

00:22:21,400 --> 00:22:25,100

The Hubble servicing team is preparing for contingencies,

522

00:22:25,100 --> 00:22:27,000

but this mission is a first,

523

00:22:27,000 --> 00:22:31,000

so no one can predict everything that could happen.

524

00:22:31,000 --> 00:22:33,800

The real test will be in space.

525

00:22:33,800 --> 00:22:38,500

-Five, four, three, two, one.

526

00:22:38,500 --> 00:22:41,300

-To zero. -And we have liftoff.

527

00:22:41,300 --> 00:22:42,900

Liftoff of the Space Shuttle Endeavour

528

00:22:42,900 --> 00:22:44,600

on an ambitious mission to service

529

00:22:44,600 --> 00:22:46,400

the Hubble Space Telescope.

530

00:22:53,600 --> 00:22:56,700

-Houston, Endeavor has a firm handshake

531

00:22:56,700 --> 00:22:58,400

with Mr. Hubble's Telescope.

532

00:23:00,800 --> 00:23:04,500

-We copy that, Covey, and there are smiles galore down here.

533

00:23:06,700 --> 00:23:08,200

-They got it. -Alright!

534

00:23:08,200 --> 00:23:10,700

[Cheers and applause]

535

00:23:14,000 --> 00:23:16,500

-Fantastic. -I forgot my glove!

536

00:23:16,500 --> 00:23:18,100

[Laughter]

537

00:23:18,100 --> 00:23:20,600

-We're going to do WFPC on day two, now.

538

00:23:20,600 --> 00:23:23,800

Sudden change of plans. -That's it, change of plan.

539

00:23:23,800 --> 00:23:26,100

-No, I think if -- -...deploy the EVA.

540

00:23:26,100 --> 00:23:27,900

-I think if the arrays are straight,

541

00:23:27,900 --> 00:23:29,300

we also have an equal chance

542

00:23:29,300 --> 00:23:31,700

that there is no such thing as further aberration.

543

00:23:31,700 --> 00:23:34,600

-That's it. -The universe is aberrated,

544

00:23:34,600 --> 00:23:36,400

and we're going to be correcting for it.

545

00:23:36,400 --> 00:23:37,400

-Actually, also...

546

00:23:37,400 --> 00:23:39,700

-Okay, and then, you're seeing

547

00:23:39,700 --> 00:23:42,400

what would be the upper outboard bistem

548

00:23:42,400 --> 00:23:45,600

on the plus V2 array.

549

00:23:45,600 --> 00:23:48,900

There's a definite kink

550

00:23:48,900 --> 00:23:52,700

right at the upper edge

551

00:23:52,700 --> 00:23:55,100

of the second panel there, as you can see,

552

00:23:55,100 --> 00:23:57,600

in the max part of the bend,

553

00:23:57,600 --> 00:24:00,400

and it looks like as the bisters --

554

00:24:00,400 --> 00:24:02,200

Of course, one is inside the other.

555

00:24:02,200 --> 00:24:06,000

It looks like the outer bistem has a kink in it,

556

00:24:06,000 --> 00:24:09,100

and it is also twisted

557

00:24:09,100 --> 00:24:13,000

approximately 90-plus degrees clockwise

558

00:24:13,000 --> 00:24:14,600

there at the kink.

559

00:24:14,600 --> 00:24:17,100

Then, it looks like it all comes back together

560

00:24:17,100 --> 00:24:20,000

within a few feet there of the kink.

561

00:24:20,000 --> 00:24:22,300

There's also -- probably hard for you all to see.

562

00:24:22,300 --> 00:24:24,300

We have to look at it with binoculars --

563

00:24:24,300 --> 00:24:30,400

a second kink couple of feet below the obvious one that

564

00:24:30,400 --> 00:24:34,900

is on the back side there of that section of the bistem.

565

00:24:34,900 --> 00:24:36,200

It's not quite as bad,

566

00:24:36,200 --> 00:24:38,500

but it does have a little crease in it.

567

00:24:38,500 --> 00:24:39,700

-Foot restraint will be occupied

568

00:24:39,700 --> 00:24:42,900

by mission specialist Kathy Thornton.

569

00:24:42,900 --> 00:24:45,700

She will be working from the end of the mechanical arm.

570

00:24:50,500 --> 00:24:55,500

This television shows Thornton at the array,

571

00:24:55,500 --> 00:24:58,700

the array to be jettisoned.

572

00:24:58,700 --> 00:25:01,500

-Okay, KT.

573

00:25:01,500 --> 00:25:03,000

You ready? -Yeah, I'm ready.

574

00:25:03,000 --> 00:25:05,200

-Okay. They say you got a go for release.

575

00:25:05,200 --> 00:25:08,000

[Indistinct talking]

576

00:25:08,000 --> 00:25:09,600

-Okay. No hands.

577

00:25:09,600 --> 00:25:13,200

[Indistinct radio chatter]

578

00:25:13,200 --> 00:25:14,700

-Okay.

579

00:25:18,000 --> 00:25:20,300

-It looks like a bird. Tom, look at it.

580

00:25:24,100 --> 00:25:25,900

-Look how stable you left that.

581

00:25:34,100 --> 00:25:35,700

There it goes.

582

00:25:39,800 --> 00:25:40,900

[Indistinct conversations]

583

00:25:40,900 --> 00:25:42,400

[Laughter]

584

00:25:44,800 --> 00:25:49,000

[Conversations continue]

585

00:25:49,000 --> 00:25:50,700

-We identified this preflight,

586

00:25:50,700 --> 00:25:53,000

in case something like this happened.

587

00:25:53,000 --> 00:25:57,000

We could go grab blankets and covers.

588

00:25:57,000 --> 00:26:00,900

-If we can have another EVA day like we did the first --

589

00:26:00,900 --> 00:26:04,700

and it looks like we're halfway there --

590

00:26:04,700 --> 00:26:06,400

we'll be well on our way

591

00:26:06,400 --> 00:26:12,300

to having a very, very successfully completed mission.

592

00:26:12,300 --> 00:26:14,900

In fact, I remember after the first day saying,

593

00:26:14,900 --> 00:26:18,000

"If we could just have two more like today,

594

00:26:18,000 --> 00:26:19,900

we'd be sure of great science."

595

00:26:19,900 --> 00:26:21,000

-Yeah.

596

00:26:21,000 --> 00:26:23,200

-So, it looks great.

597

00:26:26,800 --> 00:26:30,600

-This is the mirror.

598

00:26:30,600 --> 00:26:32,800

This is like the mirror

599

00:26:32,800 --> 00:26:35,200

in the Wide Field Camera

600

00:26:35,200 --> 00:26:36,700

that's used to correct

601
00:26:36,700 --> 00:26:40,700
for the spherical aberration in the Hubble,

602
00:26:40,700 --> 00:26:44,600
and it's done by putting the same mirror on this mirror

603
00:26:44,600 --> 00:26:46,600
that exists on the Hubble mirror,

604
00:26:46,600 --> 00:26:48,100
only with the opposite size,

605
00:26:48,100 --> 00:26:52,200
so the result is that after having the optical image

606
00:26:52,200 --> 00:26:54,300
distorted by the primary mirror,

607
00:26:54,300 --> 00:26:57,300
the distortion is removed by this secondary mirror,

608
00:26:57,300 --> 00:27:01,800
and the result is that you get a good, clear image at the end.

609
00:27:01,800 --> 00:27:03,800
-I am on it.

610
00:27:03,800 --> 00:27:05,100
Okay. Alright.

611
00:27:09,100 --> 00:27:07,200
Stop the arm.

612
00:27:09,100 --> 00:27:11,400
-Is the bay clear? -Yes.

613
00:27:11,400 --> 00:27:13,800

We're totally clear. We're ready to start in.

614

00:27:13,800 --> 00:27:15,200

-Okay.

615

00:27:15,200 --> 00:27:17,200

Right. Let's come on in.

616

00:27:17,200 --> 00:27:18,600

-Okay.

617

00:27:18,600 --> 00:27:21,600

-Nobody really believed they could do all of this work,

618

00:27:21,600 --> 00:27:25,100

and they did it and did it in fine fashion, you know,

619

00:27:25,100 --> 00:27:27,400

even with some problems along the way,

620

00:27:27,400 --> 00:27:28,700

so that was --

621

00:27:28,700 --> 00:27:30,300

that brought Hubble back to life,

622

00:27:30,300 --> 00:27:33,300

and it kind of took away some of the criticism of NASA,

623

00:27:33,300 --> 00:27:35,100

because they had now demonstrated

624

00:27:35,100 --> 00:27:37,300

that they could do something that had never been done before.

625

00:27:37,300 --> 00:27:39,500

We had never serviced a telescope,

626

00:27:39,500 --> 00:27:44,300

so when people talk about the legacy of Hubble,

627

00:27:44,300 --> 00:27:47,200

I think among its greatest legacies

628

00:27:47,200 --> 00:27:52,300

will be helping humanity understand that, yeah,

629

00:27:52,300 --> 00:27:55,300

when things go to space, we can, in fact --

630

00:27:55,300 --> 00:27:57,700

It's not hopeless, if there's something wrong.

631

00:27:57,700 --> 00:27:59,900

We can service them, in many cases,

632

00:27:59,900 --> 00:28:02,900

if we make some preparation to do that.

633

00:28:02,900 --> 00:28:04,900

-Drop.

634

00:28:04,900 --> 00:28:06,400

Drop.

635

00:28:06,400 --> 00:28:07,900

Okay. Here we come.

636

00:28:15,400 --> 00:28:16,900

Get it on. The light comes on.

637

00:28:16,900 --> 00:28:18,700

-With the camera now installed,

638

00:28:18,700 --> 00:28:21,500

Claude Nicollier will reposition Jeff Hoffman

639

00:28:21,500 --> 00:28:24,100

so that he can now completely latch

640

00:28:24,100 --> 00:28:28,200

the new instrument into the telescope.

641

00:28:28,200 --> 00:28:29,700

-Right now, it's looking very, very good

642

00:28:29,700 --> 00:28:32,800

that we've accomplished all we needed to accomplish

643

00:28:32,800 --> 00:28:35,700

for the optical correction of HST,

644

00:28:35,700 --> 00:28:38,600

and that's good news for astronomy,

645

00:28:38,600 --> 00:28:41,500

and it's good news for NASA

646

00:28:41,500 --> 00:28:44,000

to get over this little episode in our history.

647

00:28:44,000 --> 00:28:45,800

-And after five EVAs,

648

00:28:45,800 --> 00:28:48,800

space walks,

649

00:28:48,800 --> 00:28:50,000

the astronauts came home,

650

00:28:50,000 --> 00:28:51,100

and about two weeks later,

651
00:28:51,100 --> 00:28:53,300
we took off the bandages from our eyes,

652
00:28:53,300 --> 00:28:55,600
and, suddenly, Hubble was fixed.

653
00:28:55,600 --> 00:28:56,800
It was totally fixed.

654
00:28:56,800 --> 00:28:58,100
-Is this it?

655
00:28:58,100 --> 00:28:59,400
[Indistinct conversations]

656
00:29:01,500 --> 00:29:04,400
[Cheers and applause]

657
00:29:04,400 --> 00:29:06,300
-Right there! -Oh!

658
00:29:06,300 --> 00:29:08,100
[Laughs] -Boom!

659
00:29:08,100 --> 00:29:09,200
-They did it! -Hey!

660
00:29:09,200 --> 00:29:10,900
-Wait, wait, wait, wait. -No, no, no. Go.

661
00:29:10,900 --> 00:29:12,300
-Yeah, let's get a see. -Bring it up.

662
00:29:12,300 --> 00:29:14,000
-Yeah. Bring it up. -Bring it up more.

663
00:29:14,000 --> 00:29:15,400

-Come on. Come on. -Bring it up more.

664

00:29:15,400 --> 00:29:16,900

-Oh! -Come on!

665

00:29:16,900 --> 00:29:18,600

-Not bad. -That's not bad.

666

00:29:18,600 --> 00:29:20,500

-Well, can we get

667

00:29:20,500 --> 00:29:22,000

a sense for which is the brightest pixel?

668

00:29:22,000 --> 00:29:23,700

-Yeah. Could you just move the cursor around in there?

669

00:29:23,700 --> 00:29:24,600

-Yeah. The -- Oh, there!

670

00:29:24,600 --> 00:29:25,600

There! There! -Oh!

671

00:29:25,600 --> 00:29:26,900

-It's many pixels!

672

00:29:26,900 --> 00:29:28,500

-Whoa! -Not bad at all.

673

00:29:28,500 --> 00:29:33,600

-I chair the subcommittee that financed the manufacture

674

00:29:33,600 --> 00:29:37,200

of the most significant contact lens

675

00:29:37,200 --> 00:29:38,700

in American history,

676
00:29:38,700 --> 00:29:42,200
the fix on the Hubble Space Telescope

677
00:29:42,200 --> 00:29:44,600
and then bankrolled

678
00:29:44,600 --> 00:29:50,000
this extraordinary space HMO that went out

679
00:29:50,000 --> 00:29:52,200
and gave Hubble Telescope

680
00:29:52,200 --> 00:29:54,800
a new contact lens,

681
00:29:54,800 --> 00:29:57,400
and I'm happy to announce today

682
00:29:57,400 --> 00:30:00,500
that after its launch now in 1990,

683
00:30:00,500 --> 00:30:02,700
some of its earlier disappointments,

684
00:30:02,700 --> 00:30:06,200
the trouble with Hubble is over!

685
00:30:06,200 --> 00:30:11,100
We have here a picture taken of the image of a star

686
00:30:11,100 --> 00:30:14,300
with the new Faint Object Camera.

687
00:30:14,300 --> 00:30:17,100
Here, we have the picture taken prior

688
00:30:17,100 --> 00:30:21,100

to the servicing mission without the COSTAR.

689

00:30:21,100 --> 00:30:26,100

Over here, on my left, is the new picture taken

690

00:30:26,100 --> 00:30:28,500

of the same star configuration

691

00:30:28,500 --> 00:30:30,000

after COSTAR.

692

00:30:30,000 --> 00:30:32,400

This is the picture of the same galaxy,

693

00:30:32,400 --> 00:30:36,300

and then here is the picture taken of the same galaxy

694

00:30:36,300 --> 00:30:40,300

through the new Wide Field/Planetary Camera

695

00:30:40,300 --> 00:30:44,600

that was installed by our gallant and brave astronauts.

696

00:30:44,600 --> 00:30:47,100

The pictures are remarkable.

697

00:30:47,100 --> 00:30:50,100

The science that will come from the pictures

698

00:30:50,100 --> 00:30:53,400

are of historical significance.

699

00:30:53,400 --> 00:30:56,700

We will now, because of the Hubble fix,

700

00:30:56,700 --> 00:31:01,200

be able to do 21st-century science

701
00:31:05,100 --> 00:31:05,000
that will enable us to look back on the universe.

702
00:31:05,100 --> 00:31:07,400
and this is only the beginning!

703
00:31:07,400 --> 00:31:11,500
-Three, two, one.

704
00:31:11,500 --> 00:31:13,300
Ignition and liftoff,

705
00:31:13,300 --> 00:31:15,300
Discovery now on its way to service

706
00:31:15,300 --> 00:31:17,500
NASA's Hubble Space Telescope.

707
00:31:17,500 --> 00:31:21,800
-The Hubble Space Telescope is a magnificent achievement,

708
00:31:21,800 --> 00:31:24,300
because it involves so many aspects

709
00:31:24,300 --> 00:31:26,700
of expertise and support,

710
00:31:26,700 --> 00:31:28,500
everything from engineering,

711
00:31:28,500 --> 00:31:31,900
technology, cultural support,

712
00:31:31,900 --> 00:31:33,700
scientific motivation,

713
00:31:33,700 --> 00:31:35,600

political support.

714

00:31:35,600 --> 00:31:38,100

It's also very innovative

715

00:31:38,100 --> 00:31:40,700

because it involved building on the technology

716

00:31:40,700 --> 00:31:44,900

developed through the Apollo program of NASA

717

00:31:44,900 --> 00:31:46,500

and then advancing that

718

00:31:46,500 --> 00:31:48,500

to the point of having the Space Shuttle

719

00:31:48,500 --> 00:31:51,100

being able to carry satellites,

720

00:31:51,100 --> 00:31:54,400

like Hubble, into low Earth orbit

721

00:31:54,400 --> 00:31:56,200

and then creating an infrastructure

722

00:31:56,200 --> 00:31:57,800

where you can bring astronauts

723

00:31:57,800 --> 00:32:01,500

repeatedly back up to an orbiting satellite,

724

00:32:01,500 --> 00:32:04,100

connecting with that satellite, and having those astronauts

725

00:32:04,100 --> 00:32:07,000

go out in extravehicular activity

726

00:32:07,000 --> 00:32:10,300

to repair, service, upgrade that telescope,

727

00:32:10,300 --> 00:32:12,000

that satellite

728

00:32:12,000 --> 00:32:15,600

and then let it go again to continue doing its science,

729

00:32:15,600 --> 00:32:18,500

inspiring future missions and future ways

730

00:32:18,500 --> 00:32:20,700

that astronauts and science

731

00:32:20,700 --> 00:32:23,300

and engineering can all work together

732

00:32:23,300 --> 00:32:25,600

to produce new advances

733

00:32:25,600 --> 00:32:27,400

in human space exploration.

734

00:32:27,400 --> 00:32:28,500

Hubble was pretty much

735

00:32:28,500 --> 00:32:31,500

the pioneer in this kind of sustained effort,

736

00:32:31,500 --> 00:32:33,700

and we should be grateful for it.

737

00:32:33,700 --> 00:32:35,400

-We have booster ignition

738

00:32:35,400 --> 00:32:38,000

and liftoff of the Space Shuttle Discovery

739

00:32:38,000 --> 00:32:40,100

on a mission to repair the Hubble Space Telescope

740

00:32:40,100 --> 00:32:43,100

as we venture into the 21st century.

741

00:32:43,100 --> 00:32:46,200

-I hope that it helps us understand

742

00:32:46,200 --> 00:32:50,500

what humans are capable of, period.

743

00:32:50,500 --> 00:32:52,100

I mean, we --

744

00:32:52,100 --> 00:32:54,300

You know, Hubble represents

745

00:32:54,300 --> 00:32:57,000

so many different pieces of this planet

746

00:32:57,000 --> 00:32:59,500

working together in harmony.

747

00:32:59,500 --> 00:33:02,400

You know, we've got the European Space Agency,

748

00:33:02,400 --> 00:33:03,900

NASA,

749

00:33:03,900 --> 00:33:07,700

all the universities and science organizations

750

00:33:07,700 --> 00:33:12,200

all around this planet that have a vested interest

751
00:33:12,200 --> 00:33:17,200
and have reaped the benefit of Hubble.

752
00:33:17,200 --> 00:33:19,400
Yeah, I certainly hope it's shown us

753
00:33:19,400 --> 00:33:21,400
what we are capable of.

754
00:33:21,400 --> 00:33:23,600
-Liftoff of Space Shuttle Columbia

755
00:33:23,600 --> 00:33:25,500
to broaden our view of the universe

756
00:33:25,500 --> 00:33:27,400
through the Hubble Space Telescope.

757
00:33:27,400 --> 00:33:29,400
-It took about three years of training

758
00:33:29,400 --> 00:33:31,800
before we were ready to go fly.

759
00:33:31,800 --> 00:33:33,300
The Hubble missions are some

760
00:33:33,300 --> 00:33:35,000
of the most complicated space missions

761
00:33:35,000 --> 00:33:36,200
we've ever attempted,

762
00:33:36,200 --> 00:33:37,600
and the repairs were difficult,

763
00:33:37,600 --> 00:33:40,300

involved developing new tools and procedures,

764

00:33:40,300 --> 00:33:41,900
and so that's why it takes longer

765

00:33:41,900 --> 00:33:45,400
for a Hubble Space Telescope mission than it did, say,

766

00:33:45,400 --> 00:33:48,600
for a International Space Station assembly mission.

767

00:33:48,600 --> 00:33:51,100
Those you could turn around much more quickly.

768

00:33:51,100 --> 00:33:55,100

769

00:33:55,100 --> 00:33:56,800
-The loss of this valiant crew

770

00:33:56,800 --> 00:34:00,700
is something we will never...

771

00:34:00,700 --> 00:34:02,000
be able to get over, and, certainly,

772

00:34:02,000 --> 00:34:04,100
the families of all of them,

773

00:34:04,100 --> 00:34:06,500
we have assured we will do everything --

774

00:34:06,500 --> 00:34:09,200
everything we can possibly do

775

00:34:09,200 --> 00:34:11,600
to guarantee that they work their way

776

00:34:11,600 --> 00:34:15,900

through this horrific tragedy.

777

00:34:15,900 --> 00:34:18,300

-The final Hubble servicing mission that left Hubble

778

00:34:18,300 --> 00:34:20,200

as the observatory that it is today

779

00:34:20,200 --> 00:34:22,700

almost didn't happen because,

780

00:34:22,700 --> 00:34:26,100

after Columbia, Sean O'Keefe was the NASA administrator,

781

00:34:26,100 --> 00:34:29,300

and he made the decision that Hubble was too risky.

782

00:34:29,300 --> 00:34:32,900

-I think we all respected

783

00:34:32,900 --> 00:34:34,600

the administrator at the time

784

00:34:34,600 --> 00:34:37,200

who actually came out in person to tell us.

785

00:34:37,200 --> 00:34:38,700

We didn't like what he was telling us,

786

00:34:38,700 --> 00:34:40,400

but at least he didn't just send an e-mail.

787

00:34:40,400 --> 00:34:43,200

He came out and tried to explain his rationale,

788

00:34:43,200 --> 00:34:44,800

which was simply that he thought

789

00:34:44,800 --> 00:34:46,500

it was too dangerous for the astronauts

790

00:34:46,500 --> 00:34:49,200

since there was no safety net

791

00:34:49,200 --> 00:34:51,200

if something went wrong.

792

00:34:51,200 --> 00:34:54,700

-Hubble was in an orbit that the crew couldn't use

793

00:34:54,700 --> 00:34:57,700

the International Space Station as a safe haven

794

00:34:57,700 --> 00:34:59,400

if something went wrong.

795

00:34:59,400 --> 00:35:02,700

For all of the station missions, our plan was,

796

00:35:02,700 --> 00:35:05,300

if we could just get the crew somewhere to orbit,

797

00:35:05,300 --> 00:35:07,800

we could get them to the International Space Station

798

00:35:07,800 --> 00:35:10,000

and put them aboard station until we could get

799

00:35:10,000 --> 00:35:13,000

another flight to come up and rescue them.

800

00:35:13,000 --> 00:35:14,300

-But...

801
00:35:14,300 --> 00:35:19,300
So, we fortunately were able to keep people occupied

802
00:35:19,300 --> 00:35:21,100
while this was churning through the system,

803
00:35:21,100 --> 00:35:23,000
and we did some very good work

804
00:35:23,000 --> 00:35:26,100
on the possibility of robotic servicing of Hubble,

805
00:35:26,100 --> 00:35:28,200
and after a year's worth of work,

806
00:35:28,200 --> 00:35:32,600
we actually decided that it would be possible in the future,

807
00:35:32,600 --> 00:35:35,500
but we didn't think we could develop it in time

808
00:35:35,500 --> 00:35:39,400
to actually be useful for Hubble before it lost control

809
00:35:39,400 --> 00:35:42,100
or, you know, wasn't able to observe,

810
00:35:42,100 --> 00:35:45,200
and fortunately, about the time we had decided that

811
00:35:45,200 --> 00:35:47,100
is when the new administrator

812
00:35:47,100 --> 00:35:49,300
came in and said, "Let's find a way to make

813
00:35:49,300 --> 00:35:51,900

the final servicing mission happen."

814

00:35:51,900 --> 00:35:55,200

-Just under three years ago,

815

00:35:55,200 --> 00:35:58,200

NASA had to announce

816

00:35:58,200 --> 00:36:00,200

a very troubling decision --

817

00:36:00,200 --> 00:36:04,900

that decision being to cancel Shuttle Service Mission 4

818

00:36:04,900 --> 00:36:07,100

for the Hubble Space Telescope,

819

00:36:07,100 --> 00:36:10,400

and today, I'm here to announce a much more pleasant decision

820

00:36:10,400 --> 00:36:12,400

on behalf of the agency.

821

00:36:14,400 --> 00:36:18,000

We are going to add a shuttle servicing mission

822

00:36:18,000 --> 00:36:19,500

to the Hubble Space Telescope

823

00:36:19,500 --> 00:36:23,500

to the shuttle's manifest to be flown before it retires.

824

00:36:23,500 --> 00:36:25,000

We antici--

825

00:36:25,000 --> 00:36:26,500

[Cheers and applause]

826

00:36:37,400 --> 00:36:31,900



827

00:36:37,400 --> 00:36:38,800

-The public response was

828

00:36:38,800 --> 00:36:42,000

probably as important, if not more so,

829

00:36:42,000 --> 00:36:43,100

than the professional

830

00:36:43,100 --> 00:36:45,200

astronomical community's response.

831

00:36:45,200 --> 00:36:47,500

They both wanted to see Hubble serviced,

832

00:36:47,500 --> 00:36:49,000

both wanted to continue,

833

00:36:49,000 --> 00:36:52,100

but the public, in some ways, was our savior.

834

00:36:52,100 --> 00:36:53,300

I mean, they went,

835

00:36:53,300 --> 00:36:55,500

and they talked to their Congresspeople.

836

00:36:55,500 --> 00:36:58,600

They, you know, wrote editorials

837

00:36:58,600 --> 00:37:00,600

for newspapers and everything,

838

00:37:00,600 --> 00:37:04,200

and there are a lot of people on the Earth --

839

00:37:04,200 --> 00:37:07,000

The youngsters have never known a time

840

00:37:07,000 --> 00:37:09,500

without Hubble in the sky...

841

00:37:12,900 --> 00:37:16,100

[Voice breaking] ...and they -- they just...

842

00:37:16,100 --> 00:37:19,600

didn't want to see it go away.

843

00:37:19,600 --> 00:37:22,200

So, I think their investment in it,

844

00:37:22,200 --> 00:37:24,600

their connection to it

845

00:37:24,600 --> 00:37:26,900

coupled with the way

846

00:37:26,900 --> 00:37:31,200

they were able to describe that

847

00:37:31,200 --> 00:37:34,100

to the media,

848

00:37:34,100 --> 00:37:35,900

to Congress, whatever,

849

00:37:35,900 --> 00:37:39,800

it really got through to people

850

00:37:39,800 --> 00:37:41,600

and to the administrator and said,

851

00:37:41,600 --> 00:37:45,000

"You know, this is important

852

00:37:45,000 --> 00:37:48,500

for more than the science.

853

00:37:48,500 --> 00:37:51,500

So, let's find a way to make it work,"

854

00:37:51,500 --> 00:37:53,100

and we did.

855

00:38:06,200 --> 00:37:59,700

■■

856

00:38:06,200 --> 00:38:11,400

-Seven, six, five, four, three,

857

00:38:11,400 --> 00:38:15,400

two, one and liftoff

858

00:38:15,400 --> 00:38:17,400

of Space Shuttle Atlantis,

859

00:38:17,400 --> 00:38:20,100

final visit to enhance the vision of Hubble

860

00:38:20,100 --> 00:38:23,500

into the deepest grandeur of our universe.

861

00:38:23,500 --> 00:38:29,000

■■

862

00:38:29,000 --> 00:38:30,500

[Indistinct radio chatter]

863

00:38:30,500 --> 00:38:40,400

■■

864

00:38:40,400 --> 00:38:41,800

[Radio chatter continues]

865

00:38:41,800 --> 00:38:43,800

-Increase rate, Megan. -Copy.

866

00:38:43,800 --> 00:38:45,400

Increasing the rate.

867

00:38:45,400 --> 00:38:49,300

[Indistinct radio chatter]

868

00:38:49,300 --> 00:38:52,900

-...is just outside of the telescope.

869

00:38:52,900 --> 00:38:55,200

...is one foot outside of the telescope.

870

00:38:55,200 --> 00:38:58,000

Okay. Increase rate, Megan.

871

00:38:58,000 --> 00:38:59,900

-Copy. -Clear for maneuver.

872

00:38:59,900 --> 00:39:02,900

-You're clear for the maneuver. -Go for maneuver, Megan.

873

00:39:02,900 --> 00:39:05,000

-Copy. Going to the fixture.

874

00:39:05,000 --> 00:39:07,900

■■

875

00:39:07,900 --> 00:39:09,400

-I'm the witness on this.

876

00:39:09,400 --> 00:39:12,800

You actually were the last guy to pat it goodbye.

877

00:39:12,800 --> 00:39:15,000

What were you thinking when you patted Hubble goodbye?

878

00:39:15,000 --> 00:39:16,100

What was going through your mind?

879

00:39:16,100 --> 00:39:17,200

-Happy voyages.

880

00:39:17,200 --> 00:39:19,400

I hope everything that we did worked.

881

00:39:19,400 --> 00:39:21,300

-[Chuckles]

882

00:39:21,300 --> 00:39:24,800

-It's hard not to think of Hubble as something alive,

883

00:39:24,800 --> 00:39:27,800

but, you know, I really was thinking of Hubble as a friend.

884

00:39:27,800 --> 00:39:31,700

-This is a really tremendous adventure that we've been on,

885

00:39:31,700 --> 00:39:34,300

a very challenging mission.

886

00:39:34,300 --> 00:39:36,500

Hubble isn't just a satellite.

887

00:39:36,500 --> 00:39:39,500

It's about humanity's quest for knowledge.

888

00:39:39,500 --> 00:39:41,300

As Arthur C. Clarke said,

889

00:39:41,300 --> 00:39:44,100

"The only way of finding the limits of the possible

890

00:39:44,100 --> 00:39:47,500

is by going beyond them, into the impossible,"

891

00:39:47,500 --> 00:39:49,900

and on this mission, we tried some things

892

00:39:49,900 --> 00:39:51,800

that many people said was impossible --

893

00:39:51,800 --> 00:39:55,000

fixing STIS, repairing ACS,

894

00:39:55,000 --> 00:39:58,700

achieving all the content that we have in this mission.

895

00:39:58,700 --> 00:40:01,300

But we've achieved that,

896

00:40:01,300 --> 00:40:04,200

and we wish Hubble the very best.

897

00:40:04,200 --> 00:40:07,500

I want to wish Hubble its own set of adventures

898

00:40:07,500 --> 00:40:09,700

and with the new instruments we've installed

899

00:40:09,700 --> 00:40:13,600

that it may unlock further mysteries of the universe.

900

00:40:13,600 --> 00:40:15,800

-Repaired the two failing instruments,

901
00:40:15,800 --> 00:40:17,800
put in two new ones, replaced gyros,

902
00:40:17,800 --> 00:40:20,900
a whole bunch of things -- a really massive mission

903
00:40:20,900 --> 00:40:23,000
and did such an excellent job

904
00:40:23,000 --> 00:40:26,100
that we're here more than 10 years later now,

905
00:40:26,100 --> 00:40:29,000
and we're as capable as we've ever been.

906
00:40:29,000 --> 00:40:29,900
Things are still working.

907
00:40:29,900 --> 00:40:31,100
We've lost a few gyros,

908
00:40:31,100 --> 00:40:33,100
but we still have enough to operate on.

909
00:40:33,100 --> 00:40:35,400
All four of the instruments that were alive

910
00:40:35,400 --> 00:40:38,300
after the servicing mission are still going strong.

911
00:40:38,300 --> 00:40:41,200
We are supremely grateful

912
00:40:41,200 --> 00:40:43,500
for getting that last servicing mission in,

913
00:40:43,500 --> 00:40:45,600

because we would not still be operating at this point

914

00:40:45,600 --> 00:40:46,700

if we hadn't done that.

915

00:40:46,700 --> 00:40:49,300

That allowed us to get the telescope

916

00:40:49,300 --> 00:40:53,600

in a configuration for maximum following lifetime.

917

00:40:57,500 --> 00:41:00,000

-It's about newness.

918

00:41:00,000 --> 00:41:01,700

It's about challenge.

919

00:41:01,700 --> 00:41:05,400

It's about going out there in the forefront of technology

920

00:41:05,400 --> 00:41:07,600

and breaking through,

921

00:41:07,600 --> 00:41:09,600

and Hubble represents that

922

00:41:09,600 --> 00:41:12,000

to the greatest degree that I could think of,

923

00:41:12,000 --> 00:41:16,000

because it allows us to do it in a big way and in a small way.

924

00:41:16,000 --> 00:41:17,800

It allows us to do it in detectors.

925

00:41:17,800 --> 00:41:20,700

It allows us to do it in computer technology

926

00:41:20,700 --> 00:41:25,000

and optical fabrication and optical polishing,

927

00:41:25,000 --> 00:41:27,100

but it also gives us this big picture.

928

00:41:27,100 --> 00:41:30,000

It also gives us this great challenge

929

00:41:30,000 --> 00:41:32,400

of making things better.

930

00:41:39,700 --> 00:41:36,000



931

00:41:39,700 --> 00:41:42,600

-A lot of people say they feel very insignificant

932

00:41:42,600 --> 00:41:44,400

when they look at these images of --

933

00:41:44,400 --> 00:41:46,800

that show thousands of galaxies

934

00:41:46,800 --> 00:41:50,100

and tell us that there are hundreds of billions of galaxies

935

00:41:50,100 --> 00:41:51,700

beyond the Milky Way,

936

00:41:51,700 --> 00:41:54,900

and that's a certain understandable response,

937

00:41:54,900 --> 00:41:58,100

but I also feel a sense of gratitude

938

00:41:58,100 --> 00:42:00,000

and even significance myself.

939

00:42:00,000 --> 00:42:01,700

Now, these are philosophical issues,

940

00:42:01,700 --> 00:42:03,600

not science issues, right?

941

00:42:03,600 --> 00:42:06,600

But I feel a sense of significance

942

00:42:06,600 --> 00:42:08,800

that we, as humans,

943

00:42:08,800 --> 00:42:12,100

have developed or been granted the ability

944

00:42:12,100 --> 00:42:13,800

to develop instruments

945

00:42:13,800 --> 00:42:16,500

that enable us to see far beyond

946

00:42:16,500 --> 00:42:19,000

what the human eye alone could ever see

947

00:42:19,000 --> 00:42:20,400

and to think about what it means,

948

00:42:20,400 --> 00:42:23,100

to think about how we, on this planet,

949

00:42:23,100 --> 00:42:25,400

relate to star systems

950

00:42:25,400 --> 00:42:27,700

far beyond our own.

951
00:42:27,700 --> 00:42:29,400
I think that's wonderful.

952
00:42:29,400 --> 00:42:31,300
It should make us all feel

953
00:42:31,300 --> 00:42:34,300
a sense of gratitude and humility

954
00:42:34,300 --> 00:42:35,700
and also connectedness.

955
00:42:35,700 --> 00:42:37,800
You know, we're on different sides of a planet,

956
00:42:37,800 --> 00:42:41,500
but we're all connected as human beings on planet Earth

957
00:42:41,500 --> 00:42:43,800
as part of this magnificent universe.

958
00:42:43,800 --> 00:42:45,300
I think it should and does

959
00:42:45,300 --> 00:42:47,600
have a unifying effect for humanity,

960
00:42:47,600 --> 00:42:50,100
and I'm grateful for that.

961
00:42:50,100 --> 00:42:52,600
-Imagination is great, but execution's everything,

962
00:42:52,600 --> 00:42:56,800
so okay, we can imagine being able to see the cosmos,

963
00:42:56,800 --> 00:42:58,900

and that's great, and great astronomers,

964

00:42:58,900 --> 00:43:00,900

great thinkers wrote the governing equations.

965

00:43:00,900 --> 00:43:03,800

They imagined it, but what did it take

966

00:43:03,800 --> 00:43:05,600

to be able to do it in a way

967

00:43:05,600 --> 00:43:07,900

that responds to what we learn

968

00:43:07,900 --> 00:43:10,200

in a way that allows us to go beyond

969

00:43:10,200 --> 00:43:12,900

just the framing questions, you know?

970

00:43:12,900 --> 00:43:14,700

And so the Hubble Space Telescope

971

00:43:14,700 --> 00:43:17,900

is the consummation of a masterpiece of engineering

972

00:43:17,900 --> 00:43:21,500

because many of the things Hubble did and continues to do

973

00:43:21,500 --> 00:43:24,300

were miracles of engineering

974

00:43:24,300 --> 00:43:26,100

that did not exist before.

975

00:43:26,100 --> 00:43:29,600

Hubble expanded our horizons of thinking

976
00:43:29,600 --> 00:43:31,800
with an engineering solution to something

977
00:43:31,800 --> 00:43:33,300
that changed the way we viewed space.

978
00:43:33,300 --> 00:43:35,900
Space, all of a sudden, is beautiful.

979
00:43:35,900 --> 00:43:37,800
It wasn't just equations to say,

980
00:43:37,800 --> 00:43:40,100
"Well, there's an event horizon, like a black hole.

981
00:43:40,100 --> 00:43:41,700
Look, it's Hawkings' work, you know,

982
00:43:41,700 --> 00:43:44,000
and Einstein's, and, you know, others."

983
00:43:44,000 --> 00:43:45,300
It's more than that.

984
00:43:45,300 --> 00:43:46,700
It's beautiful.

985
00:43:46,700 --> 00:43:48,600
It's elegant. It's populated.

986
00:43:48,600 --> 00:43:51,000
It's not just lights and stars.

987
00:43:51,000 --> 00:43:53,700
It's connecting glow. It's the --

988
00:43:53,700 --> 00:43:55,800

You know, it's grand challenges.

989

00:43:55,800 --> 00:43:59,100

It connects other galaxies

990

00:43:59,100 --> 00:44:00,500

to suns,

991

00:44:00,500 --> 00:44:03,700

to planetary systems that we can indirectly sense.

992

00:44:03,700 --> 00:44:06,000

All that took a space telescope to do,

993

00:44:06,000 --> 00:44:07,500

and it had to be a good one.

994

00:44:07,500 --> 00:44:10,300

Hubble discovered things that are now fundamental

995

00:44:10,300 --> 00:44:12,800

in the astrophysics of our universe.

996

00:44:12,800 --> 00:44:14,500

Oh, my God.

997

00:44:14,500 --> 00:44:17,100

But the millions of engineering solutions

998

00:44:17,100 --> 00:44:19,800

that let it work, it's --

999

00:44:19,800 --> 00:44:21,800

You know, they're beyond words.

1000

00:44:21,800 --> 00:44:23,800

They're magic.

1001
00:44:23,800 --> 00:44:25,400
I think that's why

1002
00:44:25,400 --> 00:44:27,500
it was so transformative in space science.

1003
00:44:27,500 --> 00:44:29,500
It brought space science to the people

1004
00:44:29,500 --> 00:44:31,600
because it talked about all space,

1005
00:44:31,600 --> 00:44:34,100
and it stared at key places in all space

1006
00:44:34,100 --> 00:44:36,300
to tell us what could be,

1007
00:44:36,300 --> 00:44:38,900
and that is brilliant, you know?

1008
00:44:38,900 --> 00:44:40,000
Space is a tapestry.

1009
00:44:40,000 --> 00:44:41,800
It's a mosaicism of stuff,

1010
00:44:41,800 --> 00:44:43,100
some of which we can't see.

1011
00:44:43,100 --> 00:44:44,500
Hubble saw a lot of it

1012
00:44:44,500 --> 00:44:46,800
and showed us how to look at it differently,

1013
00:44:46,800 --> 00:44:48,100

and that, I think,

1014

00:44:48,100 --> 00:44:51,000

is its legacy.

1015

00:44:51,000 --> 00:44:52,200

-Humans are very good

1016

00:44:52,200 --> 00:44:54,000

at kind of putting our hearts and souls

1017

00:44:54,000 --> 00:44:56,700

into things that are made of just metal and wiring.

1018

00:44:56,700 --> 00:44:57,900

I mean, think about, perhaps,

1019

00:44:57,900 --> 00:44:59,400

the connection you might have to your car.

1020

00:44:59,400 --> 00:45:00,700

You know, your car is something

1021

00:45:00,700 --> 00:45:03,700

that is used by you every day, is touched by you.

1022

00:45:03,700 --> 00:45:05,300

It may have a personality to you.

1023

00:45:05,300 --> 00:45:06,900

It may feel very secure,

1024

00:45:06,900 --> 00:45:08,700

or it may be very contentious.

1025

00:45:08,700 --> 00:45:10,700

It's always breaking down.

1026

00:45:10,700 --> 00:45:12,500

It's natural for us

1027

00:45:12,500 --> 00:45:15,100

to sort of put ourselves out into the world

1028

00:45:15,100 --> 00:45:17,500

in things that might not really be conscious,

1029

00:45:17,500 --> 00:45:19,000

that are just machines,

1030

00:45:19,000 --> 00:45:20,900

and when you hear the Hubble Space Telescope,

1031

00:45:20,900 --> 00:45:21,800

you think of something.

1032

00:45:21,800 --> 00:45:23,300

Well, okay. It's a telescope.

1033

00:45:23,300 --> 00:45:24,500

It's a big metal tube.

1034

00:45:24,500 --> 00:45:26,100

We launched it up into space.

1035

00:45:26,100 --> 00:45:28,000

It's very far away.

1036

00:45:28,000 --> 00:45:30,000

They're seeing things that are very esoteric

1037

00:45:30,000 --> 00:45:32,600

that I wouldn't understand.

1038

00:45:32,600 --> 00:45:36,200

The thing I would ask you to do is just take a little time

1039

00:45:36,200 --> 00:45:40,100

and look at some of these pictures because if --

1040

00:45:40,100 --> 00:45:44,400

The artistic merit of what a giant cloud

1041

00:45:44,400 --> 00:45:47,400

forming hundreds of stars looks like,

1042

00:45:47,400 --> 00:45:49,500

even if you don't really understand what that is,

1043

00:45:49,500 --> 00:45:51,600

start by just looking at these beautiful pictures

1044

00:45:51,600 --> 00:45:53,200

and then start reading.

1045

00:45:53,200 --> 00:45:54,700

We go through a lot of trouble --

1046

00:45:54,700 --> 00:45:57,700

Our wonderful science writers are trying to describe

1047

00:45:57,700 --> 00:46:01,000

what you're really seeing, the drama of it, scale of it,

1048

00:46:01,000 --> 00:46:02,300

and also the connection.

1049

00:46:02,300 --> 00:46:05,400

You know, you're looking at a place where our Sun,

1050

00:46:05,400 --> 00:46:07,000

our solar system, and your body

1051

00:46:07,000 --> 00:46:08,700

literally come from these places

1052

00:46:08,700 --> 00:46:09,900

that Hubble is taking a picture of --

1053

00:46:09,900 --> 00:46:11,400

these giant clouds

1054

00:46:11,400 --> 00:46:12,800

making every chemical element

1055

00:46:12,800 --> 00:46:15,200

that there is in the universe.

1056

00:46:15,200 --> 00:46:17,700

You are part of the story,

1057

00:46:17,700 --> 00:46:19,500

and I know that can seem hard.

1058

00:46:19,500 --> 00:46:21,900

Scientists can seem like very distant people,

1059

00:46:21,900 --> 00:46:23,700

very different from the rest of the world,

1060

00:46:23,700 --> 00:46:25,200

and we're completely not.

1061

00:46:25,200 --> 00:46:26,400

You know, scientists are you.

1062

00:46:26,400 --> 00:46:28,900

Scientists are your neighbors and your friends,

1063

00:46:28,900 --> 00:46:30,900

and if you've ever asked a question, you know,

1064

00:46:30,900 --> 00:46:32,500

or if you ever looked up into the night sky

1065

00:46:32,500 --> 00:46:34,700

with wonder, you know, you're one of us.

1066

00:46:34,700 --> 00:46:38,000

You know, you get to be included along with the scientists.

1067

00:46:38,000 --> 00:46:39,600

Hubble is, to us,

1068

00:46:39,600 --> 00:46:41,500

a piece of machinery

1069

00:46:41,500 --> 00:46:44,000

that we have put our hopes and our dreams

1070

00:46:44,000 --> 00:46:47,300

and our PhD dissertations and our arguments

1071

00:46:47,300 --> 00:46:49,400

and our frustrations into,

1072

00:46:49,400 --> 00:46:51,900

and 30 years on, you know,

1073

00:46:51,900 --> 00:46:56,200

this one metal cylinder up in space carries the souls

1074

00:46:56,200 --> 00:46:58,400

of tens of thousands of people,

1075

00:46:58,400 --> 00:47:00,200

and, you know,

1076

00:47:00,200 --> 00:47:01,900

that's something that just --

1077

00:47:01,900 --> 00:47:04,100

It's a wonderful part of being human.

1078

00:47:04,100 --> 00:47:06,200

What we touch begins to carry

1079

00:47:06,200 --> 00:47:08,200

part of our humanity with it.

1080

00:48:47,133 --> 00:47:17,700

■■■

1081

00:49:07,200 --> 00:49:09,033

-Congress wasn't at all sure

1082

00:49:09,033 --> 00:49:12,600

that it wanted to pay for the Hubble,

1083

00:49:12,600 --> 00:49:16,100

and it took, really, a major effort

1084

00:49:16,100 --> 00:49:18,433

on the part of the astronomical community

1085

00:49:18,433 --> 00:49:20,633

to lobby Congress to get it --

1086

00:49:20,633 --> 00:49:25,000

the final funding approved.

1087

00:49:25,000 --> 00:49:27,433

Proxmire, who was a --

1088

00:49:27,433 --> 00:49:29,133

You may not want to use this story,

1089

00:49:29,133 --> 00:49:30,600

but I think it's a good story.

1090

00:49:30,600 --> 00:49:32,000

-I'd love to hear it.

1091

00:49:32,000 --> 00:49:35,033

-Proxmire was noted

1092

00:49:35,033 --> 00:49:38,000

for the fact that --

1093

00:49:38,000 --> 00:49:39,833

of laughing at the ways

1094

00:49:39,833 --> 00:49:41,833

government wasted money,

1095

00:49:41,833 --> 00:49:46,833

and he sent a question to NASA headquarters saying,

1096

00:49:46,833 --> 00:49:49,433

"Why should the American taxpayer pay

1097

00:49:49,433 --> 00:49:52,133

for something like the Hubble?"

1098

00:49:52,133 --> 00:49:54,633

And I did a back-of-the-envelope calculation,

1099

00:49:54,633 --> 00:49:56,133

and my answer was that,

1100

00:49:56,133 --> 00:49:59,600

for the cost of a night at the movies,

1101

00:49:59,600 --> 00:50:01,300

every American taxpayer

1102

00:50:01,300 --> 00:50:05,633

would have 15 years of exciting discoveries,

1103

00:50:05,633 --> 00:50:08,633

and I may have been off by a factor of three or four,

1104

00:50:08,633 --> 00:50:11,100

depending on how you figure launch costs

1105

00:50:11,100 --> 00:50:14,033

and the servicing missions and some other things,

1106

00:50:14,033 --> 00:50:16,033

but even if it ended up being one night

1107

00:50:16,033 --> 00:50:18,100

at the movies every year,

1108

00:50:18,100 --> 00:50:20,733

I think Hubble has been worth it.