The PATHFINDERS

1
00:00:03,803 --> 00:00:07,407
>> In a post Cold War world
of shrinking space budgets,

2
00:00:07,440 --> 00:00:11,611
NASA's Jet Propulsion Laboratory
in Pasadena, California

3
00:00:11,644 --> 00:00:15,948
was challenged to
reinvent itself.

4
00:00:15,981 --> 00:00:18,051
The lab's new
assignment from NASA:

5
00:00:18,084 --> 00:00:24,690
land safely on Mars in a
revolutionary new way.

6
00:00:24,723 --> 00:00:27,660
>> Mars is the hardest
planet to land on,

7
00:00:27,693 --> 00:00:30,696
and I want you to
do it cheaply.

8
00:00:30,729 --> 00:00:34,667
>> But could it be done?

9
00:00:34,700 --> 00:00:38,604
And who was brave or foolish
enough to sign up

10
00:00:38,637 --> 00:00:40,306
for such a risky mission?

11
00:00:40,339 --> 00:00:42,608

>> Nobody else wanted the job.

12
00:00:42,641 --> 00:00:44,377
They were afraid
to death of it.

13
00:00:47,746 --> 00:00:51,150
The rest of the lab was going,
"What are these guys doing?",

14
00:00:51,183 --> 00:00:52,452
because all
they could see

15
00:00:52,485 --> 00:00:56,923
is the most embarrassing
failure as possible.

16
00:00:56,956 --> 00:00:59,092
>> Added to the challenges
was the addition

17
00:00:59,125 --> 00:01:02,028
of an unexpected passenger.

18
00:01:02,061 --> 00:01:03,830
>> Ugh, that silly
little rover.

19
00:01:03,863 --> 00:01:06,733
It was not popular
with anybody.

20
00:01:08,501 --> 00:01:09,836
>> "Command error?"

21
00:01:09,869 --> 00:01:11,104
What's going on now?

22

00:01:11,137 --> 00:01:12,171
What's broken now?

23
00:01:12,204 --> 00:01:13,606
This thing's falling
apart on me.

24
00:01:13,639 --> 00:01:16,609
>> If you crash, you're going
to crash and burn big time.

25
00:01:16,642 --> 00:01:18,544
>> You're not allowed to fail.

26
00:01:18,577 --> 00:01:20,680
Don't you dare fail.

27
00:01:20,713 --> 00:01:24,184
Do whatever you need to do,
but don't fail.

28
00:01:43,569 --> 00:01:44,937
>> Thank you, everybody.

29
00:01:44,970 --> 00:01:47,807
Here to JPL in
Pasadena, California

30
00:01:47,840 --> 00:01:50,376
for the twentieth anniversary of
Mars Pathfinder,

31
00:01:50,409 --> 00:01:53,746
the mission that
began what is now

32
00:01:53,779 --> 00:01:56,116
a continuous
presence on Mars

33
00:01:56,515 --> 00:01:59,585
24/7 for twenty years.

34
00:01:59,618 --> 00:02:03,556
Now, to celebrate this
achievement, we have with us

35
00:02:03,589 --> 00:02:06,192
some of the movers
and shakers and doers

36
00:02:06,225 --> 00:02:08,561
who made Pathfinder
possible.

37
00:02:08,594 --> 00:02:10,963
So if you will, hold your
applause until after I've

38
00:02:10,996 --> 00:02:13,232
introduced them all.

39
00:02:13,265 --> 00:02:17,937
Here on my left is former NASA
administrator and the longest

40
00:02:17,970 --> 00:02:21,274
serving NASA administrator,
Dan Goldin.

41
00:02:21,307 --> 00:02:24,343
Former JPL Director,
Ed Stone.

42
00:02:24,376 --> 00:02:27,580
Former JPL Director,
Charles Elachi.

43
00:02:27,613 --> 00:02:31,684

And on this side, current
Director, Mike Watkins.

44
00:02:31,717 --> 00:02:36,055
And two of the very most
important folks that worked on

45
00:02:36,088 --> 00:02:38,891
the engineering side of
Pathfinder, the doers that

46
00:02:38,924 --> 00:02:41,627
made it work, Jennifer Trosper
and Brian Muirhead.

47
00:02:41,660 --> 00:02:46,666
Would you please give
them a warm welcome?

48
00:02:46,699 --> 00:02:55,741
[Appause]

49
00:02:55,774 --> 00:02:58,711
That is indeed
a warm welcome.

50
00:02:58,744 --> 00:03:00,379
So Mike, why don't
you start us off.

51
00:03:00,412 --> 00:03:02,014
What is it about this
place called Mars

52
00:03:02,047 --> 00:03:04,350
that's so special
for people?

53
00:03:04,383 --> 00:03:08,087
>> I think Mars holds a

special place in everyone's

54
00:03:08,120 --> 00:03:09,655
heart because it looks
a lot like the Earth.

55
00:03:09,688 --> 00:03:11,824
I mean, it looks like a place
we could live, it looks like a

56
00:03:11,857 --> 00:03:15,428
place that we understand, and
we could be at home on.

57
00:03:15,461 --> 00:03:18,130
And it begs the question of
what was its history, and how

58
00:03:18,163 --> 00:03:20,733
did it get the way it is, and
could there have been life

59
00:03:20,766 --> 00:03:22,435
there, could it have been
habitable?

60
00:03:22,468 --> 00:03:25,004
And I think it goes back a
long time, that people have

61
00:03:25,037 --> 00:03:27,773
wanted to answer those
questions and to get there.

62
00:03:27,806 --> 00:03:34,347
And I believe that Pathfinder
in particular, it helped us

63
00:03:34,380 --> 00:03:36,983
understand a new way of

exploring the planets.

64
00:03:37,016 --> 00:03:39,218
You know, you could argue that
Viking as the first planetary

65
00:03:39,251 --> 00:03:43,122
lander sort of pioneered in situ
science, but that was

66
00:03:43,155 --> 00:03:45,524
kind of a one-off mission.

67
00:03:45,557 --> 00:03:48,594
And I think Pathfinder showed
us not only that mobility can

68
00:03:48,627 --> 00:03:52,098
be useful, but the notion of
an ongoing interactive

69
00:03:52,131 --> 00:03:55,101
exploration of a planet, a
voyage of discovery, a mission

70
00:03:55,134 --> 00:03:58,037
of discovery, of continuous
discovery, is something that

71
00:03:58,070 --> 00:03:59,739
we really learned from
Pathfinder.

72
00:03:59,772 --> 00:04:02,875
And not only have we continued
to extend that legacy, as you

73
00:04:02,908 --> 00:04:05,711
mentioned, for twenty years,
on Mars with bigger and better

74
00:04:05,744 --> 00:04:09,015
rovers as we try to understand
and unlock the mysteries of

75
00:04:09,048 --> 00:04:11,817
Mars and answer these
questions, but it's a paradigm

76
00:04:11,850 --> 00:04:14,186
that we talk about using even
for Europa now.

77
00:04:14,219 --> 00:04:16,856
We talk about "how do we do an
interactive mission of

78
00:04:16,889 --> 00:04:18,658
discovery on other planets?

79
00:04:18,691 --> 00:04:19,892
On these ocean worlds?

80
00:04:19,926 --> 00:04:24,096
How can we emulate this Mars
mission of discovery in other

81
00:04:24,129 --> 00:04:26,866
places that are just as
fascinating as Mars?"

82
00:04:26,899 --> 00:04:30,803
>> Now, I'd like to set the
stage now as we go back

83
00:04:30,836 --> 00:04:35,107
20 years to a very
different time

84

00:04:35,140 --> 00:04:37,877
when a lot of change
was happening.

85
00:04:37,910 --> 00:04:40,613
And I think this clip
you're about to see

86
00:04:40,646 --> 00:04:44,250
will set it nicely for us.

87
00:04:44,917 --> 00:04:48,587
[Crowd chanting]

88
00:04:48,620 --> 00:04:52,225
>> In 1989, the
Berlin Wall fell,

89
00:04:52,691 --> 00:04:55,161
[Crowd cheers]

90
00:04:55,194 --> 00:04:57,930
marking the beginning
of the end of the Soviet Union,

91
00:04:58,964 --> 00:05:00,767
the end of the Cold
War,

92
00:05:03,302 --> 00:05:06,038
and the beginning of a decade
of shrinking budgets

93
00:05:06,071 --> 00:05:08,274
for America's space program.

94
00:05:11,009 --> 00:05:13,412
And "that meant major changes,"

95

00:05:13,445 --> 00:05:17,249
declared the new head of
NASA, Dan Goldin.

96
00:05:17,282 --> 00:05:19,352
>> It is scary.

97
00:05:19,718 --> 00:05:23,356
I can't promise that
everything's gonna be okay.

98
00:05:23,789 --> 00:05:26,392
>> To the shock of many,
Goldin predicted that

99
00:05:26,425 --> 00:05:29,762
the space agency's very
survival was in doubt

100
00:05:29,795 --> 00:05:31,897
unless it embraced change.

101
00:05:31,930 --> 00:05:35,968
>> But I can promise that if
we go for the survival mode,

102
00:05:36,001 --> 00:05:38,371
as an agency, in five
years we're dead.

103
00:05:40,239 --> 00:05:43,142
So let me walk you through
some of the issues...

104
00:05:43,175 --> 00:05:46,312
>> Goldin delivered the same
message at JPL.

105
00:05:46,345 --> 00:05:48,280
>> We'll never ever go back.

106
00:05:48,313 --> 00:05:51,150
JPL will never ever
look like it did.

107
00:05:51,183 --> 00:05:55,321
You will not build very many
spacecraft that look like this.

108
00:05:56,855 --> 00:06:00,626
You've got to erase that
from your mind.

109
00:06:00,659 --> 00:06:03,095
>> He wanted JPL to show how
all of NASA

110
00:06:03,128 --> 00:06:04,797
could approach its
work differently

111
00:06:04,830 --> 00:06:07,200
in the post
Cold War world;

112
00:06:07,966 --> 00:06:12,705
a concept Goldin called,
"Faster. Better. Cheaper."

113
00:06:13,605 --> 00:06:18,210
>> Part of his charge was in
fact to oversee the transition

114
00:06:18,243 --> 00:06:21,313
of the agency to new
direction, new scale missions

115
00:06:21,346 --> 00:06:23,282
and science in particular.

116
00:06:23,315 --> 00:06:27,186
>> The Jet Propulsion Lab is
going to be the catalyst

117
00:06:27,219 --> 00:06:30,556
to change the whole
NASA space program.

118
00:06:30,589 --> 00:06:33,259
>> So I was trying to
understand exactly what kinds

119
00:06:33,292 --> 00:06:35,060
of things he was
trying to promote,

120
00:06:35,093 --> 00:06:37,396
and how we could then
make them real.

121
00:06:37,429 --> 00:06:39,398
Our job was to
make them real.

122
00:06:39,431 --> 00:06:41,834
>> My words was I wanted
to darken the skies

123
00:06:41,867 --> 00:06:44,804
with a lot of satellites
and spacecraft,

124
00:06:44,837 --> 00:06:46,872
and I wanted
the American people

125
00:06:46,905 --> 00:06:49,508
to share in the excitement.

126

00:06:49,541 --> 00:06:52,445
And the first thing they did
was the Mars Pathfinder.

127
00:06:55,114 --> 00:06:53,880
Brilliant.

128
00:06:56,782 --> 00:07:02,221
>> So Dan, you came out here,
and in some of those same talks,

129
00:07:02,254 --> 00:07:05,191
you talked about the
change that was happening

130
00:07:05,224 --> 00:07:07,359
was at the speed of light.

131
00:07:07,392 --> 00:07:11,397
And you told a story about
going to Russia and visiting

132
00:07:11,430 --> 00:07:15,268
a facility, I wonder if you
could tell that story.

133
00:07:16,134 --> 00:07:20,239
>> I was sitting in my
office in early June,

134
00:07:20,272 --> 00:07:23,275
and I got a call from
the Vice President,

135
00:07:23,308 --> 00:07:27,680
and he said, "I'd like
you to show up at Blair House."

136
00:07:28,881 --> 00:07:33,752
I went to Blair House, and I

walked in, and I saw

137
00:07:33,785 --> 00:07:37,957
Yuri Koptev, the head of the
Russian Space Agency,

138
00:07:37,990 --> 00:07:40,359
standing outside.

139
00:07:40,392 --> 00:07:42,428
And I said, "Yuri, what's
going on here?

140
00:07:42,461 --> 00:07:44,196
I don't know where I'm going."

141
00:07:44,229 --> 00:07:47,933
And he said, "Well, the head
of the National Academy of

142
00:07:47,966 --> 00:07:51,003
Sciences of Russia wouldn't
let me into the meeting."

143
00:07:51,036 --> 00:07:55,341
I walk in, and there is Boris
Yeltsin sitting on the other

144
00:07:55,374 --> 00:07:59,645
side of the table, and a whole
variety of people from the

145
00:07:59,678 --> 00:08:01,113
Russian space agency,

146
00:08:01,213 --> 00:08:03,782
and me.

147
00:08:03,815 --> 00:08:08,387

And I walked up to Boris
Yeltsin through a translator

148
00:08:08,420 --> 00:08:11,924
and said, "My colleague,
Yuri Koptev,

149
00:08:11,957 --> 00:08:14,360
is not allowed
in the room."

150
00:08:14,393 --> 00:08:18,197
And the head of the National
Academy of Sciences from Russia,

151
00:08:18,230 --> 00:08:22,434
he had flames coming
out of his nostril.

152
00:08:22,467 --> 00:08:23,936
It was unbelievable.

153
00:08:23,969 --> 00:08:29,775
And, they asked Yuri to come
in, and I was then working for

154
00:08:29,808 --> 00:08:34,580
President George
H.W. Bush, Bush 41.

155
00:08:34,613 --> 00:08:39,385
And he was very concerned, as
was President Clinton, as was

156
00:08:39,418 --> 00:08:44,557
Bush 43, about the Russian
pride in their space program,

157
00:08:44,590 --> 00:08:47,359
and that their

economy had crashed,

158
00:08:47,392 --> 00:08:50,696
which is why the
Cold War ended.

159
00:08:50,729 --> 00:08:54,500
And he wanted me to bring our
programs together, and I

160
00:08:54,533 --> 00:08:59,872
worked with Boris Yeltsin to
come to Russia, and I knew I

161
00:08:59,905 --> 00:09:03,108
was going to be transferring
funds to Russia to help them,

162
00:09:03,141 --> 00:09:08,414
so I asked him if he's take me
into the SS18 factory, which I

163
00:09:08,447 --> 00:09:13,852
knew a lot about, and that's
where they built the giant

164
00:09:13,885 --> 00:09:20,126
multiple warhead vehicle in
Nepuputrusk at Uzniah.

165
00:09:21,026 --> 00:09:24,830
So he opened up the whole
Russian space program to me,

166
00:09:24,863 --> 00:09:29,401
and it was weird because I'd
went against Russia for

167
00:09:29,434 --> 00:09:32,638
twenty-five years, and I

designed a lot of systems that

168
00:09:32,671 --> 00:09:33,772
I can't talk about, but...

169
00:09:33,806 --> 00:09:36,175
>> Some of them were targeting
that same place, right?

170
00:09:36,208 --> 00:09:37,376
>> Hypothetically.

171
00:09:37,409 --> 00:09:41,714
[Laughter]

172
00:09:41,747 --> 00:09:45,050
>> And during your
confirmation hearings, you

173
00:09:45,083 --> 00:09:49,655
went around, made your visits
to various senators, and

174
00:09:49,688 --> 00:09:56,328
Senator Hollings painted a
sort of dire picture of this

175
00:09:56,361 --> 00:09:58,163
job you were thinking about
taking on.

176
00:09:58,196 --> 00:10:01,767
This is why you felt there had
to be this sort of revolution,

177
00:10:01,800 --> 00:10:02,768
did you not?

178
00:10:02,801 --> 00:10:05,170

>> Well, I'll tell you, I was
pretty excited,

179
00:10:05,203 --> 00:10:08,007
but I knew it
was problematic.

180
00:10:08,040 --> 00:10:12,344
And I knew it was going to be
really hard when I walked into

181
00:10:12,377 --> 00:10:15,414
the office of Senator Fritz
Hollings, and he told me to

182
00:10:15,447 --> 00:10:18,484
sit down, and he drew a chart
on the wall.

183
00:10:18,517 --> 00:10:23,188
And on the ordinate was
billions of dollars and on the

184
00:10:23,221 --> 00:10:25,658
abscissa was years.

185
00:10:25,691 --> 00:10:30,362
So he started in 1992, and he
drew a straight line up that

186
00:10:30,395 --> 00:10:32,798
went to 2002.

187
00:10:32,831 --> 00:10:36,869
And it started at 15 billion
and it went to 25.

188
00:10:36,902 --> 00:10:41,974
And then, he went to 1992 at
15 billion, and drew a

189
00:10:42,007 --> 00:10:44,009
straight line across.

190
00:10:44,042 --> 00:10:46,979
And he said, "If you want to
be confirmed, you're going to

191
00:10:47,012 --> 00:10:49,515
sign up to a no
growth budget."

192
00:10:49,548 --> 00:10:52,518
I said, "But that's 50
billion dollars."

193
00:10:52,551 --> 00:10:53,519
He said, "You'll
sign up to that

194
00:10:53,552 --> 00:10:55,154
or there'll
be no space program,

195
00:10:55,187 --> 00:10:57,489
what do you
want to do?"

196
00:10:57,522 --> 00:11:00,626
And then he went on to say,
"The shuttle is grounded,

197
00:11:00,659 --> 00:11:02,628
it's got hydrogen leaks.

198
00:11:02,661 --> 00:11:06,365
The space station spent all
their money and all their time.

199

00:11:06,398 --> 00:11:08,333
They have nothing.

200
00:11:08,366 --> 00:11:12,871
Galileo is deaf on
its way to Jupiter.

201
00:11:12,904 --> 00:11:14,840
Hubble is blind.

202
00:11:14,873 --> 00:11:18,877
And the weather
satellites are dead.

203
00:11:18,910 --> 00:11:22,648
Are you sure you
want this job?"

204
00:11:22,681 --> 00:11:25,551
And I said, "You bet."

205
00:11:25,584 --> 00:11:32,091
I said, "Because money is not
the magic ingredient, and that

206
00:11:32,124 --> 00:11:36,161
we need to re-invigorate the
science and technology

207
00:11:36,194 --> 00:11:39,498
creativity of the NASA team.

208
00:11:39,531 --> 00:11:41,133
And they haven't been
allowed to do that.

209
00:11:41,166 --> 00:11:42,901
I'm signing up."

210

00:11:42,934 --> 00:11:48,474
>> Ed, you had a similar sort
of realization when you were

211
00:11:48,507 --> 00:11:49,575
coming into the job,
and you went

212
00:11:49,608 --> 00:11:52,511
to visit Washington and OMB.

213
00:11:52,544 --> 00:11:55,547
And you had a stark
realization too.

214
00:11:55,580 --> 00:11:56,815
>> That's right.

215
00:11:56,848 --> 00:11:59,318
When I agreed to be Director,
it was the summer of 1990, and

216
00:11:59,351 --> 00:12:01,720
I started in January '91.

217
00:12:01,753 --> 00:12:04,490
The program was exactly as you
described it, like that, it

218
00:12:04,523 --> 00:12:07,593
was going to double in
basically a ten year period,

219
00:12:07,626 --> 00:12:09,528
and it was clear
the job I had was

220
00:12:09,561 --> 00:12:12,097
how to handle
all that growth.

221
00:12:12,130 --> 00:12:16,969
But, a visit to Washington
taught me into early '91

222
00:12:17,002 --> 00:12:20,506
already that except for NASA,
which still believed this was

223
00:12:20,539 --> 00:12:24,042
the future, the rest of the
congress and the White House

224
00:12:24,075 --> 00:12:26,078
was saying, "that's
the future."

225
00:12:26,111 --> 00:12:27,880
>> It was a crisis.

226
00:12:27,913 --> 00:12:32,050
>> And I know that you and Ed
worked very closely on this,

227
00:12:32,083 --> 00:12:35,821
and Ed, you, when given
this opportunity...

228
00:12:35,854 --> 00:12:38,624
>> We worked closely,
but he executed.

229
00:12:38,657 --> 00:12:39,725
I gave directions.

230
00:12:39,758 --> 00:12:40,659
>> That's right.

231
00:12:40,692 --> 00:12:41,627

That's right.

232
00:12:41,660 --> 00:12:43,562
It was to make it real,
as you said...

233
00:12:43,595 --> 00:12:45,030
>> Make it real,
that's right.

234
00:12:45,063 --> 00:12:50,169
Three years to launch, less
150 million dollars.

235
00:12:50,202 --> 00:12:51,637
Land on Mars.

236
00:12:51,670 --> 00:12:54,006
150 million dollars.

237
00:12:54,039 --> 00:12:57,009
Now ahead of rover, which they
added 25 for because, again,

238
00:12:57,042 --> 00:12:59,178
that was part of the advanced
technology, but it was a

239
00:12:59,211 --> 00:13:02,247
challenge, clearly, it was a
major challenge and a major

240
00:13:02,280 --> 00:13:05,250
risk that the laboratory
took to do this.

241
00:13:05,283 --> 00:13:09,454
But it really exposed the
innovation that is possible.

242
00:13:09,487 --> 00:13:11,990
>> And we had to do something
bold, it just couldn't be

243
00:13:12,023 --> 00:13:15,727
another orbiter, another this,
another that.

244
00:13:15,760 --> 00:13:21,166
It had to be really hard and
when you compare what is cost

245
00:13:21,199 --> 00:13:23,769
for Viking, that was billions.

246
00:13:23,802 --> 00:13:25,771
Okay, now we're factor
of 20 on cost,

247
00:13:25,804 --> 00:13:27,639
and factor of three
on schedule

248
00:13:27,672 --> 00:13:31,877
with technology that
they didn't have time to

249
00:13:31,910 --> 00:13:37,549
develop in advance, but again,
it came down to we didn't have

250
00:13:37,582 --> 00:13:41,286
much that year, and we needed
this to be successful.

251
00:13:41,319 --> 00:13:47,092
So I said, "Take risk,
but don't fail."

252

00:13:47,125 --> 00:13:50,729
>> Let me talk about the
background of how that was the

253
00:13:50,762 --> 00:13:55,267
background that Dan and
Ed talked about.

254
00:13:55,300 --> 00:13:57,870
Remember Dan came
in April '92.

255
00:13:57,903 --> 00:14:00,005
>> April 1st.

256
00:14:00,038 --> 00:14:03,675
>> Then in August '93,
we lost Mars Observer.

257
00:14:03,708 --> 00:14:08,113
And I remember very clearly, a
couple of weeks after that,

258
00:14:08,146 --> 00:14:10,515
I'm not sure if you remember,
that I was at home.

259
00:14:10,548 --> 00:14:11,717
At that time I was the
director for

260
00:14:11,750 --> 00:14:14,586
science, technology,
and instruments.

261
00:14:14,619 --> 00:14:16,889
And I remember exactly
where I was standing,

262
00:14:16,922 --> 00:14:19,825

I was watering the yard, it
was on a weekend.

263
00:14:19,858 --> 00:14:21,026
And my wife
comes and says,

264
00:14:21,059 --> 00:14:23,528
"Hey Wes Huntress
is on the line."

265
00:14:23,561 --> 00:14:25,364
I wonder what this is about?

266
00:14:25,397 --> 00:14:26,832
So I walked then
picked up the phone...

267
00:14:26,865 --> 00:14:31,303
Yes, he was head of the NASA
science at that time...

268
00:14:31,336 --> 00:14:33,906
So he said, "Well, I just
talked with Ed Stone,

269
00:14:33,939 --> 00:14:36,742
Dan Goldin would like you
to chair a tiger team

270
00:14:36,775 --> 00:14:39,945
to look at small
Mars missions.

271
00:14:39,978 --> 00:14:42,214
And you have only a couple of
weeks to do that."

272
00:14:42,247 --> 00:14:46,318
Now, many of you heard about

Dan Goldin and many of you

273
00:14:46,351 --> 00:14:49,554
know Dan Goldin, you never say
no for Dan Goldin.

274
00:14:49,587 --> 00:14:52,090
When he asks for something,
you say, "Yes, sir."

275
00:14:52,123 --> 00:14:55,727
So anyway, we formed a tiger
team, which included JPLers

276
00:14:55,760 --> 00:14:58,497
included external people,
included [unintelligible].

277
00:14:58,697 --> 00:15:00,766
Ed referred to the small
spacecraft that the

278
00:15:00,799 --> 00:15:04,369
military were developing.

279
00:15:04,402 --> 00:15:08,941
And we met in building 180-101
for over a few days and we

280
00:15:08,974 --> 00:15:11,543
came with a number of ideas, you
know, collectively, one of them

281
00:15:11,576 --> 00:15:12,878
being a lander,

282
00:15:12,911 --> 00:15:15,180
and we transmitted
that to headquarters.

283
00:15:15,213 --> 00:15:17,783
And of course Dan
picked up the lander.

284
00:15:17,816 --> 00:15:20,652
It was no big surprise.

285
00:15:20,685 --> 00:15:23,522
But at that time there
was no rover on it.

286
00:15:23,555 --> 00:15:28,427
So the focus was on how do we
land with a low cost on Mars,

287
00:15:28,460 --> 00:15:29,995
and to do it in three
years like Ed said.

288
00:15:30,028 --> 00:15:34,199
But then there was, in my
office, a lady by the name of

289
00:15:34,232 --> 00:15:35,801
Donna Shirley.

290
00:15:35,834 --> 00:15:37,869
She was an engineer
working on robotics.

291
00:15:37,902 --> 00:15:40,238
She comes to me and said, "You
know, you remember that rover

292
00:15:40,271 --> 00:15:41,773
we showed you a
few weeks ago?

293
00:15:41,806 --> 00:15:44,643

We think we can build
that rover in time

294
00:15:44,676 --> 00:15:46,111
to put it on the
mission."

295
00:15:46,144 --> 00:15:47,679
So of course I went
to Tony Spear,

296
00:15:47,712 --> 00:15:49,247
and Tony said,
"Look,

297
00:15:49,280 --> 00:15:52,718
I have a deadline, I
have a limited budget.

298
00:15:52,751 --> 00:15:55,120
Get the hell out of here."

299
00:15:55,153 --> 00:15:58,256
Well as you know me I don't
take no for an answer.

300
00:15:58,289 --> 00:16:00,359
So I went to Wes Huntress.

301
00:16:00,392 --> 00:16:02,027
Wes was intrigued,
but he said,

302
00:16:02,060 --> 00:16:04,296
"I don't know where to
get the money."

303
00:16:04,329 --> 00:16:06,531
So I went to Sam Vineri,
who was at that time

304
00:16:06,564 --> 00:16:08,166
in charge of technology.

305
00:16:08,199 --> 00:16:10,168
So after a little
while, Sam said,

306
00:16:10,201 --> 00:16:12,337
"I'll pay with
the 25 million

307
00:16:12,370 --> 00:16:14,673
if you can get it on
the mission."

308
00:16:14,706 --> 00:16:18,343
So I went back to Wes, and Wes
told me, "Give me 25...

309
00:16:18,376 --> 00:16:20,078
>> Sam came to me.

310
00:16:20,111 --> 00:16:22,347
>> Yeah, well let me
continue the story.

311
00:16:22,380 --> 00:16:24,916
So Wes told me, "Give me 24
hours" and I kind of guessed

312
00:16:24,949 --> 00:16:27,719
what he wanted the
24 hours for.

313
00:16:27,752 --> 00:16:31,323
So by the time I got here, Wes
must have talked with you,

314

00:16:31,356 --> 00:16:33,492
Dan said this is a bold
thing we want to do

315
00:16:33,525 --> 00:16:35,160
in addition to the landing,

316
00:16:35,193 --> 00:16:38,897
and that's how of course
when Wes said "go ahead"

317
00:16:38,930 --> 00:16:40,465
and then Ed said
"go ahead"

318
00:16:40,498 --> 00:16:43,101
and Tony Spear said
"yes sir" move on that,

319
00:16:43,134 --> 00:16:46,071
and that's how the
rover came about.

320
00:16:46,104 --> 00:16:49,641
And look at the legacy that
rover have led to,

321
00:16:49,674 --> 00:16:54,379
to Spirit, Opportunity,
Curiosity, and then Mars 2020.

322
00:16:54,412 --> 00:16:58,683
And that's the kind of small
but visionary technology

323
00:16:58,716 --> 00:17:02,854
investment, that NASA and Dan
was very well known for,

324
00:17:02,887 --> 00:17:07,025

which led us to do the great
things that we do now.

325
00:17:07,058 --> 00:17:10,362
And in my mind, I'm sure all
of you know how much I like

326
00:17:10,395 --> 00:17:13,131
the Mars helicopter that
is being looked at

327
00:17:13,164 --> 00:17:14,866
for the Mars 2020.

328
00:17:14,899 --> 00:17:17,669
In my mind, that's exactly
the same example.

329
00:17:17,702 --> 00:17:20,272
It's a bold technology
experiment,

330
00:17:20,305 --> 00:17:22,941
high risk relatively
speaking,

331
00:17:22,974 --> 00:17:25,010
but I'm sure
you'll make it work.

332
00:17:25,043 --> 00:17:27,779
And I'll bet you 20 years from
now people sitting here will be

333
00:17:27,812 --> 00:17:31,416
talking about airplanes and
balloons and helicopters

334
00:17:31,449 --> 00:17:33,351
flying and exploring Mars.

335
00:17:33,384 --> 00:17:36,154
That's the kind of thing the
kind of leadership that

336
00:17:36,187 --> 00:17:39,191
Dan provided at that
time and then Ed,

337
00:17:39,224 --> 00:17:40,725
when he was
the director,

338
00:17:40,758 --> 00:17:43,995
which really made the
revolution you see today.

339
00:17:44,028 --> 00:17:47,799
So really, Pathfinder had the
legacy not only in the landing

340
00:17:47,832 --> 00:17:51,703
and the airbags, but also in
the rovers that you see today.

341
00:17:51,736 --> 00:17:54,439
>> In fact, let's
look at the EDL,

342
00:17:54,472 --> 00:17:57,409
we have actually
the very original,

343
00:17:57,442 --> 00:18:00,512
literally
back-of-the-envelope designs,

344
00:18:00,545 --> 00:18:01,947
when this first came up.

345
00:18:01,980 --> 00:18:05,084
So if we could roll
that clip, please.

346
00:18:07,118 --> 00:18:09,955
>> Some of the original ideas
for an airbag landing

347
00:18:09,988 --> 00:18:13,758
were these back-of-the-envelope
sketches.

348
00:18:13,791 --> 00:18:17,095
As the plan envisioned,
Pathfinder dives into the

349
00:18:17,128 --> 00:18:21,566
Martian atmosphere
at 16,000 mph.

350
00:18:21,599 --> 00:18:25,003
Protected by its heat shield,
the spacecraft burns through

351
00:18:25,036 --> 00:18:30,642
the Martian atmosphere,
reducing its speed to 900 mph.

352
00:18:30,675 --> 00:18:33,512
Next, a parachute is deployed.

353
00:18:33,545 --> 00:18:36,815
Then the heat shield and back
shell are jettisoned

354
00:18:36,848 --> 00:18:40,552
and a rope drops to
detect the ground.

355

00:18:40,585 --> 00:18:42,621
The airbags inflate.

356
00:18:42,654 --> 00:18:46,925
Seconds later, the lander hits
the surface at 50 mph,

357
00:18:46,958 --> 00:18:49,828
bouncing stories high.

358
00:18:49,861 --> 00:18:55,267
After the lander finally comes
to rest, the airbags deflate,

359
00:18:55,300 --> 00:18:58,603
and an antenna rises up,
transmitting back to earth the

360
00:18:58,636 --> 00:19:04,877
news that the lander is
somehow still in one piece.

361
00:19:05,543 --> 00:19:07,479
>> Brian Muirhead...

362
00:19:07,512 --> 00:19:08,647
>> Piece of cake, Brian.

363
00:19:08,680 --> 00:19:09,514
>> That's right.

364
00:19:09,547 --> 00:19:10,748
>> That's what I
was going to say.

365
00:19:10,782 --> 00:19:14,386
>> How did you feel about this
mission when you took it on?

366

00:19:14,419 --> 00:19:17,455
>> Well it's interesting, I
was in a really nice job

367
00:19:17,488 --> 00:19:19,524
at that time, I was a
section manager,

368
00:19:19,557 --> 00:19:23,028
and I ended up talking to
Charles Elachi about well,

369
00:19:23,061 --> 00:19:24,729
this is a pretty
crazy mission,

370
00:19:24,762 --> 00:19:25,997
it's not clear it's going
to get funded,

371
00:19:26,030 --> 00:19:27,265
what should I do?

372
00:19:27,298 --> 00:19:29,067
He said, "Well, just stay
where you are for a minute,

373
00:19:29,100 --> 00:19:31,236
a little while longer, and let's
see what happens to the budget."

374
00:19:31,269 --> 00:19:38,143
When the budget came through,
then I jumped to Tony's call,

375
00:19:38,176 --> 00:19:41,846
and from that point on, it was
my job to staff the team

376
00:19:41,879 --> 00:19:47,352

that would design, build, test,
and operate this spacecraft.

377
00:19:47,385 --> 00:19:50,021
>> And there were a lot of
challenges, what would you say

378
00:19:50,054 --> 00:19:53,625
was the one that kept you up
the most at night?

379
00:19:53,658 --> 00:19:56,061
>> It has to be, if you're
going to Mars, it's always

380
00:19:56,094 --> 00:19:57,329
entry, decent and landing.

381
00:19:57,362 --> 00:19:58,897
That's what you
worry about.

382
00:19:58,930 --> 00:20:03,735
And of course, for us, we had
to invent and reinvent pieces

383
00:20:03,768 --> 00:20:06,104
of the entry, decent and
landing system.

384
00:20:06,137 --> 00:20:08,907
The biggest invention, of
course, was the airbags.

385
00:20:08,940 --> 00:20:13,178
And that was something that
when we started out,

386
00:20:13,211 --> 00:20:14,846
we did what normal

engineers do.

387
00:20:14,879 --> 00:20:17,182
We'd bring out our, onboard
our computers,

388
00:20:17,215 --> 00:20:18,583
and we model things.

389
00:20:18,616 --> 00:20:20,819
>> And we have a clip that
will give some sense of that,

390
00:20:20,852 --> 00:20:23,155
as well, if we could
roll that one.

391
00:20:24,188 --> 00:20:26,157
>> This is the surface
of the atmosphere.

392
00:20:26,190 --> 00:20:27,926
We're coming in and
we have to...

393
00:20:27,959 --> 00:20:30,262
>> I had never been a
flight system manager.

394
00:20:30,295 --> 00:20:33,331
I had delivered sizeable
things at the lab,

395
00:20:33,364 --> 00:20:37,302
but nothing like the flight
system of a spacecraft.

396
00:20:39,070 --> 00:20:43,341
The people that came around me
on the flight-system team,

397
00:20:43,374 --> 00:20:49,814
we kind of accreted a team of
radical kind-of thinkers.

398
00:20:49,847 --> 00:20:53,385
>> Muirhead was open to new
ideas, but they had to be

399
00:20:53,418 --> 00:20:57,389
subjected to tried and
true methods of proof.

400
00:20:57,422 --> 00:21:02,628
>> which is build it, test it,
break it, fix it, do it again.

401
00:21:03,161 --> 00:21:06,831
>> But not everything
could be fully tested.

402
00:21:06,864 --> 00:21:10,468
>> I was very scared of the
parachute, I've got to tell you.

403
00:21:10,501 --> 00:21:13,271
Mostly that parachute was the
one thing we couldn't test

404
00:21:13,304 --> 00:21:16,408
in any realistic way.

405
00:21:16,441 --> 00:21:19,311
>> Assuming the parachute
worked, the next challenge

406
00:21:19,344 --> 00:21:21,813
was knowing when to
inflate the airbags.

407
00:21:21,846 --> 00:21:24,383
Just seconds before
hitting the ground.

408
00:21:25,983 --> 00:21:29,154
The original idea of hanging a
rope with a sensor at the bottom

409
00:21:29,187 --> 00:21:32,658
proved unworkable, so
radar was added,

410
00:21:33,024 --> 00:21:36,027
but that solution raised
new problems.

411
00:21:36,060 --> 00:21:38,229
>> The devil's in the details.

412
00:21:38,262 --> 00:21:40,632
That's where I got
into the picture,

413
00:21:40,665 --> 00:21:42,334
was in the devil's
in the details.

414
00:21:42,367 --> 00:21:45,670
Like for example, in some of
the drop tests, we do drop tests

415
00:21:45,703 --> 00:21:48,039
on parachutes and their
radar was dropping and taking

416
00:21:48,072 --> 00:21:50,842
measurements, and it was
swinging like you would

417

00:21:50,875 --> 00:21:52,911
imagine that it would be
swinging and then we realized

418
00:21:52,944 --> 00:21:55,080
that when the radar,
when it loses lock,

419
00:21:55,113 --> 00:21:59,017
it has all these horrible
altitude measurements.

420
00:21:59,050 --> 00:22:01,252
The radar tells you these are
good measurements,

421
00:22:01,285 --> 00:22:03,488
but they are
really bad.

422
00:22:05,690 --> 00:22:07,326
>> Release the item.

423
00:22:08,192 --> 00:22:11,730
>> To increase the chance of a
safe landing, rockets were

424
00:22:11,763 --> 00:22:15,467
added in hopes of further
slowing down the lander.

425
00:22:15,500 --> 00:22:17,536
[small rockets fire]

426
00:22:17,668 --> 00:22:21,807
[cheering]

427
00:22:22,140 --> 00:22:25,711
>> So there was a set of steps
we went through where

428
00:22:25,977 --> 00:22:28,747
smart people thought about how
to make it more reliable,

429
00:22:28,780 --> 00:22:30,648
but it just kind of
added more to the

430
00:22:30,681 --> 00:22:32,283
"here's something that goes
into this basket,

431
00:22:32,316 --> 00:22:34,085
and then that basket
dumps into this tray"

432
00:22:34,118 --> 00:22:35,520
I mean so it really
gives you that

433
00:22:35,553 --> 00:22:37,055
Rube Goldberg sort
of a feeling.

434
00:22:37,488 --> 00:22:38,923
[pounding]

435
00:22:38,956 --> 00:22:41,393
>> Then there were
the airbags.

436
00:22:41,426 --> 00:22:42,227
>> Here we go.

437
00:22:42,260 --> 00:22:43,561
Rolling.

438
00:22:43,594 --> 00:22:46,398

It's going the wrong way!

439
00:22:49,100 --> 00:22:51,669
>> I remember
working with Sandia.

440
00:22:51,702 --> 00:22:54,406
We used, they had the most
powerful computer in the world

441
00:22:54,439 --> 00:22:57,308
at that time, and we brought
it to its knees

442
00:22:57,341 --> 00:22:59,711
trying to simulate
this airbag.

443
00:23:00,845 --> 00:23:04,015
>> In the early 1990s,
computer processing capabilities

444
00:23:04,048 --> 00:23:06,551
was just getting
good enough that we could

445
00:23:06,584 --> 00:23:08,586
imagine really
bringing all of these

446
00:23:08,619 --> 00:23:10,489
simulation programs together,

447
00:23:11,255 --> 00:23:12,891
but there were
certain parts of it,

448
00:23:12,924 --> 00:23:17,028
we came to realize, you really
couldn't treat very well

449
00:23:17,061 --> 00:23:18,930
with a computer simulation.

450
00:23:19,464 --> 00:23:23,201
The airbags being by far the
way the foremost example.

451
00:23:25,636 --> 00:23:28,406
>> I would guess that we
didn't understand 90%

452
00:23:28,439 --> 00:23:31,076
of the fundamental physics
that goes into the airbag.

453
00:23:33,244 --> 00:23:36,948
I would also argue that
we did not understand

454
00:23:36,981 --> 00:23:39,651
50% at the end of Pathfinder.

455
00:23:39,751 --> 00:23:41,453
[laughter]

456
00:23:42,420 --> 00:23:46,825
>> So, as if you didn't have
enough problems already,

457
00:23:46,858 --> 00:23:49,627
you had a budget problem,
and a schedule problem,

458
00:23:49,660 --> 00:23:52,263
and an engineering problem.

459
00:23:52,296 --> 00:23:55,099
>> One of the biggest

engineering problems was mass,

460
00:23:55,132 --> 00:23:56,968
managing the mass.

461
00:23:57,001 --> 00:24:00,505
And one of the things we
learned very early on is

462
00:24:00,538 --> 00:24:03,975
it's not what we can launch,
it's what we can enter.

463
00:24:04,008 --> 00:24:07,378
And so the limit on what we
felt we could enter was driven

464
00:24:07,411 --> 00:24:11,616
by a ballistic coefficient,
and that's driven by the mass

465
00:24:11,649 --> 00:24:14,018
and the drag of the vehicle.

466
00:24:14,051 --> 00:24:18,189
So, part of my job as flight
system manager, I took on, was

467
00:24:18,222 --> 00:24:24,028
to manage the mass, and so
every gram we were sensitive to,

468
00:24:24,061 --> 00:24:25,864
and we had to be very
careful about.

469
00:24:25,897 --> 00:24:29,734
And I know the rover team
remembers this, but I was

470
00:24:29,767 --> 00:24:33,505
always threatening the rover
team, Bill Layman sitting here,

471
00:24:33,538 --> 00:24:35,807
with, "if you blow your
mass number,

472
00:24:35,840 --> 00:24:38,243
I'm throwing you off
the spacecraft."

473
00:24:38,276 --> 00:24:41,246
And I meant it, and
they believed me.

474
00:24:41,279 --> 00:24:44,249
And one of the things that I
learned from that experience,

475
00:24:44,282 --> 00:24:46,618
and what this place does so
well, when you hand them

476
00:24:46,651 --> 00:24:48,219
what looks to
be an impossible job,

477
00:24:48,252 --> 00:24:51,923
with impossible constraints,
they get very creative.

478
00:24:51,956 --> 00:24:54,826
And they found the solutions
to stay within the mass,

479
00:24:54,859 --> 00:24:57,061
to add ramps and still
stay within the mass.

480
00:24:57,094 --> 00:25:01,432
So it was a wonderful example
of how creative people can be

481
00:25:01,465 --> 00:25:03,234
when you give
them a tough job,

482
00:25:03,267 --> 00:25:06,771
and then give them the
freedom, the flexibility,

483
00:25:06,804 --> 00:25:08,973
to be creative about
how they do it.

484
00:25:09,006 --> 00:25:12,010
>> So you solved the
technical problems,

485
00:25:12,043 --> 00:25:15,146
you launched on time,
you launched...

486
00:25:15,179 --> 00:25:16,047
>> On budget.

487
00:25:16,080 --> 00:25:18,616
>> Which was probably
one of the more

488
00:25:18,649 --> 00:25:20,084
important aspects of this.

489
00:25:20,117 --> 00:25:21,119
>> Well we believed...

490
00:25:21,152 --> 00:25:22,620
>> They had become the

poster child for

491
00:25:22,653 --> 00:25:23,855
"Faster. Better. Cheaper."

492
00:25:23,888 --> 00:25:26,291
>> We really believed that if
we blew the budget,

493
00:25:26,324 --> 00:25:27,692
we'd be canceled.

494
00:25:27,725 --> 00:25:28,726
And everybody on ...

495
00:25:28,759 --> 00:25:30,128
>> Yes.

496
00:25:30,161 --> 00:25:31,963
[Laughter]

497
00:25:31,996 --> 00:25:33,464
>> We believed you,
Mr. Goldin.

498
00:25:33,497 --> 00:25:35,266
And there were times when
the bean counters,

499
00:25:35,299 --> 00:25:38,536
the budget guys, were
projecting my budget

500
00:25:38,569 --> 00:25:40,805
to go as badly as my
mass was going.

501
00:25:40,838 --> 00:25:44,242
So we were at risk, but one of

the things that was wonderful

502
00:25:44,275 --> 00:25:47,245
about our review board,
we had Jim Martin,

503
00:25:47,278 --> 00:25:50,615
the Viking project manager, was
our review board chairman.

504
00:25:50,648 --> 00:25:52,817
And when Jim spoke,
people listened.

505
00:25:52,850 --> 00:25:55,186
And so, Jim would look at the
bean counters' estimate,

506
00:25:55,219 --> 00:25:58,256
and he would say, "I can't prove
they won't make it,

507
00:25:58,289 --> 00:26:00,592
so then I'll let
them keep going."

508
00:26:00,625 --> 00:26:03,494
And he would call back to
headquarters and say,

509
00:26:03,527 --> 00:26:07,532
I think, "Don't kill 'em."

510
00:26:07,565 --> 00:26:09,233
[laughter]

511
00:26:09,266 --> 00:26:12,170
>> The Viking being 20 years
before, the Viking coming out

512
00:26:12,203 --> 00:26:14,138
of Langley, being
managed there,

513
00:26:14,171 --> 00:26:18,776
another contribution by another
NASA center in all of this.

514
00:26:18,809 --> 00:26:24,849
So you launched, and seven
months later, we were at

515
00:26:24,882 --> 00:26:28,519
entry, descent and landing on
July the fourth, a morning,

516
00:26:28,552 --> 00:26:31,056
and let's see what
that was like.

517
00:26:33,290 --> 00:26:35,226
>> This is the Mars Pathfinder
flight director,

518
00:26:35,259 --> 00:26:38,997
we are currently
approximately 15 minutes away

519
00:26:39,030 --> 00:26:40,832
from cruise stage separation,

520
00:26:40,865 --> 00:26:43,167
all telemetry continues
to look nominal.

521
00:26:43,200 --> 00:26:46,571
>> EDL comm reports spacecraft
ranging channel off event.

522

00:26:53,477 --> 00:26:56,681
EDL telecom reports cruise
stage separation.

523
00:26:56,714 --> 00:26:59,050
>> Alright, this is the Mars
Pathfinder flight director,

524
00:26:59,083 --> 00:27:03,088
we have confirmed that cruise
stage separation has occurred.

525
00:27:03,188 --> 00:27:04,355
[clapping]

526
00:27:04,388 --> 00:27:06,491
Alright we will now
pass EDL operations

527
00:27:06,524 --> 00:27:08,059
to our chief engineer,

528
00:27:08,092 --> 00:27:10,161
and entry, decent and landing
lead Rob Manning,

529
00:27:10,194 --> 00:27:12,630
who will report the
real-time EDL status.

530
00:27:12,663 --> 00:27:14,599
>> Really, there's these
few minutes where

531
00:27:14,632 --> 00:27:17,769
everybody wants to know what's
happening, and you just don't.

532
00:27:19,103 --> 00:27:22,407
It's scary and at the same

time, it's exciting as hell.

533
00:27:23,340 --> 00:27:26,344
>> The spacecraft now is
about 7500 kilometers

534
00:27:26,377 --> 00:27:28,579
above the surface of Mars.

535
00:27:28,612 --> 00:27:33,218
It's still traveling at about
7.4 kilometers per second.

536
00:27:35,820 --> 00:27:37,589
Very fast.

537
00:27:39,290 --> 00:27:41,626
>> We were all
apprehensive.

538
00:27:41,659 --> 00:27:44,295
There were so many things that
could have gone wrong,

539
00:27:44,328 --> 00:27:46,731
and everything had
to go right.

540
00:27:48,999 --> 00:27:51,102
>> 30 seconds till entry.

541
00:27:52,670 --> 00:27:56,174
Spacecraft is now slowing
down very rapidly.

542
00:28:02,780 --> 00:28:04,248
We expect that the
parachute will deploy

543

00:28:04,281 --> 00:28:06,284
in about 15 seconds.

544
00:28:08,385 --> 00:28:10,422
[wind rustling]

545
00:28:13,157 --> 00:28:14,926
Parachute has now deployed.

546
00:28:15,026 --> 00:28:16,394
[clapping]

547
00:28:16,494 --> 00:28:21,032
[wind]

548
00:28:21,665 --> 00:28:23,001
[thud]

549
00:28:25,102 --> 00:28:26,037
[metallic clank]

550
00:28:27,304 --> 00:28:29,741
Lander separation should have
have occurred right about now.

551
00:28:32,943 --> 00:28:34,446
Airbags should be inflated.

552
00:28:34,546 --> 00:28:35,613
[boom]

553
00:28:40,184 --> 00:28:41,886
[rockets fire]

554
00:28:43,921 --> 00:28:45,256
[impact]

555
00:28:49,527 --> 00:28:51,930

[multiple impacts]

556
00:28:52,329 --> 00:28:54,632
>> EDL Comm,
a weak signal

557
00:28:54,665 --> 00:28:56,768
is coming in and out
of the spectrum.

558
00:28:56,801 --> 00:28:57,469
>> Yes.

559
00:28:57,569 --> 00:28:58,136
>> Roger that.

560
00:28:58,402 --> 00:28:59,604
>> Yes!

561
00:28:59,637 --> 00:29:02,206
[air deflating]

562
00:29:02,239 --> 00:29:05,710
[dramatic music]

563
00:29:25,362 --> 00:29:28,900
[motor winding]

564
00:29:35,773 --> 00:29:38,543
>> What a moment

565
00:29:38,576 --> 00:29:41,179
Jennifer, take us there,
what happened then?

566
00:29:41,212 --> 00:29:43,114
What happened at that point?

567

00:29:43,147 --> 00:29:47,185
>> Well it was crazy exciting,
because everybody was

568
00:29:47,218 --> 00:29:50,087
screaming and jumping around,
and I actually think,

569
00:29:50,120 --> 00:29:53,925
I remember we got a call from
JSC, somebody passed along

570
00:29:53,958 --> 00:29:56,861
that they weren't happy with
the demeanor of the operations

571
00:29:56,894 --> 00:29:59,697
people, and that we needed to
kind of take it easy and

572
00:29:59,730 --> 00:30:04,068
be more controlled in the
Mission Support Area.

573
00:30:05,335 --> 00:30:08,639
But my job was, after landing,
I was the flight director for

574
00:30:08,672 --> 00:30:13,477
the team of folks who had to
do the interactive deployments

575
00:30:13,510 --> 00:30:16,347
and things we needed to do to
get the rover off the lander.

576
00:30:16,380 --> 00:30:21,085
So one of the first things we
did is we had to deploy

577

00:30:21,118 --> 00:30:25,823
the camera mast so that the
camera could look for the sun,

578
00:30:25,856 --> 00:30:29,193
and then based on where the sun
was, we could figure out where

579
00:30:29,226 --> 00:30:31,195
the earth was and then point
the high gain antenna

580
00:30:31,228 --> 00:30:35,032
towards the earth, and then take
and send down those very first

581
00:30:35,065 --> 00:30:38,736
images of Mars, which are the
picture of the rover

582
00:30:38,769 --> 00:30:42,173
on the petal in its
hunched down position.

583
00:30:42,206 --> 00:30:45,843
And so, I had a procedure, we
were very well practiced, we'd

584
00:30:45,876 --> 00:30:49,013
done a lot of tests that had
gone very poorly,

585
00:30:49,046 --> 00:30:52,917
so we had a lot of experience, a
lot of contingency plans

586
00:30:52,950 --> 00:30:55,086
based on things not
going so well to date

587

00:30:55,119 --> 00:30:57,622
for those
kinds of tests.

588
00:30:57,655 --> 00:30:59,690
And the reason, you know, one
of the things about doing

589
00:30:59,723 --> 00:31:02,860
tests like that is not only
are you trying to figure out

590
00:31:02,893 --> 00:31:05,763
how to do the operations on
Mars, you're actually also

591
00:31:05,796 --> 00:31:07,832
trying to simulate
the universe.

592
00:31:07,865 --> 00:31:10,401
And that's the hard part of
those tests, where you have to

593
00:31:10,434 --> 00:31:12,904
get the sun position right,
and Mars position right, and

594
00:31:12,937 --> 00:31:15,773
all that, and so those tests
were always a lot more

595
00:31:15,806 --> 00:31:17,975
complicated than
actual operations,

596
00:31:18,008 --> 00:31:19,343
which is a good thing.

597
00:31:19,376 --> 00:31:22,847

So initially, the very first
thing we wanted to do was get

598
00:31:22,880 --> 00:31:28,119
those images down to see what
the landing site looked like

599
00:31:28,152 --> 00:31:29,887
and the rover on the petal.

600
00:31:29,920 --> 00:31:31,722
And I remember getting those
images down, and we were

601
00:31:31,755 --> 00:31:33,357
printing them out
on printers, right?

602
00:31:33,390 --> 00:31:34,491
That's where we were at.

603
00:31:34,525 --> 00:31:38,195
Actually the very first
images, I think somebody had a

604
00:31:38,228 --> 00:31:42,733
30-day trial membership of a
piece of software that they

605
00:31:42,766 --> 00:31:45,336
were watching on one of the
computer screens, and so

606
00:31:45,369 --> 00:31:48,306
everybody was going around
their computer screen because

607
00:31:48,339 --> 00:31:50,441
they and sort of
siphoned the images

608
00:31:50,474 --> 00:31:52,543
off of the image pipeline,

609
00:31:52,576 --> 00:31:55,179
and we saw these
images of this landing site.

610
00:31:55,212 --> 00:31:59,350
And I remember the next day
was the day we drove the rover

611
00:31:59,383 --> 00:32:01,652
off the lander, but I remember
driving home that night with

612
00:32:01,685 --> 00:32:07,525
that picture of the rover on
that surface of Mars that was

613
00:32:07,558 --> 00:32:10,895
taken by that camera that
Peter designed to look like a

614
00:32:10,928 --> 00:32:16,567
person looking out there, and
I just thought, "How on earth,

615
00:32:16,600 --> 00:32:22,473
are we, does a farm girl from
Ohio, grow up to be involved

616
00:32:22,506 --> 00:32:25,343
in something where we are
looking at another world?"

617
00:32:25,376 --> 00:32:27,311
I mean we are the eyes
into this other world.

618
00:32:27,344 --> 00:32:30,881
And it was overwhelming, it
was fun, and then the next day

619
00:32:30,914 --> 00:32:34,118
we came back, and we got the
rover to drive off the lander,

620
00:32:34,151 --> 00:32:37,421
and then the public
got so engaged.

621
00:32:37,454 --> 00:32:39,390
And it was just a
great experience.

622
00:32:39,423 --> 00:32:40,391
>> I want to talk
about the...

623
00:32:40,424 --> 00:32:41,192
>> Can I jump in here?

624
00:32:41,225 --> 00:32:43,861
Because the public
being engaged...

625
00:32:43,894 --> 00:32:49,700
the internet was just coming
of itself and although it

626
00:32:49,733 --> 00:32:55,506
isn't recognized, JPL was a
pioneer in the huge

627
00:32:55,539 --> 00:32:58,542
overload that was
on the internet.

628

00:32:58,575 --> 00:33:02,346
They thought about it in
advance, the work got done,

629
00:33:02,379 --> 00:33:06,283
and I don't know if the world
knows what an incredible

630
00:33:06,316 --> 00:33:10,354
communications job and
computer job that they did.

631
00:33:10,387 --> 00:33:15,126
It was phenomenal, absolutely
phenomenal, which led to the

632
00:33:15,159 --> 00:33:20,631
public being involved in such
a large, exciting experience.

633
00:33:20,664 --> 00:33:22,967
>> If you think about it,
it's a bit like today with

634
00:33:23,000 --> 00:33:24,702
social media being
so important,

635
00:33:24,735 --> 00:33:28,205
and that was a pioneering moment
in the use of the internet

636
00:33:28,238 --> 00:33:30,174
and communicating about
the space program.

637
00:33:30,274 --> 00:33:31,642
>> We were rather
primitive, though.

638

00:33:31,675 --> 00:33:35,346
We mirrored sites around the
world where we sent the data,

639
00:33:35,379 --> 00:33:37,882
so we wouldn't swamp
out the JPL servers.

640
00:33:37,915 --> 00:33:41,118
So that allowed us to get the
data out around the world.

641
00:33:41,151 --> 00:33:42,787
>> But that wasn't primitive,
it was genius!

642
00:33:42,820 --> 00:33:44,989
[laughter]

643
00:33:45,022 --> 00:33:49,994
>> A number I remember,
670 million hits over a

644
00:33:50,260 --> 00:33:53,431
three month period, or
something like that...

645
00:33:55,066 --> 00:33:54,265
>> It was the
biggest thing.

646
00:33:55,099 --> 00:33:56,000
Today, that's trivial.

647
00:33:56,033 --> 00:33:57,468
>> It was huge
at that time.

648
00:33:57,501 --> 00:33:58,669
>> At that time, it was huge.

649
00:33:58,702 --> 00:34:00,805
And that's because all the
server companies were happy to

650
00:34:00,838 --> 00:34:04,508
have access. I mean
this was helping them create

651
00:34:04,541 --> 00:34:07,912
the market for the
internet, so in that sense,

652
00:34:07,945 --> 00:34:10,948
it really stimulated
that whole area.

653
00:34:10,981 --> 00:34:14,452
>> So there was creativity
just across the whole basis.

654
00:34:14,485 --> 00:34:17,688
>> Now I can't let this
opportunity go by, Jennifer,

655
00:34:17,721 --> 00:34:20,024
without telling this, at least
one of the couple of stories

656
00:34:20,057 --> 00:34:23,661
you've told me about your
interaction with Dan that day.

657
00:34:23,694 --> 00:34:29,066
As if you didn't have enough to
worry about as flight director.

658
00:34:29,099 --> 00:34:32,069
Can you at least tell one
of those two stories?

659
00:34:32,102 --> 00:34:34,805
>> Okay, I'll tell the...

660
00:34:34,838 --> 00:34:37,908
So, as things were crazy in
the Mission Support Area, and

661
00:34:37,941 --> 00:34:40,711
people were jumping up and
down and looking at the images,

662
00:34:40,744 --> 00:34:43,681
and we tried to maintain
some level of control,

663
00:34:43,714 --> 00:34:46,016
but then we lost all
control and everybody was

664
00:34:46,049 --> 00:34:47,985
packed into this
tiny little room.

665
00:34:48,018 --> 00:34:49,820
And people hanging
over the chairs

666
00:34:49,853 --> 00:34:51,288
and looking at
the images.

667
00:34:51,321 --> 00:34:55,559
And I had a procedure that I
was supposed to be executing,

668
00:34:55,592 --> 00:34:56,760
right?

669

00:34:56,793 --> 00:34:58,362
And I had a team of people
were supposed to be reporting

670
00:34:58,395 --> 00:35:01,532
telemetry channels to me and
we were supposed to move on

671
00:35:01,565 --> 00:35:03,734
and make sure we got the
sequence to the end so we

672
00:35:03,767 --> 00:35:06,837
could drive the rover down
the ramps the next day.

673
00:35:06,870 --> 00:35:10,441
And I got to the point
where I couldn't run

674
00:35:10,474 --> 00:35:14,011
the Mission Support Area and I
didn't know who was in there,

675
00:35:14,044 --> 00:35:16,914
and I didn't know what to do
except for to say,

676
00:35:16,947 --> 00:35:19,483
"Anybody in the
Mission Support Area

677
00:35:19,516 --> 00:35:22,853
who is not on console
and not part of the team

678
00:35:22,886 --> 00:35:25,656
who needs to be in here right
now needs to leave right now

679

00:35:25,689 --> 00:35:27,191
so we can finish our job."

680
00:35:27,224 --> 00:35:29,627
And it turns out Dan Goldin
was one of the people who was

681
00:35:29,660 --> 00:35:31,262
in the Mission Support Area,

682
00:35:31,295 --> 00:35:36,433
and so I kicked him
out, and he left.

683
00:35:36,466 --> 00:35:40,337
And we got things under better
control so we could finish out

684
00:35:40,370 --> 00:35:41,906
the activities for the day.

685
00:35:41,939 --> 00:35:43,874
For the Sol.

686
00:35:43,907 --> 00:35:46,443
>> You did the right thing.

687
00:35:46,476 --> 00:35:48,212
>> Every other mission went
exactly the same way

688
00:35:48,245 --> 00:35:50,047
on landing day, right?

689
00:35:50,080 --> 00:35:51,415
Same experience every time.

690
00:35:51,448 --> 00:35:53,083
>> I think that was one

of the great experiences

691
00:35:53,116 --> 00:35:54,185
I had on Pathfinder.

692
00:35:54,218 --> 00:35:56,487
Not just that moment
in the MSA, but

693
00:35:56,520 --> 00:35:59,990
I didn't even have a job
when I took the job.

694
00:36:00,023 --> 00:36:02,793
So I took the job
because I needed a job

695
00:36:02,826 --> 00:36:04,495
and also because it
sounded exciting,

696
00:36:04,528 --> 00:36:07,965
and then I didn't really
do the job I took.

697
00:36:07,998 --> 00:36:12,403
It was underfunded, lowly
funded, and so whatever

698
00:36:12,436 --> 00:36:13,370
you were willing to do...

699
00:36:15,573 --> 00:36:14,805
>> It was
correctly funded.

700
00:36:15,606 --> 00:36:17,474
[Laughter]

701

00:36:17,507 --> 00:36:19,610
It was funded such
that people could be

702
00:36:19,643 --> 00:36:21,445
innovative and could
take ownership

703
00:36:21,478 --> 00:36:24,114
of a whole bunch of stuff.

704
00:36:24,147 --> 00:36:27,651
And so, I was in my
twenties, I guess, well,

705
00:36:27,684 --> 00:36:29,486
it's twenty years
ago, so I was ten.

706
00:36:29,519 --> 00:36:35,526
No, I was in my twenties and I
had nothing better to do

707
00:36:35,559 --> 00:36:38,028
except for this and play
volleyball on the weekends.

708
00:36:38,061 --> 00:36:39,463
So I was there all the time.

709
00:36:39,496 --> 00:36:42,633
And I will say,
the people, right?

710
00:36:42,666 --> 00:36:45,869
I mean that opportunity to be
surrounded by a small

711
00:36:45,902 --> 00:36:50,407
but insanely excellent group of

people, that I was able to

712
00:36:50,440 --> 00:36:55,246
learn from, has brought me
to where I am today.

713
00:36:55,279 --> 00:36:59,850
Because I learned from Rob
Manning and Miguel San Martin.

714
00:36:59,883 --> 00:37:01,785
And I know cruise attitude
control now, and I know the

715
00:37:01,818 --> 00:37:04,955
surface high gain antenna
pointing, and all these things,

716
00:37:04,988 --> 00:37:06,624
but there's a group of
people of people.

717
00:37:06,657 --> 00:37:09,093
And so it really
was significant,

718
00:37:09,126 --> 00:37:12,997
the way that the structure
allowed people to do

719
00:37:13,030 --> 00:37:16,000
as much as they were
willing and able to do.

720
00:37:16,033 --> 00:37:19,169
And just learn an
incredible amount.

721
00:37:19,202 --> 00:37:21,305
>> I don't think you were

prepared as a team

722
00:37:21,338 --> 00:37:23,874
for the public
reaction, to this.

723
00:37:23,907 --> 00:37:25,042
>> No.

724
00:37:25,075 --> 00:37:29,680
>> I know you had a very
personal public reaction, too,

725
00:37:29,713 --> 00:37:30,781
didn't you?

726
00:37:30,814 --> 00:37:32,616
>> Well I did, and it's
interesting because I guess

727
00:37:32,649 --> 00:37:36,553
they played the CNN footage
at some of the prisons

728
00:37:36,586 --> 00:37:38,155
around the area.

729
00:37:38,188 --> 00:37:39,389
[laughter]

730
00:37:39,423 --> 00:37:43,994
And so I got letters, and was
it Joe Courtney who was the

731
00:37:44,027 --> 00:37:45,129
head of security at the time?

732
00:37:45,162 --> 00:37:46,197
I don't remember.

733
00:37:46,230 --> 00:37:49,033
He would just regularly come
in the Building 230

734
00:37:49,066 --> 00:37:50,801
and would deliver me
a stack of letters

735
00:37:50,834 --> 00:37:53,203
that were from
federal prisoners.

736
00:37:53,236 --> 00:37:55,239
You know, saying that they
wanted to go to Mars,

737
00:37:55,272 --> 00:37:56,874
or that it was
great what we did.

738
00:37:56,907 --> 00:37:59,610
And one day, I
got a letter from a...

739
00:37:59,643 --> 00:38:03,280
Well actually, one day they put
an article in Parade magazine

740
00:38:03,313 --> 00:38:06,250
that said what I had done
and had a picture of me,

741
00:38:06,283 --> 00:38:09,019
and I got a letter
from a lady in Texas

742
00:38:09,052 --> 00:38:11,622
who had seen that article
in Parade magazine.

743
00:38:11,655 --> 00:38:13,657
And I put it on the
stack of letters

744
00:38:13,690 --> 00:38:15,025
with the federal prisoners.

745
00:38:15,058 --> 00:38:18,595
And the letter said, "I have a
son who's in the Air Force,

746
00:38:18,628 --> 00:38:21,765
and if you were ever willing
to give him a tour of JPL,

747
00:38:21,798 --> 00:38:24,068
I'm sure he would
love to come."

748
00:38:24,101 --> 00:38:25,903
And so I put it in my
stack of letters,

749
00:38:25,936 --> 00:38:27,438
and then probably three
or four months later,

750
00:38:27,471 --> 00:38:30,174
I had decided to reply
to all the letters.

751
00:38:30,207 --> 00:38:31,342
I don't know why I
decided to do that.

752
00:38:31,375 --> 00:38:34,044
So I wrote this lady and I
said sure, if this guy

753
00:38:34,077 --> 00:38:36,313
from the Air Force wants
to come and visit JPL,

754
00:38:36,346 --> 00:38:38,215
I'm happy to
give him a tour.

755
00:38:38,248 --> 00:38:42,486
And it turned out that he
didn't know his mom had

756
00:38:42,519 --> 00:38:44,788
written the letter, it was clear
she was trying to set us up,

757
00:38:44,821 --> 00:38:50,260
but he actually had quite
an interest in JPL.

758
00:38:50,293 --> 00:38:53,731
So, he took me up on the
offer, came out, he was

759
00:38:53,764 --> 00:38:55,766
looking at going to
test pilot school

760
00:38:55,799 --> 00:38:57,201
at Edwards Air Force Base.

761
00:38:57,234 --> 00:39:00,270
He came out, I gave
him a tour, and uh...

762
00:39:00,303 --> 00:39:01,805
two years later,
we got married.

763

00:39:01,838 --> 00:39:06,377
So no matter what, Pathfinder
is my favorite mission.

764
00:39:06,910 --> 00:39:10,314
[laughter and applause]

765
00:39:10,347 --> 00:39:14,385
>> Alright, moving on.

766
00:39:14,418 --> 00:39:16,487
>> You know, Blaine, one thing
I wanted to comment on that

767
00:39:16,520 --> 00:39:19,590
Jennifer just touched on, I
think one of the great

768
00:39:19,623 --> 00:39:23,394
legacies of Pathfinder and the
Mars program is it allowed us

769
00:39:23,427 --> 00:39:26,063
to do engineering the way
engineering is done.

770
00:39:26,096 --> 00:39:28,932
Which is have the same
people do a mission,

771
00:39:28,965 --> 00:39:31,835
learn what they did right or
wrong, and then do another one.

772
00:39:31,868 --> 00:39:33,270
And then do another one.

773
00:39:33,303 --> 00:39:36,140
And a lot of the same people
Jennifer mentioned, Rob and

774
00:39:36,173 --> 00:39:38,442
Miguel and Richard Cook,
and all of these people

775
00:39:38,475 --> 00:39:41,478
did Spirit and Opportunity,
did Curiosity,

776
00:39:41,511 --> 00:39:43,580
some of them are now
doing 2020 as well.

777
00:39:43,613 --> 00:39:46,850
It's really an amazing cadre
of engineers who spent their

778
00:39:46,883 --> 00:39:48,852
whole career building these
Mars missions and building

779
00:39:48,885 --> 00:39:50,954
them the right way, building
them successfully.

780
00:39:50,987 --> 00:39:52,823
And that has been something
that is really difficult to do

781
00:39:52,856 --> 00:39:54,057
in the agency.

782
00:39:54,090 --> 00:39:55,726
The fact that Mars is
relatively close

783
00:39:55,759 --> 00:39:57,294
and you can send missions
every 26 months,

784
00:39:57,327 --> 00:40:00,964
it allowed us to really build
up a knowledge base

785
00:40:00,997 --> 00:40:04,401
that we really haven't had
for any other planet.

786
00:40:04,434 --> 00:40:06,737
And it's been a fantastic
experience and I think that's

787
00:40:06,770 --> 00:40:09,373
been a lot of the secret to
this success is really that.

788
00:40:09,406 --> 00:40:12,309
It's that ability to learn
from mistakes and have the

789
00:40:12,342 --> 00:40:14,778
same people keep doing the work,
and not forget it for 20 years,

790
00:40:14,811 --> 00:40:16,980
as Brian said, after Viking.

791
00:40:17,013 --> 00:40:19,349
There was nobody really around
from Viking anymore,

792
00:40:19,382 --> 00:40:20,818
but the folks from Curiosity

793
00:40:20,851 --> 00:40:23,020
were the same
ones from Pathfinder.

794
00:40:23,253 --> 00:40:26,757

>> You arrived at the lab
about the time of Pathfinder,

795
00:40:26,790 --> 00:40:27,591
I think...

796
00:40:27,624 --> 00:40:28,559
>> A few years before.

797
00:40:28,592 --> 00:40:28,959
>> A couple years?

798
00:40:28,992 --> 00:40:30,093
>> Yeah.

799
00:40:30,127 --> 00:40:32,095
>> What kind of importance did
Pathfinder have in the

800
00:40:32,128 --> 00:40:34,398
advancement of
where we've gone?

801
00:40:34,431 --> 00:40:36,133
>> You know, as I think I
mentioned, I think Pathfinder

802
00:40:36,166 --> 00:40:39,303
really taught us two things
from the scientific

803
00:40:39,336 --> 00:40:43,040
and from the mission
perspective.

804
00:40:43,073 --> 00:40:46,777
I think we really wanted to do
these robotic explorers.

805

00:40:46,810 --> 00:40:49,279
Pathfinder was somewhat
constrained in how far it

806
00:40:49,312 --> 00:40:52,516
could backpack because of the
base station and the way it

807
00:40:52,549 --> 00:40:55,385
was designed, but
our other rovers

808
00:40:55,418 --> 00:40:58,922
really were traveling
robotic geologists.

809
00:40:58,955 --> 00:41:01,358
And I think that's really a
paradigm that we learned, and

810
00:41:01,391 --> 00:41:04,328
Curiosity was the biggest
investment that we had,

811
00:41:04,361 --> 00:41:07,764
and we again tried to
build on that legacy.

812
00:41:07,797 --> 00:41:10,200
But you go in thinking, "we're
going to drive this thing

813
00:41:10,233 --> 00:41:11,735
for two years, and we're
going to go to places

814
00:41:11,768 --> 00:41:13,103
we've never seen before,"

815
00:41:13,136 --> 00:41:15,172

and that's something that
really started with Pathfinder.

816
00:41:15,205 --> 00:41:17,741
Look around sniffing rocks that
were as far as you could get,

817
00:41:17,774 --> 00:41:20,377
and Spirit and Opportunity
going even farther

818
00:41:20,410 --> 00:41:21,845
and building on that.

819
00:41:21,878 --> 00:41:26,617
And I know from myself, I was
not an engineer on Pathfinder,

820
00:41:26,650 --> 00:41:30,454
but being on Curiosity, being
able to work with the team

821
00:41:30,487 --> 00:41:33,924
that had been successful on
that mission and other missions,

822
00:41:33,957 --> 00:41:35,526
it gives you a lot
of confidence.

823
00:41:35,559 --> 00:41:37,995
And you can sit there and go
over a lot of things that can

824
00:41:38,028 --> 00:41:40,564
go wrong, you can think
through a lot of scenarios,

825
00:41:40,597 --> 00:41:43,066
and it was just a wonderful

experience to be able to work

826
00:41:43,099 --> 00:41:45,869
with the team that had that
much experience on Mars.

827
00:41:45,902 --> 00:41:48,605
We often went, Jennifer and I
worked on Curiosity together,

828
00:41:48,638 --> 00:41:50,908
and we would go back and look,
"What did MER do here in

829
00:41:50,941 --> 00:41:53,677
Spirit and Opportunity, what
went right, what can we fix?"

830
00:41:53,710 --> 00:41:56,914
Now Jennifer is on 2020 looking
at what went right on MSL,

831
00:41:56,947 --> 00:41:59,182
what can we do better,
how can we be smarter about

832
00:41:59,215 --> 00:42:01,785
the operations and
the engineering.

833
00:42:01,818 --> 00:42:03,921
It's just a great experience.

834
00:42:03,954 --> 00:42:09,693
>> I do these oral histories
with folks, the past, present,

835
00:42:09,726 --> 00:42:13,130
and I almost always ask them
about "Faster. Better. Cheaper."

836
00:42:13,163 --> 00:42:15,265
Where is the needle?

837
00:42:15,298 --> 00:42:16,400
Where has it gone?

838
00:42:16,433 --> 00:42:18,201
Has it gone too far
one way or another?

839
00:42:18,234 --> 00:42:21,271
And it's amazing to me, the
number of people who say

840
00:42:21,304 --> 00:42:24,541
we've gone too far away from
"Faster. Better. Cheaper."

841
00:42:24,574 --> 00:42:26,710
I hear that all the time.

842
00:42:26,743 --> 00:42:31,081
>> I think the trick is to go
back to your processes and

843
00:42:31,114 --> 00:42:35,085
look at what has accreted that
is relatively low added value.

844
00:42:35,118 --> 00:42:37,921
So a lot of times, we have
process, we have ways of doing

845
00:42:37,954 --> 00:42:42,225
things that have built up
due to conservatism

846
00:42:42,258 --> 00:42:46,129

and maybe not direct
high-value return.

847
00:42:46,162 --> 00:42:48,432
And we don't always go back
and reanalyze those processes.

848
00:42:48,465 --> 00:42:51,068
So I think part of what the
whole leadership team is doing

849
00:42:51,101 --> 00:42:54,204
is going back in, looking at
the way we do our work,

850
00:42:54,237 --> 00:42:56,473
looking at what can be
streamlined, looking at where

851
00:42:56,506 --> 00:42:59,843
technology has advanced to
where the failure modes

852
00:42:59,876 --> 00:43:02,112
that we used to have in our
electronic parts are no longer

853
00:43:02,145 --> 00:43:05,382
the failure modes you have
in modern electronic parts.

854
00:43:05,415 --> 00:43:07,751
And so you can
change your process,

855
00:43:07,784 --> 00:43:09,720
you can streamline
your processes.

856
00:43:09,753 --> 00:43:13,624

There's a lot of advances in
software, autocoding and other

857
00:43:13,657 --> 00:43:17,194
kinds of things you can do
with advanced IT and advanced

858
00:43:17,227 --> 00:43:20,030
compilers that reduce error
account in software,

859
00:43:20,063 --> 00:43:21,498
so I think we're
looking at where

860
00:43:21,531 --> 00:43:23,834
we can take advantage
of new technologies

861
00:43:23,867 --> 00:43:27,137
and we're asking our
leadership team to go back.

862
00:43:27,170 --> 00:43:30,374
Working with engineers, you
guys that in the lab,

863
00:43:30,407 --> 00:43:32,843
you often know a lot of
what steps are value added

864
00:43:32,876 --> 00:43:34,077
and not value added,

865
00:43:34,110 --> 00:43:36,380
and we want to make sure
that that bubbles up.

866
00:43:36,413 --> 00:43:38,048
And as you heard Brian say,

that's a lot of what made

867
00:43:38,081 --> 00:43:40,550
Pathfinder successful, was
empowering individual

868
00:43:40,583 --> 00:43:43,387
engineers in their
workplace to say,

869
00:43:43,420 --> 00:43:45,422
"This is not the best
way to do this.

870
00:43:45,455 --> 00:43:46,990
I know a better way to do
this, either because

871
00:43:47,023 --> 00:43:50,093
technology is advanced or
because I'm smart, or because

872
00:43:50,126 --> 00:43:52,262
I've just sat here for 10
hours working on this thing

873
00:43:52,295 --> 00:43:54,965
and I know what I'm doing
in a single shift."

874
00:43:54,998 --> 00:43:56,633
And we're trying to make sure
that we get that empowerment

875
00:43:56,666 --> 00:43:57,768
down to the lowest levels,

876
00:43:57,801 --> 00:44:00,003
by working with the
line organizations.

877
00:44:00,036 --> 00:44:02,272
I think what would
also help us is

878
00:44:02,305 --> 00:44:05,008
alignment with headquarters,
with the agency.

879
00:44:05,041 --> 00:44:08,545
There are times at which the
agency strongly advocates

880
00:44:08,578 --> 00:44:11,181
technology demos, Class D
and Class C work,

881
00:44:11,214 --> 00:44:12,983
and there's other times
when they don't.

882
00:44:13,016 --> 00:44:16,319
So Cassini for example, is
Class A mission, and Mars 2020.

883
00:44:16,352 --> 00:44:18,855
These are missions
that the risk is

884
00:44:18,888 --> 00:44:21,091
intended to be
driven fairly low.

885
00:44:21,124 --> 00:44:22,793
But there are other times
where the agency can

886
00:44:22,826 --> 00:44:26,129
incentivize taking chances and
can incentivize streamlined

887
00:44:26,162 --> 00:44:28,565
processes, as they did
with Pathfinder.

888
00:44:28,598 --> 00:44:30,033
And we're actually
starting to see

889
00:44:30,066 --> 00:44:31,902
more of those
missions coming.

890
00:44:31,935 --> 00:44:34,838
Charles Elachi mentioned the
helicopter, that's a tech demo.

891
00:44:34,871 --> 00:44:38,075
It has very few or almost no
scientific requirements,

892
00:44:38,108 --> 00:44:38,976
very few requirements on it.

893
00:44:39,009 --> 00:44:40,911
It just has to get
there, and take off,

894
00:44:40,944 --> 00:44:42,612
and fly around on
Mars, and land.

895
00:44:42,645 --> 00:44:44,181
And do that a few times.

896
00:44:44,214 --> 00:44:45,182
It doesn't have
to execute

897

00:44:45,215 --> 00:44:47,084
a vastly complicated
science mission.

898
00:44:47,117 --> 00:44:50,020
So the helicopter's a good
example, there's a deep space

899
00:44:50,053 --> 00:44:53,623
optical comm technology demo
on Psyche, there's a number of

900
00:44:53,656 --> 00:44:56,960
these areas where the agency is
asking us to push the envelope

901
00:44:56,993 --> 00:44:59,362
with Class D and we
like those.

902
00:44:59,395 --> 00:45:02,165
And I think that's a great
opportunity for folks to take

903
00:45:02,198 --> 00:45:04,034
a swing through a mission like
that, or an instrument like

904
00:45:04,067 --> 00:45:05,569
that, and also take a
swing through

905
00:45:05,602 --> 00:45:07,471
the more conservative
missions.

906
00:45:07,504 --> 00:45:10,974
And that way you can kind of
see how the pointer can be set,

907

00:45:11,007 --> 00:45:12,542
as Blaine was saying.

908
00:45:12,575 --> 00:45:14,377
In this kind of mission it
needs to be set here,

909
00:45:14,410 --> 00:45:16,246
and here I can
take chances.

910
00:45:16,579 --> 00:45:19,149
>> You know I've been on MSL
and Mars 2020 and now to

911
00:45:19,182 --> 00:45:22,219
go back and talk about
Pathfinder these last few weeks

912
00:45:22,252 --> 00:45:24,688
has reminded me
of things,

913
00:45:24,721 --> 00:45:27,557
and its reminded me
that we can create

914
00:45:27,590 --> 00:45:30,961
culture by the way we make
our choices, right?

915
00:45:30,994 --> 00:45:34,064
Whether you're on a big project
or you're on a small project,

916
00:45:34,097 --> 00:45:36,299
you focus on
the content.

917
00:45:36,332 --> 00:45:39,336

You focus on being excellent
at the technical work,

918
00:45:39,369 --> 00:45:42,873
you focus on questioning things
that don't make sense to you,

919
00:45:42,906 --> 00:45:45,175
you focus on throwing
out process.

920
00:45:45,208 --> 00:45:47,611
And I actually told Richard, I
said, "You know I am

921
00:45:47,644 --> 00:45:50,647
re-invigorated to completely
ignore my management."

922
00:45:50,680 --> 00:45:52,749
[laughter]

923
00:45:52,782 --> 00:45:54,184
>> Of which you are
the management now.

924
00:45:54,217 --> 00:45:57,621
>> Of which I am
the management.

925
00:45:57,654 --> 00:46:03,026
But especially to the younger
folks who didn't have the

926
00:46:03,059 --> 00:46:07,697
Pathfinder opportunity, I think
you can create that opportunity

927
00:46:07,730 --> 00:46:12,669
by being excellent technically

and questioning.

928
00:46:12,702 --> 00:46:14,571
This place loves that.

929
00:46:14,604 --> 00:46:17,541
I think it can come from
the bottom, from the top,

930
00:46:17,574 --> 00:46:19,776
from the side, but it
comes from the people

931
00:46:19,809 --> 00:46:22,345
and what you do every day.

932
00:46:22,378 --> 00:46:27,250
>> I think of Charles, you often
times use that phrase from

933
00:46:27,283 --> 00:46:29,719
Teddy Roosevelt:
Dare Mighty Things,

934
00:46:29,752 --> 00:46:33,723
and part of what
Pathfinder put in motion

935
00:46:33,756 --> 00:46:37,194
was the daring of
audacious things,

936
00:46:37,227 --> 00:46:41,398
and Curiosity being a
very audacious thing to do,

937
00:46:41,431 --> 00:46:44,768
as well, as a
mighty thing.

938
00:46:44,801 --> 00:46:48,538
>> You know, every explorer,
they have to dare mighty things

939
00:46:48,571 --> 00:46:50,340
if they want to
push the limit.

940
00:46:50,373 --> 00:46:52,542
And that's why I like that
quote from Teddy Roosevelt

941
00:46:52,575 --> 00:46:55,078
and matter of fact
the first time

942
00:46:55,111 --> 00:46:57,848
it was quoted here at
JPL, Dan remember,

943
00:46:57,881 --> 00:47:00,584
when I was appointed
as the JPL Director,

944
00:47:00,617 --> 00:47:03,386
he delayed that
announcement by a day

945
00:47:03,419 --> 00:47:05,488
because he wanted to
be physically here.

946
00:47:05,521 --> 00:47:09,326
I remember, so he came and he
looked at all the employees

947
00:47:09,359 --> 00:47:11,761
and looked at me, and he
quoted Teddy Roosevelt

948
00:47:11,794 --> 00:47:13,630
about daring mighty things.

949
00:47:13,663 --> 00:47:16,099
And now you see
it all over lab

950
00:47:16,132 --> 00:47:17,534
because you need
to to that.

951
00:47:17,567 --> 00:47:20,337
I mean, in our business, if
you don't dare mighty things,

952
00:47:20,370 --> 00:47:22,172
if you say "this is
too difficult,"

953
00:47:22,205 --> 00:47:24,007
you have given up.

954
00:47:24,040 --> 00:47:26,743
But as long as you really try
hard to make it happen,

955
00:47:26,776 --> 00:47:29,246
then every explorer
encounters that.

956
00:47:29,279 --> 00:47:30,213
Not only us.

957
00:47:30,246 --> 00:47:31,748
And Pathfinder,
that's one example,

958
00:47:31,781 --> 00:47:34,718
where people dared

mighty things.

959
00:47:34,751 --> 00:47:37,387
One thing I thought Brian
would be mentioning,

960
00:47:37,420 --> 00:47:39,055
there was another
challenge above

961
00:47:39,088 --> 00:47:40,957
and beyond the
technical challenge.

962
00:47:40,990 --> 00:47:43,460
Is how to streamline
the implementation.

963
00:47:43,493 --> 00:47:46,029
Remember, we were at a time
where we were doing the big

964
00:47:46,062 --> 00:47:49,532
spacecraft, and all kind of
processes and reviews.

965
00:47:49,565 --> 00:47:52,469
And, a matter of fact some of
you noticed in the video

966
00:47:52,502 --> 00:47:54,537
when Dan was talking there
was a bunch of books

967
00:47:54,570 --> 00:47:56,172
sitting next to him.

968
00:47:56,205 --> 00:47:58,575
He was giving that as an
example of what would it take

969
00:47:58,608 --> 00:48:01,645
to write a proposal.

970
00:48:01,678 --> 00:48:04,281
When I was a young investigator,

971
00:48:04,314 --> 00:48:06,850
my proposal used to
be like 10 pages,

972
00:48:06,883 --> 00:48:09,085
that was in the
early '80s.

973
00:48:09,118 --> 00:48:11,087
And one of the challenges
the team had,

974
00:48:11,120 --> 00:48:14,291
and Tony and Brian
and their team,

975
00:48:14,324 --> 00:48:16,059
was able to at least to
work on streamlining

976
00:48:16,092 --> 00:48:18,628
the processes and that
required a lot of support.

977
00:48:18,661 --> 00:48:21,531
Because there were a lot of
antibodies about that.

978
00:48:21,564 --> 00:48:26,303
>> We created a skunk works
within the JPL organization.

979

00:48:26,336 --> 00:48:29,839
But more than anything, the
thing that made us successful

980
00:48:29,872 --> 00:48:32,676
I think was the fact that
we trusted each other.

981
00:48:32,709 --> 00:48:35,812
We trusted the individuals for
their skill, their ability.

982
00:48:35,845 --> 00:48:40,951
We did not do a lot of paper,
a lot of process, and we

983
00:48:40,984 --> 00:48:44,821
concurrently engineered the
system as we went along.

984
00:48:44,854 --> 00:48:47,590
And then, we depended
very much on a

985
00:48:47,623 --> 00:48:50,060
process of rapid
decision-making.

986
00:48:50,093 --> 00:48:52,862
So when something went wrong,
when there was a problem,

987
00:48:52,895 --> 00:48:55,065
I could bring together
just a handful of people.

988
00:48:55,098 --> 00:48:58,268
And in a matter of minutes
to hours maybe a few days

989

00:48:58,301 --> 00:49:01,905
we could understand the problem
and we could put a solution

990
00:49:01,938 --> 00:49:03,606
in place and we'd
go execute it.

991
00:49:03,639 --> 00:49:05,742
I mean, sometimes, and
our big projects today,

992
00:49:05,775 --> 00:49:09,446
it could take weeks to months to
make those kind of changes.

993
00:49:09,479 --> 00:49:13,249
But the relationships
that were built-

994
00:49:13,282 --> 00:49:15,852
The definition of a
high-performance team

995
00:49:15,885 --> 00:49:20,090
from Katzenback and Smith was
"a team that is personally

996
00:49:20,123 --> 00:49:22,726
committed to each
other's success."

997
00:49:22,759 --> 00:49:24,394
And I think we had that.

998
00:49:24,427 --> 00:49:27,063
>> So that was another
"daring mighty things"

999
00:49:27,096 --> 00:49:29,265

but in a different aspect.

1000
00:49:29,298 --> 00:49:31,201
>> The interesting part of
that, is that we talked about

1001
00:49:31,234 --> 00:49:32,869
the scientific, the
programmatic legacy,

1002
00:49:32,902 --> 00:49:34,137
the people at legacy
of Pathfinder,

1003
00:49:34,170 --> 00:49:36,072
all of which were
fantastically successful.

1004
00:49:36,105 --> 00:49:38,742
I think we still, you'll get a
kick out of this, Dan and

1005
00:49:38,775 --> 00:49:42,379
Brian knows this more than
anyone, we struggled to retain

1006
00:49:42,412 --> 00:49:44,514
that streamlined sense of
innovation, because the

1007
00:49:44,547 --> 00:49:47,517
natural tendency is to then
become more conservative, make

1008
00:49:47,550 --> 00:49:49,886
the next one bigger and
better, and make it work.

1009
00:49:49,919 --> 00:49:52,522
And I think the breath of

fresh air that Pathfinder was

1010
00:49:52,555 --> 00:49:54,924
is something that's still
needed because we become

1011
00:49:54,957 --> 00:49:57,494
more and more risk
averse as an agency.

1012
00:49:57,527 --> 00:50:01,197
>> I think you're
absolutely spot on.

1013
00:50:01,230 --> 00:50:03,133
I really challenge
all of you

1014
00:50:03,166 --> 00:50:06,002
to listen to what
your director said

1015
00:50:06,035 --> 00:50:10,073
and don't keep doing things
because they're safe.

1016
00:50:10,106 --> 00:50:14,244
You have to lead in
technology and science.

1017
00:50:14,277 --> 00:50:17,380
Don't get complacent
with success.

1018
00:50:17,413 --> 00:50:21,051
Always be nervous and
always push the limits.

1019
00:50:21,084 --> 00:50:24,354
>> Dan, as usual you

get the last word,

1020
00:50:24,387 --> 00:50:26,089
[laughter]

1021
00:50:26,122 --> 00:50:30,260
and I want to thank all of
the panelists for being here.

1022
00:50:30,293 --> 00:50:33,063
It's been a very interesting
hour of discussion

1023
00:50:33,096 --> 00:50:38,802
and we are going to close out
by reflecting with a video on

1024
00:50:38,835 --> 00:50:42,105
what is happened in the
last 20 years at Mars.

1025
00:50:42,138 --> 00:50:43,606
It's very impressive.

1026
00:50:43,639 --> 00:50:45,608
Thank you all for coming.

1027
00:50:45,641 --> 00:50:47,577
[Applause]

1028
00:50:51,981 --> 00:50:53,250
[Whoosh]

1029
00:50:54,484 --> 00:50:57,654
[Poof]

1030
00:50:57,687 --> 00:50:58,922
>> Roger that.

1031
00:50:58,955 --> 00:51:00,757
>> Okay we got a good strong
signal now.

1032
00:51:00,790 --> 00:51:04,394
[Cheers]

1033
00:51:04,427 --> 00:51:05,195
[Clapping]

1034
00:51:05,228 --> 00:51:06,629
>> Woo!

1035
00:51:06,662 --> 00:51:10,901
[Cheering and clapping]

1036
00:51:32,455 --> 00:51:33,990
[Rockets]

1037
00:51:43,733 --> 00:51:44,801
[bang]

1038
00:51:49,939 --> 00:51:51,208
[Whoosh]

1039
00:51:53,109 --> 00:51:53,810
[Poof]

1040
00:51:55,811 --> 00:51:57,214
[Boom]

1041
00:51:57,513 --> 00:51:58,348
>> Stand by.

1042
00:51:58,448 --> 00:51:59,816
>> The rover has landed
base-petal down.

1043
00:51:59,849 --> 00:52:01,384
Which means, right side up.

1044
00:52:01,417 --> 00:52:04,354
[cheers and clapping]

1045
00:52:26,042 --> 00:52:27,410
[metallic clanking]

1046
00:52:27,743 --> 00:52:28,511
>> 60 meters.

1047
00:52:28,544 --> 00:52:29,679
>> Come on!

1048
00:52:31,447 --> 00:52:32,415
>> 30 meters!

1049
00:52:32,615 --> 00:52:35,485
[Rockets]

1050
00:52:35,885 --> 00:52:37,053
27 meters.

1051
00:52:37,086 --> 00:52:37,420
[Rockets]

1052
00:52:37,453 --> 00:52:38,388
20 meters.

1053
00:52:38,421 --> 00:52:39,956
15 meters. Standing
by for touchdown.

1054
00:52:39,989 --> 00:52:41,457
[rockets]

1055

00:52:41,490 --> 00:52:41,824
[impact]

1056
00:52:41,857 --> 00:52:46,062
[cheering]

1057
00:53:01,811 --> 00:53:04,781
[rockets]

1058
00:53:09,285 --> 00:53:10,353
>> Touchdown confirmed!

1059
00:53:10,386 --> 00:53:11,421
We're safe on Mars!

1060
00:53:11,454 --> 00:53:12,855
[cheers]

1061
00:53:12,888 --> 00:53:14,757
>> Woo hoo hoo hoo hoo hoo!

1062
00:53:14,790 --> 00:53:16,893
[cheers]

1063
00:53:16,926 --> 00:53:18,428
[clapping]

1064
00:53:18,461 --> 00:53:20,496
>> Time to see where our
Curiosity will take us.

1065
00:53:20,529 --> 00:53:24,868
[cheering and clapping]