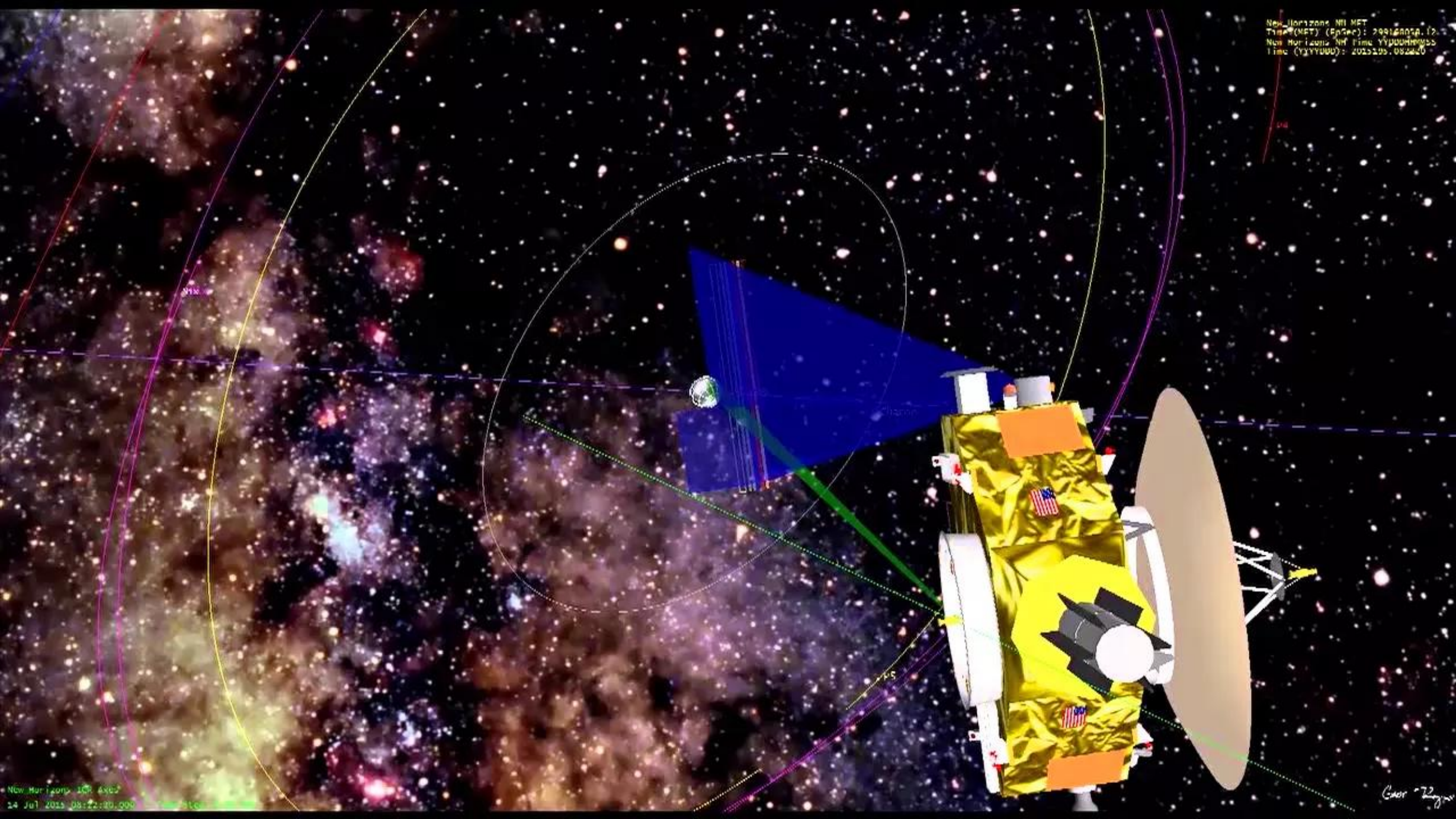
New Horizons MU MET
New Horizons MU Time YYYYDDHHMMSS
New Horizons IAU Axes
24 Jul 2015 08:22:00.000

1
00:00:15,719 --> 00:00:20,090
From the Johns Hopkins Applied Physics Laboratory
in Laurel, Maryland, welcome to NASA's New

2
00:00:20,090 --> 00:00:22,410
Horizons Countdown to Pluto.

3
00:00:22,410 --> 00:00:26,460
I'm Mike Buckley from APL Communications and
Public Affairs with the update from Pluto's

4
00:00:26,460 --> 00:00:31,250
doorstep as we count down to New Horizons
historic flyby of the Pluto system on July

5
00:00:31,250 --> 00:00:32,410
14th.

6
00:00:32,410 --> 00:00:38,330
We're 21 days away from the Pluto flyby, just
under 16 million miles from Pluto, and activity

7
00:00:38,330 --> 00:00:40,530
across the team is picking up.

8
00:00:40,530 --> 00:00:45,180
Let's get the latest on that activity with
an operations update.

9
00:00:45,180 --> 00:00:56,080
Now, with us is Gabe Rogers, the New Horizons
spacecraft systems engineer and guidance and

10
00:00:56,080 --> 00:00:57,100
control lead.

11
00:00:57,100 --> 00:00:58,380
Gabe, thanks for joining us.

12
00:00:58,380 --> 00:00:59,380
Thanks for having me, Mike.

13
00:00:59,380 --> 00:01:03,290
Now, you work on the guidance and control
system, which, you know, the name implies

14
00:01:03,290 --> 00:01:06,049
that this would be a critical system on anything
that flies.

15
00:01:06,049 --> 00:01:10,330
But, tell us a little bit how important it
is for a spacecraft that's flying so far from

16
00:01:10,330 --> 00:01:12,020
home and has so much to do.

17
00:01:12,020 --> 00:01:14,200
Well, guidance control is very important.

18
00:01:14,200 --> 00:01:19,990
If we are not pointed accurately, then we
won't be able to collect the science and images.

19
00:01:19,990 --> 00:01:23,540
We won't be able to conduct the trajectory
correction maneuvers.

20
00:01:23,540 --> 00:01:27,360
And we wouldn't be able to point back to the
Earth to downlink the telemetry.

21
00:01:27,360 --> 00:01:33,070
So, we have very fine pointing requirements
on New Horizons and it all has to be pre-programmed

22
00:01:33,070 --> 00:01:35,110
so that we get the best images for the scientists.

23
00:01:35,110 --> 00:01:38,590
Yeah, pre-programmed because, I mean, New Horizons is counted on to do a lot of it on

24
00:01:38,590 --> 00:01:40,380
its own because it's flying so far.

25
00:01:40,380 --> 00:01:45,040
We get the commands up and rely on the spacecraft to do what we tell it to do.

26
00:01:45,040 --> 00:01:46,040
Absolutely.

27
00:01:46,040 --> 00:01:49,780
We design all of these things and upload two week sequences way in advance and then it's

28
00:01:49,780 --> 00:01:54,659
up to the spacecraft to basically know where it is in order to point to the planet correctly

29
00:01:54,659 --> 00:01:56,000
and take the best images.

30
00:01:56,000 --> 00:01:58,240
Now, you mentioned trajectory corrections.

31
00:01:58,240 --> 00:02:04,270
On June 14th, right, the team marked out the P minus 30 days mark by conducting a TCM.

32
00:02:04,270 --> 00:02:05,270
Yes.

33
00:02:05,270 --> 00:02:06,270
As we call them.

34
00:02:06,270 --> 00:02:07,760
So, tell us why those--they're so important.

35
00:02:07,760 --> 00:02:13,659
Well, we need to be arriving at Pluto at the
right time and at the right location in order

36
00:02:13,659 --> 00:02:18,150
to maintain the geometry that we designed
for all of the science observations.

37
00:02:18,150 --> 00:02:22,260
It's also very important to get there at the
proper time in order to conduct the Pluto

38
00:02:22,260 --> 00:02:27,920
and Charon occultations where we actually
fly behind the planet and the sun then sort

39
00:02:27,920 --> 00:02:32,190
of goes out and the scientists are able to
collect observations that'll tell them the

40
00:02:32,190 --> 00:02:33,620
composition of the atmosphere.

41
00:02:33,620 --> 00:02:38,700
If you don't get there at the proper time,
you're not going to be able to do those observations.

42
00:02:38,700 --> 00:02:44,400
And so, we very subtly have to adjust the
trajectory of the spacecraft in order to make

43
00:02:44,400 --> 00:02:46,860
sure we get there at just the right time.

44
00:02:46,860 --> 00:02:47,860
Okay.

45
00:02:47,860 --> 00:02:49,510
What did this latest one do specifically?

46
00:02:49,510 --> 00:02:51,840
Well, the--we were coming in a little bit
early.

47
00:02:51,840 --> 00:02:57,950
So, this last one slowed us down by about
80 seconds and it changed the arrival point

48
00:02:57,950 --> 00:02:59,850
by a few hundred kilometers.

49
00:02:59,850 --> 00:03:04,560
We have pretty tight requirements and 100
kilometer by 150 kilometer box and we were

50
00:03:04,560 --> 00:03:06,380
outside that box.

51
00:03:06,380 --> 00:03:08,709
Following this maneuver, we're back inside
that box.

52
00:03:08,709 --> 00:03:09,709
Okay.

53
00:03:09,709 --> 00:03:14,280
Well, why don't we take a look at the activity
inside mission operations on June 14th?

54
00:03:14,280 --> 00:03:16,840
I've got this number right here.

55
00:03:16,840 --> 00:03:18,959
[Unintelligible] as you get another--.

56
00:03:18,959 --> 00:03:30,120
--That's the, I would assume, from the expected--.

57
00:03:30,120 --> 00:03:36,740
[--Unintelligible] to reform the status, please
do so.

58
00:03:36,740 --> 00:03:38,510
No, no.

59
00:03:38,510 --> 00:03:39,510
[Unintelligible].

60
00:03:39,510 --> 00:03:42,030
This is [unintelligible].

61
00:03:42,030 --> 00:03:43,800
Yes
Yes.

62
00:03:43,800 --> 00:03:44,800
The [unintelligible].

63
00:03:44,800 --> 00:03:45,800
Copy that.

64
00:03:45,800 --> 00:03:46,800
Sandy H, [unintelligible] Pluto one.

65
00:03:46,800 --> 00:03:50,180
Mach to Sandy H, Pluto One, status is green.

66
00:03:50,180 --> 00:03:51,690
Navigation [unintelligible] Pluto One.

67
00:03:51,690 --> 00:03:52,810
Navigation is green.

68
00:03:52,810 --> 00:03:56,570
Doppler is [unintelligible] consistent with
free pass last night [unintelligible].

69
00:03:56,570 --> 00:03:57,570
Copy that.

70
00:03:57,570 --> 00:03:58,570
Thank you.

71
00:03:58,570 --> 00:03:59,950
Pop, Mama and Pluto One.

72
00:03:59,950 --> 00:04:01,080
[Unintelligible] is green.

73
00:04:01,080 --> 00:04:02,080
Autonomy.

74
00:04:02,080 --> 00:04:03,080
Autonomy is green.

75
00:04:03,080 --> 00:04:04,080
[Unintelligible] is disabled.

76
00:04:04,080 --> 00:04:05,590
[Unintelligible] Mama and Pluto One.

77
00:04:05,590 --> 00:04:08,220
Mama, this is [unintelligible] and Pluto One.

78
00:04:08,220 --> 00:04:09,720
All systems are [unintelligible].

79
00:04:09,720 --> 00:04:14,930
So, this morning's course correction was to
make sure that we hit that aim point of 7,800

80
00:04:14,930 --> 00:04:15,930
miles.

81
00:04:15,930 --> 00:04:24,940
And so, this was--if you do the course correction
early, we can use less propellant than if

82
00:04:24,940 --> 00:04:29,060
we wait and do it a little bit later.

83
00:04:29,060 --> 00:04:30,449
[Unintelligible] went perfect.

84
00:04:30,449 --> 00:04:35,530
Yeah, we're ecstatic because we needed this
burn to get right back down on the center

85
00:04:35,530 --> 00:04:41,190
line so that we can do a hole in one at Pluto
and it worked perfectly.

86
00:04:41,190 --> 00:04:45,640
We have three more opportunities to do another
burn to try and tweak up the orbit.

87
00:04:45,640 --> 00:04:51,199
We're hoping we don't have to do any, but
there's a high likelihood that we will have

88
00:04:51,199 --> 00:04:55,050
to do at least one more.

89
00:04:55,050 --> 00:04:59,190
So, what activity is next for spacecraft operations
and for the team?

90
00:04:59,190 --> 00:05:03,551
So, the next few weeks, we are still collecting
optical navigation images to verify that we

91
00:05:03,551 --> 00:05:05,520
are on the correct path to Pluto.

92
00:05:05,520 --> 00:05:10,650
We're also collecting increasing science observations
and we're starting to execute the Phase A

93
00:05:10,650 --> 00:05:11,650
loads.

94
00:05:11,650 --> 00:05:14,750
Those are the loads that we developed years
ago and put on a shelf, essentially.

95
00:05:14,750 --> 00:05:17,660
And now, we're, for the first time, actually
executing them on the spacecraft.

96
00:05:17,660 --> 00:05:18,930
So, it's an exciting time.

97
00:05:18,930 --> 00:05:19,930
All those years, right?

98
00:05:19,930 --> 00:05:21,040
And the planning to get those on.

99
00:05:21,040 --> 00:05:22,590
Now, you're seeing them work--.

100
00:05:22,590 --> 00:05:23,590
Yes--.

101
00:05:23,590 --> 00:05:24,590
On the spacecraft, too.

102
00:05:24,590 --> 00:05:26,490

Speaking of the spacecraft, everything healthy?

103
00:05:26,490 --> 00:05:28,060
Everything looks good on board?

104
00:05:28,060 --> 00:05:29,060
Everything's healthy.

105
00:05:29,060 --> 00:05:32,430
All the hardware right now is operating nominally
and the spacecraft is performing the sequences

106
00:05:32,430 --> 00:05:33,490
that we gave it.

107
00:05:33,490 --> 00:05:37,280
So, the images look wonderful and we're excited
to see what's next.

108
00:05:37,280 --> 00:05:38,280
All right.

109
00:05:38,280 --> 00:05:39,280
Well, thanks, Gabe.

110
00:05:39,280 --> 00:05:40,280
Thanks, Mike.

111
00:05:40,280 --> 00:05:48,830
And now, for a science update.

112
00:05:48,830 --> 00:05:52,480
Project Scientist Hal Weaver is here to fill
us in on New Horizons science.

113
00:05:52,480 --> 00:05:53,610
Hal, thanks for joining us.

114

00:05:53,610 --> 00:05:54,610
Hi, Mike.

115
00:05:54,610 --> 00:05:55,750
Glad to be back.

116
00:05:55,750 --> 00:06:00,850
The--one of the bigger announcements over
the past week was another all clear for New

117
00:06:00,850 --> 00:06:02,730
Horizons and the hazard search.

118
00:06:02,730 --> 00:06:03,730
Can you fill us in on that?

119
00:06:03,730 --> 00:06:04,730
Yeah.

120
00:06:04,730 --> 00:06:07,610
That's one of the most important things we're
doing right now during the approach to Pluto.

121
00:06:07,610 --> 00:06:13,720
In fact, this is by far the deepest we've
looked for new satellites and potential dust

122
00:06:13,720 --> 00:06:17,699
in the system that could--you know, that would,
you know, could potentially pose a hazard

123
00:06:17,699 --> 00:06:19,290
to the spacecraft.

124
00:06:19,290 --> 00:06:23,480
And so, we took 384 images, each of them 10
seconds long.

125
00:06:23,480 --> 00:06:29,199

So, over an hour straight staring at the Pluto system trying to pick out new satellites and

126
00:06:29,199 --> 00:06:30,699
little dust particles.

127
00:06:30,699 --> 00:06:35,509
And again, so, saw the--saw Pluto, Charon, the four other moons--.

128
00:06:35,509 --> 00:06:36,509
Yes--.

129
00:06:36,509 --> 00:06:37,720
But, still nothing smaller inside that.

130
00:06:37,720 --> 00:06:38,720
Yeah.

131
00:06:38,720 --> 00:06:42,210
The thing that was so hard for Hubble to see, the Styx--the smallest satellite is now a

132
00:06:42,210 --> 00:06:44,669
piece of cake for LORRI on New Horizons.

133
00:06:44,669 --> 00:06:46,300
So, we easily see that.

134
00:06:46,300 --> 00:06:49,030
We go well below the brightness of Styx.

135
00:06:49,030 --> 00:06:54,139
We're not--still not seeing anything, which is great, you know, from the perspective of

136
00:06:54,139 --> 00:06:55,990
danger to the spacecraft.

137
00:06:55,990 --> 00:06:59,820
With the LORRI camera, the Long Range Reconnaissance Imager, the tool that we're looking to look

138
00:06:59,820 --> 00:07:04,350
into the system at this point, it seems that the views of the Pluto system now, especially

139
00:07:04,350 --> 00:07:07,930
from that camera, are quickly getting better and better.

140
00:07:07,930 --> 00:07:10,430
Tell us about the improvement that we've seen over even the past week.

141
00:07:10,430 --> 00:07:11,430
Oh, yeah.

142
00:07:11,430 --> 00:07:13,569
It's--like you say, it's getting better and better.

143
00:07:13,569 --> 00:07:19,940
Just the cool thing is we're 20 days out, Pluto is now 20 pixels across in LORRI.

144
00:07:19,940 --> 00:07:21,110
You know, it's dramatically improved.

145
00:07:21,110 --> 00:07:23,940
We're starting to see more and more surface features on the planet.

146
00:07:23,940 --> 00:07:29,620
And, you know, another 10 days and it'll be another twice as big as that.

147
00:07:29,620 --> 00:07:34,220

And then, you know, roughly three days out,
it gets to be 100 pixels across and then 1,000

148
00:07:34,220 --> 00:07:35,220
pixels across.

149
00:07:35,220 --> 00:07:36,220
Yeah.

150
00:07:36,220 --> 00:07:37,220
And it's going to come quickly.

151
00:07:37,220 --> 00:07:38,220
I mean--.

152
00:07:38,220 --> 00:07:39,220
Oh, yeah--.

153
00:07:39,220 --> 00:07:40,220
We're going to see it bigger and bigger and
bigger as we go and then it's passed.

154
00:07:40,220 --> 00:07:41,220
That's right.

155
00:07:41,220 --> 00:07:42,220
Exactly.

156
00:07:42,220 --> 00:07:44,210
We just ramp up the coverage, you know, take
more and more images.

157
00:07:44,210 --> 00:07:49,800
We want to get as detailed a view of Pluto's
surface and Charon's surface and best looks

158
00:07:49,800 --> 00:07:52,370
possible for all of the other moons in the
system.

159
00:07:52,370 --> 00:07:56,340
And, you know, we're going to cram as much
as we can.

160
00:07:56,340 --> 00:08:00,940
Point out to the people are able to check
the pictures that LORRI is taking on the New

161
00:08:00,940 --> 00:08:01,940
Horizons website.

162
00:08:01,940 --> 00:08:07,090
I mean, there's the raw image page where within
48 hours of those pictures being received

163
00:08:07,090 --> 00:08:09,710
on the ground, they're up on the website for
people to check out.

164
00:08:09,710 --> 00:08:10,710
Oh, yeah.

165
00:08:10,710 --> 00:08:13,250
We think it's very important to share with
the public.

166
00:08:13,250 --> 00:08:14,840
Let them share in the excitement of Pluto.

167
00:08:14,840 --> 00:08:18,660
They can watch it themselves getting bigger
and bigger and more--you know, you can see

168
00:08:18,660 --> 00:08:22,610
more and more surface features by looking--going
to the LORRI website.

169
00:08:22,610 --> 00:08:26,490

We actually tried to get it up even within
48 hours as--you know, when it lands on the

170
00:08:26,490 --> 00:08:27,490
ground.

171
00:08:27,490 --> 00:08:31,789
So, a lot of people seem to be having fun
with those images and we're happy to have

172
00:08:31,789 --> 00:08:32,789
them share.

173
00:08:32,789 --> 00:08:33,789
Okay.

174
00:08:33,789 --> 00:08:37,360
So, what--what's coming up then over the week
or so for the science team and science observations?

175
00:08:37,360 --> 00:08:41,810
Yeah, just ramping up the coverage, more and
more observations, getting better and better

176
00:08:41,810 --> 00:08:43,080
resolution.

177
00:08:43,080 --> 00:08:49,269
We have a couple of--you know, more very important
deep searches with LORRI, you know, trying

178
00:08:49,269 --> 00:08:54,309
to even go even farther to look for satellites--new
satellites and dust just to make sure the

179
00:08:54,309 --> 00:08:55,309
coast is clear.

180
00:08:55,309 --> 00:08:57,119

And so far, everything is looking great.

181
00:08:57,119 --> 00:08:58,119
Thanks, Hal.

182
00:08:58,119 --> 00:09:02,139
And we've heard from lots of people who can't
wait to see Pluto up close.

183
00:09:02,139 --> 00:09:05,800
You can only imagine the excitement among
the mission scientists and engineers who've

184
00:09:05,800 --> 00:09:08,980
invested so much time and energy to reach
this distant world.

185
00:09:08,980 --> 00:09:11,389
But, why do they love Pluto?

186
00:09:11,389 --> 00:09:21,730
Let's meet a real Plutophile.

187
00:09:21,730 --> 00:09:31,990
I'm Bill McKinnon.

188
00:09:31,990 --> 00:09:36,670
I work at Washington University in St. Louis
and I'm interested in pretty much everything

189
00:09:36,670 --> 00:09:43,529
about Pluto, but really its geology and geophysics
and especially its origin and where it came

190
00:09:43,529 --> 00:09:44,699
from and how it evolved.

191
00:09:44,699 --> 00:09:49,079
When I began to work on Pluto, literally the

number of people who were thinking about Pluto

192
00:09:49,079 --> 00:09:50,970
you could count on the finger--you know, fingers
of your hands.

193
00:09:50,970 --> 00:09:59,139
And it was--sort of a fun little hobby, okay,
to be sort of a Plutophile in those days.

194
00:09:59,139 --> 00:10:07,199
We have a fantastic new vision of the solar
system that it went through a violent phase

195
00:10:07,199 --> 00:10:13,690
of instability and the giant planets were
much more closer together in the beginning

196
00:10:13,690 --> 00:10:16,990
and then they spread out and they scattered
small bodies everywhere, but especially bodies

197
00:10:16,990 --> 00:10:18,429
into what we call the Kuiper Belt.

198
00:10:18,429 --> 00:10:23,910
And Pluto is, at the moment, still the king
of the Kuiper Belt in terms of linear dimension,

199
00:10:23,910 --> 00:10:25,379
the largest body there.

200
00:10:25,379 --> 00:10:30,679
But, even though without there at nearly 40
astronomical units and travels in a big archival

201
00:10:30,679 --> 00:10:35,799
[sp] orbit farther and closer to the sun over
hundreds of years, it actually was born much

202
00:10:35,799 --> 00:10:37,459
closer to the sun.

203
00:10:37,459 --> 00:10:41,410
If Pluto formed close to the sun, that means
it probably formed pretty fast.

204
00:10:41,410 --> 00:10:44,259
And when you form fast, you get hot.

205
00:10:44,259 --> 00:10:48,319
And therefore, it melted its ice and the rock
settled into the center and now you have great

206
00:10:48,319 --> 00:10:49,319
setup.

207
00:10:49,319 --> 00:10:55,260
You have basically a rock core, an ice shell
over that, and then in-between--sandwiched

208
00:10:55,260 --> 00:11:00,800
in-between would be an ocean of liquid water
with all sorts of interesting dissolved chemicals.

209
00:11:00,800 --> 00:11:04,949
And the best way we can tell that is probably
to just study the geology and the composition

210
00:11:04,949 --> 00:11:08,350
of the surface in detail, which is exactly
what we're going to do.

211
00:11:08,350 --> 00:11:12,920
And we--if it's pretty round, we'll be much
more comfortable with it being an active body

212
00:11:12,920 --> 00:11:16,950
and maybe even having an ocean today, which

would be very exciting.

213
00:11:16,950 --> 00:11:18,699
I think we will see craters.

214
00:11:18,699 --> 00:11:23,389
I think we will see the remnants of icy volcanic
structures.

215
00:11:23,389 --> 00:11:26,839
And I know that sounds bizarre and some--we
even call it--have a bizarre name for it.

216
00:11:26,839 --> 00:11:28,519
We call it cryovolcanism, cold volcanism.

217
00:11:28,519 --> 00:11:33,769
We're talking about it erupted ammonia or
it erupted methane and even erupted liquid

218
00:11:33,769 --> 00:11:34,769
nitrogen.

219
00:11:34,769 --> 00:11:38,410
These are the kinds of things that could go
on on the surface of Pluto.

220
00:11:38,410 --> 00:11:43,079
Anybody who thinks that when we go to Pluto,
we're going to find cold dead ice balls is

221
00:11:43,079 --> 00:11:45,199
in for a rude shock.

222
00:11:45,199 --> 00:11:49,299
But, I'm really hoping to see a very active
and dynamic world.

223
00:11:49,299 --> 00:11:56,079

I'm Bill McKinnon and I'm a Plutophile because
Pluto is the last unexplored outpost of the

224
00:11:56,079 --> 00:11:57,199
solar system.

225
00:11:57,199 --> 00:11:58,420
The furthest, the farthest, the least known.

226
00:11:58,420 --> 00:12:06,881
Now, the mission has a great tool to supposedly
get all that science data and that's the New

227
00:12:06,881 --> 00:12:07,881
Horizons spacecraft.

228
00:12:07,881 --> 00:12:12,490
But, you have to get it to the right place
at the right time and tell it what to do.

229
00:12:12,490 --> 00:12:16,829
So, we brought mission encounter manager Mark
Holdridge back to help explain how that happens.

230
00:12:16,829 --> 00:12:18,199
So, Mark, thanks for coming back.

231
00:12:18,199 --> 00:12:19,199
You're welcome.

232
00:12:19,199 --> 00:12:23,259
I guess first, let's start with even just
the overall goals of the New Horizons mission

233
00:12:23,259 --> 00:12:28,779
and what science it wants to achieve in the
Pluto system and you get one shot at this.

234
00:12:28,779 --> 00:12:29,779

What are we looking for?

235
00:12:29,779 --> 00:12:33,230
Well, the scientists have dozens and dozens
of observations they want to take of the Pluto

236
00:12:33,230 --> 00:12:34,230
system.

237
00:12:34,230 --> 00:12:36,380
Pluto, Charon, and the other moons of Pluto.

238
00:12:36,380 --> 00:12:40,949
And they prioritize those in level one, level
two, and level three requirements so that

239
00:12:40,949 --> 00:12:46,009
we can perform various trades on which ones
we can do or others that maybe we can't.

240
00:12:46,009 --> 00:12:51,249
And then we expect that the bulk of the requirements
will be satisfied during closest approach.

241
00:12:51,249 --> 00:12:55,869
The level one requirements, they require really
the highest resolution observations.

242
00:12:55,869 --> 00:12:56,869
And there's a whole list.

243
00:12:56,869 --> 00:13:00,069
I mean, their ideas of just not getting some,
but there's a long list of things the team

244
00:13:00,069 --> 00:13:01,069
wants to get.

245
00:13:01,069 --> 00:13:02,069

Right.

246
00:13:02,069 --> 00:13:03,069
Hundreds and hundreds of observations.

247
00:13:03,069 --> 00:13:04,069
Okay.

248
00:13:04,069 --> 00:13:09,209
With those observations, then, tell us how
you design, then, a flyby that gets all that

249
00:13:09,209 --> 00:13:10,209
information.

250
00:13:10,209 --> 00:13:11,470
How do you work that with the spacecraft?

251
00:13:11,470 --> 00:13:14,209
So, we really have, like, two competing activities.

252
00:13:14,209 --> 00:13:19,359
One is delivering the spacecraft to the target
in the prescribed box, the window that we're

253
00:13:19,359 --> 00:13:23,360
trying to hit, the 90 by 60 mile box within
the prescribed time.

254
00:13:23,360 --> 00:13:25,670
So, that's really a navigation challenge.

255
00:13:25,670 --> 00:13:28,089
And then we have the science observations
themselves.

256
00:13:28,089 --> 00:13:33,910
So, we have to stitch a timeline together
that accommodates both of those types of requirements

257
00:13:33,910 --> 00:13:37,860
so that we can both deliver the spacecraft
and perform the various observations that

258
00:13:37,860 --> 00:13:38,860
we're looking to do.

259
00:13:38,860 --> 00:13:43,869
And you have to design sequences then that
are loaded onto the spacecraft well ahead

260
00:13:43,869 --> 00:13:44,869
of time, right?

261
00:13:44,869 --> 00:13:47,800
That actually--and they're timed to execute
and do different things.

262
00:13:47,800 --> 00:13:48,800
Right.

263
00:13:48,800 --> 00:13:53,489
So, we actually have developed the sequence
for the seven days leading up to closest approach.

264
00:13:53,489 --> 00:13:58,029
We started that years ago and have performed
a number of different iterations with it and

265
00:13:58,029 --> 00:13:59,980
tested and tested the heck out of it.

266
00:13:59,980 --> 00:14:04,579
But, that's actually loaded up about nine
days out from closest approach.

267
00:14:04,579 --> 00:14:07,499
And starting at seven days out, that sequence

starts.

268
00:14:07,499 --> 00:14:11,309
And the spacecraft is pretty much running
on autopilot for the most part.

269
00:14:11,309 --> 00:14:17,670
It's executing these commands at very rigid
absolute times as we've built into the command

270
00:14:17,670 --> 00:14:18,670
sequences.

271
00:14:18,670 --> 00:14:20,529
Now, how intricate a dance are those command
sequences?

272
00:14:20,529 --> 00:14:24,519
What does the spacecraft have to do or how
do you have to make sure it moves between

273
00:14:24,519 --> 00:14:27,230
so many sequences without skipping a beat?

274
00:14:27,230 --> 00:14:28,230
Right.

275
00:14:28,230 --> 00:14:31,429
So, as you can see from the picture behind
me, the spacecraft rigid.

276
00:14:31,429 --> 00:14:35,410
So, everything has to be pointed one thing
at a time.

277
00:14:35,410 --> 00:14:39,809
So, if we're doing a science observation,
we can do pointing for one observation, then

278

00:14:39,809 --> 00:14:44,690
we slew the spacecraft a little bit and point
to the next object that we want to look at.

279
00:14:44,690 --> 00:14:48,249
And then we'll point back to Earth, for instance,
to play data back or send additional commands

280
00:14:48,249 --> 00:14:49,249
up.

281
00:14:49,249 --> 00:14:54,040
So, it's really a time choreographing of the
pointing of the spacecraft that's required

282
00:14:54,040 --> 00:14:55,819
to carry all this out.

283
00:14:55,819 --> 00:14:58,190
And also, too, I mean, even--these are all
happening within seconds.

284
00:14:58,190 --> 00:15:00,709
I mean, it's going from observation from observation.

285
00:15:00,709 --> 00:15:01,709
Right.

286
00:15:01,709 --> 00:15:05,860
We have a very dense set of observations because
we want to make the best use of the time during

287
00:15:05,860 --> 00:15:07,110
the closest approach.

288
00:15:07,110 --> 00:15:11,299
During that day, plus and minus a day or so
from closest approach to get the very best

289

00:15:11,299 --> 00:15:12,759
data that we can.

290
00:15:12,759 --> 00:15:18,109
And so, the spacecraft, at that point, pretty much is Pluto pointing, as you might expect.

291
00:15:18,109 --> 00:15:22,299
We're not doing a whole lot of communications with the spacecraft directly other than the

292
00:15:22,299 --> 00:15:25,609
occultations that we have when we fly by the shadows of Pluto.

293
00:15:25,609 --> 00:15:28,149
So, it's not just as simple as pointing.

294
00:15:28,149 --> 00:15:32,970
There's a whole element of timing and precision to make sure that you get the observations

295
00:15:32,970 --> 00:15:34,910
that are programmed and they're in the right place.

296
00:15:34,910 --> 00:15:38,660
So, let's take a look at how that works.

297
00:15:38,660 --> 00:15:43,220
After a journey of over 3 billion miles and nine years in flight, NASA's New Horizons

298
00:15:43,220 --> 00:15:48,239
spacecraft flies by Pluto and its moons on July 14, 2015.

299
00:15:48,239 --> 00:15:51,739
I'm Mark Holdridge, New Horizons encounter mission manager.

300
00:15:51,739 --> 00:15:56,680
Doing successful science at Pluto depends
on pinpoint accuracy and targeting New Horizons

301
00:15:56,680 --> 00:15:57,680
cameras.

302
00:15:57,680 --> 00:16:02,889
While traveling at a speed of 36,000 miles
per hour, 14 kilometers a second, one of our

303
00:16:02,889 --> 00:16:08,389
challenges is that Pluto was only discovered
in 1930 and its journey around the sun is

304
00:16:08,389 --> 00:16:09,910
248 years.

305
00:16:09,910 --> 00:16:13,889
So, we've only been following it for about
one-third of its orbit.

306
00:16:13,889 --> 00:16:15,809
It's hard to know its precise position.

307
00:16:15,809 --> 00:16:20,720
So, we're actually using the New Horizons
long range camera, LORRI, to more accurately

308
00:16:20,720 --> 00:16:23,470
refine where Pluto is.

309
00:16:23,470 --> 00:16:29,379
Starting on January 25th, we're taking pictures
using LORRI, New Horizons longest range imager,

310
00:16:29,379 --> 00:16:32,639
which we use both for navigation and for science.

311
00:16:32,639 --> 00:16:36,699
Of course, we'll get more and more precise
results as we get closer to Pluto, getting

312
00:16:36,699 --> 00:16:41,720
ready for a truly close approach and flyby
on July 14, 2015.

313
00:16:41,720 --> 00:16:45,609
That's when we really need precise pointing,
when we're whizzing by the planet and its

314
00:16:45,609 --> 00:16:46,609
moons.

315
00:16:46,609 --> 00:16:51,639
So, here I am like a tourist visiting Washington,
D.C., driving down the mall and trying to

316
00:16:51,639 --> 00:16:54,480
take a clear shot of the Washington Monument.

317
00:16:54,480 --> 00:16:58,540
Of course, to get the clearest picture, I
have to move the camera taking into account

318
00:16:58,540 --> 00:17:03,109
the speed of the car I'm riding in and knowing
exactly when to click the shutter.

319
00:17:03,109 --> 00:17:06,680
And for a large object like the Washington
Monument, I have to take several images to

320
00:17:06,680 --> 00:17:15,510
get the whole monument in the field of view.

321
00:17:15,510 --> 00:17:20,159

That's just what we'll be doing with our long range camera which has a narrow field of view,

322
00:17:20,159 --> 00:17:24,449
taking lots of individual shots and make up a mosaic or composite image.

323
00:17:24,449 --> 00:17:27,819
So, for New Horizons, it's much more complicated than being a tourist.

324
00:17:27,819 --> 00:17:29,750
And since I'm not driving, why don't we try a little thought experiment?

325
00:17:29,750 --> 00:17:41,929
I'm going to put on a blindfold and then try to take a picture of the monument.

326
00:17:41,929 --> 00:17:45,460
At Pluto, New Horizons is more than four and a half light hours from Earth.

327
00:17:45,460 --> 00:17:49,799
So, there's no way mission control can do any kind of real time adjustment.

328
00:17:49,799 --> 00:17:52,269
All our commands have been sent up in advance.

329
00:17:52,269 --> 00:17:54,259
All our instruments are completely pre-sequenced.

330
00:17:54,259 --> 00:17:59,519
We've been at this for many years, planning and refining and re-planning.

331
00:17:59,519 --> 00:18:04,330
Our encounter sequence has some 25,000 lines of code and we don't want to make any last

332
00:18:04,330 --> 00:18:06,559
minute changes that might create problems.

333
00:18:06,559 --> 00:18:12,610
But, what we can do is change the time when
we start the sequence based on updated navigation

334
00:18:12,610 --> 00:18:14,750
data as we get close.

335
00:18:14,750 --> 00:18:20,550
But, in order to know where and when to start
taking pictures, we have to know Pluto's exact

336
00:18:20,550 --> 00:18:21,550
location.

337
00:18:21,550 --> 00:18:27,700
And this is where LORRI is once again our
spyglass or optical navigation tool.

338
00:18:27,700 --> 00:18:33,730
So, we do have to figure out exactly how far
we are from Pluto and we do that using the

339
00:18:33,730 --> 00:18:34,900
parallax effect.

340
00:18:34,900 --> 00:18:35,900
Sound complicated?

341
00:18:35,900 --> 00:18:41,330
Well, it is rocket science, but let's see
how it works.

342
00:18:41,330 --> 00:18:42,700
See that traffic light?

343
00:18:42,700 --> 00:18:47,840
As we get closer, it seems to rise higher
in the sky relative to the background objects.

344
00:18:47,840 --> 00:18:52,590
Simple geometry permits us to estimate our
absolute distance to the object by measuring

345
00:18:52,590 --> 00:18:54,340
how much the background has shifted.

346
00:18:54,340 --> 00:19:00,279
For Pluto, as we approach, we use LORRI to
see how fast it's appearing to change position

347
00:19:00,279 --> 00:19:02,210
against the fixed background stars.

348
00:19:02,210 --> 00:19:05,620
It's only going to be in the final days we're
going to get the best shots of Pluto and the

349
00:19:05,620 --> 00:19:07,460
vital navigation data needed.

350
00:19:07,460 --> 00:19:08,539
It's going to be awesome.

351
00:19:08,539 --> 00:19:12,980
But, combining rocket science and lots of
practice, we have a very good shot at getting

352
00:19:12,980 --> 00:19:15,600
some great shots of Pluto and its moons.

353
00:19:15,600 --> 00:19:17,049
Stay tuned and follow us online.

354

00:19:17,049 --> 00:19:21,370
You look a little warmer now than when you originally shot that piece.

355
00:19:21,370 --> 00:19:22,370
So--.

356
00:19:22,370 --> 00:19:23,370
Yeah, yeah.

357
00:19:23,370 --> 00:19:26,799
That was a good explanation of exactly how we get some of that data and the challenges

358
00:19:26,799 --> 00:19:27,799
of that.

359
00:19:27,799 --> 00:19:30,649
But, it's not over after that because now, we have to get all that information back to

360
00:19:30,649 --> 00:19:31,649
Earth.

361
00:19:31,649 --> 00:19:32,649
Right.

362
00:19:32,649 --> 00:19:35,120
Take us through the timeline and then some of the challenge of sending that because it's

363
00:19:35,120 --> 00:19:36,919
not something that happens overnight; is it?

364
00:19:36,919 --> 00:19:37,919
Right.

365
00:19:37,919 --> 00:19:41,009
So, everybody's going to be very excited to

see the data as it comes off the spacecraft

366
00:19:41,009 --> 00:19:42,389
as soon as possible.

367
00:19:42,389 --> 00:19:47,120
We'll initially be playing backup browse data
set to get lower resolution data and a quick

368
00:19:47,120 --> 00:19:51,679
look at the imagery that we took and the other
science data that we took during the flyby.

369
00:19:51,679 --> 00:19:55,870
But, the actual data rates are between one
and two kilobits a second.

370
00:19:55,870 --> 00:19:57,350
So, they're fairly slow data rates.

371
00:19:57,350 --> 00:20:01,870
So, the data is going to come off at a very
gradual rate over the course of roughly 16

372
00:20:01,870 --> 00:20:03,750
months before we get it all back.

373
00:20:03,750 --> 00:20:05,020
And it's different types that you're able
to see.

374
00:20:05,020 --> 00:20:08,240
I mean, you're getting a first look by--about
the end of the year.

375
00:20:08,240 --> 00:20:14,100
And then after that, through 2016, the high
resolution material, you get to see the--really

376

00:20:14,100 --> 00:20:16,240
get to see inside the [unintelligible].

377
00:20:16,240 --> 00:20:17,240
Right.

378
00:20:17,240 --> 00:20:21,139
So, initially, the data--the quick look data
or the browse data is compressed.

379
00:20:21,139 --> 00:20:26,309
And then what we do is we play back the raw
data, the uncompressed data, to get the true

380
00:20:26,309 --> 00:20:31,259
sort of un-doctored science data in its purest
form and that takes a lot longer to play back.

381
00:20:31,259 --> 00:20:33,170
That's really why it takes 16 months.

382
00:20:33,170 --> 00:20:34,170
Yeah.

383
00:20:34,170 --> 00:20:35,170
And discoveries, too.

384
00:20:35,170 --> 00:20:36,480
I mean, we'll have discoveries later in 2015.

385
00:20:36,480 --> 00:20:38,460
We'll have discoveries in 2016 throughout.

386
00:20:38,460 --> 00:20:39,460
So--.

387
00:20:39,460 --> 00:20:40,460
Right--.

388
00:20:40,460 --> 00:20:41,460
We have something to look forward.

389
00:20:41,460 --> 00:20:42,460
Right.

390
00:20:42,460 --> 00:20:43,700
So, it's kind of like during the approach
phase where we're--data's gradually kind of

391
00:20:43,700 --> 00:20:45,960
trickling in as Pluto's getting bigger and
bigger.

392
00:20:45,960 --> 00:20:47,889
After the flyby, it'll be much the same way.

393
00:20:47,889 --> 00:20:52,159
The scientists will keep discovering new things
for months and months afterwards.

394
00:20:52,159 --> 00:20:53,159
All right.

395
00:20:53,159 --> 00:20:54,890
Well, Mark, again, thanks for coming back
to explain all this.

396
00:20:54,890 --> 00:20:55,890
My pleasure.

397
00:20:55,890 --> 00:20:58,410
Very exciting times ahead, Mike.

398
00:20:58,410 --> 00:21:01,260
NASA is exploring the solar system and behind.

399
00:21:01,260 --> 00:21:04,889

And with its 3 billion mile voyage, New Horizons is way out there.

400
00:21:04,889 --> 00:21:07,330
But, just how far is that?

401
00:21:07,330 --> 00:21:11,350
Let's watch as NASA planetary science division director, Jim Green, takes us on the path

402
00:21:11,350 --> 00:21:13,500
to Pluto.

403
00:21:13,500 --> 00:21:14,580
Hi.

404
00:21:14,580 --> 00:21:17,820
I'm Jim Green.

405
00:21:17,820 --> 00:21:21,090
I'm the Director of Planetary Science at NASA.

406
00:21:21,090 --> 00:21:26,679
And we're here just outside the National Air and Space Museum in Washington, D.C. to take

407
00:21:26,679 --> 00:21:33,830
the Planetary Science walk.

408
00:21:33,830 --> 00:21:39,009
And I hope at the end of this, you'll get an appreciation for how far Pluto really is

409
00:21:39,009 --> 00:21:40,440
away from the Earth.

410
00:21:40,440 --> 00:21:43,419
Here we are at the sun, the center of our solar system.

411
00:21:43,419 --> 00:21:47,190
Of course, life on Earth can exist without
the sun.

412
00:21:47,190 --> 00:21:53,799
As you can see, the terrestrial planets are
maybe 40 feet away from the sun.

413
00:21:53,799 --> 00:21:58,659
Mercury, Venus, Earth, and Mars.

414
00:21:58,659 --> 00:22:09,159
Of course, the Earth is the most studied planet
of our solar system.

415
00:22:09,159 --> 00:22:14,669
Our satellites are performing all kinds of
observations that give us weather, that give

416
00:22:14,669 --> 00:22:19,659
us the information that we need on our daily
lives to live here on Earth.

417
00:22:19,659 --> 00:22:21,410
It's our pale blue dot.

418
00:22:21,410 --> 00:22:25,700
Beyond Earth, Mars is the most studied planet
of our solar system.

419
00:22:25,700 --> 00:22:29,440
We've had 42 missions to Mars.

420
00:22:29,440 --> 00:22:35,169
Only 16 of them actually have either flown
by, orbited, or landed on Mars.

421
00:22:35,169 --> 00:22:39,549

Mars was really quite different than it is
today and it's past.

422
00:22:39,549 --> 00:22:46,380
We believe it had clouds, rivers, lakes, oceans,
but climate change occurred and it's now a

423
00:22:46,380 --> 00:22:48,299
much more aired planet.

424
00:22:48,299 --> 00:22:49,379
Okay.

425
00:22:49,379 --> 00:22:55,150
We're on our way to Jupiter, but we have to
pass through an area where the asteroids live.

426
00:22:55,150 --> 00:23:00,080
They're actually a planet that was trying
to come together, but Jupiter's gravity has

427
00:23:00,080 --> 00:23:01,960
kept them apart.

428
00:23:01,960 --> 00:23:07,360
Right now, we have a mission called Dawn that's
now getting into orbit around Ceres, the largest

429
00:23:07,360 --> 00:23:09,860
asteroid in the Asteroid Belt.

430
00:23:09,860 --> 00:23:15,299
Here's where the asteroids would be in this
particular area and we're now heading to Jupiter.

431
00:23:15,299 --> 00:23:20,139
But, Jupiter is five times further from the
sun than the Earth is.

432

00:23:20,139 --> 00:23:23,370
Here we are, Jupiter, our largest planet.

433
00:23:23,370 --> 00:23:29,299
We've had several flybys of Jupiter starting
with the Pioneer 10 and 11, then Voyager 1

434
00:23:29,299 --> 00:23:30,299
and 2.

435
00:23:30,299 --> 00:23:32,390
We have studied many of the moons.

436
00:23:32,390 --> 00:23:44,990
Some of the fabulous moves of Jupiter, like,
Ganymede, Callisto, Europa, and Io.

437
00:23:44,990 --> 00:23:48,669
Here we are at the beautiful ring planet,
Saturn.

438
00:23:48,669 --> 00:23:50,760
Saturn's been studied now for many years.

439
00:23:50,760 --> 00:23:55,409
We've had flybys by the voyagers, but now,
we have Cassini.

440
00:23:55,409 --> 00:23:56,500
Cassini's in orbit.

441
00:23:56,500 --> 00:24:02,030
It's been in orbit for about 10 years now
and is making fabulous observations of the

442
00:24:02,030 --> 00:24:04,750
planet, its rings, and its many moons.

443
00:24:04,750 --> 00:24:08,970

It's much bigger than the next two planets,
Uranus and Neptune.

444
00:24:08,970 --> 00:24:14,059
But, that's an even bigger hike.

445
00:24:14,059 --> 00:24:22,520
Well, here we are now at the other end of
a very long block and we're only at the planet

446
00:24:22,520 --> 00:24:23,879
Uranus.

447
00:24:23,879 --> 00:24:25,970
Uranus has been visited by the Voyager.

448
00:24:25,970 --> 00:24:27,879
It's what we call an ice giant.

449
00:24:27,879 --> 00:24:30,419
It's made up of a lot of ices like ammonia.

450
00:24:30,419 --> 00:24:38,419
But, Uranus is much like Neptune and Neptune
is an even greater hike down this next block.

451
00:24:38,419 --> 00:24:45,470
Wow, what a walk.

452
00:24:45,470 --> 00:24:49,580
Neptune's been visited by only one spacecraft,
Voyager 2.

453
00:24:49,580 --> 00:24:54,080
And it found an array of new moons, fabulous
magnetic field.

454
00:24:54,080 --> 00:24:59,659
One of the moons, Triton, orbits the planet

in the opposite direction that our moon orbits

455
00:24:59,659 --> 00:25:00,659
the Earth.

456
00:25:00,659 --> 00:25:02,169
It's called retrograde.

457
00:25:02,169 --> 00:25:05,970
We believe Triton may be a Pluto-like object.

458
00:25:05,970 --> 00:25:09,130
We'll only find out when we get to Pluto.

459
00:25:09,130 --> 00:25:10,759
And that's our last stop.

460
00:25:10,759 --> 00:25:15,320
It's almost another half a block from Neptune
it's so far away.

461
00:25:15,320 --> 00:25:20,240
Now, even though this took us tens of minutes
to actually make this walk, the New Horizons

462
00:25:20,240 --> 00:25:26,600
spacecraft was launched over nine years ago
and it's getting now very close to Pluto.

463
00:25:26,600 --> 00:25:28,039
Finally, here we are at Pluto.

464
00:25:28,039 --> 00:25:31,419
This flyby is going to be absolutely spectacular.

465
00:25:31,419 --> 00:25:36,929
We're going to be able to see this body as
we've never seen it before.

466
00:25:36,929 --> 00:25:38,529
Really up close and personal.

467
00:25:38,529 --> 00:25:45,789
You know, Pluto is an object of wonder ever
since it was discovered in 1930.

468
00:25:45,789 --> 00:25:48,290
We now know that Pluto has five moons.

469
00:25:48,290 --> 00:25:51,380
As we get closer to it, we may even find more
moons.

470
00:25:51,380 --> 00:25:53,570
It may even have rings.

471
00:25:53,570 --> 00:25:55,379
We know that Pluto has an atmosphere.

472
00:25:55,379 --> 00:26:03,210
But, Pluto is really one of hundreds and perhaps
thousands of objects we call Kuiper Belt objects.

473
00:26:03,210 --> 00:26:08,169
What we'll learn from Pluto will tell us about
that initial event that brought the solar

474
00:26:08,169 --> 00:26:09,570
system together.

475
00:26:09,570 --> 00:26:14,700
It's the last major body in our solar system
that we really need to visit.

476
00:26:14,700 --> 00:26:18,840
It's the end of a basic reconnaissance of
our solar system.

477
00:26:18,840 --> 00:26:23,610
You know, I'd like to think in the future
that we'll find so many fascinating things

478
00:26:23,610 --> 00:26:26,389
out about Pluto, we'll want to go back.

479
00:26:26,389 --> 00:26:31,530
So, today, we're only a few months away from
the encounter.

480
00:26:31,530 --> 00:26:35,940
We're less than an astronomical unit, the
distance between the Earth and the sun.

481
00:26:35,940 --> 00:26:40,040
That distance away from this fascinating object.

482
00:26:40,040 --> 00:26:45,720
Please come online and follow the excitement
as we get closer and closer to Pluto.

483
00:26:45,720 --> 00:26:46,970
We'll unveil it.

484
00:26:46,970 --> 00:26:49,019
We'll see what it's like.

485
00:26:49,019 --> 00:26:51,960
Pluto, we're on our way.

486
00:26:51,960 --> 00:26:54,860
Now, that's extreme exploration.

487
00:26:54,860 --> 00:26:59,539
And that's also the latest from NASA's New
Horizons mission on Pluto's doorstep.

488

00:26:59,539 --> 00:27:04,960
Twenty one days and 16 million miles to go
until the flyby, the countdown to Pluto continues.