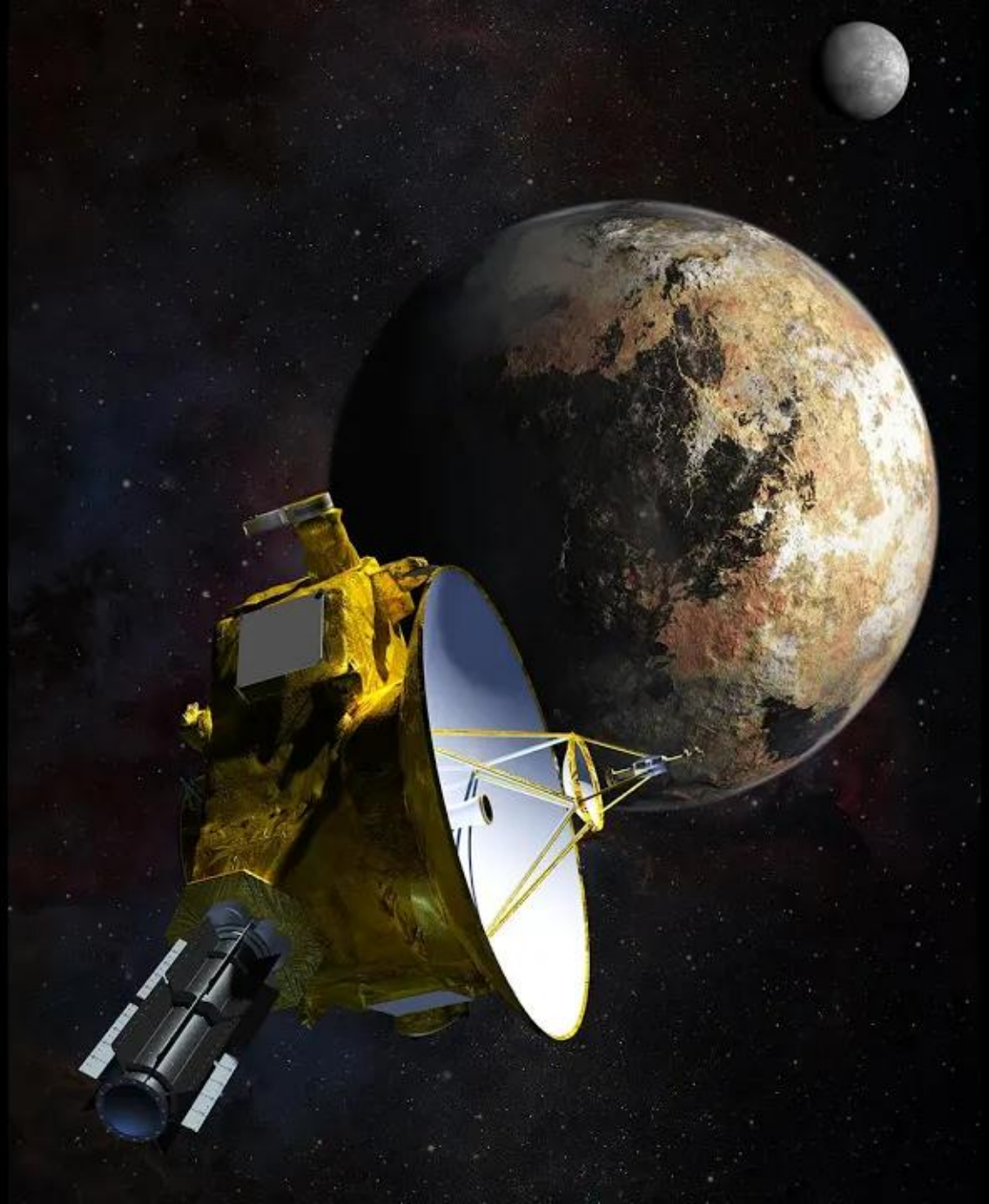

1
00:00:06,150 --> 00:00:04,230
there's a mysterious zone far out in our

2
00:00:09,030 --> 00:00:06,160
solar system

3
00:00:12,150 --> 00:00:09,040
it's a region of ice worlds some

4
00:00:14,789 --> 00:00:12,160
solitary some with moons

5
00:00:18,070 --> 00:00:14,799
their names may be unfamiliar

6
00:00:23,349 --> 00:00:21,349
but they hold clues to all our origins

7
00:00:26,470 --> 00:00:23,359
and the first of these worlds and the

8
00:00:29,269 --> 00:00:26,480
one we'll reach in 2015 is the king of

9
00:00:31,990 --> 00:00:29,279
the kuiper belt pluto

10
00:00:35,350 --> 00:00:32,000
the long journey of nasa's new horizons

11
00:00:37,990 --> 00:00:35,360
mission began in 2006 aboard america's

12
00:00:40,150 --> 00:00:38,000
biggest baddest rocket tricked out with

13
00:00:42,389 --> 00:00:40,160

every conceivable booster we built a

14
00:00:44,549 --> 00:00:42,399
very light spacecraft and bought a very

15
00:00:46,790 --> 00:00:44,559
large launch vehicle and the combination

16
00:00:50,630 --> 00:00:46,800
is ferocious but in some sense it all

17
00:00:53,430 --> 00:00:50,640
began in 1930 with clyde tombaugh 24

18
00:00:55,990 --> 00:00:53,440
years old and fresh off a farm in kansas

19
00:00:58,869 --> 00:00:56,000
but willing to spend long hours scanning

20
00:00:59,750 --> 00:00:58,879
star fields to find a moving point of

21
00:01:02,549 --> 00:00:59,760
light

22
00:01:04,630 --> 00:01:02,559
humanity's first glimpse of pluto

23
00:01:07,109 --> 00:01:04,640
the dream of actually getting to pluto

24
00:01:09,510 --> 00:01:07,119
began with a six-year-old boy in love

25
00:01:11,670 --> 00:01:09,520
with science who grew up to lead a team

26
00:01:14,230 --> 00:01:11,680
of brilliant researchers and engineers

27
00:01:15,350 --> 00:01:14,240
with dogged persistence through decades

28
00:01:18,550 --> 00:01:15,360
of planning

29
00:01:20,789 --> 00:01:18,560
and building and testing a race against

30
00:01:23,350 --> 00:01:20,799
time just to get to the launch pad

31
00:01:26,070 --> 00:01:23,360
exploring the outer solar system

32
00:01:28,230 --> 00:01:26,080
because it's so far takes a lot of time

33
00:01:30,710 --> 00:01:28,240
it requires a lot of patience a lot of

34
00:01:33,190 --> 00:01:30,720
dedication a lot of perseverance but

35
00:01:35,990 --> 00:01:33,200
it's the frontier assuming all goes well

36
00:01:37,910 --> 00:01:36,000
at pluto nasa may choose to extend the

37
00:01:40,789 --> 00:01:37,920
adventure further out into the kuiper

38
00:01:42,950 --> 00:01:40,799

belt the solar system's mysterious third

39
00:01:44,550 --> 00:01:42,960
zone this is maybe the one chance in my

40
00:01:46,550 --> 00:01:44,560
lifetime that we're going to get a

41
00:01:48,789 --> 00:01:46,560
spacecraft out there and look up close

42
00:01:53,990 --> 00:01:48,799
at one of these kuiper belt objects

43
00:01:58,870 --> 00:01:56,550
new horizons wakes up for the last time

44
00:02:01,429 --> 00:01:58,880
from hibernation new horizons is

45
00:02:03,429 --> 00:02:01,439
speeding towards pluto at a phenomenal

46
00:02:07,190 --> 00:02:03,439
rate and we can't wait for it to get

47
00:02:09,589 --> 00:02:07,200
there january 27 2015 six months of

48
00:02:12,550 --> 00:02:09,599
approach science begins

49
00:02:15,990 --> 00:02:12,560
july 14 2015

50
00:02:19,910 --> 00:02:16,000
new horizons long journey three billion

51
00:02:23,350 --> 00:02:19,920
miles nine years in flight and 85 years

52
00:02:26,710 --> 00:02:23,360
of speculation about pluto climaxes in

53
00:02:27,830 --> 00:02:26,720
one day of close approach and flyby you

54
00:02:29,750 --> 00:02:27,840
know we're around in third base and

55
00:02:32,630 --> 00:02:29,760
we're headed home the dream

56
00:02:39,160 --> 00:02:32,640
the adventure the promise of discovery

57
00:02:49,110 --> 00:02:47,190
[Music]

58
00:02:51,030 --> 00:02:49,120
studying pluto and its neighbors from

59
00:02:53,750 --> 00:02:51,040
earth is one of the toughest challenges

60
00:02:56,150 --> 00:02:53,760
in astronomy

61
00:02:59,509 --> 00:02:56,160
it takes the largest telescopes and most

62
00:03:01,670 --> 00:02:59,519
advanced instrumentation on the planet

63
00:03:04,149 --> 00:03:01,680

and it's tough even for the hubble space

64
00:03:06,550 --> 00:03:04,159
telescope

65
00:03:09,830 --> 00:03:06,560
it takes time from the discovery of

66
00:03:12,470 --> 00:03:09,840
pluto in 1930 to nasa approving the new

67
00:03:16,149 --> 00:03:12,480
horizons mission in 2001

68
00:03:19,030 --> 00:03:16,159
to arriving at the planet in 2015. it's

69
00:03:21,670 --> 00:03:19,040
been 85 years and time passing is

70
00:03:23,910 --> 00:03:21,680
definitely an actor in our story

71
00:03:26,550 --> 00:03:23,920
but it's the combination of human skill

72
00:03:28,789 --> 00:03:26,560
cutting edge image processing and sheer

73
00:03:30,830 --> 00:03:28,799
bloody minded persistence that has

74
00:03:33,110 --> 00:03:30,840
resulted in the most important

75
00:03:36,390 --> 00:03:33,120
discoveries and that's a tale as true

76
00:03:40,149 --> 00:03:36,400
today as back in 1930 when pluto was

77
00:03:43,350 --> 00:03:40,159
first found by clyde tombaugh

78
00:03:46,070 --> 00:03:43,360
in 2011 at the seti institute near san

79
00:03:48,630 --> 00:03:46,080
francisco mark showalter used hubble

80
00:03:49,670 --> 00:03:48,640
data to discover two new moons around

81
00:03:51,110 --> 00:03:49,680
pluto

82
00:03:52,869 --> 00:03:51,120
although he was actually looking for

83
00:03:55,030 --> 00:03:52,879
possible rings

84
00:03:57,270 --> 00:03:55,040
showalter has found rings associated

85
00:03:59,589 --> 00:03:57,280
with small moons around other planets

86
00:04:01,270 --> 00:03:59,599
and that was kind of the motivation for

87
00:04:03,350 --> 00:04:01,280
checking out pluto it's got two little

88
00:04:05,750 --> 00:04:03,360

satellites satellites raise clouds of

89
00:04:07,990 --> 00:04:05,760
dust let's see what might be there it's

90
00:04:10,710 --> 00:04:08,000
easy to take artistic license to show

91
00:04:13,350 --> 00:04:10,720
what pluto's rings might look like in

92
00:04:15,110 --> 00:04:13,360
reality it's incredibly hard to see

93
00:04:17,590 --> 00:04:15,120
faint objects against the dense

94
00:04:20,390 --> 00:04:17,600
background star field and the glare from

95
00:04:22,150 --> 00:04:20,400
pluto and its large moon carom we came

96
00:04:23,990 --> 00:04:22,160
up with this trick where you take the

97
00:04:25,909 --> 00:04:24,000
images and then you rotate the camera 90

98
00:04:27,430 --> 00:04:25,919
degrees you take more images and if you

99
00:04:29,350 --> 00:04:27,440
do that all just right you can do this

100
00:04:30,710 --> 00:04:29,360
thing where all that glare cancels out

101
00:04:32,550 --> 00:04:30,720
and what we're left with is just the

102
00:04:34,150 --> 00:04:32,560
rings we can think of it as a stack of

103
00:04:36,469 --> 00:04:34,160
images think of it as like a cube

104
00:04:38,790 --> 00:04:36,479
looking down so let's uh let's turn it

105
00:04:40,629 --> 00:04:38,800
on its side so now if we start peeling

106
00:04:42,950 --> 00:04:40,639
off the layers and looking downward

107
00:04:45,270 --> 00:04:42,960
through the stack things suddenly become

108
00:04:47,670 --> 00:04:45,280
much much cleaner for example hydra and

109
00:04:49,430 --> 00:04:47,680
nyx show up very very cleanly but the

110
00:04:51,510 --> 00:04:49,440
thing that immediately caught my eye was

111
00:04:53,909 --> 00:04:51,520
this little dot right there it's not a

112
00:04:55,510 --> 00:04:53,919
perfectly sharp hot pixel like over here

113
00:04:57,749 --> 00:04:55,520

and that's what made it pretty

114
00:04:59,830 --> 00:04:57,759
convincing to me that we had seen a very

115
00:05:02,550 --> 00:04:59,840
small moon of pluto that nobody had seen

116
00:05:04,710 --> 00:05:02,560
before to be sure you've detected a real

117
00:05:07,110 --> 00:05:04,720
moon or planet you have to show it's

118
00:05:09,110 --> 00:05:07,120
moving unlike the background stars the

119
00:05:10,550 --> 00:05:09,120
thing that makes moons distinctive is if

120
00:05:12,230 --> 00:05:10,560
we come back later they'd all have

121
00:05:13,909 --> 00:05:12,240
shifted because they all orbit the

122
00:05:15,909 --> 00:05:13,919
central planet this required a great

123
00:05:17,510 --> 00:05:15,919
deal of patience to then wait about six

124
00:05:20,230 --> 00:05:17,520
days until we got our next set of

125
00:05:22,070 --> 00:05:20,240
observations of the pluto system sure

126
00:05:23,830 --> 00:05:22,080
enough the object was still there it had

127
00:05:25,990 --> 00:05:23,840
moved by just about the right amount to

128
00:05:28,390 --> 00:05:26,000
be something orbiting pluto and we knew

129
00:05:30,310 --> 00:05:28,400
we had a moon next year showalter and

130
00:05:32,870 --> 00:05:30,320
colleagues went back and built on

131
00:05:33,909 --> 00:05:32,880
lessons learned to see what else might

132
00:05:35,830 --> 00:05:33,919
be there

133
00:05:38,469 --> 00:05:35,840
summer 2012.

134
00:05:41,590 --> 00:05:38,479
now mark had 15 more days of hubble

135
00:05:43,909 --> 00:05:41,600
observations now what you can see here

136
00:05:46,710 --> 00:05:43,919
are three time steps each of those time

137
00:05:48,629 --> 00:05:46,720
steps is actually about 45 minutes of

138
00:05:50,550 --> 00:05:48,639

data that means it's long enough that

139
00:05:52,629 --> 00:05:50,560
the little moons move it's moving back

140
00:05:54,790 --> 00:05:52,639
and forth in the three frame sequence

141
00:05:56,309 --> 00:05:54,800
hydra is moving nyx is moving i mean it

142
00:05:57,749 --> 00:05:56,319
doesn't take a rocket scientist to say

143
00:05:59,430 --> 00:05:57,759
that that looks like a little moon of

144
00:06:01,029 --> 00:05:59,440
pluto it's moving just the way the

145
00:06:03,270 --> 00:06:01,039
others are they're all going around the

146
00:06:05,189 --> 00:06:03,280
planet in the same direction and so it

147
00:06:06,469 --> 00:06:05,199
was just a couple of weeks later that we

148
00:06:08,309 --> 00:06:06,479
made the announcement that the fifth

149
00:06:11,830 --> 00:06:08,319
moon had been discovered

150
00:06:13,909 --> 00:06:11,840
patience persistence ingenuity that was

151
00:06:16,550 --> 00:06:13,919
exactly what led to the discovery of

152
00:06:19,510 --> 00:06:16,560
pluto back in 1930

153
00:06:21,670 --> 00:06:19,520
in kansas in the 1920s clyde tombaugh

154
00:06:23,590 --> 00:06:21,680
grew up in hard times and built

155
00:06:25,430 --> 00:06:23,600
telescopes using leftover farm

156
00:06:27,590 --> 00:06:25,440
implements

157
00:06:30,390 --> 00:06:27,600
to check the accuracy of his best

158
00:06:32,870 --> 00:06:30,400
telescope he sent drawings of mars and

159
00:06:34,710 --> 00:06:32,880
jupiter to the lowell observatory in

160
00:06:36,950 --> 00:06:34,720
flagstaff arizona

161
00:06:37,990 --> 00:06:36,960
they were looking for staff and he was

162
00:06:40,710 --> 00:06:38,000
hired

163
00:06:43,510 --> 00:06:40,720

along with observing the stars he stoked

164
00:06:46,550 --> 00:06:43,520
the furnace and shoveled snow

165
00:06:49,589 --> 00:06:46,560
but one assignment made history

166
00:06:52,230 --> 00:06:49,599
day after day he'd used this machine

167
00:06:55,110 --> 00:06:52,240
known as a blink comparator to look for

168
00:06:58,070 --> 00:06:55,120
anything in his images that moved

169
00:07:01,270 --> 00:06:58,080
it was tedious painstaking work but on

170
00:07:04,629 --> 00:07:01,280
plates taken on january 23rd and 29th

171
00:07:07,589 --> 00:07:04,639
and analyzed in february he saw a small

172
00:07:08,950 --> 00:07:07,599
dot that did move against the fixed

173
00:07:10,710 --> 00:07:08,960
stars

174
00:07:13,110 --> 00:07:10,720
announcing the results after careful

175
00:07:15,510 --> 00:07:13,120
confirmation the observatory made it

176
00:07:16,550 --> 00:07:15,520
easy to find the new planet by heading

177
00:07:18,390 --> 00:07:16,560
arrows

178
00:07:20,629 --> 00:07:18,400
this is an incredible work of

179
00:07:22,390 --> 00:07:20,639
observational astronomy and having done

180
00:07:24,390 --> 00:07:22,400
something similar but with much more

181
00:07:25,830 --> 00:07:24,400
powerful tools i can really appreciate

182
00:07:28,790 --> 00:07:25,840
his achievement

183
00:07:30,550 --> 00:07:28,800
for decades pluto remained more or less

184
00:07:33,029 --> 00:07:30,560
a point of light

185
00:07:34,870 --> 00:07:33,039
but in the mid 70s dale crookshank and

186
00:07:37,670 --> 00:07:34,880
colleagues attached cameras with

187
00:07:38,950 --> 00:07:37,680
infrared filters to a telescope at kitt

188
00:07:41,670 --> 00:07:38,960

peak

189
00:07:43,510 --> 00:07:41,680
detectors or sensors had been improved

190
00:07:44,869 --> 00:07:43,520
and larger telescopes had become

191
00:07:47,990 --> 00:07:44,879
available

192
00:07:49,909 --> 00:07:48,000
well we did that work in 1976 and found

193
00:07:51,110 --> 00:07:49,919
evidence for frozen methane on pluto's

194
00:07:52,869 --> 00:07:51,120
surface

195
00:07:55,990 --> 00:07:52,879
it was several years later that we found

196
00:07:57,990 --> 00:07:56,000
the evidence for the other isis in 1978

197
00:08:00,629 --> 00:07:58,000
astronomers jim christie and bob

198
00:08:03,270 --> 00:08:00,639
harrington analyzed new plates taken at

199
00:08:05,510 --> 00:08:03,280
the u.s naval observatory in flagstaff

200
00:08:08,390 --> 00:08:05,520
christie noted an elongation to the

201
00:08:09,830 --> 00:08:08,400
north of pluto one month later the bump

202
00:08:11,430 --> 00:08:09,840
had disappeared

203
00:08:14,230 --> 00:08:11,440
from this and other evidence they

204
00:08:15,110 --> 00:08:14,240
concluded that pluto like earth had a

205
00:08:16,309 --> 00:08:15,120
moon

206
00:08:20,950 --> 00:08:16,319
charon

207
00:08:23,430 --> 00:08:20,960
occurring in the 1980s astronomers

208
00:08:26,150 --> 00:08:23,440
calculated that the moon was almost half

209
00:08:28,309 --> 00:08:26,160
the size of its parent body so large

210
00:08:31,830 --> 00:08:28,319
that both objects spin around their

211
00:08:34,310 --> 00:08:31,840
mutual center of gravity outside pluto

212
00:08:36,709 --> 00:08:34,320
pluto and charon were the first double

213
00:08:38,949 --> 00:08:36,719

dwarf planet combo discovered in our

214
00:08:40,550 --> 00:08:38,959
solar system using the basic physics of

215
00:08:42,870 --> 00:08:40,560
their orbits and the distance between

216
00:08:46,150 --> 00:08:42,880
them astronomers could calculate their

217
00:08:48,790 --> 00:08:46,160
mass and size pluto was a little smaller

218
00:08:52,230 --> 00:08:48,800
than earth's moon about 1500 miles in

219
00:08:55,910 --> 00:08:52,240
diameter and had only one tenth its mass

220
00:08:58,949 --> 00:08:55,920
between 1985 and 1990 astronomers were

221
00:09:01,829 --> 00:08:58,959
in luck as pluto and karen orbited their

222
00:09:04,389 --> 00:09:01,839
mutual center of gravity each passed in

223
00:09:07,030 --> 00:09:04,399
turn in front of the other the so-called

224
00:09:09,190 --> 00:09:07,040
mutual events allowed astronomers like

225
00:09:10,710 --> 00:09:09,200
mark bowie to capture the changing

226
00:09:13,670 --> 00:09:10,720
patterns of light

227
00:09:15,910 --> 00:09:13,680
patiently buoy created a map of pluto

228
00:09:18,630 --> 00:09:15,920
pluto turned out to have one of the two

229
00:09:19,990 --> 00:09:18,640
most contrasty surfaces in the entire

230
00:09:21,590 --> 00:09:20,000
solar system

231
00:09:24,150 --> 00:09:21,600
in the mid 90s

232
00:09:26,389 --> 00:09:24,160
and alan stern used the hubble space

233
00:09:28,389 --> 00:09:26,399
telescope to make the first direct

234
00:09:30,550 --> 00:09:28,399
images of pluto's surface and it's

235
00:09:32,150 --> 00:09:30,560
exciting to mark and i and to our whole

236
00:09:34,389 --> 00:09:32,160
scientific team

237
00:09:36,630 --> 00:09:34,399
to be able to see this object that no

238
00:09:38,949 --> 00:09:36,640

humans really could glimpse as a real

239
00:09:41,990 --> 00:09:38,959
planet as a real object in the solar

240
00:09:44,310 --> 00:09:42,000
system previously in 2005 hal weaver and

241
00:09:46,710 --> 00:09:44,320
alan stern used the hubble for another

242
00:09:49,509 --> 00:09:46,720
close-up look at pluto and cairon they

243
00:09:52,310 --> 00:09:49,519
discovered two small dim moons where

244
00:09:54,710 --> 00:09:52,320
only charon had been seen before

245
00:09:57,350 --> 00:09:54,720
now we know from mark showalter's work

246
00:10:00,070 --> 00:09:57,360
that there are two more moons making the

247
00:10:03,110 --> 00:10:00,080
current total of five and that pluto is

248
00:10:05,269 --> 00:10:03,120
a genuine many planetary system

249
00:10:08,389 --> 00:10:05,279
from its size and orbit astronomers

250
00:10:10,870 --> 00:10:08,399
estimated that pluto is perhaps 70 rock

251
00:10:13,430 --> 00:10:10,880
and 30 ice that makes it one of the

252
00:10:15,750 --> 00:10:13,440
largest of a whole new class of objects

253
00:10:18,150 --> 00:10:15,760
the ice dwarf planets making up what's

254
00:10:20,470 --> 00:10:18,160
known as the kuiper belt this region is

255
00:10:23,190 --> 00:10:20,480
named for gerrard kuiper a leading mid

256
00:10:25,350 --> 00:10:23,200
20th century planetary astronomer kuiper

257
00:10:27,509 --> 00:10:25,360
suggested that the solar system didn't

258
00:10:29,910 --> 00:10:27,519
end with neptune and pluto but that

259
00:10:33,269 --> 00:10:29,920
there should be a disk of other worlds

260
00:10:35,829 --> 00:10:33,279
beyond them in 1992 from a mountaintop

261
00:10:38,630 --> 00:10:35,839
in hawaii david jewett and jane liu

262
00:10:41,430 --> 00:10:38,640
found the first kuiper belt object they

263
00:10:43,269 --> 00:10:41,440

were using new and highly sensitive ccds

264
00:10:45,190 --> 00:10:43,279
like the sensors in a modern digital

265
00:10:47,110 --> 00:10:45,200
camera but their technique was

266
00:10:48,630 --> 00:10:47,120
essentially an updated version of

267
00:10:50,790 --> 00:10:48,640
tombaugh's work

268
00:10:53,590 --> 00:10:50,800
take carefully registered images of a

269
00:10:57,269 --> 00:10:53,600
patch of sky and see if anything moves

270
00:10:59,829 --> 00:10:57,279
against the distant stars this one qb1

271
00:11:02,310 --> 00:10:59,839
did just that it was only a few hundred

272
00:11:06,470 --> 00:11:02,320
kilometers across ten times smaller than

273
00:11:08,630 --> 00:11:06,480
pluto but still huge compared to a comet

274
00:11:13,110 --> 00:11:08,640
since then teams of astronomers have

275
00:11:17,750 --> 00:11:15,350
informed by cutting-edge astronomy but

276
00:11:19,829 --> 00:11:17,760
with a fair dose of artistic license

277
00:11:22,150 --> 00:11:19,839
let's take a trip through this third

278
00:11:25,430 --> 00:11:22,160
zone of our solar system we used to

279
00:11:27,509 --> 00:11:25,440
think of the solar system of consisting

280
00:11:29,350 --> 00:11:27,519
of two different types of planets the

281
00:11:30,949 --> 00:11:29,360
planets we call the terrestrial planets

282
00:11:33,430 --> 00:11:30,959
which are earth-like planets that would

283
00:11:36,389 --> 00:11:33,440
be mercury venus earth and mars

284
00:11:39,269 --> 00:11:36,399
next out the asteroid belt fragments of

285
00:11:40,710 --> 00:11:39,279
worlds smash to pieces by gravitation

286
00:11:43,990 --> 00:11:40,720
and collisions

287
00:11:46,150 --> 00:11:44,000
then come the four gas giants

288
00:11:49,269 --> 00:11:46,160

jupiter and its moons

289
00:11:51,750 --> 00:11:49,279
saturn with its magnificent rings

290
00:11:53,590 --> 00:11:51,760
uranus also ringed

291
00:11:55,110 --> 00:11:53,600
and neptune

292
00:11:57,430 --> 00:11:55,120
and then pluto was this kind of you know

293
00:11:59,590 --> 00:11:57,440
odd guy out it was this little object at

294
00:12:01,590 --> 00:11:59,600
the edge of the solar system and then

295
00:12:03,509 --> 00:12:01,600
when we found all these other

296
00:12:06,310 --> 00:12:03,519
kuiper belt objects this is kind of

297
00:12:09,269 --> 00:12:06,320
almost a third type of object so for the

298
00:12:11,350 --> 00:12:09,279
first time ever we'll be able to fly by

299
00:12:14,470 --> 00:12:11,360
a brand new object

300
00:12:16,470 --> 00:12:14,480
an object that's been forming for

301
00:12:18,790 --> 00:12:16,480
billions of years

302
00:12:21,030 --> 00:12:18,800
and understand what outer parts of the

303
00:12:24,230 --> 00:12:21,040
solar system are all about

304
00:12:26,870 --> 00:12:24,240
by july 2015 we'll know for sure what

305
00:12:29,110 --> 00:12:26,880
pluto and its moons look like and that

306
00:12:31,590 --> 00:12:29,120
will provide breakthrough information on

307
00:12:33,670 --> 00:12:31,600
all those other ice dwarf planets the

308
00:12:36,069 --> 00:12:33,680
most numerous planetary objects in the

309
00:12:37,670 --> 00:12:36,079
entire solar system that make up the

310
00:12:42,550 --> 00:12:37,680
kuiper belt

311
00:12:44,790 --> 00:12:42,560
doughnut bulging up above and down below

312
00:12:45,829 --> 00:12:44,800
the ecliptic where most of the planets

313
00:12:48,230 --> 00:12:45,839

move

314
00:12:50,389 --> 00:12:48,240
it's kind of like the asteroid belt but

315
00:12:52,150 --> 00:12:50,399
much bigger it has hundreds of times

316
00:12:55,430 --> 00:12:52,160
more objects in it than the asteroid

317
00:12:57,590 --> 00:12:55,440
belt let's now visit five named kbos in

318
00:13:02,310 --> 00:12:57,600
the exact positions they'll be in on

319
00:13:05,030 --> 00:13:02,320
july 14 2015 the day when new horizons

320
00:13:06,949 --> 00:13:05,040
flies by pluto

321
00:13:09,590 --> 00:13:06,959
was one of the first kuiper belt objects

322
00:13:12,310 --> 00:13:09,600
discovered it's about 1 000 kilometers

323
00:13:15,190 --> 00:13:12,320
in diameter a reddish world covered in

324
00:13:18,230 --> 00:13:15,200
water ice methane and ethane

325
00:13:22,069 --> 00:13:18,240
and like many kbos it has a tiny moon of

326
00:13:26,790 --> 00:13:24,310
up above and down below the plane of the

327
00:13:30,710 --> 00:13:26,800
solar system numerous kbos have been

328
00:13:32,949 --> 00:13:30,720
flung about by neptune's gravity

329
00:13:35,910 --> 00:13:32,959
this region is known as the scattered

330
00:13:41,910 --> 00:13:39,189
one of the largest of these kbos eris is

331
00:13:43,680 --> 00:13:41,920
close in size to pluto and is made of

332
00:13:45,590 --> 00:13:43,690
rock and methane ice

333
00:13:48,629 --> 00:13:45,600
[Music]

334
00:13:50,710 --> 00:13:48,639
astronomers categorize kbos by the tilt

335
00:13:54,470 --> 00:13:50,720
of their orbits relative to the plane of

336
00:13:59,590 --> 00:13:56,550
and one of the more highly inclined

337
00:14:02,230 --> 00:13:59,600
orbits belongs to makemake named for a

338
00:14:03,829 --> 00:14:02,240

hawaiian creation deity

339
00:14:05,750 --> 00:14:03,839
some of these have

340
00:14:07,269 --> 00:14:05,760
methane or water ice on their surfaces

341
00:14:09,350 --> 00:14:07,279
some of them just seem to be covered in

342
00:14:10,870 --> 00:14:09,360
some brownish gunk there are gray

343
00:14:12,470 --> 00:14:10,880
objects out there there are brown

344
00:14:14,870 --> 00:14:12,480
objects out there they seem to be

345
00:14:17,990 --> 00:14:14,880
distinct populations

346
00:14:19,670 --> 00:14:18,000
some of them seem to be very spherical

347
00:14:21,509 --> 00:14:19,680
and so they probably have worn interiors

348
00:14:23,189 --> 00:14:21,519
and then others are peculiar shapes

349
00:14:24,949 --> 00:14:23,199
which suggest they're very cold and

350
00:14:27,670 --> 00:14:24,959
strong

351
00:14:31,910 --> 00:14:27,680
perhaps the most bizarre and unexpected

352
00:14:35,670 --> 00:14:31,920
kbo is haumeo a kbo shaped like an

353
00:14:37,990 --> 00:14:35,680
american football made of rock and ice

354
00:14:40,870 --> 00:14:38,000
it's white with red splotches and

355
00:14:43,509 --> 00:14:40,880
orbited by at least two moons

356
00:14:47,110 --> 00:14:43,519
one of the strangest orbits of any kbo

357
00:14:49,430 --> 00:14:47,120
belongs to sedna discovered in 2003

358
00:14:53,110 --> 00:14:49,440
its orbit is the most eccentric of any

359
00:14:55,990 --> 00:14:53,120
kbo now known bringing it as close as 76

360
00:14:59,670 --> 00:14:56,000
au to the sun but then carrying it

361
00:15:00,790 --> 00:14:59,680
outward to 936 times the earth sun

362
00:15:03,829 --> 00:15:00,800
distance

363
00:15:06,069 --> 00:15:03,839

sedna's strange 11 000 year orbit seems

364
00:15:08,310 --> 00:15:06,079
to link it to an even vaster cloud of

365
00:15:11,350 --> 00:15:08,320
objects ready for exploration by future

366
00:15:14,550 --> 00:15:11,360
generations the oort cloud is an immense

367
00:15:17,030 --> 00:15:14,560
ice box of long period comets from 10 to

368
00:15:19,509 --> 00:15:17,040
100 times more distant than the kuiper

369
00:15:21,430 --> 00:15:19,519
belt surrounding all the known worlds of

370
00:15:22,949 --> 00:15:21,440
our solar system there's a real record

371
00:15:25,189 --> 00:15:22,959
of the early history of the solar system

372
00:15:27,110 --> 00:15:25,199
out there in cold storage at the edge of

373
00:15:30,310 --> 00:15:27,120
the solar system this is what was left

374
00:15:31,189 --> 00:15:30,320
over pluto is the first member of that

375
00:15:33,350 --> 00:15:31,199
group

376
00:15:35,509 --> 00:15:33,360
but to begin humanity's exploration of

377
00:15:36,550 --> 00:15:35,519
the kuiper belt you first have to get to

378
00:15:38,389 --> 00:15:36,560
pluto

379
00:15:41,509 --> 00:15:38,399
and that means getting a mission

380
00:15:44,470 --> 00:15:41,519
approved a spacecraft designed and built

381
00:15:47,970 --> 00:15:44,480
and delivered to the launch pad on time

382
00:15:56,150 --> 00:15:47,980
and none of that was easy

383
00:15:59,509 --> 00:15:56,160
[Music]

384
00:16:01,990 --> 00:15:59,519
2015 may be the year of pluto but

385
00:16:03,749 --> 00:16:02,000
getting there has taken many long years

386
00:16:06,470 --> 00:16:03,759
of effort

387
00:16:08,550 --> 00:16:06,480
and for new horizons there's a date when

388
00:16:11,590 --> 00:16:08,560

things got started

389
00:16:15,590 --> 00:16:13,430
it was the year when george herbert

390
00:16:18,629 --> 00:16:15,600
walker bush became president and the

391
00:16:21,110 --> 00:16:18,639
berlin wall fell

392
00:16:23,590 --> 00:16:21,120
far from earth it was also the year when

393
00:16:26,230 --> 00:16:23,600
nasa's voyager spacecraft flew by

394
00:16:29,829 --> 00:16:26,240
neptune and returned the first images of

395
00:16:33,990 --> 00:16:31,670
hairstyles of some new horizon

396
00:16:37,670 --> 00:16:34,000
scientists were very different but for

397
00:16:40,150 --> 00:16:37,680
them may 5th 1989 was a most important

398
00:16:42,710 --> 00:16:40,160
date that's the day that i marched into

399
00:16:45,590 --> 00:16:42,720
the then division director for planetary

400
00:16:48,230 --> 00:16:45,600
science at nasa headquarters jeff briggs

401
00:16:49,509 --> 00:16:48,240
as a graduate student and asked him

402
00:16:50,550 --> 00:16:49,519
why we aren't studying a mission to

403
00:16:52,470 --> 00:16:50,560
pluto

404
00:16:53,990 --> 00:16:52,480
and he responded because no one's ever

405
00:16:55,749 --> 00:16:54,000
asked me before

406
00:16:58,310 --> 00:16:55,759
that seems like a brilliant idea why

407
00:17:00,550 --> 00:16:58,320
don't we do that space missions rely on

408
00:17:03,590 --> 00:17:00,560
hundreds if not thousands of people but

409
00:17:05,990 --> 00:17:03,600
sometimes it takes someone with passion

410
00:17:09,510 --> 00:17:06,000
and persistence to make things happen

411
00:17:10,949 --> 00:17:09,520
and for new horizons that's alan stern

412
00:17:12,470 --> 00:17:10,959
i was interested in this when i was a

413
00:17:14,150 --> 00:17:12,480

boy so i've been somewhere between in

414
00:17:16,150 --> 00:17:14,160
the groove and stuck in a rut for 40

415
00:17:17,829 --> 00:17:16,160
years there had been some thought about

416
00:17:20,470 --> 00:17:17,839
sending one of the twin voyager

417
00:17:22,390 --> 00:17:20,480
spacecraft past pluto to complete the

418
00:17:24,230 --> 00:17:22,400
exploration of the known solar system

419
00:17:26,710 --> 00:17:24,240
but in the 70s the scientific

420
00:17:28,630 --> 00:17:26,720
establishment wasn't convinced pluto was

421
00:17:31,669 --> 00:17:28,640
all that interesting young grad students

422
00:17:33,110 --> 00:17:31,679
like alan mark bowie and fran bagano

423
00:17:36,710 --> 00:17:33,120
thought differently

424
00:17:38,230 --> 00:17:36,720
back in all about late 1989 or so there

425
00:17:40,310 --> 00:17:38,240
was a bunch of us who were really keen

426
00:17:42,870 --> 00:17:40,320
to go to pluto and the thing that drew

427
00:17:45,669 --> 00:17:42,880
me to it the most was the fact that we

428
00:17:47,510 --> 00:17:45,679
knew so little here's the frontier so it

429
00:17:49,909 --> 00:17:47,520
was a bit of an opportunity for young

430
00:17:51,990 --> 00:17:49,919
people to come in and say hey where are

431
00:17:54,470 --> 00:17:52,000
we going to go next what's the next

432
00:17:57,510 --> 00:17:54,480
great frontier that we should go explore

433
00:18:00,070 --> 00:17:57,520
and it was clear out to the kuiper belt

434
00:18:02,950 --> 00:18:00,080
alan fran mark and a small band of

435
00:18:05,590 --> 00:18:02,960
enthusiasts became known as the pluto

436
00:18:07,110 --> 00:18:05,600
underground so we realized to make this

437
00:18:10,070 --> 00:18:07,120
happen we had to get together and

438
00:18:12,470 --> 00:18:10,080

campaign hard to make the case

439
00:18:14,630 --> 00:18:12,480
to go there and explore this little

440
00:18:17,029 --> 00:18:14,640
planet with all its moons all through

441
00:18:19,430 --> 00:18:17,039
the 90s there were many competing plans

442
00:18:22,549 --> 00:18:19,440
for a pluto mission like the pluto fast

443
00:18:25,590 --> 00:18:22,559
flyby the pluto kuiper express a pluto

444
00:18:27,110 --> 00:18:25,600
mission was on then off then on then off

445
00:18:28,470 --> 00:18:27,120
the pluto mission had been a cat it

446
00:18:30,630 --> 00:18:28,480
would have been dead long ago because

447
00:18:33,590 --> 00:18:30,640
they only get nine lives and we've had

448
00:18:36,230 --> 00:18:33,600
significantly more than nine stoppages

449
00:18:38,070 --> 00:18:36,240
and odd twists and turns what finally

450
00:18:40,710 --> 00:18:38,080
turned the tide was the national

451
00:18:42,470 --> 00:18:40,720
academy's decadal survey a consensus

452
00:18:44,549 --> 00:18:42,480
document from leading planetary

453
00:18:47,190 --> 00:18:44,559
scientists that ranked a kuiper belt

454
00:18:49,590 --> 00:18:47,200
pluto mission highest in priority for

455
00:18:52,070 --> 00:18:49,600
medium class budgets finally after

456
00:18:54,710 --> 00:18:52,080
competitive proposals were evaluated new

457
00:18:56,390 --> 00:18:54,720
horizons which teamed alan stern with

458
00:18:58,470 --> 00:18:56,400
the johns hopkins applied physics

459
00:19:00,470 --> 00:18:58,480
laboratory apl and several other

460
00:19:05,430 --> 00:19:00,480
institutions across the country was

461
00:19:08,870 --> 00:19:05,440
selected by nasa on november 29 2001.

462
00:19:12,870 --> 00:19:08,880
now plans on paper became metal in clean

463
00:19:14,950 --> 00:19:12,880

rooms in 2004 lead scientist alan stern

464
00:19:16,549 --> 00:19:14,960
described the mission's key science

465
00:19:19,430 --> 00:19:16,559
objective well you know the key to

466
00:19:21,350 --> 00:19:19,440
planetary science is um that you really

467
00:19:22,950 --> 00:19:21,360
have to go places to get the resolution

468
00:19:24,950 --> 00:19:22,960
to get up close enough to really see

469
00:19:27,190 --> 00:19:24,960
what's going on we want to get up close

470
00:19:29,029 --> 00:19:27,200
and personal the very best resolution of

471
00:19:31,270 --> 00:19:29,039
current telescopes looking at pluto

472
00:19:34,230 --> 00:19:31,280
would give this kind of fuzzy image of a

473
00:19:36,789 --> 00:19:34,240
much more familiar world but here's what

474
00:19:38,630 --> 00:19:36,799
new horizons would see if flying over

475
00:19:41,029 --> 00:19:38,640
new york city

476
00:19:43,590 --> 00:19:41,039
lakes in central park

477
00:19:46,070 --> 00:19:43,600
dwarves on the hudson river

478
00:19:48,789 --> 00:19:46,080
new horizons is the first really of a

479
00:19:51,590 --> 00:19:48,799
whole new breed of spacecraft that is

480
00:19:53,590 --> 00:19:51,600
focusing on a very specific task for

481
00:19:56,150 --> 00:19:53,600
this first mission to pluto the

482
00:19:58,870 --> 00:19:56,160
questions are basic what do pluto and

483
00:20:01,110 --> 00:19:58,880
karen look like what are they made of

484
00:20:03,510 --> 00:20:01,120
how do their atmospheres behave

485
00:20:05,590 --> 00:20:03,520
we have to really be disciplined and say

486
00:20:07,990 --> 00:20:05,600
we can't do everything let's focus on

487
00:20:09,750 --> 00:20:08,000
the primary questions and design the

488
00:20:12,310 --> 00:20:09,760

instruments to answer those primary

489
00:20:14,310 --> 00:20:12,320
questions the long range imager laurie

490
00:20:16,470 --> 00:20:14,320
will be used for navigation approaching

491
00:20:19,350 --> 00:20:16,480
pluto and close-up views during the

492
00:20:21,750 --> 00:20:19,360
flyby the wide-angle camera ralph has

493
00:20:24,789 --> 00:20:21,760
both visible light and infrared sensors

494
00:20:27,830 --> 00:20:24,799
to map pluto and karen and characterize

495
00:20:30,070 --> 00:20:27,840
their icy surfaces there are two fields

496
00:20:32,549 --> 00:20:30,080
and particles detectors to probe the

497
00:20:35,270 --> 00:20:32,559
solar wind at pluto

498
00:20:37,110 --> 00:20:35,280
the large radio antenna is an essential

499
00:20:39,909 --> 00:20:37,120
communications device

500
00:20:41,909 --> 00:20:39,919
but both rex and alice and ultraviolet

501
00:20:44,310 --> 00:20:41,919
imaging spectrometer are part of

502
00:20:45,909 --> 00:20:44,320
experiments to analyze pluto's

503
00:20:48,149 --> 00:20:45,919
atmosphere

504
00:20:50,310 --> 00:20:48,159
and there's the venetia bernie student

505
00:20:52,950 --> 00:20:50,320
dust counter built by undergrads at uc

506
00:20:56,070 --> 00:20:52,960
boulder and honoring the school girl who

507
00:20:57,990 --> 00:20:56,080
named pluto back in 1930. together the

508
00:21:00,710 --> 00:20:58,000
seven science instruments comprise the

509
00:21:03,190 --> 00:21:00,720
most powerful set of detectors ever sent

510
00:21:05,270 --> 00:21:03,200
on a first flyby of any world in our

511
00:21:07,590 --> 00:21:05,280
solar system but their innovative and

512
00:21:10,070 --> 00:21:07,600
highly miniaturized design means that

513
00:21:13,270 --> 00:21:10,080

even when all are operating they draw

514
00:21:15,029 --> 00:21:13,280
less power than half a 60 watt bulb and

515
00:21:18,789 --> 00:21:15,039
they're intended to work together

516
00:21:23,909 --> 00:21:21,750
after building comes testing but always

517
00:21:25,510 --> 00:21:23,919
with an eye on the clock and the

518
00:21:27,909 --> 00:21:25,520
calendar

519
00:21:30,789 --> 00:21:27,919
it's very very important that we launch

520
00:21:32,710 --> 00:21:30,799
in either 2006 or 2007. we have to make

521
00:21:34,950 --> 00:21:32,720
that deadline if you want to fly to

522
00:21:37,350 --> 00:21:34,960
pluto on the quickest route you need

523
00:21:40,789 --> 00:21:37,360
jupiter in position and that means we

524
00:21:42,310 --> 00:21:40,799
have to launch in january of 2006. it

525
00:21:44,310 --> 00:21:42,320
feels a little bit like being strapped

526
00:21:46,789 --> 00:21:44,320
to a train going 500 miles an hour the

527
00:21:49,990 --> 00:21:46,799
test program involves teams of engineers

528
00:21:51,990 --> 00:21:50,000
at johns hopkins apl and then at nasa's

529
00:21:53,110 --> 00:21:52,000
goddard space flight center once we

530
00:21:55,270 --> 00:21:53,120
launch this

531
00:21:57,750 --> 00:21:55,280
we can't go after with a screwdriver we

532
00:21:59,190 --> 00:21:57,760
can't go fix anything that isn't working

533
00:22:00,950 --> 00:21:59,200
we make sure that we carry plenty of

534
00:22:02,789 --> 00:22:00,960
spare equipment on board the spacecraft

535
00:22:05,110 --> 00:22:02,799
our main computer breaks we have a

536
00:22:06,710 --> 00:22:05,120
backup if our main transmitter breaks we

537
00:22:08,630 --> 00:22:06,720
have a backup one of the things we do is

538
00:22:09,990 --> 00:22:08,640

we put the whole spacecraft on a

539
00:22:12,710 --> 00:22:10,000
gigantic

540
00:22:13,990 --> 00:22:12,720
vibration table a paint shaker and shake

541
00:22:16,390 --> 00:22:14,000
it and

542
00:22:18,310 --> 00:22:16,400
and then test it after that and shake it

543
00:22:20,149 --> 00:22:18,320
again and test it again so that's what

544
00:22:22,630 --> 00:22:20,159
we're doing from now to launch along

545
00:22:24,950 --> 00:22:22,640
with testing the spacecraft new horizons

546
00:22:27,110 --> 00:22:24,960
needs to train and test its human

547
00:22:29,909 --> 00:22:27,120
operators and for a mission plan to

548
00:22:32,549 --> 00:22:29,919
reach pluto in 2015 it's important to

549
00:22:35,510 --> 00:22:32,559
have young people on board early so

550
00:22:38,230 --> 00:22:35,520
they'll be around a close approach it's

551
00:22:39,350 --> 00:22:38,240
good that we can do that so they will

552
00:22:42,149 --> 00:22:39,360
have

553
00:22:43,909 --> 00:22:42,159
both the time the focus to stay with the

554
00:22:45,909 --> 00:22:43,919
mission over this long period of time

555
00:22:49,430 --> 00:22:45,919
many of the faces you see around mission

556
00:22:51,669 --> 00:22:49,440
control in 2004 and 2005 are young and

557
00:22:53,830 --> 00:22:51,679
enthusiastic spacecraft engineers

558
00:22:56,149 --> 00:22:53,840
normally we're focused on subsystems and

559
00:22:57,669 --> 00:22:56,159
instruments in the spacecraft surviving

560
00:22:59,029 --> 00:22:57,679
that duration but

561
00:23:01,430 --> 00:22:59,039
you know for people we have to have a

562
00:23:03,830 --> 00:23:01,440
longevity plan they be committing the

563
00:23:05,029 --> 00:23:03,840

prime of their careers to this mission

564
00:23:07,350 --> 00:23:05,039
to pluto

565
00:23:09,909 --> 00:23:07,360
knowing they'd be a decade older when

566
00:23:12,149 --> 00:23:09,919
new horizons reaches its primary target

567
00:23:14,789 --> 00:23:12,159
the ability to practice things

568
00:23:16,950 --> 00:23:14,799
in those years far out there

569
00:23:20,710 --> 00:23:16,960
are all part of the planning now

570
00:23:27,830 --> 00:23:20,720
to assure mission success then

571
00:23:32,390 --> 00:23:29,270
yes

572
00:23:35,190 --> 00:23:32,400
in late 2005 the action shifts to cape

573
00:23:37,350 --> 00:23:35,200
canaveral new horizons may be light and

574
00:23:40,470 --> 00:23:37,360
relatively small but launching it to

575
00:23:42,070 --> 00:23:40,480
pluto requires america's most powerful

576
00:23:44,310 --> 00:23:42,080
rocket

577
00:23:46,470 --> 00:23:44,320
the atlas v

578
00:23:48,950 --> 00:23:46,480
new horizons will be traveling so far

579
00:23:51,269 --> 00:23:48,960
from the sun that solar panels wouldn't

580
00:23:54,310 --> 00:23:51,279
be sufficient so the department of

581
00:23:56,549 --> 00:23:54,320
energy delivered an rtg that would power

582
00:23:59,750 --> 00:23:56,559
the pluto mission by turning heat from

583
00:24:02,470 --> 00:23:59,760
the radioactive decay of plutonium into

584
00:24:04,710 --> 00:24:02,480
electricity

585
00:24:07,029 --> 00:24:04,720
working round the clock they arrive at

586
00:24:09,430 --> 00:24:07,039
pad 41 before dawn

587
00:24:12,310 --> 00:24:09,440
on behalf of nasa and the entire new

588
00:24:15,029 --> 00:24:12,320

horizons team stern wanted to be the

589
00:24:17,830 --> 00:24:15,039
last to bid the spacecraft bon voyage

590
00:24:21,909 --> 00:24:17,840
before closing up the hatch on january

591
00:24:24,630 --> 00:24:21,919
19 2006 after 17 years of planning

592
00:24:26,870 --> 00:24:24,640
building and testing a picture-perfect

593
00:24:29,269 --> 00:24:26,880
launch that thrilled onlookers in

594
00:24:38,549 --> 00:24:29,279
florida and the mission operations team

595
00:24:44,070 --> 00:24:41,669
pluto and then beyond despite immense

596
00:24:46,950 --> 00:24:44,080
technical and timetable challenges the

597
00:24:47,990 --> 00:24:46,960
mission had made its window and was on

598
00:24:50,710 --> 00:24:48,000
its way

599
00:24:53,669 --> 00:24:50,720
new horizons velocity at launch was the

600
00:24:55,590 --> 00:24:53,679
fastest ever traveling almost 60 times

601
00:24:58,230 --> 00:24:55,600
faster than a jetliner

602
00:24:59,430 --> 00:24:58,240
in just nine hours it passed the orbit

603
00:25:01,830 --> 00:24:59,440
of the moon

604
00:25:03,029 --> 00:25:01,840
apollo had taken almost 10 times that

605
00:25:05,590 --> 00:25:03,039
long

606
00:25:08,149 --> 00:25:05,600
one year later a slingshot gravity

607
00:25:10,149 --> 00:25:08,159
assist from the giant planet jupiter

608
00:25:12,310 --> 00:25:10,159
provided another two kilometers per

609
00:25:15,430 --> 00:25:12,320
second boost cutting travel time the

610
00:25:17,830 --> 00:25:15,440
pluto by three full years

611
00:25:20,630 --> 00:25:17,840
but this was more than just a jump in

612
00:25:23,669 --> 00:25:20,640
speed the jupiter flyby was a scientific

613
00:25:25,909 --> 00:25:23,679

dress rehearsal for pluto new horizons

614
00:25:31,590 --> 00:25:25,919
instruments returned detailed images of

615
00:25:37,909 --> 00:25:34,470
then it was off across the empty ocean

616
00:25:40,950 --> 00:25:37,919
of space with no new land in sight till

617
00:25:43,190 --> 00:25:40,960
pluto in 2015.

618
00:25:45,430 --> 00:25:43,200
the spacecraft had been tested and

619
00:25:48,149 --> 00:25:45,440
passed with flying colors

620
00:25:50,149 --> 00:25:48,159
now it was time to test the humans and

621
00:25:54,549 --> 00:25:50,159
the ground systems

622
00:25:56,549 --> 00:25:54,559
july 5th 2013 it's day one of a nine-day

623
00:25:59,269 --> 00:25:56,559
encounter rehearsal the main success

624
00:26:02,630 --> 00:25:59,279
criteria for this rehearsal is for the

625
00:26:04,789 --> 00:26:02,640
spacecraft to flawlessly perform its

626
00:26:06,950 --> 00:26:04,799
activities as if it were pluto with

627
00:26:08,710 --> 00:26:06,960
everything the same except that pluto's

628
00:26:12,230 --> 00:26:08,720
not there

629
00:26:14,470 --> 00:26:12,240
the dates in 2013 were carefully chosen

630
00:26:16,310 --> 00:26:14,480
so that earth-received times would be

631
00:26:19,990 --> 00:26:16,320
identical to those for the real

632
00:26:22,310 --> 00:26:20,000
encounter in 2015.

633
00:26:24,950 --> 00:26:22,320
mission managers wanted scientists and

634
00:26:28,630 --> 00:26:24,960
engineers to experience the stress of

635
00:26:31,909 --> 00:26:28,640
time critical 24 7 operations expected

636
00:26:34,070 --> 00:26:31,919
for july 2015. we're flying by an object

637
00:26:35,830 --> 00:26:34,080
that is a huge distance from earth and

638
00:26:39,110 --> 00:26:35,840

we're trying to hit a box that's 100 by

639
00:26:41,110 --> 00:26:39,120
150 kilometers wide and that then leads

640
00:26:43,510 --> 00:26:41,120
into maneuver planning and and

641
00:26:45,590 --> 00:26:43,520
trajectory control needed to thread that

642
00:26:47,830 --> 00:26:45,600
that needle and hit that small box it's

643
00:26:50,549 --> 00:26:47,840
way the heck out there this rehearsal

644
00:26:53,350 --> 00:26:50,559
would actually be uploading commands to

645
00:26:55,669 --> 00:26:53,360
new horizons to instruct the spacecraft

646
00:26:58,710 --> 00:26:55,679
to run through the exact same set of

647
00:27:00,310 --> 00:26:58,720
observations as in 2015. there

648
00:27:02,310 --> 00:27:00,320
definitely is an element of risk

649
00:27:03,669 --> 00:27:02,320
involved but from one standpoint if you

650
00:27:05,430 --> 00:27:03,679
didn't do any simulation with the real

651
00:27:07,830 --> 00:27:05,440
spacecraft at all you could argue that

652
00:27:10,149 --> 00:27:07,840
could pose more risk because you don't

653
00:27:12,870 --> 00:27:10,159
want such a critical activity only being

654
00:27:15,669 --> 00:27:12,880
done once on flight those are all

655
00:27:19,350 --> 00:27:15,679
invaluable to get us ready

656
00:27:21,590 --> 00:27:19,360
and and practiced for the one and only

657
00:27:23,669 --> 00:27:21,600
shot we'll have to explore the pluto

658
00:27:25,269 --> 00:27:23,679
system we've been waiting uh 12 years

659
00:27:28,470 --> 00:27:25,279
since we wrote the proposals to do this

660
00:27:30,789 --> 00:27:28,480
rehearsal it's the last big step before

661
00:27:34,710 --> 00:27:30,799
we can do the encounter we think that we

662
00:27:36,230 --> 00:27:34,720
are about 10 million miles out from

663
00:27:37,830 --> 00:27:36,240

pluto and closing

664
00:27:39,390 --> 00:27:37,840
but so far so good

665
00:27:52,710 --> 00:27:39,400
we're off to the races

666
00:27:54,190 --> 00:27:52,720
[Music]

667
00:27:56,710 --> 00:27:54,200
today is our

668
00:27:59,110 --> 00:27:56,720
2724th day in flight this has been a

669
00:28:00,870 --> 00:27:59,120
long time coming literally i only want

670
00:28:02,700 --> 00:28:00,880
to say thanks for all the work let them

671
00:28:14,389 --> 00:28:02,710
eat cake

672
00:28:15,630 --> 00:28:14,399
[Music]

673
00:28:21,430 --> 00:28:15,640
july 12

674
00:28:24,310 --> 00:28:21,440
2013 standing in for july 14 2015.

675
00:28:28,870 --> 00:28:24,320
this is it a minute-by-minute simulation

676
00:28:32,870 --> 00:28:30,950
it's make or break

677
00:28:34,870 --> 00:28:32,880
well it's it's the most important

678
00:28:36,870 --> 00:28:34,880
because we've best been spending the 24

679
00:28:37,750 --> 00:28:36,880
hours of the most intense activities

680
00:28:39,510 --> 00:28:37,760
that we've been running on the

681
00:28:41,430 --> 00:28:39,520
spacecraft and this is the longest that

682
00:28:43,669 --> 00:28:41,440
we've been out of contact since we've

683
00:28:46,310 --> 00:28:43,679
entered in counter rehearsal this may be

684
00:28:48,549 --> 00:28:46,320
a rehearsal but new horizons has been

685
00:28:51,029 --> 00:28:48,559
firing its thrusters and spinning in

686
00:28:53,669 --> 00:28:51,039
space identical maneuvers to those

687
00:28:56,230 --> 00:28:53,679
planned for 2015.

688
00:28:59,510 --> 00:28:56,240

on encounter day the spacecraft will be

689
00:29:02,149 --> 00:28:59,520
too busy taking data to send back images

690
00:29:06,549 --> 00:29:02,159
that's why it's first simple i'm a live

691
00:29:22,549 --> 00:29:09,510
sometime within the next minute dss 43

692
00:29:26,710 --> 00:29:24,310
we're good we're nominal spacecraft's

693
00:29:28,549 --> 00:29:26,720
nominal and it looks like

694
00:29:30,710 --> 00:29:28,559
all the observations that we had planned

695
00:29:32,710 --> 00:29:30,720
between last track and this track

696
00:29:34,070 --> 00:29:32,720
happened this gives us good confidence

697
00:29:36,470 --> 00:29:34,080
at least the spacecraft has been

698
00:29:38,630 --> 00:29:36,480
performing all of those twists and turns

699
00:29:41,029 --> 00:29:38,640
that we've been anticipating it to over

700
00:29:42,710 --> 00:29:41,039
the last seven days i like to say that

701
00:29:44,549 --> 00:29:42,720
at the flyby i don't want to be learning

702
00:29:46,070 --> 00:29:44,559
anything about the ground system or the

703
00:29:48,389 --> 00:29:46,080
spacecraft of the team i want to be

704
00:29:50,470 --> 00:29:48,399
learning only about the pluto system no

705
00:29:52,389 --> 00:29:50,480
spacecraft has ever been to pluto or nor

706
00:29:54,310 --> 00:29:52,399
will ever go back in our lifetime pluto

707
00:29:56,149 --> 00:29:54,320
is every child's favorite planet you

708
00:29:57,430 --> 00:29:56,159
know you ask anyone under the age of six

709
00:29:58,789 --> 00:29:57,440
and they're gonna say pluto we don't

710
00:30:00,870 --> 00:29:58,799
exactly know what pluto looks like but

711
00:30:02,789 --> 00:30:00,880
it looks very exciting from the images

712
00:30:04,470 --> 00:30:02,799
we have from the hubble space telescope

713
00:30:06,950 --> 00:30:04,480

so far we really can't wait to get there

714
00:30:09,269 --> 00:30:06,960
and see what it actually looks like so

715
00:30:10,870 --> 00:30:09,279
if anybody says that pluto is boring or

716
00:30:11,909 --> 00:30:10,880
not important

717
00:30:14,549 --> 00:30:11,919
no way

718
00:30:16,549 --> 00:30:14,559
before new horizons arrives at pluto

719
00:30:19,510 --> 00:30:16,559
most everything we think we know about

720
00:30:20,549 --> 00:30:19,520
the planet and its moons is up for grabs

721
00:30:22,230 --> 00:30:20,559
virtually

722
00:30:24,549 --> 00:30:22,240
every place we've sent a spacecraft on a

723
00:30:26,389 --> 00:30:24,559
first reconnaissance mission like this

724
00:30:29,269 --> 00:30:26,399
that we find out that our earth-based

725
00:30:31,909 --> 00:30:29,279
notions were flat wrong so i'll tell you

726
00:30:34,070 --> 00:30:31,919
what we expect but i

727
00:30:36,149 --> 00:30:34,080
before anything what we expect is to be

728
00:30:39,029 --> 00:30:36,159
surprised

729
00:30:41,909 --> 00:30:39,039
from the 1990s through today stern has

730
00:30:44,389 --> 00:30:41,919
been consistent in avoiding speculation

731
00:30:46,310 --> 00:30:44,399
you get the same answer everybody's

732
00:30:48,149 --> 00:30:46,320
gotten from me for

733
00:30:51,269 --> 00:30:48,159
almost 20 years

734
00:30:52,710 --> 00:30:51,279
i don't make predictions except for one

735
00:30:54,870 --> 00:30:52,720
my best guess is

736
00:30:56,630 --> 00:30:54,880
we're gonna find something wonderful but

737
00:30:59,830 --> 00:30:56,640
in the final months leading up to the

738
00:31:02,710 --> 00:30:59,840

july 2015 encounter it's hard for most

739
00:31:04,789 --> 00:31:02,720
humans not to imagine what we'll see

740
00:31:06,789 --> 00:31:04,799
many planetary scientists like paul

741
00:31:09,590 --> 00:31:06,799
shank based their expectations in what

742
00:31:12,230 --> 00:31:09,600
we saw when voyager 2 reached neptune

743
00:31:14,950 --> 00:31:12,240
and specifically as it flew by its moon

744
00:31:16,950 --> 00:31:14,960
triton voyager was a 10 year long

745
00:31:18,630 --> 00:31:16,960
exploration of the outer solar system

746
00:31:20,870 --> 00:31:18,640
and every time they got to a planet it

747
00:31:22,230 --> 00:31:20,880
was basically the first time anybody had

748
00:31:24,870 --> 00:31:22,240
really seen those bodies so when they

749
00:31:26,470 --> 00:31:24,880
got to jupiter they were greeted with

750
00:31:28,950 --> 00:31:26,480
enormous surprises the erupting

751
00:31:31,110 --> 00:31:28,960
volcanoes on an aisle were just

752
00:31:32,710 --> 00:31:31,120
completely unexpected and so when they

753
00:31:35,830 --> 00:31:32,720
got to uranus there were more surprises

754
00:31:37,750 --> 00:31:35,840
the exotic trains of miranda and ariel

755
00:31:39,269 --> 00:31:37,760
for example were not expected so by the

756
00:31:41,269 --> 00:31:39,279
time they got to neptune they were kind

757
00:31:43,750 --> 00:31:41,279
of accustomed to the idea that they were

758
00:31:44,870 --> 00:31:43,760
going to be surprised and sure enough

759
00:31:47,190 --> 00:31:44,880
triton

760
00:31:49,750 --> 00:31:47,200
completely blew them away bonnie baratti

761
00:31:52,389 --> 00:31:49,760
was at nasa's jet propulsion lab as the

762
00:31:55,909 --> 00:31:52,399
first images of triton a moon of nearly

763
00:31:58,630 --> 00:31:55,919

1700 miles diameter came down fright was

764
00:32:00,789 --> 00:31:58,640
almost a twin of pluto it's about the

765
00:32:02,950 --> 00:32:00,799
same size about the same brightness

766
00:32:05,269 --> 00:32:02,960
originally triton was probably a kuiper

767
00:32:07,190 --> 00:32:05,279
belt object just like pluto floating

768
00:32:09,590 --> 00:32:07,200
around in space but then it got too

769
00:32:12,310 --> 00:32:09,600
close to neptune and it got captured by

770
00:32:15,029 --> 00:32:12,320
neptune's gravitational field recently

771
00:32:17,909 --> 00:32:15,039
paul shank enhanced the original voyager

772
00:32:19,669 --> 00:32:17,919
data to create this detailed flyover of

773
00:32:22,870 --> 00:32:19,679
triton it has

774
00:32:24,470 --> 00:32:22,880
odd patches not blob like features kind

775
00:32:27,190 --> 00:32:24,480
of like amoebas crawling around on the

776
00:32:29,350 --> 00:32:27,200
surface triton has very few impact

777
00:32:32,310 --> 00:32:29,360
craters its surface is extremely young

778
00:32:35,110 --> 00:32:32,320
geologically and it actually has

779
00:32:37,909 --> 00:32:35,120
geysers spurting material off into space

780
00:32:41,509 --> 00:32:37,919
here is a body that is

781
00:32:44,389 --> 00:32:41,519
hundreds of degrees below zero so cold

782
00:32:46,710 --> 00:32:44,399
it's forlorn it's barren we just didn't

783
00:32:48,630 --> 00:32:46,720
expect to see this activity on trade it

784
00:32:50,789 --> 00:32:48,640
was quite a surprise if you just assumed

785
00:32:52,470 --> 00:32:50,799
that pluto was going to look exactly

786
00:32:54,149 --> 00:32:52,480
like triton which is the most similar

787
00:32:56,630 --> 00:32:54,159
object we know about then you might

788
00:32:59,190 --> 00:32:56,640

expect to find a very interesting body

789
00:33:01,509 --> 00:32:59,200
but triton is not the only dynamic ice

790
00:33:03,269 --> 00:33:01,519
world in the outer solar system

791
00:33:05,750 --> 00:33:03,279
sixteen years later the cassini

792
00:33:09,110 --> 00:33:05,760
spacecraft sent back images of saturn's

793
00:33:11,509 --> 00:33:09,120
moon enceladus about 300 miles across

794
00:33:13,750 --> 00:33:11,519
this is a tiny little moon and enceladus

795
00:33:16,630 --> 00:33:13,760
is actually a winter wonderland it's

796
00:33:18,789 --> 00:33:16,640
very bright it reflects almost all the

797
00:33:19,669 --> 00:33:18,799
radiation that falls on it and it has

798
00:33:23,590 --> 00:33:19,679
these

799
00:33:26,470 --> 00:33:23,600
huge ice volcanoes spewing out from its

800
00:33:28,710 --> 00:33:26,480
south pole and enceladus is continuously

801
00:33:31,029 --> 00:33:28,720
giving off puffs of water vapor and so

802
00:33:33,190 --> 00:33:31,039
if you start to see puffs of water vapor

803
00:33:34,950 --> 00:33:33,200
coming off pluto as new horizons gets

804
00:33:35,990 --> 00:33:34,960
closer that would be exceedingly

805
00:33:39,029 --> 00:33:36,000
interesting

806
00:33:40,789 --> 00:33:39,039
but what forces can power volcanoes in

807
00:33:44,470 --> 00:33:40,799
the deep freeze of the outer solar

808
00:33:46,310 --> 00:33:44,480
system triton and pluto are both balls

809
00:33:48,310 --> 00:33:46,320
of ice with presumably rock in the

810
00:33:51,190 --> 00:33:48,320
center and so one of the sources of

811
00:33:53,110 --> 00:33:51,200
energy is radioactive decay inside the

812
00:33:56,070 --> 00:33:53,120
rock which gives off heat just like the

813
00:33:58,470 --> 00:33:56,080

earth is heated if you just let pluto

814
00:34:00,710 --> 00:33:58,480
sit there and pump the heat out of the

815
00:34:02,549 --> 00:34:00,720
rocks you you generate enough energy to

816
00:34:05,590 --> 00:34:02,559
melt a couple of hundred kilometers

817
00:34:07,669 --> 00:34:05,600
worth of ice it's still possible to have

818
00:34:10,230 --> 00:34:07,679
an ocean beneath a relatively thick eye

819
00:34:13,109 --> 00:34:10,240
shell the eye shell might be 100 miles

820
00:34:15,430 --> 00:34:13,119
thick also over billions of years the

821
00:34:18,550 --> 00:34:15,440
ice shell gets thicker and thicker and

822
00:34:21,589 --> 00:34:18,560
thicker as pluto cools and as it does so

823
00:34:23,430 --> 00:34:21,599
it squeezes the water underneath and if

824
00:34:25,270 --> 00:34:23,440
you squeeze the water too much then it

825
00:34:27,109 --> 00:34:25,280
may well actually create fractures and

826
00:34:28,389 --> 00:34:27,119
the water could get out of the surface

827
00:34:30,470 --> 00:34:28,399
when you're going out to the edge of the

828
00:34:31,829 --> 00:34:30,480
solar system you kind of have to expect

829
00:34:34,470 --> 00:34:31,839
some surprises and we're going to see

830
00:34:36,710 --> 00:34:34,480
them at pluto as well just as triton and

831
00:34:39,270 --> 00:34:36,720
enceladus were mere dots before

832
00:34:41,829 --> 00:34:39,280
spacecraft reached them until now pluto

833
00:34:43,510 --> 00:34:41,839
has been an astronomer's planet

834
00:34:46,629 --> 00:34:43,520
that's about to change

835
00:34:50,710 --> 00:34:46,639
we are going to start off as astronomers

836
00:34:52,470 --> 00:34:50,720
and we'll be using astronomical tools to

837
00:34:54,069 --> 00:34:52,480
try and sharpen up our images and pull

838
00:34:56,710 --> 00:34:54,079

every last little bit of detail out of

839
00:34:58,630 --> 00:34:56,720
these fuzzy blobs we gradually turn from

840
00:35:00,950 --> 00:34:58,640
astronomers into geologists as we get

841
00:35:03,510 --> 00:35:00,960
closer and it becomes a real world jeff

842
00:35:05,829 --> 00:35:03,520
moore was in the room at jpl as those

843
00:35:07,910 --> 00:35:05,839
trident images came down but he also

844
00:35:09,990 --> 00:35:07,920
enjoys field work and thinks we'll

845
00:35:12,550 --> 00:35:10,000
recognize some similar planetary

846
00:35:14,710 --> 00:35:12,560
processes and work on pluto as back on

847
00:35:17,670 --> 00:35:14,720
earth so i'm a geologist and although we

848
00:35:20,310 --> 00:35:17,680
don't expect to see oceans on pluto

849
00:35:22,230 --> 00:35:20,320
there are common processes which operate

850
00:35:25,190 --> 00:35:22,240
on this planet which are likely to

851
00:35:27,430 --> 00:35:25,200
operate also on pluto and its moons

852
00:35:29,990 --> 00:35:27,440
while the scales are very different

853
00:35:32,710 --> 00:35:30,000
erosion shapes landforms here on earth

854
00:35:34,790 --> 00:35:32,720
and all across the solar system there

855
00:35:36,550 --> 00:35:34,800
are these little finger-like projections

856
00:35:39,270 --> 00:35:36,560
that are formed by the process of

857
00:35:41,109 --> 00:35:39,280
erosion where wind and water have

858
00:35:43,109 --> 00:35:41,119
sculpted this landscape by taking

859
00:35:45,829 --> 00:35:43,119
advantage of small differences in the

860
00:35:48,230 --> 00:35:45,839
strength of the original rock creating

861
00:35:51,030 --> 00:35:48,240
large huge fantastic landscapes such as

862
00:35:53,270 --> 00:35:51,040
on jupiter's moon callisto and we can

863
00:35:54,950 --> 00:35:53,280

anticipate that we may perhaps also see

864
00:35:58,710 --> 00:35:54,960
landscapes like this

865
00:36:01,430 --> 00:35:58,720
on pluto and its moons pluto's 248-year

866
00:36:03,670 --> 00:36:01,440
orbit is more eccentric than our solar

867
00:36:06,310 --> 00:36:03,680
system's terrestrial and gas giant

868
00:36:07,589 --> 00:36:06,320
planets greatly varying its distance to

869
00:36:09,589 --> 00:36:07,599
the sun

870
00:36:11,990 --> 00:36:09,599
but it's typical of many other objects

871
00:36:14,630 --> 00:36:12,000
in the kuiper belt and newly discovered

872
00:36:17,750 --> 00:36:14,640
planets around other stars

873
00:36:19,990 --> 00:36:17,760
that plus its highly angled polar tilt

874
00:36:22,069 --> 00:36:20,000
combined to produce strong seasonal

875
00:36:23,829 --> 00:36:22,079
effects in fact the seasons the pluto

876
00:36:26,150 --> 00:36:23,839
are amongst the most extreme of any

877
00:36:28,710 --> 00:36:26,160
seasons in any world that we know of

878
00:36:31,030 --> 00:36:28,720
orbiting the sun and those extremes may

879
00:36:33,910 --> 00:36:31,040
be one reason why its surface is also

880
00:36:36,550 --> 00:36:33,920
extremely contrasty pluto is perhaps the

881
00:36:38,310 --> 00:36:36,560
most intensely bright and dark place

882
00:36:40,310 --> 00:36:38,320
that we've seen in the solar system this

883
00:36:42,710 --> 00:36:40,320
dark surface collects more heat it warms

884
00:36:45,670 --> 00:36:42,720
up like asphalt does on a sunny day here

885
00:36:47,829 --> 00:36:45,680
on the earth and if there were frost had

886
00:36:50,230 --> 00:36:47,839
settled on this dark surface they're

887
00:36:52,310 --> 00:36:50,240
being heated up and driven off and the

888
00:36:54,310 --> 00:36:52,320

transportation of this material could

889
00:36:56,950 --> 00:36:54,320
also be creating wind so you might see

890
00:36:58,870 --> 00:36:56,960
small dunes oriented along the periphery

891
00:37:01,750 --> 00:36:58,880
of the dark surface showing this process

892
00:37:03,750 --> 00:37:01,760
in action for planetary scientists color

893
00:37:06,550 --> 00:37:03,760
can be a clue to the composition of

894
00:37:08,470 --> 00:37:06,560
surfaces that can't be sampled directly

895
00:37:09,750 --> 00:37:08,480
on the earth these kinds of colors from

896
00:37:12,470 --> 00:37:09,760
red to

897
00:37:15,190 --> 00:37:12,480
dark gray are generated entirely by the

898
00:37:17,510 --> 00:37:15,200
presence or absence of rust on pluto we

899
00:37:21,109 --> 00:37:17,520
see also these same ranges of colors

900
00:37:23,589 --> 00:37:21,119
from gray to bright white to yellow to

901
00:37:25,670 --> 00:37:23,599
red to black but there it must be due to

902
00:37:28,069 --> 00:37:25,680
a completely different process at nasa's

903
00:37:30,150 --> 00:37:28,079
ames research center near san francisco

904
00:37:32,870 --> 00:37:30,160
long-time pluto researcher dale

905
00:37:34,950 --> 00:37:32,880
crookshank and post-doc chris matarese

906
00:37:37,430 --> 00:37:34,960
conduct experiments to see what

907
00:37:39,589 --> 00:37:37,440
processes might create the colors we see

908
00:37:41,990 --> 00:37:39,599
on pluto starting with gases like

909
00:37:44,230 --> 00:37:42,000
methane and nitrogen and the extreme low

910
00:37:45,109 --> 00:37:44,240
temperatures we know are found there in

911
00:37:48,150 --> 00:37:45,119
our

912
00:37:50,790 --> 00:37:48,160
cold chamber we can produce a thin film

913
00:37:53,510 --> 00:37:50,800

of ice and then after that expose them

914
00:37:56,069 --> 00:37:53,520
to a beam of electrons which are charged

915
00:37:58,550 --> 00:37:56,079
particles comparable to what comes in to

916
00:38:00,390 --> 00:37:58,560
pluto's surface from space we find that

917
00:38:03,750 --> 00:38:00,400
when we

918
00:38:06,390 --> 00:38:03,760
shine ultraviolet light or electrons on

919
00:38:09,190 --> 00:38:06,400
simple molecules before too long the

920
00:38:11,430 --> 00:38:09,200
simple molecules are broken apart and by

921
00:38:13,990 --> 00:38:11,440
natural processes they reassemble into

922
00:38:15,910 --> 00:38:14,000
more complex chemicals

923
00:38:18,870 --> 00:38:15,920
so far the colors we make in the lab

924
00:38:21,430 --> 00:38:18,880
from irradiating these ices is is fairly

925
00:38:23,030 --> 00:38:21,440
close to what we see on pluto there are

926
00:38:25,750 --> 00:38:23,040
tones of yellow

927
00:38:28,710 --> 00:38:25,760
light brown up through fairly dark red

928
00:38:31,829 --> 00:38:28,720
and if we carry the processing by

929
00:38:33,589 --> 00:38:31,839
ultraviolet light to an extreme degree

930
00:38:37,270 --> 00:38:33,599
the material actually turns black and

931
00:38:39,910 --> 00:38:37,280
this is almost the color of pure carbon

932
00:38:42,390 --> 00:38:39,920
seeing how radiation transforms simple

933
00:38:44,630 --> 00:38:42,400
ices into complex and colorful organic

934
00:38:46,950 --> 00:38:44,640
molecules should help interpret the

935
00:38:49,829 --> 00:38:46,960
close-up views of pluto's surface that

936
00:38:51,510 --> 00:38:49,839
will be sent back by new horizons color

937
00:38:52,710 --> 00:38:51,520
translates to

938
00:38:59,990 --> 00:38:52,720

the

939
00:39:00,870 --> 00:39:00,000
over a year 10 000 years 10 million

940
00:39:04,710 --> 00:39:00,880
years

941
00:39:06,550 --> 00:39:04,720
that may in turn tell us more about the

942
00:39:08,790 --> 00:39:06,560
nature of the exposure of pluto's

943
00:39:09,910 --> 00:39:08,800
surface and even the age of pluto's

944
00:39:12,150 --> 00:39:09,920
surface

945
00:39:14,790 --> 00:39:12,160
dale crookshank began observing pluto

946
00:39:17,910 --> 00:39:14,800
back in 1976

947
00:39:19,030 --> 00:39:17,920
now 39 years later he's ready for its

948
00:39:20,710 --> 00:39:19,040
close-up

949
00:39:23,190 --> 00:39:20,720
we can say that pluto is chemically

950
00:39:25,030 --> 00:39:23,200
active chemically dynamic we don't know

951
00:39:27,750 --> 00:39:25,040
yet if it's geologically active and

952
00:39:29,670 --> 00:39:27,760
dynamic but that's what new horizons is

953
00:39:33,349 --> 00:39:29,680
going to tell us we've been surprised in

954
00:39:35,109 --> 00:39:33,359
that way before as we've passed other

955
00:39:37,670 --> 00:39:35,119
planetary bodies that we had thought

956
00:39:40,390 --> 00:39:37,680
were totally cold dead

957
00:39:42,950 --> 00:39:40,400
inert worlds and find that there are

958
00:39:43,990 --> 00:39:42,960
geysers there are ice flows there are

959
00:39:45,829 --> 00:39:44,000
cracks

960
00:39:48,069 --> 00:39:45,839
and all kinds of evidence for geological

961
00:39:50,470 --> 00:39:48,079
activity i can still remember the first

962
00:39:52,150 --> 00:39:50,480
time i saw pluto in a telescope and it

963
00:39:53,430 --> 00:39:52,160

was just a little dot that you could

964
00:39:55,270 --> 00:39:53,440
barely see

965
00:39:57,030 --> 00:39:55,280
it will be amazing that within a period

966
00:39:59,349 --> 00:39:57,040
of hours it will be transformed from

967
00:40:01,910 --> 00:39:59,359
this tiny dot that i study as an

968
00:40:04,309 --> 00:40:01,920
astronomer to this huge

969
00:40:06,870 --> 00:40:04,319
geologic world that will be able to see

970
00:40:08,950 --> 00:40:06,880
volcanoes and faults and ices and

971
00:40:10,870 --> 00:40:08,960
mountains and craters i mean it'll be

972
00:40:12,230 --> 00:40:10,880
truly an amazing experience to see it

973
00:40:14,870 --> 00:40:12,240
transformed

974
00:40:17,109 --> 00:40:14,880
so from sophisticated lab experiments

975
00:40:18,950 --> 00:40:17,119
from exploring other worlds and from

976
00:40:21,750 --> 00:40:18,960
applying insights from terrestrial

977
00:40:25,030 --> 00:40:21,760
processes what should we expect when we

978
00:40:26,470 --> 00:40:25,040
get to pluto in july 2015

979
00:40:28,230 --> 00:40:26,480
but the only thing that would surprise

980
00:40:30,870 --> 00:40:28,240
me would be if we turned out not to be

981
00:40:34,390 --> 00:40:30,880
surprised but enjoying the scientific

982
00:40:38,470 --> 00:40:34,400
surprises to come means avoiding dangers

983
00:40:47,349 --> 00:40:38,480
on the last few million miles to pluto

984
00:40:52,710 --> 00:40:50,309
december 6 2014

985
00:40:55,190 --> 00:40:52,720
in mission control alice bowman and her

986
00:40:57,430 --> 00:40:55,200
team wait to get confirmation that new

987
00:40:58,870 --> 00:40:57,440
horizons has exited what's called

988
00:41:01,349 --> 00:40:58,880

hibernation

989
00:41:03,670 --> 00:41:01,359
for two-thirds of its three billion mile

990
00:41:06,150 --> 00:41:03,680
journey most spacecraft systems have

991
00:41:08,630 --> 00:41:06,160
been turned off saving wear and tear on

992
00:41:10,870 --> 00:41:08,640
the science instruments new horizon

993
00:41:13,750 --> 00:41:10,880
sends a simple signal once a week just

994
00:41:16,470 --> 00:41:13,760
to say i'm still a-ok

995
00:41:18,150 --> 00:41:16,480
alice's team has a unique way of showing

996
00:41:20,390 --> 00:41:18,160
spacecraft status

997
00:41:23,109 --> 00:41:20,400
when new horizons is hibernating their

998
00:41:25,270 --> 00:41:23,119
bear mascot is safely asleep

999
00:41:26,950 --> 00:41:25,280
when the spacecraft wakes up they put on

1000
00:41:29,750 --> 00:41:26,960
its party hat

1001
00:41:33,030 --> 00:41:29,760
if all goes well this will be the 18th

1002
00:41:36,950 --> 00:41:33,040
time spacecraft and bear have woken up

1003
00:41:38,950 --> 00:41:36,960
but december 2014 is different vips from

1004
00:41:41,349 --> 00:41:38,960
nasa are on hand

1005
00:41:43,109 --> 00:41:41,359
two film crews document the action as

1006
00:41:45,670 --> 00:41:43,119
alan explains the benefits of

1007
00:41:46,950 --> 00:41:45,680
hibernation it lowers our cost because

1008
00:41:49,670 --> 00:41:46,960
we don't need to have

1009
00:41:51,750 --> 00:41:49,680
people babysitting the spacecraft 24 7.

1010
00:41:52,870 --> 00:41:51,760
outside interest in new horizons is

1011
00:41:55,430 --> 00:41:52,880
building

1012
00:41:59,190 --> 00:41:55,440
if all goes well new horizons will stay

1013
00:42:06,710 --> 00:41:59,200

awake flying by pluto in july 2015 and

1014
00:42:12,390 --> 00:42:09,910
tonight data trickles in and alice has

1015
00:42:13,990 --> 00:42:12,400
to wait to be certain new horizons is

1016
00:42:16,470 --> 00:42:14,000
fully awake

1017
00:42:18,630 --> 00:42:16,480
we should be getting it momentarily

1018
00:42:21,109 --> 00:42:18,640
it should be any minute now it's like

1019
00:42:38,150 --> 00:42:21,119
watching paint dry i figure if i stare

1020
00:42:50,780 --> 00:42:40,550
we have a nominal wake-up of the new

1021
00:42:55,750 --> 00:42:54,230
[Music]

1022
00:42:58,550 --> 00:42:55,760
our bear he's going to be here for a

1023
00:42:59,670 --> 00:42:58,560
while this is a watershed day we have

1024
00:43:01,829 --> 00:42:59,680
completed

1025
00:43:02,790 --> 00:43:01,839
the cruise across three billion miles of

1026
00:43:07,510 --> 00:43:02,800
space

1027
00:43:10,069 --> 00:43:07,520
after nine years i'm glad to see

1028
00:43:12,630 --> 00:43:10,079
hibernation behind us and active ops

1029
00:43:15,109 --> 00:43:12,640
ahead here on to pluto but there are

1030
00:43:17,829 --> 00:43:15,119
still hundreds of tasks to ensure a safe

1031
00:43:20,470 --> 00:43:17,839
flyby in july 2015.

1032
00:43:22,630 --> 00:43:20,480
january 27th new horizons has been

1033
00:43:25,589 --> 00:43:22,640
sending back technical data and all

1034
00:43:27,829 --> 00:43:25,599
seems fine but today is the first time

1035
00:43:30,950 --> 00:43:27,839
hal weaver and andy ching will be seeing

1036
00:43:32,790 --> 00:43:30,960
new science images

1037
00:43:34,870 --> 00:43:32,800
yeah let's try that again

1038
00:43:38,069 --> 00:43:34,880

chang is lead scientist for the lorry

1039
00:43:39,990 --> 00:43:38,079
camera glory is used for navigation to

1040
00:43:42,150 --> 00:43:40,000
find the targets and to correct the

1041
00:43:44,309 --> 00:43:42,160
trajectory so we get to the right place

1042
00:43:46,790 --> 00:43:44,319
at the right time voltage currents

1043
00:43:49,910 --> 00:43:46,800
temperatures all look normal

1044
00:43:51,349 --> 00:43:49,920
no error messages this is it let's let's

1045
00:43:52,630 --> 00:43:51,359
check out

1046
00:44:00,390 --> 00:43:52,640
the

1047
00:44:04,550 --> 00:44:00,400
peak pixel 55.

1048
00:44:08,230 --> 00:44:06,550
all right so great there they are let's

1049
00:44:10,950 --> 00:44:08,240
look at the whole for project scientist

1050
00:44:13,750 --> 00:44:10,960
hal weaver even the jump in size from

1051
00:44:15,750 --> 00:44:13,760
one to two pixels was significant this

1052
00:44:17,829 --> 00:44:15,760
is a real milestone in the new horizons

1053
00:44:20,150 --> 00:44:17,839
mission the very first images of pluto

1054
00:44:22,150 --> 00:44:20,160
in the pluto encounter year

1055
00:44:24,390 --> 00:44:22,160
i hadn't turned lori on hadn't gotten

1056
00:44:26,309 --> 00:44:24,400
any images since last summer last july

1057
00:44:27,910 --> 00:44:26,319
but this is it this is the start of it

1058
00:44:29,190 --> 00:44:27,920
ours she blows

1059
00:44:31,030 --> 00:44:29,200
we really don't know what we're going to

1060
00:44:32,790 --> 00:44:31,040
see that's what this mission is all

1061
00:44:34,550 --> 00:44:32,800
about what is the surface of pluto i

1062
00:44:37,750 --> 00:44:34,560
really like how big is it what are the

1063
00:44:40,550 --> 00:44:37,760

orbits really so it's nothing but the

1064
00:44:43,109 --> 00:44:40,560
delightful surprises coming for us

1065
00:44:44,630 --> 00:44:43,119
but some of the surprises may not be

1066
00:44:47,030 --> 00:44:44,640
quite so welcome

1067
00:44:48,470 --> 00:44:47,040
as new horizons gets still closer to the

1068
00:44:50,550 --> 00:44:48,480
pluto system

1069
00:44:53,030 --> 00:44:50,560
lori will be able to identify small

1070
00:44:56,710 --> 00:44:53,040
moons and possible rings that can't be

1071
00:45:00,790 --> 00:44:59,030
john spencer is leading the you has

1072
00:45:03,750 --> 00:45:00,800
campaign

1073
00:45:05,670 --> 00:45:03,760
uhas stands for unknown hazards we may

1074
00:45:07,910 --> 00:45:05,680
find new moons or even rings around

1075
00:45:09,910 --> 00:45:07,920
pluto and if we see anything like that

1076
00:45:11,829 --> 00:45:09,920
we're going to want to

1077
00:45:14,150 --> 00:45:11,839
determine whether it poses a threat to

1078
00:45:15,109 --> 00:45:14,160
the spacecraft because if it does if

1079
00:45:17,990 --> 00:45:15,119
there's

1080
00:45:19,829 --> 00:45:18,000
debris that we might run into that might

1081
00:45:21,349 --> 00:45:19,839
damage or kill the spacecraft then we

1082
00:45:22,950 --> 00:45:21,359
want to

1083
00:45:24,950 --> 00:45:22,960
evaluate that hazard and determine

1084
00:45:27,349 --> 00:45:24,960
whether we should take any evasive

1085
00:45:30,069 --> 00:45:27,359
action to find out just how vulnerable

1086
00:45:32,390 --> 00:45:30,079
new horizons might be to even tiny dust

1087
00:45:34,550 --> 00:45:32,400
particles the mission sent samples of

1088
00:45:37,109 --> 00:45:34,560

spacecraft components to the white sands

1089
00:45:39,589 --> 00:45:37,119
test range

1090
00:45:42,069 --> 00:45:39,599
technicians at white sands set up gun

1091
00:45:44,550 --> 00:45:42,079
tests to assess how vulnerable new

1092
00:45:45,670 --> 00:45:44,560
horizons outer covers and cables might

1093
00:45:46,630 --> 00:45:45,680
be

1094
00:45:50,710 --> 00:45:46,640
we

1095
00:45:53,030 --> 00:45:50,720
shoot

1096
00:45:54,550 --> 00:45:53,040
things into parts of models of the

1097
00:45:56,790 --> 00:45:54,560
spacecraft

1098
00:45:59,270 --> 00:45:56,800
while the results might look dangerous

1099
00:46:01,829 --> 00:45:59,280
the mission has options to take evasive

1100
00:46:03,750 --> 00:46:01,839
action

1101
00:46:06,150 --> 00:46:03,760
one of the backup strategies we have if

1102
00:46:08,309 --> 00:46:06,160
we feel we need to give the spacecraft

1103
00:46:11,190 --> 00:46:08,319
extra protection is that we orient it so

1104
00:46:13,109 --> 00:46:11,200
that the high gain antenna here which is

1105
00:46:14,950 --> 00:46:13,119
literally pretty bulletproof and can

1106
00:46:16,309 --> 00:46:14,960
protect the spacecraft is going to be

1107
00:46:17,270 --> 00:46:16,319
facing forward

1108
00:46:30,069 --> 00:46:17,280
in

1109
00:46:31,589 --> 00:46:30,079
particles that hit the spacecraft are

1110
00:46:34,069 --> 00:46:31,599
most likely to hit that antenna where

1111
00:46:35,750 --> 00:46:34,079
they won't cause us problems and only a

1112
00:46:38,069 --> 00:46:35,760
small part of the spacecraft around the

1113
00:46:40,230 --> 00:46:38,079

edges is going to be exposed to those

1114
00:46:42,470 --> 00:46:40,240
particles that would protect the guts of

1115
00:46:43,829 --> 00:46:42,480
the spacecraft but limit the pointing of

1116
00:46:48,309 --> 00:46:43,839
the cameras

1117
00:46:50,550 --> 00:46:48,319
so the spacecraft has to point in one

1118
00:46:52,230 --> 00:46:50,560
direction the cameras can only point in

1119
00:46:53,910 --> 00:46:52,240
a limited range of directions this

1120
00:46:55,589 --> 00:46:53,920
limits the amount of times we can

1121
00:46:57,510 --> 00:46:55,599
photograph the system as we go past

1122
00:46:59,349 --> 00:46:57,520
because we can only photograph objects

1123
00:47:01,109 --> 00:46:59,359
when they're just in the right angle

1124
00:47:02,630 --> 00:47:01,119
that we can look at them while

1125
00:47:04,309 --> 00:47:02,640
protecting the spacecraft with the main

1126
00:47:06,230 --> 00:47:04,319
antenna another option is to take

1127
00:47:07,589 --> 00:47:06,240
different trajectories through the pluto

1128
00:47:10,390 --> 00:47:07,599
system

1129
00:47:11,910 --> 00:47:10,400
that's called the shabbat play shabbat

1130
00:47:13,349 --> 00:47:11,920
is the best acronym in the space

1131
00:47:15,349 --> 00:47:13,359
business

1132
00:47:17,349 --> 00:47:15,359
it stands for safe haven

1133
00:47:19,750 --> 00:47:17,359
by other trajectory

1134
00:47:22,230 --> 00:47:19,760
and it is is the word we use to

1135
00:47:24,630 --> 00:47:22,240
represent our backup plans at pluto the

1136
00:47:26,069 --> 00:47:24,640
second shabbat takes us much closer to

1137
00:47:29,030 --> 00:47:26,079
pluto

1138
00:47:31,910 --> 00:47:29,040

into the region where atmospheric drag

1139
00:47:33,349 --> 00:47:31,920
depletes orbits of any debris which we

1140
00:47:35,030 --> 00:47:33,359
think would be

1141
00:47:37,030 --> 00:47:35,040
the safest hail mary pass that we could

1142
00:47:38,710 --> 00:47:37,040
fly if we have to do something different

1143
00:47:41,270 --> 00:47:38,720
than the nominal we are coming into the

1144
00:47:43,349 --> 00:47:41,280
pluto system with the ability if we

1145
00:47:45,589 --> 00:47:43,359
learn something we don't expect to be

1146
00:47:48,069 --> 00:47:45,599
able to make a change

1147
00:47:50,630 --> 00:47:48,079
and get the goods but those decisions

1148
00:47:52,790 --> 00:47:50,640
can only be made in the last month

1149
00:47:54,790 --> 00:47:52,800
before closest approach and there'll be

1150
00:47:58,549 --> 00:47:54,800
limited time to evaluate the best

1151
00:48:01,190 --> 00:47:58,559
options so in february 2015 spencer's

1152
00:48:04,069 --> 00:48:01,200
you has team including ring specialist

1153
00:48:06,390 --> 00:48:04,079
mark showalter and postdoc simon porter

1154
00:48:08,150 --> 00:48:06,400
are running through a readiness test

1155
00:48:09,829 --> 00:48:08,160
now they're on the clock and being

1156
00:48:12,150 --> 00:48:09,839
scored for whether they can work through

1157
00:48:14,630 --> 00:48:12,160
the calculations fast enough to decide

1158
00:48:17,109 --> 00:48:14,640
on a trajectory correction maneuver that

1159
00:48:19,430 --> 00:48:17,119
might prevent loss of mission

1160
00:48:22,710 --> 00:48:19,440
and that makes this exercise more

1161
00:48:25,030 --> 00:48:22,720
critical than any that have gone before

1162
00:48:27,430 --> 00:48:25,040
the difference between this and previous

1163
00:48:29,190 --> 00:48:27,440

operational readiness tests is that this

1164
00:48:31,510 --> 00:48:29,200
is where we have to demonstrate to put

1165
00:48:33,910 --> 00:48:31,520
the project in nasa that we can do this

1166
00:48:38,950 --> 00:48:33,920
but the only test that really matters

1167
00:48:42,069 --> 00:48:38,960
comes on july 14 2015 that one day will

1168
00:48:48,980 --> 00:48:42,079
pay off 26 years of dreams

1169
00:48:55,589 --> 00:48:52,950
[Music]

1170
00:48:58,069 --> 00:48:55,599
for the science team the year of pluto

1171
00:49:00,390 --> 00:48:58,079
began with another meeting to review the

1172
00:49:02,630 --> 00:49:00,400
latest data on the pluto system and to

1173
00:49:03,990 --> 00:49:02,640
hear updates on how the spacecraft was

1174
00:49:05,990 --> 00:49:04,000
performing

1175
00:49:07,829 --> 00:49:06,000
mission manager glenn fountain who'd

1176
00:49:11,190 --> 00:49:07,839
been with the project from its start

1177
00:49:13,109 --> 00:49:11,200
summarized remaining risks red boxes are

1178
00:49:16,710 --> 00:49:13,119
possibilities that could kill the

1179
00:49:19,190 --> 00:49:16,720
mission but now in 2015 there are more

1180
00:49:21,190 --> 00:49:19,200
and more green boxes risks that have

1181
00:49:23,030 --> 00:49:21,200
been minimized something

1182
00:49:24,309 --> 00:49:23,040
that we haven't thought of still might

1183
00:49:26,390 --> 00:49:24,319
happen

1184
00:49:28,710 --> 00:49:26,400
but i'm confident

1185
00:49:30,710 --> 00:49:28,720
that whatever happens whatever

1186
00:49:34,230 --> 00:49:30,720
fate throws at us

1187
00:49:37,510 --> 00:49:34,240
this team will be able to resolve it and

1188
00:49:39,750 --> 00:49:37,520

we'll go on to get wonderful data when

1189
00:49:42,309 --> 00:49:39,760
we get to pluto we have a fantastically

1190
00:49:45,270 --> 00:49:42,319
talented team of people who have worked

1191
00:49:47,109 --> 00:49:45,280
very hard we've tested the sequences

1192
00:49:49,589 --> 00:49:47,119
inside and out and while there are

1193
00:49:51,910 --> 00:49:49,599
always unknown unknowns i'm very

1194
00:49:53,589 --> 00:49:51,920
confident and really looking forward to

1195
00:49:55,829 --> 00:49:53,599
the curtain rising along with

1196
00:49:57,910 --> 00:49:55,839
mind-bending technical details there

1197
00:50:00,710 --> 00:49:57,920
also was a sense of history in the

1198
00:50:03,190 --> 00:50:00,720
making to document the long years of

1199
00:50:05,589 --> 00:50:03,200
effort to get this close to pluto the

1200
00:50:07,910 --> 00:50:05,599
mission recreated a team photograph

1201
00:50:10,470 --> 00:50:07,920
taken in 2004

1202
00:50:12,950 --> 00:50:10,480
as glenn allen and alice had carefully

1203
00:50:15,030 --> 00:50:12,960
planned back then many of the scientists

1204
00:50:17,510 --> 00:50:15,040
and engineers were still actively

1205
00:50:20,069 --> 00:50:17,520
engaged in new horizons and looking

1206
00:50:21,510 --> 00:50:20,079
forward to july 2015.

1207
00:50:24,150 --> 00:50:21,520
we have

1208
00:50:27,190 --> 00:50:24,160
worked hard to get a coherent team

1209
00:50:29,030 --> 00:50:27,200
because if you don't have a good team to

1210
00:50:30,470 --> 00:50:29,040
operate the spacecraft to do the

1211
00:50:32,630 --> 00:50:30,480
planning

1212
00:50:35,589 --> 00:50:32,640
you will fail

1213
00:50:37,349 --> 00:50:35,599

and so we worked a plan

1214
00:50:38,630 --> 00:50:37,359
early in the mission

1215
00:50:40,390 --> 00:50:38,640
to have

1216
00:50:43,030 --> 00:50:40,400
younger people

1217
00:50:43,750 --> 00:50:43,040
with the right amount of experience

1218
00:50:45,750 --> 00:50:43,760
to

1219
00:50:48,710 --> 00:50:45,760
be on the mission and it's just like

1220
00:50:50,549 --> 00:50:48,720
watching your kids grow it's like all of

1221
00:50:52,309 --> 00:50:50,559
a sudden

1222
00:50:54,549 --> 00:50:52,319
where did the time go

1223
00:50:57,030 --> 00:50:54,559
you know they are older they're more

1224
00:50:58,790 --> 00:50:57,040
mature and they're now the very

1225
00:51:00,790 --> 00:50:58,800
experienced veterans

1226
00:51:03,910 --> 00:51:00,800
but the hard work of mission planning

1227
00:51:05,270 --> 00:51:03,920
was by no means over even this close to

1228
00:51:07,829 --> 00:51:05,280
encounter day

1229
00:51:10,230 --> 00:51:07,839
while exploring pluto in 2015 is

1230
00:51:12,630 --> 00:51:10,240
exciting in itself new horizons was

1231
00:51:15,030 --> 00:51:12,640
recommended in part as a mission that

1232
00:51:17,510 --> 00:51:15,040
might continue on farther out into the

1233
00:51:20,069 --> 00:51:17,520
kuiper belt that takes identifying

1234
00:51:22,630 --> 00:51:20,079
potential targets now for a still more

1235
00:51:25,510 --> 00:51:22,640
distant flyby should nasa approve an

1236
00:51:28,309 --> 00:51:25,520
extended mission this challenging task

1237
00:51:30,630 --> 00:51:28,319
was assigned to john spencer mark bowie

1238
00:51:32,069 --> 00:51:30,640

and a team of young postdocs

1239
00:51:34,549 --> 00:51:32,079
and like everything else about this

1240
00:51:37,030 --> 00:51:34,559
mission it wasn't easy bowie and john

1241
00:51:39,670 --> 00:51:37,040
spencer had been using earth's largest

1242
00:51:42,470 --> 00:51:39,680
telescopes in hawaii and chile but even

1243
00:51:44,950 --> 00:51:42,480
earth's best couldn't crack this task

1244
00:51:47,670 --> 00:51:44,960
but the basic problem is

1245
00:51:50,470 --> 00:51:47,680
the earth's atmosphere is just a mess at

1246
00:51:51,750 --> 00:51:50,480
these scales there's a limit and that's

1247
00:51:55,270 --> 00:51:51,760
what we've been beating our heads

1248
00:51:57,829 --> 00:51:55,280
against now with time running out we had

1249
00:51:59,829 --> 00:51:57,839
to turn to hubble and so it's we sort of

1250
00:52:02,870 --> 00:51:59,839
not so jokingly talk about hubble to the

1251
00:52:04,470 --> 00:52:02,880
rescue without hubble we would not have

1252
00:52:06,390 --> 00:52:04,480
these objects mark and his young

1253
00:52:08,710 --> 00:52:06,400
collaborators came up with innovative

1254
00:52:10,950 --> 00:52:08,720
search techniques using custom software

1255
00:52:13,430 --> 00:52:10,960
what that does is makes the stars smear

1256
00:52:14,549 --> 00:52:13,440
out and makes the kuiper belt objects

1257
00:52:16,549 --> 00:52:14,559
hold still

1258
00:52:19,030 --> 00:52:16,559
it's been a lot of work but to do

1259
00:52:20,549 --> 00:52:19,040
something as exciting as this has been

1260
00:52:22,150 --> 00:52:20,559
just so much fun i've been plugging

1261
00:52:23,829 --> 00:52:22,160
through the data today

1262
00:52:26,230 --> 00:52:23,839
because it's fresh data and i just

1263
00:52:27,829 --> 00:52:26,240

really really wanted to to know what the

1264
00:52:30,870 --> 00:52:27,839
answer was well we would have been in

1265
00:52:33,589 --> 00:52:30,880
big trouble if we didn't find the kbo

1266
00:52:35,190 --> 00:52:33,599
in time so there was this pressure but

1267
00:52:37,109 --> 00:52:35,200
honestly we had the best people in the

1268
00:52:39,430 --> 00:52:37,119
world working on the problem and we did

1269
00:52:42,150 --> 00:52:39,440
it and we just do the math write the

1270
00:52:44,549 --> 00:52:42,160
software crunch the pixels

1271
00:52:46,950 --> 00:52:44,559
and then i create this graphic

1272
00:52:48,630 --> 00:52:46,960
and from that point on it's what i call

1273
00:52:51,349 --> 00:52:48,640
wet wear that's what you got in your

1274
00:52:53,670 --> 00:52:51,359
head in reality kbos are moving against

1275
00:52:55,829 --> 00:52:53,680
the fixed stars mark came up with a way

1276
00:52:58,390 --> 00:52:55,839
of making them more obvious by flipping

1277
00:53:02,549 --> 00:52:58,400
that around and making the stars appear

1278
00:53:03,990 --> 00:53:02,559
to move and any kbo's stand still

1279
00:53:07,270 --> 00:53:04,000
right in the middle there's something

1280
00:53:09,990 --> 00:53:07,280
that's just holding dead constant

1281
00:53:11,990 --> 00:53:10,000
and that's the kuiper belt talk

1282
00:53:14,150 --> 00:53:12,000
you can't argue with that it was a

1283
00:53:16,230 --> 00:53:14,160
high-tech variant of the approach that

1284
00:53:18,710 --> 00:53:16,240
had been instrumental in exploring the

1285
00:53:19,829 --> 00:53:18,720
pluto system right from the start but at

1286
00:53:21,750 --> 00:53:19,839
the core

1287
00:53:24,790 --> 00:53:21,760
it's a technique that hasn't really

1288
00:53:26,870 --> 00:53:24,800

changed since tombow's day you have two

1289
00:53:29,589 --> 00:53:26,880
pictures of the sky taken at different

1290
00:53:31,829 --> 00:53:29,599
times and you're looking for the stuff

1291
00:53:32,790 --> 00:53:31,839
that moves as soon as you see something

1292
00:53:36,150 --> 00:53:32,800
real

1293
00:53:38,390 --> 00:53:36,160
there is absolutely no question about it

1294
00:53:39,190 --> 00:53:38,400
as soon as it flashes on the screen in

1295
00:53:40,710 --> 00:53:39,200
just

1296
00:53:43,190 --> 00:53:40,720
a millisecond

1297
00:53:45,510 --> 00:53:43,200
there it is it's real and you know i

1298
00:53:48,950 --> 00:53:45,520
found another kyber belt object but

1299
00:53:50,870 --> 00:53:48,960
finding a kbo is only half the battle

1300
00:53:53,030 --> 00:53:50,880
is it located where new horizons can

1301
00:53:55,510 --> 00:53:53,040
reach it with available fuel once you

1302
00:53:57,190 --> 00:53:55,520
have the orbit then we and we know

1303
00:53:58,470 --> 00:53:57,200
where the spacecraft is and where it's

1304
00:54:01,190 --> 00:53:58,480
going to be

1305
00:54:03,109 --> 00:54:01,200
we can figure out how much fuel the

1306
00:54:05,829 --> 00:54:03,119
spacecraft is going to need to use to

1307
00:54:07,670 --> 00:54:05,839
get to these objects with more hubble

1308
00:54:09,990 --> 00:54:07,680
time new horizons got a pleasant

1309
00:54:11,910 --> 00:54:10,000
surprise it looked like we might

1310
00:54:14,150 --> 00:54:11,920
actually have to burn the engines to

1311
00:54:16,870 --> 00:54:14,160
miss the object

1312
00:54:18,230 --> 00:54:16,880
which was a pretty exciting concept

1313
00:54:19,589 --> 00:54:18,240

you know it's a good thing we looked

1314
00:54:20,950 --> 00:54:19,599
because you wouldn't want to run into

1315
00:54:23,349 --> 00:54:20,960
one of these things these cold

1316
00:54:24,390 --> 00:54:23,359
classicals they're pretty much as they

1317
00:54:27,190 --> 00:54:24,400
were

1318
00:54:28,390 --> 00:54:27,200
4.5 billion years ago they're little

1319
00:54:29,990 --> 00:54:28,400
fossils

1320
00:54:31,349 --> 00:54:30,000
that's incredible

1321
00:54:32,390 --> 00:54:31,359
we have no idea what they're going to

1322
00:54:35,510 --> 00:54:32,400
look like

1323
00:54:38,390 --> 00:54:35,520
so with potential targets found at last

1324
00:54:40,390 --> 00:54:38,400
it was on the pluto i'm feeling pretty

1325
00:54:41,670 --> 00:54:40,400
exhilarated at this point

1326
00:54:43,670 --> 00:54:41,680
you know you're at the top of the roller

1327
00:54:45,270 --> 00:54:43,680
coaster you're about to

1328
00:54:48,069 --> 00:54:45,280
go down that

1329
00:54:50,470 --> 00:54:48,079
dizzying thrilling uh ride into the

1330
00:54:52,710 --> 00:54:50,480
system just seeing pluto there getting

1331
00:54:55,750 --> 00:54:52,720
bigger and bigger it gives me goosebumps

1332
00:54:57,270 --> 00:54:55,760
today we're only a few months away from

1333
00:54:59,829 --> 00:54:57,280
the encounter

1334
00:55:01,670 --> 00:54:59,839
we're less than an astronomical unit the

1335
00:55:04,390 --> 00:55:01,680
distance between the earth and the sun

1336
00:55:07,750 --> 00:55:04,400
that distance away from this fascinating

1337
00:55:09,589 --> 00:55:07,760
object it's the last major body in our

1338
00:55:11,990 --> 00:55:09,599

solar system that we really need to

1339
00:55:13,589 --> 00:55:12,000
visit to be putting the capstone on the

1340
00:55:14,549 --> 00:55:13,599
initial reconnaissance of the solar

1341
00:55:15,990 --> 00:55:14,559
system

1342
00:55:18,150 --> 00:55:16,000
it's heartwarming

1343
00:55:20,710 --> 00:55:18,160
and it it feels like something that

1344
00:55:23,030 --> 00:55:20,720
makes a career worthwhile

1345
00:55:24,630 --> 00:55:23,040
as spacecraft goes new horizons is a

1346
00:55:27,270 --> 00:55:24,640
very small team

1347
00:55:30,390 --> 00:55:27,280
but still we've been working on this

1348
00:55:32,549 --> 00:55:30,400
for over a decade and you add it all up

1349
00:55:35,670 --> 00:55:32,559
and it's about two and a half million

1350
00:55:38,950 --> 00:55:35,680
work hours to get ourselves to pluto we

1351
00:55:40,390 --> 00:55:38,960
have waited first the four years that we

1352
00:55:42,950 --> 00:55:40,400
couldn't hardly think about because we

1353
00:55:44,069 --> 00:55:42,960
were running so fast and then it is

1354
00:55:46,069 --> 00:55:44,079
oh

1355
00:55:49,910 --> 00:55:46,079
we wait and we wait

1356
00:55:52,150 --> 00:55:49,920
and now we are ready to begin

1357
00:55:54,710 --> 00:55:52,160
the encounter we have had delayed

1358
00:55:56,870 --> 00:55:54,720
gratification the year of pluto is you

1359
00:55:58,069 --> 00:55:56,880
know simultaneously a beginning and an

1360
00:56:03,109 --> 00:55:58,079
ending

1361
00:56:05,829 --> 00:56:03,119
our objective we're accomplishing the

1362
00:56:07,990 --> 00:56:05,839
flyby of the pluto system for the first

1363
00:56:09,829 --> 00:56:08,000

time but it's also the beginning of a

1364
00:56:11,990 --> 00:56:09,839
whole new chapter for science of really

1365
00:56:14,309 --> 00:56:12,000
being able to explore these objects as

1366
00:56:15,190 --> 00:56:14,319
the data comes down over a period of

1367
00:56:17,109 --> 00:56:15,200
months

1368
00:56:18,870 --> 00:56:17,119
you know in bringing in post-docs and

1369
00:56:20,309 --> 00:56:18,880
the younger scientists who some of them

1370
00:56:22,630 --> 00:56:20,319
were in high school when we started this

1371
00:56:25,430 --> 00:56:22,640
project and now they have their phds and

1372
00:56:28,390 --> 00:56:25,440
they are spectacular experts and very

1373
00:56:29,510 --> 00:56:28,400
talented at what they do i was in

1374
00:56:31,910 --> 00:56:29,520
preschool

1375
00:56:34,710 --> 00:56:31,920
when alan first started talking about a

1376
00:56:36,789 --> 00:56:34,720
pluto mission and finishing high school

1377
00:56:39,829 --> 00:56:36,799
and starting college when it was built

1378
00:56:42,950 --> 00:56:39,839
and in grad school for the crews having

1379
00:56:44,870 --> 00:56:42,960
young people come into these programs

1380
00:56:47,910 --> 00:56:44,880
gaining the experience they're going to

1381
00:56:50,150 --> 00:56:47,920
be the next generation of explorers

1382
00:56:52,630 --> 00:56:50,160
we've never been to a kbo we've never

1383
00:56:53,990 --> 00:56:52,640
been anywhere close to a kbo this this

1384
00:56:56,950 --> 00:56:54,000
is the

1385
00:56:58,789 --> 00:56:56,960
the most unexplored area of the entire

1386
00:57:01,910 --> 00:56:58,799
solar system which is another way saying

1387
00:57:04,069 --> 00:57:01,920
this is the most unknown area that we as

1388
00:57:06,630 --> 00:57:04,079

humans can reach with spacecraft we

1389
00:57:09,030 --> 00:57:06,640
can't wait to get to pluto and to july

1390
00:57:11,829 --> 00:57:09,040
14th and see what the surface looks like

1391
00:57:15,589 --> 00:57:11,839
we're ready to go and it's showtime we

1392
00:57:17,829 --> 00:57:15,599
are capable of continuing an adventure

1393
00:57:21,910 --> 00:57:17,839
that humanity began

1394
00:57:23,910 --> 00:57:21,920
100 000 years ago as our ancestors

1395
00:57:27,589 --> 00:57:23,920
walked out of africa

1396
00:57:28,390 --> 00:57:27,599
and we are continuing that exploration

1397
00:57:29,829 --> 00:57:28,400
and

1398
00:57:35,410 --> 00:57:29,839
this country

1399
00:57:35,420 --> 00:58:00,470
[Music]

1400
00:58:33,270 --> 00:58:02,790
so