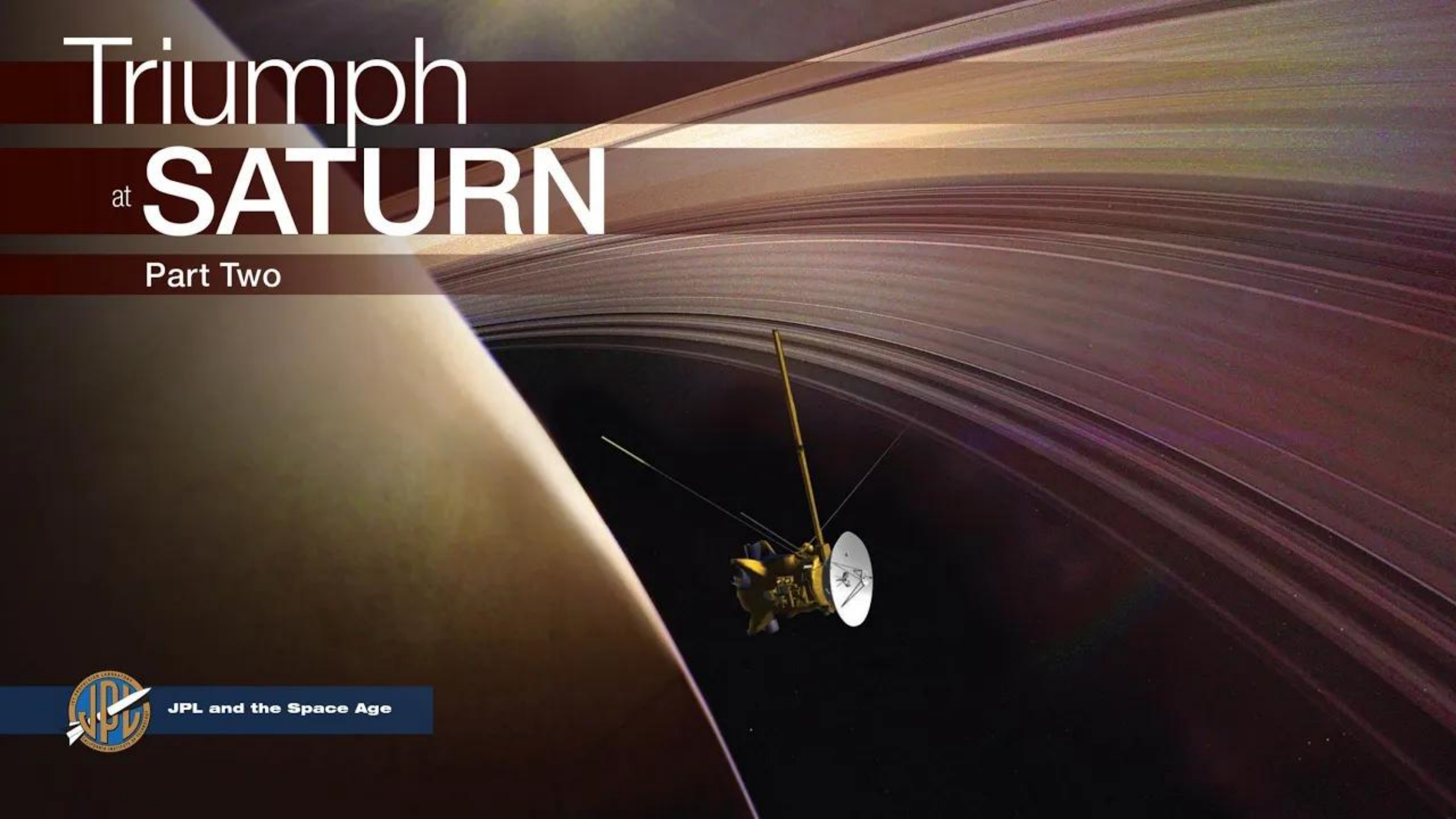
Triumph at SATURN

Part Two



JPL and the Space Age

1
00:00:00,060 --> 00:00:13,110
[Music]

2
00:00:18,310 --> 00:00:15,749
goodbye cassini

3
00:00:20,870 --> 00:00:18,320
your mission's fini

4
00:00:23,509 --> 00:00:20,880
bravo

5
00:00:27,349 --> 00:00:23,519
have some linguine

6
00:00:30,550 --> 00:00:27,359
you showed us saturn's rings and lots of

7
00:00:32,590 --> 00:00:30,560
pretty things heightens probe took a

8
00:00:36,630 --> 00:00:32,600
dive early

9
00:00:39,190 --> 00:00:36,640
2005 landed on titan

10
00:00:43,110 --> 00:00:39,200
it was exciting

11
00:00:48,310 --> 00:00:43,120
your mission of

12
00:00:55,990 --> 00:00:52,730
dazzled our eyes now

13
00:01:03,910 --> 00:00:56,000

[Music]

14
00:01:09,670 --> 00:01:07,030
in 1997 an ambitious international

15
00:01:11,030 --> 00:01:09,680
mission launches to saturn at wood for

16
00:01:13,270 --> 00:01:11,040
the first time

17
00:01:16,070 --> 00:01:13,280
attempt to place an orbiting spacecraft

18
00:01:19,109 --> 00:01:16,080
around the planet and land a probe on a

19
00:01:20,870 --> 00:01:19,119
moon in the outer solar system

20
00:01:25,990 --> 00:01:20,880
but it was a mission that had to fight

21
00:01:27,990 --> 00:01:26,000
its way just to reach the launch pad

22
00:01:29,109 --> 00:01:28,000
our congress has had some agony over the

23
00:01:30,710 --> 00:01:29,119
program

24
00:01:32,469 --> 00:01:30,720
we're going to have to operate under a

25
00:01:34,950 --> 00:01:32,479
very strict fund ceiling and an

26
00:01:36,630 --> 00:01:34,960
unyielding schedule

27
00:01:38,630 --> 00:01:36,640
we are all going to have to strive for

28
00:01:40,310 --> 00:01:38,640
as we go through this process is a

29
00:01:43,270 --> 00:01:40,320
continual search for the least

30
00:01:45,749 --> 00:01:43,280
unacceptable solution

31
00:01:47,030 --> 00:01:45,759
the journey to saturn took seven long

32
00:01:49,030 --> 00:01:47,040
years

33
00:01:51,749 --> 00:01:49,040
and being captured into orbit depended

34
00:01:54,550 --> 00:01:51,759
on what would happen during just three

35
00:01:56,630 --> 00:01:54,560
hours

36
00:01:58,709 --> 00:01:56,640
we chased everything that could go wrong

37
00:02:00,789 --> 00:01:58,719
down the rabbit hole we went down every

38
00:02:03,510 --> 00:02:00,799

path of if this goes wrong what do we do

39
00:02:05,910 --> 00:02:03,520
if that goes wrong what do we do

40
00:02:07,429 --> 00:02:05,920
all stations on that soi systems uh just

41
00:02:09,029 --> 00:02:07,439
an advisory we're coming up on the time

42
00:02:11,830 --> 00:02:09,039
that the critical sequence will initiate

43
00:02:13,830 --> 00:02:11,840
the turn to the fbi burn attitude

44
00:02:15,910 --> 00:02:13,840
this was one of those moments where

45
00:02:17,750 --> 00:02:15,920
you're either in orbit or you're a

46
00:02:19,430 --> 00:02:17,760
billion dollar flyby

47
00:02:24,250 --> 00:02:19,440
yeah

48
00:02:32,070 --> 00:02:29,589
[Applause]

49
00:02:34,710 --> 00:02:32,080
with cassini safely in orbit

50
00:02:36,550 --> 00:02:34,720
science quickly took center stage

51
00:02:39,110 --> 00:02:36,560
beginning with dazzling images of

52
00:02:42,070 --> 00:02:39,120
saturn's rings

53
00:02:43,750 --> 00:02:42,080
i'm surprised at how surprised i am at

54
00:02:47,670 --> 00:02:43,760
the beauty and the clarity of these

55
00:02:51,990 --> 00:02:50,070
investigating saturn's iconic rings will

56
00:02:55,270 --> 00:02:52,000
be just one part of what will turn out

57
00:03:00,390 --> 00:02:55,280
to be 13 years of discoveries about the

58
00:03:05,670 --> 00:03:02,830
and what will be realized about saturn's

59
00:03:07,830 --> 00:03:05,680
moons will even transform how we think

60
00:03:10,309 --> 00:03:07,840
about our solar system

61
00:03:14,790 --> 00:03:10,319
and open up new pathways for the future

62
00:03:20,070 --> 00:03:17,830
around one planet we find two moons that

63
00:03:23,830 --> 00:03:20,080

could potentially have the key

64
00:03:26,470 --> 00:03:23,840
ingredients to support life

65
00:03:40,949 --> 00:03:26,480
triumph at saturn

66
00:03:44,949 --> 00:03:43,990
for some scientists the saturnian moon

67
00:03:46,710 --> 00:03:44,959
titan

68
00:03:49,670 --> 00:03:46,720
has been a higher priority for

69
00:03:51,270 --> 00:03:49,680
exploration than even saturn or any

70
00:03:53,589 --> 00:03:51,280
other planet

71
00:03:56,869 --> 00:03:53,599
that's because titan may resemble what

72
00:03:59,910 --> 00:03:56,879
earth was like billions of years ago

73
00:04:02,390 --> 00:03:59,920
making this moon a kind of time machine

74
00:04:04,789 --> 00:04:02,400
that preserves and deep freeze many of

75
00:04:07,429 --> 00:04:04,799
the conditions that led to life on our

76
00:04:12,229 --> 00:04:09,750
titan is the only moon in our solar

77
00:04:15,830 --> 00:04:12,239
system having a dense atmosphere made

78
00:04:18,150 --> 00:04:15,840
mostly of nitrogen just like the earth

79
00:04:20,150 --> 00:04:18,160
there are smaller amounts of methane and

80
00:04:21,509 --> 00:04:20,160
ethane that break down into organic

81
00:04:25,110 --> 00:04:21,519
compounds

82
00:04:27,350 --> 00:04:25,120
creating the moon's smoggy orange haze

83
00:04:30,390 --> 00:04:27,360
titan's extremely cold temperatures

84
00:04:31,990 --> 00:04:30,400
turned some gases into liquids which led

85
00:04:34,070 --> 00:04:32,000
scientists to wonder

86
00:04:37,110 --> 00:04:34,080
could titan have oceans

87
00:04:39,350 --> 00:04:37,120
made not of water but of liquid methane

88
00:04:41,590 --> 00:04:39,360

and ethane

89
00:04:43,710 --> 00:04:41,600
these questions made the unmasking of

90
00:04:47,749 --> 00:04:43,720
titan a major objective of the

91
00:04:51,670 --> 00:04:49,590
and before the release of the huygens

92
00:04:55,350 --> 00:04:51,680
probe cassini would have the first

93
00:04:57,830 --> 00:04:55,360
opportunity to see this moon close up

94
00:05:00,070 --> 00:04:57,840
with hope sky high that the spacecraft

95
00:05:01,830 --> 00:05:00,080
might see titan's surface

96
00:05:04,150 --> 00:05:01,840
scientists were eager to share the

97
00:05:10,150 --> 00:05:04,160
five-hour plus flyby

98
00:05:13,590 --> 00:05:11,670
and you're watching live coverage from

99
00:05:16,629 --> 00:05:13,600
the jet propulsion laboratory in

100
00:05:19,990 --> 00:05:16,639
pasadena california tonight the cassini

101
00:05:22,070 --> 00:05:20,000
spacecraft has its first close encounter

102
00:05:24,469 --> 00:05:22,080
with saturn's largest and most

103
00:05:26,870 --> 00:05:24,479
intriguing moon titan

104
00:05:29,270 --> 00:05:26,880
this is the closest we have ever been to

105
00:05:31,670 --> 00:05:29,280
titan and over the next five and a half

106
00:05:34,629 --> 00:05:31,680
hours we hope to see the best images we

107
00:05:37,189 --> 00:05:34,639
have ever seen of titan and here on nasa

108
00:05:39,189 --> 00:05:37,199
tv you will see those images just

109
00:05:40,390 --> 00:05:39,199
minutes after they actually arrive on

110
00:05:42,950 --> 00:05:40,400
the ground

111
00:05:44,790 --> 00:05:42,960
and right on cue the images began

112
00:05:46,629 --> 00:05:44,800
streaming down

113
00:05:48,790 --> 00:05:46,639

but it quickly became apparent that

114
00:05:50,629 --> 00:05:48,800
titan wasn't ready for its first

115
00:05:52,790 --> 00:05:50,639
close-up

116
00:05:55,430 --> 00:05:52,800
we have just received exciting word that

117
00:05:58,629 --> 00:05:55,440
we have the first image in

118
00:06:00,390 --> 00:05:58,639
okay so this looks like um

119
00:06:03,029 --> 00:06:00,400
voids

120
00:06:04,710 --> 00:06:03,039
it takes a bit of processing to bring

121
00:06:06,790 --> 00:06:04,720
out features

122
00:06:09,189 --> 00:06:06,800
what appeared at first glance to be

123
00:06:11,270 --> 00:06:09,199
black and white smudges left scientists

124
00:06:14,469 --> 00:06:11,280
and viewers alike puzzled as to what

125
00:06:21,270 --> 00:06:15,990
look at that

126
00:06:25,749 --> 00:06:23,510
anything stand out in your mind at this

127
00:06:26,950 --> 00:06:25,759
point yeah it's been a very strange

128
00:06:28,870 --> 00:06:26,960
evening

129
00:06:30,469 --> 00:06:28,880
if you uh put me against a wall and said

130
00:06:32,309 --> 00:06:30,479
what's cloud and what isn't cloud i

131
00:06:34,629 --> 00:06:32,319
really couldn't tell you i assume that

132
00:06:36,550 --> 00:06:34,639
much of this is surface features

133
00:06:38,790 --> 00:06:36,560
yeah these are

134
00:06:41,110 --> 00:06:38,800
low contrast not really sure what we're

135
00:06:43,590 --> 00:06:41,120
looking at here

136
00:06:46,150 --> 00:06:43,600
with us now is torrance johnson one of

137
00:06:50,070 --> 00:06:46,160
the imaging scientists to kind of give

138
00:06:52,550 --> 00:06:50,080

us the overall what does it mean

139
00:06:54,070 --> 00:06:52,560
well i think first off the the main

140
00:06:56,790 --> 00:06:54,080
thing that tonight's meant for us is

141
00:06:57,670 --> 00:06:56,800
we've had a very successful encounter

142
00:07:00,230 --> 00:06:57,680
we're

143
00:07:02,629 --> 00:07:00,240
really looking at a great hall of data

144
00:07:04,150 --> 00:07:02,639
here and when you saw some of this stuff

145
00:07:06,390 --> 00:07:04,160
coming in there's clearly stuff to be

146
00:07:09,430 --> 00:07:06,400
seen there on that surface understanding

147
00:07:11,350 --> 00:07:09,440
it's a different issue and

148
00:07:12,710 --> 00:07:11,360
one of the things that all of us

149
00:07:14,790 --> 00:07:12,720
on the project have been talking about

150
00:07:18,230 --> 00:07:14,800
for a long time is this sort of

151
00:07:20,230 --> 00:07:18,240
cooperative science approach

152
00:07:23,350 --> 00:07:20,240
we knew titan was a tough target was

153
00:07:25,110 --> 00:07:23,360
going to hold its secrets tightly and so

154
00:07:26,870 --> 00:07:25,120
we designed this mission and the

155
00:07:29,110 --> 00:07:26,880
experiments to hit it with everything

156
00:07:30,550 --> 00:07:29,120
we've got this is our first chance to do

157
00:07:32,629 --> 00:07:30,560
that really

158
00:07:34,950 --> 00:07:32,639
we're really going to have to do a full

159
00:07:39,270 --> 00:07:34,960
up complete body scan of titan to figure

160
00:07:45,189 --> 00:07:41,430
this encounter confirmed that titan

161
00:07:47,670 --> 00:07:45,199
would be as complex as it was obscure

162
00:07:49,990 --> 00:07:47,680
fortunately there are many more cassini

163
00:07:52,550 --> 00:07:50,000

flybys still ahead

164
00:07:55,670 --> 00:07:52,560
but next up to explore titan is the

165
00:07:57,749 --> 00:07:55,680
european space agency's huygens probe

166
00:08:00,230 --> 00:07:57,759
that will try to descend all the way to

167
00:08:02,710 --> 00:08:00,240
the moon's surface

168
00:08:04,070 --> 00:08:02,720
uh the procedure here is pretty standard

169
00:08:05,510 --> 00:08:04,080
we're going to follow right through the

170
00:08:08,790 --> 00:08:05,520
mlp

171
00:08:10,629 --> 00:08:08,800
the idea is a series of brief reports

172
00:08:13,189 --> 00:08:10,639
eight weeks have passed

173
00:08:15,430 --> 00:08:13,199
and it is the eve of christmas eve as

174
00:08:16,390 --> 00:08:15,440
leaders of the cassini-huygens team hold

175
00:08:18,950 --> 00:08:16,400
a go

176
00:08:20,950 --> 00:08:18,960
no-go meeting on whether to release the

177
00:08:23,350 --> 00:08:20,960
huygens probe

178
00:08:25,430 --> 00:08:23,360
we had two opportunities to update this

179
00:08:27,430 --> 00:08:25,440
one of the titan flights there are no

180
00:08:29,670 --> 00:08:27,440
known technical issues with which to

181
00:08:31,270 --> 00:08:29,680
contend making this meeting mostly a

182
00:08:33,589 --> 00:08:31,280
formality

183
00:08:35,110 --> 00:08:33,599
navigation has flown a precision

184
00:08:36,550 --> 00:08:35,120
trajectory so there was no need for us

185
00:08:38,709 --> 00:08:36,560
to make any updates

186
00:08:40,469 --> 00:08:38,719
um tracking data has been absolutely

187
00:08:41,829 --> 00:08:40,479
excellently lately dsn has been doing a

188
00:08:43,990 --> 00:08:41,839

really good job

189
00:08:46,070 --> 00:08:44,000
and julie's team has doing a marvelous

190
00:08:47,750 --> 00:08:46,080
job she has given us recently really

191
00:08:48,949 --> 00:08:47,760
great viewers so

192
00:09:03,030 --> 00:08:48,959
without that

193
00:09:06,389 --> 00:09:04,870
based on what we've heard here from the

194
00:09:09,430 --> 00:09:06,399
representatives of the people that did

195
00:09:12,710 --> 00:09:09,440
the work it's very clear that the

196
00:09:14,710 --> 00:09:12,720
orbiter jpl part of this team

197
00:09:15,990 --> 00:09:14,720
is ready to proceed

198
00:09:19,030 --> 00:09:16,000
the probe

199
00:09:21,350 --> 00:09:19,040
go so

200
00:09:24,630 --> 00:09:21,360
we are green for tomorrow

201
00:09:27,430 --> 00:09:26,150
okay well let me just

202
00:09:29,509 --> 00:09:27,440
add

203
00:09:32,630 --> 00:09:29,519
my enormous thanks from the european

204
00:09:33,670 --> 00:09:32,640
side for the uh terrific collaborative

205
00:09:35,670 --> 00:09:33,680
effort

206
00:09:37,350 --> 00:09:35,680
on the u.s side it's just been great to

207
00:09:39,509 --> 00:09:37,360
be working with you

208
00:09:40,470 --> 00:09:39,519
and i think we're all very appreciative

209
00:09:42,550 --> 00:09:40,480
and so

210
00:09:49,269 --> 00:09:42,560
let's go

211
00:09:54,550 --> 00:09:52,870
southwood's remarks were heartfelt

212
00:09:58,070 --> 00:09:54,560
as four years earlier the mission had

213
00:10:00,870 --> 00:09:58,080

faced what seemed an unsolvable problem

214
00:10:02,829 --> 00:10:00,880
a design flaw found on huygens receiver

215
00:10:05,670 --> 00:10:02,839
located on the cassini

216
00:10:07,829 --> 00:10:05,680
spacecraft an in-flight test revealed

217
00:10:10,470 --> 00:10:07,839
the receiver was incapable of adjusting

218
00:10:14,389 --> 00:10:10,480
to doppler shifts changes in radio

219
00:10:18,550 --> 00:10:16,310
that would leave huygens data nearly

220
00:10:22,630 --> 00:10:18,560
worthless

221
00:10:24,630 --> 00:10:22,640
a major fix required a hands-on solution

222
00:10:27,670 --> 00:10:24,640
impossible to do with the probe a

223
00:10:30,150 --> 00:10:27,680
billion miles away

224
00:10:32,790 --> 00:10:30,160
knowing little could be done to huygens

225
00:10:34,470 --> 00:10:32,800
the best hope rested with cassini when

226
00:10:36,069 --> 00:10:34,480
mission planners realized that

227
00:10:38,069 --> 00:10:36,079
adjustments to the spacecraft's

228
00:10:41,750 --> 00:10:38,079
trajectory could minimize radio

229
00:10:46,949 --> 00:10:43,829
this required cassini to fly higher

230
00:10:49,350 --> 00:10:46,959
above titan and at a relatively slower

231
00:10:51,269 --> 00:10:49,360
speed which would allow the data to be

232
00:10:53,750 --> 00:10:51,279
accurately recorded as the probe

233
00:10:56,470 --> 00:10:53,760
descended

234
00:10:58,710 --> 00:10:56,480
but this solution was not free

235
00:11:02,550 --> 00:10:58,720
it would cost cassini a quarter of its

236
00:11:06,230 --> 00:11:04,310
this sacrifice confirmed that

237
00:11:08,470 --> 00:11:06,240
cassini-huygens was truly an

238
00:11:10,389 --> 00:11:08,480

international partnership

239
00:11:12,949 --> 00:11:10,399
for without this decision

240
00:11:17,269 --> 00:11:12,959
huygens was assured of being seen as a

241
00:11:21,750 --> 00:11:19,910
the crisis was now only a memory

242
00:11:24,069 --> 00:11:21,760
and it was now time for the probe to

243
00:11:39,590 --> 00:11:24,079
detach from cassini to begin its

244
00:11:43,750 --> 00:11:41,750
there's a jpl saying that for some

245
00:11:45,590 --> 00:11:43,760
celestial reason

246
00:11:48,150 --> 00:11:45,600
major mission events always seem to

247
00:11:49,190 --> 00:11:48,160
happen on holidays weekends late at

248
00:11:52,470 --> 00:11:49,200
night or

249
00:11:54,629 --> 00:11:52,480
a combination of the three

250
00:11:58,069 --> 00:11:54,639
the probe's release is no exception to

251
00:12:01,829 --> 00:11:58,079
the rule it is christmas eve i'd like to

252
00:12:03,750 --> 00:12:01,839
start the poll in five minutes

253
00:12:06,069 --> 00:12:03,760
on hand to show their support for the

254
00:12:08,069 --> 00:12:06,079
cassini team are leaders of the huygens

255
00:12:11,030 --> 00:12:08,079
probe

256
00:12:13,750 --> 00:12:11,040
jpl director charles alachi

257
00:12:16,550 --> 00:12:13,760
caltech president david baltimore

258
00:12:19,190 --> 00:12:16,560
and arriving just in the nick of time

259
00:12:21,590 --> 00:12:19,200
jpl veteran tom gavin

260
00:12:37,750 --> 00:12:21,600
whose job title includes the phrase

261
00:12:37,760 --> 00:12:54,310
earliest carrier lock is 7.29

262
00:12:54,320 --> 00:12:58,230
that's right

263
00:13:16,949 --> 00:13:12,990

[Applause]

264
00:13:19,190 --> 00:13:16,959
with the huygens probe now on its own

265
00:13:20,949 --> 00:13:19,200
silently free-falling to titan for the

266
00:13:23,190 --> 00:13:20,959
next 21 days

267
00:13:25,269 --> 00:13:23,200
the cassini team can relax and enjoy the

268
00:13:28,790 --> 00:13:25,279
holidays

269
00:13:31,269 --> 00:13:28,800
especially new year's day

270
00:13:33,190 --> 00:13:31,279
that was because jpl was sponsoring a

271
00:13:35,750 --> 00:13:33,200
float in the pasadena tournament of

272
00:13:40,069 --> 00:13:35,760
rose's parade for only the third time in

273
00:13:48,740 --> 00:13:43,269
the float featured nine jpl missions

274
00:13:48,750 --> 00:13:54,430
[Music]

275
00:13:54,440 --> 00:14:07,829
[Applause]

276
00:14:15,590 --> 00:14:10,389
the huygens dive into titan is the most

277
00:14:22,230 --> 00:14:17,350
the descent through the atmosphere is

278
00:14:25,910 --> 00:14:24,230
the hope is that the probe's batteries

279
00:14:27,509 --> 00:14:25,920
will last long enough to reach the

280
00:14:32,389 --> 00:14:27,519
surface

281
00:14:36,629 --> 00:14:34,230
because there could be lakes or seas of

282
00:14:40,580 --> 00:14:36,639
methane the probe has been designed to

283
00:14:44,710 --> 00:14:42,790
[Music]

284
00:14:51,990 --> 00:14:44,720
but first huygens has to survive the

285
00:14:57,829 --> 00:14:54,629
the entry speed is more than 12 000

286
00:15:03,350 --> 00:15:00,629
soon temperatures are soaring over 3000

287
00:15:05,590 --> 00:15:03,360
degrees fahrenheit

288
00:15:07,910 --> 00:15:05,600

if the heat shield does its job the

289
00:15:10,230 --> 00:15:07,920
science instruments inside the probe

290
00:15:26,069 --> 00:15:10,240
will have no idea there is an inferno

291
00:15:29,509 --> 00:15:28,310
after surviving the initial phase of the

292
00:15:40,310 --> 00:15:29,519
descent

293
00:15:43,269 --> 00:15:42,230
nearer the surface the winds begin to

294
00:15:47,269 --> 00:15:43,279
calm

295
00:15:55,749 --> 00:15:47,279
and titan's orange haze begins to clear

296
00:16:01,189 --> 00:15:58,470
so imagine descending down through a

297
00:16:03,189 --> 00:16:01,199
misty cloudy atmosphere and suddenly

298
00:16:06,150 --> 00:16:03,199
below you breaks this

299
00:16:09,829 --> 00:16:06,160
vista of this very bright hill

300
00:16:12,230 --> 00:16:09,839
with channels that are carved by liquid

301
00:16:14,389 --> 00:16:12,240
with rounded pebbles that were evidently

302
00:16:16,389 --> 00:16:14,399
rolled and tumbled by liquid that was

303
00:16:18,629 --> 00:16:16,399
what the huygens probe saw and it showed

304
00:16:20,870 --> 00:16:18,639
us that methane not only is in the

305
00:16:23,189 --> 00:16:20,880
atmosphere but has been raining and

306
00:16:25,430 --> 00:16:23,199
producing weather and carving features

307
00:16:40,389 --> 00:16:25,440
in the landscape for long periods of

308
00:16:45,749 --> 00:16:43,509
as huygens lands in a triumphant plop

309
00:16:48,470 --> 00:16:45,759
history is made

310
00:16:50,949 --> 00:16:48,480
and better yet the probe's batteries are

311
00:16:53,269 --> 00:16:50,959
still working

312
00:16:57,509 --> 00:16:53,279
what huygens sees seems to resemble a

313
00:17:04,230 --> 00:16:59,670

right in front are rocks made of frozen

314
00:17:10,390 --> 00:17:08,150
there are no signs of lakes or seas

315
00:17:13,750 --> 00:17:10,400
but huygens view is only a single spot

316
00:17:15,829 --> 00:17:13,760
on a moon larger than the planet mercury

317
00:17:21,270 --> 00:17:15,839
the global reconnaissance will come from

318
00:17:26,390 --> 00:17:24,470
[Music]

319
00:17:29,110 --> 00:17:26,400
on many of cassini's orbits around

320
00:17:30,070 --> 00:17:29,120
saturn the spacecraft will fly near

321
00:17:32,230 --> 00:17:30,080
titan

322
00:17:34,870 --> 00:17:32,240
allowing navigators to use the moon's

323
00:17:38,230 --> 00:17:34,880
mass to alter trajectories while at the

324
00:17:40,870 --> 00:17:38,240
same time conserving fuel

325
00:17:43,510 --> 00:17:40,880
these flybys are also opportunities to

326
00:17:45,590 --> 00:17:43,520
use cassini's powerful radar to

327
00:17:48,630 --> 00:17:45,600
penetrate through swathes of the moon's

328
00:17:50,630 --> 00:17:48,640
hazy atmosphere

329
00:17:52,870 --> 00:17:50,640
the radio waves that bounce back from

330
00:17:55,270 --> 00:17:52,880
titan's surface can be turned by

331
00:17:56,870 --> 00:17:55,280
scientists into topographical maps

332
00:18:01,029 --> 00:17:56,880
[Music]

333
00:18:02,870 --> 00:18:01,039
piece by piece swath by swath titan is

334
00:18:04,310 --> 00:18:02,880
revealed

335
00:18:05,990 --> 00:18:04,320
let's start at the beginning and run to

336
00:18:07,510 --> 00:18:06,000
the end and just see what interesting

337
00:18:09,430 --> 00:18:07,520
things we see and maybe you can point

338
00:18:11,830 --> 00:18:09,440

out the things that you've seen too

339
00:18:13,190 --> 00:18:11,840
okay here is the new swath as it comes

340
00:18:15,590 --> 00:18:13,200
through here

341
00:18:17,830 --> 00:18:15,600
titan really is in in some ways a kind

342
00:18:19,110 --> 00:18:17,840
of a cosmic striptease act because we

343
00:18:21,590 --> 00:18:19,120
can't see

344
00:18:23,909 --> 00:18:21,600
the surface and the normal wavelengths

345
00:18:26,310 --> 00:18:23,919
that our eyes would use and the radar

346
00:18:28,310 --> 00:18:26,320
operates by making images in narrow

347
00:18:32,630 --> 00:18:28,320
strips and so strip by strip in

348
00:18:34,549 --> 00:18:32,640
different places titan has been unveiled

349
00:18:36,549 --> 00:18:34,559
in that slide you can see a feature that

350
00:18:38,310 --> 00:18:36,559
runs almost perpendicular to the

351
00:18:40,549 --> 00:18:38,320
altimetry track

352
00:18:43,110 --> 00:18:40,559
so we see the end of the dunes here and

353
00:18:45,909 --> 00:18:43,120
you see the dunes peter out they get

354
00:18:48,150 --> 00:18:45,919
brighter which is interesting here

355
00:18:50,070 --> 00:18:48,160
massive dunes are seen

356
00:18:52,230 --> 00:18:50,080
made not of sand

357
00:18:54,630 --> 00:18:52,240
but of organic molecules containing

358
00:18:56,310 --> 00:18:54,640
carbon

359
00:18:58,630 --> 00:18:56,320
from the email traffic last night i saw

360
00:19:01,190 --> 00:18:58,640
together nobody sees a magic island in

361
00:19:02,870 --> 00:19:01,200
the data that we have correct

362
00:19:04,310 --> 00:19:02,880
i i think that's correct tell me what

363
00:19:07,110 --> 00:19:04,320

you want to zoom in on the beginning of

364
00:19:12,870 --> 00:19:09,669
a large dark basin turns out to be a

365
00:19:14,789 --> 00:19:12,880
lake full of methane

366
00:19:17,990 --> 00:19:14,799
it is the first of hundreds of deep

367
00:19:20,710 --> 00:19:18,000
lakes and seas that will be found

368
00:19:24,310 --> 00:19:20,720
most of the observation of this lake

369
00:19:26,870 --> 00:19:24,320
they show a subsurface reflection so the

370
00:19:30,070 --> 00:19:26,880
depth of this particular lake is about

371
00:19:32,150 --> 00:19:30,080
100 meters as we can see from the axis

372
00:19:34,070 --> 00:19:32,160
of the image is it right to get out of

373
00:19:38,470 --> 00:19:34,080
this that the small lakes don't seem to

374
00:19:40,630 --> 00:19:38,480
be any shallower than the larger lakes

375
00:19:44,390 --> 00:19:40,640
titan strange's discovery is a

376
00:19:46,710 --> 00:19:44,400
continent-sized area named xanadu

377
00:19:49,480 --> 00:19:46,720
here are canyons and mountains that

378
00:19:51,590 --> 00:19:49,490
resemble no other place on this moon

379
00:19:54,310 --> 00:19:51,600
[Music]

380
00:19:56,950 --> 00:19:54,320
it is as if one scientist said it's from

381
00:19:58,950 --> 00:19:56,960
another world

382
00:19:59,990 --> 00:19:58,960
one thing just to make a quick comment

383
00:20:02,630 --> 00:20:00,000
is that

384
00:20:05,029 --> 00:20:02,640
i am always very impressed by the radar

385
00:20:07,669 --> 00:20:05,039
planning teams they absolutely got it

386
00:20:10,149 --> 00:20:07,679
right on the bull's eye because this is

387
00:20:11,909 --> 00:20:10,159
you know a long way away flying by

388
00:20:15,669 --> 00:20:11,919

kilometers per second and they put it

389
00:20:20,549 --> 00:20:18,230
titan may even have volcanoes that gush

390
00:20:23,669 --> 00:20:20,559
out an icy mixture of water and other

391
00:20:32,789 --> 00:20:25,990
and this water comes from a hidden ocean

392
00:20:37,750 --> 00:20:35,270
and whenever water is mentioned it's not

393
00:20:39,909 --> 00:20:37,760
long before the question is raised

394
00:20:42,549 --> 00:20:39,919
is this a place that could possibly

395
00:20:44,630 --> 00:20:42,559
support life

396
00:20:47,270 --> 00:20:44,640
giant titan the size of the planet

397
00:20:49,590 --> 00:20:47,280
mercury has a global liquid water ocean

398
00:20:52,470 --> 00:20:49,600
underneath its icy crust

399
00:20:53,750 --> 00:20:52,480
as well as methane lakes and seas at the

400
00:20:56,149 --> 00:20:53,760
north pole

401
00:20:58,630 --> 00:20:56,159
and we wonder could those methane lakes

402
00:21:00,470 --> 00:20:58,640
and seas support a different kind of

403
00:21:05,110 --> 00:21:00,480
life

404
00:21:09,830 --> 00:21:08,070
there's still more that was discovered

405
00:21:11,510 --> 00:21:09,840
this moon has weather

406
00:21:15,270 --> 00:21:11,520
and seasons

407
00:21:17,990 --> 00:21:15,280
here it rains not water but methane that

408
00:21:19,909 --> 00:21:18,000
floats down like snow

409
00:21:22,630 --> 00:21:19,919
it's so earth-like that this is a very

410
00:21:24,870 --> 00:21:22,640
familiar place the chemistry in the

411
00:21:29,190 --> 00:21:24,880
atmosphere is much more complex than

412
00:21:31,909 --> 00:21:29,200
expected and the system as a whole

413
00:21:33,750 --> 00:21:31,919

is just as intricate as earth in terms

414
00:21:37,110 --> 00:21:33,760
of the atmosphere interacting with the

415
00:21:38,950 --> 00:21:37,120
surface and the materials on the surface

416
00:21:40,950 --> 00:21:38,960
site has a methane cycle just like earth

417
00:21:42,549 --> 00:21:40,960
has a water cycle and being able to

418
00:21:44,950 --> 00:21:42,559
watch that in action

419
00:21:46,470 --> 00:21:44,960
seeing the the lakes on the surface the

420
00:21:48,789 --> 00:21:46,480
channels that have been carved into the

421
00:21:50,789 --> 00:21:48,799
surface and then actually seeing clouds

422
00:21:53,110 --> 00:21:50,799
forming in the atmosphere and rain the

423
00:21:54,950 --> 00:21:53,120
effect of rain on the surface that whole

424
00:22:15,510 --> 00:21:54,960
cycle has been one of the things that's

425
00:22:23,350 --> 00:22:18,149
saturn's moon enceladus was also a

426
00:22:28,789 --> 00:22:25,669
it is the most reflective object in the

427
00:22:30,950 --> 00:22:28,799
entire solar system

428
00:22:34,070 --> 00:22:30,960
and a great mystery was why this moon

429
00:22:35,750 --> 00:22:34,080
seemed to have so few craters

430
00:22:37,750 --> 00:22:35,760
theories abounded

431
00:22:40,310 --> 00:22:37,760
might there be some internal heat source

432
00:22:42,870 --> 00:22:40,320
that melts ice on the surface which then

433
00:22:44,950 --> 00:22:42,880
fills in the holes

434
00:22:47,669 --> 00:22:44,960
could volcanoes or geysers account for

435
00:22:50,710 --> 00:22:47,679
the moon's shiny facade

436
00:22:55,110 --> 00:22:50,720
or was enceladus just a dead airless

437
00:22:58,870 --> 00:22:57,270
cassini would find the answer

438
00:23:00,710 --> 00:22:58,880

sending shock waves through the

439
00:23:02,390 --> 00:23:00,720
scientific community

440
00:23:04,470 --> 00:23:02,400
all of it brought about by one of the

441
00:23:06,149 --> 00:23:04,480
spacecraft's least known science

442
00:23:09,510 --> 00:23:06,159
instruments

443
00:23:12,070 --> 00:23:09,520
the spacecraft's magnetometer

444
00:23:13,909 --> 00:23:12,080
it's a kind of high-tech compass

445
00:23:15,270 --> 00:23:13,919
that makes measurements of magnetic

446
00:23:17,190 --> 00:23:15,280
fields

447
00:23:19,350 --> 00:23:17,200
it's so sensitive that it can even

448
00:23:20,789 --> 00:23:19,360
detect the spacecraft's own magnetic

449
00:23:23,669 --> 00:23:20,799
emissions

450
00:23:25,750 --> 00:23:23,679
to cancel out those unwanted signals

451
00:23:29,190 --> 00:23:25,760
this instrument was marooned out on the

452
00:23:31,990 --> 00:23:29,200
end of cassini's long boom

453
00:23:34,830 --> 00:23:32,000
on this flyby no one was expecting there

454
00:23:37,190 --> 00:23:34,840
would be much from the lonely

455
00:23:39,110 --> 00:23:37,200
instrument i must confess we weren't

456
00:23:40,630 --> 00:23:39,120
expecting to see anything

457
00:23:42,470 --> 00:23:40,640
and so we didn't look at the data for a

458
00:23:44,230 --> 00:23:42,480
couple of days

459
00:23:45,350 --> 00:23:44,240
um and then when we went in and looked

460
00:23:46,390 --> 00:23:45,360
at the data

461
00:23:48,630 --> 00:23:46,400
um

462
00:23:51,430 --> 00:23:48,640
only magnetometer people can get excited

463
00:23:53,430 --> 00:23:51,440

by our data because you sort of plotted

464
00:23:54,789 --> 00:23:53,440
as a on a on a scale where you look at

465
00:23:57,110 --> 00:23:54,799
the whole day

466
00:23:58,310 --> 00:23:57,120
and we had to look at the wiggles

467
00:24:00,230 --> 00:23:58,320
on the plot

468
00:24:02,390 --> 00:24:00,240
and they looked strange

469
00:24:05,029 --> 00:24:02,400
the expectation was that saturn's

470
00:24:08,549 --> 00:24:05,039
magnetic field would extend straight out

471
00:24:11,190 --> 00:24:08,559
and flow directly through enceladus

472
00:24:13,590 --> 00:24:11,200
instead the magnetic field was curving

473
00:24:15,590 --> 00:24:13,600
around the moon

474
00:24:18,789 --> 00:24:15,600
there were also unexpected signs of

475
00:24:20,310 --> 00:24:18,799
ionized water vapor molecules

476
00:24:23,350 --> 00:24:20,320
these were measurements that could be

477
00:24:36,149 --> 00:24:23,360
translated into sounds as the spacecraft

478
00:24:41,750 --> 00:24:38,710
and so it was clear that

479
00:24:44,149 --> 00:24:41,760
there was a source of water group ions

480
00:24:45,430 --> 00:24:44,159
in the vicinity of enceladus

481
00:24:46,950 --> 00:24:45,440
and in addition to that there was

482
00:24:48,310 --> 00:24:46,960
something strange going on in the

483
00:24:51,110 --> 00:24:48,320
magnetic field

484
00:24:53,830 --> 00:24:51,120
it looked as if enceladus was a much

485
00:24:55,510 --> 00:24:53,840
bigger obstacle to the flow of plasma

486
00:24:56,710 --> 00:24:55,520
and field coming from saturn it was

487
00:24:58,390 --> 00:24:56,720
almost as if

488
00:25:00,470 --> 00:24:58,400

the magnetic field of saturn and the

489
00:25:02,390 --> 00:25:00,480
plasma of and we've been stood off from

490
00:25:05,029 --> 00:25:02,400
the surface of the moon

491
00:25:07,269 --> 00:25:05,039
unsure of the accuracy of the data

492
00:25:11,190 --> 00:25:07,279
dowerdy and her team awaited the results

493
00:25:12,470 --> 00:25:11,200
of a second closer flyby

494
00:25:14,710 --> 00:25:12,480
and i must confess we looked at that

495
00:25:16,390 --> 00:25:14,720
data straight away

496
00:25:19,110 --> 00:25:16,400
we were a little concerned about the

497
00:25:21,669 --> 00:25:19,120
calibration of the instrument um

498
00:25:23,110 --> 00:25:21,679
but that there seemed to be something

499
00:25:25,990 --> 00:25:23,120
in the data

500
00:25:28,390 --> 00:25:26,000
which was pointing to

501
00:25:29,909 --> 00:25:28,400
an atmospheric signature of some kind

502
00:25:31,590 --> 00:25:29,919
and at that stage we were talking about

503
00:25:34,710 --> 00:25:31,600
an atmosphere covering the entire

504
00:25:39,830 --> 00:25:37,669
not everyone on dougherty's team agreed

505
00:25:41,909 --> 00:25:39,840
for one thing tiny enceladus lacks

506
00:25:45,110 --> 00:25:41,919
enough gravity to hold an atmosphere in

507
00:25:49,830 --> 00:25:47,350
in hopes of solving the mystery

508
00:25:52,710 --> 00:25:49,840
dougherty proposed flying even closer to

509
00:25:54,710 --> 00:25:52,720
enceladus on the next flyby

510
00:25:57,269 --> 00:25:54,720
doing so would upset trajectory and

511
00:25:59,990 --> 00:25:57,279
science plans long ago mapped out

512
00:26:02,310 --> 00:26:00,000
but dowardy's argument won the day

513
00:26:04,870 --> 00:26:02,320

navigators plotted out a new course that

514
00:26:08,950 --> 00:26:04,880
sent cassini skimming just over 100

515
00:26:12,630 --> 00:26:10,789
for the couple of nights before that fly

516
00:26:14,230 --> 00:26:12,640
by i didn't sleep

517
00:26:15,669 --> 00:26:14,240
what happened if we had seen nothing at

518
00:26:17,430 --> 00:26:15,679
all no one would ever have believed

519
00:26:19,510 --> 00:26:17,440
anything i said again

520
00:26:21,430 --> 00:26:19,520
and i i didn't sleep well at all but

521
00:26:22,830 --> 00:26:21,440
then we got the data back

522
00:26:25,830 --> 00:26:22,840
and it was

523
00:26:27,909 --> 00:26:25,840
spectacular in the southern polar region

524
00:26:30,310 --> 00:26:27,919
cassini found the landscape free of

525
00:26:32,149 --> 00:26:30,320
craters yet littered with house-sized

526
00:26:34,710 --> 00:26:32,159
boulders of ice

527
00:26:40,630 --> 00:26:34,720
carved out along bluish trenches that

528
00:26:44,230 --> 00:26:42,549
the moon would no longer be known for

529
00:26:46,870 --> 00:26:44,240
being smooth

530
00:26:49,750 --> 00:26:46,880
here was a fractured surface

531
00:26:53,190 --> 00:26:49,760
containing criss-crossing faults folds

532
00:27:00,310 --> 00:26:55,909
these crevices tell us that enceladus is

533
00:27:03,110 --> 00:27:02,230
from these fissures more than a mile

534
00:27:09,269 --> 00:27:03,120
deep

535
00:27:14,070 --> 00:27:11,669
nicknamed cold faithful they are

536
00:27:23,110 --> 00:27:14,080
continuously spraying out massive jets

537
00:27:27,510 --> 00:27:25,350
the speculation from more than a decade

538
00:27:29,669 --> 00:27:27,520

before that the shiny surface of

539
00:27:32,310 --> 00:27:29,679
enceladus might be the result of ice

540
00:27:34,870 --> 00:27:32,320
volcanism turned out to be true

541
00:27:39,909 --> 00:27:34,880
a momentous discovery that began with

542
00:27:43,430 --> 00:27:41,510
i thought okay

543
00:27:44,950 --> 00:27:43,440
my reputation is saved they're not going

544
00:27:48,870 --> 00:27:44,960
to think i'm crazy

545
00:27:51,269 --> 00:27:48,880
um but also it made me feel really proud

546
00:27:52,950 --> 00:27:51,279
of what magnetometer instruments can do

547
00:27:56,149 --> 00:27:52,960
because you know in some ways because

548
00:27:58,710 --> 00:27:56,159
we're just wiggly data on a plot

549
00:28:00,470 --> 00:27:58,720
it's very hard to get people enthused by

550
00:28:02,789 --> 00:28:00,480
our data

551
00:28:06,950 --> 00:28:02,799
you sort of media guys as well is really

552
00:28:11,590 --> 00:28:09,669
the detection of geysers was stunning

553
00:28:13,669 --> 00:28:11,600
for it meant the existence of liquid

554
00:28:22,070 --> 00:28:13,679
water near the surface of this bitterly

555
00:28:26,789 --> 00:28:24,549
and that turned enceladus in an instant

556
00:28:32,710 --> 00:28:26,799
into a prime target for the remainder of

557
00:28:38,389 --> 00:28:35,269
previous plans were tossed aside in

558
00:28:40,470 --> 00:28:38,399
favor of adding more enceladus flybys

559
00:28:51,269 --> 00:28:40,480
including dramatic plunges through the

560
00:28:54,630 --> 00:28:52,789
what is that

561
00:28:57,590 --> 00:28:54,640
and look at this little thing here this

562
00:29:00,950 --> 00:28:59,190
it's so complex

563
00:29:04,149 --> 00:29:00,960

the question is are both of them coming

564
00:29:05,590 --> 00:29:04,159
out of the tiger stripes

565
00:29:08,070 --> 00:29:05,600
be nice to get a temperature measurement

566
00:29:10,230 --> 00:29:08,080
right on that

567
00:29:11,510 --> 00:29:10,240
look at that it looks almost like like a

568
00:29:13,269 --> 00:29:11,520
river

569
00:29:16,149 --> 00:29:13,279
but see that that's in shadow but we can

570
00:29:21,269 --> 00:29:16,159
still see because the moon is so bright

571
00:29:21,279 --> 00:29:26,630
enceladus is as small as it is bright

572
00:29:30,149 --> 00:29:28,630
this small when compared to earth and

573
00:29:32,789 --> 00:29:30,159
our moon

574
00:29:35,269 --> 00:29:32,799
given its diminutive size it was thought

575
00:29:41,430 --> 00:29:35,279
enceladus would have long ago lost any

576
00:29:46,789 --> 00:29:44,149
and what scientists wondered was causing

577
00:29:48,710 --> 00:29:46,799
enceladus plumes to spray out these hot

578
00:29:51,029 --> 00:29:48,720
spots

579
00:29:53,110 --> 00:29:51,039
the answer involves saturn's massive

580
00:29:55,269 --> 00:29:53,120
tidal forces

581
00:29:57,909 --> 00:29:55,279
they create friction inside the moon's

582
00:30:01,430 --> 00:29:57,919
interior where there exists an ocean of

583
00:30:04,389 --> 00:30:01,440
water a tremendous discovery

584
00:30:08,389 --> 00:30:04,399
and liquid from this ocean wells upward

585
00:30:15,510 --> 00:30:08,399
creating the moon's hot spots

586
00:30:19,269 --> 00:30:17,510
and from these plumes scientists

587
00:30:21,510 --> 00:30:19,279
discovered that the moon's ocean

588
00:30:23,430 --> 00:30:21,520

contained salts and complex organic

589
00:30:26,549 --> 00:30:23,440
molecules

590
00:30:28,549 --> 00:30:26,559
likely created by hydrothermal vents

591
00:30:35,190 --> 00:30:28,559
the exact conditions believed to have

592
00:30:40,110 --> 00:30:37,430
for many these discoveries about this

593
00:30:41,350 --> 00:30:40,120
tiny moon was cassini's biggest triumph

594
00:30:43,430 --> 00:30:41,360
[Music]

595
00:30:45,990 --> 00:30:43,440
for enceladus is now one of the most

596
00:31:06,149 --> 00:30:46,000
promising destinations to search for

597
00:31:10,870 --> 00:31:08,470
cassini's discoveries during the first

598
00:31:14,710 --> 00:31:10,880
four years at saturn raised new

599
00:31:19,110 --> 00:31:17,190
with a spacecraft in excellent health

600
00:31:22,310 --> 00:31:19,120
nasa twice extended the mission's

601
00:31:28,870 --> 00:31:24,549
over the course of 13 years the

602
00:31:31,990 --> 00:31:28,880
spacecraft orbited saturn 294 times

603
00:31:33,830 --> 00:31:32,000
no two orbits were alike

604
00:31:35,269 --> 00:31:33,840
determining the pathways for these

605
00:31:38,389 --> 00:31:35,279
intricate loops

606
00:31:39,830 --> 00:31:38,399
is the work of true rocket scientists or

607
00:31:42,149 --> 00:31:39,840
as they are called

608
00:31:44,149 --> 00:31:42,159
tour designers

609
00:31:46,149 --> 00:31:44,159
they are mathematical wizards who

610
00:31:48,950 --> 00:31:46,159
charted courses through the maze of

611
00:31:51,190 --> 00:31:48,960
saturn's 80 plus moons and its ring

612
00:31:53,590 --> 00:31:51,200
system

613
00:31:56,549 --> 00:31:53,600

tour should be ranked green that is half

614
00:31:59,269 --> 00:31:56,559
of the job of these three tour designers

615
00:32:00,389 --> 00:31:59,279
the other half trying to please 200

616
00:32:02,950 --> 00:32:00,399
scientists

617
00:32:04,870 --> 00:32:02,960
this tour is probably a yellow because i

618
00:32:08,070 --> 00:32:04,880
hate to keep having this email exchange

619
00:32:09,830 --> 00:32:08,080
back and forth looks bad i think

620
00:32:12,230 --> 00:32:09,840
we're taking in all the science

621
00:32:14,549 --> 00:32:12,240
requirements which are you know could be

622
00:32:16,950 --> 00:32:14,559
a stack that thick we're kind of like a

623
00:32:19,430 --> 00:32:16,960
tour guide bringing a big group of kids

624
00:32:21,350 --> 00:32:19,440
or scientists to disneyland

625
00:32:23,430 --> 00:32:21,360
and the only problem is we have to stick

626
00:32:24,710 --> 00:32:23,440
together as a group we all have to do

627
00:32:25,669 --> 00:32:24,720
the same thing

628
00:32:27,830 --> 00:32:25,679
and

629
00:32:29,269 --> 00:32:27,840
it's again trying to please everyone

630
00:32:36,950 --> 00:32:29,279
equally

631
00:32:39,430 --> 00:32:36,960
the end of the tour selection process

632
00:32:42,230 --> 00:32:39,440
then we've done our job

633
00:32:43,990 --> 00:32:42,240
you can see that all of the tours have a

634
00:32:45,190 --> 00:32:44,000
large number of southern hemisphere

635
00:32:46,630 --> 00:32:45,200
coverage

636
00:32:49,269 --> 00:32:46,640
of the eyes

637
00:32:50,310 --> 00:32:49,279
we have evaluated the nominal

638
00:32:52,990 --> 00:32:50,320

uh

639
00:32:54,789 --> 00:32:53,000
tours that came out last week any

640
00:32:56,549 --> 00:32:54,799
modifications are things that we're

641
00:32:59,110 --> 00:32:56,559
going to have to grapple with as a group

642
00:32:59,909 --> 00:32:59,120
this week we can't have a an input

643
00:33:01,990 --> 00:32:59,919
that's

644
00:33:06,310 --> 00:33:02,000
a mix of the two unless we all

645
00:33:11,509 --> 00:33:08,070
they debate it out they listen to each

646
00:33:13,509 --> 00:33:11,519
other it gets heated at times is is that

647
00:33:15,190 --> 00:33:13,519
a reasonable approach that's what i

648
00:33:17,110 --> 00:33:15,200
think i would like

649
00:33:18,870 --> 00:33:17,120
but i have an objection to that yeah are

650
00:33:19,909 --> 00:33:18,880
we making the right choice for the right

651
00:33:22,310 --> 00:33:19,919
reasons

652
00:33:23,990 --> 00:33:22,320
well that's every team is going to have

653
00:33:26,389 --> 00:33:24,000
to think about that because we're not

654
00:33:28,630 --> 00:33:26,399
going to do the allocation until after

655
00:33:30,710 --> 00:33:28,640
the tour is selected so in a sense you

656
00:33:32,310 --> 00:33:30,720
are taking that risk it can be very

657
00:33:34,070 --> 00:33:32,320
frustrating first because in one meeting

658
00:33:35,990 --> 00:33:34,080
someone will say well do a you got to do

659
00:33:37,509 --> 00:33:36,000
a and the next meeting they'll say oh

660
00:33:38,389 --> 00:33:37,519
you can't do that you have to do this

661
00:33:40,630 --> 00:33:38,399
instead

662
00:33:42,710 --> 00:33:40,640
just a strategic comment

663
00:33:44,710 --> 00:33:42,720

i think everybody in this room knows how

664
00:33:46,710 --> 00:33:44,720
rushed the evaluation of all these tours

665
00:33:49,110 --> 00:33:46,720
were because they came in so late it

666
00:33:51,430 --> 00:33:49,120
starts out everybody's on different ends

667
00:33:53,350 --> 00:33:51,440
sometimes yelling sometimes red-faced

668
00:33:54,710 --> 00:33:53,360
really mad like they're really trying to

669
00:33:56,310 --> 00:33:54,720
make sure they get hurt the tour

670
00:33:58,149 --> 00:33:56,320
designers have been looking at what is

671
00:34:01,909 --> 00:33:58,159
the flexibility

672
00:34:03,029 --> 00:34:01,919
in a given tour to raise and lower the

673
00:34:04,470 --> 00:34:03,039
altitude

674
00:34:05,590 --> 00:34:04,480
you know we have to look at the ripple

675
00:34:07,750 --> 00:34:05,600
effect

676
00:34:08,710 --> 00:34:07,760
when you're up high out of the orbit

677
00:34:10,629 --> 00:34:08,720
plane you're up way above starting to

678
00:34:12,790 --> 00:34:10,639
get a good view of the rings but you're

679
00:34:13,909 --> 00:34:12,800
not around any of the other moons

680
00:34:15,589 --> 00:34:13,919
and so the people that want to look at

681
00:34:17,109 --> 00:34:15,599
the rings want to be up high and look at

682
00:34:19,109 --> 00:34:17,119
the rings the other people want to be

683
00:34:20,950 --> 00:34:19,119
down in the same plane with the rings

684
00:34:22,950 --> 00:34:20,960
where they can visit all the other moons

685
00:34:24,310 --> 00:34:22,960
and that's a huge tug of war you know

686
00:34:25,669 --> 00:34:24,320
it's such that the j2 perturbations

687
00:34:27,270 --> 00:34:25,679
aren't maximized

688
00:34:28,710 --> 00:34:27,280

what you're hearing here and i said it

689
00:34:29,829 --> 00:34:28,720
earlier what are you hearing from people

690
00:34:31,990 --> 00:34:29,839
in this room

691
00:34:35,750 --> 00:34:32,000
size they haven't had a chance to really

692
00:34:37,270 --> 00:34:35,760
evaluate the information in a way

693
00:34:39,669 --> 00:34:37,280
well enough so they think we've got the

694
00:34:41,510 --> 00:34:39,679
right decision and so i think we went

695
00:34:43,190 --> 00:34:41,520
through the stressful times

696
00:34:44,550 --> 00:34:43,200
earlier in the week you know meeting

697
00:34:45,589 --> 00:34:44,560
with each disciplined working group

698
00:34:47,109 --> 00:34:45,599
because

699
00:34:48,950 --> 00:34:47,119
you know we sit in front of these you

700
00:34:50,230 --> 00:34:48,960
know 40 or 50

701
00:34:51,750 --> 00:34:50,240
you know world-renowned scientists in a

702
00:34:52,950 --> 00:34:51,760
specific field and it's and it's kind of

703
00:34:54,710 --> 00:34:52,960
like a congressional hearing where they

704
00:34:56,230 --> 00:34:54,720
just fire off questions you know one

705
00:34:58,150 --> 00:34:56,240
after the other

706
00:35:00,550 --> 00:34:58,160
you really have to know your stuff and

707
00:35:02,950 --> 00:35:00,560
understand every idiosyncrasy of each

708
00:35:04,390 --> 00:35:02,960
specific tour but after they got hurt i

709
00:35:05,750 --> 00:35:04,400
mean people kind of calm down a little

710
00:35:07,430 --> 00:35:05,760
bit but eventually everybody gets quick

711
00:35:09,589 --> 00:35:07,440
yeah that's kind of the best thing so

712
00:35:11,510 --> 00:35:09,599
we're very lucky that the spacecraft is

713
00:35:14,950 --> 00:35:11,520

very highly functional and we have a lot

714
00:35:17,030 --> 00:35:14,960
of fuel all the tours are are good and i

715
00:35:18,230 --> 00:35:17,040
feel happy if any of them got selected i

716
00:35:19,670 --> 00:35:18,240
mean all of them are going to be really

717
00:35:20,790 --> 00:35:19,680
exciting

718
00:35:22,470 --> 00:35:20,800
um

719
00:35:25,829 --> 00:35:22,480
i mean just

720
00:35:27,990 --> 00:35:25,839
like we have ansel adams riding on the

721
00:35:30,950 --> 00:35:28,000
spacecraft

722
00:35:33,829 --> 00:35:30,960
i'm talking about pictures but i mean

723
00:35:35,030 --> 00:35:33,839
the other stuff is is is neat too i mean

724
00:35:36,470 --> 00:35:35,040
some of these instruments they can just

725
00:35:38,069 --> 00:35:36,480
take a picture

726
00:35:39,030 --> 00:35:38,079
and they can tell you what it's made out

727
00:35:41,750 --> 00:35:39,040
of

728
00:35:43,750 --> 00:35:41,760
you know but really star trek didn't

729
00:35:45,910 --> 00:35:43,760
have instruments this cool you know they

730
00:35:47,030 --> 00:35:45,920
just had this like green ray knee or you

731
00:35:48,870 --> 00:35:47,040
know and it did everything right their

732
00:35:49,990 --> 00:35:48,880
tricorder or whatever or the really

733
00:35:51,190 --> 00:35:50,000
amazing stuff is when they find

734
00:35:53,190 --> 00:35:51,200
something that's like

735
00:35:55,430 --> 00:35:53,200
they have no idea they have like a

736
00:35:57,190 --> 00:35:55,440
iapetus that that ridge what happens

737
00:35:59,030 --> 00:35:57,200
it's like the equator is actually marked

738
00:36:00,470 --> 00:35:59,040

it's like when i was a kid i had a globe

739
00:36:02,150 --> 00:36:00,480
that got messed up and the equator kind

740
00:36:03,109 --> 00:36:02,160
of stuck out i mean that's that's the

741
00:36:04,470 --> 00:36:03,119
way i have it it says there's this

742
00:36:12,710 --> 00:36:04,480
mountain ridge right along the equator

743
00:36:17,270 --> 00:36:14,710
this meeting was only one of several

744
00:36:19,510 --> 00:36:17,280
taking place

745
00:36:21,829 --> 00:36:19,520
it is at this larger gathering where the

746
00:36:23,670 --> 00:36:21,839
proposals of the tour designers

747
00:36:25,349 --> 00:36:23,680
representing a year's worth of work with

748
00:36:28,470 --> 00:36:25,359
little time off for weekends and

749
00:36:30,710 --> 00:36:28,480
holidays will be judged

750
00:36:32,630 --> 00:36:30,720
compared to the usual agenda today is

751
00:36:34,710 --> 00:36:32,640
turned upside down

752
00:36:35,589 --> 00:36:34,720
and the reason for that is

753
00:36:36,870 --> 00:36:35,599
tour

754
00:36:40,230 --> 00:36:36,880
design

755
00:36:43,270 --> 00:36:40,240
is the main topic of this whole meeting

756
00:36:44,790 --> 00:36:43,280
you'll notice that there's some

757
00:36:46,950 --> 00:36:44,800
filming or video

758
00:36:50,470 --> 00:36:46,960
going on this is a

759
00:36:55,510 --> 00:36:50,480
jpl activity to document how

760
00:36:58,069 --> 00:36:55,520
decisions are made on projects and but

761
00:37:01,430 --> 00:36:58,079
and uh well they go have a cutting and

762
00:37:03,910 --> 00:37:01,440
editing process so i'm not sure that

763
00:37:05,829 --> 00:37:03,920

we'll recognize it necessarily when it's

764
00:37:07,829 --> 00:37:05,839
any case it's like the worst take-home

765
00:37:09,030 --> 00:37:07,839
final ever invented you have 200

766
00:37:10,550 --> 00:37:09,040
professors

767
00:37:11,990 --> 00:37:10,560
you know and the hardest questions you

768
00:37:13,270 --> 00:37:12,000
can think of and you're just kind of

769
00:37:16,230 --> 00:37:13,280
slogging through it trying to get it

770
00:37:17,270 --> 00:37:16,240
done and then you hand it in uh pf7

771
00:37:19,109 --> 00:37:17,280
11

772
00:37:20,790 --> 00:37:19,119
they're both very much like six and six

773
00:37:22,470 --> 00:37:20,800
h9 it kind of feels good to have it

774
00:37:23,990 --> 00:37:22,480
handed in but you're not really awake

775
00:37:25,670 --> 00:37:24,000
enough for really much of emotion or

776
00:37:28,710 --> 00:37:25,680
anything nation so you end up with a

777
00:37:30,150 --> 00:37:28,720
titan flyby at apolapsus

778
00:37:32,310 --> 00:37:30,160
and uh or

779
00:37:33,750 --> 00:37:32,320
at periapsis and then you come back then

780
00:37:35,750 --> 00:37:33,760
you do a pie transfer then you crank up

781
00:37:37,910 --> 00:37:35,760
again so there's a lot of inclined

782
00:37:40,150 --> 00:37:37,920
time in this and when it comes from an

783
00:37:42,870 --> 00:37:40,160
infinite number of possibilities the

784
00:37:45,109 --> 00:37:42,880
tours are whittled down to nine

785
00:37:47,349 --> 00:37:45,119
next the science teams are to rank them

786
00:37:51,190 --> 00:37:47,359
as green acceptable

787
00:37:53,510 --> 00:37:51,200
yellow partially acceptable or red not

788
00:37:55,270 --> 00:37:53,520

acceptable but it sounds like six h9 and

789
00:37:58,390 --> 00:37:55,280
eight should either both be

790
00:38:00,790 --> 00:37:58,400
um both be red or both be yellow

791
00:38:03,510 --> 00:38:00,800
but wanting more wiggle room scientists

792
00:38:08,310 --> 00:38:03,520
introduce a new color to the voting

793
00:38:13,510 --> 00:38:09,589
okay

794
00:38:14,950 --> 00:38:13,520
uh 6h9 three greens a lime and a red uh

795
00:38:16,630 --> 00:38:14,960
i mean it's kind of like our job was

796
00:38:17,510 --> 00:38:16,640
over just waiting to hear the result i

797
00:38:18,630 --> 00:38:17,520
mean

798
00:38:20,550 --> 00:38:18,640
i guess it's kind of like the jury

799
00:38:21,990 --> 00:38:20,560
coming in but you're too tired to care

800
00:38:23,750 --> 00:38:22,000
what your sentence is so you're talking

801
00:38:32,230 --> 00:38:23,760
about pf9 for titan

802
00:38:38,390 --> 00:38:34,150
no doubt the winning tour has left the

803
00:38:40,950 --> 00:38:38,400
scientists equally happy and unhappy

804
00:38:42,790 --> 00:38:40,960
the tour designers are just plain happy

805
00:38:44,950 --> 00:38:42,800
for the first time in a year they will

806
00:38:47,829 --> 00:38:44,960
have their lives back

807
00:38:48,710 --> 00:38:47,839
it's done it's over the decision's been

808
00:38:49,829 --> 00:38:48,720
made

809
00:38:51,910 --> 00:38:49,839
you know we were

810
00:38:58,030 --> 00:38:51,920
happy but also just absolutely felt like

811
00:38:58,040 --> 00:39:10,550
[Music]

812
00:39:14,870 --> 00:39:12,790
hello this is arthur clark

813
00:39:16,710 --> 00:39:14,880

joining you from my

814
00:39:18,710 --> 00:39:16,720
home in colombo

815
00:39:21,109 --> 00:39:18,720
sri lanka

816
00:39:22,230 --> 00:39:21,119
i am delighted to be part of this event

817
00:39:25,270 --> 00:39:22,240
to mark

818
00:39:27,510 --> 00:39:25,280
cassini's flyby of japanese

819
00:39:30,470 --> 00:39:27,520
when science fiction writer arthur c

820
00:39:32,950 --> 00:39:30,480
clarke wrote the classic 2001 a space

821
00:39:37,109 --> 00:39:32,960
odyssey he chose for the book's final

822
00:39:38,470 --> 00:39:37,119
scene saturn's moon iapetus

823
00:39:40,950 --> 00:39:38,480
as you know

824
00:39:43,829 --> 00:39:40,960
i have more than a passing interest in

825
00:39:46,550 --> 00:39:43,839
saturn

826
00:39:49,190 --> 00:39:46,560
in the movie version of 2001

827
00:39:51,910 --> 00:39:49,200
the ending scene was changed to jupiter

828
00:39:54,390 --> 00:39:51,920
but for clark iapetus remained a place

829
00:39:56,710 --> 00:39:54,400
of deep mystery

830
00:39:58,710 --> 00:39:56,720
he shared his enthusiasm for saturn's

831
00:40:01,349 --> 00:39:58,720
third largest moon with those who

832
00:40:05,589 --> 00:40:01,359
gathered in jpl's auditorium to witness

833
00:40:07,349 --> 00:40:05,599
images of iapetus as they first arrived

834
00:40:11,030 --> 00:40:07,359
this is a particularly exciting moment

835
00:40:13,589 --> 00:40:11,040
for fans of 2001 a space odyssey because

836
00:40:15,030 --> 00:40:13,599
that's where the lone astronaut dave

837
00:40:17,430 --> 00:40:15,040
bowman

838
00:40:20,230 --> 00:40:17,440

discovers the saturn monolith

839
00:40:23,430 --> 00:40:20,240
which turns out to be a gateway

840
00:40:25,430 --> 00:40:23,440
to the stars more than 40 years later i

841
00:40:27,510 --> 00:40:25,440
can't remember why i placed the saturn

842
00:40:28,950 --> 00:40:27,520
bond with antiopetus

843
00:40:32,069 --> 00:40:28,960
but i've always had this strange

844
00:40:33,190 --> 00:40:32,079
fascination for saturn and his family of

845
00:40:34,950 --> 00:40:33,200
moons

846
00:40:37,430 --> 00:40:34,960
by the way that family has been growing

847
00:40:40,069 --> 00:40:37,440
at a very impressive rate

848
00:40:42,230 --> 00:40:40,079
when cassini was launched we knew of

849
00:40:46,309 --> 00:40:42,240
only 18 moons

850
00:40:49,030 --> 00:40:46,319
i understand it's now 60 i'm counting

851
00:40:51,750 --> 00:40:49,040
i can't resist the temptation to say

852
00:40:54,630 --> 00:40:51,760
my god is full of moons

853
00:40:57,190 --> 00:40:54,640
so i'm going to keep my fingers crossed

854
00:40:58,550 --> 00:40:57,200
with what cassini discovers at the

855
00:41:00,390 --> 00:40:58,560
apetus

856
00:41:02,710 --> 00:41:00,400
i want to thank everyone associated with

857
00:41:04,230 --> 00:41:02,720
this mission the science projects are

858
00:41:06,470 --> 00:41:04,240
tremendously important for our

859
00:41:10,870 --> 00:41:06,480
understanding of the solar system

860
00:41:14,870 --> 00:41:10,880
who knows one day our survival on earth

861
00:41:16,630 --> 00:41:14,880
may depend on what we discover out there

862
00:41:19,460 --> 00:41:16,640
this is arthur clark

863
00:41:30,470 --> 00:41:19,470

wishing you a successful flyby

864
00:41:32,950 --> 00:41:30,480
[Applause]

865
00:41:40,870 --> 00:41:32,960
what cassini saw at iapetus was

866
00:41:44,550 --> 00:41:42,790
many of the observations focused on

867
00:41:46,710 --> 00:41:44,560
examining a mountain ridge on the

868
00:41:48,950 --> 00:41:46,720
equator

869
00:41:55,430 --> 00:41:48,960
that contributes to the moon's unusual

870
00:41:59,910 --> 00:41:58,150
these mountains made mostly of ice

871
00:42:01,349 --> 00:41:59,920
are among the tallest in the solar

872
00:42:04,309 --> 00:42:01,359
system

873
00:42:07,270 --> 00:42:04,319
soaring 12 miles high more than twice

874
00:42:09,510 --> 00:42:07,280
that of mount everest

875
00:42:12,069 --> 00:42:09,520
scientists have more than one idea as to

876
00:42:14,230 --> 00:42:12,079
how they may have formed

877
00:42:16,470 --> 00:42:14,240
one thought is that perhaps when iapetus

878
00:42:19,270 --> 00:42:16,480
was more fluid or pliable it was

879
00:42:21,510 --> 00:42:19,280
spinning very very fast and so it sort

880
00:42:24,309 --> 00:42:21,520
of bulged out at its equator as it was

881
00:42:26,309 --> 00:42:24,319
spinning and as it cooled off

882
00:42:28,150 --> 00:42:26,319
then it held that shape

883
00:42:30,309 --> 00:42:28,160
actually had that mountain range going

884
00:42:33,109 --> 00:42:30,319
around it

885
00:42:34,950 --> 00:42:33,119
while the bulge remains to be solved

886
00:42:36,870 --> 00:42:34,960
scientists believe they are on more

887
00:42:42,309 --> 00:42:36,880
solid ground as to the reason why

888
00:42:46,790 --> 00:42:43,829

one of the puzzles going all the way

889
00:42:49,190 --> 00:42:46,800
back to voyager is is that dark material

890
00:42:51,510 --> 00:42:49,200
coming from inside iapetus maybe some

891
00:42:54,309 --> 00:42:51,520
kind of volcanic eruption or is it

892
00:42:55,589 --> 00:42:54,319
coming from outside and cassini solved

893
00:42:57,750 --> 00:42:55,599
that puzzle

894
00:42:59,910 --> 00:42:57,760
turns out that there's a captured moon

895
00:43:01,510 --> 00:42:59,920
phoebe in the outer part of the saturn

896
00:43:04,069 --> 00:43:01,520
system

897
00:43:07,670 --> 00:43:04,079
dust from phoebe comes in and gets swept

898
00:43:10,829 --> 00:43:07,680
up onto one side of iapetus coating that

899
00:43:14,150 --> 00:43:10,839
side in almost a charcoal black

900
00:43:15,990 --> 00:43:14,160
material this black material absorbs

901
00:43:17,910 --> 00:43:16,000
heat from the sun

902
00:43:21,190 --> 00:43:17,920
turning the moon's water ice into a

903
00:43:25,589 --> 00:43:21,200
vapor that accumulates like snow

904
00:43:28,309 --> 00:43:25,599
falling on the trailing side of iapetus

905
00:43:33,110 --> 00:43:28,319
the result is the moon's distinct yin

906
00:43:33,120 --> 00:43:37,829
[Music]

907
00:43:42,230 --> 00:43:40,630
phoebe the moon responsible for iapetus

908
00:43:43,990 --> 00:43:42,240
dark material

909
00:43:49,589 --> 00:43:44,000
resides on the outskirts of the

910
00:43:54,470 --> 00:43:51,910
this is a frozen artifact from the time

911
00:43:56,710 --> 00:43:54,480
when the solar system was forming

912
00:43:58,790 --> 00:43:56,720
its battered surface speaks of a violent

913
00:44:01,349 --> 00:43:58,800

past

914
00:44:04,069 --> 00:44:01,359
everywhere there are ancient craters

915
00:44:06,230 --> 00:44:04,079
and landslides

916
00:44:08,710 --> 00:44:06,240
phoebe was the first saturnian moon

917
00:44:10,630 --> 00:44:08,720
cassini saw up close

918
00:44:12,870 --> 00:44:10,640
and it proved to be a harbinger of the

919
00:44:14,710 --> 00:44:12,880
bounty to come

920
00:44:17,349 --> 00:44:14,720
for at the time of cassini's launch

921
00:44:19,910 --> 00:44:17,359
there were just 18 confirmed saturnian

922
00:44:26,550 --> 00:44:23,670
now there are 82

923
00:44:30,470 --> 00:44:26,560
these moons are as diverse in shape size

924
00:44:33,109 --> 00:44:30,480
and composition as they are numerous

925
00:44:36,430 --> 00:44:33,119
battered mimas with its massive crater

926
00:44:37,670 --> 00:44:36,440
resembles the death star from star wars

927
00:44:40,470 --> 00:44:37,680
[Music]

928
00:44:43,109 --> 00:44:40,480
hyperion resembles a sponge

929
00:44:45,349 --> 00:44:43,119
its interior is full of voids

930
00:44:48,630 --> 00:44:45,359
so much so that it's thought of more as

931
00:44:53,349 --> 00:44:48,640
a rubble pile than a solid body

932
00:44:53,359 --> 00:44:57,750
prometheus a potato

933
00:45:03,430 --> 00:45:01,589
and pan a ravioli

934
00:45:05,190 --> 00:45:03,440
these and other moons are part of

935
00:45:08,710 --> 00:45:05,200
saturn's intricate system that

936
00:45:11,130 --> 00:45:08,720
influences the rings the magnetosphere

937
00:45:14,069 --> 00:45:11,140
and even the planet

938
00:45:16,870 --> 00:45:14,079

[Music]

939
00:45:20,950 --> 00:45:16,880
and while best known for its rings

940
00:45:22,950 --> 00:45:20,960
saturn is deserving of its own attention

941
00:45:24,950 --> 00:45:22,960
it is the second largest planet in the

942
00:45:27,670 --> 00:45:24,960
solar system

943
00:45:34,630 --> 00:45:27,680
in volume saturn could hold more than

944
00:45:38,230 --> 00:45:37,109
composed mostly of helium and hydrogen

945
00:45:41,589 --> 00:45:38,240
gases

946
00:45:43,430 --> 00:45:41,599
the planet has no solid surface

947
00:45:49,510 --> 00:45:43,440
although deep within there is thought to

948
00:45:53,109 --> 00:45:52,069
despite its size saturn is astonishingly

949
00:45:55,750 --> 00:45:53,119
light

950
00:45:58,150 --> 00:45:55,760
less dense than water

951
00:45:59,750 --> 00:45:58,160
if it could be placed in an imaginary

952
00:46:03,510 --> 00:45:59,760
giant bathtub

953
00:46:06,550 --> 00:46:05,349
the planet's spin rate is also

954
00:46:08,630 --> 00:46:06,560
impressive

955
00:46:10,309 --> 00:46:08,640
the saturn day is only ten and a half

956
00:46:12,630 --> 00:46:10,319
hours long

957
00:46:14,550 --> 00:46:12,640
this rapid rotation causes the planet to

958
00:46:19,109 --> 00:46:14,560
bulge out at the equator

959
00:46:23,589 --> 00:46:21,670
saturn's butterscotch exterior appears

960
00:46:26,790 --> 00:46:23,599
bland and calm

961
00:46:29,030 --> 00:46:26,800
but this appearance is deceiving

962
00:46:31,670 --> 00:46:29,040
beneath the cloud tops is a churning

963
00:46:33,829 --> 00:46:31,680

cauldron of lightning and wind speeds

964
00:46:34,630 --> 00:46:33,839
that can reach over a thousand miles an

965
00:46:37,349 --> 00:46:34,640
hour

966
00:46:43,030 --> 00:46:37,359
and about every 30 earth years saturn

967
00:46:46,630 --> 00:46:45,270
cassini had the good timing to witness

968
00:46:49,030 --> 00:46:46,640
one

969
00:46:53,030 --> 00:46:49,040
this raging storm would grow to encircle

970
00:46:57,589 --> 00:46:55,349
even more amazing is what can be seen at

971
00:46:59,750 --> 00:46:57,599
saturn's poles

972
00:47:00,710 --> 00:46:59,760
saturn has something unique in the solar

973
00:47:02,790 --> 00:47:00,720
system

974
00:47:04,630 --> 00:47:02,800
it has a hexagon

975
00:47:10,470 --> 00:47:04,640
circling the north pole

976
00:47:17,589 --> 00:47:12,790
you can almost imagine horses on a

977
00:47:22,549 --> 00:47:19,910
we don't know why it keeps its six-sided

978
00:47:24,790 --> 00:47:22,559
shape it's some kind of a wave pattern

979
00:47:27,589 --> 00:47:24,800
that goes around saturn but it's very

980
00:47:31,030 --> 00:47:27,599
stable it's been there for decades it's

981
00:47:33,349 --> 00:47:31,040
about two earth diameters across

982
00:47:34,230 --> 00:47:33,359
at the very center right at the north

983
00:47:37,109 --> 00:47:34,240
pole

984
00:47:39,270 --> 00:47:37,119
there's a giant hurricane it's about

985
00:47:42,230 --> 00:47:39,280
half the size of the continental united

986
00:47:47,829 --> 00:47:42,240
states with wind speeds about four times

987
00:47:53,829 --> 00:47:50,549
a second monster storm was discovered at

988
00:47:56,150 --> 00:47:53,839

saturn's south pole

989
00:47:58,630 --> 00:47:56,160
it is also ringed with towering clouds

990
00:48:00,710 --> 00:47:58,640
but lacks a hexagon

991
00:48:05,030 --> 00:48:00,720
and while this vortex looks like a

992
00:48:09,430 --> 00:48:06,950
these are just some of the wonders of

993
00:48:11,910 --> 00:48:09,440
saturn witnessed by cassini

994
00:48:14,630 --> 00:48:11,920
but still to come is an entirely

995
00:48:31,910 --> 00:48:14,640
different way to explore the planet

996
00:48:37,589 --> 00:48:35,349
by 2017 cassini had circled saturn more

997
00:48:39,109 --> 00:48:37,599
than 250 times

998
00:48:40,870 --> 00:48:39,119
and the mission's achievements had

999
00:48:43,109 --> 00:48:40,880
earned the praise of many

1000
00:48:46,230 --> 00:48:43,119
including the first human ever to set

1001
00:48:47,030 --> 00:48:46,240
foot on another celestial body

1002
00:48:48,390 --> 00:48:47,040
hi

1003
00:48:51,430 --> 00:48:48,400
i'm neil armstrong

1004
00:48:53,510 --> 00:48:51,440
we're here at the cincinnati observatory

1005
00:48:55,030 --> 00:48:53,520
armstrong recorded this message to the

1006
00:48:58,549 --> 00:48:55,040
cassini team

1007
00:49:00,309 --> 00:48:58,559
four years before his passing

1008
00:49:03,109 --> 00:49:00,319
it has been said

1009
00:49:05,910 --> 00:49:03,119
science is about what is and engineering

1010
00:49:08,390 --> 00:49:05,920
is about what can be

1011
00:49:11,190 --> 00:49:08,400
the christina huygens program has

1012
00:49:13,670 --> 00:49:11,200
demonstrated the best of both

1013
00:49:15,510 --> 00:49:13,680

and you are the people who made it the

1014
00:49:17,109 --> 00:49:15,520
enormous success

1015
00:49:19,349 --> 00:49:17,119
that it has been

1016
00:49:21,109 --> 00:49:19,359
and is

1017
00:49:23,109 --> 00:49:21,119
some of you are in

1018
00:49:25,430 --> 00:49:23,119
science of what is

1019
00:49:26,790 --> 00:49:25,440
unraveling the secrets of the saturnian

1020
00:49:28,790 --> 00:49:26,800
system

1021
00:49:30,630 --> 00:49:28,800
someone's had a full-time job just

1022
00:49:32,710 --> 00:49:30,640
counting moons

1023
00:49:35,670 --> 00:49:32,720
the number of your new discoveries is

1024
00:49:38,390 --> 00:49:35,680
nothing short of amazing

1025
00:49:39,510 --> 00:49:38,400
some of you were in the what can be

1026
00:49:41,349 --> 00:49:39,520
category

1027
00:49:44,069 --> 00:49:41,359
you're involved in the design of the

1028
00:49:46,150 --> 00:49:44,079
spacecraft and the trajectories system

1029
00:49:47,829 --> 00:49:46,160
design and operation

1030
00:49:50,150 --> 00:49:47,839
instrumentation

1031
00:49:52,230 --> 00:49:50,160
how to make the measurements programming

1032
00:49:56,150 --> 00:49:52,240
the computers

1033
00:49:59,470 --> 00:49:56,160
we all give you our very best wishes

1034
00:50:03,030 --> 00:49:59,480
to continue your outstanding performance

1035
00:50:07,910 --> 00:50:03,040
congratulations to each and every one of

1036
00:50:13,109 --> 00:50:10,870
cassini's original lifetime warranty was

1037
00:50:14,630 --> 00:50:13,119
for four years at saturn

1038
00:50:16,309 --> 00:50:14,640

the mission more than doubled that

1039
00:50:18,069 --> 00:50:16,319
guarantee

1040
00:50:20,309 --> 00:50:18,079
in 2017

1041
00:50:22,549 --> 00:50:20,319
20 years after its launch

1042
00:50:24,950 --> 00:50:22,559
the spacecraft was still performing

1043
00:50:27,109 --> 00:50:24,960
beyond expectations

1044
00:50:27,910 --> 00:50:27,119
it's like the spacecraft just now broke

1045
00:50:38,950 --> 00:50:27,920
in

1046
00:50:41,109 --> 00:50:38,960
and before that happens the spacecraft

1047
00:50:42,950 --> 00:50:41,119
has to be set on a course that will

1048
00:50:49,430 --> 00:50:42,960
ensure it will not crash into one of

1049
00:50:55,030 --> 00:50:53,270
given that enceladus now appears to have

1050
00:50:59,030 --> 00:50:55,040
all the ingredients that could harbor

1051
00:51:03,190 --> 00:51:01,030
and frankly we have a very nice home for

1052
00:51:05,349 --> 00:51:03,200
microbes it's room temperature inside

1053
00:51:07,670 --> 00:51:05,359
the spacecraft a hardy microbe could

1054
00:51:09,349 --> 00:51:07,680
easily have hitched a ride along

1055
00:51:11,750 --> 00:51:09,359
we went through a lot of studies on

1056
00:51:13,829 --> 00:51:11,760
disposal options for the spacecraft some

1057
00:51:15,829 --> 00:51:13,839
of them were to take it into a very long

1058
00:51:17,510 --> 00:51:15,839
loopy orbits of saturn

1059
00:51:19,910 --> 00:51:17,520
where it would be stable for thousands

1060
00:51:22,230 --> 00:51:19,920
of years but the scientific benefit

1061
00:51:24,870 --> 00:51:22,240
wasn't there we also had options to go

1062
00:51:26,710 --> 00:51:24,880
back to jupiter go to go out to uranus

1063
00:51:28,950 --> 00:51:26,720

go to the trojan asteroids we could have

1064
00:51:31,270 --> 00:51:28,960
exercised a lot of those options but

1065
00:51:33,030 --> 00:51:31,280
none of them had the strength and appeal

1066
00:51:34,950 --> 00:51:33,040
of a scientific mission at saturn we

1067
00:51:37,750 --> 00:51:34,960
were built for saturn saturn was

1068
00:51:39,990 --> 00:51:37,760
absolutely just bristling with things we

1069
00:51:41,910 --> 00:51:40,000
hadn't yet explored

1070
00:51:43,990 --> 00:51:41,920
once we chose to stay we had to figure

1071
00:51:46,150 --> 00:51:44,000
out how to dispose of the spacecraft

1072
00:51:47,990 --> 00:51:46,160
cleanly

1073
00:51:50,710 --> 00:51:48,000
it's decided to end the mission by

1074
00:51:53,589 --> 00:51:50,720
plunging cassini into saturn

1075
00:51:56,790 --> 00:51:53,599
but not before attempting to dive 22

1076
00:52:08,309 --> 00:51:56,800
times between the planet and the rings

1077
00:52:08,319 --> 00:52:18,470
okay

1078
00:52:23,190 --> 00:52:21,030
this is where cassini is right now in

1079
00:52:24,630 --> 00:52:23,200
its orbit of saturn it's below the ring

1080
00:52:27,510 --> 00:52:24,640
plane

1081
00:52:29,829 --> 00:52:27,520
which goes out here will come over

1082
00:52:32,230 --> 00:52:29,839
the top of the rings again

1083
00:52:35,589 --> 00:52:32,240
in a few days we do this every seven and

1084
00:52:38,870 --> 00:52:35,599
a half days on april 22nd

1085
00:52:41,589 --> 00:52:38,880
the spacecraft will fly fairly close to

1086
00:52:43,190 --> 00:52:41,599
saturn's big moon titan and titan has

1087
00:52:45,430 --> 00:52:43,200
enough gravitation

1088
00:52:47,030 --> 00:52:45,440

that we can use it to trade orbital

1089
00:52:49,030 --> 00:52:47,040
momentum between

1090
00:52:51,670 --> 00:52:49,040
titan going around saturn and the

1091
00:52:53,030 --> 00:52:51,680
spacecraft going around saturn and with

1092
00:52:55,430 --> 00:52:53,040
that trade-off

1093
00:52:57,910 --> 00:52:55,440
a marvelous thing happens

1094
00:52:58,870 --> 00:52:57,920
the orbit of the spacecraft jumps

1095
00:53:01,270 --> 00:52:58,880
inward

1096
00:53:02,870 --> 00:53:01,280
towards saturn so that the next close

1097
00:53:05,589 --> 00:53:02,880
flyby of saturn

1098
00:53:09,510 --> 00:53:05,599
will be in between the rings and

1099
00:53:13,750 --> 00:53:11,510
is that dangerous

1100
00:53:16,309 --> 00:53:13,760
we don't really know but who knows we

1101
00:53:17,910 --> 00:53:16,319
might run into some big ring particles

1102
00:53:19,910 --> 00:53:17,920
in there that we can't see

1103
00:53:21,589 --> 00:53:19,920
in our observations

1104
00:53:23,670 --> 00:53:21,599
if that happens

1105
00:53:24,950 --> 00:53:23,680
oh well it's been a good mission

1106
00:53:27,190 --> 00:53:24,960
if it doesn't

1107
00:53:30,150 --> 00:53:27,200
clobber the spacecraft right away

1108
00:53:32,230 --> 00:53:30,160
then we'll have 22 more flights through

1109
00:53:34,309 --> 00:53:32,240
all the way out a million miles

1110
00:53:36,150 --> 00:53:34,319
it's a million mile high roller coaster

1111
00:53:39,109 --> 00:53:36,160
picture yourself going click click click

1112
00:53:41,430 --> 00:53:39,119
click up a huge roller coaster and then

1113
00:53:43,349 --> 00:53:41,440

starting in it's just falling

1114
00:53:45,829 --> 00:53:43,359
as we whip through the

1115
00:53:49,030 --> 00:53:45,839
space between the rings and planet

1116
00:54:00,230 --> 00:53:49,040
we'll be going 120

1117
00:54:05,670 --> 00:54:03,030
the most important thing i think is the

1118
00:54:07,670 --> 00:54:05,680
moment when cassini's signal reaches the

1119
00:54:10,390 --> 00:54:07,680
earth that means

1120
00:54:11,990 --> 00:54:10,400
that the spacecraft has gone through i

1121
00:54:13,030 --> 00:54:12,000
don't know maybe a thousand different

1122
00:54:15,030 --> 00:54:13,040
commands

1123
00:54:17,190 --> 00:54:15,040
turning the spacecraft operating the

1124
00:54:19,510 --> 00:54:17,200
cameras and spectrometers and dust

1125
00:54:21,270 --> 00:54:19,520
detectors and magnetometer

1126
00:54:23,270 --> 00:54:21,280
they make their observation the

1127
00:54:24,710 --> 00:54:23,280
spacecraft keeps turning and twisting to

1128
00:54:27,589 --> 00:54:24,720
point everything

1129
00:54:30,230 --> 00:54:27,599
and the moment the signal hits earth we

1130
00:54:32,710 --> 00:54:30,240
know that all of that in the past day

1131
00:54:39,589 --> 00:54:32,720
has been successful and i think that's

1132
00:54:44,230 --> 00:54:42,390
but before there can be party time

1133
00:54:46,710 --> 00:54:44,240
there's the less glamorous work of

1134
00:54:48,950 --> 00:54:46,720
creating those commands

1135
00:54:50,950 --> 00:54:48,960
and sometimes testing them in tucked

1136
00:54:53,670 --> 00:54:50,960
away labs

1137
00:54:56,150 --> 00:54:53,680
i think we're good to go

1138
00:54:58,470 --> 00:54:56,160

well this is this is um

1139
00:54:59,910 --> 00:54:58,480
another sea kernel so after this meeting

1140
00:55:02,710 --> 00:54:59,920
i'm going to have to switch out this

1141
00:55:04,309 --> 00:55:02,720
that's right for 467. this is 444. okay

1142
00:55:06,309 --> 00:55:04,319
and this won't run in real time because

1143
00:55:07,589 --> 00:55:06,319
it's synced up to the real spacecraft so

1144
00:55:09,829 --> 00:55:07,599
we're just going to end up sitting there

1145
00:55:10,549 --> 00:55:09,839
so it's got a reminder of when the first

1146
00:55:13,990 --> 00:55:10,559
point

1147
00:55:15,990 --> 00:55:14,000
right so the first aacs command is at um

1148
00:55:17,270 --> 00:55:16,000
10 52 38

1149
00:55:20,309 --> 00:55:17,280
yeah yeah this is interesting what we're

1150
00:55:22,710 --> 00:55:20,319
setting up is we're practicing a main

1151
00:55:25,190 --> 00:55:22,720
engine maneuver we could need in the

1152
00:55:27,589 --> 00:55:25,200
last few weeks of the mission so to

1153
00:55:30,069 --> 00:55:27,599
either come up out of the atmosphere or

1154
00:55:33,030 --> 00:55:30,079
go down into the atmosphere so actually

1155
00:55:34,630 --> 00:55:33,040
we're just simulating uh about a one

1156
00:55:36,630 --> 00:55:34,640
meter per second

1157
00:55:39,030 --> 00:55:36,640
main engine burn so the engine is going

1158
00:55:41,510 --> 00:55:39,040
to burn for how many seconds not sure

1159
00:55:43,190 --> 00:55:41,520
actually four or five seconds

1160
00:55:45,829 --> 00:55:43,200
do you remember jody

1161
00:55:48,549 --> 00:55:45,839
joni how long does the burn last

1162
00:55:51,030 --> 00:55:48,559
on one one meter

1163
00:55:53,030 --> 00:55:51,040

six okay and what the spacecraft does is

1164
00:55:53,910 --> 00:55:53,040
the spacecraft always starts from earth

1165
00:55:55,829 --> 00:55:53,920
point

1166
00:55:57,589 --> 00:55:55,839
and it does a roll

1167
00:56:00,309 --> 00:55:57,599
and then it does a yaw

1168
00:56:02,870 --> 00:56:00,319
and then you'll onya

1169
00:56:04,710 --> 00:56:02,880
and then unwind and come back to earth

1170
00:56:06,630 --> 00:56:04,720
point and then relay all the data back

1171
00:56:08,630 --> 00:56:06,640
down to earth we'll be able because

1172
00:56:10,950 --> 00:56:08,640
we're in the integrated test lab we'll

1173
00:56:12,390 --> 00:56:10,960
be able to see all the data in real time

1174
00:56:15,670 --> 00:56:12,400
so we're actually going to call it out

1175
00:56:17,990 --> 00:56:15,680
in real time since we're practicing it

1176
00:56:22,230 --> 00:56:18,000
what does

1177
00:56:25,530 --> 00:56:24,309
it stands for she who always must be

1178
00:56:28,950 --> 00:56:25,540
obeyed

1179
00:56:33,829 --> 00:56:31,829
you should take about 29 minutes so here

1180
00:56:35,190 --> 00:56:33,839
it is when's your turn

1181
00:56:35,990 --> 00:56:35,200
and they're calling something out right

1182
00:56:37,190 --> 00:56:36,000
now

1183
00:56:40,870 --> 00:56:37,200
system

1184
00:56:47,510 --> 00:56:44,710
the roll the wine roll turn is complete

1185
00:56:51,109 --> 00:56:47,520
the reaction wheels have powered off

1186
00:56:53,750 --> 00:56:51,119
oh yeah there it is up here we go

1187
00:56:56,470 --> 00:56:53,760
hey attitude control yeah

1188
00:57:00,710 --> 00:56:59,109

i wasn't listening they said it tina

1189
00:57:03,270 --> 00:57:00,720
tina called it out

1190
00:57:04,789 --> 00:57:03,280
tina i can't hear you i'm sorry

1191
00:57:06,789 --> 00:57:04,799
you and musashi are going to have to

1192
00:57:08,230 --> 00:57:06,799
speak up

1193
00:57:09,750 --> 00:57:08,240
you're going to have to develop your

1194
00:57:11,670 --> 00:57:09,760
julie voice

1195
00:57:14,230 --> 00:57:11,680
she was literally just saying the words

1196
00:57:22,549 --> 00:57:14,240
oh i have to announce when you said call

1197
00:57:28,470 --> 00:57:25,109
it is now more than a month later

1198
00:57:30,309 --> 00:57:28,480
all of the testing of commands is over

1199
00:57:32,630 --> 00:57:30,319
and on this evening team members and

1200
00:57:34,870 --> 00:57:32,640
their families and friends have gathered

1201
00:57:39,030 --> 00:57:34,880
to see if cassini will survive its first

1202
00:57:44,309 --> 00:57:41,510
the event has been given a name

1203
00:57:46,390 --> 00:57:44,319
gateway to the grand finale

1204
00:57:49,430 --> 00:57:46,400
well i just want to welcome everyone to

1205
00:57:51,510 --> 00:57:49,440
our gateway to cassini's grand finale

1206
00:57:54,230 --> 00:57:51,520
and this is a cassini

1207
00:57:55,990 --> 00:57:54,240
family event and i'm so happy to see so

1208
00:57:57,510 --> 00:57:56,000
many people here

1209
00:57:59,670 --> 00:57:57,520
to share and what's about to happen

1210
00:58:02,950 --> 00:57:59,680
tonight

1211
00:58:05,349 --> 00:58:02,960
in 1990 linda spilker stood on this same

1212
00:58:07,109 --> 00:58:05,359
stage speaking of saturn's rings

1213
00:58:09,510 --> 00:58:07,119

rings are more transitory elements of

1214
00:58:12,230 --> 00:58:09,520
this three decades later she is

1215
00:58:15,190 --> 00:58:12,240
cassini's project scientist and this

1216
00:58:17,829 --> 00:58:15,200
evening's master of ceremonies

1217
00:58:20,390 --> 00:58:17,839
so at midnight tonight will be the first

1218
00:58:23,109 --> 00:58:20,400
time cassini turns back to the earth

1219
00:58:25,990 --> 00:58:23,119
sends a signal and lets us know that it

1220
00:58:28,870 --> 00:58:26,000
successfully navigated through this gap

1221
00:58:31,589 --> 00:58:28,880
where it's flown for the very very first

1222
00:58:33,349 --> 00:58:31,599
time so we we have a lot in store it'll

1223
00:58:35,910 --> 00:58:33,359
be very exciting

1224
00:58:37,910 --> 00:58:35,920
while awaiting news at midnight updates

1225
00:58:39,430 --> 00:58:37,920
are given on cassini's latest science

1226
00:58:41,910 --> 00:58:39,440
discoveries

1227
00:58:43,750 --> 00:58:41,920
and a time-honored jpl ritual is

1228
00:58:45,270 --> 00:58:43,760
acknowledged

1229
00:58:47,190 --> 00:58:45,280
now i'm i'm not particularly

1230
00:58:49,030 --> 00:58:47,200
superstitious but you know there's a

1231
00:58:51,190 --> 00:58:49,040
long-standing

1232
00:58:53,190 --> 00:58:51,200
jpl tradition

1233
00:58:55,190 --> 00:58:53,200
so last night

1234
00:58:56,710 --> 00:58:55,200
i went out and i decided we needed to

1235
00:58:59,109 --> 00:58:56,720
have

1236
00:59:01,190 --> 00:58:59,119
some lucky peanuts

1237
00:59:02,870 --> 00:59:01,200
just in case and i thought about it some

1238
00:59:06,710 --> 00:59:02,880

more and i thought

1239
00:59:10,390 --> 00:59:06,720
maybe we need two jars

1240
00:59:14,150 --> 00:59:12,150
and with that i'd like to introduce the

1241
00:59:15,990 --> 00:59:14,160
cassini virtual singers

1242
00:59:18,549 --> 00:59:16,000
the virtual singers really take the

1243
00:59:22,390 --> 00:59:18,559
heart and the soul of cassini

1244
00:59:23,670 --> 00:59:22,400
and capture it with music so

1245
00:59:25,910 --> 00:59:23,680
tonight

1246
00:59:28,549 --> 00:59:25,920
live from jpl

1247
00:59:33,270 --> 00:59:28,559
in pasadena california

1248
00:59:37,360 --> 00:59:33,280
just back from their multi-world tour

1249
00:59:46,470 --> 00:59:37,370
we now have the cassini virtual singers

1250
00:59:46,480 --> 00:59:51,220
flies over the seas

1251
01:00:04,260 --> 00:59:56,500
[Music]

1252
01:00:15,460 --> 01:00:04,270
to me

1253
01:00:15,470 --> 01:00:21,589
[Music]

1254
01:00:34,549 --> 01:00:29,430
he

1255
01:00:36,870 --> 01:00:34,559
flight team members slip away to take up

1256
01:00:39,829 --> 01:00:36,880
their positions on console in mission

1257
01:00:39,839 --> 01:00:57,800
power voice check on

1258
01:01:01,030 --> 01:00:59,349
[Music]

1259
01:01:02,390 --> 01:01:01,040
flight director and project manager i'd

1260
01:01:05,349 --> 01:01:02,400
like to announce at this time that all

1261
01:01:06,549 --> 01:01:05,359
stations are ready to support

1262
01:01:44,789 --> 01:01:06,559
copy it

1263
01:01:48,789 --> 01:01:46,710

okay what we're looking at here is the

1264
01:01:51,030 --> 01:01:48,799
mission support area and they each have

1265
01:01:53,270 --> 01:01:51,040
their various stations looking at

1266
01:01:55,270 --> 01:01:53,280
different aspects of the spacecraft and

1267
01:01:57,109 --> 01:01:55,280
they just went through a check to make

1268
01:02:01,029 --> 01:01:57,119
sure that everyone can hear everyone

1269
01:02:02,870 --> 01:02:01,039
else in the msa and we also have sound

1270
01:02:04,069 --> 01:02:02,880
into that room as well so eric do you

1271
01:02:05,510 --> 01:02:04,079
want to talk about what we're seeing on

1272
01:02:08,309 --> 01:02:05,520
the screen over here

1273
01:02:10,390 --> 01:02:08,319
yeah so on the left that is the signal

1274
01:02:12,870 --> 01:02:10,400
that deep space network is currently

1275
01:02:15,349 --> 01:02:12,880
detecting which is nothing it's just a

1276
01:02:16,950 --> 01:02:15,359
flat noise signal right now

1277
01:02:19,910 --> 01:02:16,960
but what we're all going to be looking

1278
01:02:22,309 --> 01:02:19,920
for here is for a spike to pop up out of

1279
01:02:24,309 --> 01:02:22,319
that noise and when we see that spike it

1280
01:02:27,670 --> 01:02:24,319
means that we're receiving a signal from

1281
01:02:32,690 --> 01:02:30,390
we have expand carrier signal detection

1282
01:02:50,710 --> 01:02:32,700
and the open loop receiver

1283
01:02:53,589 --> 01:02:50,720
[Applause]

1284
01:02:56,230 --> 01:02:53,599
that's a nice booming signal

1285
01:02:57,910 --> 01:02:56,240
so that carrier signal is there

1286
01:02:59,589 --> 01:02:57,920
we'll have to wait a few more minutes

1287
01:03:05,190 --> 01:02:59,599
until that we will see if there's actual

1288
01:03:09,829 --> 01:03:07,589

receiving back cassini's carrier tone

1289
01:03:13,190 --> 01:03:09,839
means the spacecraft has survived the

1290
01:03:18,789 --> 01:03:14,870
signal just came booming through right

1291
01:03:23,349 --> 01:03:21,109
along with feelings of relief is the

1292
01:03:26,150 --> 01:03:23,359
hope that science data will soon begin

1293
01:03:32,630 --> 01:03:28,950
but now comes a moment of confusion

1294
01:03:35,349 --> 01:03:32,640
how to best listen for cassini's signal

1295
01:03:38,630 --> 01:03:35,359
esco systems cassini ace uh the station

1296
01:03:40,069 --> 01:03:38,640
is currently looking for the x-span

1297
01:03:41,670 --> 01:03:40,079
one-way carrier signal and they're also

1298
01:03:43,029 --> 01:03:41,680
going to attempt to lock up to the 1896

1299
01:03:46,549 --> 01:03:43,039
rate so uh stand by one i'll let you

1300
01:03:51,670 --> 01:03:48,950
asus is flight director don't have them

1301
01:03:53,750 --> 01:03:51,680
lock up on the 18996

1302
01:03:56,309 --> 01:03:53,760
okay you just wanted to look for carrier

1303
01:03:58,549 --> 01:03:56,319
and the scope systems cassini's the

1304
01:04:01,910 --> 01:03:58,559
station has locked up to the

1305
01:04:04,069 --> 01:04:01,920
x-band one-way signal at neg 140db which

1306
01:04:07,029 --> 01:04:04,079
is expected for the 1896 right

1307
01:04:07,039 --> 01:04:09,829
copy

1308
01:04:09,839 --> 01:04:20,230
exposed

1309
01:04:24,710 --> 01:04:22,069
the moment of uncertainty ends as

1310
01:04:26,710 --> 01:04:24,720
quickly as it began and cassini begins

1311
01:04:31,190 --> 01:04:26,720
transmitting its science data sooner

1312
01:04:36,710 --> 01:04:34,069
flight connector on net

1313
01:04:41,109 --> 01:04:36,720

well we're waiting for 1205 but it looks

1314
01:04:41,119 --> 01:04:45,160
um

1315
01:04:59,990 --> 01:04:56,240
[Applause]

1316
01:05:03,349 --> 01:05:01,589
well if there's any more questions i'd

1317
01:05:05,109 --> 01:05:03,359
be happy to take questions i mean that's

1318
01:05:06,390 --> 01:05:05,119
this is the the big moment that we

1319
01:05:08,230 --> 01:05:06,400
waited for

1320
01:05:11,109 --> 01:05:08,240
and it's here and it's every bit as good

1321
01:05:14,150 --> 01:05:11,119
as we had hoped

1322
01:05:18,789 --> 01:05:14,160
we're okay for 22 weeks

1323
01:05:23,349 --> 01:05:20,549
the spacecraft went through the ring

1324
01:05:25,349 --> 01:05:23,359
plane just clean as can be there are no

1325
01:05:27,270 --> 01:05:25,359
indications of fault protection

1326
01:05:28,470 --> 01:05:27,280
telemetry data playback is exactly where

1327
01:05:29,829 --> 01:05:28,480
it's supposed to be

1328
01:05:31,990 --> 01:05:29,839
we can all go home we don't have to

1329
01:05:46,710 --> 01:05:32,000
spend all night fixing everything up

1330
01:05:50,950 --> 01:05:48,309
acs go ahead

1331
01:05:52,950 --> 01:05:50,960
the downlink roll has started at this

1332
01:05:55,349 --> 01:05:52,960
time we would like to report that all

1333
01:05:57,430 --> 01:05:55,359
the initial conditions checked out um

1334
01:06:00,230 --> 01:05:57,440
initial attitude and wheel speeds look

1335
01:06:02,309 --> 01:06:00,240
good all instruments are on the star

1336
01:06:06,069 --> 01:06:02,319
tracker is tracking five stars so that

1337
01:06:08,950 --> 01:06:06,079
looks good both sun sensors a and b are

1338
01:06:11,510 --> 01:06:08,960

both on so they match each other's

1339
01:06:12,710 --> 01:06:11,520
telemetry at this time we're waiting for

1340
01:06:15,829 --> 01:06:12,720
the role

1341
01:06:17,990 --> 01:06:15,839
to give us a full quadrant checkout for

1342
01:06:20,309 --> 01:06:18,000
the rest of the path other than that acs

1343
01:06:22,549 --> 01:06:20,319
looks great

1344
01:06:24,309 --> 01:06:22,559
copy

1345
01:06:26,549 --> 01:06:24,319
flight director and project manager this

1346
01:06:28,309 --> 01:06:26,559
is systems lead all subsystems have

1347
01:06:30,630 --> 01:06:28,319
reported in including the sip lead at

1348
01:06:32,760 --> 01:06:30,640
this time and everything is nominal

1349
01:06:57,890 --> 01:06:32,770
congratulations everyone

1350
01:06:57,900 --> 01:07:01,910
[Music]

1351
01:07:06,069 --> 01:07:04,150
hello everyone i'm gay ye hill and

1352
01:07:09,029 --> 01:07:06,079
welcome to nasa's jet propulsion

1353
01:07:11,270 --> 01:07:09,039
laboratory after two decades in space

1354
01:07:13,109 --> 01:07:11,280
nasa's cassidy spacecraft reached the

1355
01:07:15,910 --> 01:07:13,119
end of its remarkable journey of

1356
01:07:18,789 --> 01:07:15,920
exploration today the spacecraft made

1357
01:07:21,349 --> 01:07:18,799
its final approach to the giant planet

1358
01:07:23,990 --> 01:07:21,359
and plunged into the saturn's upper

1359
01:07:26,710 --> 01:07:24,000
atmosphere ending this extraordinary

1360
01:07:29,190 --> 01:07:26,720
mission but due to the vast distance

1361
01:07:31,109 --> 01:07:29,200
between earth the cassini mission has

1362
01:07:32,710 --> 01:07:31,119
actually not ended

1363
01:07:34,870 --> 01:07:32,720

not yet

1364
01:07:36,230 --> 01:07:34,880
the grand finale event is still a week

1365
01:07:38,069 --> 01:07:36,240
away

1366
01:07:41,349 --> 01:07:38,079
this is a rehearsal

1367
01:07:44,549 --> 01:07:41,359
the sun isn't up yet and more than

1368
01:07:46,870 --> 01:07:44,559
hundred cassini scientists engineers

1369
01:07:49,270 --> 01:07:46,880
alumni their friends and family have

1370
01:07:51,829 --> 01:07:49,280
gathered in mission control here von

1371
01:07:53,829 --> 01:07:51,839
carmen auditorium at jpl

1372
01:07:56,549 --> 01:07:53,839
beckman auditorium at cal what's true

1373
01:07:59,190 --> 01:07:56,559
for engineers is also true for jpl's

1374
01:08:01,109 --> 01:07:59,200
public communications team

1375
01:08:03,430 --> 01:08:01,119
a little pre-planning to work out the

1376
01:08:06,069 --> 01:08:03,440
kinks can be worth its weight in gold

1377
01:08:08,630 --> 01:08:06,079
australia it's 4 00 a.m here in

1378
01:08:12,069 --> 01:08:08,640
california the loss of signal really

1379
01:08:13,430 --> 01:08:12,079
happened uh at about 3 30 pacific time a

1380
01:08:15,750 --> 01:08:13,440
half hour ago

1381
01:08:17,590 --> 01:08:15,760
why is the team here

1382
01:08:20,470 --> 01:08:17,600
we thought it'd be over we will be

1383
01:08:23,030 --> 01:08:20,480
checking back with you in just

1384
01:08:25,510 --> 01:08:23,040
a couple more minutes there is a huge

1385
01:08:27,749 --> 01:08:25,520
crowd at beckman auditorium at caltech

1386
01:08:30,550 --> 01:08:27,759
right now cassini science team member

1387
01:08:33,749 --> 01:08:30,560
morgan cable is there morgan what is it

1388
01:08:41,110 --> 01:08:36,630

hi gay this is morgan here at caltech

1389
01:08:46,229 --> 01:08:44,229
i believe we're going to a bumper

1390
01:08:49,030 --> 01:08:46,239
and i'm one of those hoping that cassini

1391
01:08:52,149 --> 01:08:49,040
will hang in there and fight

1392
01:08:53,829 --> 01:08:52,159
for the very last seconds of data what's

1393
01:08:55,510 --> 01:08:53,839
going on

1394
01:08:58,149 --> 01:08:55,520
well we've just got the

1395
01:09:00,229 --> 01:08:58,159
word that the cassini has given us its

1396
01:09:03,349 --> 01:09:00,239
last bit of data

1397
01:09:06,390 --> 01:09:03,359
the room is celebrating

1398
01:09:09,110 --> 01:09:06,400
lots of hugs going on a few tears with

1399
01:09:11,669 --> 01:09:09,120
me now is nasa director of planetary

1400
01:09:13,829 --> 01:09:11,679
science jim green jim thanks for joining

1401
01:09:15,910 --> 01:09:13,839
us you know gay this really has been a

1402
01:09:18,309 --> 01:09:15,920
historic mission before we do that let's

1403
01:09:20,630 --> 01:09:18,319
take a moment to chat with jpl director

1404
01:09:22,630 --> 01:09:20,640
mike watkins what's your feeling about

1405
01:09:24,709 --> 01:09:22,640
the success of the cassini mission you

1406
01:09:26,789 --> 01:09:24,719
know i could not be more proud about the

1407
01:09:29,910 --> 01:09:26,799
role that we've had in this mission with

1408
01:09:32,870 --> 01:09:29,920
me now is alvaro gimenez the esa

1409
01:09:36,149 --> 01:09:32,880
director and the director of science

1410
01:09:37,950 --> 01:09:36,159
roberto uh issa director of science

1411
01:09:40,870 --> 01:09:37,960
roberto

1412
01:09:43,160 --> 01:09:40,880
battiston batistan

1413
01:09:45,110 --> 01:09:43,170

batista

1414
01:09:47,749 --> 01:09:45,120
[Laughter]

1415
01:09:48,630 --> 01:09:47,759
but all kidding aside the planning paid

1416
01:09:50,630 --> 01:09:48,640
off

1417
01:09:52,870 --> 01:09:50,640
for the elaborate multimedia and

1418
01:09:55,590 --> 01:09:52,880
interactive coverage of cassini's grand

1419
01:09:59,110 --> 01:09:55,600
finale would be watched by millions and

1420
01:10:03,590 --> 01:10:00,709
nasa jpl

1421
01:10:07,160 --> 01:10:03,600
cassini's grand finale

1422
01:10:10,790 --> 01:10:07,170
and earn jpl its first ever emmy

1423
01:10:13,350 --> 01:10:10,800
[Music]

1424
01:10:16,630 --> 01:10:13,360
i got to thank the stars that made a

1425
01:10:18,950 --> 01:10:16,640
bunch of geeky rocket scientists

1426
01:10:20,370 --> 01:10:18,960
rocket engineers and scientists indus

1427
01:10:30,550 --> 01:10:20,380
rock stars

1428
01:10:35,510 --> 01:10:33,270
here's the huygens image of the um

1429
01:10:37,669 --> 01:10:35,520
gullies less than a week remains before

1430
01:10:39,750 --> 01:10:37,679
cassini's end

1431
01:10:41,750 --> 01:10:39,760
and team members from around the world

1432
01:10:44,070 --> 01:10:41,760
are arriving to take part in the grand

1433
01:10:46,310 --> 01:10:44,080
finale

1434
01:10:47,830 --> 01:10:46,320
this is the final meeting of the science

1435
01:10:50,470 --> 01:10:47,840
radar group

1436
01:10:53,110 --> 01:10:50,480
we've actually been at this for 40 years

1437
01:10:55,590 --> 01:10:53,120
this is an image from 1976 it's one of

1438
01:10:58,229 --> 01:10:55,600

1439
01:11:00,310 --> 01:10:58,239
and here's what became the huygens probe

1440
01:11:01,590 --> 01:11:00,320
beaming the data to cassini which is

1441
01:11:02,470 --> 01:11:01,600
flying by

1442
01:11:04,310 --> 01:11:02,480
so

1443
01:11:07,590 --> 01:11:04,320
that far in time and i want to make a

1444
01:11:10,310 --> 01:11:07,600
caveat as they meet a billion miles away

1445
01:11:13,350 --> 01:11:10,320
cassini is flying by titan for the last

1446
01:11:19,030 --> 01:11:16,070
right now cassini is flying close to

1447
01:11:21,189 --> 01:11:19,040
titan 74 000 miles away

1448
01:11:23,750 --> 01:11:21,199
and titan's gravity

1449
01:11:25,270 --> 01:11:23,760
has given cassini its final push it's

1450
01:11:28,630 --> 01:11:25,280
goodbye kiss

1451
01:11:33,830 --> 01:11:30,630
and toast to great spacecraft a

1452
01:11:34,870 --> 01:11:33,840
wonderful mission and our final pass by

1453
01:11:37,669 --> 01:11:34,880
titans

1454
01:11:39,510 --> 01:11:37,679
i worked on the cassini mission for over

1455
01:11:41,590 --> 01:11:39,520
30 years and that's the time it takes

1456
01:11:43,270 --> 01:11:41,600
saturn to circle the sun

1457
01:11:45,189 --> 01:11:43,280
a single time

1458
01:11:47,030 --> 01:11:45,199
and when you work on a mission for that

1459
01:11:49,189 --> 01:11:47,040
long of a time and when you work for

1460
01:11:51,350 --> 01:11:49,199
people many of whom stayed and were

1461
01:11:53,990 --> 01:11:51,360
there as long as i was

1462
01:11:55,590 --> 01:11:54,000
you really start to feel like family you

1463
01:11:57,910 --> 01:11:55,600

get to know each other you take

1464
01:12:00,790 --> 01:11:57,920
vacations together you attend meetings

1465
01:12:02,790 --> 01:12:00,800
together you see your families grow up

1466
01:12:04,550 --> 01:12:02,800
together and then when the mission ends

1467
01:12:06,630 --> 01:12:04,560
it's hard because you know you'll keep

1468
01:12:09,110 --> 01:12:06,640
in touch with this family these people

1469
01:12:11,590 --> 01:12:09,120
who feel like friends and yet you also

1470
01:12:13,030 --> 01:12:11,600
know you'll go your separate ways so for

1471
01:12:15,030 --> 01:12:13,040
the people who have been with the team

1472
01:12:16,709 --> 01:12:15,040
from the beginning thank you and i hope

1473
01:12:18,470 --> 01:12:16,719
you found this you are now 30 years

1474
01:12:20,790 --> 01:12:18,480
wiser and smarter

1475
01:12:22,229 --> 01:12:20,800
and this has been a great experience but

1476
01:12:24,070 --> 01:12:22,239
for the people who joined later

1477
01:12:26,550 --> 01:12:24,080
hopefully you found that also a great

1478
01:12:28,390 --> 01:12:26,560
stepping stone and great experience for

1479
01:12:33,110 --> 01:12:28,400
you guys to lead the future of planetary

1480
01:12:37,590 --> 01:12:34,950
for the cookies

1481
01:12:39,750 --> 01:12:37,600
the next day cassini engineers gather

1482
01:12:43,669 --> 01:12:39,760
for their last in-flight operations

1483
01:12:49,510 --> 01:12:46,630
5502 is when we predict to hit 100 duty

1484
01:12:52,950 --> 01:12:49,520
cycle and aacs predicts loss of signal

1485
01:12:55,030 --> 01:12:52,960
12 seconds after that navigation duane

1486
01:12:57,510 --> 01:12:55,040
as of yesterday at about

1487
01:12:59,990 --> 01:12:57,520
1 30 in the afternoon we had our

1488
01:13:03,430 --> 01:13:00,000

last titan 5 eye

1489
01:13:06,310 --> 01:13:03,440
and we're on our way into saturn now

1490
01:13:09,750 --> 01:13:06,320
dsn mike so we had seven passes last

1491
01:13:12,310 --> 01:13:09,760
week 14 command files um including the

1492
01:13:14,070 --> 01:13:12,320
last set of built so we have no more

1493
01:13:15,750 --> 01:13:14,080
commanding for real time

1494
01:13:17,910 --> 01:13:15,760
that's 101. jen

1495
01:13:21,270 --> 01:13:17,920
okay the spacecraft's basically nominal

1496
01:13:23,110 --> 01:13:21,280
we have no new isas no other errors and

1497
01:13:25,910 --> 01:13:23,120
then basically we've got the the end of

1498
01:13:29,270 --> 01:13:25,920
the sequence we're just clocking out

1499
01:13:31,590 --> 01:13:29,280
here we are knowing that this is the end

1500
01:13:33,750 --> 01:13:31,600
is very sad but knowing in a mission

1501
01:13:35,830 --> 01:13:33,760
like like cassini where we had an ending

1502
01:13:38,470 --> 01:13:35,840
date we had a sequence of events to

1503
01:13:40,229 --> 01:13:38,480
follow gave us some purpose

1504
01:13:42,310 --> 01:13:40,239
all the teams stepped up i'm very

1505
01:13:44,229 --> 01:13:42,320
grateful for all your support and i just

1506
01:13:47,030 --> 01:13:44,239
want to say thank you

1507
01:13:48,790 --> 01:13:47,040
does anyone else have anything uh yeah

1508
01:13:51,350 --> 01:13:48,800
just because everyone else has piled on

1509
01:13:52,870 --> 01:13:51,360
with the thank yous uh you

1510
01:13:54,870 --> 01:13:52,880
here and in the room and out on the

1511
01:13:56,390 --> 01:13:54,880
phone have rocked the world

1512
01:13:59,030 --> 01:13:56,400
and this is our last meeting with a

1513
01:14:01,350 --> 01:13:59,040

spacecraft uh but it has just been an

1514
01:14:03,189 --> 01:14:01,360
incredible ride i am very very proud to

1515
01:14:05,830 --> 01:14:03,199
have been associated with all of you

1516
01:14:07,350 --> 01:14:05,840
um and as an incentive for next meeting

1517
01:14:09,750 --> 01:14:07,360
when we don't have

1518
01:14:24,950 --> 01:14:09,760
a spacecraft we will bring donuts thanks

1519
01:14:29,510 --> 01:14:27,350
there is two hours two hours two hours

1520
01:14:32,790 --> 01:14:29,520
two hours ago yep

1521
01:14:35,350 --> 01:14:32,800
it is now 2 55 in the morning in

1522
01:14:36,070 --> 01:14:35,360
california we've got about two hours to

1523
01:14:37,990 --> 01:14:36,080
go

1524
01:14:40,229 --> 01:14:38,000
until the end

1525
01:14:42,709 --> 01:14:40,239
science data on the recorders is done

1526
01:14:45,189 --> 01:14:42,719
we're currently in our real-time plunge

1527
01:14:46,790 --> 01:14:45,199
configuration um so everything now is

1528
01:14:49,350 --> 01:14:46,800
essentially real-time data from the

1529
01:14:52,390 --> 01:14:49,360
instruments as we go into the planet the

1530
01:14:54,709 --> 01:14:52,400
ffts will begin to

1531
01:14:56,310 --> 01:14:54,719
fade and decrease and then at just one

1532
01:15:17,590 --> 01:14:56,320
point they'll just disappear entirely

1533
01:15:21,510 --> 01:15:19,350
it's really hard to end the mission this

1534
01:15:24,870 --> 01:15:21,520
way this one's been my companion

1535
01:15:27,430 --> 01:15:24,880
constant companion for 22 years

1536
01:15:29,830 --> 01:15:27,440
my job has always been

1537
01:15:32,149 --> 01:15:29,840
take care of the spacecraft

1538
01:15:33,830 --> 01:15:32,159

everything's working just perfectly i

1539
01:15:35,510 --> 01:15:33,840
mean you have to recognize the fact that

1540
01:15:36,470 --> 01:15:35,520
we're out of propellants

1541
01:15:39,270 --> 01:15:36,480
but

1542
01:15:42,630 --> 01:15:39,280
i have no idea how i'm going to feel

1543
01:15:42,640 --> 01:15:46,790
look this is my screen up here

1544
01:15:50,950 --> 01:15:49,110
so this this screen here is the last 10

1545
01:15:53,990 --> 01:15:50,960
minutes of the one up at the top the one

1546
01:15:54,709 --> 01:15:54,000
at the top is kind of the big picture

1547
01:15:57,030 --> 01:15:54,719
and

1548
01:15:59,350 --> 01:15:57,040
this one has atmosphere modeled

1549
01:16:01,830 --> 01:15:59,360
this is also the last 10 minutes but

1550
01:16:03,350 --> 01:16:01,840
this one does not have atmosphere model

1551
01:16:04,950 --> 01:16:03,360
so what we're going to what we're hoping

1552
01:16:06,709 --> 01:16:04,960
to see when we get to the very end and

1553
01:16:08,229 --> 01:16:06,719
get into the atmosphere

1554
01:16:10,070 --> 01:16:08,239
this one's going to start being

1555
01:16:11,990 --> 01:16:10,080
different from this one right now they

1556
01:16:13,669 --> 01:16:12,000
look very similar

1557
01:16:15,510 --> 01:16:13,679
once this one starts

1558
01:16:17,030 --> 01:16:15,520
changing from this one

1559
01:16:19,110 --> 01:16:17,040
then we know that we're in the

1560
01:16:20,630 --> 01:16:19,120
atmosphere and we're experiencing drag

1561
01:16:23,030 --> 01:16:20,640
on spacecraft

1562
01:16:24,709 --> 01:16:23,040
about a minute before loss of signal the

1563
01:16:27,030 --> 01:16:24,719

other squat we've got over the attitude

1564
01:16:28,630 --> 01:16:27,040
control system those charts on the right

1565
01:16:30,310 --> 01:16:28,640
of that screen

1566
01:16:31,910 --> 01:16:30,320
are showing thruster activity and we're

1567
01:16:34,550 --> 01:16:31,920
going to watch those just go right up

1568
01:16:36,070 --> 01:16:34,560
the up the wall so to speak and again

1569
01:16:38,229 --> 01:16:36,080
for about a minute i mean everything

1570
01:16:39,030 --> 01:16:38,239
happens so fast right now

1571
01:16:41,110 --> 01:16:39,040
okay

1572
01:16:43,030 --> 01:16:41,120
so what we're seeing is uh each of these

1573
01:16:44,870 --> 01:16:43,040
little places where the the curve turns

1574
01:16:46,709 --> 01:16:44,880
around is where the thrusters are firing

1575
01:16:48,550 --> 01:16:46,719
we're trying to control the orientation

1576
01:16:49,910 --> 01:16:48,560
of the spacecraft and every time we see

1577
01:16:52,070 --> 01:16:49,920
a little change of direction that's a

1578
01:16:53,510 --> 01:16:52,080
thruster pulse and those pulses are

1579
01:16:54,709 --> 01:16:53,520
getting more and more frequent and the

1580
01:16:57,189 --> 01:16:54,719
reason for that is we're getting closer

1581
01:16:59,830 --> 01:16:57,199
to saturn and uh its gravity gradient is

1582
01:17:01,910 --> 01:16:59,840
starting to rotate the spacecraft around

1583
01:17:03,430 --> 01:17:01,920
what's going to happen is eventually

1584
01:17:04,630 --> 01:17:03,440
instead of balancing slowly along the

1585
01:17:06,070 --> 01:17:04,640
edge and it's just gonna be sitting

1586
01:17:07,990 --> 01:17:06,080
right on the edge firing the thrusters

1587
01:17:10,790 --> 01:17:08,000
continuously all the way up to the point

1588
01:17:12,709 --> 01:17:10,800

where um the thrusters are on fully and

1589
01:17:14,590 --> 01:17:12,719
it can no longer maintain that attitude

1590
01:17:17,110 --> 01:17:14,600
and then we'll just drift outside of

1591
01:17:23,750 --> 01:17:17,120
our thresholds and then we'll be

1592
01:17:34,800 --> 01:17:25,430
when do we want to tear up the

1593
01:17:41,189 --> 01:17:39,030
[Applause]

1594
01:17:44,550 --> 01:17:41,199
if you think of cassini as a symphony

1595
01:17:46,149 --> 01:17:44,560
this is the final final movement there's

1596
01:17:48,390 --> 01:17:46,159
so many emotions i mean it's such a

1597
01:17:49,910 --> 01:17:48,400
great sweet ride it's been it's been a

1598
01:17:51,510 --> 01:17:49,920
triumph

1599
01:17:53,590 --> 01:17:51,520
we are a village

1600
01:17:55,110 --> 01:17:53,600
it has been a phenomenal teamwork we

1601
01:17:57,910 --> 01:17:55,120
finish each other's sentences we tie

1602
01:17:59,669 --> 01:17:57,920
each other's shoes it is absolutely

1603
01:18:01,189 --> 01:17:59,679
going to be something that i will i will

1604
01:18:03,760 --> 01:18:01,199
never be able to recreate and i will

1605
01:18:06,790 --> 01:18:03,770
miss it greatly

1606
01:18:09,189 --> 01:18:06,800
[Music]

1607
01:18:11,270 --> 01:18:09,199
among those arriving is mike watkins

1608
01:18:14,149 --> 01:18:11,280
just now these were not always at

1609
01:18:20,310 --> 01:18:16,630
a couple hours a little bit

1610
01:18:28,709 --> 01:18:20,320
watkins is one year into leading jpl

1611
01:18:33,709 --> 01:18:30,870
hello everyone i'm gay ye hill and

1612
01:18:40,149 --> 01:18:33,719
welcome to nasa's jet propulsion

1613
01:18:46,149 --> 01:18:42,390

the spacecraft made its final approach

1614
01:18:49,430 --> 01:18:46,159
to the giant planet meanwhile it is 4

1615
01:18:52,630 --> 01:18:49,440
a.m here in california the sun is not up

1616
01:18:55,270 --> 01:18:52,640
yet and more than 1500 cassini

1617
01:18:57,830 --> 01:18:55,280
scientists engineers alumni friends and

1618
01:19:00,310 --> 01:18:57,840
family have gathered for this moment how

1619
01:19:02,550 --> 01:19:00,320
does it feel todd to be here hi gay well

1620
01:19:05,669 --> 01:19:02,560
it's great to be back as you and i sat

1621
01:19:08,790 --> 01:19:05,679
there in 2004 we never dreamt we'd be

1622
01:19:10,709 --> 01:19:08,800
here in 2017 still talking about cassini

1623
01:19:13,350 --> 01:19:10,719
and collecting science data so

1624
01:19:16,070 --> 01:19:13,360
i'm just thrilled to be here uh even

1625
01:19:18,709 --> 01:19:16,080
even having aged some years since soi

1626
01:19:28,709 --> 01:19:18,719
flight director systems league go ahead

1627
01:19:32,950 --> 01:19:30,390
the spacecraft has just crossed 40

1628
01:19:34,149 --> 01:19:32,960
degrees north latitude

1629
01:19:36,229 --> 01:19:34,159
thank you

1630
01:19:38,550 --> 01:19:36,239
the trajectory is the very latest

1631
01:19:40,870 --> 01:19:38,560
trajectory that we've reconstructed with

1632
01:19:45,830 --> 01:19:40,880
the latest data that we could get so

1633
01:19:58,229 --> 01:19:48,390
so it's pretty accurate

1634
01:19:58,239 --> 01:20:02,550
systems lead mission planning

1635
01:20:08,310 --> 01:20:04,550
spacecraft has just crossed 30 degrees

1636
01:20:10,070 --> 01:20:08,320
north latitude altitude is 6 000 miles

1637
01:20:12,709 --> 01:20:10,080
thank you

1638
01:20:22,149 --> 01:20:12,719

miles

1639
01:20:27,350 --> 01:20:24,709
well we are a little over 10 minutes

1640
01:20:30,070 --> 01:20:27,360
away from the loss of signal so we will

1641
01:20:32,229 --> 01:20:30,080
be focusing our attention to the control

1642
01:20:34,709 --> 01:20:32,239
room very soon now but before we do

1643
01:20:36,709 --> 01:20:34,719
let's take a moment to chat with jpl

1644
01:20:39,189 --> 01:20:36,719
director mike watkins

1645
01:20:40,950 --> 01:20:39,199
so mike how are you feeling

1646
01:20:42,709 --> 01:20:40,960
well first good morning

1647
01:20:43,830 --> 01:20:42,719
yes very early we always tend to do

1648
01:20:45,750 --> 01:20:43,840
these events somehow at three in the

1649
01:20:46,870 --> 01:20:45,760
morning or five in the morning he do

1650
01:20:48,709 --> 01:20:46,880
that

1651
01:20:50,870 --> 01:20:48,719
but you know it's kind of a bittersweet

1652
01:20:52,470 --> 01:20:50,880
uh event for all of us i think for me

1653
01:20:53,350 --> 01:20:52,480
personally it's more sweet than better

1654
01:20:55,750 --> 01:20:53,360
because

1655
01:20:56,709 --> 01:20:55,760
cassini's been such a fantastic mission

1656
01:20:58,310 --> 01:20:56,719
but i think you know one of the

1657
01:21:00,470 --> 01:20:58,320
important things about these events is

1658
01:21:02,229 --> 01:21:00,480
to celebrate the incredible hard work

1659
01:21:03,510 --> 01:21:02,239
the decades of hard work of the team

1660
01:21:05,590 --> 01:21:03,520
that designed

1661
01:21:07,110 --> 01:21:05,600
built and operated cassini and that's

1662
01:21:09,030 --> 01:21:07,120
really right the heart of the spacecraft

1663
01:21:10,470 --> 01:21:09,040

is really the people that worked on it

1664
01:21:12,390 --> 01:21:10,480
and the people that have been operating

1665
01:21:14,470 --> 01:21:12,400
it and this is a great time to celebrate

1666
01:21:16,229 --> 01:21:14,480
those those that level of dedication

1667
01:21:18,709 --> 01:21:16,239
that devotion you know to work on

1668
01:21:20,550 --> 01:21:18,719
something for 10 20 30 years that that's

1669
01:21:26,550 --> 01:21:20,560
that's sort of unparalleled

1670
01:21:26,560 --> 01:21:30,790
systems this is acs-1

1671
01:21:33,430 --> 01:21:32,229
we're still waiting for a transition to

1672
01:21:34,950 --> 01:21:33,440
high rate mode but it looks like we're

1673
01:21:38,310 --> 01:21:34,960
going to start accumulating thruster on

1674
01:21:40,709 --> 01:21:38,320
time um at a at a higher rate now and

1675
01:21:43,669 --> 01:21:40,719
our attitude control error is

1676
01:21:44,550 --> 01:21:43,679
starting to to be more active

1677
01:21:57,590 --> 01:21:44,560
okay

1678
01:21:57,600 --> 01:22:16,190
oh yeah

1679
01:22:16,200 --> 01:22:35,990
[Music]

1680
01:22:40,390 --> 01:22:38,390
what you're actually defiant we have

1681
01:22:50,520 --> 01:22:40,400
lots of signal that actually benefits

1682
01:22:50,530 --> 01:23:14,790
[Music]

1683
01:23:18,470 --> 01:23:17,430
project manager flight director

1684
01:23:25,189 --> 01:23:18,480
go ahead

1685
01:23:29,830 --> 01:23:27,750
one one five five four six

1686
01:23:34,229 --> 01:23:29,840
for the s band so that would be the end

1687
01:23:38,629 --> 01:23:36,950
project manager on fso accord

1688
01:23:39,510 --> 01:23:38,639

i hope you're all

1689
01:23:42,070 --> 01:23:39,520
as

1690
01:23:44,390 --> 01:23:42,080
deeply proud of this amazing

1691
01:23:46,790 --> 01:23:44,400
accomplishment congratulations to you

1692
01:23:49,590 --> 01:23:46,800
all this has been an incredible mission

1693
01:23:51,990 --> 01:23:49,600
an incredible spacecraft and you're all

1694
01:23:53,350 --> 01:23:52,000
an incredible team

1695
01:23:54,950 --> 01:23:53,360
i'm going to call this the end of

1696
01:23:59,170 --> 01:23:54,960
mission

1697
01:24:38,229 --> 01:23:59,180
project manager off the net

1698
01:24:38,239 --> 01:24:46,000
four three three five and seven four

1699
01:24:50,070 --> 01:24:47,590
[Music]

1700
01:24:52,709 --> 01:24:50,080
my feeling was i want to hug somebody

1701
01:24:58,070 --> 01:24:52,719
and share saying goodbye and that was

1702
01:25:02,070 --> 01:24:59,669
manager program manager is confirmed

1703
01:25:04,070 --> 01:25:02,080
into a mission at one one five five four

1704
01:25:05,030 --> 01:25:04,080
six

1705
01:25:06,790 --> 01:25:05,040
uh

1706
01:25:09,590 --> 01:25:06,800
this concludes cassini's thirteen year

1707
01:25:11,990 --> 01:25:09,600
exploration of the saturn system

1708
01:25:14,550 --> 01:25:12,000
the looks that you see on people's faces

1709
01:25:16,229 --> 01:25:14,560
we're not acting we felt that

1710
01:25:17,990 --> 01:25:16,239
you're looking at raw emotion at that

1711
01:25:20,709 --> 01:25:18,000
point i thought i was going to be okay

1712
01:25:24,149 --> 01:25:20,719
and i wasn't we did it and it worked but

1713
01:25:43,130 --> 01:25:24,159

it's over now what this long time yeah

1714
01:26:39,990 --> 01:25:54,950
[Music]

1715
01:26:44,310 --> 01:26:42,470
whenever lead this is acs

1716
01:26:46,870 --> 01:26:44,320
acs go ahead

1717
01:26:48,149 --> 01:26:46,880
the post burn unwind roll turn is

1718
01:26:49,510 --> 01:26:48,159
complete

1719
01:26:51,030 --> 01:26:49,520
copy thanks

1720
01:26:53,189 --> 01:26:51,040
fso quartz

1721
01:26:54,870 --> 01:26:53,199
flight director go ahead yeah you can go

1722
01:26:57,270 --> 01:26:54,880
ahead and check people off net we'll

1723
01:26:59,350 --> 01:26:57,280
debrief everybody in here on the net and

1724
01:27:02,470 --> 01:26:59,360
we'll walk through what we need to do uh

1725
01:27:04,870 --> 01:27:02,480
including what happens with the dtus

1726
01:27:07,270 --> 01:27:04,880
okay copy got it thank you manu believes

1727
01:27:08,550 --> 01:27:07,280
this is thermal

1728
01:27:10,950 --> 01:27:08,560
terminal go ahead

1729
01:27:13,110 --> 01:27:10,960
the thermal devices subsystem is nominal

1730
01:27:16,950 --> 01:27:13,120
following the maneuver

1731
01:27:22,709 --> 01:27:19,270
copy sounds good thanks for your support

1732
01:27:26,390 --> 01:27:24,390
tom go ahead

1733
01:27:28,709 --> 01:27:26,400
yeah i'd like to report that telecom is

1734
01:27:30,709 --> 01:27:28,719
nominal the subsystem is nominal and the

1735
01:27:32,709 --> 01:27:30,719
doppler and telemetry look

1736
01:27:32,970 --> 01:27:32,719
good so we would request to sign off the

1737
01:27:34,629 --> 01:27:32,980
net

1738
01:27:37,430 --> 01:27:34,639

[Music]

1739
01:27:39,350 --> 01:27:37,440
copy sounds good thanks for your support

1740
01:27:42,950 --> 01:27:39,360
cds go ahead

1741
01:27:44,790 --> 01:27:42,960
yeah we know that the cds system is uh

1742
01:27:47,110 --> 01:27:44,800
nominal at this time and we'd like to

1743
01:27:50,629 --> 01:27:47,120
sign off the net

1744
01:27:57,750 --> 01:27:52,870
power is the middle and uh i'd like to

1745
01:28:03,590 --> 01:28:00,790
copy thanks power

1746
01:28:05,990 --> 01:28:03,600
maneuver lead system full protection

1747
01:28:07,990 --> 01:28:06,000
sfp go ahead

1748
01:28:09,110 --> 01:28:08,000
i can confirm no fall protection

1749
01:28:10,790 --> 01:28:09,120
activity

1750
01:28:13,990 --> 01:28:10,800
and all

1751
01:28:15,430 --> 01:28:14,000
telemetry is per predict as of page 10

1752
01:28:17,510 --> 01:28:15,440
on the procedure

1753
01:28:19,350 --> 01:28:17,520
and ssp would like permission to go off

1754
01:28:24,229 --> 01:28:19,360
net

1755
01:28:29,270 --> 01:28:26,390
final status for the ltm on outside is

1756
01:28:30,229 --> 01:28:29,280
about once a off request for uh singing

1757
01:28:36,950 --> 01:28:30,239
up

1758
01:28:41,270 --> 01:28:39,270
commands in the maneuver and i've done

1759
01:28:43,590 --> 01:28:41,280
my final queries and it looks like a

1760
01:28:46,470 --> 01:28:43,600
nominal burn so i'm requesting uh

1761
01:28:48,540 --> 01:28:46,480
permission to sign off the net

1762
01:28:51,270 --> 01:28:48,550
okay copy thanks for your support

1763
01:28:54,229 --> 01:28:51,280

[Music]

1764
01:28:57,669 --> 01:28:55,590
prop go ahead

1765
01:28:59,430 --> 01:28:57,679
uh burn time was nailed within about

1766
01:29:03,840 --> 01:28:59,440
half a second so it looks like a good

1767
01:29:03,850 --> 01:29:07,430
[Music]

1768
01:29:07,440 --> 01:29:14,070
ace maneuver lead on episode

1769
01:29:19,669 --> 01:29:15,990
yes at this time all subsystems have

1770
01:29:23,030 --> 01:29:19,679
reported a nominal burn for otm 469 so i

1771
01:29:24,790 --> 01:29:23,040
will be signing off as systems lead

1772
01:29:30,260 --> 01:29:24,800
copy that thank you