
MESSENGER

1
00:00:11,749 --> 00:00:09,190
good afternoon welcome to nasa

2
00:00:13,270 --> 00:00:11,759
headquarters in washington d.c my name

3
00:00:16,710 --> 00:00:13,280
is dwayne brown with the office of

4
00:00:18,630 --> 00:00:16,720
communications today we celebrate

5
00:00:19,990 --> 00:00:18,640
we celebrate one of nasa's most

6
00:00:22,710 --> 00:00:20,000
successful

7
00:00:25,670 --> 00:00:22,720
science projects nasa's messenger

8
00:00:27,830 --> 00:00:25,680
mission to the planet mercury

9
00:00:30,230 --> 00:00:27,840
you will hear some of the outstanding

10
00:00:32,310 --> 00:00:30,240
and unprecedented science findings in

11
00:00:34,150 --> 00:00:32,320
addition to the engineering

12
00:00:35,270 --> 00:00:34,160
accomplishments of this fantastic

13
00:00:37,030 --> 00:00:35,280

mission

14
00:00:38,549 --> 00:00:37,040
and you'll hear that this is not just

15
00:00:40,709 --> 00:00:38,559
the end

16
00:00:42,310 --> 00:00:40,719
it's a new beginning

17
00:00:43,670 --> 00:00:42,320
a new beginning to study the vast

18
00:00:46,950 --> 00:00:43,680
amounts of data

19
00:00:49,029 --> 00:00:46,960
that has come from this mission

20
00:00:51,029 --> 00:00:49,039
we will have brief presentations and

21
00:00:53,830 --> 00:00:51,039
we'll open up for questions now phone

22
00:00:56,229 --> 00:00:53,840
lines our audience and social media and

23
00:00:58,069 --> 00:00:56,239
there's a lot of buzz on social media

24
00:01:01,270 --> 00:00:58,079
about the accomplishments of this

25
00:01:04,149 --> 00:01:01,280
mission send those questions in to

26
00:01:06,550 --> 00:01:04,159
ask nasa and everything you hear today

27
00:01:09,590 --> 00:01:06,560
and much much more is available online

28
00:01:10,710 --> 00:01:09,600
at www.nasa.gov

29
00:01:12,630 --> 00:01:10,720
messenger

30
00:01:14,550 --> 00:01:12,640
to set the stage

31
00:01:16,630 --> 00:01:14,560
to set the celebration

32
00:01:18,950 --> 00:01:16,640
it's my honor and pleasure to hand the

33
00:01:21,590 --> 00:01:18,960
mic over to the head

34
00:01:23,590 --> 00:01:21,600
the associate administrator five-time

35
00:01:28,230 --> 00:01:23,600
space shuttle flown astronaut

36
00:01:30,149 --> 00:01:28,240
dr john grunsfeld to set the stage sir

37
00:01:31,510 --> 00:01:30,159
thank you very much duane

38
00:01:33,190 --> 00:01:31,520

really exciting to be here for this

39
00:01:35,030 --> 00:01:33,200
celebration

40
00:01:36,789 --> 00:01:35,040
messenger is going to create a new

41
00:01:39,670 --> 00:01:36,799
crater on mercury at some point in the

42
00:01:41,990 --> 00:01:39,680
very near future and rather than be sad

43
00:01:44,469 --> 00:01:42,000
about that we really are celebrating

44
00:01:46,950 --> 00:01:44,479
just a fantastic mission

45
00:01:50,469 --> 00:01:46,960
nasa's mission is to innovate

46
00:01:52,230 --> 00:01:50,479
explore discover and inspire and i can

47
00:01:54,230 --> 00:01:52,240
think of no better example than the

48
00:01:56,230 --> 00:01:54,240
messenger spacecraft

49
00:01:58,389 --> 00:01:56,240
in order to get to mercury

50
00:02:01,109 --> 00:01:58,399
new technology had to be invented new

51
00:02:02,950 --> 00:02:01,119
ways of handling some common spacecraft

52
00:02:06,149 --> 00:02:02,960
problems getting rid of heat you know

53
00:02:08,949 --> 00:02:06,159
staying cool we all need to stay cool

54
00:02:11,190 --> 00:02:08,959
new scientific instruments and mercury

55
00:02:14,150 --> 00:02:11,200
has provided plenty of surprises for us

56
00:02:16,229 --> 00:02:14,160
it's shown uh to be fil and we've filled

57
00:02:18,229 --> 00:02:16,239
the scientific world and the whole world

58
00:02:20,229 --> 00:02:18,239
with new discoveries about this planet

59
00:02:22,390 --> 00:02:20,239
that we never expected

60
00:02:24,869 --> 00:02:22,400
and it's inspired a world and will

61
00:02:26,949 --> 00:02:24,879
continue to inspire a world uh in this

62
00:02:28,630 --> 00:02:26,959
new beginning so we're very excited to

63
00:02:30,470 --> 00:02:28,640

hear about some of those results today

64
00:02:34,949 --> 00:02:30,480
and what's in store for the future and

65
00:02:38,869 --> 00:02:36,869
ladies and gentlemen let's take a trip

66
00:02:40,150 --> 00:02:38,879
to mercury

67
00:02:42,229 --> 00:02:40,160
first up

68
00:02:43,670 --> 00:02:42,239
you're here jim green

69
00:02:46,869 --> 00:02:43,680
director

70
00:02:48,470 --> 00:02:46,879
nasa's planetary science division

71
00:02:53,350 --> 00:02:48,480
jim i think we're ready to go to mercury

72
00:02:57,430 --> 00:02:55,750
welcome to the celebration

73
00:02:59,110 --> 00:02:57,440
you know we're celebrating messenger at

74
00:03:01,670 --> 00:02:59,120
the planet mercury

75
00:03:02,949 --> 00:03:01,680
mercury is our first planet the closest

76
00:03:04,949 --> 00:03:02,959
one to the sun

77
00:03:06,070 --> 00:03:04,959
and it's an enormously hostile

78
00:03:07,910 --> 00:03:06,080
environment

79
00:03:09,670 --> 00:03:07,920
enormous heat

80
00:03:11,990 --> 00:03:09,680
buffeting the planet buffeting its

81
00:03:13,910 --> 00:03:12,000
magnetic field and we want to know much

82
00:03:16,390 --> 00:03:13,920
more about it how it

83
00:03:18,070 --> 00:03:16,400
came together its origin and what's on

84
00:03:20,550 --> 00:03:18,080
the surface and in fact what's

85
00:03:24,149 --> 00:03:20,560
underneath the surface too

86
00:03:27,589 --> 00:03:24,159
now messenger was launched in 2004

87
00:03:30,070 --> 00:03:27,599
got into orbit in 2011

88
00:03:32,550 --> 00:03:30,080

and in those four years it has taken an

89
00:03:34,550 --> 00:03:32,560
amazing array of data

90
00:03:37,030 --> 00:03:34,560
the spacecraft and the instruments have

91
00:03:38,869 --> 00:03:37,040
worked virtually flawlessly over those

92
00:03:42,070 --> 00:03:38,879
four years

93
00:03:43,589 --> 00:03:42,080
now the data is on earth we have it now

94
00:03:45,910 --> 00:03:43,599
and we're going to continue to make

95
00:03:48,470 --> 00:03:45,920
wonderful discoveries with it but

96
00:03:50,630 --> 00:03:48,480
messenger is a mission sadly in that

97
00:03:52,949 --> 00:03:50,640
respect will end

98
00:03:55,350 --> 00:03:52,959
and in fact hmm

99
00:03:56,750 --> 00:03:55,360
it looks like messenger just

100
00:03:58,789 --> 00:03:56,760
entered its

101
00:04:01,830 --> 00:03:58,799
4065th orbit

102
00:04:04,309 --> 00:04:01,840
it has a mere 40 orbits left

103
00:04:06,789 --> 00:04:04,319
when it will run out of fuel crash into

104
00:04:09,110 --> 00:04:06,799
the surface creating another crater on

105
00:04:11,429 --> 00:04:09,120
that beautiful planet

106
00:04:12,390 --> 00:04:11,439
now what i've asked is for the team to

107
00:04:14,070 --> 00:04:12,400
come

108
00:04:16,550 --> 00:04:14,080
and talk about the science and indeed

109
00:04:19,030 --> 00:04:16,560
the technologies now our science team

110
00:04:21,349 --> 00:04:19,040
could talk all day about messenger

111
00:04:23,510 --> 00:04:21,359
so we are going to limit it to the top

112
00:04:25,749 --> 00:04:23,520
10 science results

113
00:04:27,110 --> 00:04:25,759

that have come so far from the mission

114
00:04:29,350 --> 00:04:27,120
and as i mentioned

115
00:04:31,590 --> 00:04:29,360
more data that we have in the archive

116
00:04:33,510 --> 00:04:31,600
will be analyzed in such great detail

117
00:04:34,390 --> 00:04:33,520
that we'll learn many more things about

118
00:04:41,510 --> 00:04:34,400
it

119
00:04:44,469 --> 00:04:41,520
hostile environment around mercury i've

120
00:04:46,950 --> 00:04:44,479
asked the key messenger team members on

121
00:04:49,909 --> 00:04:46,960
the technical side to come and give us

122
00:04:52,629 --> 00:04:49,919
the secrets about how they made

123
00:04:54,870 --> 00:04:52,639
these major technical advances happen to

124
00:04:58,629 --> 00:04:54,880
enable that mission to survive as long

125
00:05:00,550 --> 00:04:58,639
as it has and has done a spectacular job

126
00:05:01,830 --> 00:05:00,560
now i know messenger will have a big

127
00:05:03,430 --> 00:05:01,840
impact

128
00:05:05,029 --> 00:05:03,440
and with respect to that let's get

129
00:05:06,230 --> 00:05:05,039
started let me turn it back over to

130
00:05:07,430 --> 00:05:06,240
dwayne

131
00:05:09,430 --> 00:05:07,440
thanks jim

132
00:05:11,510 --> 00:05:09,440
ladies and gentlemen again

133
00:05:13,830 --> 00:05:11,520
send those questions in at hashtag ask

134
00:05:16,150 --> 00:05:13,840
nasa you heard from dr john grunsfeld

135
00:05:17,590 --> 00:05:16,160
the associate administrator

136
00:05:20,230 --> 00:05:17,600
setting the stage

137
00:05:21,670 --> 00:05:20,240
one of many missions in our vast science

138
00:05:24,150 --> 00:05:21,680

portfolio

139
00:05:26,469 --> 00:05:24,160
and you've heard from jim green and now

140
00:05:28,110 --> 00:05:26,479
as only nasa can do we're going to do

141
00:05:31,830 --> 00:05:28,120
just like a countdown

142
00:05:33,749 --> 00:05:31,840
10987 but this time it's about science

143
00:05:35,590 --> 00:05:33,759
and who better to explain

144
00:05:37,830 --> 00:05:35,600
that science is the principle

145
00:05:39,830 --> 00:05:37,840
investigator from the messenger mission

146
00:05:42,469 --> 00:05:39,840
sean solomon sean

147
00:05:43,510 --> 00:05:42,479
thank you duane thank you jim thank you

148
00:05:45,909 --> 00:05:43,520
john

149
00:05:48,150 --> 00:05:45,919
the messenger team is delighted to be

150
00:05:50,550 --> 00:05:48,160
here to celebrate

151
00:05:52,790 --> 00:05:50,560
four years of orbital operations at

152
00:05:55,510 --> 00:05:52,800
mercury after three flybys of the

153
00:05:57,430 --> 00:05:55,520
innermost planet it is pretty difficult

154
00:06:00,710 --> 00:05:57,440
to take all of those observations all of

155
00:06:02,550 --> 00:06:00,720
those discoveries and make a top 10 list

156
00:06:05,110 --> 00:06:02,560
but that's what jim asked us to do so

157
00:06:07,830 --> 00:06:05,120
that's what we've got for you today so

158
00:06:10,550 --> 00:06:07,840
let me start with number 10. number 10

159
00:06:11,990 --> 00:06:10,560
we call field aligned currents what does

160
00:06:14,550 --> 00:06:12,000
that mean it means that there are

161
00:06:16,870 --> 00:06:14,560
electrical currents that are flowing

162
00:06:17,990 --> 00:06:16,880
down magnetic field lines and back out

163
00:06:20,230 --> 00:06:18,000

again

164
00:06:21,990 --> 00:06:20,240
earth has such field aligned currents

165
00:06:24,390 --> 00:06:22,000
they were not expected to be seen at

166
00:06:27,350 --> 00:06:24,400
mercury because these currents

167
00:06:29,909 --> 00:06:27,360
at earth close in earth's

168
00:06:31,110 --> 00:06:29,919
ionosphere and mercury has no permanent

169
00:06:32,710 --> 00:06:31,120
ionosphere

170
00:06:34,629 --> 00:06:32,720
these field online currents and mercury

171
00:06:36,790 --> 00:06:34,639
are down by a factor of 100 in magnitude

172
00:06:38,629 --> 00:06:36,800
from those at earth but they don't close

173
00:06:40,230 --> 00:06:38,639
in the ionosphere they close inside the

174
00:06:43,350 --> 00:06:40,240
planet

175
00:06:45,430 --> 00:06:43,360
the current has to flow radially down

176
00:06:47,270 --> 00:06:45,440
through the resistive outer layers of

177
00:06:48,469 --> 00:06:47,280
the planet and then laterally at some

178
00:06:50,629 --> 00:06:48,479
depth where the

179
00:06:53,189 --> 00:06:50,639
interior is more electrically conductive

180
00:06:54,710 --> 00:06:53,199
so not only is this showing us something

181
00:06:56,629 --> 00:06:54,720
about the magnetosphere it's telling us

182
00:06:58,950 --> 00:06:56,639
about the interior of

183
00:07:00,830 --> 00:06:58,960
mercury in a way that we didn't expect

184
00:07:02,469 --> 00:07:00,840
and we're still working

185
00:07:04,790 --> 00:07:02,479
on

186
00:07:06,550 --> 00:07:04,800
the details of the mechanisms of this

187
00:07:07,909 --> 00:07:06,560
process

188
00:07:12,150 --> 00:07:07,919

number nine

189
00:07:14,469 --> 00:07:12,160
this is a mystery that goes back to

190
00:07:17,990 --> 00:07:14,479
mariner 10. the only other spacecraft to

191
00:07:20,150 --> 00:07:18,000
visit mercury 40 years ago a little more

192
00:07:22,230 --> 00:07:20,160
and they discovered what seemed to be

193
00:07:23,589 --> 00:07:22,240
bursts of energetic particles only they

194
00:07:25,270 --> 00:07:23,599
didn't know what those particles were

195
00:07:27,589 --> 00:07:25,280
they didn't know what the energies of

196
00:07:29,270 --> 00:07:27,599
those particles were and so messenger

197
00:07:31,670 --> 00:07:29,280
carried a payload to answer those

198
00:07:34,309 --> 00:07:31,680
questions and the answer was

199
00:07:36,469 --> 00:07:34,319
that the particles are electrons

200
00:07:38,710 --> 00:07:36,479
bursts of energetic electrons are seen

201
00:07:40,870 --> 00:07:38,720
with the energetic particle detector

202
00:07:43,510 --> 00:07:40,880
having energies of thousands of electron

203
00:07:44,869 --> 00:07:43,520
volts up to 100 times that value almost

204
00:07:45,749 --> 00:07:44,879
every orbit

205
00:07:47,589 --> 00:07:45,759
these

206
00:07:49,350 --> 00:07:47,599
bursts are seen with many other

207
00:07:51,909 --> 00:07:49,360
instruments as well and you saw on the

208
00:07:53,430 --> 00:07:51,919
animation the location over about

209
00:07:56,309 --> 00:07:53,440
almost four years

210
00:07:58,869 --> 00:07:56,319
the locations of these bursts mapped out

211
00:08:00,550 --> 00:07:58,879
with our x-ray spectrometer we're still

212
00:08:02,309 --> 00:08:00,560
working on the mechanism of what

213
00:08:03,670 --> 00:08:02,319

accelerates these electrons to these

214
00:08:05,510 --> 00:08:03,680
very high energies and that's an

215
00:08:06,950 --> 00:08:05,520
interesting research topic that the team

216
00:08:08,309 --> 00:08:06,960
is pursuing

217
00:08:12,869 --> 00:08:08,319
number eight

218
00:08:14,710 --> 00:08:12,879
magnetosphere itself the magnetic field

219
00:08:17,029 --> 00:08:14,720
and magnetosphere was first sampled by

220
00:08:19,749 --> 00:08:17,039
mariner 10 but it took an orbiter to

221
00:08:22,950 --> 00:08:19,759
work out some of the incredible dynamics

222
00:08:24,469 --> 00:08:22,960
uh the magnetic field of mercury is a

223
00:08:26,230 --> 00:08:24,479
miniature of that of the earth and so

224
00:08:28,390 --> 00:08:26,240
the magnetosphere is small relative to

225
00:08:30,309 --> 00:08:28,400
the planet the sun is close what you're

226
00:08:32,389 --> 00:08:30,319
looking at in the animation

227
00:08:34,709 --> 00:08:32,399
is an equatorial slice

228
00:08:36,389 --> 00:08:34,719
of charged particles in mercury's

229
00:08:37,350 --> 00:08:36,399
equatorial plane

230
00:08:42,230 --> 00:08:37,360
that are

231
00:08:44,470 --> 00:08:42,240
energized and activated by the uh

232
00:08:45,750 --> 00:08:44,480
opening and closing of magnetic field

233
00:08:48,230 --> 00:08:45,760
lines uh

234
00:08:49,990 --> 00:08:48,240
at the sub-solar point uh and you see

235
00:08:51,509 --> 00:08:50,000
wave phenomena that are carrying these

236
00:08:54,310 --> 00:08:51,519
charged particles uh through the

237
00:08:56,630 --> 00:08:54,320
magnetosphere and outward down the tail

238
00:08:59,829 --> 00:08:56,640

region away from the sun

239
00:09:01,910 --> 00:08:59,839
it's an incredibly dynamic planet uh in

240
00:09:03,509 --> 00:09:01,920
terms of its magnetosphere the time

241
00:09:05,910 --> 00:09:03,519
scale for phenomena in mercury's

242
00:09:07,269 --> 00:09:05,920
magnetosphere is 100 times faster than

243
00:09:09,190 --> 00:09:07,279
it is at earth

244
00:09:10,790 --> 00:09:09,200
so it's a different kind of

245
00:09:12,389 --> 00:09:10,800
magnetosphere from any other in the

246
00:09:14,150 --> 00:09:12,399
solar system

247
00:09:17,190 --> 00:09:14,160
number seven on our top ten list is

248
00:09:19,829 --> 00:09:17,200
mercury's seasonal exosphere mercury has

249
00:09:22,070 --> 00:09:19,839
a very tenuous atmosphere of neutral

250
00:09:24,230 --> 00:09:22,080
particles that has been known since

251
00:09:25,910 --> 00:09:24,240
again mariner 10 and a variety of

252
00:09:27,269 --> 00:09:25,920
earth-based

253
00:09:31,030 --> 00:09:27,279
observations

254
00:09:32,949 --> 00:09:31,040
but messenger has measured that

255
00:09:34,790 --> 00:09:32,959
atmosphere over and over again nearly

256
00:09:35,670 --> 00:09:34,800
continuously over more than 10 mercury

257
00:09:38,870 --> 00:09:35,680
years

258
00:09:40,790 --> 00:09:38,880
and the dominant species show regular

259
00:09:43,350 --> 00:09:40,800
variations what you're seeing in the

260
00:09:46,310 --> 00:09:43,360
animation is a depiction of a mercury

261
00:09:48,070 --> 00:09:46,320
sodium atmosphere which glows as a

262
00:09:49,910 --> 00:09:48,080
result of sunlight

263
00:09:51,910 --> 00:09:49,920

exciting the sodium atoms and the

264
00:09:53,910 --> 00:09:51,920
exothermic portions of the orbit as you

265
00:09:55,750 --> 00:09:53,920
can see mercury is moving in and out

266
00:09:58,470 --> 00:09:55,760
relative to the sun because it's in an

267
00:10:01,430 --> 00:09:58,480
eccentric orbit the radiation pressure

268
00:10:03,590 --> 00:10:01,440
on those sodium atoms is so strong that

269
00:10:06,150 --> 00:10:03,600
they're literally pushing the sodium

270
00:10:08,949 --> 00:10:06,160
atoms away from mercury's gravity field

271
00:10:12,389 --> 00:10:08,959
into a tail and mercury has an orange

272
00:10:15,509 --> 00:10:12,399
glowing tail like a comet that extends

273
00:10:17,110 --> 00:10:15,519
millions of kilometers away from the sun

274
00:10:20,949 --> 00:10:17,120
so

275
00:10:24,069 --> 00:10:20,959
the mechanisms and the interplay of uh

276
00:10:25,670 --> 00:10:24,079
the heliosphere and mercury's surface uh

277
00:10:27,269 --> 00:10:25,680
are still being unraveled but the

278
00:10:28,790 --> 00:10:27,279
exosphere has a lot to say about that

279
00:10:30,470 --> 00:10:28,800
process

280
00:10:33,190 --> 00:10:30,480
number six on our list

281
00:10:35,110 --> 00:10:33,200
is global contraction this is an idea

282
00:10:36,790 --> 00:10:35,120
also that goes back to mariner 10 but of

283
00:10:38,230 --> 00:10:36,800
course mariner 10 didn't see the entire

284
00:10:39,509 --> 00:10:38,240
surface of mercury didn't measure

285
00:10:41,190 --> 00:10:39,519
topography

286
00:10:44,310 --> 00:10:41,200
didn't have the kind of high resolution

287
00:10:46,470 --> 00:10:44,320
images that messenger acquired after

288
00:10:49,269 --> 00:10:46,480

many many years in orbit you're looking

289
00:10:51,910 --> 00:10:49,279
at an animation of an incredible

290
00:10:55,829 --> 00:10:51,920
scarp called the carnegie root base

291
00:10:58,470 --> 00:10:55,839
one of these shortening structures that

292
00:11:01,430 --> 00:10:58,480
preserves the record of mercury's

293
00:11:03,269 --> 00:11:01,440
shrinkage it happens to cross a big

294
00:11:05,829 --> 00:11:03,279
impact crater about 130 kilometers

295
00:11:08,550 --> 00:11:05,839
across but

296
00:11:10,630 --> 00:11:08,560
the topography and the the sheer number

297
00:11:12,949 --> 00:11:10,640
of these features has allowed us to

298
00:11:15,190 --> 00:11:12,959
confirm that mercury contracted by much

299
00:11:17,110 --> 00:11:15,200
more than we appreciated before the

300
00:11:19,590 --> 00:11:17,120
messenger mission by as much as seven

301
00:11:22,150 --> 00:11:19,600
kilometers in radius that's and that's

302
00:11:24,150 --> 00:11:22,160
simply the result of interior cooling uh

303
00:11:26,630 --> 00:11:24,160
and the uh the cooling and

304
00:11:29,829 --> 00:11:26,640
solidification in part of mercury's

305
00:11:31,590 --> 00:11:29,839
astonishing the large core

306
00:11:33,350 --> 00:11:31,600
the

307
00:11:35,670 --> 00:11:33,360
top

308
00:11:38,230 --> 00:11:35,680
scientific finding number five

309
00:11:40,150 --> 00:11:38,240
is volcanic deposits

310
00:11:42,710 --> 00:11:40,160
there was a debate following the mariner

311
00:11:45,350 --> 00:11:42,720
10 mission as to how important volcanism

312
00:11:47,269 --> 00:11:45,360
was in the history of mercury's

313
00:11:48,790 --> 00:11:47,279

geological evolution

314
00:11:50,949 --> 00:11:48,800
with

315
00:11:52,550 --> 00:11:50,959
sides ranging from not very important at

316
00:11:53,670 --> 00:11:52,560
all to very important what you see from

317
00:11:55,670 --> 00:11:53,680
these

318
00:11:57,190 --> 00:11:55,680
messenger images is that volcanism was

319
00:11:59,990 --> 00:11:57,200
extraordinarily important you see

320
00:12:02,069 --> 00:12:00,000
valleys carved by hot

321
00:12:04,470 --> 00:12:02,079
low viscosity lavas

322
00:12:06,310 --> 00:12:04,480
filling large impact structures we've

323
00:12:08,790 --> 00:12:06,320
also measured the composition of the

324
00:12:10,790 --> 00:12:08,800
surf of the surface

325
00:12:13,350 --> 00:12:10,800
with the x-ray spectrometer that allows

326
00:12:15,829 --> 00:12:13,360
us to determine the abundances of major

327
00:12:18,389 --> 00:12:15,839
rock-forming elements like magnesium and

328
00:12:20,550 --> 00:12:18,399
aluminum relative to silicon

329
00:12:23,910 --> 00:12:20,560
these are telling us that mercury's

330
00:12:26,150 --> 00:12:23,920
lavas varied in chemistry over time and

331
00:12:27,829 --> 00:12:26,160
over space and they sample different

332
00:12:29,030 --> 00:12:27,839
parts of the interior

333
00:12:32,150 --> 00:12:29,040
from different depths at different

334
00:12:33,509 --> 00:12:32,160
temperatures so we have a record if only

335
00:12:35,430 --> 00:12:33,519
we can read it

336
00:12:37,350 --> 00:12:35,440
and we're working on that now of the

337
00:12:39,269 --> 00:12:37,360
melting history of mercury's interior

338
00:12:41,030 --> 00:12:39,279

and the eruptive history of mercury's

339
00:12:42,629 --> 00:12:41,040
volcanic deposits

340
00:12:44,710 --> 00:12:42,639
number four on the

341
00:12:47,030 --> 00:12:44,720
top ten list of scientific results are

342
00:12:48,790 --> 00:12:47,040
the hollows hollows are a landform we

343
00:12:51,190 --> 00:12:48,800
didn't expect were discovered for the

344
00:12:53,030 --> 00:12:51,200
first time by messenger once it got into

345
00:12:54,949 --> 00:12:53,040
orbit and took high-resolution images

346
00:12:56,710 --> 00:12:54,959
you're seeing hollows in this animation

347
00:12:59,110 --> 00:12:56,720
on the floor of a crater about 30

348
00:13:00,069 --> 00:12:59,120
kilometers across all throughout the

349
00:13:02,629 --> 00:13:00,079
floor

350
00:13:03,430 --> 00:13:02,639
hollows are bright

351
00:13:07,590 --> 00:13:03,440
they're

352
00:13:09,350 --> 00:13:07,600
created by the loss of near-service

353
00:13:11,670 --> 00:13:09,360
material that's been excavated by

354
00:13:13,990 --> 00:13:11,680
impacts they are some of the youngest

355
00:13:15,910 --> 00:13:14,000
features on the planet they they have

356
00:13:18,069 --> 00:13:15,920
virtually no impact craters on top of

357
00:13:19,430 --> 00:13:18,079
them there's nothing on mercury service

358
00:13:22,310 --> 00:13:19,440
that is younger

359
00:13:25,030 --> 00:13:22,320
so this speaks to uh some unstable

360
00:13:27,670 --> 00:13:25,040
material uh whose identity we're still

361
00:13:30,310 --> 00:13:27,680
working out but it says that on a

362
00:13:31,990 --> 00:13:30,320
geological time scale uh there are

363
00:13:34,389 --> 00:13:32,000

processes going on other than impact

364
00:13:36,629 --> 00:13:34,399
cratering uh very rapidly on mercury an

365
00:13:37,590 --> 00:13:36,639
astonishing surprise

366
00:13:38,470 --> 00:13:37,600
number

367
00:13:41,430 --> 00:13:38,480
three

368
00:13:43,269 --> 00:13:41,440
is the offset magnetic field

369
00:13:46,069 --> 00:13:43,279
mariner 10 discovered

370
00:13:48,550 --> 00:13:46,079
mercury's magnetic field we thought it

371
00:13:50,870 --> 00:13:48,560
would be rather earth-like a miniature

372
00:13:53,430 --> 00:13:50,880
of earth's magnetic field and it is

373
00:13:56,069 --> 00:13:53,440
it's dominantly the field of a dipole

374
00:13:58,710 --> 00:13:56,079
that equivalent to a bar magnet but the

375
00:14:00,629 --> 00:13:58,720
earth's magnetic field is located at the

376
00:14:03,350 --> 00:14:00,639
center of the planet mercury's magnetic

377
00:14:05,110 --> 00:14:03,360
field is offset it's offset by 20 of a

378
00:14:07,030 --> 00:14:05,120
planet radius which is more than any

379
00:14:08,949 --> 00:14:07,040
other planet in the solar system and we

380
00:14:11,269 --> 00:14:08,959
don't know why but what it means is that

381
00:14:12,629 --> 00:14:11,279
the field is very asymmetric the

382
00:14:14,150 --> 00:14:12,639
northern hemisphere field is much

383
00:14:15,670 --> 00:14:14,160
stronger than the southern hemisphere

384
00:14:16,870 --> 00:14:15,680
field you see the field lines in this

385
00:14:19,030 --> 00:14:16,880
animation

386
00:14:20,310 --> 00:14:19,040
and that means that processes governed

387
00:14:21,990 --> 00:14:20,320
by the magnetic field like the

388
00:14:24,470 --> 00:14:22,000

interaction of charged particles with

389
00:14:26,629 --> 00:14:24,480
the surface must be asymmetric as well

390
00:14:28,629 --> 00:14:26,639
we're looking for evidence of that and

391
00:14:31,269 --> 00:14:28,639
none of the theories for how

392
00:14:33,509 --> 00:14:31,279
a dynamo might have generated a magnetic

393
00:14:35,670 --> 00:14:33,519
field in mercury prior to our mission

394
00:14:38,230 --> 00:14:35,680
predicted this large an offset so the

395
00:14:40,790 --> 00:14:38,240
dynamo modelers are back at their

396
00:14:43,750 --> 00:14:40,800
drawing boards making new models

397
00:14:45,829 --> 00:14:43,760
number two on our top science list there

398
00:14:47,829 --> 00:14:45,839
are the polar deposits now the polar

399
00:14:49,509 --> 00:14:47,839
deposits were discovered by earth-based

400
00:14:51,350 --> 00:14:49,519
radar more than 20 years ago and you're

401
00:14:53,509 --> 00:14:51,360
seeing a mosaic

402
00:14:54,550 --> 00:14:53,519
from messenger but the red areas are

403
00:14:56,949 --> 00:14:54,560
areas

404
00:15:02,389 --> 00:14:59,269
the surface has a high radar back

405
00:15:04,790 --> 00:15:02,399
scatter and those were postulated even

406
00:15:06,710 --> 00:15:04,800
20 years ago to consist of water ice and

407
00:15:08,550 --> 00:15:06,720
we took a variety of measurements to

408
00:15:10,790 --> 00:15:08,560
test that idea one was simply measuring

409
00:15:13,350 --> 00:15:10,800
the topography you saw the topographic

410
00:15:15,509 --> 00:15:13,360
map here another was to take a neutron

411
00:15:18,550 --> 00:15:15,519
spectrometer and what you're seeing

412
00:15:20,790 --> 00:15:18,560
there is a map of neutron flux which is

413
00:15:22,949 --> 00:15:20,800

reduced at high latitudes

414
00:15:25,430 --> 00:15:22,959
in the right amount for the polar

415
00:15:27,990 --> 00:15:25,440
deposits to consist of water ice and

416
00:15:30,629 --> 00:15:28,000
finally the topography with models of

417
00:15:32,710 --> 00:15:30,639
solar illumination permits modeling of

418
00:15:41,990 --> 00:15:32,720
the

419
00:15:43,990 --> 00:15:42,000
areas where water ice is stable for

420
00:15:45,829 --> 00:15:44,000
geologically long periods of time either

421
00:15:48,550 --> 00:15:45,839
at the surface or within a few tens of

422
00:15:51,269 --> 00:15:48,560
centimeters of the surface so

423
00:15:53,110 --> 00:15:51,279
with all of the experiments we took an

424
00:15:55,509 --> 00:15:53,120
altimeter an imaging system a neutron

425
00:15:57,030 --> 00:15:55,519
spectrometer and models of temperature

426
00:15:58,790 --> 00:15:57,040
and shadow

427
00:16:01,749 --> 00:15:58,800
we confirmed

428
00:16:04,069 --> 00:16:01,759
with each test that the planet closest

429
00:16:05,350 --> 00:16:04,079
to the sun indeed harbors water ice at

430
00:16:06,710 --> 00:16:05,360
both poles

431
00:16:09,749 --> 00:16:06,720
number one

432
00:16:11,350 --> 00:16:09,759
our top science result uh and one of the

433
00:16:13,670 --> 00:16:11,360
most surprising is that mercury is a

434
00:16:16,150 --> 00:16:13,680
volatile rich planet now what does that

435
00:16:18,629 --> 00:16:16,160
mean it means that prior to our mission

436
00:16:20,949 --> 00:16:18,639
all of the theories almost all uh for

437
00:16:23,590 --> 00:16:20,959
how mercury was assembled to end up as

438
00:16:25,829 --> 00:16:23,600

dense as it is predicted that mercury

439
00:16:27,269 --> 00:16:25,839
would be deficient in all the elements

440
00:16:28,710 --> 00:16:27,279
that are easily removed at high

441
00:16:31,590 --> 00:16:28,720
temperature with the volatile elements

442
00:16:33,509 --> 00:16:31,600
you're seeing a plot of potassium

443
00:16:36,550 --> 00:16:33,519
versus another element that is not

444
00:16:39,829 --> 00:16:36,560
volatile and mercury is as volatile rich

445
00:16:41,829 --> 00:16:39,839
as mars and as volatile rich as earth

446
00:16:44,790 --> 00:16:41,839
it was not predicted to be so you're

447
00:16:46,629 --> 00:16:44,800
seeing maps here of potassium and sulfur

448
00:16:48,949 --> 00:16:46,639
another volatile element we could be

449
00:16:52,310 --> 00:16:48,959
showing you maps of

450
00:16:53,910 --> 00:16:52,320
of sodium or chlorine and mercury is

451
00:16:55,670 --> 00:16:53,920
much more abundant in all of those

452
00:16:59,990 --> 00:16:55,680
volatile constituents than it was

453
00:17:02,150 --> 00:17:00,000
predicted to be uh or then uh

454
00:17:05,189 --> 00:17:02,160
we expected even before we took our

455
00:17:07,270 --> 00:17:05,199
instruments to mercury so uh the ideas

456
00:17:08,789 --> 00:17:07,280
for how the inner planets got assembled

457
00:17:12,069 --> 00:17:08,799
and how the

458
00:17:13,829 --> 00:17:12,079
building blocks of planetary materials

459
00:17:15,750 --> 00:17:13,839
were delivered to the inner solar system

460
00:17:17,909 --> 00:17:15,760
and survived the process of planetary

461
00:17:20,150 --> 00:17:17,919
accretion are all being changed by

462
00:17:22,470 --> 00:17:20,160
messenger's results

463
00:17:24,470 --> 00:17:22,480

so i'll stop there but i'll say that we

464
00:17:26,789 --> 00:17:24,480
still do have two weeks

465
00:17:29,510 --> 00:17:26,799
of operations to go we're collecting

466
00:17:31,190 --> 00:17:29,520
data we've collected uh more than 10

467
00:17:33,190 --> 00:17:31,200
terabytes of data

468
00:17:35,510 --> 00:17:33,200
so we've been delivering those data to

469
00:17:37,430 --> 00:17:35,520
the planetary science community

470
00:17:39,510 --> 00:17:37,440
the messenger science team and in fact

471
00:17:41,669 --> 00:17:39,520
the planetary science community all over

472
00:17:43,190 --> 00:17:41,679
the world will be looking at these data

473
00:17:46,470 --> 00:17:43,200
from this mission

474
00:17:48,950 --> 00:17:46,480
for years probably for decades as we try

475
00:17:50,950 --> 00:17:48,960
to understand uh the origin and

476
00:17:53,590 --> 00:17:50,960
evolution of mercury and its place in

477
00:17:54,789 --> 00:17:53,600
the inner solar system dwayne

478
00:17:57,669 --> 00:17:54,799
thanks sean well ladies and gentlemen

479
00:18:00,310 --> 00:17:57,679
you've heard the top ten now remember

480
00:18:01,830 --> 00:18:00,320
that's the top ten now a lot more on

481
00:18:03,990 --> 00:18:01,840
president of science findings from this

482
00:18:06,470 --> 00:18:04,000
highly successful mission all online at

483
00:18:08,710 --> 00:18:06,480
www.nasa.gov

484
00:18:10,710 --> 00:18:08,720
messenger and for social media the folks

485
00:18:11,990 --> 00:18:10,720
out there listening to this send your

486
00:18:14,630 --> 00:18:12,000
questions in

487
00:18:16,390 --> 00:18:14,640
the public is abuzz about this mission

488
00:18:19,750 --> 00:18:16,400

at hashtag

489
00:18:20,789 --> 00:18:19,760
ask nasa keep those questions coming

490
00:18:22,310 --> 00:18:20,799
now

491
00:18:24,870 --> 00:18:22,320
let's talk about the engineering

492
00:18:26,630 --> 00:18:24,880
accomplishments and there's so many it

493
00:18:28,950 --> 00:18:26,640
takes more than one person we've got the

494
00:18:31,669 --> 00:18:28,960
dynamic duo they're going to share with

495
00:18:33,510 --> 00:18:31,679
you some of the incredible findings

496
00:18:35,669 --> 00:18:33,520
dan o'shaughnessy

497
00:18:38,310 --> 00:18:35,679
messenger systems engineer and helene

498
00:18:40,950 --> 00:18:38,320
winters messenger project manager both

499
00:18:42,390 --> 00:18:40,960
from john's hopkins university applied

500
00:18:44,070 --> 00:18:42,400
physics laboratory

501
00:18:45,590 --> 00:18:44,080
in lower maryland and over to the

502
00:18:47,350 --> 00:18:45,600
dynamic duo

503
00:18:49,830 --> 00:18:47,360
thanks duane i'm really excited to be

504
00:18:51,270 --> 00:18:49,840
here to brag about the exploits of the

505
00:18:52,870 --> 00:18:51,280
engineering team

506
00:18:54,630 --> 00:18:52,880
and all the innovations that enabled

507
00:18:56,789 --> 00:18:54,640
this incredible mission so we're going

508
00:18:58,710 --> 00:18:56,799
to start it off in no particular order

509
00:19:01,190 --> 00:18:58,720
with our top 10 as well

510
00:19:02,950 --> 00:19:01,200
number 10 the first mercury orbiter as

511
00:19:04,950 --> 00:19:02,960
uh sean mentioned

512
00:19:07,350 --> 00:19:04,960
mercury had been visited by mariner 10

513
00:19:08,870 --> 00:19:07,360

in the 1970s but it was not an orbiter

514
00:19:10,630 --> 00:19:08,880
mission partially because it's

515
00:19:12,710 --> 00:19:10,640
exceedingly challenging to get into

516
00:19:14,870 --> 00:19:12,720
orbit about mercury

517
00:19:16,630 --> 00:19:14,880
what messenger did in order to capture

518
00:19:18,230 --> 00:19:16,640
into orbit about mercury is it loaded up

519
00:19:20,630 --> 00:19:18,240
with propellant launch we were more than

520
00:19:23,270 --> 00:19:20,640
half propellant at launch 600 kilograms

521
00:19:24,950 --> 00:19:23,280
of liquid rocket fuel when we launched

522
00:19:26,870 --> 00:19:24,960
and even that was insufficient and so we

523
00:19:27,909 --> 00:19:26,880
had to borrow energy from the inner

524
00:19:30,470 --> 00:19:27,919
planets

525
00:19:32,630 --> 00:19:30,480
as we went on this interplanetary syst

526
00:19:34,630 --> 00:19:32,640
or inner solar system carousel ride

527
00:19:37,350 --> 00:19:34,640
around and around flying past the

528
00:19:39,190 --> 00:19:37,360
planets a record six times to borrow

529
00:19:41,750 --> 00:19:39,200
some gravity from those planets and

530
00:19:43,830 --> 00:19:41,760
enabling us to catch up with mercury and

531
00:19:45,750 --> 00:19:43,840
then forming performing one large

532
00:19:49,270 --> 00:19:45,760
breaking maneuver slowing the spacecraft

533
00:19:51,270 --> 00:19:49,280
down by a mere 1900 miles an hour to

534
00:19:52,710 --> 00:19:51,280
capture into orbit about mercury and

535
00:19:54,630 --> 00:19:52,720
another unique thing about this

536
00:19:57,029 --> 00:19:54,640
trajectory is messenger is actually a

537
00:20:00,070 --> 00:19:57,039
flyby mission and an orbiter mission all

538
00:20:01,590 --> 00:20:00,080

in one as we had three mercury flybys

539
00:20:03,990 --> 00:20:01,600
prior to capturing into orbit about

540
00:20:05,510 --> 00:20:04,000
mercury and the flybys offer a unique

541
00:20:07,430 --> 00:20:05,520
perspective of the planet because you're

542
00:20:11,110 --> 00:20:07,440
in locations that you can't observe the

543
00:20:11,120 --> 00:20:16,950
number nine economy of space

544
00:20:19,110 --> 00:20:17,990
five

545
00:20:21,909 --> 00:20:19,120
four

546
00:20:25,590 --> 00:20:21,919
three main engine start two

547
00:20:28,070 --> 00:20:25,600
one and zero and liftoff of messenger on

548
00:20:32,630 --> 00:20:28,080
nasa's mission to mercury a planetary

549
00:20:35,830 --> 00:20:34,390
messenger was launched on a delta ii

550
00:20:38,230 --> 00:20:35,840
heavy that was the largest launch

551
00:20:39,909 --> 00:20:38,240
vehicle available to the mission

552
00:20:43,110 --> 00:20:39,919
that meant that our mass was constrained

553
00:20:46,870 --> 00:20:43,120
to 1100 kilograms at launch well as dan

554
00:20:49,270 --> 00:20:46,880
mentioned 54 of this or 600 kilograms

555
00:20:51,669 --> 00:20:49,280
was consumed by the propellant required

556
00:20:53,750 --> 00:20:51,679
to fly that trajectory so we were left

557
00:20:56,470 --> 00:20:53,760
with 500 kilograms for the the

558
00:20:58,149 --> 00:20:56,480
spacecraft and its payload so we had to

559
00:20:59,990 --> 00:20:58,159
be innovative in

560
00:21:02,230 --> 00:21:00,000
coming up with their design to minimize

561
00:21:05,190 --> 00:21:02,240
the mass

562
00:21:07,669 --> 00:21:05,200
one such example is our propellant tanks

563
00:21:09,830 --> 00:21:07,679

they're made of an ultra thin titanium

564
00:21:12,470 --> 00:21:09,840
that's anywhere from half millimeter to

565
00:21:15,830 --> 00:21:12,480
a millimeter in thickness

566
00:21:18,549 --> 00:21:15,840
um we also had our structure is is made

567
00:21:20,390 --> 00:21:18,559
of a composite material a lightweight

568
00:21:22,549 --> 00:21:20,400
composite material

569
00:21:24,630 --> 00:21:22,559
we also had to limit our power because

570
00:21:27,350 --> 00:21:24,640
power requirements translate pretty

571
00:21:30,710 --> 00:21:27,360
directly into additional mass

572
00:21:32,549 --> 00:21:30,720
so our entire payload operates off at

573
00:21:34,549 --> 00:21:32,559
peak off about

574
00:21:36,470 --> 00:21:34,559
90 watts of power

575
00:21:38,789 --> 00:21:36,480
so all the science observations that

576
00:21:41,350 --> 00:21:38,799
sean described

577
00:21:43,750 --> 00:21:41,360
for across all the instruments operate

578
00:21:46,390 --> 00:21:43,760
on about the same power as a standard

579
00:21:49,270 --> 00:21:46,400
household light bulb

580
00:21:51,190 --> 00:21:49,280
number eight the sunscreen so of course

581
00:21:52,789 --> 00:21:51,200
getting to mercury orbit was exceedingly

582
00:21:54,230 --> 00:21:52,799
challenging

583
00:21:56,230 --> 00:21:54,240
as we talked about with the trajectory

584
00:21:58,710 --> 00:21:56,240
and the mass savings that we had to

585
00:22:00,549 --> 00:21:58,720
take into account but actually operating

586
00:22:02,630 --> 00:22:00,559
from orbit might be a more substantial

587
00:22:04,950 --> 00:22:02,640
challenge so messenger used this very

588
00:22:07,350 --> 00:22:04,960

large sun shade depicted here it's a

589
00:22:08,789 --> 00:22:07,360
ceramic cloth and it's very effective at

590
00:22:10,710 --> 00:22:08,799
isolating us from the thermal

591
00:22:12,549 --> 00:22:10,720
environment of the sun it's very

592
00:22:14,070 --> 00:22:12,559
lightweight and on the front side of the

593
00:22:16,230 --> 00:22:14,080
shade you might see temperatures in

594
00:22:17,830 --> 00:22:16,240
excess of 600 degrees fahrenheit hot

595
00:22:18,870 --> 00:22:17,840
enough to cook your pizza and on the

596
00:22:20,789 --> 00:22:18,880
back side of the shade it's a

597
00:22:22,549 --> 00:22:20,799
comfortable room temperature

598
00:22:24,710 --> 00:22:22,559
but the sun isn't the only thermal

599
00:22:27,029 --> 00:22:24,720
challenge that it messenger faces

600
00:22:28,630 --> 00:22:27,039
actually there's substantial infrared

601
00:22:30,630 --> 00:22:28,640
heating that is reflected from the

602
00:22:32,310 --> 00:22:30,640
planet back towards the spacecraft and

603
00:22:34,870 --> 00:22:32,320
serves to heat the components behind the

604
00:22:37,190 --> 00:22:34,880
sunshade so messenger uses an intricate

605
00:22:38,870 --> 00:22:37,200
dance of orientation changes to help

606
00:22:40,950 --> 00:22:38,880
balance the heating across the various

607
00:22:42,950 --> 00:22:40,960
surfaces of the spacecraft to keep all

608
00:22:45,029 --> 00:22:42,960
of our sensitive electronics below their

609
00:22:46,549 --> 00:22:45,039
peak operating temperatures

610
00:22:48,470 --> 00:22:46,559
and then finally although

611
00:22:50,390 --> 00:22:48,480
counterintuitive messenger actually

612
00:22:52,310 --> 00:22:50,400
carries a great number of heaters on

613
00:22:54,390 --> 00:22:52,320

board because when we pass behind the

614
00:22:56,710 --> 00:22:54,400
planet and into this plant planet's

615
00:22:58,230 --> 00:22:56,720
eclipse excuse me

616
00:23:00,070 --> 00:22:58,240
temperatures on the spacecraft plummet

617
00:23:02,149 --> 00:23:00,080
drastically and we have to be concerned

618
00:23:03,590 --> 00:23:02,159
about freezing propellants and cooling

619
00:23:05,190 --> 00:23:03,600
electronics below their operating

620
00:23:07,590 --> 00:23:05,200
temperature so we operate a great deal

621
00:23:10,230 --> 00:23:07,600
of heaters during that time period

622
00:23:11,750 --> 00:23:10,240
number seven harnessing the power

623
00:23:13,510 --> 00:23:11,760
being in orbit about the innermost

624
00:23:16,390 --> 00:23:13,520
planet in our solar system we don't

625
00:23:18,549 --> 00:23:16,400
generally have trouble producing power

626
00:23:22,230 --> 00:23:18,559
but being in such close proximity to the

627
00:23:23,669 --> 00:23:22,240
sun can present a problem for the power

628
00:23:24,950 --> 00:23:23,679
system

629
00:23:27,110 --> 00:23:24,960
so

630
00:23:30,390 --> 00:23:27,120
except when we're in eclipse

631
00:23:31,669 --> 00:23:30,400
we run off the battery

632
00:23:34,149 --> 00:23:31,679
we have

633
00:23:36,470 --> 00:23:34,159
innovative design in our solar arrays

634
00:23:39,190 --> 00:23:36,480
our solar arrays are comprised of

635
00:23:41,430 --> 00:23:39,200
one-third solar cells and two-thirds

636
00:23:44,070 --> 00:23:41,440
optical solar reflectors or basically

637
00:23:45,909 --> 00:23:44,080
mirrors to reflect the sunlight and help

638
00:23:48,230 --> 00:23:45,919

manage the temperature

639
00:23:50,789 --> 00:23:48,240
the solar panels are also articulating

640
00:23:54,390 --> 00:23:50,799
so we can use the arms to tilt the solar

641
00:23:57,350 --> 00:23:54,400
panels um to reduce the heating

642
00:24:00,070 --> 00:23:57,360
when the sun's in close proximity

643
00:24:03,830 --> 00:24:00,080
number six no side dishes

644
00:24:05,510 --> 00:24:03,840
so this picture you're about to see of

645
00:24:07,190 --> 00:24:05,520
this block of metal i've been an

646
00:24:08,710 --> 00:24:07,200
engineer on this mission for 10 years

647
00:24:12,149 --> 00:24:08,720
and it looks like a block of metal to me

648
00:24:13,990 --> 00:24:12,159
too but to an rf or a radio frequency or

649
00:24:15,269 --> 00:24:14,000
communications engineer these are like

650
00:24:17,110 --> 00:24:15,279
the looking at a picture of your

651
00:24:19,510 --> 00:24:17,120
firstborn they're they're beautiful this

652
00:24:21,269 --> 00:24:19,520
antenna design is elegant typically for

653
00:24:23,269 --> 00:24:21,279
a deep space mission what you might see

654
00:24:24,630 --> 00:24:23,279
is a parabolic dish antenna like a

655
00:24:25,510 --> 00:24:24,640
satellite dish that would sit in your

656
00:24:27,190 --> 00:24:25,520
yard

657
00:24:29,190 --> 00:24:27,200
messenger couldn't use such a dish

658
00:24:31,029 --> 00:24:29,200
because it's heavy and the gimbal that

659
00:24:32,710 --> 00:24:31,039
is required to keep the dish trained on

660
00:24:34,390 --> 00:24:32,720
the earth while we keep our sun shade

661
00:24:36,390 --> 00:24:34,400
pointed towards the sun would have

662
00:24:38,149 --> 00:24:36,400
required complexity that would wouldn't

663
00:24:40,070 --> 00:24:38,159

have been tolerant of the thermal

664
00:24:42,470 --> 00:24:40,080
environment that we experienced or the

665
00:24:44,549 --> 00:24:42,480
heating that we experience at mercury

666
00:24:46,549 --> 00:24:44,559
so this elegant design was actually

667
00:24:48,630 --> 00:24:46,559
borrowed from the military

668
00:24:50,870 --> 00:24:48,640
and repurposed for messenger and has

669
00:24:53,430 --> 00:24:50,880
allowed us as sean had mentioned to

670
00:24:55,510 --> 00:24:53,440
downlink more than 10 terabytes of data

671
00:24:57,909 --> 00:24:55,520
from the spacecraft even though it's as

672
00:24:59,510 --> 00:24:57,919
much as 100 million miles away from

673
00:25:01,590 --> 00:24:59,520
earth

674
00:25:03,430 --> 00:25:01,600
number five cybox

675
00:25:05,190 --> 00:25:03,440
messenger's payload is comprised of

676
00:25:07,269 --> 00:25:05,200
seven science instruments in a radio

677
00:25:10,149 --> 00:25:07,279
science experiment

678
00:25:12,390 --> 00:25:10,159
so each one of these has different

679
00:25:14,789 --> 00:25:12,400
operational constraints and different

680
00:25:17,029 --> 00:25:14,799
goals for the science so planning for

681
00:25:19,110 --> 00:25:17,039
them is very complex especially if done

682
00:25:22,149 --> 00:25:19,120
manually so we've developed an

683
00:25:24,870 --> 00:25:22,159
application called cybox that allows us

684
00:25:27,430 --> 00:25:24,880
to automatically generate

685
00:25:29,750 --> 00:25:27,440
the instrument command sequences based

686
00:25:32,230 --> 00:25:29,760
on the instrument constraints and goals

687
00:25:33,430 --> 00:25:32,240
and spacecraft operational constraints

688
00:25:35,110 --> 00:25:33,440

as well

689
00:25:37,190 --> 00:25:35,120
and because it's automatically generated

690
00:25:40,870 --> 00:25:37,200
it allows us to readily reprocess if any

691
00:25:44,070 --> 00:25:42,470
number four

692
00:25:45,909 --> 00:25:44,080
fire sale

693
00:25:48,390 --> 00:25:45,919
so

694
00:25:50,310 --> 00:25:48,400
messenger had these six record six

695
00:25:51,909 --> 00:25:50,320
planetary flybys but those planetary

696
00:25:53,350 --> 00:25:51,919
gravity assists actually didn't come for

697
00:25:55,430 --> 00:25:53,360
free

698
00:25:57,029 --> 00:25:55,440
it requires extremely precise

699
00:25:58,470 --> 00:25:57,039
positioning of the spacecraft when you

700
00:26:00,230 --> 00:25:58,480
fly past the planet to keep the

701
00:26:02,630 --> 00:26:00,240
trajectory kinked in the right way so

702
00:26:04,149 --> 00:26:02,640
that you're on your way to mercury

703
00:26:05,430 --> 00:26:04,159
and that's indicated in the inset

704
00:26:07,669 --> 00:26:05,440
graphic there with the concentric

705
00:26:09,590 --> 00:26:07,679
ellipses so as messenger flies toward

706
00:26:11,110 --> 00:26:09,600
the planet we typically would use a

707
00:26:13,110 --> 00:26:11,120
sequence of rocket maneuvers small

708
00:26:14,950 --> 00:26:13,120
maneuvers to ensure this targeting

709
00:26:16,470 --> 00:26:14,960
happens as expected

710
00:26:18,070 --> 00:26:16,480
however messenger was able to take

711
00:26:20,549 --> 00:26:18,080
advantage of its unique position in the

712
00:26:22,789 --> 00:26:20,559
solar system and able to take advantage

713
00:26:25,029 --> 00:26:22,799

of the sunlight that is impinging on the

714
00:26:27,110 --> 00:26:25,039
solar arrays and the sun shade and that

715
00:26:29,510 --> 00:26:27,120
produces a very small but persistent

716
00:26:31,269 --> 00:26:29,520
force on the spacecraft by modifying the

717
00:26:33,269 --> 00:26:31,279
position of the solar arrays and the

718
00:26:35,029 --> 00:26:33,279
orientation of our sun shade we're

719
00:26:36,230 --> 00:26:35,039
actually able to steer that force in

720
00:26:38,070 --> 00:26:36,240
such a way that we were able to

721
00:26:40,390 --> 00:26:38,080
eliminate all of these fly-by-targeting

722
00:26:42,470 --> 00:26:40,400
maneuvers and we're able to be the first

723
00:26:46,149 --> 00:26:42,480
mission to successfully demonstrate

724
00:26:49,990 --> 00:26:48,310
number three it takes a village

725
00:26:51,110 --> 00:26:50,000
this is not intended to be a political

726
00:26:53,510 --> 00:26:51,120
statement but we thought it was

727
00:26:55,190 --> 00:26:53,520
appropriate for a mission there's so

728
00:26:56,230 --> 00:26:55,200
many people who've been involved in this

729
00:26:57,430 --> 00:26:56,240
mission

730
00:26:59,430 --> 00:26:57,440
we've had

731
00:27:01,029 --> 00:26:59,440
probably a couple thousand contributors

732
00:27:02,630 --> 00:27:01,039
if we look at those

733
00:27:04,070 --> 00:27:02,640
small and large parts that people have

734
00:27:06,149 --> 00:27:04,080
played in the mission

735
00:27:08,230 --> 00:27:06,159
the majority of our team is comprised of

736
00:27:10,710 --> 00:27:08,240
scientists and engineers

737
00:27:12,149 --> 00:27:10,720
our science team draws from almost 30

738
00:27:14,710 --> 00:27:12,159

states and we have international

739
00:27:17,029 --> 00:27:14,720
representation as well

740
00:27:18,470 --> 00:27:17,039
the role of the engineering team though

741
00:27:19,830 --> 00:27:18,480
on this mission is a little different

742
00:27:22,149 --> 00:27:19,840
than most

743
00:27:23,990 --> 00:27:22,159
the team has been very active throughout

744
00:27:26,310 --> 00:27:24,000
operations

745
00:27:28,710 --> 00:27:26,320
they're active day-to-day in orbit

746
00:27:32,149 --> 00:27:28,720
management and orientation management

747
00:27:35,510 --> 00:27:32,159
and thermal management as well

748
00:27:37,510 --> 00:27:35,520
number two beyond the last drop

749
00:27:38,950 --> 00:27:37,520
so when you think of rocket propulsion

750
00:27:40,549 --> 00:27:38,960
typically you think of something like we

751
00:27:42,470 --> 00:27:40,559
saw in the video earlier of the

752
00:27:44,149 --> 00:27:42,480
messengers launch or maybe what you see

753
00:27:45,830 --> 00:27:44,159
in this animation here where we have

754
00:27:46,789 --> 00:27:45,840
thrusters that are blowing fire and

755
00:27:48,549 --> 00:27:46,799
smoke

756
00:27:49,830 --> 00:27:48,559
well messengers propulsion engineers are

757
00:27:51,350 --> 00:27:49,840
actually a little bit more creative and

758
00:27:52,549 --> 00:27:51,360
what they thought of was a deflating

759
00:27:54,710 --> 00:27:52,559
balloon

760
00:27:56,149 --> 00:27:54,720
so

761
00:27:57,990 --> 00:27:56,159
here late in the mission messenger

762
00:28:00,389 --> 00:27:58,000
requires active management of the

763
00:28:01,909 --> 00:28:00,399

trajectory to keep us off the surface of

764
00:28:03,669 --> 00:28:01,919
the planet so solar gravity is

765
00:28:05,669 --> 00:28:03,679
attempting to drag us down into the

766
00:28:06,789 --> 00:28:05,679
planet and we fight that with our rocket

767
00:28:09,510 --> 00:28:06,799
engines

768
00:28:11,510 --> 00:28:09,520
but on april 6th we actually ran out of

769
00:28:13,830 --> 00:28:11,520
propellant we burned through all 600

770
00:28:15,190 --> 00:28:13,840
kilograms of propellants that we had

771
00:28:17,269 --> 00:28:15,200
launched with

772
00:28:19,350 --> 00:28:17,279
tanks are bone dry but rather than

773
00:28:21,669 --> 00:28:19,360
giving in and succumbing to the

774
00:28:23,909 --> 00:28:21,679
forces of solar gravity we're actually

775
00:28:26,310 --> 00:28:23,919
able to rely on the onboard helium gas

776
00:28:28,389 --> 00:28:26,320
which we normally use to pressurize our

777
00:28:30,230 --> 00:28:28,399
propellant tanks we're able to push that

778
00:28:32,470 --> 00:28:30,240
out the thrusters and boost the

779
00:28:34,630 --> 00:28:32,480
spacecraft's speed by another 20 miles

780
00:28:37,350 --> 00:28:34,640
per hour allowing us to live yet another

781
00:28:39,190 --> 00:28:37,360
month through the month of april

782
00:28:40,870 --> 00:28:39,200
number one hovering

783
00:28:44,070 --> 00:28:40,880
as you've heard we've been in orbit for

784
00:28:46,549 --> 00:28:44,080
over four years enabled in no small part

785
00:28:48,549 --> 00:28:46,559
through innovation such as solar sailing

786
00:28:51,350 --> 00:28:48,559
and through close thermal management and

787
00:28:54,149 --> 00:28:51,360
more recently through repurposing this

788
00:28:56,389 --> 00:28:54,159

pressure as a propellant

789
00:28:57,669 --> 00:28:56,399
and now we're flying a new trajectory

790
00:28:59,990 --> 00:28:57,679
over the last

791
00:29:01,269 --> 00:29:00,000
month and a half or so of the

792
00:29:03,190 --> 00:29:01,279
mission

793
00:29:05,110 --> 00:29:03,200
this is inspired by

794
00:29:08,470 --> 00:29:05,120
the science team's great interest in

795
00:29:09,909 --> 00:29:08,480
what we can learn at very low altitudes

796
00:29:11,669 --> 00:29:09,919
there's some things such as perhaps

797
00:29:12,950 --> 00:29:11,679
crustal magnetism that we might be able

798
00:29:14,710 --> 00:29:12,960
to observe

799
00:29:16,710 --> 00:29:14,720
at very low altitudes that we couldn't

800
00:29:17,430 --> 00:29:16,720
see at higher altitudes

801
00:29:19,430 --> 00:29:17,440
so

802
00:29:21,830 --> 00:29:19,440
in this period of time we're executing a

803
00:29:23,669 --> 00:29:21,840
series of maneuvers in rapid succession

804
00:29:27,430 --> 00:29:23,679
to keep us in this tight

805
00:29:29,029 --> 00:29:27,440
low altitude band at closest approach

806
00:29:30,950 --> 00:29:29,039
so um

807
00:29:33,269 --> 00:29:30,960
on the at the end of this month though

808
00:29:34,630 --> 00:29:33,279
we will lose our battle with solar

809
00:29:36,470 --> 00:29:34,640
gravity and

810
00:29:39,590 --> 00:29:36,480
we will come in at

811
00:29:42,470 --> 00:29:39,600
3.9 kilometers a second which is about 8

812
00:29:43,510 --> 00:29:42,480
700 miles per hour

813
00:29:44,870 --> 00:29:43,520

but

814
00:29:47,029 --> 00:29:44,880
because of the

815
00:29:49,590 --> 00:29:47,039
technological innovations

816
00:29:50,950 --> 00:29:49,600
that enabled us to maximize the science

817
00:29:53,430 --> 00:29:50,960
return

818
00:29:57,190 --> 00:29:53,440
we should be studying mercury science

819
00:29:58,389 --> 00:29:57,200
long past when our crater is created

820
00:29:59,990 --> 00:29:58,399
well thanks

821
00:30:01,830 --> 00:30:00,000
well as you can tell i've kind of

822
00:30:03,909 --> 00:30:01,840
switched my position i'm sitting down

823
00:30:05,590 --> 00:30:03,919
now and we're going to go to social

824
00:30:06,630 --> 00:30:05,600
media because there's a lot of buzz out

825
00:30:08,470 --> 00:30:06,640
there

826
00:30:11,110 --> 00:30:08,480
send those questions in to

827
00:30:13,029 --> 00:30:11,120
ask nasa you've heard the top 10

828
00:30:14,149 --> 00:30:13,039
in science

829
00:30:15,830 --> 00:30:14,159
top 10

830
00:30:17,830 --> 00:30:15,840
engineering i think we're going to see

831
00:30:20,470 --> 00:30:17,840
if we can do some top 10 on social media

832
00:30:22,950 --> 00:30:20,480
how's that so my colleague here sharon

833
00:30:24,389 --> 00:30:22,960
lazich i gotta get that name right i

834
00:30:26,789 --> 00:30:24,399
think i got that right

835
00:30:29,669 --> 00:30:26,799
um she is going to

836
00:30:31,830 --> 00:30:29,679
see what we've got here and um are you

837
00:30:33,590 --> 00:30:31,840
enjoying the celebration i'm loving it i

838
00:30:35,590 --> 00:30:33,600

heard there's a cake afterwards so i

839
00:30:37,430 --> 00:30:35,600
didn't hear that

840
00:30:38,549 --> 00:30:37,440
so what's going on on social media

841
00:30:39,990 --> 00:30:38,559
sharon

842
00:30:41,750 --> 00:30:40,000
well great thank you duane for the

843
00:30:43,430 --> 00:30:41,760
lovely introduction uh we have a couple

844
00:30:45,750 --> 00:30:43,440
of really great questions uh the first

845
00:30:48,310 --> 00:30:45,760
one comes from jason will we be able to

846
00:30:51,110 --> 00:30:48,320
know precisely when and where messenger

847
00:30:54,549 --> 00:30:51,120
will impact mercury's surface and will

848
00:30:59,430 --> 00:30:57,269
dan that's yours so

849
00:31:01,990 --> 00:30:59,440
um the exact location i guess depending

850
00:31:04,870 --> 00:31:02,000
upon how exact you want to be uh we we

851
00:31:07,990 --> 00:31:04,880
do know uh that we will impact on april

852
00:31:10,389 --> 00:31:08,000
30th we do have one more maneuver to

853
00:31:13,029 --> 00:31:10,399
boost our minimum altitude up scheduled

854
00:31:14,710 --> 00:31:13,039
for the 24th of april assuming that

855
00:31:16,310 --> 00:31:14,720
maneuver goes as planned we will be

856
00:31:17,710 --> 00:31:16,320
impacting the surface on the 30th of

857
00:31:21,269 --> 00:31:17,720
april around

858
00:31:23,590 --> 00:31:21,279
1925 utc

859
00:31:25,669 --> 00:31:23,600
that impact will not be in view it will

860
00:31:27,269 --> 00:31:25,679
happen during a planetary occultation so

861
00:31:29,750 --> 00:31:27,279
the spacecraft will pass behind the

862
00:31:32,549 --> 00:31:29,760
planet out of view of the earth

863
00:31:34,950 --> 00:31:32,559

and will just not emerge again and we do

864
00:31:37,590 --> 00:31:34,960
have an approximate lat and long for

865
00:31:40,149 --> 00:31:37,600
that impact location which is about 54

866
00:31:41,990 --> 00:31:40,159
degrees north so it's about two-thirds

867
00:31:44,630 --> 00:31:42,000
of the way up the planet so it's up near

868
00:31:46,549 --> 00:31:44,640
the north pole um

869
00:31:49,430 --> 00:31:46,559
so that's that's our current estimate uh

870
00:31:50,950 --> 00:31:49,440
best estimate of the impact location

871
00:31:52,710 --> 00:31:50,960
great thanks

872
00:31:54,149 --> 00:31:52,720
uh we have another two questions

873
00:31:56,310 --> 00:31:54,159
actually that i'm going to combine one

874
00:31:57,990 --> 00:31:56,320
from alex the other from brian out of

875
00:31:59,509 --> 00:31:58,000
all the new discoveries that messenger

876
00:32:00,870 --> 00:31:59,519
made what do you think is the most

877
00:32:07,430 --> 00:32:00,880
interesting and which do you think is

878
00:32:11,029 --> 00:32:09,669
i can take that question

879
00:32:11,909 --> 00:32:11,039
but

880
00:32:15,110 --> 00:32:11,919
we've

881
00:32:16,310 --> 00:32:15,120
partly answered that

882
00:32:20,230 --> 00:32:16,320
the

883
00:32:23,350 --> 00:32:20,240
surprising

884
00:32:25,590 --> 00:32:23,360
bulk composition of mercury which is

885
00:32:28,470 --> 00:32:25,600
important because

886
00:32:31,110 --> 00:32:28,480
it allows us to reject most of the ideas

887
00:32:32,230 --> 00:32:31,120
for how mercury was assembled as a

888
00:32:33,830 --> 00:32:32,240

planet

889
00:32:35,909 --> 00:32:33,840
at the beginning of the

890
00:32:38,870 --> 00:32:35,919
history of the solar system

891
00:32:40,870 --> 00:32:38,880
and is now forcing

892
00:32:43,990 --> 00:32:40,880
those who

893
00:32:46,870 --> 00:32:44,000
do numerical simulations of solar system

894
00:32:50,070 --> 00:32:46,880
formation to come up with new ideas that

895
00:32:52,789 --> 00:32:50,080
would explain the chemistry that we see

896
00:32:55,509 --> 00:32:52,799
but perhaps the most interesting

897
00:32:59,269 --> 00:32:55,519
might be the polar deposits

898
00:33:01,590 --> 00:32:59,279
which was number two on our list but uh

899
00:33:05,110 --> 00:33:01,600
they're interesting because messenger

900
00:33:06,470 --> 00:33:05,120
not only verified that the

901
00:33:07,750 --> 00:33:06,480
north polar

902
00:33:10,230 --> 00:33:07,760
deposits

903
00:33:12,230 --> 00:33:10,240
first seen by radar consists dominantly

904
00:33:15,669 --> 00:33:12,240
of water rise but they're interesting

905
00:33:17,750 --> 00:33:15,679
for a second reason and that is that

906
00:33:19,269 --> 00:33:17,760
our laser altimeter and our imaging

907
00:33:22,870 --> 00:33:19,279
system which was able to image these

908
00:33:25,269 --> 00:33:22,880
deposits using scattered sunlight

909
00:33:29,190 --> 00:33:25,279
shows that most of these deposits are

910
00:33:31,350 --> 00:33:29,200
don't consist of water ice uh

911
00:33:34,389 --> 00:33:31,360
directly at the surface but rather water

912
00:33:37,590 --> 00:33:34,399
ice covered by a dark layer which we

913
00:33:38,870 --> 00:33:37,600

think is 20 or 30 centimeters thick

914
00:33:40,389 --> 00:33:38,880
and that dark layer is darker than

915
00:33:43,190 --> 00:33:40,399
anything else on mercury and it is

916
00:33:45,430 --> 00:33:43,200
volatile because it it is only in areas

917
00:33:47,509 --> 00:33:45,440
of permanent shadow in areas where the

918
00:33:49,669 --> 00:33:47,519
thermal models say water i should not be

919
00:33:51,350 --> 00:33:49,679
stable at the surface but

920
00:33:54,470 --> 00:33:51,360
it's still very much

921
00:33:55,990 --> 00:33:54,480
colder than the average mercury material

922
00:33:58,230 --> 00:33:56,000
so the the team has put forward the

923
00:34:00,710 --> 00:33:58,240
hypothesis that this dark material is in

924
00:34:03,110 --> 00:34:00,720
fact uh organic

925
00:34:05,029 --> 00:34:03,120
carbonaceous material delivered to

926
00:34:06,389 --> 00:34:05,039
mercury by the same objects that brought

927
00:34:09,030 --> 00:34:06,399
the water rise

928
00:34:11,510 --> 00:34:09,040
stored in these deep freezes at the

929
00:34:12,470 --> 00:34:11,520
north and south poles and giving us a

930
00:34:15,349 --> 00:34:12,480
record

931
00:34:17,589 --> 00:34:15,359
in these poles of the delivery probably

932
00:34:20,710 --> 00:34:17,599
from the outer solar system not only of

933
00:34:23,109 --> 00:34:20,720
water ice but of of what on our planet

934
00:34:25,669 --> 00:34:23,119
were once uh some of the building blocks

935
00:34:28,470 --> 00:34:25,679
of organic chemistry and life here on

936
00:34:29,270 --> 00:34:28,480
the planet closest to the sun so mercury

937
00:34:31,349 --> 00:34:29,280
uh

938
00:34:33,510 --> 00:34:31,359

therefore preserves a record of some

939
00:34:36,149 --> 00:34:33,520
very interesting processes in solar

940
00:34:38,790 --> 00:34:36,159
system history and uh those polar

941
00:34:40,790 --> 00:34:38,800
regions i think are calling out to

942
00:34:43,190 --> 00:34:40,800
people like jim green and saying

943
00:34:45,430 --> 00:34:43,200
send us another spacecraft we have some

944
00:34:46,950 --> 00:34:45,440
more stories to tell

945
00:34:49,909 --> 00:34:46,960
you know from my perspective i'm a

946
00:34:52,470 --> 00:34:49,919
magnetospheric physicist and so i really

947
00:34:54,790 --> 00:34:52,480
enjoyed the magnetic field topologies

948
00:34:56,629 --> 00:34:54,800
the concept that the the northern and

949
00:34:58,710 --> 00:34:56,639
southern hemisphere magnetic field

950
00:35:00,790 --> 00:34:58,720
intensities are different and how does

951
00:35:03,829 --> 00:35:00,800
that how does that really happen inside

952
00:35:06,230 --> 00:35:03,839
a planet you know also the oral currents

953
00:35:07,270 --> 00:35:06,240
the concept of of these field aligned

954
00:35:08,630 --> 00:35:07,280
currents

955
00:35:11,430 --> 00:35:08,640
coming down

956
00:35:13,670 --> 00:35:11,440
through the crust across the large core

957
00:35:17,190 --> 00:35:13,680
where the currents must be existing that

958
00:35:20,069 --> 00:35:17,200
are facilitating moving that that uh

959
00:35:22,230 --> 00:35:20,079
current then up out of the other side

960
00:35:24,069 --> 00:35:22,240
that's really fascinating i never would

961
00:35:26,390 --> 00:35:24,079
have thought of that idea and it really

962
00:35:27,990 --> 00:35:26,400
takes these real observations to to

963
00:35:30,150 --> 00:35:28,000

allow us to really think about the

964
00:35:33,109 --> 00:35:30,160
physics of what's going on and try to

965
00:35:35,430 --> 00:35:33,119
understand what's happening in nature

966
00:35:36,310 --> 00:35:35,440
okay sharon um let's take one more and

967
00:35:37,670 --> 00:35:36,320
then we're going to go to the phone

968
00:35:40,150 --> 00:35:37,680
lines because we've got media watching

969
00:35:42,069 --> 00:35:40,160
this program around the country so uh no

970
00:35:43,910 --> 00:35:42,079
social media is a buzz but uh then we'll

971
00:35:45,589 --> 00:35:43,920
come back so one more then we'll go to

972
00:35:47,670 --> 00:35:45,599
phone lines what do you have excellent

973
00:35:50,390 --> 00:35:47,680
uh as a follow-on

974
00:35:52,950 --> 00:35:50,400
to the ice deposits tc asks did

975
00:35:54,710 --> 00:35:52,960
messenger find any water on mercury and

976
00:35:56,710 --> 00:35:54,720
what does this mean for the future and

977
00:36:00,950 --> 00:35:56,720
for the future of or the potential for

978
00:36:04,230 --> 00:36:02,150
okay

979
00:36:05,270 --> 00:36:04,240
good question tc

980
00:36:08,550 --> 00:36:05,280
um

981
00:36:09,990 --> 00:36:08,560
if by water tc means liquid water the

982
00:36:12,390 --> 00:36:10,000
answer is no

983
00:36:14,550 --> 00:36:12,400
if by water you mean the the chemical

984
00:36:17,109 --> 00:36:14,560
compound h2o yes

985
00:36:19,510 --> 00:36:17,119
we have it in the water ice um we don't

986
00:36:21,750 --> 00:36:19,520
see anything in the geological features

987
00:36:23,190 --> 00:36:21,760
that's indicative of running water as we

988
00:36:25,349 --> 00:36:23,200

see on mars

989
00:36:27,829 --> 00:36:25,359
and some other many other bodies farther

990
00:36:29,910 --> 00:36:27,839
out in the solar system and and even in

991
00:36:32,550 --> 00:36:29,920
the spectral observations our team

992
00:36:34,950 --> 00:36:32,560
looked for evidence of water being uh

993
00:36:37,829 --> 00:36:34,960
taken up by other minerals and changing

994
00:36:40,950 --> 00:36:37,839
the mineralogy uh by hydration and we

995
00:36:43,270 --> 00:36:40,960
saw no evidence in the spectroscopy of

996
00:36:45,510 --> 00:36:43,280
that having gone on so

997
00:36:47,910 --> 00:36:45,520
it is not likely that that

998
00:36:51,349 --> 00:36:47,920
on a regular basis there is liquid water

999
00:36:53,270 --> 00:36:51,359
on mercury and so i think mercury as a

1000
00:36:56,069 --> 00:36:53,280
place to study

1001
00:36:59,030 --> 00:36:56,079
all of the processes that lead to

1002
00:37:00,790 --> 00:36:59,040
astrobiology and habitability

1003
00:37:02,630 --> 00:37:00,800
it's really the beginning chapters

1004
00:37:04,870 --> 00:37:02,640
rather than the later chapters of the

1005
00:37:06,870 --> 00:37:04,880
chapters that talk about the delivery of

1006
00:37:08,470 --> 00:37:06,880
the building blocks for life which are

1007
00:37:10,710 --> 00:37:08,480
extraordinarily well preserved on

1008
00:37:11,910 --> 00:37:10,720
mercury rather than

1009
00:37:14,390 --> 00:37:11,920
the later

1010
00:37:15,349 --> 00:37:14,400
organic chemistry and and development of

1011
00:37:17,670 --> 00:37:15,359
life

1012
00:37:20,069 --> 00:37:17,680
that on our planet must have followed

1013
00:37:22,550 --> 00:37:20,079

rather quickly

1014
00:37:24,150 --> 00:37:22,560
okay let's go to the phone lines and for

1015
00:37:25,670 --> 00:37:24,160
the folks on social media i know you're

1016
00:37:28,150 --> 00:37:25,680
excited about this keep those questions

1017
00:37:30,870 --> 00:37:28,160
coming at hashtag ask nasa but we're

1018
00:37:32,790 --> 00:37:30,880
gonna go to phone lines and uh welcome

1019
00:37:35,030 --> 00:37:32,800
to the celebration we have uh marcia

1020
00:37:36,069 --> 00:37:35,040
dunn from the associated press welcome

1021
00:37:38,470 --> 00:37:36,079
marsha

1022
00:37:39,829 --> 00:37:38,480
well thank you dwayne um can you hear me

1023
00:37:42,470 --> 00:37:39,839
loud and clear

1024
00:37:45,990 --> 00:37:42,480
yes um i have a question about um you

1025
00:37:48,710 --> 00:37:46,000
know the upcoming april 30th impact

1026
00:37:51,349 --> 00:37:48,720
how big and how deep of a crater are you

1027
00:37:53,349 --> 00:37:51,359
anticipating i'm assuming the spacecraft

1028
00:37:55,750 --> 00:37:53,359
will be pretty much obliterated and i

1029
00:37:56,630 --> 00:37:55,760
think i heard that science will be

1030
00:37:58,790 --> 00:37:56,640
uh

1031
00:38:01,829 --> 00:37:58,800
coming back up until the bitter end

1032
00:38:08,230 --> 00:38:05,510
yes so we will be uh we plan to be in

1033
00:38:09,750 --> 00:38:08,240
communication with the spacecraft

1034
00:38:13,510 --> 00:38:09,760
until minutes before that final

1035
00:38:15,510 --> 00:38:13,520
occultation so up until about maybe 10

1036
00:38:17,670 --> 00:38:15,520
to 15 minutes before

1037
00:38:19,270 --> 00:38:17,680
messenger makes its final plunge into

1038
00:38:21,109 --> 00:38:19,280

the planet we will be in communication

1039
00:38:23,589 --> 00:38:21,119
with the spacecraft we will be

1040
00:38:27,430 --> 00:38:23,599
collecting data off of its solid state

1041
00:38:33,270 --> 00:38:30,870
the crater itself current

1042
00:38:35,510 --> 00:38:33,280
projections suggest um given that we're

1043
00:38:37,270 --> 00:38:35,520
coming in at the 3.9 kilometers per

1044
00:38:39,750 --> 00:38:37,280
second obviously it's extremely high

1045
00:38:41,510 --> 00:38:39,760
velocity uh the spacecraft itself is on

1046
00:38:43,430 --> 00:38:41,520
the order of about three meters across

1047
00:38:45,910 --> 00:38:43,440
wing tip to wingtip but we will create

1048
00:38:48,150 --> 00:38:45,920
about a 16 meter crater on the surface

1049
00:38:49,750 --> 00:38:48,160
of mercury

1050
00:38:53,190 --> 00:38:49,760
i don't know how deep the cradle will be

1051
00:38:58,790 --> 00:38:56,870
can i add one thing to that answer

1052
00:39:01,510 --> 00:38:58,800
on mercury some of the brightest

1053
00:39:04,069 --> 00:39:01,520
deposits on the surface are young impact

1054
00:39:05,910 --> 00:39:04,079
craters and we know that there are a

1055
00:39:07,670 --> 00:39:05,920
variety of processes that serve to

1056
00:39:09,030 --> 00:39:07,680
darken the surface

1057
00:39:11,109 --> 00:39:09,040
collectively known as space weathering

1058
00:39:13,430 --> 00:39:11,119
that operate on on the moon and other

1059
00:39:15,589 --> 00:39:13,440
airless bodies like asteroids on mercury

1060
00:39:18,390 --> 00:39:15,599
they seem to operate faster than on any

1061
00:39:20,310 --> 00:39:18,400
other body because the flux of

1062
00:39:22,550 --> 00:39:20,320
micrometeoroids or dust

1063
00:39:23,910 --> 00:39:22,560

and the the

1064
00:39:26,710 --> 00:39:23,920
flux of

1065
00:39:28,150 --> 00:39:26,720
energetic ions and electrons is higher

1066
00:39:29,990 --> 00:39:28,160
on mercury than it is on those other

1067
00:39:32,790 --> 00:39:30,000
bodies um

1068
00:39:36,230 --> 00:39:32,800
but we still don't know the the rates of

1069
00:39:38,790 --> 00:39:36,240
of these processes very well so having a

1070
00:39:39,910 --> 00:39:38,800
an impact grader even a small one

1071
00:39:43,910 --> 00:39:39,920
whose

1072
00:39:45,670 --> 00:39:43,920
origin date is precisely known

1073
00:39:47,030 --> 00:39:45,680
will be an important benchmark and there

1074
00:39:48,950 --> 00:39:47,040
is another

1075
00:39:51,829 --> 00:39:48,960
mission heading to mercury in a couple

1076
00:39:54,150 --> 00:39:51,839
of years and that's the beppy colombo

1077
00:39:56,069 --> 00:39:54,160
mission which is a joint mission of the

1078
00:39:58,390 --> 00:39:56,079
european space agency and the japan

1079
00:39:59,750 --> 00:39:58,400
aerospace exploration agency and it's

1080
00:40:01,109 --> 00:39:59,760
carrying in nasa

1081
00:40:05,829 --> 00:40:01,119
uh

1082
00:40:10,309 --> 00:40:05,839
launching i believe in 2017 and due to

1083
00:40:12,870 --> 00:40:10,319
arrival january 2024 uh and so uh they

1084
00:40:14,630 --> 00:40:12,880
will be very interested in the answer to

1085
00:40:17,430 --> 00:40:14,640
uh that question as to where this crater

1086
00:40:19,349 --> 00:40:17,440
is and we'll be looking for uh signs of

1087
00:40:21,109 --> 00:40:19,359
this crater and and if they can make

1088
00:40:23,270 --> 00:40:21,119

measurements of it uh they'll know

1089
00:40:24,950 --> 00:40:23,280
precisely how long that region has been

1090
00:40:26,950 --> 00:40:24,960
exposed to space and that will be an

1091
00:40:29,430 --> 00:40:26,960
important uh

1092
00:40:32,470 --> 00:40:29,440
uh an important study that

1093
00:40:34,790 --> 00:40:32,480
that comes a decade from now

1094
00:40:36,390 --> 00:40:34,800
our next caller discovery channel irene

1095
00:40:38,630 --> 00:40:36,400
clarks

1096
00:40:39,829 --> 00:40:38,640
irene uh welcome to the celebration how

1097
00:40:41,670 --> 00:40:39,839
are you

1098
00:40:44,150 --> 00:40:41,680
i'm good thanks very much um my

1099
00:40:46,710 --> 00:40:44,160
questions for dr solomon um

1100
00:40:49,190 --> 00:40:46,720
so you've had four years a month and

1101
00:40:52,390 --> 00:40:49,200
and six weeks and now we're down to the

1102
00:40:54,390 --> 00:40:52,400
final days um what is it that you'd like

1103
00:40:56,390 --> 00:40:54,400
to see out of the

1104
00:40:58,870 --> 00:40:56,400
from the science perspective

1105
00:41:02,470 --> 00:40:58,880
in this last last few laps around the

1106
00:41:08,790 --> 00:41:05,270
we've had two uh our primary objectives

1107
00:41:10,069 --> 00:41:08,800
for the last month of operations and uh

1108
00:41:11,990 --> 00:41:10,079
we're going to have to be analyzing the

1109
00:41:13,030 --> 00:41:12,000
data for a while to see how well we did

1110
00:41:15,109 --> 00:41:13,040
but one

1111
00:41:16,870 --> 00:41:15,119
was mentioned by helene and that is to

1112
00:41:19,430 --> 00:41:16,880
look for

1113
00:41:21,750 --> 00:41:19,440

portions of mercury's crust that are

1114
00:41:24,150 --> 00:41:21,760
magnetized

1115
00:41:26,950 --> 00:41:24,160
the the problem at mercury in finding

1116
00:41:29,270 --> 00:41:26,960
magnetized crust which is easy to see at

1117
00:41:30,870 --> 00:41:29,280
mars and almost as easy to see at the

1118
00:41:32,150 --> 00:41:30,880
moon is that

1119
00:41:34,230 --> 00:41:32,160
on mercury

1120
00:41:36,470 --> 00:41:34,240
there are also magnetic fields generated

1121
00:41:37,910 --> 00:41:36,480
by current systems in the magnetosphere

1122
00:41:39,670 --> 00:41:37,920
and because the magnetosphere is so

1123
00:41:41,030 --> 00:41:39,680
small those current systems are close to

1124
00:41:43,829 --> 00:41:41,040
the surface

1125
00:41:45,750 --> 00:41:43,839
and therefore seeing a small crustal

1126
00:41:47,910 --> 00:41:45,760
magnetic field is a real challenge to

1127
00:41:50,470 --> 00:41:47,920
separate it from the external fields

1128
00:41:52,150 --> 00:41:50,480
that are competing in magnitude with the

1129
00:41:54,069 --> 00:41:52,160
with the internal field and we have to

1130
00:41:56,069 --> 00:41:54,079
get very close to the surface if we're

1131
00:41:58,470 --> 00:41:56,079
going to have a chance and and the other

1132
00:42:00,550 --> 00:41:58,480
uh primary objective of this last month

1133
00:42:01,910 --> 00:42:00,560
was to look at some of these polar

1134
00:42:04,069 --> 00:42:01,920
deposits

1135
00:42:06,550 --> 00:42:04,079
with our neutron spectrometer

1136
00:42:08,309 --> 00:42:06,560
in the animation that i showed we were

1137
00:42:10,790 --> 00:42:08,319
looking at very

1138
00:42:12,790 --> 00:42:10,800

broad averages of the neutron flux over

1139
00:42:14,550 --> 00:42:12,800
the north polar region

1140
00:42:16,550 --> 00:42:14,560
simply because the field of view of the

1141
00:42:17,990 --> 00:42:16,560
neutron spectrometer included most of

1142
00:42:20,150 --> 00:42:18,000
the north polar region when it was

1143
00:42:22,309 --> 00:42:20,160
flying overhead but as we

1144
00:42:24,870 --> 00:42:22,319
reduce the altitude we have a few

1145
00:42:28,230 --> 00:42:24,880
chances to look into

1146
00:42:30,470 --> 00:42:28,240
craters that have polar deposits and and

1147
00:42:33,349 --> 00:42:30,480
measure the neutron flux over individual

1148
00:42:35,030 --> 00:42:33,359
craters so uh that's a rare opportunity

1149
00:42:37,190 --> 00:42:35,040
that is only enabled by these low

1150
00:42:40,309 --> 00:42:37,200
altitude observations so irene those are

1151
00:42:45,829 --> 00:42:41,670
we'll be working on these data for a

1152
00:42:47,190 --> 00:42:45,839
long time but we hope that we can uh

1153
00:42:49,750 --> 00:42:47,200
declare that these goals were

1154
00:42:50,630 --> 00:42:49,760
successfully met uh within a few months

1155
00:42:53,430 --> 00:42:50,640
time

1156
00:42:55,750 --> 00:42:53,440
now these um uh crustal magnetic fields

1157
00:42:58,150 --> 00:42:55,760
that are trapped in the soils or

1158
00:43:00,790 --> 00:42:58,160
are during a time an era when mercury in

1159
00:43:02,710 --> 00:43:00,800
its past had a magnetic field perhaps

1160
00:43:05,430 --> 00:43:02,720
in a different orientation

1161
00:43:08,950 --> 00:43:05,440
and therefore you know when the

1162
00:43:11,030 --> 00:43:08,960
magma the volcanic material solidifies

1163
00:43:13,349 --> 00:43:11,040

captures that magnetic field direction

1164
00:43:15,829 --> 00:43:13,359
and then the field continues to evolve

1165
00:43:17,270 --> 00:43:15,839
that tells us a lot about its history so

1166
00:43:19,670 --> 00:43:17,280
i'm really excited about those

1167
00:43:23,030 --> 00:43:19,680
observations of course

1168
00:43:25,910 --> 00:43:23,040
well without the detection of crustal

1169
00:43:28,069 --> 00:43:25,920
magnetic anomalies all we know for sure

1170
00:43:30,790 --> 00:43:28,079
is that mercury had a magnetic field 40

1171
00:43:33,510 --> 00:43:30,800
years ago because mariner 10 first

1172
00:43:35,030 --> 00:43:33,520
observant and

1173
00:43:36,309 --> 00:43:35,040
mercury has a magnetic field today

1174
00:43:39,030 --> 00:43:36,319
because we've been measuring it for the

1175
00:43:41,270 --> 00:43:39,040
last four years so that's 40 years of a

1176
00:43:42,790 --> 00:43:41,280
temporal baseline that could go back 4

1177
00:43:45,030 --> 00:43:42,800
billion years right

1178
00:43:46,390 --> 00:43:45,040
so stay tuned we're working on those

1179
00:43:50,390 --> 00:43:46,400
data

1180
00:43:54,710 --> 00:43:52,230
i like that little debate that went on

1181
00:43:55,510 --> 00:43:54,720
there oh yes

1182
00:43:57,510 --> 00:43:55,520
um

1183
00:43:58,950 --> 00:43:57,520
we only have a little more time left i

1184
00:43:59,990 --> 00:43:58,960
know a lot of folks are sending in

1185
00:44:01,990 --> 00:44:00,000
questions but we're going to get to

1186
00:44:04,950 --> 00:44:02,000
those questions throughout the day

1187
00:44:06,630 --> 00:44:04,960
singing around at hashtag ask nasa i'ma

1188
00:44:09,109 --> 00:44:06,640

go back to my colleague here sharon

1189
00:44:11,589 --> 00:44:09,119
sharon uh what's coming up here lots of

1190
00:44:14,069 --> 00:44:11,599
buzz here we have uh two questions

1191
00:44:15,430 --> 00:44:14,079
actually from roman that go together um

1192
00:44:16,470 --> 00:44:15,440
and a couple of people have been asking

1193
00:44:18,470 --> 00:44:16,480
about this

1194
00:44:20,710 --> 00:44:18,480
will the solar sailing

1195
00:44:22,390 --> 00:44:20,720
was the solar sailing planned or is this

1196
00:44:24,870 --> 00:44:22,400
something that you adapted to during the

1197
00:44:27,190 --> 00:44:24,880
mission and could a future mission to

1198
00:44:29,670 --> 00:44:27,200
mercury use a larger solar sail to

1199
00:44:30,870 --> 00:44:29,680
reduce the need for fuel

1200
00:44:32,630 --> 00:44:30,880
so i think everyone's going to look at

1201
00:44:35,270 --> 00:44:32,640
me for this question

1202
00:44:37,589 --> 00:44:35,280
we already are

1203
00:44:40,069 --> 00:44:37,599
um no it certainly was not planned uh it

1204
00:44:41,829 --> 00:44:40,079
was sort of a happy coincidence uh that

1205
00:44:42,790 --> 00:44:41,839
allowed us to do this

1206
00:44:45,109 --> 00:44:42,800
um

1207
00:44:47,750 --> 00:44:45,119
and we we actually didn't exploit this

1208
00:44:50,069 --> 00:44:47,760
technique until our first mercury flyby

1209
00:44:51,589 --> 00:44:50,079
and it was only a couple of weeks before

1210
00:44:54,390 --> 00:44:51,599
the first mercury flyby where we

1211
00:44:56,390 --> 00:44:54,400
realized that this might be a usable

1212
00:44:58,069 --> 00:44:56,400
option for eliminating some of these

1213
00:45:00,950 --> 00:44:58,079

propulsive maneuvers

1214
00:45:03,589 --> 00:45:00,960
that demonstration worked very nicely

1215
00:45:05,190 --> 00:45:03,599
although it was not as complicated as we

1216
00:45:06,870 --> 00:45:05,200
got to be later in the mission when we

1217
00:45:08,710 --> 00:45:06,880
had a little bit more time to do it more

1218
00:45:09,829 --> 00:45:08,720
carefully and considered

1219
00:45:12,390 --> 00:45:09,839
certainly

1220
00:45:14,630 --> 00:45:12,400
any spacecraft that is going to visit

1221
00:45:16,710 --> 00:45:14,640
mercury is going to experience a great

1222
00:45:18,550 --> 00:45:16,720
deal of solar radiation

1223
00:45:20,390 --> 00:45:18,560
whether a spacecraft takes advantage of

1224
00:45:23,430 --> 00:45:20,400
that solar radiation is of course up to

1225
00:45:24,710 --> 00:45:23,440
the designers but we do believe uh

1226
00:45:26,550 --> 00:45:24,720
that it's certainly a technique that

1227
00:45:29,030 --> 00:45:26,560
could be used now messenger wasn't

1228
00:45:31,109 --> 00:45:29,040
making drastic changes to its trajectory

1229
00:45:33,030 --> 00:45:31,119
it's certainly a small spacecraft

1230
00:45:34,790 --> 00:45:33,040
but we didn't need drastic changes to

1231
00:45:36,069 --> 00:45:34,800
our trajectory for this particular

1232
00:45:38,150 --> 00:45:36,079
application

1233
00:45:39,589 --> 00:45:38,160
if you want to get to mercury with only

1234
00:45:41,430 --> 00:45:39,599
a solar sail you certainly need

1235
00:45:43,829 --> 00:45:41,440
something that probably is outside our

1236
00:45:45,349 --> 00:45:43,839
current technology base but you know

1237
00:45:46,870 --> 00:45:45,359
many people are starting to think

1238
00:45:48,309 --> 00:45:46,880

through those types of missions and

1239
00:45:49,829 --> 00:45:48,319
explore the technology that would be

1240
00:45:51,349 --> 00:45:49,839
required

1241
00:45:53,430 --> 00:45:51,359
you know from my perspective this is

1242
00:45:55,510 --> 00:45:53,440
really one of the great things about

1243
00:45:57,990 --> 00:45:55,520
nasa and and the teams that really

1244
00:45:59,750 --> 00:45:58,000
understand uh not only your spacecraft

1245
00:46:00,870 --> 00:45:59,760
systems but also working with the

1246
00:46:02,309 --> 00:46:00,880
scientists to understand the

1247
00:46:05,349 --> 00:46:02,319
environments they're in

1248
00:46:07,510 --> 00:46:05,359
uh what constantly surprised me uh quite

1249
00:46:09,030 --> 00:46:07,520
pleasantly although sean and i would

1250
00:46:10,950 --> 00:46:09,040
joke about it a little bit is sean would

1251
00:46:13,030 --> 00:46:10,960
call me up and say hey we got another so

1252
00:46:15,910 --> 00:46:13,040
much fuel we can stay up another year

1253
00:46:18,550 --> 00:46:15,920
and uh that was really great uh all all

1254
00:46:21,430 --> 00:46:18,560
unanticipated all unplanned but that's

1255
00:46:23,589 --> 00:46:21,440
just absolute genius uh to be able to

1256
00:46:26,790 --> 00:46:23,599
take and use these techniques to benefit

1257
00:46:28,950 --> 00:46:26,800
the mission and and more so the science

1258
00:46:31,349 --> 00:46:28,960
and that makes uh that makes messenger

1259
00:46:33,510 --> 00:46:31,359
particularly special

1260
00:46:37,030 --> 00:46:33,520
for us to understand learn about and

1261
00:46:38,470 --> 00:46:37,040
then apply to our next missions

1262
00:46:39,910 --> 00:46:38,480
okay before we go back to the phone

1263
00:46:41,990 --> 00:46:39,920

lines uh we're going to take one more

1264
00:46:43,750 --> 00:46:42,000
question from social media then go to

1265
00:46:46,230 --> 00:46:43,760
the phone lines and then we're going to

1266
00:46:47,190 --> 00:46:46,240
begin this wrap up the celebration

1267
00:46:49,510 --> 00:46:47,200
sharon

1268
00:46:51,750 --> 00:46:49,520
great our last question comes from ryan

1269
00:46:57,430 --> 00:46:51,760
um what is the biggest unanswered

1270
00:46:57,440 --> 00:47:02,390
the biggest

1271
00:47:02,400 --> 00:47:07,430
ten brian

1272
00:47:14,390 --> 00:47:08,950
you haven't solved them all so there is

1273
00:47:19,750 --> 00:47:15,990
um

1274
00:47:22,790 --> 00:47:19,760
there are several questions that i think

1275
00:47:25,670 --> 00:47:22,800
can best be answered by some future

1276
00:47:27,430 --> 00:47:25,680
lander mission

1277
00:47:29,510 --> 00:47:27,440
anytime you measure the

1278
00:47:31,750 --> 00:47:29,520
composition remotely you'd like to have

1279
00:47:33,829 --> 00:47:31,760
some ground truth

1280
00:47:35,990 --> 00:47:33,839
of the composition

1281
00:47:38,790 --> 00:47:36,000
unlike mars unlike the moon we have no

1282
00:47:40,549 --> 00:47:38,800
samples of mercury in our meteorite

1283
00:47:42,630 --> 00:47:40,559
collection

1284
00:47:45,750 --> 00:47:42,640
so a lander could give us that ground

1285
00:47:49,109 --> 00:47:45,760
truth and of course i'd love to know

1286
00:47:52,549 --> 00:47:49,119
what that dark material is in the polar

1287
00:47:54,309 --> 00:47:52,559
craters that host water ice

1288
00:47:56,630 --> 00:47:54,319

it's it's uh

1289
00:47:58,230 --> 00:47:56,640
educated guess right now that it's

1290
00:48:01,030 --> 00:47:58,240
organic material from the outer solar

1291
00:48:02,069 --> 00:48:01,040
system but if we could send uh

1292
00:48:03,109 --> 00:48:02,079
some

1293
00:48:05,910 --> 00:48:03,119
uh

1294
00:48:08,069 --> 00:48:05,920
in-situ and analytical

1295
00:48:09,990 --> 00:48:08,079
instruments on a lander that could

1296
00:48:11,910 --> 00:48:10,000
actually sample that stuff dig through

1297
00:48:15,109 --> 00:48:11,920
and make sure there is ice underneath

1298
00:48:17,190 --> 00:48:15,119
and then tell us what that material is

1299
00:48:19,109 --> 00:48:17,200
i think that would be a terrific mission

1300
00:48:22,309 --> 00:48:19,119
so i i think you might get a different

1301
00:48:24,950 --> 00:48:22,319
answer from different scientists but uh

1302
00:48:27,109 --> 00:48:24,960
for my money ryan that's my answer

1303
00:48:30,950 --> 00:48:27,119
now from my perspective that's that's

1304
00:48:36,069 --> 00:48:33,670
and and the reason why is in planetary

1305
00:48:38,549 --> 00:48:36,079
science over the last 50 years we've

1306
00:48:43,190 --> 00:48:38,559
really put in place a very methodical

1307
00:48:45,829 --> 00:48:43,200
program where we fly by we orbit we land

1308
00:48:47,910 --> 00:48:45,839
we rove and we return samples and that

1309
00:48:50,230 --> 00:48:47,920
has served us incredibly well as we

1310
00:48:52,790 --> 00:48:50,240
learn about these bodies and study them

1311
00:48:55,510 --> 00:48:52,800
to the detail that we need to

1312
00:48:56,870 --> 00:48:55,520
we've done our flybys with messenger

1313
00:48:58,950 --> 00:48:56,880

but before then

1314
00:49:01,430 --> 00:48:58,960
indeed the the mariner spacecraft

1315
00:49:03,430 --> 00:49:01,440
mariner 10 went by a couple times

1316
00:49:05,430 --> 00:49:03,440
now we've gotten into orbit and indeed

1317
00:49:06,390 --> 00:49:05,440
that next step is getting down to the

1318
00:49:08,630 --> 00:49:06,400
surface

1319
00:49:10,549 --> 00:49:08,640
and that really propels our science

1320
00:49:12,150 --> 00:49:10,559
forward

1321
00:49:14,069 --> 00:49:12,160
we're going to take one more question

1322
00:49:16,710 --> 00:49:14,079
from the phone and then my colleague

1323
00:49:18,549 --> 00:49:16,720
here sharon has a message to the entire

1324
00:49:19,750 --> 00:49:18,559
messenger team that would be certainly

1325
00:49:22,390 --> 00:49:19,760
appropriate

1326
00:49:24,150 --> 00:49:22,400
and then we have a pretty special ending

1327
00:49:25,109 --> 00:49:24,160
for the celebration so let's go back to

1328
00:49:27,670 --> 00:49:25,119
the phone

1329
00:49:30,309 --> 00:49:27,680
to kelly beatty from sky and telescope

1330
00:49:32,230 --> 00:49:30,319
welcome to the celebration kelly

1331
00:49:34,549 --> 00:49:32,240
and thanks very much dwayne um this is

1332
00:49:37,030 --> 00:49:34,559
for sean um you spoke of the bulk

1333
00:49:38,630 --> 00:49:37,040
composition of mercury as being volatile

1334
00:49:40,870 --> 00:49:38,640
rich and yet you've also talked a little

1335
00:49:42,549 --> 00:49:40,880
bit about things that might be veneering

1336
00:49:45,349 --> 00:49:42,559
on the surface in the polls the whole

1337
00:49:47,270 --> 00:49:45,359
planet is dark maybe from carbon can you

1338
00:49:50,150 --> 00:49:47,280

walk us through the argument of why you

1339
00:49:53,349 --> 00:49:50,160
think the bulk composition of mercury is

1340
00:49:54,950 --> 00:49:53,359
volatile rich thank you

1341
00:49:55,910 --> 00:49:54,960
kelly always asks tough science

1342
00:49:56,710 --> 00:49:55,920
questions

1343
00:49:58,630 --> 00:49:56,720
he's

1344
00:50:00,870 --> 00:49:58,640
well trained

1345
00:50:02,230 --> 00:50:00,880
went to my alma mater

1346
00:50:03,510 --> 00:50:02,240
but

1347
00:50:05,829 --> 00:50:03,520
here are some of the arguments i would

1348
00:50:10,390 --> 00:50:05,839
use kelly

1349
00:50:15,990 --> 00:50:13,270
it would be hard to explain many of the

1350
00:50:17,910 --> 00:50:16,000
chemical variations and elemental

1351
00:50:19,109 --> 00:50:17,920
variations that we see in terms of a

1352
00:50:20,390 --> 00:50:19,119
veneer

1353
00:50:21,910 --> 00:50:20,400
because

1354
00:50:23,270 --> 00:50:21,920
many of the

1355
00:50:26,870 --> 00:50:23,280
elemental

1356
00:50:27,829 --> 00:50:26,880
measurements relate to geological units

1357
00:50:29,750 --> 00:50:27,839
um

1358
00:50:32,230 --> 00:50:29,760
uh many of the characteristics

1359
00:50:34,549 --> 00:50:32,240
associated with color uh and spectral

1360
00:50:37,030 --> 00:50:34,559
reflectance uh relate to geological

1361
00:50:38,870 --> 00:50:37,040
units for instance uh i'm not sure

1362
00:50:40,950 --> 00:50:38,880
everybody can see what i see so i guess

1363
00:50:43,589 --> 00:50:40,960

i won't point to that but

1364
00:50:45,670 --> 00:50:43,599
an example is the the low reflectance

1365
00:50:48,069 --> 00:50:45,680
material which was identified on the

1366
00:50:50,950 --> 00:50:48,079
basis of spectral mapping is all

1367
00:50:52,790 --> 00:50:50,960
associated with excavated material

1368
00:50:54,470 --> 00:50:52,800
material that was once in depth and has

1369
00:50:57,349 --> 00:50:54,480
been brought to the surface by by

1370
00:51:00,069 --> 00:50:57,359
impacts and and therefore uh can't be

1371
00:51:02,150 --> 00:51:00,079
where it is now because of some veneer

1372
00:51:04,069 --> 00:51:02,160
uh the abundances we're seeing of some

1373
00:51:05,190 --> 00:51:04,079
of these volatile elements are

1374
00:51:09,349 --> 00:51:05,200
are

1375
00:51:11,990 --> 00:51:09,359
with each other or with other major

1376
00:51:14,390 --> 00:51:12,000
elements like iron as they would if they

1377
00:51:16,549 --> 00:51:14,400
came from common solar system materials

1378
00:51:18,950 --> 00:51:16,559
and were laid down as a veneer moreover

1379
00:51:21,750 --> 00:51:18,960
there are geological processes that tell

1380
00:51:22,790 --> 00:51:21,760
us their volatiles at depth one of them

1381
00:51:26,069 --> 00:51:22,800
is

1382
00:51:28,630 --> 00:51:26,079
are the hollows deposits which are

1383
00:51:30,470 --> 00:51:28,640
almost exclusively confined to impact

1384
00:51:32,630 --> 00:51:30,480
craters

1385
00:51:35,030 --> 00:51:32,640
and represent material that's unstable

1386
00:51:37,750 --> 00:51:35,040
at the surface of mercury

1387
00:51:38,790 --> 00:51:37,760
but presumably were stable at some depth

1388
00:51:41,670 --> 00:51:38,800

and

1389
00:51:44,069 --> 00:51:41,680
went through some recent loss process

1390
00:51:45,750 --> 00:51:44,079
only when that material was excavated by

1391
00:51:47,349 --> 00:51:45,760
an impact crater brought to the surface

1392
00:51:48,950 --> 00:51:47,359
and then exposed to mercury service

1393
00:51:52,390 --> 00:51:48,960
conditions

1394
00:51:56,150 --> 00:51:52,400
uh secondly uh among the volcanic

1395
00:51:59,430 --> 00:51:56,160
deposits of mercury are uh

1396
00:52:02,069 --> 00:51:59,440
dozens of pyroclastic deposits

1397
00:52:04,390 --> 00:52:02,079
these are uh by analogy with similar

1398
00:52:06,230 --> 00:52:04,400
deposits on the moon

1399
00:52:09,109 --> 00:52:06,240
identified on the basis of their

1400
00:52:10,309 --> 00:52:09,119
brightness on the basis of the

1401
00:52:12,710 --> 00:52:10,319
differences in color from their

1402
00:52:13,670 --> 00:52:12,720
surroundings the central

1403
00:52:15,430 --> 00:52:13,680
vent

1404
00:52:17,030 --> 00:52:15,440
that

1405
00:52:20,069 --> 00:52:17,040
appears to be the source of material

1406
00:52:22,230 --> 00:52:20,079
that mantles the surrounding terrain

1407
00:52:25,430 --> 00:52:22,240
pyroclastic deposits are products of

1408
00:52:27,829 --> 00:52:25,440
explosive volcanism that on earth and on

1409
00:52:29,910 --> 00:52:27,839
the moon and other bodies is driven by

1410
00:52:33,190 --> 00:52:29,920
the release of volatiles from a rising

1411
00:52:35,670 --> 00:52:33,200
magma as pressure uh is reduced uh as

1412
00:52:38,150 --> 00:52:35,680
this magma gets closer to the surface

1413
00:52:40,309 --> 00:52:38,160

and so somewhere along the path of

1414
00:52:42,549 --> 00:52:40,319
erupting magmas at least on these dozens

1415
00:52:44,710 --> 00:52:42,559
of sites of pyroclastic deposits there

1416
00:52:46,390 --> 00:52:44,720
must have been volatiles in the interior

1417
00:52:49,190 --> 00:52:46,400
that were

1418
00:52:51,349 --> 00:52:49,200
part of the magma system and

1419
00:52:53,990 --> 00:52:51,359
were released from the magma and helped

1420
00:52:55,349 --> 00:52:54,000
drive these explosive volcanic eruptions

1421
00:52:57,670 --> 00:52:55,359
so you have the measurements of the

1422
00:53:01,270 --> 00:52:57,680
volatile species at the surface

1423
00:53:03,430 --> 00:53:01,280
which don't match any particular

1424
00:53:06,069 --> 00:53:03,440
other object in the solar system that

1425
00:53:08,309 --> 00:53:06,079
that could have

1426
00:53:10,950 --> 00:53:08,319
been a source of a veneer and then you

1427
00:53:13,030 --> 00:53:10,960
have geological processes which point to

1428
00:53:14,950 --> 00:53:13,040
interior volatiles in the hollows and

1429
00:53:17,190 --> 00:53:14,960
the pyroclastic deposits so i think

1430
00:53:19,349 --> 00:53:17,200
kelly we're stuck with mercury having

1431
00:53:21,030 --> 00:53:19,359
volatiles in the interior as well as the

1432
00:53:23,349 --> 00:53:21,040
surface we're looking at more than a

1433
00:53:25,990 --> 00:53:23,359
veneer and we need to come up with a

1434
00:53:27,349 --> 00:53:26,000
with a model for mercury's formation

1435
00:53:29,670 --> 00:53:27,359
that accounts not only for its

1436
00:53:31,589 --> 00:53:29,680
anonymously high density presumably

1437
00:53:35,270 --> 00:53:31,599
because it's got a very high abundance

1438
00:53:36,870 --> 00:53:35,280

of iron metal occupying it excuse me its

1439
00:53:39,030 --> 00:53:36,880
core but

1440
00:53:41,910 --> 00:53:39,040
the process of planetary equation must

1441
00:53:45,589 --> 00:53:41,920
have involved the uh

1442
00:53:47,589 --> 00:53:45,599
accumulation and retention of uh

1443
00:53:49,190 --> 00:53:47,599
now at least four uh

1444
00:53:50,870 --> 00:53:49,200
elements that are

1445
00:53:52,710 --> 00:53:50,880
volatile under other

1446
00:53:55,109 --> 00:53:52,720
other systems like

1447
00:53:56,710 --> 00:53:55,119
potassium like sodium like sulfur and

1448
00:53:59,430 --> 00:53:56,720
like chlorine which is extremely

1449
00:54:00,710 --> 00:53:59,440
volatile so

1450
00:54:02,390 --> 00:54:00,720
i don't think we can get around it with

1451
00:54:04,309 --> 00:54:02,400
a veneer and

1452
00:54:06,390 --> 00:54:04,319
you and i can debate that

1453
00:54:08,549 --> 00:54:06,400
if you wish kelly but i think the

1454
00:54:09,750 --> 00:54:08,559
arguments are strong

1455
00:54:12,390 --> 00:54:09,760
okay

1456
00:54:14,470 --> 00:54:12,400
so before we close out uh sharon i i

1457
00:54:16,470 --> 00:54:14,480
think it'll be appropriate to share uh

1458
00:54:17,670 --> 00:54:16,480
what i think is the sentiment for all

1459
00:54:19,829 --> 00:54:17,680
the folks watching this across the

1460
00:54:21,109 --> 00:54:19,839
country and uh to the team that folks

1461
00:54:22,790 --> 00:54:21,119
are thinking

1462
00:54:24,630 --> 00:54:22,800
yeah we have one final comment this

1463
00:54:27,190 --> 00:54:24,640

comes from messenger the messenger

1464
00:54:28,870 --> 00:54:27,200
twitter handle and it says please give

1465
00:54:30,790 --> 00:54:28,880
my thanks to the team it's been a

1466
00:54:32,549 --> 00:54:30,800
wonderful and exciting trip

1467
00:54:40,150 --> 00:54:32,559
a nice hand for the messenger team

1468
00:54:43,990 --> 00:54:41,589
so ladies and gentlemen i want to thank

1469
00:54:46,630 --> 00:54:44,000
you for joining the celebration

1470
00:54:48,950 --> 00:54:46,640
uh congratulations to the messenger team

1471
00:54:51,190 --> 00:54:48,960
their commitment their determination one

1472
00:54:53,270 --> 00:54:51,200
of nasa's most successful

1473
00:54:54,069 --> 00:54:53,280
science projects

1474
00:54:56,630 --> 00:54:54,079
and

1475
00:54:59,030 --> 00:54:56,640
it's one of those times when it makes

1476
00:55:00,230 --> 00:54:59,040
you feel really good as nasa continues

1477
00:55:03,670 --> 00:55:00,240
its quest

1478
00:55:05,589 --> 00:55:03,680
to the social system and beyond

1479
00:55:08,069 --> 00:55:05,599
we're going to end with a video

1480
00:55:12,309 --> 00:55:08,079
which i think says it all

1481
00:55:16,630 --> 00:55:12,319
the music is by david dexter britain

1482
00:55:19,510 --> 00:55:18,309
it's not goodbye