1
00:00:21,029 --> 00:00:14,870
liftoff we have a liftoff 32 minutes

2
00:00:21,039 --> 00:00:37,190
tower cleared

3
00:00:37,200 --> 00:00:56,630
again

4
00:00:56,640 --> 00:01:01,910
one

5
00:01:06,789 --> 00:01:04,390
welcome to this edition of nasa images

6
00:01:09,109 --> 00:01:06,799
i'm lynn bondurant during this show

7
00:01:11,830 --> 00:01:09,119
we're focusing on results of spacecraft

8
00:01:14,630 --> 00:01:11,840
examination of comet halley and the

9
00:01:16,789 --> 00:01:14,640
seventh planet from the sun uranus

10
00:01:20,710 --> 00:01:16,799
let's begin with some images from uranus

11
00:01:22,950 --> 00:01:20,720
acquired in early 1986. the place is the

12
00:01:31,670 --> 00:01:22,960
nasa jet propulsion laboratory in

13
00:01:36,870 --> 00:01:34,789

well just about two minutes ago

14
00:01:37,910 --> 00:01:36,880
voyager 2 passed through its closest

15
00:01:45,510 --> 00:01:37,920
approach

16
00:01:53,510 --> 00:01:48,469
next speaker is dr bradford smith the

17
00:01:58,389 --> 00:01:55,910
just uh just for the moment let me show

18
00:02:00,230 --> 00:01:58,399
you a lower resolution

19
00:02:02,069 --> 00:02:00,240
image that we have

20
00:02:04,870 --> 00:02:02,079
so what you're seeing here is where it

21
00:02:06,789 --> 00:02:04,880
is very red you're seeing a lot of haze

22
00:02:09,270 --> 00:02:06,799
and where it's blue it's relatively free

23
00:02:11,350 --> 00:02:09,280
of haze and the first thing you notice

24
00:02:12,550 --> 00:02:11,360
is though is that as you look toward the

25
00:02:14,390 --> 00:02:12,560
limb of course you're going to be

26
00:02:16,070 --> 00:02:14,400
looking through more atmosphere and

27
00:02:17,750 --> 00:02:16,080
seeing more haze and so we see this

28
00:02:19,910 --> 00:02:17,760
brightish

29
00:02:22,070 --> 00:02:19,920
what we call limb brightening around the

30
00:02:23,750 --> 00:02:22,080
limb of the planet indicating looking

31
00:02:25,830 --> 00:02:23,760
into the atmosphere and seeing quite a

32
00:02:30,710 --> 00:02:25,840
bit of the particulates of haze that are

33
00:02:35,990 --> 00:02:32,869
i thought it might be a good time now to

34
00:02:37,270 --> 00:02:36,000
give a summary of what we've learned so

35
00:02:38,390 --> 00:02:37,280
far it's going to be a very brief

36
00:02:40,390 --> 00:02:38,400
summary and i'm certainly not going to

37
00:02:42,550 --> 00:02:40,400
be able to go into many details but at

38
00:02:44,150 --> 00:02:42,560

least just to review where we stand and

39
00:02:45,110 --> 00:02:44,160
what we've done over the last several

40
00:02:47,030 --> 00:02:45,120
hours

41
00:02:49,509 --> 00:02:47,040
we have been seeing the playback of

42
00:02:52,150 --> 00:02:49,519
recorded photographs taken primarily of

43
00:02:55,270 --> 00:02:52,160
the satellites the the major satellites

44
00:02:57,350 --> 00:02:55,280
the five satellites of uranus uh at the

45
00:02:58,470 --> 00:02:57,360
time that we passed by those most

46
00:03:00,869 --> 00:02:58,480
closely

47
00:03:03,830 --> 00:03:00,879
i think that i want to run through some

48
00:03:06,309 --> 00:03:03,840
of those i think we'll start out with

49
00:03:07,830 --> 00:03:06,319
this one of ariel this is a part of a

50
00:03:08,790 --> 00:03:07,840
mosaic

51
00:03:11,750 --> 00:03:08,800
of the

52
00:03:12,869 --> 00:03:11,760
satellites

53
00:03:14,710 --> 00:03:12,879
and

54
00:03:16,949 --> 00:03:14,720
the whole mosaic

55
00:03:18,710 --> 00:03:16,959
consisted of this in the upper left

56
00:03:21,750 --> 00:03:18,720
and one picture down the lower left and

57
00:03:23,110 --> 00:03:21,760
some of the more interesting things are

58
00:03:25,509 --> 00:03:23,120
such

59
00:03:26,710 --> 00:03:25,519
views as this

60
00:03:28,390 --> 00:03:26,720
a rather

61
00:03:30,149 --> 00:03:28,400
large bright area which is probably

62
00:03:32,630 --> 00:03:30,159
associated with a crater another crater

63
00:03:33,589 --> 00:03:32,640

here bright area

64
00:03:34,470 --> 00:03:33,599
and

65
00:03:36,550 --> 00:03:34,480
then

66
00:03:38,710 --> 00:03:36,560
moving on with another view of ariel the

67
00:03:40,070 --> 00:03:38,720
upper right and some of these canyons

68
00:03:42,390 --> 00:03:40,080
through here

69
00:03:44,470 --> 00:03:42,400
down around this area much of the

70
00:03:47,190 --> 00:03:44,480
unusual terrain and

71
00:03:50,149 --> 00:03:47,200
quite strange

72
00:03:52,149 --> 00:03:50,159
another view the lower right and this

73
00:03:53,910 --> 00:03:52,159
feature right here

74
00:03:54,710 --> 00:03:53,920
it appears that some of these valleys

75
00:03:57,190 --> 00:03:54,720
are

76
00:04:00,470 --> 00:03:59,030
uh there's been internal activity on

77
00:04:02,470 --> 00:04:00,480
these moons and a lot of it and it's

78
00:04:05,350 --> 00:04:02,480
surprising

79
00:04:07,350 --> 00:04:05,360
move on then to over on this is not as

80
00:04:09,429 --> 00:04:07,360
anywhere near as close as the as the one

81
00:04:11,509 --> 00:04:09,439
we just saw

82
00:04:14,710 --> 00:04:11,519
and miranda this is a somewhat distant

83
00:04:16,789 --> 00:04:14,720
shot of miranda we will get much closer

84
00:04:18,710 --> 00:04:16,799
unusual feature we saw there was called

85
00:04:20,550 --> 00:04:18,720
this chevron formation but we'll get a

86
00:04:23,189 --> 00:04:20,560
better picture of that as we get in

87
00:04:25,670 --> 00:04:23,199
closer to miranda

88
00:04:27,189 --> 00:04:25,680

because indeed we did get close this is

89
00:04:29,749 --> 00:04:27,199
the one where we saw things down to a

90
00:04:34,230 --> 00:04:29,759
kilometer resolution and structure here

91
00:04:36,230 --> 00:04:34,240
in miranda which is quite quite amazing

92
00:04:37,749 --> 00:04:36,240
the black dropout across the middle here

93
00:04:39,350 --> 00:04:37,759
we believe is somewhere in the

94
00:04:41,030 --> 00:04:39,360
transmission and since this is played

95
00:04:42,629 --> 00:04:41,040
back from a tape recorder another

96
00:04:45,909 --> 00:04:42,639
playback will recover the information

97
00:04:48,950 --> 00:04:47,110
here a

98
00:04:51,030 --> 00:04:48,960
curious flow of material down in this

99
00:04:53,430 --> 00:04:51,040
direction that's what it appears to be

100
00:04:54,710 --> 00:04:53,440
uh but of course it was further analysis

101
00:04:56,390 --> 00:04:54,720
to see what it is but something's been

102
00:04:57,350 --> 00:04:56,400
going on in miranda it's a very small

103
00:05:00,230 --> 00:04:57,360
moon

104
00:05:02,070 --> 00:05:00,240
uh 500 kilometers across and uh

105
00:05:03,430 --> 00:05:02,080
just to have this much activity in such

106
00:05:04,230 --> 00:05:03,440
a moon is quite different than what we

107
00:05:06,150 --> 00:05:04,240
saw

108
00:05:08,550 --> 00:05:06,160
for example in the moons of saturn

109
00:05:11,029 --> 00:05:08,560
another part of the mosaic still another

110
00:05:11,990 --> 00:05:11,039
part again very curious markings on the

111
00:05:13,430 --> 00:05:12,000
surface

112
00:05:15,510 --> 00:05:13,440
and right in the middle the chevron we

113
00:05:18,629 --> 00:05:15,520

saw at a great distance is now

114
00:05:22,629 --> 00:05:20,710
what is it well further analysis may

115
00:05:24,629 --> 00:05:22,639
tell we hope

116
00:05:29,029 --> 00:05:24,639
and then backing off with a wide-angle

117
00:05:31,749 --> 00:05:29,039
lens to get the comp complete picture

118
00:05:33,590 --> 00:05:31,759
and then looking back toward uranus and

119
00:05:34,950 --> 00:05:33,600
let's now talk a little bit

120
00:05:38,230 --> 00:05:34,960
about all the other things we've seen

121
00:05:39,350 --> 00:05:38,240
besides photographing the satellites

122
00:05:41,110 --> 00:05:39,360
we have

123
00:05:43,830 --> 00:05:41,120
discovered uh

124
00:05:45,110 --> 00:05:43,840
one more small satellite making ten in

125
00:05:48,390 --> 00:05:45,120
all that have been discovered by the

126
00:05:50,870 --> 00:05:48,400
voyager and its approach and near miss

127
00:05:53,510 --> 00:05:50,880
of or close approach to the planet

128
00:05:56,310 --> 00:05:53,520
uranus we also discovered another ring

129
00:05:59,590 --> 00:05:56,320
above so that makes a total of 10

130
00:06:01,749 --> 00:05:59,600
small moons discovered and 10 rings uh

131
00:06:03,990 --> 00:06:01,759
one discovered by voyage by voyager the

132
00:06:06,790 --> 00:06:04,000
other were known previously this is a

133
00:06:08,710 --> 00:06:06,800
ring picture taken from on the approach

134
00:06:11,590 --> 00:06:08,720
to uranus

135
00:06:13,590 --> 00:06:11,600
and you can see the major the i think

136
00:06:15,670 --> 00:06:13,600
this is the epsilon ring is a bright one

137
00:06:17,909 --> 00:06:15,680
and then some others inside of it we

138
00:06:20,230 --> 00:06:17,919

also tried another one going when we got

139
00:06:21,990 --> 00:06:20,240
behind the planet with the sun shining

140
00:06:23,909 --> 00:06:22,000
through the rings toward

141
00:06:25,270 --> 00:06:23,919
the the voyager spacecraft to take a

142
00:06:27,749 --> 00:06:25,280
picture then

143
00:06:29,670 --> 00:06:27,759
we expected to see a very bright glimmer

144
00:06:30,790 --> 00:06:29,680
because of the very small particles in

145
00:06:33,590 --> 00:06:30,800
the ring which

146
00:06:36,070 --> 00:06:33,600
when this backlighting arrangement would

147
00:06:38,070 --> 00:06:36,080
tend to glow just as when you see dust

148
00:06:39,590 --> 00:06:38,080
motes in the sunlight shining through a

149
00:06:41,110 --> 00:06:39,600
window towards you you can see lots more

150
00:06:43,029 --> 00:06:41,120
dust than you can if you actually look

151
00:06:45,430 --> 00:06:43,039
at from this point of view of the sun

152
00:06:47,670 --> 00:06:45,440
small particles tend to scatter light

153
00:06:49,350 --> 00:06:47,680
directly forward keep it going

154
00:06:51,189 --> 00:06:49,360
surprisingly enough we saw very little

155
00:06:52,469 --> 00:06:51,199
in that from that viewpoint which is a

156
00:06:53,749 --> 00:06:52,479
bit of a mystery how come there's a

157
00:06:55,749 --> 00:06:53,759
little dust

158
00:06:58,150 --> 00:06:55,759
we've measured the magnetic field now we

159
00:06:58,950 --> 00:06:58,160
it was very almost before almost we were

160
00:07:00,950 --> 00:06:58,960
almost

161
00:07:02,710 --> 00:07:00,960
two uranus before we discovered that

162
00:07:04,870 --> 00:07:02,720
there was indeed a magnetic field if it

163
00:07:06,790 --> 00:07:04,880

hadn't had no magnetic field that would

164
00:07:08,230 --> 00:07:06,800
have been a real problem but there is

165
00:07:10,070 --> 00:07:08,240
it's about 15 percent weaker than the

166
00:07:12,070 --> 00:07:10,080
earth's on the surface

167
00:07:15,189 --> 00:07:12,080
as curious thing about it is this uranus

168
00:07:16,870 --> 00:07:15,199
has its axis pointed pretty much

169
00:07:17,830 --> 00:07:16,880
it's pole south pole by committee

170
00:07:19,189 --> 00:07:17,840
decision

171
00:07:21,189 --> 00:07:19,199
pointed toward the sun so if the sun's

172
00:07:23,430 --> 00:07:21,199
over there that's where the

173
00:07:26,710 --> 00:07:23,440
this pole is spinning around like this

174
00:07:29,430 --> 00:07:26,720
on that axis the magnetic the magnetic

175
00:07:31,350 --> 00:07:29,440
field however is on a pole at an angle

176
00:07:33,589 --> 00:07:31,360
55 degrees so as

177
00:07:36,230 --> 00:07:33,599
as the

178
00:07:37,990 --> 00:07:36,240
as uranus spins around on its spin axis

179
00:07:40,390 --> 00:07:38,000
the magnetic field is spinning around

180
00:07:42,950 --> 00:07:40,400
like this which is making is going to

181
00:07:48,230 --> 00:07:42,960
make some very curious

182
00:07:51,909 --> 00:07:49,830
we have

183
00:07:54,629 --> 00:07:51,919
displayed now on the screen a picture of

184
00:07:56,830 --> 00:07:54,639
titania there'll be two of these

185
00:07:59,110 --> 00:07:56,840
very much the same one is sort of

186
00:08:00,629 --> 00:07:59,120
insurance for the other

187
00:08:02,150 --> 00:08:00,639
this one is in

188
00:08:03,909 --> 00:08:02,160

and the second one should be coming in

189
00:08:07,510 --> 00:08:03,919
any minute in the meantime

190
00:08:09,510 --> 00:08:07,520
we have also had the best two pictures

191
00:08:13,029 --> 00:08:09,520
of

192
00:08:14,950 --> 00:08:13,039
umbriel which is here very

193
00:08:16,150 --> 00:08:14,960
almost featureless

194
00:08:18,309 --> 00:08:16,160
and by the way these are the two

195
00:08:19,430 --> 00:08:18,319
pictures that came in there

196
00:08:21,589 --> 00:08:19,440
are

197
00:08:24,150 --> 00:08:21,599
very similar to each other

198
00:08:27,029 --> 00:08:24,160
taken very close together

199
00:08:29,110 --> 00:08:27,039
i think the thing which uh surprised uh

200
00:08:31,270 --> 00:08:29,120
most of us was not that miranda

201
00:08:33,509 --> 00:08:31,280
necessarily had all these tectonic

202
00:08:35,430 --> 00:08:33,519
structures uh on the surface but that

203
00:08:37,430 --> 00:08:35,440
there was such a variety

204
00:08:39,190 --> 00:08:37,440
that it was really a very complex

205
00:08:40,469 --> 00:08:39,200
distribution

206
00:08:43,589 --> 00:08:40,479
and i think the other thing that

207
00:08:45,430 --> 00:08:43,599
surprised me was the extreme relief uh

208
00:08:47,910 --> 00:08:45,440
which uh which seems to be present on

209
00:08:50,630 --> 00:08:47,920
the surface it's not a very subtle uh

210
00:08:54,790 --> 00:08:50,640
property at all one sees very very

211
00:08:56,949 --> 00:08:54,800
sharp scarps of ridges one sees a groove

212
00:08:58,550 --> 00:08:56,959
terrain one sees terrain similar to that

213
00:09:00,790 --> 00:08:58,560

which we saw on enceladus which is

214
00:09:02,949 --> 00:09:00,800
somewhat twisted it's just a remarkably

215
00:09:04,150 --> 00:09:02,959
complex surface

216
00:09:05,829 --> 00:09:04,160
and uh

217
00:09:08,949 --> 00:09:05,839
these are those cliffs up at the top

218
00:09:10,870 --> 00:09:08,959
those are very high cliffs

219
00:09:13,269 --> 00:09:10,880
which uh

220
00:09:15,829 --> 00:09:13,279
which are quite remarkable uh they're

221
00:09:16,790 --> 00:09:15,839
they terminate a very rugged hilly

222
00:09:19,910 --> 00:09:16,800
terrain

223
00:09:24,070 --> 00:09:19,920
uh which uh uh may well be a place where

224
00:09:25,990 --> 00:09:24,080
there is a basically lateral thrusting

225
00:09:29,110 --> 00:09:26,000
and

226
00:09:30,550 --> 00:09:29,120
down the lower portion of the planet

227
00:09:31,509 --> 00:09:30,560
we call it a planet it looks like yes

228
00:09:33,829 --> 00:09:31,519
that's right

229
00:09:35,829 --> 00:09:33,839
this moon uranus we saw we see again

230
00:09:37,269 --> 00:09:35,839
some of the same curious lines that are

231
00:09:38,790 --> 00:09:37,279
going that's right that's right

232
00:09:41,350 --> 00:09:38,800
fractures this the surface has been

233
00:09:43,350 --> 00:09:41,360
heavily fractured uh by some sort of

234
00:09:45,829 --> 00:09:43,360
processing uh there may well be some

235
00:09:46,870 --> 00:09:45,839
layering on it in the in the lower right

236
00:09:49,030 --> 00:09:46,880
hand

237
00:09:50,550 --> 00:09:49,040
portion of this image where one sees

238
00:09:52,150 --> 00:09:50,560

these alternating dark and lighter

239
00:09:54,710 --> 00:09:52,160
streaks that's right

240
00:09:56,550 --> 00:09:54,720
perhaps that's layering of material it's

241
00:09:58,630 --> 00:09:56,560
really a remarkably complex surface for

242
00:10:00,470 --> 00:09:58,640
an object that's barely 300 miles in

243
00:10:02,310 --> 00:10:00,480
diameter

244
00:10:04,230 --> 00:10:02,320
the rings of uranus have some provided

245
00:10:06,710 --> 00:10:04,240
some thrills and surprises for several

246
00:10:09,190 --> 00:10:06,720
voyager scientists those who specialize

247
00:10:11,030 --> 00:10:09,200
in studying planetary rings one of those

248
00:10:13,590 --> 00:10:11,040
is dr jeff cuzzy from nasa's ames

249
00:10:15,430 --> 00:10:13,600
research center and he's with me now and

250
00:10:17,430 --> 00:10:15,440
just let's talk about these strange

251
00:10:19,030 --> 00:10:17,440
rings and i'm going to ask if somebody

252
00:10:22,310 --> 00:10:19,040
can to put up

253
00:10:25,030 --> 00:10:22,320
on uh on one of our video ports 70 this

254
00:10:26,870 --> 00:10:25,040
picture we want uh jeff

255
00:10:28,150 --> 00:10:26,880
the rings have been

256
00:10:29,030 --> 00:10:28,160
well we knew about that they were there

257
00:10:33,269 --> 00:10:29,040
before

258
00:10:34,550 --> 00:10:33,279
but we've discovered quite a bit more

259
00:10:35,910 --> 00:10:34,560
about them and particularly about the

260
00:10:38,150 --> 00:10:35,920
detailed structure since we've been

261
00:10:40,310 --> 00:10:38,160
there what can you say about them well

262
00:10:42,630 --> 00:10:40,320
you know the main rings of uranus oliver

263
00:10:45,509 --> 00:10:42,640

were known from stellar occultations uh

264
00:10:48,630 --> 00:10:45,519
several of us who think about rings

265
00:10:50,230 --> 00:10:48,640
tend to associate small objects debris

266
00:10:52,389 --> 00:10:50,240
if you like of

267
00:10:54,230 --> 00:10:52,399
leftover from the formation of the moons

268
00:10:56,150 --> 00:10:54,240
and the planet that are associated with

269
00:10:58,790 --> 00:10:56,160
rings when you have all this debris

270
00:11:00,870 --> 00:10:58,800
around with the impacting meteoroids

271
00:11:02,710 --> 00:11:00,880
that are always there you always expect

272
00:11:05,190 --> 00:11:02,720
to have dust now this dust is very

273
00:11:07,110 --> 00:11:05,200
short-lived because it drags into the

274
00:11:09,030 --> 00:11:07,120
planet it gets destroyed by the magnetic

275
00:11:10,710 --> 00:11:09,040
fields better way one thing another so

276
00:11:12,949 --> 00:11:10,720
the location of the dust is a very

277
00:11:16,230 --> 00:11:12,959
important tracer of where the material

278
00:11:18,470 --> 00:11:16,240
is and so we were very uh eagerly

279
00:11:20,710 --> 00:11:18,480
anticipating the existence of the

280
00:11:22,310 --> 00:11:20,720
structure of the dust now because of the

281
00:11:24,710 --> 00:11:22,320
magnetic field

282
00:11:26,790 --> 00:11:24,720
and probably because of the the

283
00:11:28,949 --> 00:11:26,800
perturbing effect of the magnetic field

284
00:11:30,230 --> 00:11:28,959
on the charged particles that are small

285
00:11:32,389 --> 00:11:30,240
most of the dust seems to have been

286
00:11:33,910 --> 00:11:32,399
removed from the uranus system and this

287
00:11:35,910 --> 00:11:33,920
is the picture we got at that point yeah

288
00:11:38,630 --> 00:11:35,920

that is an absolutely spectacular

289
00:11:40,389 --> 00:11:38,640
picture and it shows basically that most

290
00:11:42,630 --> 00:11:40,399
of the region

291
00:11:45,430 --> 00:11:42,640
of the known rings is

292
00:11:47,509 --> 00:11:45,440
is more or less replete with dust

293
00:11:49,910 --> 00:11:47,519
the voyager uranus encounter has shed

294
00:11:53,910 --> 00:11:49,920
new light on this unique planet

295
00:11:56,630 --> 00:11:53,920
some of the preliminary findings include

296
00:11:58,550 --> 00:11:56,640
10 new moons were discovered one new

297
00:12:00,470 --> 00:11:58,560
ring was found

298
00:12:02,870 --> 00:12:00,480
two shepherding moons are located near

299
00:12:04,790 --> 00:12:02,880
the epsilon ring

300
00:12:06,870 --> 00:12:04,800
the rings are slightly varying in

301
00:12:08,829 --> 00:12:06,880
composition and color

302
00:12:11,509 --> 00:12:08,839
and are complex in

303
00:12:13,190 --> 00:12:11,519
structure the five known moons are an

304
00:12:15,509 --> 00:12:13,200
ice rock mixture

305
00:12:16,949 --> 00:12:15,519
with evidence of ancient geological

306
00:12:19,670 --> 00:12:16,959
activity

307
00:12:22,150 --> 00:12:19,680
ariel was volcanic in the past

308
00:12:24,629 --> 00:12:22,160
miranda is considered the strangest body

309
00:12:25,590 --> 00:12:24,639
in the solar system by many jpl team

310
00:12:29,509 --> 00:12:25,600
members

311
00:12:33,269 --> 00:12:29,519
it has scarps cliffs and layering

312
00:12:35,910 --> 00:12:33,279
the atmosphere of uranus is 15 helium

313
00:12:37,670 --> 00:12:35,920

and the rest is hydrogen ammonia and

314
00:12:40,069 --> 00:12:37,680
methane

315
00:12:41,829 --> 00:12:40,079
the planet may have a rocky core of the

316
00:12:43,670 --> 00:12:41,839
size of earth

317
00:12:46,710 --> 00:12:43,680
uranus is covered with an ocean of

318
00:12:48,790 --> 00:12:46,720
mostly water methane and ammonia our

319
00:12:51,750 --> 00:12:48,800
next report comes to us from the nasa

320
00:12:54,790 --> 00:12:51,760
ames research center near san francisco

321
00:12:56,790 --> 00:12:54,800
the report was released in 1987

322
00:12:59,110 --> 00:12:56,800
and summarizes some of the findings of

323
00:13:01,670 --> 00:12:59,120
the pioneer venus spacecraft which

324
00:13:04,710 --> 00:13:01,680
earlier examined comet halley as it

325
00:13:07,110 --> 00:13:04,720
looped around the sun

326
00:13:08,310 --> 00:13:07,120
as long as man has been conscious of the

327
00:13:10,550 --> 00:13:08,320
sky

328
00:13:11,990 --> 00:13:10,560
comets have been objects of special

329
00:13:14,150 --> 00:13:12,000
fascination

330
00:13:19,509 --> 00:13:14,160
our ancestors thought they were omens of

331
00:13:25,350 --> 00:13:22,389
today we see them much differently

332
00:13:27,750 --> 00:13:25,360
dr jeffrey cuzzy is a nasa scientist who

333
00:13:29,990 --> 00:13:27,760
specializes in comets today we know

334
00:13:32,389 --> 00:13:30,000
comets are not magical apparitions but

335
00:13:34,949 --> 00:13:32,399
mountain-sized dirty snowballs of ice

336
00:13:36,710 --> 00:13:34,959
and rocky dust there are living fossils

337
00:13:38,629 --> 00:13:36,720
left over from the early days of the

338
00:13:40,470 --> 00:13:38,639

formation of the solar system but there

339
00:13:41,990 --> 00:13:40,480
may have been some truth to the old

340
00:13:44,150 --> 00:13:42,000
superstition

341
00:13:45,829 --> 00:13:44,160
a large comet hitting earth may have

342
00:13:48,230 --> 00:13:45,839
been the cause of the death of the

343
00:13:49,990 --> 00:13:48,240
dinosaurs and other comets may have

344
00:13:51,910 --> 00:13:50,000
caused earlier episodes of mass

345
00:13:54,310 --> 00:13:51,920
extinction

346
00:13:55,750 --> 00:13:54,320
even today earth is not entirely safe

347
00:13:59,269 --> 00:13:55,760
from comets

348
00:14:01,910 --> 00:13:59,279
in 1908 in a remote area in russia 200

349
00:14:04,389 --> 00:14:01,920
square miles of forest were blown down

350
00:14:07,350 --> 00:14:04,399
by an explosion with the force of a 12

351
00:14:09,590 --> 00:14:07,360
megaton bomb

352
00:14:13,590 --> 00:14:09,600
it was probably caused by a large comet

353
00:14:19,829 --> 00:14:16,069
experts estimate that a comet strikes

354
00:14:21,269 --> 00:14:19,839
earth about once every million years

355
00:14:23,430 --> 00:14:21,279
there are a number of reasons for

356
00:14:25,189 --> 00:14:23,440
studying comics well the more we learn

357
00:14:26,629 --> 00:14:25,199
about the material comets are made of

358
00:14:29,110 --> 00:14:26,639
and the way that material is put

359
00:14:31,110 --> 00:14:29,120
together the better idea we'll have of

360
00:14:33,509 --> 00:14:31,120
the situation on which the planets of

361
00:14:35,670 --> 00:14:33,519
the solar system form it is extremely

362
00:14:38,069 --> 00:14:35,680
difficult to reconstruct our planet's

363
00:14:40,069 --> 00:14:38,079

origins by studying the material it is

364
00:14:42,790 --> 00:14:40,079
composed of today

365
00:14:45,430 --> 00:14:42,800
even the oldest rocks on earth have been

366
00:14:47,829 --> 00:14:45,440
changed and modified repeatedly by

367
00:14:49,269 --> 00:14:47,839
geological processes such as melting and

368
00:14:51,910 --> 00:14:49,279
solidification

369
00:14:54,629 --> 00:14:51,920
wind and water erosion

370
00:14:56,870 --> 00:14:54,639
in the 1970s nasa studied a number of

371
00:14:58,949 --> 00:14:56,880
different missions to halley's comet one

372
00:15:00,949 --> 00:14:58,959
of the brightest and best known of the

373
00:15:02,790 --> 00:15:00,959
thousand or so comets that pass

374
00:15:05,189 --> 00:15:02,800
periodically by earth

375
00:15:08,790 --> 00:15:05,199
but budgetary constraints kept such

376
00:15:12,790 --> 00:15:11,910
nevertheless the 1986 return of halley's

377
00:15:15,910 --> 00:15:12,800
comet

378
00:15:17,910 --> 00:15:15,920
proved to be a scientific spectacular

379
00:15:24,470 --> 00:15:17,920
almost all the world's telescopes were

380
00:15:30,069 --> 00:15:27,670
in addition the soviet union japan and

381
00:15:32,069 --> 00:15:30,079
the european space agency launched

382
00:15:51,189 --> 00:15:32,079
spacecraft to rendezvous with a famous

383
00:15:55,910 --> 00:15:53,509
meanwhile at nasa's ames research center

384
00:15:58,150 --> 00:15:55,920
in mountain view california u.s

385
00:15:59,829 --> 00:15:58,160
scientists found an innovative way to

386
00:16:01,189 --> 00:15:59,839
participate

387
00:16:04,069 --> 00:16:01,199
richard femmel

388
00:16:07,509 --> 00:16:04,079

nasa's pioneer project manager

389
00:16:09,749 --> 00:16:07,519
in 1981 we started looking into how

390
00:16:11,670 --> 00:16:09,759
we could use an existing spacecraft to

391
00:16:13,430 --> 00:16:11,680
make measurements of halley's comet as

392
00:16:15,430 --> 00:16:13,440
it came by

393
00:16:17,670 --> 00:16:15,440
this spacecraft is the pioneer venus

394
00:16:19,829 --> 00:16:17,680
orbiter which was already in orbit

395
00:16:23,110 --> 00:16:19,839
around the planet venus it was inserted

396
00:16:24,870 --> 00:16:23,120
in orbit in december of 1978

397
00:16:27,110 --> 00:16:24,880
the surface of venus is completely

398
00:16:28,949 --> 00:16:27,120
obscured by a heavy cloud cover so we

399
00:16:30,069 --> 00:16:28,959
really knew very little about the

400
00:16:31,590 --> 00:16:30,079
surface

401
00:16:34,310 --> 00:16:31,600
of the planet

402
00:16:35,350 --> 00:16:34,320
the pioneer venus mission consisted of a

403
00:16:38,069 --> 00:16:35,360
pair of

404
00:16:40,790 --> 00:16:38,079
the orbiter and a multi-probe which

405
00:16:42,790 --> 00:16:40,800
carried four instrumented probes which

406
00:16:45,110 --> 00:16:42,800
were released before the spacecraft

407
00:16:46,710 --> 00:16:45,120
reached venus and they plunged to the

408
00:16:48,389 --> 00:16:46,720
surface of venus making their

409
00:16:49,910 --> 00:16:48,399
measurements with the instruments on

410
00:16:52,069 --> 00:16:49,920
board as they were probes were

411
00:16:54,790 --> 00:16:52,079
descending to the planet's surface

412
00:16:56,949 --> 00:16:54,800
together the orbiter and the moly probes

413
00:16:59,990 --> 00:16:56,959

provided information about

414
00:17:03,110 --> 00:17:00,000
the atmosphere of venus and why it is so

415
00:17:05,189 --> 00:17:03,120
searingly hot and dense

416
00:17:07,270 --> 00:17:05,199
also another instrument on board the

417
00:17:09,510 --> 00:17:07,280
spacecraft took thousands of images of

418
00:17:11,270 --> 00:17:09,520
the cloud cover of the planet venus

419
00:17:13,590 --> 00:17:11,280
helping to explain the atmospheric

420
00:17:15,829 --> 00:17:13,600
circulation about the planet and

421
00:17:17,669 --> 00:17:15,839
unraveling many of the mysteries that

422
00:17:19,590 --> 00:17:17,679
venus has held

423
00:17:22,150 --> 00:17:19,600
fortunately the cosmos arranged it so

424
00:17:23,829 --> 00:17:22,160
that we had a ringside seat as halley's

425
00:17:26,230 --> 00:17:23,839
comet came by

426
00:17:27,750 --> 00:17:26,240
in its path closest to the sun which is

427
00:17:29,830 --> 00:17:27,760
the time when the comet is its most

428
00:17:31,990 --> 00:17:29,840
active

429
00:17:33,350 --> 00:17:32,000
halley's like all comets is made up of

430
00:17:36,150 --> 00:17:33,360
several parts

431
00:17:38,310 --> 00:17:36,160
the nucleus is a large dirty snowball

432
00:17:40,710 --> 00:17:38,320
frozen as hard as marble

433
00:17:45,029 --> 00:17:40,720
it is composed of roughly 40 percent

434
00:17:46,630 --> 00:17:45,039
water ice 10 frozen gases and 50

435
00:17:48,870 --> 00:17:46,640
dust and rock

436
00:17:51,669 --> 00:17:48,880
when a comet's looping orbit carries it

437
00:17:54,150 --> 00:17:51,679
close to the sun the intense sunlight

438
00:17:55,350 --> 00:17:54,160

begins to boil dust and gas from its

439
00:17:58,230 --> 00:17:55,360
surface

440
00:18:01,190 --> 00:17:58,240
invisible hydrogen gas forms a large

441
00:18:04,549 --> 00:18:01,200
egg-shaped cloud called a coma and the

442
00:18:06,230 --> 00:18:04,559
comet develops two spectacular tails a

443
00:18:07,590 --> 00:18:06,240
straight tail made of electrically

444
00:18:09,750 --> 00:18:07,600
charged gas

445
00:18:12,789 --> 00:18:09,760
and a curved dust tail

446
00:18:14,950 --> 00:18:12,799
at the university of colorado boulder dr

447
00:18:17,270 --> 00:18:14,960
ian stewart chief scientist of the

448
00:18:19,110 --> 00:18:17,280
pioneer halley's mission determined that

449
00:18:21,190 --> 00:18:19,120
he could make unique and valuable

450
00:18:23,990 --> 00:18:21,200
measurements of the comet using one of

451
00:18:25,909 --> 00:18:24,000
the orbiter's instruments

452
00:18:27,590 --> 00:18:25,919
in 1983 when we looked into the

453
00:18:29,110 --> 00:18:27,600
possibility of observing halle from

454
00:18:30,630 --> 00:18:29,120
pioneer venus we realized that it would

455
00:18:32,470 --> 00:18:30,640
come within shouting distance

456
00:18:33,909 --> 00:18:32,480
celestially speaking and that we could

457
00:18:36,310 --> 00:18:33,919
make really valuable measurements of the

458
00:18:37,750 --> 00:18:36,320
hydrogen coma when dr stewart explained

459
00:18:39,750 --> 00:18:37,760
his conclusions to us we were

460
00:18:41,190 --> 00:18:39,760
immediately enthusiastic

461
00:18:43,110 --> 00:18:41,200
we knew of course that it would mean a

462
00:18:44,870 --> 00:18:43,120
lot of extra work but we also knew that

463
00:18:47,990 --> 00:18:44,880

it would provide the united states with

464
00:18:49,510 --> 00:18:48,000
a unique halle mission capable of making

465
00:18:52,070 --> 00:18:49,520
continuous measurements through the

466
00:18:54,950 --> 00:18:52,080
entire perihelion when the comet was at

467
00:18:57,510 --> 00:18:54,960
its most active relative to using the

468
00:19:00,070 --> 00:18:57,520
ultraviolet spectrometer instrument to

469
00:19:02,789 --> 00:19:00,080
look at comet halley

470
00:19:05,270 --> 00:19:02,799
that was not originally planned as part

471
00:19:06,390 --> 00:19:05,280
of the pioneer venus

472
00:19:09,350 --> 00:19:06,400
orbiter

473
00:19:13,590 --> 00:19:09,360
experiments as they were laid out errol

474
00:19:14,710 --> 00:19:13,600
montoya pioneer program manager for nasa

475
00:19:17,190 --> 00:19:14,720
we had

476
00:19:19,830 --> 00:19:17,200
very innovative bright people say what

477
00:19:22,549 --> 00:19:19,840
if we rotated the cam the spacecraft so

478
00:19:24,390 --> 00:19:22,559
it would look out at comet halley well

479
00:19:25,990 --> 00:19:24,400
it turned out that

480
00:19:27,669 --> 00:19:26,000
the mission could be accomplished the

481
00:19:29,430 --> 00:19:27,679
gathering of these uh of these

482
00:19:32,070 --> 00:19:29,440
measurements using the ultraviolet

483
00:19:34,070 --> 00:19:32,080
spectrometer device at no additional

484
00:19:36,230 --> 00:19:34,080
cost the operation seems to be going

485
00:19:38,230 --> 00:19:36,240
very very smoothly at this point

486
00:19:41,270 --> 00:19:38,240
the spacecraft instrument that dr

487
00:19:44,549 --> 00:19:41,280
stewart used is called an ultraviolet

488
00:19:47,029 --> 00:19:44,559

spectrometer like a prism a spectrometer

489
00:19:48,470 --> 00:19:47,039
divides light into different colors or

490
00:19:50,390 --> 00:19:48,480
wavelengths

491
00:19:52,870 --> 00:19:50,400
by measuring the brightness of the light

492
00:19:55,750 --> 00:19:52,880
at each color scientists can tell a

493
00:19:58,789 --> 00:19:55,760
great deal about its source

494
00:20:01,029 --> 00:19:58,799
dr stewart's ultraviolet spectrometer is

495
00:20:03,590 --> 00:20:01,039
fixed to the rotating orbiter

496
00:20:05,909 --> 00:20:03,600
so the spacecraft had to be reoriented

497
00:20:06,950 --> 00:20:05,919
in order to observe the comet now

498
00:20:09,510 --> 00:20:06,960
normally

499
00:20:11,990 --> 00:20:09,520
the spacecraft in orbit around venus is

500
00:20:13,830 --> 00:20:12,000
orbiting with the high gain antenna

501
00:20:16,150 --> 00:20:13,840
pointed towards the south ecliptic pole

502
00:20:18,070 --> 00:20:16,160
or we would look at it as upside down as

503
00:20:19,270 --> 00:20:18,080
the spacecraft is spinning

504
00:20:21,510 --> 00:20:19,280
in order to

505
00:20:23,830 --> 00:20:21,520
observe halley's comet which is coming

506
00:20:26,870 --> 00:20:23,840
by venus up and above we had to

507
00:20:27,909 --> 00:20:26,880
carefully rotate the spacecraft 135

508
00:20:29,750 --> 00:20:27,919
degrees

509
00:20:31,990 --> 00:20:29,760
so that the ultraviolet spectrometer

510
00:20:35,110 --> 00:20:32,000
would be looking up and have the comet

511
00:20:36,710 --> 00:20:35,120
in its field of view as it rotated once

512
00:20:38,470 --> 00:20:36,720
every 12 seconds

513
00:20:40,549 --> 00:20:38,480

in the process of doing this a number of

514
00:20:42,470 --> 00:20:40,559
things had to be paid attention to we

515
00:20:44,950 --> 00:20:42,480
had to keep the solar panels properly

516
00:20:46,390 --> 00:20:44,960
oriented so they were receiving sunlight

517
00:20:49,190 --> 00:20:46,400
and to provide the power for the

518
00:20:51,029 --> 00:20:49,200
spacecraft we had to make sure that our

519
00:20:53,029 --> 00:20:51,039
star tracker had a bright star in the

520
00:20:54,630 --> 00:20:53,039
field of view so that we were would be

521
00:20:56,789 --> 00:20:54,640
able to maneuver and check the

522
00:21:00,149 --> 00:20:56,799
orientation of the spacecraft and we

523
00:21:02,070 --> 00:21:00,159
also had constraints on the position

524
00:21:04,789 --> 00:21:02,080
because the high gain antenna can only

525
00:21:07,270 --> 00:21:04,799
move a limited amount in elevation and

526
00:21:09,669 --> 00:21:07,280
that has to stay pointed at earth as it

527
00:21:11,990 --> 00:21:09,679
is de-spun halley's orbit takes it from

528
00:21:15,190 --> 00:21:12,000
the outer reaches of the solar system

529
00:21:17,590 --> 00:21:15,200
about the orbit of uranus to within 55

530
00:21:19,270 --> 00:21:17,600
million miles of the sun well because

531
00:21:21,190 --> 00:21:19,280
halley's comet is most active when it's

532
00:21:23,190 --> 00:21:21,200
close to the sun it is most important to

533
00:21:25,590 --> 00:21:23,200
observe it at that time as halley's

534
00:21:28,390 --> 00:21:25,600
comet made its closest approach to venus

535
00:21:30,870 --> 00:21:28,400
and we were in the midst of our critical

536
00:21:32,230 --> 00:21:30,880
imaging sequence to get an image of the

537
00:21:34,310 --> 00:21:32,240
comet's coma

538
00:21:35,350 --> 00:21:34,320

nature through a number of obstacles in

539
00:21:36,549 --> 00:21:35,360
our way

540
00:21:39,190 --> 00:21:36,559
threatening

541
00:21:42,710 --> 00:21:39,200
to disrupt the entire data stream for us

542
00:21:44,470 --> 00:21:42,720
first we had a giant solar flare which

543
00:21:46,470 --> 00:21:44,480
interfered with radio communications

544
00:21:48,549 --> 00:21:46,480
between the spacecraft and earth that

545
00:21:50,630 --> 00:21:48,559
was followed then by rain

546
00:21:53,830 --> 00:21:50,640
in the mojave desert and snowstorm in

547
00:21:56,950 --> 00:21:53,840
madrid and both of these also

548
00:21:58,710 --> 00:21:56,960
attenuated the radio signal causing more

549
00:22:00,310 --> 00:21:58,720
errors in the data

550
00:22:01,909 --> 00:22:00,320
well in spite of all these problems we

551
00:22:03,350 --> 00:22:01,919
were able to get all of the data that we

552
00:22:05,350 --> 00:22:03,360
needed the centerpiece of our

553
00:22:07,350 --> 00:22:05,360
observations of the of the comet was

554
00:22:09,669 --> 00:22:07,360
this false color image of the hydrogen

555
00:22:11,830 --> 00:22:09,679
coma the scale is immense it's the image

556
00:22:12,789 --> 00:22:11,840
that you see is 12 million by 8 million

557
00:22:15,270 --> 00:22:12,799
miles

558
00:22:17,029 --> 00:22:15,280
and briefly as during its passage past

559
00:22:19,830 --> 00:22:17,039
the sun halley was the largest object in

560
00:22:21,590 --> 00:22:19,840
the solar system the image uses color to

561
00:22:22,789 --> 00:22:21,600
represent brightness the blues and reds

562
00:22:25,270 --> 00:22:22,799
are the darker

563
00:22:26,549 --> 00:22:25,280

levels of light and the yellows and

564
00:22:27,430 --> 00:22:26,559
greens are the brightest parts of the

565
00:22:29,350 --> 00:22:27,440
comet

566
00:22:30,789 --> 00:22:29,360
well analyzing the image and other data

567
00:22:33,029 --> 00:22:30,799
allowed us to

568
00:22:34,950 --> 00:22:33,039
estimate the rate at which water was

569
00:22:36,950 --> 00:22:34,960
subliming away evaporating away from the

570
00:22:38,630 --> 00:22:36,960
ices of the nucleus our measurements

571
00:22:40,710 --> 00:22:38,640
turned out to be in reasonable accord

572
00:22:42,230 --> 00:22:40,720
with european and soviet measurements

573
00:22:43,669 --> 00:22:42,240
and they indicate that the comet is

574
00:22:45,990 --> 00:22:43,679
losing one or two hundredths of a

575
00:22:47,430 --> 00:22:46,000
percent of its total mass each time it

576
00:22:49,750 --> 00:22:47,440
passes the sun

577
00:22:51,590 --> 00:22:49,760
before this last visit many scientists

578
00:22:54,149 --> 00:22:51,600
had assumed hallie's was a relatively

579
00:22:55,990 --> 00:22:54,159
fresh comet so the extent of the erosion

580
00:22:59,830 --> 00:22:56,000
and the amount of dark crust on the

581
00:23:02,470 --> 00:22:59,840
nucleus came as a surprise

582
00:23:05,830 --> 00:23:02,480
pioneer venus observations showed large

583
00:23:07,750 --> 00:23:05,840
daily variations as much as 25 percent

584
00:23:09,270 --> 00:23:07,760
in the rate at which water was boiling

585
00:23:11,669 --> 00:23:09,280
off the comet

586
00:23:14,070 --> 00:23:11,679
the best explanation for this is that

587
00:23:16,630 --> 00:23:14,080
only portions of the comet's surface had

588
00:23:18,710 --> 00:23:16,640

freshly exposed ice that could act as

589
00:23:21,029 --> 00:23:18,720
sources of water vapor

590
00:23:23,190 --> 00:23:21,039
the evaporation rate varied depending on

591
00:23:25,350 --> 00:23:23,200
how much of this fresh material was

592
00:23:27,190 --> 00:23:25,360
exposed to sunlight as the nucleus

593
00:23:29,430 --> 00:23:27,200
rotated

594
00:23:31,350 --> 00:23:29,440
the orbiter's observations fit nicely

595
00:23:34,149 --> 00:23:31,360
with those of the european spacecraft

596
00:23:35,430 --> 00:23:34,159
jato which passed about 300 miles from

597
00:23:38,149 --> 00:23:35,440
the nucleus

598
00:23:40,870 --> 00:23:38,159
its cameras revealed a cold black object

599
00:23:43,029 --> 00:23:40,880
three to four times larger than the size

600
00:23:44,950 --> 00:23:43,039
estimated for a fresh comet

601
00:23:47,510 --> 00:23:44,960
the nucleus also appeared highly

602
00:23:49,909 --> 00:23:47,520
irregular almost potato shaped

603
00:23:52,870 --> 00:23:49,919
suggesting it was once much larger and

604
00:23:55,750 --> 00:23:52,880
has eroded away over a long time

605
00:23:58,070 --> 00:23:55,760
pictures from jotto also showed gas jets

606
00:24:00,549 --> 00:23:58,080
spewing from the nucleus and the orbiter

607
00:24:04,310 --> 00:24:00,559
measured their velocities as high as one

608
00:24:07,029 --> 00:24:04,320
thousand one hundred miles an hour

609
00:24:09,510 --> 00:24:07,039
while the gas escapes most of the dust

610
00:24:12,390 --> 00:24:09,520
that boils off the nucleus remains in

611
00:24:14,549 --> 00:24:12,400
the comet's feeble gravitational grip as

612
00:24:17,430 --> 00:24:14,559
the comet moves back out away from the

613
00:24:24,549 --> 00:24:17,440

sun the dust rains back onto the comet's

614
00:24:29,350 --> 00:24:26,630
scientists have begun to realize that

615
00:24:31,510 --> 00:24:29,360
this dust plays a central role in the

616
00:24:33,750 --> 00:24:31,520
life cycle of a comet well when the

617
00:24:34,549 --> 00:24:33,760
layer of dust becomes about three inches

618
00:24:37,430 --> 00:24:34,559
thick

619
00:24:38,789 --> 00:24:37,440
it'll act as an insulating blanket and

620
00:24:41,029 --> 00:24:38,799
insulate the ice from the heat of the

621
00:24:43,430 --> 00:24:41,039
sun and once that happens the ice no

622
00:24:46,310 --> 00:24:43,440
longer evaporates so the comet loses all

623
00:24:48,549 --> 00:24:46,320
its cometary features like tails and

624
00:24:50,710 --> 00:24:48,559
dust tails and iron tails

625
00:24:52,789 --> 00:24:50,720
and then it looks a lot like an asteroid

626
00:24:55,110 --> 00:24:52,799
scientists estimate that comets make

627
00:24:57,590 --> 00:24:55,120
only a thousand or so passes around the

628
00:25:00,789 --> 00:24:57,600
sun before they're reduced to inactive

629
00:25:03,350 --> 00:25:00,799
objects like asteroids

630
00:25:06,789 --> 00:25:03,360
with even a partial dust crust a comet

631
00:25:09,029 --> 00:25:06,799
is slower to warm up and develop a tail

632
00:25:11,430 --> 00:25:09,039
once heated however the dust blanket

633
00:25:14,710 --> 00:25:11,440
retains the warmth and the comet keeps

634
00:25:16,630 --> 00:25:14,720
its tail longer

635
00:25:21,269 --> 00:25:16,640
that's why halley's was brighter in

636
00:25:26,789 --> 00:25:24,630
then in december when it was approaching

637
00:25:28,950 --> 00:25:26,799
the orbiter's observations showed that

638
00:25:31,510 --> 00:25:28,960

the nucleus remains surprisingly

639
00:25:34,230 --> 00:25:31,520
inactive until a few weeks before the

640
00:25:36,630 --> 00:25:34,240
comet's closest approach to the sun

641
00:25:38,870 --> 00:25:36,640
but it stayed 30 percent more active on

642
00:25:40,710 --> 00:25:38,880
the outbound leg of its journey

643
00:25:42,630 --> 00:25:40,720
it is surprising that the activity turns

644
00:25:44,070 --> 00:25:42,640
on so suddenly the comet gets to within

645
00:25:45,990 --> 00:25:44,080
a certain distance of the sun then it

646
00:25:47,990 --> 00:25:46,000
starts to pop like popcorn

647
00:25:50,149 --> 00:25:48,000
the pioneer venus orbiter made a number

648
00:25:51,750 --> 00:25:50,159
of other important observations

649
00:25:55,110 --> 00:25:51,760
for instance it measured the

650
00:25:57,830 --> 00:25:55,120
concentrations of hydrogen oxygen carbon

651
00:25:59,190 --> 00:25:57,840
and hydroxyl ions given off by halley's

652
00:26:01,110 --> 00:25:59,200
nucleus

653
00:26:03,750 --> 00:26:01,120
combined with the observations made by

654
00:26:05,909 --> 00:26:03,760
other spacecraft this information is

655
00:26:07,830 --> 00:26:05,919
helping scientists calculate the comet's

656
00:26:09,669 --> 00:26:07,840
composition

657
00:26:12,070 --> 00:26:09,679
while it has given scientists a much

658
00:26:14,789 --> 00:26:12,080
better picture of what halley's is like

659
00:26:16,630 --> 00:26:14,799
the new data is also raising questions

660
00:26:18,070 --> 00:26:16,640
that can only be answered by future

661
00:26:20,950 --> 00:26:18,080
comet missions

662
00:26:23,510 --> 00:26:20,960
one such mission is craft but comet

663
00:26:25,510 --> 00:26:23,520

rendezvous and asteroid flyby it

664
00:26:27,990 --> 00:26:25,520
involves shooting a probe into the heart

665
00:26:30,230 --> 00:26:28,000
of a comet nucleus to get the first

666
00:26:31,909 --> 00:26:30,240
direct measurements of what it is made

667
00:26:33,669 --> 00:26:31,919
of

668
00:26:36,630 --> 00:26:33,679
scientists will study the new

669
00:26:39,029 --> 00:26:36,640
information on halley's for decades

670
00:26:41,510 --> 00:26:39,039
as a result our knowledge about the

671
00:26:43,909 --> 00:26:41,520
origin of the solar system about its

672
00:26:46,390 --> 00:26:43,919
primordial mountain-sized building

673
00:26:48,630 --> 00:26:46,400
blocks and how they join together to

674
00:26:50,870 --> 00:26:48,640
form the earth and other planets will

675
00:26:52,470 --> 00:26:50,880
continue to grow

676
00:26:54,789 --> 00:26:52,480
in this fashion

677
00:26:57,110 --> 00:26:54,799
humanity will gain the understanding of

678
00:27:00,950 --> 00:26:57,120
its ultimate environment

679
00:27:05,669 --> 00:27:02,630
that's all we have for this edition of

680
00:27:07,990 --> 00:27:05,679
nasa images but before we go let me

681
00:27:10,230 --> 00:27:08,000
remind you that you're cordially invited

682
00:27:12,230 --> 00:27:10,240
to see the displays at the visitor

683
00:27:13,110 --> 00:27:12,240
center here at the nasa lewis research

684
00:27:14,710 --> 00:27:13,120
center

685
00:27:16,870 --> 00:27:14,720
we're located near the hopkins

686
00:27:18,710 --> 00:27:16,880
international airport in cleveland

687
00:27:21,190 --> 00:27:18,720
admission is free