
Europa

1
00:00:07,430 --> 00:00:05,349
well good morning let's go ahead and get

2
00:00:09,990 --> 00:00:07,440
started i'm ralph mcnutt of the applied

3
00:00:11,830 --> 00:00:10,000
physics laboratory a division of johns

4
00:00:14,629 --> 00:00:11,840
hopkins university

5
00:00:16,550 --> 00:00:14,639
and uh the panel this this panel this

6
00:00:19,349 --> 00:00:16,560
morning is going to be on exploring the

7
00:00:21,349 --> 00:00:19,359
outer solar system we have three talks

8
00:00:23,509 --> 00:00:21,359
and we're going to try to do about 20

9
00:00:26,070 --> 00:00:23,519
minutes per talk with about five minutes

10
00:00:27,670 --> 00:00:26,080
for questions and then that will give us

11
00:00:30,390 --> 00:00:27,680
uh plenty of time to have a panel

12
00:00:33,110 --> 00:00:30,400
discussion i think that this will be uh

13
00:00:34,389 --> 00:00:33,120

should be an interesting panel um of

14
00:00:36,310 --> 00:00:34,399
course we've been hearing about how

15
00:00:38,630 --> 00:00:36,320
difficult all of this is although we all

16
00:00:40,790 --> 00:00:38,640
tend to make this easy and of course the

17
00:00:42,470 --> 00:00:40,800
getting to the outer planets is

18
00:00:44,470 --> 00:00:42,480
an interesting challenge in and of

19
00:00:47,270 --> 00:00:44,480
itself it's not some place that we've

20
00:00:48,869 --> 00:00:47,280
been to with very many spacecraft but

21
00:00:50,549 --> 00:00:48,879
we'll find out a little bit from the

22
00:00:52,470 --> 00:00:50,559
panelists about

23
00:00:54,470 --> 00:00:52,480
some of the issues that are involved so

24
00:00:56,150 --> 00:00:54,480
the first speaker is going to be

25
00:00:57,910 --> 00:00:56,160
torrence johnson let me give you a

26
00:00:59,270 --> 00:00:57,920
little bit of background about torrance

27
00:01:01,110 --> 00:00:59,280
although i think

28
00:01:03,910 --> 00:01:01,120
i think he probably doesn't need that

29
00:01:05,429 --> 00:01:03,920
much of an introduction to most of you

30
00:01:08,310 --> 00:01:05,439
torence of course is a planetary

31
00:01:10,710 --> 00:01:08,320
scientist he got his phd at caltech back

32
00:01:12,710 --> 00:01:10,720
in 1970 and was the project scientist

33
00:01:14,950 --> 00:01:12,720
for the galileo mission

34
00:01:17,030 --> 00:01:14,960
and directed the galileo science teams

35
00:01:18,710 --> 00:01:17,040
through that mission

36
00:01:20,550 --> 00:01:18,720
he's currently involved in ongoing

37
00:01:22,550 --> 00:01:20,560
research with the properties of giant

38
00:01:24,469 --> 00:01:22,560

planet satellites and is a member of the

39
00:01:26,230 --> 00:01:24,479
cassini science team

40
00:01:28,070 --> 00:01:26,240
and he's also the chief scientist for

41
00:01:30,870 --> 00:01:28,080
solar system exploration the solar

42
00:01:32,469 --> 00:01:30,880
system exploration directorate at jpl

43
00:01:41,510 --> 00:01:32,479
where he's involved in planning for the

44
00:01:46,069 --> 00:01:43,429
well thanks ralph uh

45
00:01:48,550 --> 00:01:46,079
my title here is an uh outer solar

46
00:01:50,950 --> 00:01:48,560
system exploration and archetype for the

47
00:01:52,310 --> 00:01:50,960
scientific method that's because the

48
00:01:54,630 --> 00:01:52,320
organizers

49
00:01:58,230 --> 00:01:54,640
uh told me this was a very academic and

50
00:02:00,789 --> 00:01:58,240
serious audience and that i should

51
00:02:02,550 --> 00:02:00,799
prepare something suitably lofty

52
00:02:04,789 --> 00:02:02,560
what that really means is i'm going to

53
00:02:06,630 --> 00:02:04,799
talk a bit about how we decide what

54
00:02:07,749 --> 00:02:06,640
sorts of objectives

55
00:02:09,990 --> 00:02:07,759
we

56
00:02:12,070 --> 00:02:10,000
undertake an outer solar system of

57
00:02:13,830 --> 00:02:12,080
exploration and how those are affected

58
00:02:16,309 --> 00:02:13,840
by the very long

59
00:02:18,470 --> 00:02:16,319
periods of time that it takes to get to

60
00:02:20,470 --> 00:02:18,480
the outer solar system which makes

61
00:02:21,990 --> 00:02:20,480
things a little bit more difficult than

62
00:02:24,630 --> 00:02:22,000
for some of the terrestrial planets

63
00:02:26,710 --> 00:02:24,640

where we have much higher launch rates

64
00:02:28,150 --> 00:02:26,720
and cadences

65
00:02:33,509 --> 00:02:28,160
so let me um

66
00:02:39,990 --> 00:02:35,589
talks yesterday

67
00:02:42,229 --> 00:02:40,000
discussed things like the effect of

68
00:02:44,550 --> 00:02:42,239
how science was perceived by the public

69
00:02:46,869 --> 00:02:44,560
and by the media and so forth which

70
00:02:48,630 --> 00:02:46,879
could be sort of summed up in many cases

71
00:02:50,790 --> 00:02:48,640
as

72
00:02:59,190 --> 00:02:50,800
we send a bunch of spacecraft out there

73
00:03:04,229 --> 00:03:02,070
scientists amazed astounded textbooks

74
00:03:05,430 --> 00:03:04,239
rewritten unexpected results stunned

75
00:03:06,710 --> 00:03:05,440
scientists

76
00:03:08,309 --> 00:03:06,720
um

77
00:03:10,710 --> 00:03:08,319
i can't tell you how many times i've had

78
00:03:12,869 --> 00:03:10,720
those types of questions from uh from

79
00:03:15,030 --> 00:03:12,879
media says why aren't you amazed by what

80
00:03:16,550 --> 00:03:15,040
you've just found at sutter

81
00:03:19,910 --> 00:03:16,560
our friends uh

82
00:03:21,670 --> 00:03:19,920
working on the uh higgs boson are in

83
00:03:22,470 --> 00:03:21,680
this situation now

84
00:03:25,190 --> 00:03:22,480
uh

85
00:03:27,750 --> 00:03:25,200
tell me again sir you spent billions of

86
00:03:29,830 --> 00:03:27,760
euros to find a particle that you were

87
00:03:31,509 --> 00:03:29,840
almost absolutely certain was there in

88
00:03:35,110 --> 00:03:31,519

the first place and what are you going

89
00:03:41,430 --> 00:03:39,190
in fact the reality is more complex

90
00:03:43,190 --> 00:03:41,440
but saying scientists confirm their

91
00:03:45,270 --> 00:03:43,200
model while finding some new puzzles

92
00:03:47,830 --> 00:03:45,280
doesn't make quite as lively copy for

93
00:03:51,670 --> 00:03:47,840
the morning paper

94
00:03:55,110 --> 00:03:53,670
we do follow the scientific method while

95
00:03:57,190 --> 00:03:55,120
trying to

96
00:04:00,949 --> 00:03:57,200
develop the objectives and the

97
00:04:03,190 --> 00:04:00,959
experiments for our missions and uh that

98
00:04:05,350 --> 00:04:03,200
was illustrated very nicely yesterday in

99
00:04:07,509 --> 00:04:05,360
some of the talks related to the advice

100
00:04:09,270 --> 00:04:07,519
that the national academies and other

101
00:04:11,670 --> 00:04:09,280
advisory bodies

102
00:04:13,990 --> 00:04:11,680
give to the program here in the u.s and

103
00:04:16,469 --> 00:04:14,000
there are similar types of road maps and

104
00:04:17,749 --> 00:04:16,479
so forth done in the other space

105
00:04:19,430 --> 00:04:17,759
programs

106
00:04:21,189 --> 00:04:19,440
and it does operate in a more deliberate

107
00:04:23,270 --> 00:04:21,199
fashion

108
00:04:26,390 --> 00:04:23,280
this is particularly

109
00:04:27,510 --> 00:04:26,400
evident when you look at the way

110
00:04:30,150 --> 00:04:27,520
the outer

111
00:04:32,469 --> 00:04:30,160
solar system exploration has proceeded

112
00:04:35,749 --> 00:04:32,479
because of the vast distances and very

113
00:04:37,510 --> 00:04:35,759

very long flight times involved it means

114
00:04:40,629 --> 00:04:37,520
that you have to select experiments

115
00:04:42,710 --> 00:04:40,639
sometimes years before it launches based

116
00:04:44,310 --> 00:04:42,720
on best available scientific evidence

117
00:04:46,230 --> 00:04:44,320
but not necessarily data from the

118
00:04:47,990 --> 00:04:46,240
previous mission which might still be on

119
00:04:49,909 --> 00:04:48,000
its way for instance

120
00:04:51,749 --> 00:04:49,919
and so things have to be designed to be

121
00:04:54,390 --> 00:04:51,759
reprogrammable

122
00:04:56,230 --> 00:04:54,400
mission operations procedures have to be

123
00:04:57,670 --> 00:04:56,240
flexible so that they can take advantage

124
00:05:00,150 --> 00:04:57,680
of things that get discovered between

125
00:05:01,830 --> 00:05:00,160
the time when you made your plans and

126
00:05:07,189 --> 00:05:01,840
when you're actually sitting there

127
00:05:10,710 --> 00:05:09,029
now i'm going to illustrate that process

128
00:05:13,430 --> 00:05:10,720
not by telling you everything that we've

129
00:05:14,390 --> 00:05:13,440
done in outer solar system exploration

130
00:05:15,990 --> 00:05:14,400
you would

131
00:05:18,310 --> 00:05:16,000
even if you're really interested in this

132
00:05:20,950 --> 00:05:18,320
topic you would begin to glaze over

133
00:05:23,189 --> 00:05:20,960
after the 60th or 70th slide if i went

134
00:05:25,110 --> 00:05:23,199
through that type of

135
00:05:26,310 --> 00:05:25,120
procedure so what i'm going to do is

136
00:05:29,110 --> 00:05:26,320
take two

137
00:05:30,790 --> 00:05:29,120
specific areas that are somewhat linked

138
00:05:33,270 --> 00:05:30,800

and talk about how

139
00:05:35,590 --> 00:05:33,280
our objectives for those have changed

140
00:05:37,990 --> 00:05:35,600
through the process of a series of outer

141
00:05:40,150 --> 00:05:38,000
planet explorations

142
00:05:42,950 --> 00:05:40,160
one is the outer planet atmospheric

143
00:05:45,029 --> 00:05:42,960
compositions and the other is the nature

144
00:05:47,110 --> 00:05:45,039
and history of giant planet satellites

145
00:05:47,990 --> 00:05:47,120
these questions are actually linked

146
00:05:51,430 --> 00:05:48,000
through

147
00:05:53,430 --> 00:05:51,440
the scientific goals because they relate

148
00:05:56,150 --> 00:05:53,440
very directly to the

149
00:05:58,629 --> 00:05:56,160
our understanding of the solar nebula

150
00:06:00,710 --> 00:05:58,639
out of which the planets formed and also

151
00:06:03,510 --> 00:06:00,720
our understanding that has progressed

152
00:06:08,629 --> 00:06:03,520
over the years as to what the process is

153
00:06:13,189 --> 00:06:10,629
now i'm going to warn you up front

154
00:06:16,309 --> 00:06:13,199
particularly ralph that i'm going to

155
00:06:19,110 --> 00:06:16,319
mostly ignore a third major theme that

156
00:06:22,629 --> 00:06:19,120
would also be worthy of an entire paper

157
00:06:25,670 --> 00:06:22,639
which is the exploration of the magnetic

158
00:06:27,110 --> 00:06:25,680
and plasma environments of these planets

159
00:06:29,029 --> 00:06:27,120
i'm going to touch on that in this

160
00:06:31,590 --> 00:06:29,039
particular talk only as it sort of

161
00:06:33,350 --> 00:06:31,600
relates to the issue of the interactions

162
00:06:35,590 --> 00:06:33,360
of those environments with their

163
00:06:36,950 --> 00:06:35,600

satellites for instance

164
00:06:38,469 --> 00:06:36,960
so you can ask

165
00:06:40,070 --> 00:06:38,479
and when we get to the panel you can ask

166
00:06:42,070 --> 00:06:40,080
ralph about how you go about

167
00:06:43,590 --> 00:06:42,080
investigating

168
00:06:45,430 --> 00:06:43,600
the magnetospheres of planets i'll

169
00:06:47,510 --> 00:06:45,440
remind you that at the beginning of the

170
00:06:49,589 --> 00:06:47,520
space program we knew of only one

171
00:06:52,870 --> 00:06:49,599
magnetosphere other than the earth

172
00:06:53,830 --> 00:06:52,880
which was jupiter it was defined and dec

173
00:06:55,749 --> 00:06:53,840
and and

174
00:06:57,270 --> 00:06:55,759
identified initially through radio

175
00:06:59,430 --> 00:06:57,280
astronomy

176
00:07:01,350 --> 00:06:59,440
so that was that was a major theme in in

177
00:07:02,950 --> 00:07:01,360
outer planet exploration running along

178
00:07:06,710 --> 00:07:02,960
in parallel with some of the ones that

179
00:07:10,070 --> 00:07:08,790
so let me take you back to the beginning

180
00:07:12,230 --> 00:07:10,080
of outer planets

181
00:07:15,110 --> 00:07:12,240
exploration which is not quite back 50

182
00:07:17,350 --> 00:07:15,120
years but almost

183
00:07:20,390 --> 00:07:17,360
and take you back to sort of uh solar

184
00:07:22,070 --> 00:07:20,400
system version 1.0 which is what we

185
00:07:24,070 --> 00:07:22,080
started planning the outer planet

186
00:07:26,309 --> 00:07:24,080
programs with

187
00:07:29,029 --> 00:07:26,319
only 10 years after the mariner 2

188
00:07:32,390 --> 00:07:29,039

launched that we started thinking about

189
00:07:33,589 --> 00:07:32,400
outer solar system exploration

190
00:07:35,670 --> 00:07:33,599
because

191
00:07:37,110 --> 00:07:35,680
as was pointed out by several speakers

192
00:07:39,510 --> 00:07:37,120
yesterday

193
00:07:41,670 --> 00:07:39,520
we had this wonderful grand alignment of

194
00:07:44,309 --> 00:07:41,680
the outer planets that allowed very

195
00:07:47,110 --> 00:07:44,319
short trip times for at least a few

196
00:07:47,909 --> 00:07:47,120
specific launch dates

197
00:07:50,390 --> 00:07:47,919
and

198
00:07:52,550 --> 00:07:50,400
one of my very first nasa briefings was

199
00:07:54,390 --> 00:07:52,560
listening to john naugle tell us about

200
00:07:56,230 --> 00:07:54,400
the grand tour in washington i was a

201
00:08:00,629 --> 00:07:56,240
postdoc at the time

202
00:08:08,550 --> 00:08:00,639
and i thought getting to neptune in 1989

203
00:08:12,150 --> 00:08:10,070
and we were all very distressed when

204
00:08:14,390 --> 00:08:12,160
that grand idea got

205
00:08:16,550 --> 00:08:14,400
scoped but it was resurrected rather

206
00:08:17,830 --> 00:08:16,560
rapidly as was also discussed by several

207
00:08:19,430 --> 00:08:17,840
speakers

208
00:08:20,710 --> 00:08:19,440
yesterday and

209
00:08:22,950 --> 00:08:20,720
i'll point out one of the things that

210
00:08:24,830 --> 00:08:22,960
didn't get much discussion yesterday was

211
00:08:26,469 --> 00:08:24,840
that actually the first part of that

212
00:08:29,270 --> 00:08:26,479
resurrection

213
00:08:32,230 --> 00:08:29,280

even before voyager was jim van allen

214
00:08:34,389 --> 00:08:32,240
pushing very hard on getting a fast

215
00:08:35,350 --> 00:08:34,399
simple spacecraft out to jupiter to find

216
00:08:37,430 --> 00:08:35,360
out what was there with that

217
00:08:40,469 --> 00:08:37,440
magnetosphere and of course to carry van

218
00:08:43,509 --> 00:08:40,479
allen's geiger counter with it

219
00:08:45,670 --> 00:08:43,519
and uh so pioneers 10 and 11 were very

220
00:08:47,110 --> 00:08:45,680
much a part of this kind of restructured

221
00:08:49,590 --> 00:08:47,120
idea they were designed to get out there

222
00:08:51,750 --> 00:08:49,600
to jupiter find out what was there

223
00:08:54,710 --> 00:08:51,760
voyager follow along with more of the

224
00:08:56,550 --> 00:08:54,720
objectives of the grand tour and

225
00:08:58,150 --> 00:08:56,560
but go only to jupiter and saturn that

226
00:09:00,630 --> 00:08:58,160
was all that was promised but they would

227
00:09:01,990 --> 00:09:00,640
be launched at times which would enable

228
00:09:04,310 --> 00:09:02,000
pieces of the old grand tour

229
00:09:08,550 --> 00:09:04,320
trajectories to be uh

230
00:09:12,870 --> 00:09:10,470
okay let me take you back to our state

231
00:09:16,550 --> 00:09:12,880
of knowledge of the solar nebula and the

232
00:09:17,750 --> 00:09:16,560
giant planets at that at that time

233
00:09:18,790 --> 00:09:17,760
uh

234
00:09:22,630 --> 00:09:18,800
we

235
00:09:25,430 --> 00:09:22,640
quantitative understanding of what the

236
00:09:26,630 --> 00:09:25,440
planets were formed out of and how they

237
00:09:28,949 --> 00:09:26,640
were formed

238
00:09:30,470 --> 00:09:28,959

and by modern standards it was quite

239
00:09:32,790 --> 00:09:30,480
simplistic which is one of the things

240
00:09:34,710 --> 00:09:32,800
that's changed over this period of time

241
00:09:37,110 --> 00:09:34,720
but al cameron

242
00:09:40,310 --> 00:09:37,120
put together quantitative pressure

243
00:09:42,550 --> 00:09:40,320
temperature density models of the solar

244
00:09:44,230 --> 00:09:42,560
nebula and of course he changed it

245
00:09:46,870 --> 00:09:44,240
several times per year so people were

246
00:09:49,430 --> 00:09:46,880
always playing kick up pickup

247
00:09:51,030 --> 00:09:49,440
with coming along afterwards and

248
00:09:53,350 --> 00:09:51,040
trying to figure out what the how their

249
00:09:55,750 --> 00:09:53,360
models matched uh l's

250
00:09:57,590 --> 00:09:55,760
several months after he published it

251
00:09:59,670 --> 00:09:57,600
and that was coupled with giant planet

252
00:10:01,030 --> 00:09:59,680
formation models

253
00:10:03,190 --> 00:10:01,040
which

254
00:10:05,030 --> 00:10:03,200
were again quantitative but by modern

255
00:10:06,630 --> 00:10:05,040
standards quite simplistic the idea

256
00:10:09,509 --> 00:10:06,640
being that if you've got something as

257
00:10:11,430 --> 00:10:09,519
big as jupiter or saturn

258
00:10:14,790 --> 00:10:11,440
it would hold a hydrogen helium

259
00:10:16,310 --> 00:10:14,800
atmosphere and would not cause major

260
00:10:18,710 --> 00:10:16,320
fractionation

261
00:10:20,470 --> 00:10:18,720
by escape by gene's escape from the top

262
00:10:22,790 --> 00:10:20,480
of the atmosphere

263
00:10:25,509 --> 00:10:22,800

all of that was true and so we expected

264
00:10:28,230 --> 00:10:25,519
at that time and this was uh embedded in

265
00:10:30,069 --> 00:10:28,240
the advices from the national academy

266
00:10:32,230 --> 00:10:30,079
that when we got to an outer planet

267
00:10:34,470 --> 00:10:32,240
atmosphere we would see essentially an

268
00:10:37,190 --> 00:10:34,480
unchanged sample of the gas from the

269
00:10:40,389 --> 00:10:37,200
solar nebula collected by this massive

270
00:10:42,470 --> 00:10:40,399
gravity and preserved for our use for 4

271
00:10:43,509 --> 00:10:42,480
billion years

272
00:10:46,470 --> 00:10:43,519
so

273
00:10:48,470 --> 00:10:46,480
hydrogen to helium ratio

274
00:10:51,030 --> 00:10:48,480
sort of became the mantra

275
00:10:53,509 --> 00:10:51,040
of the people interested in the gas

276
00:10:55,990 --> 00:10:53,519
giants at that time the holy grail if

277
00:10:58,150 --> 00:10:56,000
you will if we measure the hydrogen and

278
00:11:00,790 --> 00:10:58,160
helium ratio in these atmospheres we

279
00:11:03,910 --> 00:11:00,800
will be measuring the original hydrogen

280
00:11:05,910 --> 00:11:03,920
helium gas that came

281
00:11:08,069 --> 00:11:05,920
that from which the sun was originally

282
00:11:10,710 --> 00:11:08,079
formed it was believed actually at that

283
00:11:12,230 --> 00:11:10,720
point that that would be a better

284
00:11:14,069 --> 00:11:12,240
indicator of the original hydrogen

285
00:11:16,470 --> 00:11:14,079
helium ratio than what we actually

286
00:11:19,030 --> 00:11:16,480
measure in today's sun because

287
00:11:21,590 --> 00:11:19,040
things going on with solar

288
00:11:23,910 --> 00:11:21,600

interior burning and thermal at

289
00:11:25,590 --> 00:11:23,920
nucleosynthesis and so forth have been

290
00:11:32,470 --> 00:11:25,600
changing the hydrogen helium ratio in

291
00:11:35,350 --> 00:11:33,670
the

292
00:11:38,150 --> 00:11:35,360
composition of that original solar

293
00:11:40,470 --> 00:11:38,160
nebula also played a role in setting the

294
00:11:42,470 --> 00:11:40,480
state of knowledge of the giant planet

295
00:11:44,550 --> 00:11:42,480
satellites at that time

296
00:11:45,590 --> 00:11:44,560
we didn't know much about them it's

297
00:11:47,430 --> 00:11:45,600
amazing

298
00:11:49,269 --> 00:11:47,440
to think about how little we knew at

299
00:11:51,110 --> 00:11:49,279
that time we didn't really know masses

300
00:11:53,430 --> 00:11:51,120
radiuses how bright they were i mean how

301
00:11:54,870 --> 00:11:53,440
reflective they were compositions

302
00:11:56,710 --> 00:11:54,880
ephemerities

303
00:11:58,629 --> 00:11:56,720
general view amongst most of my

304
00:12:01,430 --> 00:11:58,639
colleagues in the uh

305
00:12:03,430 --> 00:12:01,440
estrada astronomy and geology world was

306
00:12:07,990 --> 00:12:03,440
we're gonna go see cratered mud balls

307
00:12:12,550 --> 00:12:10,629
we did know a few things

308
00:12:14,470 --> 00:12:12,560
uh this came from my own thesis actually

309
00:12:17,829 --> 00:12:14,480
i collected all the information we had

310
00:12:19,910 --> 00:12:17,839
some of it from my own data about the uh

311
00:12:22,230 --> 00:12:19,920
brightness or reflective qualities the

312
00:12:24,310 --> 00:12:22,240
albedo of the satellites

313
00:12:26,230 --> 00:12:24,320

and their density and all those big

314
00:12:29,269 --> 00:12:26,240
boxes and error bars there because we

315
00:12:30,710 --> 00:12:29,279
didn't know what their radii were

316
00:12:32,550 --> 00:12:30,720
and we didn't know what their masses

317
00:12:34,550 --> 00:12:32,560
were very accurately

318
00:12:37,350 --> 00:12:34,560
so as you can see you could run anywhere

319
00:12:40,150 --> 00:12:37,360
from a few some of these boxes like the

320
00:12:42,790 --> 00:12:40,160
one for callisto j4 as it was called in

321
00:12:44,790 --> 00:12:42,800
most of the ephemerides at the time

322
00:12:47,030 --> 00:12:44,800
could run from a density of one up to a

323
00:12:49,269 --> 00:12:47,040
density of three and we had some things

324
00:12:54,389 --> 00:12:49,279
that obviously had fairly high density

325
00:12:59,350 --> 00:12:56,550
the voyager imaging team at that time

326
00:13:02,550 --> 00:12:59,360
only had two geologists on it

327
00:13:03,990 --> 00:13:02,560
i think larry soderblum and

328
00:13:05,190 --> 00:13:04,000
hal mazurski

329
00:13:07,829 --> 00:13:05,200
and

330
00:13:10,069 --> 00:13:07,839
the planning was based on this type of

331
00:13:11,110 --> 00:13:10,079
information they said okay well we got

332
00:13:12,949 --> 00:13:11,120
kind of

333
00:13:14,310 --> 00:13:12,959
rocky satellites and icy satellites

334
00:13:15,990 --> 00:13:14,320
we'll go buy one of each even though

335
00:13:17,829 --> 00:13:16,000
they're four out there and that's that's

336
00:13:22,310 --> 00:13:17,839
what the early planning for voyager was

337
00:13:29,030 --> 00:13:24,470
but

338
00:13:30,710 --> 00:13:29,040

data and theory for the outer planet uh

339
00:13:33,670 --> 00:13:30,720
satellites and

340
00:13:35,350 --> 00:13:33,680
the systems in general was exploding at

341
00:13:37,590 --> 00:13:35,360
this period of time

342
00:13:39,910 --> 00:13:37,600
that same camera never nebula model that

343
00:13:42,710 --> 00:13:39,920
was applied to understanding what the

344
00:13:46,069 --> 00:13:42,720
atmospheres of the planets might be like

345
00:13:47,110 --> 00:13:46,079
was applied taken and used by john lewis

346
00:13:51,030 --> 00:13:47,120
to

347
00:13:53,350 --> 00:13:51,040
what the compositions of the satellite

348
00:13:55,350 --> 00:13:53,360
should be like and he noted that hey you

349
00:13:58,069 --> 00:13:55,360
know if you take that solar nebula

350
00:13:59,750 --> 00:13:58,079
composition and take it that gas down to

351
00:14:02,470 --> 00:13:59,760
the temperature and pressure that there

352
00:14:03,829 --> 00:14:02,480
is there in al cameron's nebula you're

353
00:14:05,509 --> 00:14:03,839
going to get

354
00:14:07,509 --> 00:14:05,519
satellites that are rather interesting

355
00:14:08,629 --> 00:14:07,519
there'll be about half and half rock and

356
00:14:10,710 --> 00:14:08,639
ice

357
00:14:11,829 --> 00:14:10,720
and if they're big enough like lunar

358
00:14:13,990 --> 00:14:11,839
size

359
00:14:16,230 --> 00:14:14,000
radioactive heating is enough to

360
00:14:18,150 --> 00:14:16,240
melt that ice so he said hey these

361
00:14:19,590 --> 00:14:18,160
aren't just going to be inner ice balls

362
00:14:20,949 --> 00:14:19,600
they could actually be really

363
00:14:25,750 --> 00:14:20,959

interesting

364
00:14:30,069 --> 00:14:27,110
several other things were occurring at

365
00:14:32,550 --> 00:14:30,079
the same time

366
00:14:35,110 --> 00:14:32,560
there was an occultation of a star by

367
00:14:37,030 --> 00:14:35,120
ganymede in 1972.

368
00:14:38,629 --> 00:14:37,040
uh this was one of the only accurate

369
00:14:40,069 --> 00:14:38,639
ways to get radii

370
00:14:42,230 --> 00:14:40,079
measurements at that time we'd already

371
00:14:44,470 --> 00:14:42,240
measured the radius of io that way a

372
00:14:47,030 --> 00:14:44,480
couple of years a year or so earlier

373
00:14:48,790 --> 00:14:47,040
that determined the radius accurately

374
00:14:52,150 --> 00:14:48,800
this pioneer

375
00:14:53,430 --> 00:14:52,160
early recon of the system at jupiter

376
00:14:54,470 --> 00:14:53,440
allowed

377
00:14:57,590 --> 00:14:54,480
the

378
00:14:59,269 --> 00:14:57,600
mass of ganymede to be measured fairly

379
00:15:01,030 --> 00:14:59,279
accurately that was the only one it got

380
00:15:03,110 --> 00:15:01,040
very close to

381
00:15:04,949 --> 00:15:03,120
and that density matched lewis model

382
00:15:07,590 --> 00:15:04,959
almost exactly

383
00:15:09,829 --> 00:15:07,600
it got a density of just about two which

384
00:15:12,310 --> 00:15:09,839
when you accounted for pressure effects

385
00:15:14,790 --> 00:15:12,320
gave you a rock to ice ratio of about 50

386
00:15:18,389 --> 00:15:16,310
in addition to which we found out that

387
00:15:20,230 --> 00:15:18,399
iowa was active somehow or another there

388
00:15:22,629 --> 00:15:20,240

was sodium emission

389
00:15:24,470 --> 00:15:22,639
lines sodium d-lines

390
00:15:27,189 --> 00:15:24,480
from resident scattering of sunlight

391
00:15:29,829 --> 00:15:27,199
discovered around io at that time

392
00:15:32,389 --> 00:15:29,839
and the reflection spectra of

393
00:15:35,030 --> 00:15:32,399
ganymede and callisto were taken i and

394
00:15:36,949 --> 00:15:35,040
europa and show that there was water ice

395
00:15:38,829 --> 00:15:36,959
on the surface of these uh of these

396
00:15:41,910 --> 00:15:38,839
bodies so we had

397
00:15:43,590 --> 00:15:41,920
some uh inkling that the the sort of

398
00:15:45,350 --> 00:15:43,600
models that lewis was putting together

399
00:15:46,949 --> 00:15:45,360
were correct and this mind you is about

400
00:15:49,829 --> 00:15:46,959
the time that instruments were being

401
00:15:50,870 --> 00:15:49,839
chosen for voyager so think about that

402
00:15:52,550 --> 00:15:50,880
okay

403
00:15:55,749 --> 00:15:52,560
that's what the

404
00:15:58,710 --> 00:15:55,759
lewis model using the cameron nebula

405
00:16:01,350 --> 00:15:58,720
looked like and the basic point here is

406
00:16:03,030 --> 00:16:01,360
that at the distance of jupiter this is

407
00:16:05,670 --> 00:16:03,040
log pressure log

408
00:16:07,910 --> 00:16:05,680
temperature here and the planetary

409
00:16:10,069 --> 00:16:07,920
symbols there show the distance out in

410
00:16:11,910 --> 00:16:10,079
the solar system that's where the water

411
00:16:14,230 --> 00:16:11,920
line is just around jupiter you can

412
00:16:16,870 --> 00:16:14,240
start condensing water in that nebula

413
00:16:18,870 --> 00:16:16,880

and keeping it as ice for over 4 billion

414
00:16:20,069 --> 00:16:18,880
years

415
00:16:21,590 --> 00:16:20,079
this was

416
00:16:25,030 --> 00:16:21,600
illustrating the

417
00:16:28,870 --> 00:16:25,040
occultation of ganymede that's myself

418
00:16:31,670 --> 00:16:28,880
there on the left in my billbottom phase

419
00:16:33,990 --> 00:16:31,680
with bob bob carlson with me

420
00:16:36,310 --> 00:16:34,000
we were measuring one chord of that

421
00:16:39,110 --> 00:16:36,320
occultation the other was measured by a

422
00:16:42,069 --> 00:16:39,120
colleague of ours in india at the same

423
00:16:43,749 --> 00:16:42,079
time and we got the radius measured very

424
00:16:47,030 --> 00:16:43,759
accurately

425
00:16:49,990 --> 00:16:47,040
that's spectra of in this case ganymede

426
00:16:53,350 --> 00:16:50,000
and europa published by carl pilcher i

427
00:16:55,590 --> 00:16:53,360
worked nasa for many years still works

428
00:16:58,150 --> 00:16:55,600
out with the

429
00:16:59,990 --> 00:16:58,160
institute out in ames

430
00:17:01,829 --> 00:17:00,000
ridgeway and mccord which showed that

431
00:17:03,350 --> 00:17:01,839
those objects were covered with water

432
00:17:05,110 --> 00:17:03,360
ice

433
00:17:07,429 --> 00:17:05,120
okay now

434
00:17:09,350 --> 00:17:07,439
not long after that

435
00:17:12,309 --> 00:17:09,360
think about this that you know we had

436
00:17:15,110 --> 00:17:12,319
the uh uh flybys of

437
00:17:16,870 --> 00:17:15,120
uh jupiter by pioneers 10 and 11 just a

438
00:17:18,710 --> 00:17:16,880

year or two before this this was a

439
00:17:20,789 --> 00:17:18,720
briefing that i gave

440
00:17:21,829 --> 00:17:20,799
to the complex

441
00:17:24,309 --> 00:17:21,839
committee

442
00:17:27,350 --> 00:17:24,319
in 1975

443
00:17:29,830 --> 00:17:27,360
pushing for a new jupiter mission

444
00:17:30,830 --> 00:17:29,840
even though we hadn't even launched

445
00:17:33,750 --> 00:17:30,840
voyager

446
00:17:36,070 --> 00:17:33,760
yet was based on this theoretical

447
00:17:38,310 --> 00:17:36,080
understanding lewis's models that these

448
00:17:40,230 --> 00:17:38,320
objects might really be interesting

449
00:17:42,230 --> 00:17:40,240
worlds in their own right and that we

450
00:17:43,590 --> 00:17:42,240
needed despite

451
00:17:45,909 --> 00:17:43,600
the fact we knew we were going to get

452
00:17:47,350 --> 00:17:45,919
lovely voyager data we needed to go back

453
00:17:49,110 --> 00:17:47,360
and get

454
00:17:51,430 --> 00:17:49,120
detailed

455
00:17:56,230 --> 00:17:51,440
study of these objects and we could do

456
00:17:59,350 --> 00:17:57,669
this is the state of knowledge of the

457
00:18:03,350 --> 00:17:59,360
satellites after

458
00:18:05,669 --> 00:18:03,360
the pioneer 10 and 11 flybys and this

459
00:18:08,070 --> 00:18:05,679
now is showing density and radius rather

460
00:18:10,549 --> 00:18:08,080
than albedo but you see two distinct

461
00:18:13,510 --> 00:18:10,559
clusters and on this type of diagram i

462
00:18:15,669 --> 00:18:13,520
see things fall on a line of density and

463
00:18:18,390 --> 00:18:15,679

radius down here in the bottom of this

464
00:18:21,190 --> 00:18:18,400
chart and rocky things fall up in the

465
00:18:22,630 --> 00:18:21,200
top where the terrestrial planets are

466
00:18:24,150 --> 00:18:22,640
it's interesting to note that this is

467
00:18:26,870 --> 00:18:24,160
pretty much the state of knowledge we

468
00:18:28,950 --> 00:18:26,880
now have for the best studied exoplanets

469
00:18:32,870 --> 00:18:28,960
that we are now beginning to get we have

470
00:18:38,549 --> 00:18:34,950
so when we were briefing

471
00:18:41,270 --> 00:18:38,559
the public and the reporters at the cape

472
00:18:43,350 --> 00:18:41,280
just before the voyager 2 launch

473
00:18:45,110 --> 00:18:43,360
this was the sort of cartoon we made up

474
00:18:46,390 --> 00:18:45,120
for them of what the satellites would be

475
00:18:48,230 --> 00:18:46,400
like

476
00:18:50,870 --> 00:18:48,240
and in many ways it was really quite

477
00:18:52,950 --> 00:18:50,880
sophisticated we knew that io was rocky

478
00:18:54,549 --> 00:18:52,960
up in the left we knew that ganymede and

479
00:18:56,950 --> 00:18:54,559
callisto

480
00:18:59,270 --> 00:18:56,960
contained water and we suspected they

481
00:19:00,470 --> 00:18:59,280
had cores and enough heat to produce

482
00:19:03,669 --> 00:19:00,480
oceans

483
00:19:05,669 --> 00:19:03,679
picture

484
00:19:07,350 --> 00:19:05,679
at this time we didn't know much about

485
00:19:08,549 --> 00:19:07,360
europa the reason that there aren't any

486
00:19:10,870 --> 00:19:08,559
oceans

487
00:19:12,950 --> 00:19:10,880
shown on europa is we didn't know its

488
00:19:15,110 --> 00:19:12,960

density well enough to know how thick

489
00:19:16,470 --> 00:19:15,120
the ice was the highest the ice has to

490
00:19:21,510 --> 00:19:16,480
be

491
00:19:23,430 --> 00:19:21,520
able to actually uh melt and produce an

492
00:19:28,549 --> 00:19:23,440
ocean under it so that was a question

493
00:19:33,270 --> 00:19:30,950
so we had modified the voyager plans a

494
00:19:35,669 --> 00:19:33,280
bit based on all of this understanding

495
00:19:37,510 --> 00:19:35,679
and theoretical discussion

496
00:19:38,870 --> 00:19:37,520
we couldn't reselect the instruments at

497
00:19:41,029 --> 00:19:38,880
this point

498
00:19:44,390 --> 00:19:41,039
but we did add a couple more satellite

499
00:19:46,789 --> 00:19:44,400
scientists and we increased the flybys

500
00:19:48,630 --> 00:19:46,799
due to some very fine trajectory work by

501
00:19:51,029 --> 00:19:48,640
jeff briggs also worked at nasa

502
00:19:52,230 --> 00:19:51,039
headquarters for a long time who found

503
00:19:54,390 --> 00:19:52,240
out that you could because of the

504
00:19:55,669 --> 00:19:54,400
resonant orbits

505
00:19:58,870 --> 00:19:55,679
get several

506
00:20:00,549 --> 00:19:58,880
satellite flybys with each voyager pass

507
00:20:03,590 --> 00:20:00,559
so voyager

508
00:20:04,950 --> 00:20:03,600
planning and science was modified to do

509
00:20:10,549 --> 00:20:04,960
that

510
00:20:14,390 --> 00:20:10,559
is a not scientifically correct uh photo

511
00:20:16,149 --> 00:20:14,400
montage so showing the uh voyager family

512
00:20:17,830 --> 00:20:16,159
portrait of all four of the alliance

513
00:20:19,750 --> 00:20:17,840

satellites

514
00:20:21,510 --> 00:20:19,760
just to remind you we found cratered

515
00:20:24,149 --> 00:20:21,520
callisto

516
00:20:27,190 --> 00:20:24,159
ganymede cratered areas but areas that

517
00:20:30,230 --> 00:20:27,200
also look geologically active

518
00:20:35,190 --> 00:20:32,310
very very puzzling

519
00:20:38,630 --> 00:20:35,200
very few craters clearly indicating some

520
00:20:41,270 --> 00:20:38,640
form of of resurfacing and

521
00:20:42,870 --> 00:20:41,280
the ocean models versus we have a thin

522
00:20:44,870 --> 00:20:42,880
ice

523
00:20:46,149 --> 00:20:44,880
crust on top of a

524
00:20:48,070 --> 00:20:46,159
warm mud

525
00:20:50,070 --> 00:20:48,080
models where the two types of models

526
00:20:52,789 --> 00:20:50,080
that were that came out of voyager at

527
00:20:58,390 --> 00:20:55,350
io's volcanism

528
00:21:00,549 --> 00:20:58,400
active volcanism a big plume rising over

529
00:21:03,190 --> 00:21:00,559
the limb on the right side there

530
00:21:06,149 --> 00:21:03,200
shooting up 100 kilometers or more

531
00:21:09,110 --> 00:21:06,159
shooting dust and sulfur dioxide gas and

532
00:21:14,830 --> 00:21:09,120
and condensed sulfur dioxide out

533
00:21:19,830 --> 00:21:17,750
so at that point

534
00:21:21,029 --> 00:21:19,840
we were still planning the galileo

535
00:21:23,830 --> 00:21:21,039
mission

536
00:21:26,070 --> 00:21:23,840
that was 1979 when we were there the

537
00:21:29,350 --> 00:21:26,080
galileo mission had actually gotten its

538
00:21:31,110 --> 00:21:29,360

start in 1978

539
00:21:33,510 --> 00:21:31,120
and we took the voyager data then and

540
00:21:35,830 --> 00:21:33,520
said okay well what can we do based on

541
00:21:38,710 --> 00:21:35,840
the voyager data to change our galileo

542
00:21:45,350 --> 00:21:40,870
in 1976

543
00:21:47,430 --> 00:21:45,360
over a year before voyager launched our

544
00:21:48,950 --> 00:21:47,440
science our

545
00:21:50,710 --> 00:21:48,960
science assessment group which was

546
00:21:51,430 --> 00:21:50,720
headed by jim van allen

547
00:21:53,350 --> 00:21:51,440
uh

548
00:21:54,950 --> 00:21:53,360
made recommendations to headquarters and

549
00:21:58,070 --> 00:21:54,960
ao was put out

550
00:22:01,510 --> 00:21:58,080
and that's contained in in

551
00:22:04,149 --> 00:22:01,520
the the ao materials and followed the

552
00:22:06,149 --> 00:22:04,159
directions and priorities for complex

553
00:22:07,830 --> 00:22:06,159
reports of that era

554
00:22:09,909 --> 00:22:07,840
key elements in that was hydrogen and

555
00:22:12,149 --> 00:22:09,919
helium was still king

556
00:22:13,669 --> 00:22:12,159
we needed to get that information

557
00:22:15,510 --> 00:22:13,679
although

558
00:22:17,669 --> 00:22:15,520
the theoreticians were already beginning

559
00:22:20,230 --> 00:22:17,679
to mumble things about well the helium

560
00:22:22,390 --> 00:22:20,240
might condense out and fall toward the

561
00:22:24,070 --> 00:22:22,400
core and it might not be quite as simple

562
00:22:26,789 --> 00:22:24,080
as we thought

563
00:22:29,270 --> 00:22:26,799

and in addition to that there was an

564
00:22:30,950 --> 00:22:29,280
increase in emphasis on satellites and

565
00:22:32,630 --> 00:22:30,960
interaction with the magnetospheres

566
00:22:35,029 --> 00:22:32,640
because of all this activity we saw

567
00:22:37,270 --> 00:22:35,039
around ohio and other places so they

568
00:22:40,390 --> 00:22:37,280
they went up to the the top of the

569
00:22:47,190 --> 00:22:43,110
this was that report in august of 1976

570
00:22:47,200 --> 00:22:52,230
the galileo mission

571
00:22:57,110 --> 00:22:53,750
and preparing for that and trying to

572
00:22:59,669 --> 00:22:57,120
respond to to voyager as i said the

573
00:23:02,549 --> 00:22:59,679
voyager 1 and 2

574
00:23:03,990 --> 00:23:02,559
flyby produced a number of surprises

575
00:23:08,230 --> 00:23:04,000
i will point out that the active

576
00:23:10,630 --> 00:23:08,240
volcanism wasn't really a surprise

577
00:23:12,710 --> 00:23:10,640
there was a paper earlier that year by

578
00:23:14,310 --> 00:23:12,720
peel at all stand peel it all they said

579
00:23:17,350 --> 00:23:14,320
oh tidal heating ought to be able to

580
00:23:19,590 --> 00:23:17,360
produce volcanism on io the surprise to

581
00:23:20,870 --> 00:23:19,600
a scientist was much more subtle

582
00:23:23,350 --> 00:23:20,880
was that

583
00:23:25,029 --> 00:23:23,360
everybody should have known that tidal

584
00:23:26,710 --> 00:23:25,039
heating was capable of happening on the

585
00:23:28,470 --> 00:23:26,720
satellites except for the fact that if

586
00:23:29,750 --> 00:23:28,480
you looked in the ephemeris books they

587
00:23:31,750 --> 00:23:29,760
all showed the eccentricity the

588
00:23:33,190 --> 00:23:31,760

satellites were zero

589
00:23:35,430 --> 00:23:33,200
can't get tidal heating with zero

590
00:23:37,990 --> 00:23:35,440
eccentricity

591
00:23:42,470 --> 00:23:40,549
the dynamicist knew that the average

592
00:23:43,990 --> 00:23:42,480
eccentricity was zero but with all of

593
00:23:45,990 --> 00:23:44,000
this interaction between the gravity of

594
00:23:47,990 --> 00:23:46,000
the satellites the instantaneous

595
00:23:48,710 --> 00:23:48,000
eccentricity was not zero and you could

596
00:23:50,789 --> 00:23:48,720
get

597
00:23:52,549 --> 00:23:50,799
tidal heating so tidal heating came

598
00:23:54,789 --> 00:23:52,559
strongly to the fore at this point in

599
00:23:56,310 --> 00:23:54,799
terms of satellite

600
00:23:59,110 --> 00:23:56,320
possibilities

601
00:24:00,710 --> 00:23:59,120
and we modified the mission plan to

602
00:24:02,710 --> 00:24:00,720
increase the number of satellite

603
00:24:05,190 --> 00:24:02,720
encounters for galileo from three to

604
00:24:06,950 --> 00:24:05,200
twelve

605
00:24:09,269 --> 00:24:06,960
nasa only wanted 3 because they wanted

606
00:24:13,990 --> 00:24:09,279
to keep the cost down and we also stuck

607
00:24:17,430 --> 00:24:14,950
several things were happening

608
00:24:19,590 --> 00:24:17,440
simultaneously at this point okay we

609
00:24:21,350 --> 00:24:19,600
were planting galileo voyager was now

610
00:24:22,230 --> 00:24:21,360
flying by saturn

611
00:24:24,310 --> 00:24:22,240
and

612
00:24:27,350 --> 00:24:24,320
for the purposes of this story

613
00:24:30,310 --> 00:24:28,710

major

614
00:24:33,029 --> 00:24:30,320
important thing that voyager found at

615
00:24:35,510 --> 00:24:33,039
saturn is what it didn't see

616
00:24:37,350 --> 00:24:35,520
it didn't see the surface of titan

617
00:24:39,909 --> 00:24:37,360
but it did establish that it had a huge

618
00:24:42,230 --> 00:24:39,919
thick hydrocarbon rich atmosphere

619
00:24:43,510 --> 00:24:42,240
and it didn't see a lot of craters on

620
00:24:47,750 --> 00:24:43,520
enceladus

621
00:24:52,870 --> 00:24:47,760
of vesta

622
00:24:56,470 --> 00:24:55,269
so that type of thinking went into

623
00:25:01,909 --> 00:24:56,480
cassini

624
00:25:04,070 --> 00:25:01,919
jointly with esa three years after

625
00:25:06,710 --> 00:25:04,080
voyager encounter with saturn in five

626
00:25:08,310 --> 00:25:06,720
years before the galileo launch

627
00:25:11,110 --> 00:25:08,320
originally it was planned as sort of a

628
00:25:13,590 --> 00:25:11,120
super super galileo with probes for both

629
00:25:16,310 --> 00:25:13,600
saturn and titan

630
00:25:18,390 --> 00:25:16,320
too expensive is d scoped at that point

631
00:25:19,909 --> 00:25:18,400
titan got the nod partially because of

632
00:25:21,269 --> 00:25:19,919
the cooperation with our european

633
00:25:22,070 --> 00:25:21,279
colleagues

634
00:25:24,070 --> 00:25:22,080
who

635
00:25:25,669 --> 00:25:24,080
in this in the studies were going to

636
00:25:27,750 --> 00:25:25,679
build the probe

637
00:25:30,070 --> 00:25:27,760
very interested in titan there were

638
00:25:32,470 --> 00:25:30,080

problems in doing a deep enough probe at

639
00:25:34,549 --> 00:25:32,480
saturn and so titan got the nod and

640
00:25:36,630 --> 00:25:34,559
enceladus went to the top of the list

641
00:25:38,630 --> 00:25:36,640
again on the theme of scientists

642
00:25:40,710 --> 00:25:38,640
surprised and astounded

643
00:25:43,029 --> 00:25:40,720
it was no surprise that we saw stuff

644
00:25:45,430 --> 00:25:43,039
going on at enceladus the reason we saw

645
00:25:47,430 --> 00:25:45,440
stuff going on in enceladus with cassini

646
00:25:52,230 --> 00:25:47,440
was because it was on the top of our

647
00:25:57,750 --> 00:25:53,750
that's where we were with the science

648
00:26:01,110 --> 00:25:57,760
assessment study for cassini

649
00:26:03,750 --> 00:26:01,120
galileo launched jupiter arrival

650
00:26:06,230 --> 00:26:03,760
i said i would to try to to go over all

651
00:26:08,870 --> 00:26:06,240
of galileo's discoveries would take two

652
00:26:11,110 --> 00:26:08,880
or three more days of seminar

653
00:26:13,830 --> 00:26:11,120
probe went in

654
00:26:16,230 --> 00:26:13,840
big surprise

655
00:26:18,070 --> 00:26:16,240
the atmosphere was not solar composition

656
00:26:19,909 --> 00:26:18,080
and i won't go into the details of this

657
00:26:21,909 --> 00:26:19,919
but basically it's enriched in both

658
00:26:24,630 --> 00:26:21,919
condensable heavy elements and in the

659
00:26:26,630 --> 00:26:24,640
noble gases indicating that the

660
00:26:28,549 --> 00:26:26,640
makeup of that atmosphere is more

661
00:26:32,149 --> 00:26:28,559
complicated than just capturing a big

662
00:26:36,149 --> 00:26:33,669
more complicated

663
00:26:38,230 --> 00:26:36,159

and the delivery of those noble gases is

664
00:26:40,310 --> 00:26:38,240
particularly problematic because it

665
00:26:42,470 --> 00:26:40,320
implies that those gases must have been

666
00:26:44,950 --> 00:26:42,480
delivered by way of being trapped in

667
00:26:47,430 --> 00:26:44,960
very cold ice

668
00:26:50,070 --> 00:26:47,440
colder than one would expect from solar

669
00:26:53,590 --> 00:26:50,080
nebular models at jupiter's distance so

670
00:26:55,269 --> 00:26:53,600
there's some complexity going on there

671
00:26:58,149 --> 00:26:55,279
those

672
00:27:00,870 --> 00:26:58,159
results are factored into the types of

673
00:27:03,990 --> 00:27:00,880
uh objectives we now have for juno

674
00:27:08,310 --> 00:27:04,000
and also led to the decadal survey

675
00:27:12,470 --> 00:27:10,630
that we do a um

676
00:27:14,390 --> 00:27:12,480
a saturn probe to complement this

677
00:27:16,710 --> 00:27:14,400
information

678
00:27:18,710 --> 00:27:16,720
okay

679
00:27:21,909 --> 00:27:18,720
this is going to be a fast slide show

680
00:27:23,590 --> 00:27:21,919
because my moderator is giving me a two

681
00:27:25,909 --> 00:27:23,600
minute mark

682
00:27:27,669 --> 00:27:25,919
ganymede's got its own magnetic field

683
00:27:30,470 --> 00:27:27,679
things we found

684
00:27:35,750 --> 00:27:33,430
got high temperature silicate volcanism

685
00:27:38,549 --> 00:27:35,760
stuff going on all the time

686
00:27:40,630 --> 00:27:38,559
magma generation on io is

687
00:27:44,310 --> 00:27:40,640
by unit mass

688
00:27:46,470 --> 00:27:44,320

rate a thousand times out of the earth

689
00:27:49,430 --> 00:27:46,480
europa which you'll hear a lot more from

690
00:27:52,230 --> 00:27:49,440
on from a subsequent speaker

691
00:27:56,870 --> 00:27:55,190
ice flow surfaces clearly resurfaced

692
00:27:59,269 --> 00:27:56,880
things moved around on the surface

693
00:28:03,350 --> 00:27:59,279
looking very much like

694
00:28:08,870 --> 00:28:05,269
i used to have one here with the titanic

695
00:28:13,350 --> 00:28:10,950
magnetic signatures of oceans if i told

696
00:28:15,110 --> 00:28:13,360
the complex committees years earlier

697
00:28:15,909 --> 00:28:15,120
that we're going to take a magnetometer

698
00:28:20,149 --> 00:28:15,919
to

699
00:28:21,510 --> 00:28:20,159
probably have thrown me out of the room

700
00:28:23,590 --> 00:28:21,520
so it's fortunate that we took the

701
00:28:25,350 --> 00:28:23,600
magnetometer anyway for other good

702
00:28:28,389 --> 00:28:25,360
reasons

703
00:28:31,029 --> 00:28:28,399
it basically the magnetic field is

704
00:28:33,430 --> 00:28:31,039
deflected around and

705
00:28:35,830 --> 00:28:33,440
these satellites as if they were acting

706
00:28:38,389 --> 00:28:35,840
like global electro electrically

707
00:28:40,710 --> 00:28:38,399
conducting spheres and

708
00:28:42,950 --> 00:28:40,720
gee what can be electrically conducting

709
00:28:47,830 --> 00:28:42,960
not ice rock or ionospheres at that

710
00:28:54,950 --> 00:28:48,789
so

711
00:28:56,310 --> 00:28:54,960
and you'll hear more about that from bob

712
00:28:58,070 --> 00:28:56,320
paprilatto

713
00:28:59,110 --> 00:28:58,080

so i'm going to end this up with coming

714
00:29:02,630 --> 00:28:59,120
to the

715
00:29:07,430 --> 00:29:02,640
cassini and you'll hear more of that

716
00:29:13,029 --> 00:29:10,149
we did put a probe into titan's surface

717
00:29:14,950 --> 00:29:13,039
and the mars guys screwed us up and put

718
00:29:16,470 --> 00:29:14,960
a picture of one of their no that's

719
00:29:19,590 --> 00:29:16,480
actually that's actually tight in the

720
00:29:24,310 --> 00:29:22,389
but also looks like it's been fluid worn

721
00:29:26,470 --> 00:29:24,320
and in this case the fluid is probably

722
00:29:28,149 --> 00:29:26,480
liquid hydrocarbons almost certainly

723
00:29:29,830 --> 00:29:28,159
like hydrocarbons

724
00:29:31,590 --> 00:29:29,840
and we got a view of those from sort of

725
00:29:34,789 --> 00:29:31,600
an airplane window point of view on the

726
00:29:36,310 --> 00:29:34,799
way down with the with the huygens probe

727
00:29:38,710 --> 00:29:36,320
showing

728
00:29:40,710 --> 00:29:38,720
valley networks

729
00:29:43,110 --> 00:29:40,720
and we landed in something that was not

730
00:29:44,310 --> 00:29:43,120
like this but was a little moist this is

731
00:29:47,110 --> 00:29:44,320
a methane

732
00:29:49,029 --> 00:29:47,120
ethane lake in the northern areas

733
00:29:51,110 --> 00:29:49,039
which

734
00:29:53,110 --> 00:29:51,120
was discovered by the uh

735
00:29:56,310 --> 00:29:53,120
by the radar this is this is a radar

736
00:29:57,110 --> 00:29:56,320
image colorized for radar reflectivity

737
00:30:00,470 --> 00:29:57,120
and

738
00:30:02,549 --> 00:30:00,480

you'll see more of that too i suspect

739
00:30:04,230 --> 00:30:02,559
we also have specular reflection from

740
00:30:05,909 --> 00:30:04,240
the infrared off those lakes because we

741
00:30:07,990 --> 00:30:05,919
took several instruments that could see

742
00:30:10,870 --> 00:30:08,000
through the clouds

743
00:30:12,710 --> 00:30:10,880
and then enceladus

744
00:30:15,110 --> 00:30:12,720
enceladus plumes i said it wasn't

745
00:30:16,549 --> 00:30:15,120
surprising we saw something enceladus

746
00:30:18,310 --> 00:30:16,559
because we knew it was an interesting

747
00:30:20,070 --> 00:30:18,320
place but i must admit

748
00:30:21,430 --> 00:30:20,080
that these pictures of plumes on

749
00:30:23,269 --> 00:30:21,440
enceladus

750
00:30:25,830 --> 00:30:23,279
heat flow from that southern polar

751
00:30:29,990 --> 00:30:28,070
blooms on the terminator

752
00:30:31,909 --> 00:30:30,000
planetary heat flow

753
00:30:33,830 --> 00:30:31,919
implied by those plumes

754
00:30:36,070 --> 00:30:33,840
is that the

755
00:30:37,909 --> 00:30:36,080
heat flow in those cracks that are

756
00:30:39,430 --> 00:30:37,919
producing the plumes

757
00:30:42,789 --> 00:30:39,440
may be

758
00:30:45,269 --> 00:30:42,799
10 times what you see in geyser fields

759
00:30:46,389 --> 00:30:45,279
in yellowstone

760
00:30:49,830 --> 00:30:46,399
so

761
00:30:51,990 --> 00:30:49,840
amazed surprised astounded

762
00:30:59,830 --> 00:30:52,000
well yes actually

763
00:31:04,789 --> 00:31:02,310

and out of time but we have about five

764
00:31:11,350 --> 00:31:04,799
minutes for questions turrets don't run

765
00:31:11,360 --> 00:31:15,590
don't be shy

766
00:31:19,990 --> 00:31:16,710
oh

767
00:31:24,710 --> 00:31:22,549
that's not a problem yes please

768
00:31:26,710 --> 00:31:24,720
thank you for that uh wonderful talk my

769
00:31:28,870 --> 00:31:26,720
name is mangala sharma i'm an astronomer

770
00:31:30,389 --> 00:31:28,880
with the department of state um i have a

771
00:31:33,509 --> 00:31:30,399
question for

772
00:31:36,950 --> 00:31:33,519
how you went from two scientists

773
00:31:39,029 --> 00:31:36,960
on on on the galileo excuse me on the uh

774
00:31:41,269 --> 00:31:39,039
voyager team first to

775
00:31:43,669 --> 00:31:41,279
you know several hundreds of scientists

776
00:31:45,269 --> 00:31:43,679
who work with you at jpl now and who are

777
00:31:47,110 --> 00:31:45,279
on all of these missions

778
00:31:49,350 --> 00:31:47,120
well let me be just a

779
00:31:53,190 --> 00:31:49,360
i was really speaking of scientists

780
00:31:55,990 --> 00:31:53,200
uh we started out with with voyager

781
00:31:57,669 --> 00:31:56,000
having a science team that had about for

782
00:32:00,230 --> 00:31:57,679
the for the imaging team now this

783
00:32:02,230 --> 00:32:00,240
imaging team had about 10 or 12

784
00:32:04,470 --> 00:32:02,240
scientists on it but they were mostly

785
00:32:06,870 --> 00:32:04,480
people who were interested in the

786
00:32:08,630 --> 00:32:06,880
atmosphere of jupiter

787
00:32:10,230 --> 00:32:08,640
because the satellites weren't believed

788
00:32:12,310 --> 00:32:10,240

to be too interesting at that time we

789
00:32:15,029 --> 00:32:12,320
only had a couple of geologists

790
00:32:18,230 --> 00:32:15,039
nasa then re-looked at the

791
00:32:20,549 --> 00:32:18,240
uh the the team and the objectives as

792
00:32:22,789 --> 00:32:20,559
the mission progressed and added some

793
00:32:24,470 --> 00:32:22,799
more scientists to the team and then

794
00:32:27,029 --> 00:32:24,480
most of the scientists on the team had

795
00:32:28,389 --> 00:32:27,039
their own their own post-docs and

796
00:32:29,750 --> 00:32:28,399
graduate students

797
00:32:31,830 --> 00:32:29,760
and then there were other teams that

798
00:32:34,470 --> 00:32:31,840
were dealing with the magnetosphere and

799
00:32:36,310 --> 00:32:34,480
so forth so now then you add in the

800
00:32:39,830 --> 00:32:36,320
international

801
00:32:43,669 --> 00:32:39,840
cooperation aspect of it we had many uh

802
00:32:46,310 --> 00:32:43,679
french spectroscopists on that that team

803
00:32:47,350 --> 00:32:46,320
and when we got to cassini as you will

804
00:32:49,669 --> 00:32:47,360
hear

805
00:32:52,230 --> 00:32:49,679
there was a massive collaboration with

806
00:32:53,509 --> 00:32:52,240
esa so that we have perhaps 400

807
00:32:56,070 --> 00:32:53,519
scientists

808
00:33:00,149 --> 00:32:56,080
actively engaged with about 50 50 split

809
00:33:02,230 --> 00:33:00,159
between uh uh the u.s and europe on that

810
00:33:03,990 --> 00:33:02,240
and so the scientists are also working

811
00:33:06,389 --> 00:33:04,000
as project managers for their own

812
00:33:08,549 --> 00:33:06,399
instruments and uh

813
00:33:11,430 --> 00:33:08,559

usually they have an instrument manager

814
00:33:12,950 --> 00:33:11,440
but they're they're uh their so-called

815
00:33:14,950 --> 00:33:12,960
pis you have pis of each of the

816
00:33:17,830 --> 00:33:14,960
instruments each of these missions had

817
00:33:19,990 --> 00:33:17,840
approximately 11 instruments on it and i

818
00:33:21,590 --> 00:33:20,000
was speaking mostly about the

819
00:33:23,509 --> 00:33:21,600
imaging team when i was talking about

820
00:33:25,269 --> 00:33:23,519
the number of scientists we had but even

821
00:33:27,430 --> 00:33:25,279
there that that was an expansion and

822
00:33:30,230 --> 00:33:27,440
each of the other teams also under with

823
00:33:32,070 --> 00:33:30,240
an expansion like that

824
00:33:33,669 --> 00:33:32,080
correct so i'm amazed i haven't thought

825
00:33:35,029 --> 00:33:33,679
to ask you this question before in all

826
00:33:39,269 --> 00:33:35,039
the years that i've known you tonight i

827
00:33:43,350 --> 00:33:41,669
so i mean you you portrayed this

828
00:33:45,750 --> 00:33:43,360
rigorous approach to following the

829
00:33:48,230 --> 00:33:45,760
scientific method which uh it really is

830
00:33:50,230 --> 00:33:48,240
a nice example of that paradigm of all

831
00:33:52,070 --> 00:33:50,240
of the surprises that that you guys did

832
00:33:54,710 --> 00:33:52,080
find and you personally what actually

833
00:33:56,950 --> 00:33:54,720
surprised you the most

834
00:34:00,950 --> 00:33:56,960
what was the most amazing thing that you

835
00:34:08,149 --> 00:34:03,830
at jupiter with galileo

836
00:34:09,109 --> 00:34:08,159
to come up with titan i did not expect

837
00:34:10,629 --> 00:34:09,119
to see

838
00:34:13,030 --> 00:34:10,639

a

839
00:34:16,310 --> 00:34:13,040
on

840
00:34:18,710 --> 00:34:16,320
titan that looked so earth-like it was

841
00:34:21,270 --> 00:34:18,720
eerie when we came when we when we came

842
00:34:21,990 --> 00:34:21,280
down there and it's apparently because

843
00:34:24,869 --> 00:34:22,000
the

844
00:34:27,109 --> 00:34:24,879
hydrological cycle even at near liquid

845
00:34:29,750 --> 00:34:27,119
nitrogen temperatures

846
00:34:31,510 --> 00:34:29,760
using liquid hydrocarbons produces the

847
00:34:33,430 --> 00:34:31,520
same physics and the same sorts of

848
00:34:36,629 --> 00:34:33,440
things at

849
00:34:38,389 --> 00:34:36,639
at jupiter i would have to say that uh

850
00:34:40,230 --> 00:34:38,399
the uh

851
00:34:42,230 --> 00:34:40,240
most of the things we found were things

852
00:34:44,470 --> 00:34:42,240
that we weren't went looking for you'll

853
00:34:46,230 --> 00:34:44,480
find margie kivelson in her part of that

854
00:34:47,829 --> 00:34:46,240
van allen report said we're going to be

855
00:34:52,389 --> 00:34:47,839
looking for magnetic fields at the

856
00:34:57,270 --> 00:34:54,149
getting the induction signatures of the

857
00:34:58,630 --> 00:34:57,280
oceans i think was the the biggest the

858
00:35:00,390 --> 00:34:58,640
biggest major factor that wasn't

859
00:35:02,310 --> 00:35:00,400
something we could count on and it was a

860
00:35:04,630 --> 00:35:02,320
surprise to find that all three of the

861
00:35:11,430 --> 00:35:04,640
ic satellites seem to have

862
00:35:16,470 --> 00:35:14,230
taurus we talked a little bit earlier

863
00:35:18,470 --> 00:35:16,480

just in conversation about

864
00:35:21,750 --> 00:35:18,480
and then you mentioned it just now that

865
00:35:24,390 --> 00:35:21,760
the state of knowledge of planets in our

866
00:35:26,710 --> 00:35:24,400
own solar system back in the 70s is sort

867
00:35:29,430 --> 00:35:26,720
of the state of knowledge we have now

868
00:35:31,109 --> 00:35:29,440
about exoplanets today

869
00:35:33,589 --> 00:35:31,119
and we'll touch on this later in the

870
00:35:35,829 --> 00:35:33,599
panel discussion in the afternoon

871
00:35:37,270 --> 00:35:35,839
but where do you see

872
00:35:39,670 --> 00:35:37,280
the

873
00:35:42,630 --> 00:35:39,680
line between

874
00:35:45,510 --> 00:35:42,640
the planetary program and the more

875
00:35:47,510 --> 00:35:45,520
astrophysical exoplanet program

876
00:35:49,349 --> 00:35:47,520
and how are what do you see as the ways

877
00:35:50,870 --> 00:35:49,359
to make sure we're not stove pipe

878
00:35:52,470 --> 00:35:50,880
between those two

879
00:35:53,430 --> 00:35:52,480
programs for what is really a very

880
00:35:55,030 --> 00:35:53,440
common

881
00:35:56,790 --> 00:35:55,040
set of goals

882
00:35:59,910 --> 00:35:56,800
that's a very good question i'm hoping

883
00:36:01,030 --> 00:35:59,920
your panel will and and you will address

884
00:36:03,670 --> 00:36:01,040
some of that

885
00:36:06,470 --> 00:36:03,680
it's very obvious from our perspective

886
00:36:08,470 --> 00:36:06,480
you and me as scientists looking at this

887
00:36:09,990 --> 00:36:08,480
once you are not just counting these

888
00:36:13,030 --> 00:36:10,000

things

889
00:36:15,910 --> 00:36:13,040
but actually putting them on mass radius

890
00:36:18,310 --> 00:36:15,920
diagrams you were doing planetology

891
00:36:20,870 --> 00:36:18,320
and the community is beating a path in

892
00:36:23,109 --> 00:36:20,880
that direction as we speak

893
00:36:25,030 --> 00:36:23,119
how nasa is going to be able to respond

894
00:36:27,990 --> 00:36:25,040
within their system to that

895
00:36:30,710 --> 00:36:28,000
with their different uh pieces of the

896
00:36:32,870 --> 00:36:30,720
traditional uh disciplines at nasa is a

897
00:36:35,109 --> 00:36:32,880
challenge and i hope jim green may have

898
00:36:36,630 --> 00:36:35,119
a chance to speak to that

899
00:36:38,630 --> 00:36:36,640
let's get one more quick question you

900
00:36:40,230 --> 00:36:38,640
know i uh i was going to ask pretty much

901
00:36:42,550 --> 00:36:40,240
the question was just asked but then

902
00:36:44,470 --> 00:36:42,560
that got me to then

903
00:36:47,190 --> 00:36:44,480
going out a little further in the solar

904
00:36:48,790 --> 00:36:47,200
system well beyond pluto i know pluto

905
00:36:52,550 --> 00:36:48,800
has got its

906
00:36:54,630 --> 00:36:52,560
2015 mission oh do you predict within

907
00:36:57,990 --> 00:36:54,640
the next years that we'll go out to some

908
00:36:59,829 --> 00:36:58,000
of those larger bodies beyond pluto

909
00:37:01,430 --> 00:36:59,839
if they can put my thing on i can just i

910
00:37:03,589 --> 00:37:01,440
can show you one slide that shows the

911
00:37:05,589 --> 00:37:03,599
answer to that okay

912
00:37:17,510 --> 00:37:05,599
put torrence's uh

913
00:37:21,190 --> 00:37:19,030

sorry

914
00:37:27,270 --> 00:37:21,200
johnson yeah

915
00:37:31,670 --> 00:37:29,829
yeah you always leave a slide at the end

916
00:37:32,790 --> 00:37:31,680
real last yeah the real life slide

917
00:37:34,310 --> 00:37:32,800
that's fine

918
00:37:35,109 --> 00:37:34,320
okay

919
00:37:38,630 --> 00:37:35,119
and

920
00:37:43,510 --> 00:37:41,349
okay this is what we're doing now

921
00:37:45,030 --> 00:37:43,520
and that's the new horizons on the way

922
00:37:48,630 --> 00:37:45,040
out

923
00:37:51,589 --> 00:37:48,640
this is a timeline the green bars are

924
00:37:54,710 --> 00:37:51,599
the time it took to plan the mission the

925
00:37:58,069 --> 00:37:54,720
red bars are how long it took to fly it

926
00:37:59,510 --> 00:37:58,079
and the symbols inside the red bars are

927
00:38:01,109 --> 00:37:59,520
planetary encounters we've had

928
00:38:04,950 --> 00:38:01,119
continuous data coming back from the

929
00:38:07,990 --> 00:38:04,960
outer solar system for 40 years

930
00:38:09,670 --> 00:38:08,000
okay we have juno on the way out

931
00:38:11,510 --> 00:38:09,680
get to jupiter you notice that

932
00:38:14,550 --> 00:38:11,520
everything is

933
00:38:16,950 --> 00:38:14,560
and then there's nothing after juno new

934
00:38:18,790 --> 00:38:16,960
horizons and the end of the

935
00:38:21,270 --> 00:38:18,800
extended mission for cassini there'll be

936
00:38:23,990 --> 00:38:21,280
an inevitable gap of a decade or more

937
00:38:27,349 --> 00:38:24,000
before we get a planet a saddle uh

938
00:38:29,510 --> 00:38:27,359

satellite back after this 19 1915 i mean

939
00:38:30,870 --> 00:38:29,520
2015 is going to be great it's going to

940
00:38:33,829 --> 00:38:30,880
be really great going to have lots of

941
00:38:35,910 --> 00:38:33,839
stuff going on but beyond that uh

942
00:38:37,109 --> 00:38:35,920
there's not much in the pipeline and

943
00:38:39,349 --> 00:38:37,119
even if we

944
00:38:42,230 --> 00:38:39,359
reverse that tomorrow there would be an

945
00:38:43,750 --> 00:38:42,240
inevitable inevitable gap so we're back

946
00:38:45,190 --> 00:38:43,760
to one of these things like occurred in

947
00:38:47,829 --> 00:38:45,200
the 80s that we saw referred to

948
00:38:54,950 --> 00:38:47,839
yesterday

949
00:38:59,829 --> 00:38:56,870
so the next talk is going to be given by

950
00:39:01,750 --> 00:38:59,839
arturo russo on europe's rendezvous with

951
00:39:03,589 --> 00:39:01,760
titan the european space agency's

952
00:39:06,230 --> 00:39:03,599
contribution to the cassini-huygens

953
00:39:08,390 --> 00:39:06,240
mission to the saturnian system

954
00:39:09,990 --> 00:39:08,400
and just by way of introduction let me

955
00:39:12,470 --> 00:39:10,000
mention that

956
00:39:14,870 --> 00:39:12,480
arturo is a former professor of history

957
00:39:17,829 --> 00:39:14,880
of physics at the university of palermo

958
00:39:20,310 --> 00:39:17,839
italy and his research is in the history

959
00:39:22,230 --> 00:39:20,320
of 20th century physics

960
00:39:24,069 --> 00:39:22,240
he's published on quantum physics the

961
00:39:26,630 --> 00:39:24,079
science industry relationship in italy

962
00:39:29,030 --> 00:39:26,640
in the u.s between the two world wars

963
00:39:30,790 --> 00:39:29,040

cosmic ray physics uh particle physics

964
00:39:32,630 --> 00:39:30,800
at cern in the history of space research

965
00:39:35,270 --> 00:39:32,640
and telecommunications

966
00:39:36,550 --> 00:39:35,280
in europe and i think that this is uh

967
00:39:39,030 --> 00:39:36,560
probably going to be very interesting

968
00:39:42,150 --> 00:39:39,040
talk as torrance was mentioning

969
00:39:43,910 --> 00:39:42,160
of course cassini was a an international

970
00:39:44,710 --> 00:39:43,920
mission and i think that's something

971
00:39:48,150 --> 00:39:44,720
that

972
00:39:51,030 --> 00:39:48,160
uh tends to get overlooked a lot on this

973
00:39:52,710 --> 00:39:51,040
side of the pond uh more so than it more

974
00:39:55,109 --> 00:39:52,720
so than it should and yet

975
00:39:57,030 --> 00:39:55,119
the if i remember correctly and and

976
00:39:59,589 --> 00:39:57,040
perhaps i'll get corrected but i believe

977
00:40:01,349 --> 00:39:59,599
that the the seeds of um

978
00:40:03,510 --> 00:40:01,359
what turned into cassini huygens

979
00:40:05,750 --> 00:40:03,520
actually were originally planted in in

980
00:40:08,870 --> 00:40:05,760
europe with daniel gautier and and wing

981
00:40:10,390 --> 00:40:08,880
win it about 1982 if memory serves me

982
00:40:12,870 --> 00:40:10,400
correctly so

983
00:40:14,230 --> 00:40:12,880
um and last but not least if it hadn't

984
00:40:16,710 --> 00:40:14,240
been for the fact that it was an

985
00:40:19,190 --> 00:40:16,720
international mission uh we probably

986
00:40:21,750 --> 00:40:19,200
wouldn't have flown it but anyway so

987
00:40:30,550 --> 00:40:21,760
let's uh let's welcome our next speaker

988
00:40:37,030 --> 00:40:33,270

thank you and i'm very happy to be here

989
00:40:39,349 --> 00:40:37,040
but let me apologize for my english now

990
00:40:47,349 --> 00:40:39,359
but if you don't like it i can shift to

991
00:40:51,589 --> 00:40:49,589
the cassini huygens mission to saturn

992
00:40:52,870 --> 00:40:51,599
and its satellite system is the most

993
00:40:54,950 --> 00:40:52,880
ambitious

994
00:40:56,230 --> 00:40:54,960
effort in planetary exploration even

995
00:40:59,430 --> 00:40:56,240
mounted

996
00:41:02,069 --> 00:40:59,440
it was launched in october 1997 and the

997
00:41:05,190 --> 00:41:02,079
mission was realized as a joint endeavor

998
00:41:09,349 --> 00:41:05,200
of nasa the european space agency

999
00:41:11,670 --> 00:41:09,359
isa and the italian space agency asi

1000
00:41:14,550 --> 00:41:11,680
it consists of a spacecraft performing

1001
00:41:16,710 --> 00:41:14,560
multiple orbital tours around saturn

1002
00:41:19,030 --> 00:41:16,720
and the probe released from the main

1003
00:41:21,829 --> 00:41:19,040
spacecraft to parachute through

1004
00:41:25,190 --> 00:41:21,839
atmosphere to the surface of saturn's

1005
00:41:27,510 --> 00:41:25,200
largest and most intriguing satellite

1006
00:41:30,309 --> 00:41:27,520
that is titan

1007
00:41:32,470 --> 00:41:30,319
nasa provided the orbiter

1008
00:41:35,270 --> 00:41:32,480
isa provided the probe

1009
00:41:37,030 --> 00:41:35,280
and as provided the high gain antenna

1010
00:41:38,390 --> 00:41:37,040
and other hardware system for the

1011
00:41:40,470 --> 00:41:38,400
orbiter

1012
00:41:43,030 --> 00:41:40,480
the scientific instruments were realized

1013
00:41:46,309 --> 00:41:43,040

by scientific teams in the u.s

1014
00:41:47,990 --> 00:41:46,319
and initials member states

1015
00:41:50,470 --> 00:41:48,000
as you know both the orbiter and the

1016
00:41:52,870 --> 00:41:50,480
probe have successfully accomplished

1017
00:41:55,910 --> 00:41:52,880
their scientific missions

1018
00:41:58,150 --> 00:41:55,920
the huygens or probe completed its

1019
00:42:01,950 --> 00:41:58,160
mission on the very day of its descent

1020
00:42:03,910 --> 00:42:01,960
through titan's atmosphere on 14 january

1021
00:42:05,829 --> 00:42:03,920
2005

1022
00:42:10,630 --> 00:42:05,839
while the nominal mission of the cassini

1023
00:42:11,349 --> 00:42:10,640
orbiter came to the end on 30 june

1024
00:42:13,829 --> 00:42:11,359
to

1025
00:42:17,030 --> 00:42:13,839
2008 four years after the spacecraft

1026
00:42:19,109 --> 00:42:17,040
entered orbit around saturn nasa however

1027
00:42:20,630 --> 00:42:19,119
has approved two extensions of mission

1028
00:42:24,309 --> 00:42:20,640
that is now due to go through the

1029
00:42:26,230 --> 00:42:24,319
september night 2017.

1030
00:42:27,990 --> 00:42:26,240
in this presentation i will briefly

1031
00:42:30,550 --> 00:42:28,000
discuss three aspects of the history of

1032
00:42:32,309 --> 00:42:30,560
cassini-huygens as seen from a european

1033
00:42:34,710 --> 00:42:32,319
perspective

1034
00:42:36,150 --> 00:42:34,720
the first is the institutional framework

1035
00:42:38,309 --> 00:42:36,160
which set the stage for the

1036
00:42:41,270 --> 00:42:38,319
establishment of an important european

1037
00:42:43,430 --> 00:42:41,280
effort in planetary exploration

1038
00:42:45,750 --> 00:42:43,440

during more than two decades in fact the

1039
00:42:47,829 --> 00:42:45,760
european space science community

1040
00:42:50,309 --> 00:42:47,839
felt that for technical and financial

1041
00:42:52,630 --> 00:42:50,319
reasons europe could not compete with

1042
00:42:55,589 --> 00:42:52,640
important programs in the united states

1043
00:42:57,829 --> 00:42:55,599
and in a soviet union in this field

1044
00:42:59,910 --> 00:42:57,839
it was only in the mid-1980s that an

1045
00:43:02,710 --> 00:42:59,920
ambitious european planetary mission was

1046
00:43:04,630 --> 00:43:02,720
considered as a realistic possibility

1047
00:43:06,470 --> 00:43:04,640
following the successful jotto mission

1048
00:43:08,630 --> 00:43:06,480
to comet highly

1049
00:43:12,470 --> 00:43:08,640
so huygens was the first european

1050
00:43:14,710 --> 00:43:12,480
mission devoted to planetary exploration

1051
00:43:16,870 --> 00:43:14,720
the second aspect is the decision-making

1052
00:43:18,550 --> 00:43:16,880
process which led to the selection of

1053
00:43:20,470 --> 00:43:18,560
the huygens mission

1054
00:43:22,230 --> 00:43:20,480
by issa

1055
00:43:24,710 --> 00:43:22,240
the decision to adopt a scientific

1056
00:43:27,589 --> 00:43:24,720
mission in esap's program is the outcome

1057
00:43:29,750 --> 00:43:27,599
of a highly competitive process

1058
00:43:31,349 --> 00:43:29,760
involving the various national and

1059
00:43:33,990 --> 00:43:31,359
disciplinary

1060
00:43:36,309 --> 00:43:34,000
sectors of the space science community

1061
00:43:39,030 --> 00:43:36,319
the east executive staff the european

1062
00:43:41,750 --> 00:43:39,040
space industry the space policies in

1063
00:43:43,910 --> 00:43:41,760

esa's member states the relations with

1064
00:43:47,349 --> 00:43:43,920
nasa and others pay potential

1065
00:43:50,550 --> 00:43:47,359
international partners and so on

1066
00:43:53,589 --> 00:43:50,560
finally the nasa is a relationship is

1067
00:43:55,510 --> 00:43:53,599
the third focus of my analysis

1068
00:43:58,150 --> 00:43:55,520
while scientific cooperation worked

1069
00:44:00,950 --> 00:43:58,160
smoothly and resulted in the successful

1070
00:44:03,109 --> 00:44:00,960
achievement of missions objectives

1071
00:44:05,190 --> 00:44:03,119
it was not so easy to cope with the

1072
00:44:07,109 --> 00:44:05,200
different political and institutional

1073
00:44:09,270 --> 00:44:07,119
frameworks in which the two agencies

1074
00:44:11,589 --> 00:44:09,280
were operating

1075
00:44:13,270 --> 00:44:11,599
the difference in the budget procedures

1076
00:44:14,710 --> 00:44:13,280
is particularly important in this

1077
00:44:17,589 --> 00:44:14,720
context

1078
00:44:19,990 --> 00:44:17,599
decision making can be very long for isa

1079
00:44:23,030 --> 00:44:20,000
but once a project has been selected its

1080
00:44:25,670 --> 00:44:23,040
financial location is also approved

1081
00:44:28,230 --> 00:44:25,680
so provided no cost escalation occurs

1082
00:44:30,870 --> 00:44:28,240
the project becomes legally binding for

1083
00:44:32,710 --> 00:44:30,880
member states and there is no threat of

1084
00:44:34,390 --> 00:44:32,720
cancellation

1085
00:44:37,190 --> 00:44:34,400
nasa on the contrary is a national

1086
00:44:39,829 --> 00:44:37,200
agency whose overall program and budget

1087
00:44:42,309 --> 00:44:39,839
has to be negotiated annually with the

1088
00:44:44,630 --> 00:44:42,319

federal government and the congress

1089
00:44:46,870 --> 00:44:44,640
funds can be always be shifted from one

1090
00:44:49,349 --> 00:44:46,880
program to another on the basis of

1091
00:44:57,589 --> 00:44:49,359
political considerations congressional

1092
00:45:06,710 --> 00:44:58,870
the idea

1093
00:45:11,190 --> 00:45:08,950
a page the programmatic framework for

1094
00:45:13,990 --> 00:45:11,200
the selection of the huygens mission

1095
00:45:16,150 --> 00:45:14,000
is the so-called horizon 2000 long-term

1096
00:45:19,349 --> 00:45:16,160
plan for space science

1097
00:45:21,349 --> 00:45:19,359
approved in 1985 by the space ministers

1098
00:45:23,990 --> 00:45:21,359
of asa member states

1099
00:45:25,829 --> 00:45:24,000
the basic philosophy of horizon 2000 was

1100
00:45:27,349 --> 00:45:25,839
the establishment of two classes of

1101
00:45:28,870 --> 00:45:27,359
projects

1102
00:45:30,829 --> 00:45:28,880
the first included

1103
00:45:33,030 --> 00:45:30,839
four predefined

1104
00:45:35,430 --> 00:45:33,040
cornerstones that is ambitious and

1105
00:45:38,790 --> 00:45:35,440
technological challenging missions to be

1106
00:45:40,790 --> 00:45:38,800
realized over a 20-year period of time

1107
00:45:42,950 --> 00:45:40,800
the second class included a number of

1108
00:45:46,230 --> 00:45:42,960
standard missions to be selected through

1109
00:45:48,550 --> 00:45:46,240
a competitive selection procedure

1110
00:45:50,630 --> 00:45:48,560
within the framework of horizon 2000

1111
00:45:53,670 --> 00:45:50,640
planetary science finally received a

1112
00:45:55,430 --> 00:45:53,680
proper role in the european space effort

1113
00:45:58,630 --> 00:45:55,440

one of the cornerstone in fact was

1114
00:46:02,309 --> 00:45:58,640
devoted to an ambitious project

1115
00:46:04,309 --> 00:46:02,319
for a comet sample return mission

1116
00:46:07,990 --> 00:46:04,319
this eventually became the rosetta

1117
00:46:10,069 --> 00:46:08,000
mission launched in 2004.

1118
00:46:12,230 --> 00:46:10,079
moreover planetary mission proposal

1119
00:46:14,230 --> 00:46:12,240
could be now submitted for competitive

1120
00:46:15,190 --> 00:46:14,240
selection in the standard mission

1121
00:46:17,829 --> 00:46:15,200
program

1122
00:46:20,550 --> 00:46:17,839
and the isa director at that time

1123
00:46:22,470 --> 00:46:20,560
director of science roger bonnet wanted

1124
00:46:24,550 --> 00:46:22,480
to foster planetary missions in the

1125
00:46:26,230 --> 00:46:24,560
selection process for the new standard

1126
00:46:29,190 --> 00:46:26,240
mission

1127
00:46:31,670 --> 00:46:29,200
but why titan well this has

1128
00:46:33,829 --> 00:46:31,680
some way anticipated by

1129
00:46:35,670 --> 00:46:33,839
by the previous speaker

1130
00:46:37,589 --> 00:46:35,680
the idea of a mission to saturn and its

1131
00:46:39,589 --> 00:46:37,599
satellite system can be traced back to

1132
00:46:42,630 --> 00:46:39,599
the early 1980s on the wave of the

1133
00:46:45,270 --> 00:46:42,640
successful voyager missions one of the

1134
00:46:47,589 --> 00:46:45,280
most important discoveries of voyager 1

1135
00:46:49,990 --> 00:46:47,599
was the intriguing composition

1136
00:46:51,829 --> 00:46:50,000
of the atmosphere of saturn's largest

1137
00:46:55,430 --> 00:46:51,839
moon

1138
00:46:57,270 --> 00:46:55,440

not only was it confirmed

1139
00:46:59,670 --> 00:46:57,280
that molecular nitrogen was the main

1140
00:47:02,309 --> 00:46:59,680
constituent of the atmosphere of titan

1141
00:47:04,870 --> 00:47:02,319
which was a few percent of methane but

1142
00:47:07,510 --> 00:47:04,880
the infrared spectrometer and voyager

1143
00:47:09,190 --> 00:47:07,520
showed that many organic molecules were

1144
00:47:09,910 --> 00:47:09,200
also present

1145
00:47:12,470 --> 00:47:09,920
the

1146
00:47:14,870 --> 00:47:12,480
surface of titan was completely obscured

1147
00:47:17,270 --> 00:47:14,880
from the voyager camera by a thick

1148
00:47:19,349 --> 00:47:17,280
orange brown smoke made of a mixture of

1149
00:47:21,510 --> 00:47:19,359
various hydrocarbon and nitrogen

1150
00:47:25,030 --> 00:47:21,520
compounds

1151
00:47:28,470 --> 00:47:25,040
to the eyes of the voyager scientists

1152
00:47:31,349 --> 00:47:28,480
daniel got the gotier and others this

1153
00:47:33,510 --> 00:47:31,359
planet-like satellite resembled what our

1154
00:47:34,870 --> 00:47:33,520
earth should have looked like some four

1155
00:47:37,829 --> 00:47:34,880
billions

1156
00:47:39,750 --> 00:47:37,839
years ago before organic life started to

1157
00:47:42,069 --> 00:47:39,760
colonize its surface

1158
00:47:43,910 --> 00:47:42,079
and produce oxygen by green plant

1159
00:47:45,750 --> 00:47:43,920
photosynthesis

1160
00:47:47,990 --> 00:47:45,760
the fundamental difference between the

1161
00:47:50,470 --> 00:47:48,000
early earth and titan is the low

1162
00:47:52,790 --> 00:47:50,480
temperature of the latter's surface

1163
00:47:55,430 --> 00:47:52,800

which makes it impossible the presence

1164
00:47:56,549 --> 00:47:55,440
of liquid water and then the emergence

1165
00:47:59,109 --> 00:47:56,559
of life

1166
00:48:01,430 --> 00:47:59,119
on the contrary the intense organic

1167
00:48:03,030 --> 00:48:01,440
chemistry at work in the primitive earth

1168
00:48:05,829 --> 00:48:03,040
did have a chance to evolve into

1169
00:48:07,349 --> 00:48:05,839
probiotic chemistry and eventually into

1170
00:48:10,150 --> 00:48:07,359
biology

1171
00:48:12,470 --> 00:48:10,160
subsequent erosion plate tectonics and

1172
00:48:14,470 --> 00:48:12,480
the evolution of life itself have

1173
00:48:17,030 --> 00:48:14,480
obliterated all records of those

1174
00:48:19,030 --> 00:48:17,040
original conditions and processes on our

1175
00:48:21,270 --> 00:48:19,040
blue planet

1176
00:48:23,109 --> 00:48:21,280
titan now could provide the earth human

1177
00:48:25,190 --> 00:48:23,119
inhabitants of today

1178
00:48:26,230 --> 00:48:25,200
with an opportunity to travel back in

1179
00:48:28,309 --> 00:48:26,240
time

1180
00:48:34,390 --> 00:48:28,319
if they were able to travel in spain in

1181
00:48:36,470 --> 00:48:35,589
so

1182
00:48:42,790 --> 00:48:36,480
as

1183
00:48:45,829 --> 00:48:42,800
29 european scientists

1184
00:48:47,190 --> 00:48:45,839
submitted to esa proposals for a saturn

1185
00:48:49,030 --> 00:48:47,200
titan mission

1186
00:48:51,670 --> 00:48:49,040
to be realized in the framework of

1187
00:48:54,549 --> 00:48:51,680
horizon 2000

1188
00:48:56,790 --> 00:48:54,559

the project cassini as they named it

1189
00:48:58,710 --> 00:48:56,800
called for a saturn orbiter carrying a

1190
00:49:01,430 --> 00:48:58,720
probe to be parachuted through the

1191
00:49:03,910 --> 00:49:01,440
atmosphere of the titan the interest was

1192
00:49:06,309 --> 00:49:03,920
in the atmosphere of titan

1193
00:49:08,150 --> 00:49:06,319
mainly in the atmosphere the project was

1194
00:49:11,190 --> 00:49:08,160
to be realized by nisa nasa

1195
00:49:13,589 --> 00:49:11,200
collaboration with europe providing the

1196
00:49:15,510 --> 00:49:13,599
orbiter and nasa

1197
00:49:18,069 --> 00:49:15,520
the titan probe

1198
00:49:19,990 --> 00:49:18,079
18 scientific institutions from several

1199
00:49:21,190 --> 00:49:20,000
isa member states were represented in

1200
00:49:23,030 --> 00:49:21,200
the group

1201
00:49:25,829 --> 00:49:23,040
whose membership involved included

1202
00:49:28,829 --> 00:49:25,839
representatives of four disciplines

1203
00:49:30,390 --> 00:49:28,839
atmospheric science planetology

1204
00:49:33,030 --> 00:49:30,400
magnetospheric

1205
00:49:35,349 --> 00:49:33,040
physics and exobiology

1206
00:49:37,510 --> 00:49:35,359
the underlying idea was to study the

1207
00:49:39,910 --> 00:49:37,520
whole of the saturnian system

1208
00:49:41,430 --> 00:49:39,920
including specific objectives for each

1209
00:49:43,910 --> 00:49:41,440
of its elements

1210
00:49:47,190 --> 00:49:43,920
the planet in its ring the magnetosphere

1211
00:49:50,069 --> 00:49:47,200
the icy satellite and titan

1212
00:49:52,710 --> 00:49:50,079
this concept of system science was an

1213
00:49:55,190 --> 00:49:52,720

important element in fostering a large

1214
00:49:56,950 --> 00:49:55,200
support behind the cassini project

1215
00:49:58,390 --> 00:49:56,960
within the european

1216
00:50:00,870 --> 00:49:58,400
science community

1217
00:50:04,630 --> 00:50:00,880
and promoting the mission through esa's

1218
00:50:06,069 --> 00:50:04,640
highly competitive selection process

1219
00:50:07,750 --> 00:50:06,079
the european initiative had a

1220
00:50:09,109 --> 00:50:07,760
counterpart on the other side of the

1221
00:50:11,030 --> 00:50:09,119
atlantic

1222
00:50:13,030 --> 00:50:11,040
the project for a saturn orbiter and

1223
00:50:16,549 --> 00:50:13,040
titan probe mission was among those

1224
00:50:18,390 --> 00:50:16,559
recommended in 1918 1983

1225
00:50:21,270 --> 00:50:18,400
by the solar system exploration

1226
00:50:23,190 --> 00:50:21,280
committee the sikh the sac of the nasa

1227
00:50:24,870 --> 00:50:23,200
advisory council

1228
00:50:27,349 --> 00:50:24,880
it has been mentioned

1229
00:50:29,270 --> 00:50:27,359
yesterday so i will not go back

1230
00:50:30,390 --> 00:50:29,280
to this

1231
00:50:32,069 --> 00:50:30,400
team

1232
00:50:34,230 --> 00:50:32,079
but i want to mention that these

1233
00:50:36,150 --> 00:50:34,240
initiatives can receive an important

1234
00:50:37,829 --> 00:50:36,160
institutional support by the space

1235
00:50:40,069 --> 00:50:37,839
science committee of the european

1236
00:50:42,150 --> 00:50:40,079
science foundation and the space science

1237
00:50:43,270 --> 00:50:42,160
board of the american national research

1238
00:50:46,390 --> 00:50:43,280

council

1239
00:50:48,230 --> 00:50:46,400
in every 1982 these two organizations

1240
00:50:50,549 --> 00:50:48,240
established a joint working group to

1241
00:50:52,829 --> 00:50:50,559
define the framework for a nisa nasa

1242
00:50:55,109 --> 00:50:52,839
cooperation in planetary

1243
00:50:56,790 --> 00:50:55,119
exploration the joint working group

1244
00:50:58,710 --> 00:50:56,800
eventually recommended that three

1245
00:51:00,710 --> 00:50:58,720
missions should be carried out as

1246
00:51:02,150 --> 00:51:00,720
cooperative projects by the turn of the

1247
00:51:04,710 --> 00:51:02,160
century

1248
00:51:07,589 --> 00:51:04,720
listed in order of the launch sequence

1249
00:51:10,150 --> 00:51:07,599
these were a saturn orbiter titan probe

1250
00:51:12,790 --> 00:51:10,160
a multiple asteroid orbit and a mars

1251
00:51:14,630 --> 00:51:12,800
surface rover this represents represents

1252
00:51:17,030 --> 00:51:14,640
also the priority in planetary

1253
00:51:18,630 --> 00:51:17,040
exploration as seen at that particular

1254
00:51:19,510 --> 00:51:18,640
moment

1255
00:51:22,950 --> 00:51:19,520
so

1256
00:51:24,630 --> 00:51:22,960
you have already seen that an assessment

1257
00:51:27,829 --> 00:51:24,640
study of the cassini project was

1258
00:51:32,150 --> 00:51:27,839
conducted in europe between april 1984

1259
00:51:35,349 --> 00:51:32,160
and june 1985 by a team of 13 scientists

1260
00:51:37,750 --> 00:51:35,359
knife from the u.s and four for europe

1261
00:51:40,630 --> 00:51:37,760
reversing here the idea of the original

1262
00:51:43,430 --> 00:51:40,640
proposal the titan probe was soon

1263
00:51:44,390 --> 00:51:43,440

identified as isa's contribution to the

1264
00:51:46,150 --> 00:51:44,400
mission

1265
00:51:48,870 --> 00:51:46,160
while nasa would provide the main

1266
00:51:50,390 --> 00:51:48,880
spacecraft based on the mariner mark ii

1267
00:51:52,309 --> 00:51:50,400
spacecraft

1268
00:51:54,309 --> 00:51:52,319
the titan probe for its part was

1269
00:51:56,150 --> 00:51:54,319
considered within the technical

1270
00:51:57,270 --> 00:51:56,160
capability of the european space

1271
00:51:59,750 --> 00:51:57,280
industry

1272
00:52:02,069 --> 00:51:59,760
and the estimated costs were within the

1273
00:52:04,790 --> 00:52:02,079
budget allocated to a standard mission

1274
00:52:07,750 --> 00:52:04,800
of horizon two thousand

1275
00:52:09,910 --> 00:52:07,760
the challenger accident in january 1986

1276
00:52:11,750 --> 00:52:09,920
forces the dramatic redefinition of

1277
00:52:13,670 --> 00:52:11,760
nasa's planning

1278
00:52:15,829 --> 00:52:13,680
but the mariner marks ii program was

1279
00:52:19,190 --> 00:52:15,839
eventually confirmed but with the

1280
00:52:20,790 --> 00:52:19,200
two-year delay that deferred the start

1281
00:52:23,190 --> 00:52:20,800
of the cassini project

1282
00:52:26,630 --> 00:52:23,200
until 1991.

1283
00:52:28,470 --> 00:52:26,640
on this basis issa decided to support an

1284
00:52:31,190 --> 00:52:28,480
industrial feasibility study of the

1285
00:52:32,470 --> 00:52:31,200
titan probe to be built in europe

1286
00:52:34,870 --> 00:52:32,480
again the

1287
00:52:36,069 --> 00:52:34,880
group of american scientists and

1288
00:52:39,349 --> 00:52:36,079

engineers

1289
00:52:41,430 --> 00:52:39,359
collaborated in this feasibility study

1290
00:52:43,230 --> 00:52:41,440
the study report was published in

1291
00:52:45,109 --> 00:52:43,240
september

1292
00:52:47,990 --> 00:52:45,119
1988

1293
00:52:50,470 --> 00:52:48,000
one month later the esa decision-making

1294
00:52:55,430 --> 00:52:50,480
bodies were called to select the first

1295
00:53:00,309 --> 00:52:56,230
so

1296
00:53:03,430 --> 00:53:00,319
on october 25 1988 the european space

1297
00:53:05,750 --> 00:53:03,440
science community at large convened in a

1298
00:53:07,430 --> 00:53:05,760
built in the beautiful medieval city of

1299
00:53:09,750 --> 00:53:07,440
bruges in belgium

1300
00:53:12,309 --> 00:53:09,760
to discuss five mission proposals

1301
00:53:15,589 --> 00:53:12,319
submitted to isa for the selection of

1302
00:53:17,589 --> 00:53:15,599
the next scientific mission

1303
00:53:19,750 --> 00:53:17,599
the european titan probe in the

1304
00:53:21,270 --> 00:53:19,760
cooperative is a nasa cassini mission

1305
00:53:23,270 --> 00:53:21,280
was one of them

1306
00:53:25,430 --> 00:53:23,280
three other mission proposals addressed

1307
00:53:28,230 --> 00:53:25,440
ultraviolet astronomy radio astronomy

1308
00:53:30,549 --> 00:53:28,240
and gamma-ray astronomy respectively the

1309
00:53:33,109 --> 00:53:30,559
last one called the vesta was a

1310
00:53:35,109 --> 00:53:33,119
cooperative endeavour of issa the french

1311
00:53:37,430 --> 00:53:35,119
space agency kness

1312
00:53:38,870 --> 00:53:37,440
and the soviet space research institute

1313
00:53:40,630 --> 00:53:38,880

iki

1314
00:53:43,270 --> 00:53:40,640
it aimed at visiting a number of

1315
00:53:45,109 --> 00:53:43,280
asteroids and comets by two spacecraft

1316
00:53:48,549 --> 00:53:45,119
spacecraft with

1317
00:53:52,710 --> 00:53:48,559
release module and penetrators

1318
00:53:54,790 --> 00:53:52,720
as usual in the esa selection procedure

1319
00:53:56,549 --> 00:53:54,800
after the public discussion within the

1320
00:53:58,950 --> 00:53:56,559
scientific community

1321
00:54:00,470 --> 00:53:58,960
the agency's scientific advisory bodies

1322
00:54:02,710 --> 00:54:00,480
were called to issue their

1323
00:54:04,870 --> 00:54:02,720
recommendation about which of the

1324
00:54:08,069 --> 00:54:04,880
proposed mission should be selected by

1325
00:54:09,430 --> 00:54:08,079
the agency's science policy committee on

1326
00:54:11,829 --> 00:54:09,440
top blue

1327
00:54:14,069 --> 00:54:11,839
composed of the national delegations of

1328
00:54:16,870 --> 00:54:14,079
esa member states

1329
00:54:20,549 --> 00:54:16,880
this in fact was a two-step procedure

1330
00:54:23,510 --> 00:54:20,559
first the astronomy working group

1331
00:54:25,510 --> 00:54:23,520
and the solar system working group

1332
00:54:28,230 --> 00:54:25,520
would issue a recommendation in their

1333
00:54:30,630 --> 00:54:28,240
respective fields of interest

1334
00:54:31,670 --> 00:54:30,640
second the space science advisory

1335
00:54:33,430 --> 00:54:31,680
committee

1336
00:54:35,349 --> 00:54:33,440
the sac would make the final

1337
00:54:38,390 --> 00:54:35,359
recommendation to the isa director of

1338
00:54:39,190 --> 00:54:38,400

science and the spc

1339
00:54:45,270 --> 00:54:39,200
so

1340
00:54:47,589 --> 00:54:45,280
choice was between cassini and vesta

1341
00:54:49,910 --> 00:54:47,599
a very difficult choice indeed

1342
00:54:52,230 --> 00:54:49,920
as both missions were dedicated to

1343
00:54:54,789 --> 00:54:52,240
planetary exploration and considered

1344
00:54:56,470 --> 00:54:54,799
excellent and scientifically highly

1345
00:54:58,470 --> 00:54:56,480
interesting

1346
00:55:01,589 --> 00:54:58,480
the decision of course was a matter of

1347
00:55:03,670 --> 00:55:01,599
politics as well as of science

1348
00:55:05,990 --> 00:55:03,680
from the scientific point of view a

1349
00:55:08,630 --> 00:55:06,000
close-up study of a number of asteroids

1350
00:55:11,190 --> 00:55:08,640
and comets was as interesting as and

1351
00:55:12,710 --> 00:55:11,200
exciting as parachuting a probe on the

1352
00:55:14,870 --> 00:55:12,720
planetary body

1353
00:55:17,109 --> 00:55:14,880
in the outer solar system

1354
00:55:19,829 --> 00:55:17,119
the vesta mission promised to pursue an

1355
00:55:21,430 --> 00:55:19,839
extended small body exploration program

1356
00:55:24,549 --> 00:55:21,440
that he said began

1357
00:55:27,430 --> 00:55:24,559
with the job to fly by of comet harley

1358
00:55:29,349 --> 00:55:27,440
cassini for its part would lead europe

1359
00:55:31,990 --> 00:55:29,359
to the frontiers of solar system

1360
00:55:33,750 --> 00:55:32,000
exploration and the european industry

1361
00:55:36,870 --> 00:55:33,760
would acquire unique know-how in the

1362
00:55:38,710 --> 00:55:36,880
domain of atmospheric re-entry probes

1363
00:55:40,950 --> 00:55:38,720

the two missions however were very

1364
00:55:43,910 --> 00:55:40,960
different as regards the political

1365
00:55:47,190 --> 00:55:43,920
support scientific constituency and

1366
00:55:50,230 --> 00:55:48,950
cassini has been conceived from the very

1367
00:55:51,990 --> 00:55:50,240
beginning as an eastern as a

1368
00:55:53,990 --> 00:55:52,000
collaborative project in which ease of

1369
00:55:55,910 --> 00:55:54,000
visibility would be secured by the fact

1370
00:55:57,829 --> 00:55:55,920
that titan probe would be built in

1371
00:56:00,069 --> 00:55:57,839
europe and this mission operated by the

1372
00:56:02,470 --> 00:56:00,079
european space operation center

1373
00:56:04,069 --> 00:56:02,480
in in darmstadt germany

1374
00:56:05,990 --> 00:56:04,079
there was a variegated a large

1375
00:56:09,030 --> 00:56:06,000
investigated scientific constitution

1376
00:56:11,829 --> 00:56:09,040
constituency in europe and in the united

1377
00:56:14,390 --> 00:56:11,839
states and the american colleagues were

1378
00:56:18,069 --> 00:56:14,400
eagerly waiting for the decision

1379
00:56:19,190 --> 00:56:18,079
by isaf because they wanted to use this

1380
00:56:21,190 --> 00:56:19,200
selection

1381
00:56:23,270 --> 00:56:21,200
in support of their own

1382
00:56:25,109 --> 00:56:23,280
lobbying activity for the cassini

1383
00:56:26,710 --> 00:56:25,119
approval in the u.s

1384
00:56:28,710 --> 00:56:26,720
in support of vesta there was the

1385
00:56:30,549 --> 00:56:28,720
powerful lobby of the french space

1386
00:56:33,030 --> 00:56:30,559
agency the kness

1387
00:56:34,950 --> 00:56:33,040
the french space policy makers insisted

1388
00:56:37,030 --> 00:56:34,960

that vesta would provide the european

1389
00:56:39,109 --> 00:56:37,040
space science community with the

1390
00:56:41,510 --> 00:56:39,119
opportunity to establish a cooperative

1391
00:56:43,670 --> 00:56:41,520
venture with the soviet union

1392
00:56:45,910 --> 00:56:43,680
thus restoring a measure of balance in

1393
00:56:48,470 --> 00:56:45,920
international cooperation after the

1394
00:56:51,270 --> 00:56:48,480
difficulties experienced in the past

1395
00:56:55,750 --> 00:56:53,030
mission and so on

1396
00:56:58,630 --> 00:56:55,760
so discard the discussion was

1397
00:57:01,829 --> 00:56:58,640
very lively and impassionate and finally

1398
00:57:03,589 --> 00:57:01,839
a formal vote was called by which the

1399
00:57:05,990 --> 00:57:03,599
solar system

1400
00:57:08,069 --> 00:57:06,000
working group recommended cassini as the

1401
00:57:09,670 --> 00:57:08,079
candidate projects in the field of solar

1402
00:57:12,150 --> 00:57:09,680
system

1403
00:57:13,430 --> 00:57:12,160
it was now up to the sac made to make

1404
00:57:16,150 --> 00:57:13,440
the final

1405
00:57:18,309 --> 00:57:16,160
choice between cassini

1406
00:57:20,710 --> 00:57:18,319
and the candidate project recommended by

1407
00:57:23,030 --> 00:57:20,720
the astronomy working group

1408
00:57:24,630 --> 00:57:23,040
that is the gamma-ray astronomy mission

1409
00:57:26,230 --> 00:57:24,640
grasp

1410
00:57:28,069 --> 00:57:26,240
the discussion within the seven

1411
00:57:30,150 --> 00:57:28,079
membership of the committee covered all

1412
00:57:31,190 --> 00:57:30,160
aspects of the important decision to be

1413
00:57:33,190 --> 00:57:31,200

taken

1414
00:57:34,710 --> 00:57:33,200
on the one hand the supporters of the

1415
00:57:36,789 --> 00:57:34,720
gamma-ray mission claimed a

1416
00:57:39,510 --> 00:57:36,799
well-established european tradition of

1417
00:57:40,950 --> 00:57:39,520
scientific excellency in high energy

1418
00:57:42,950 --> 00:57:40,960
astrophysics

1419
00:57:45,430 --> 00:57:42,960
on the other hand the cassini advocates

1420
00:57:47,750 --> 00:57:45,440
stressed the importance of opening a new

1421
00:57:49,589 --> 00:57:47,760
fascinating territory to european space

1422
00:57:51,589 --> 00:57:49,599
science

1423
00:57:53,910 --> 00:57:51,599
moreover by paying the ticket for the

1424
00:57:55,990 --> 00:57:53,920
titan probe isa would provide european

1425
00:57:58,470 --> 00:57:56,000
planetary scientists with access to the

1426
00:58:00,549 --> 00:57:58,480
nasa-built saturn orbiter

1427
00:58:03,190 --> 00:58:00,559
in the event the advocate of cassini

1428
00:58:05,510 --> 00:58:03,200
succeeded in convincing the majority of

1429
00:58:07,270 --> 00:58:05,520
the sag members to support the saturn

1430
00:58:09,349 --> 00:58:07,280
titan mission

1431
00:58:10,950 --> 00:58:09,359
which was thus formally recommended by

1432
00:58:13,589 --> 00:58:10,960
the representatives of the european

1433
00:58:16,309 --> 00:58:13,599
space science community as isa's next

1434
00:58:18,309 --> 00:58:16,319
scientific project

1435
00:58:21,430 --> 00:58:18,319
the esa science policy committee finally

1436
00:58:23,910 --> 00:58:21,440
endorsed the sac recommendation and it

1437
00:58:25,589 --> 00:58:23,920
decided that the probe should have its

1438
00:58:28,150 --> 00:58:25,599

own name

1439
00:58:30,309 --> 00:58:28,160
and they and this was the christian

1440
00:58:32,950 --> 00:58:30,319
huygens which was the discovery who was

1441
00:58:35,589 --> 00:58:32,960
the discoverer of titan

1442
00:58:36,470 --> 00:58:35,599
huygens thus entered the issa scientific

1443
00:58:39,349 --> 00:58:36,480
program

1444
00:58:41,109 --> 00:58:39,359
as europe's first planetary mission and

1445
00:58:44,069 --> 00:58:41,119
the first mission

1446
00:58:45,750 --> 00:58:44,079
in the horizon 2000 long-term

1447
00:58:47,589 --> 00:58:45,760
program

1448
00:58:49,190 --> 00:58:47,599
what about the u.s

1449
00:58:50,549 --> 00:58:49,200
it took one year

1450
00:58:55,190 --> 00:58:50,559
but eventually

1451
00:58:57,349 --> 00:58:55,200
the congress approved in october 1989

1452
00:59:00,309 --> 00:58:57,359
the mariner mark ii program which

1453
00:59:02,549 --> 00:59:00,319
included both cassini and the cometary

1454
00:59:04,710 --> 00:59:02,559
mission craft

1455
00:59:06,309 --> 00:59:04,720
nasa and issa then issued parallel

1456
00:59:08,069 --> 00:59:06,319
announcement of opportunity for

1457
00:59:09,109 --> 00:59:08,079
instrument proposals on the saturn

1458
00:59:12,549 --> 00:59:09,119
orbiter

1459
00:59:14,470 --> 00:59:12,559
and the titan probe respectively

1460
00:59:16,230 --> 00:59:14,480
following peer review on both sides of

1461
00:59:18,510 --> 00:59:16,240
the atlantic the two space agencies

1462
00:59:21,190 --> 00:59:18,520
approved the scientific payload and

1463
00:59:23,829 --> 00:59:21,200

interdisciplinary investigation

1464
00:59:25,589 --> 00:59:23,839
finally a memorandum of understanding

1465
00:59:27,589 --> 00:59:25,599
was signed by nasa in issa on the

1466
00:59:28,630 --> 00:59:27,599
cassini oregon's mission

1467
00:59:31,349 --> 00:59:28,640
and

1468
00:59:34,069 --> 00:59:31,359
saw the the mission was well on its way

1469
00:59:36,789 --> 00:59:34,079
towards its scheduled launch in november

1470
00:59:38,710 --> 00:59:36,799
1995.

1471
00:59:40,630 --> 00:59:38,720
the way however proved to be fraught

1472
00:59:43,030 --> 00:59:40,640
with the faculties arising less from

1473
00:59:46,470 --> 00:59:43,040
technical problems than from political

1474
00:59:49,829 --> 00:59:46,480
uncertainty in the united states

1475
00:59:52,549 --> 00:59:49,839
in october 1991 the u.s congress dwarfed

1476
00:59:54,789 --> 00:59:52,559
the 13 increase for the nasa budget

1477
00:59:57,589 --> 00:59:54,799
requested by the white house

1478
01:00:00,710 --> 00:59:57,599
approving only a three percent increase

1479
01:00:03,430 --> 01:00:00,720
hard enough to compensate for inflation

1480
01:00:05,430 --> 01:00:03,440
as a consequence nasa decided to delay

1481
01:00:08,230 --> 01:00:05,440
the launch of the saturn mission until

1482
01:00:10,630 --> 01:00:08,240
october 1997.

1483
01:00:12,789 --> 01:00:10,640
all this could hardly be accepted in

1484
01:00:14,789 --> 01:00:12,799
europe

1485
01:00:17,109 --> 01:00:14,799
a two-year delay would cost this an

1486
01:00:18,870 --> 01:00:17,119
additional 30 million dollar visa

1487
01:00:20,230 --> 01:00:18,880
director general wrote to the nasa

1488
01:00:22,549 --> 01:00:20,240

administrator

1489
01:00:23,990 --> 01:00:22,559
such unilateral decision is not in the

1490
01:00:26,230 --> 01:00:24,000
spirit of the memorandum of

1491
01:00:28,950 --> 01:00:26,240
understanding he concluded

1492
01:00:31,030 --> 01:00:28,960
knowledge irritation was expressed by

1493
01:00:34,789 --> 01:00:31,040
the european space science community you

1494
01:00:35,750 --> 01:00:34,799
see here a quotation in a letter of self

1495
01:00:39,030 --> 01:00:35,760
to

1496
01:00:40,549 --> 01:00:39,040
its counterpart in the united states

1497
01:00:44,549 --> 01:00:40,559
and here you have a

1498
01:00:46,390 --> 01:00:44,559
an exception of comments in the

1499
01:00:49,589 --> 01:00:46,400
science policy committee the swiss

1500
01:00:50,950 --> 01:00:49,599
delegate the dutch delegate the chair of

1501
01:00:54,230 --> 01:00:50,960
the sarc

1502
01:00:57,990 --> 01:00:56,069
despite all efforts it was hardly

1503
01:01:00,150 --> 01:00:58,000
possible for esa and the european

1504
01:01:02,390 --> 01:01:00,160
scientists to influence the us congress

1505
01:01:04,230 --> 01:01:02,400
debates on such an important item in the

1506
01:01:07,430 --> 01:01:04,240
federal budget

1507
01:01:10,069 --> 01:01:07,440
so in autumn 1989 the congress had

1508
01:01:13,109 --> 01:01:10,079
approved the kraft affinity program

1509
01:01:14,710 --> 01:01:13,119
within a budget limit of 1.6

1510
01:01:17,190 --> 01:01:14,720
billion dollars

1511
01:01:19,390 --> 01:01:17,200
and the cost of cassini was now cassini

1512
01:01:22,069 --> 01:01:19,400
alone was estimated at about

1513
01:01:22,950 --> 01:01:22,079

1.7 billion dollars

1514
01:01:25,190 --> 01:01:22,960
so

1515
01:01:27,670 --> 01:01:25,200
one of the mission had to be cancelled

1516
01:01:29,990 --> 01:01:27,680
and eventually nasa decided to cancel

1517
01:01:31,829 --> 01:01:30,000
the craft mission and undertake a

1518
01:01:33,910 --> 01:01:31,839
significant reconfiguration of the

1519
01:01:35,589 --> 01:01:33,920
cassini project in order to reduce its

1520
01:01:38,390 --> 01:01:35,599
cost

1521
01:01:42,150 --> 01:01:38,400
that was not the end of the story

1522
01:01:44,630 --> 01:01:42,160
a new budgetary crisis burst in 1994 and

1523
01:01:48,230 --> 01:01:44,640
in this situation

1524
01:01:50,789 --> 01:01:48,240
either cassini or the gamma-ray

1525
01:01:53,910 --> 01:01:50,799
axoff mission that eventually became

1526
01:01:55,750 --> 01:01:53,920
chandra had to be canceled by nasa

1527
01:01:57,990 --> 01:01:55,760
and the prospect for cassini were not

1528
01:02:00,549 --> 01:01:58,000
encouraging as the mission did not enjoy

1529
01:02:02,309 --> 01:02:00,559
the support from nasa administrators

1530
01:02:04,069 --> 01:02:02,319
called daniel goldin

1531
01:02:07,029 --> 01:02:04,079
cassini in fact was the perfect

1532
01:02:08,630 --> 01:02:07,039
antithesis of golden's faster cheaper

1533
01:02:10,870 --> 01:02:08,640
and better policy

1534
01:02:13,270 --> 01:02:10,880
a mammoth mission conceived 10 years

1535
01:02:15,109 --> 01:02:13,280
later earlier which would not provide

1536
01:02:16,549 --> 01:02:15,119
scientific results until more than 10

1537
01:02:18,710 --> 01:02:16,559
years later

1538
01:02:20,710 --> 01:02:18,720

its cost was to be measured in billions

1539
01:02:23,190 --> 01:02:20,720
of dollars and the failure at launch or

1540
01:02:25,349 --> 01:02:23,200
beyond would have been devastating

1541
01:02:28,150 --> 01:02:25,359
moreover its management suffered from

1542
01:02:31,750 --> 01:02:28,160
the complexity of a large international

1543
01:02:33,510 --> 01:02:31,760
cooperation and an 18 instrument payload

1544
01:02:35,910 --> 01:02:33,520
coming from countless scientific

1545
01:02:38,789 --> 01:02:35,920
institutions in two continents

1546
01:02:41,430 --> 01:02:38,799
so he did not hide his distrust toward

1547
01:02:43,109 --> 01:02:41,440
cassini and apparently he was prepared

1548
01:02:45,029 --> 01:02:43,119
to cancel it

1549
01:02:47,430 --> 01:02:45,039
let's keep this one

1550
01:02:48,789 --> 01:02:47,440
the reactions again were very strong in

1551
01:02:50,069 --> 01:02:48,799
europe

1552
01:02:52,470 --> 01:02:50,079
here you see

1553
01:02:54,630 --> 01:02:52,480
a letter this is an unprecedented

1554
01:02:56,470 --> 01:02:54,640
initiative taken by the isa director

1555
01:02:59,349 --> 01:02:56,480
general jean-marie luton who wrote to

1556
01:03:03,990 --> 01:02:59,359
the u.s vice president al gore

1557
01:03:08,549 --> 01:03:06,630
and a strong diplomatic action was taken

1558
01:03:10,710 --> 01:03:08,559
by isa member states governments whose

1559
01:03:12,710 --> 01:03:10,720
ambassadors in washington appealed to

1560
01:03:15,109 --> 01:03:12,720
the state department to worry about the

1561
01:03:18,069 --> 01:03:15,119
devastating consequences of the eventual

1562
01:03:20,710 --> 01:03:18,079
cancellation of the cassini mission

1563
01:03:23,109 --> 01:03:20,720

in the event

1564
01:03:25,510 --> 01:03:23,119
president bill kill clinton

1565
01:03:27,109 --> 01:03:25,520
came to nasa's aid by redirecting other

1566
01:03:30,950 --> 01:03:27,119
spending in order to shore up the

1567
01:03:33,029 --> 01:03:30,960
agency's science budget but

1568
01:03:34,950 --> 01:03:33,039
golding

1569
01:03:36,789 --> 01:03:34,960
the nasa administrator demanded that the

1570
01:03:38,789 --> 01:03:36,799
world cassini program including the

1571
01:03:41,029 --> 01:03:38,799
huygens probe and the antenna under

1572
01:03:43,990 --> 01:03:41,039
development in italy should be submitted

1573
01:03:46,230 --> 01:03:44,000
on to an independent review by a team of

1574
01:03:48,549 --> 01:03:46,240
external scientists

1575
01:03:50,710 --> 01:03:48,559
this again was felt in europe as an

1576
01:03:52,630 --> 01:03:50,720
unacceptable violation of the

1577
01:03:55,670 --> 01:03:52,640
cooperative spirit but

1578
01:03:56,789 --> 01:03:55,680
after some tense meeting the review was

1579
01:03:58,710 --> 01:03:56,799
eventually

1580
01:04:01,190 --> 01:03:58,720
accepted

1581
01:04:03,029 --> 01:04:01,200
finally following the

1582
01:04:05,670 --> 01:04:03,039
review the cassini-huygens development

1583
01:04:08,069 --> 01:04:05,680
program went on smoothly

1584
01:04:11,270 --> 01:04:08,079
the mission was successfully launched on

1585
01:04:13,990 --> 01:04:11,280
15 october 1997 and after seven year

1586
01:04:17,990 --> 01:04:14,000
cruise cassini entered orbit around

1587
01:04:20,710 --> 01:04:18,000
saturn on first july 2004

1588
01:04:21,750 --> 01:04:20,720

six months later on christmas day as you

1589
01:04:23,750 --> 01:04:21,760
can see

1590
01:04:26,789 --> 01:04:23,760
huygens was released by the mother

1591
01:04:29,829 --> 01:04:26,799
spacecraft and started its 20 days

1592
01:04:31,910 --> 01:04:29,839
and 4 million kilometer cruise towards

1593
01:04:35,829 --> 01:04:31,920
titan

1594
01:04:37,910 --> 01:04:35,839
on friday 14 january 2005

1595
01:04:40,470 --> 01:04:37,920
a group of nervous and excited

1596
01:04:42,950 --> 01:04:40,480
scientists gathered in the control room

1597
01:04:44,870 --> 01:04:42,960
of the european space operations center

1598
01:04:46,950 --> 01:04:44,880
in darmstadt germany

1599
01:04:49,270 --> 01:04:46,960
to attend this hypocal event in the

1600
01:04:51,910 --> 01:04:49,280
history of planetary exploration

1601
01:04:55,029 --> 01:04:51,920
and enjoy hopefully the crowning

1602
01:04:56,870 --> 01:04:55,039
achievement of their scientific life

1603
01:04:59,430 --> 01:04:56,880
for the first time since the beginning

1604
01:05:03,190 --> 01:04:59,440
of the space age a human artifact would

1605
01:05:04,710 --> 01:05:03,200
be landed on another world in the outer

1606
01:05:06,789 --> 01:05:04,720
solar system

1607
01:05:09,910 --> 01:05:06,799
the scientists and their distinguished

1608
01:05:13,750 --> 01:05:09,920
guests including ministers space agency

1609
01:05:16,309 --> 01:05:13,760
officials and journalists were waiting

1610
01:05:19,029 --> 01:05:16,319
around noon the news arrived that a

1611
01:05:21,430 --> 01:05:19,039
faint radio signal from the probe had

1612
01:05:23,990 --> 01:05:21,440
been picked up by the green bank radio

1613
01:05:26,710 --> 01:05:24,000

telescope in west virginia

1614
01:05:29,910 --> 01:05:26,720
huygens then had survived the entry

1615
01:05:31,270 --> 01:05:29,920
phase and was alive

1616
01:05:33,430 --> 01:05:31,280
late in the afternoon the first

1617
01:05:36,069 --> 01:05:33,440
scientific data related by the cassini

1618
01:05:38,789 --> 01:05:36,079
spacecraft arrived at sock

1619
01:05:41,270 --> 01:05:38,799
scientists hurted to analyze and soon

1620
01:05:45,190 --> 01:05:41,280
the press got the first stunning images

1621
01:05:53,750 --> 01:05:47,589
a long week of intense work and

1622
01:05:53,760 --> 01:05:56,069
but

1623
01:05:56,079 --> 01:06:02,829
everyone has his own flag

1624
01:06:11,109 --> 01:06:05,190
excellent uh let's take time for a

1625
01:06:16,710 --> 01:06:13,910
as you're up west centres uh thanks very

1626
01:06:19,349 --> 01:06:16,720
much our tour it's it's uh too bad we

1627
01:06:20,309 --> 01:06:19,359
couldn't get a another talk just like

1628
01:06:22,390 --> 01:06:20,319
yours

1629
01:06:24,069 --> 01:06:22,400
from the u.s side

1630
01:06:26,789 --> 01:06:24,079
because i assure you

1631
01:06:28,150 --> 01:06:26,799
that the drama associated with getting a

1632
01:06:29,029 --> 01:06:28,160
new start

1633
01:06:30,710 --> 01:06:29,039
for

1634
01:06:33,829 --> 01:06:30,720
cassini

1635
01:06:35,589 --> 01:06:33,839
and also preventing its cancellation

1636
01:06:36,549 --> 01:06:35,599
uh is also

1637
01:06:39,990 --> 01:06:36,559
filled

1638
01:06:42,630 --> 01:06:40,000

with a great deal of drama on the u.s

1639
01:06:46,390 --> 01:06:42,640
side and particularly inside the halls

1640
01:06:47,589 --> 01:06:46,400
of nasa itself just to comment

1641
01:06:50,470 --> 01:06:47,599
i was the

1642
01:06:51,670 --> 01:06:50,480
pre-project study scientist for cassini

1643
01:06:53,589 --> 01:06:51,680
and i was also the associate

1644
01:06:55,349 --> 01:06:53,599
administrator at nasa

1645
01:06:57,829 --> 01:06:55,359
who had to deal with the potential

1646
01:07:01,190 --> 01:06:57,839
cancellation of cassini

1647
01:07:03,829 --> 01:07:01,200
and every morning i went into my office

1648
01:07:05,829 --> 01:07:03,839
and i printed my resignation letter

1649
01:07:10,710 --> 01:07:05,839
dated it stuck it in my pocket and went

1650
01:07:14,230 --> 01:07:12,309
so there were a couple of necessary

1651
01:07:17,829 --> 01:07:14,240
steps we had to go through to convince

1652
01:07:19,910 --> 01:07:17,839
mr golden uh not to cancel cassini

1653
01:07:22,069 --> 01:07:19,920
and so the congress came to our rescue

1654
01:07:24,390 --> 01:07:22,079
the administration came to our rescue

1655
01:07:25,349 --> 01:07:24,400
the scientists came to our rescue and

1656
01:07:28,950 --> 01:07:25,359
europe

1657
01:07:32,470 --> 01:07:28,960
thank you very much came to our rescue

1658
01:07:35,109 --> 01:07:32,480
you saved both cassini and axa

1659
01:07:39,109 --> 01:07:35,119
you saved both cassini and aksaf

1660
01:07:45,190 --> 01:07:41,589
hi i'm peter markowski

1661
01:07:47,029 --> 01:07:45,200
i'm struck by the parallels of

1662
01:07:49,029 --> 01:07:47,039
the international cooperation aspect of

1663
01:07:51,670 --> 01:07:49,039

this with the ispm

1664
01:07:53,670 --> 01:07:51,680
earlier in the 1980s kind of the

1665
01:07:55,589 --> 01:07:53,680
political battles and then the european

1666
01:07:58,630 --> 01:07:55,599
protests

1667
01:08:01,430 --> 01:07:58,640
when esa was planning

1668
01:08:03,510 --> 01:08:01,440
and deciding on cassini in the 80s were

1669
01:08:05,510 --> 01:08:03,520
there explicit concerns both from the

1670
01:08:06,549 --> 01:08:05,520
scientific community and from esa

1671
01:08:08,230 --> 01:08:06,559
planners

1672
01:08:12,549 --> 01:08:08,240
that

1673
01:08:13,430 --> 01:08:12,559
like ispm will happen again

1674
01:08:21,269 --> 01:08:13,440
um

1675
01:08:25,829 --> 01:08:24,709
maybe you have read the the quotation of

1676
01:08:29,910 --> 01:08:25,839
the

1677
01:08:31,590 --> 01:08:29,920
once

1678
01:08:33,189 --> 01:08:31,600
what is

1679
01:08:35,669 --> 01:08:33,199
we cannot

1680
01:08:42,229 --> 01:08:35,679
go again through the same story and then

1681
01:08:46,709 --> 01:08:44,550
experience so

1682
01:08:49,269 --> 01:08:46,719
but in this case there was a different

1683
01:08:51,349 --> 01:08:49,279
situation in fact because first of all

1684
01:08:53,669 --> 01:08:51,359
there was a strong constituency behind

1685
01:08:56,309 --> 01:08:53,679
cassini in the united states probably

1686
01:08:59,430 --> 01:08:56,319
much stronger than it was in the case of

1687
01:09:01,110 --> 01:08:59,440
a ispm i i guess so

1688
01:09:03,349 --> 01:09:01,120

and secondly

1689
01:09:06,470 --> 01:09:03,359
there was a new balance of powers

1690
01:09:07,430 --> 01:09:06,480
between the two agencies

1691
01:09:09,590 --> 01:09:07,440
thank you

1692
01:09:11,349 --> 01:09:09,600
one final quick question

1693
01:09:14,149 --> 01:09:11,359
thank you arturo this is really fabulous

1694
01:09:16,309 --> 01:09:14,159
work so um i have a question about

1695
01:09:18,709 --> 01:09:16,319
the previous inter-institutional

1696
01:09:20,630 --> 01:09:18,719
relationships that are going into

1697
01:09:22,550 --> 01:09:20,640
the decision about cassini from the

1698
01:09:24,070 --> 01:09:22,560
european side so you mentioned it was

1699
01:09:25,590 --> 01:09:24,080
going up against a mission that was

1700
01:09:27,349 --> 01:09:25,600
involving the the french and the

1701
01:09:29,269 --> 01:09:27,359
russians who of course had had a long

1702
01:09:31,669 --> 01:09:29,279
history of cooperation already by that

1703
01:09:34,550 --> 01:09:31,679
point through the 1970s right and i'm

1704
01:09:36,789 --> 01:09:34,560
wondering to what extent there was a

1705
01:09:37,749 --> 01:09:36,799
you can't hear

1706
01:09:40,229 --> 01:09:37,759
okay

1707
01:09:42,309 --> 01:09:40,239
let me try this way so you mentioned

1708
01:09:45,030 --> 01:09:42,319
that moment in bruges when they were

1709
01:09:47,510 --> 01:09:45,040
making the decision to have cassini or

1710
01:09:50,149 --> 01:09:47,520
to have one of four other missions

1711
01:09:52,789 --> 01:09:50,159
and one of them you said was a russian

1712
01:09:54,550 --> 01:09:52,799
and french collaboration yes vesta so of

1713
01:09:56,229 --> 01:09:54,560

course the russians and the french had

1714
01:09:58,310 --> 01:09:56,239
already been collaborating for many

1715
01:10:00,870 --> 01:09:58,320
years through the 1970s right so that

1716
01:10:02,709 --> 01:10:00,880
was an existing cooperative arrangement

1717
01:10:05,830 --> 01:10:02,719
but i'm wondering if there was first of

1718
01:10:07,669 --> 01:10:05,840
all institutional precedence for the

1719
01:10:10,229 --> 01:10:07,679
relationship between

1720
01:10:11,910 --> 01:10:10,239
europe and america or if this was a new

1721
01:10:14,709 --> 01:10:11,920
collaboration that had really been

1722
01:10:17,910 --> 01:10:14,719
formed through individual relationships

1723
01:10:19,510 --> 01:10:17,920
on voyager if this was europe attempting

1724
01:10:21,669 --> 01:10:19,520
to make some bridges with the united

1725
01:10:23,510 --> 01:10:21,679
states in a way that they hadn't before

1726
01:10:25,590 --> 01:10:23,520
and what would lead them to make the

1727
01:10:27,590 --> 01:10:25,600
political decision to work with the

1728
01:10:29,910 --> 01:10:27,600
united states as opposed to support

1729
01:10:31,189 --> 01:10:29,920
another russian and french collaboration

1730
01:10:33,110 --> 01:10:31,199
so i just want to know a little bit more

1731
01:10:35,350 --> 01:10:33,120
about that moment of decision making

1732
01:10:36,870 --> 01:10:35,360
that is a long story but anyway the

1733
01:10:39,590 --> 01:10:36,880
french

1734
01:10:41,990 --> 01:10:39,600
had a long tradition of collaboration

1735
01:10:43,990 --> 01:10:42,000
with the soviet union

1736
01:10:46,229 --> 01:10:44,000
and issa had a long tradition of

1737
01:10:48,750 --> 01:10:46,239
cooperation with nasa

1738
01:10:50,390 --> 01:10:48,760

so as far as i know there was no

1739
01:10:52,390 --> 01:10:50,400
institutionalized

1740
01:10:53,430 --> 01:10:52,400
collaboration between

1741
01:10:55,669 --> 01:10:53,440
europe

1742
01:10:58,390 --> 01:10:55,679
and the soviet union but there were

1743
01:11:00,630 --> 01:10:58,400
personal contacts and individual

1744
01:11:02,310 --> 01:11:00,640
forms of cooperation in the case of

1745
01:11:05,510 --> 01:11:02,320
vesta there is another

1746
01:11:08,790 --> 01:11:05,520
aspect that the mission was conceived

1747
01:11:10,149 --> 01:11:08,800
and early developed by kness and iki

1748
01:11:13,270 --> 01:11:10,159
so isa

1749
01:11:15,270 --> 01:11:13,280
joined at a later stage and within the

1750
01:11:18,310 --> 01:11:15,280
east staff there was not

1751
01:11:20,550 --> 01:11:18,320
that much interest in

1752
01:11:23,430 --> 01:11:20,560
getting involved in this in this mission

1753
01:11:25,430 --> 01:11:23,440
because they were they felt they were

1754
01:11:27,189 --> 01:11:25,440
should be considered as something like a

1755
01:11:29,590 --> 01:11:27,199
junior partner

1756
01:11:32,470 --> 01:11:29,600
vis-a-vis the french and the