
AbSciCon
2019

1
00:00:00,790 --> 00:00:07,320
[Music]

2
00:00:10,950 --> 00:00:09,110
[Applause]

3
00:00:13,140 --> 00:00:10,960
first I really appreciated the

4
00:00:16,020 --> 00:00:13,150
presentation by a honeybee very nice

5
00:00:31,290 --> 00:00:16,030
work we also were one of the groups that

6
00:00:34,860 --> 00:00:31,300
received a cold tech okay

7
00:00:37,530 --> 00:00:34,870
we received a a cold tech grant and we

8
00:00:41,160 --> 00:00:37,540
pursued a very specific path with this

9
00:00:44,100 --> 00:00:41,170
we have had several cryo bot projects at

10
00:00:45,540 --> 00:00:44,110
the lab now for the past 10 years in

11
00:00:47,220 --> 00:00:45,550
fact and have looked at a lot of

12
00:00:49,590 --> 00:00:47,230
different technologies everything from

13
00:00:53,100 --> 00:00:49,600

melt probes to closed cycle hot water

14
00:00:57,330 --> 00:00:53,110
drills and a an alternative that we hit

15
00:01:00,540 --> 00:00:57,340
on back in 2015 was using tuned

16
00:01:04,590 --> 00:01:00,550
wavelength lasers that match the

17
00:01:07,010 --> 00:01:04,600
absorption frequency of solid ice and so

18
00:01:10,620 --> 00:01:07,020
the idea came up as well if you build a

19
00:01:12,480 --> 00:01:10,630
small highly efficient probe to get

20
00:01:15,960 --> 00:01:12,490
through a short distance of ice we're

21
00:01:17,550 --> 00:01:15,970
not talking about a full depth 20

22
00:01:19,950 --> 00:01:17,560
kilometer penetrator here this is more

23
00:01:22,469 --> 00:01:19,960
of a lightweight Lander style mission

24
00:01:26,640 --> 00:01:22,479
whether it's a Martian polar cap or or

25
00:01:29,789 --> 00:01:26,650
the Europa Lander and we needed a place

26
00:01:32,359 --> 00:01:29,799
to to test this concept and so there

27
00:01:34,710 --> 00:01:32,369
really weren't any true cryo bot

28
00:01:38,999 --> 00:01:34,720
chambers available in which there was a

29
00:01:42,270 --> 00:01:39,009
large cylinder of ice kept at Europa

30
00:01:43,710 --> 00:01:42,280
temperatures and and vacuum and so we

31
00:01:45,899 --> 00:01:43,720
designed and built this facility we're

32
00:01:50,399 --> 00:01:45,909
operating it now it is active up and

33
00:01:52,800 --> 00:01:50,409
running in Austin and when we first got

34
00:01:54,539 --> 00:01:52,810
it running and had had a slug of ice in

35
00:01:57,330 --> 00:01:54,549
there sitting at liquid nitrogen

36
00:01:59,580 --> 00:01:57,340
temperature the first thing that we

37
00:02:02,460 --> 00:01:59,590
wanted to look at was an old question

38
00:02:06,600 --> 00:02:02,470

that had been kind of raised in the

39
00:02:08,999 --> 00:02:06,610
2000s regarding whether a pure a passive

40
00:02:11,069 --> 00:02:09,009
thermal probe was going to stall out

41
00:02:14,780 --> 00:02:11,079
there were suggestions from this from

42
00:02:17,280 --> 00:02:14,790
German researcher DLR and so we built a

43
00:02:21,030 --> 00:02:17,290
three point two centimeter diameter

44
00:02:22,500 --> 00:02:21,040
system and tested that out in the ice

45
00:02:24,509 --> 00:02:22,510
fully expecting that

46
00:02:29,910 --> 00:02:24,519
was going to stall out and so here's a

47
00:02:33,240 --> 00:02:29,920
video that hopefully will play and this

48
00:02:35,699 --> 00:02:33,250
is this is sped up about 300 times just

49
00:02:37,649 --> 00:02:35,709
so you get the idea here that things are

50
00:02:39,690 --> 00:02:37,659
not happening fast when you're going to

51
00:02:41,670 --> 00:02:39,700
early passive thermal however the thing

52
00:02:43,800 --> 00:02:41,680
that surprised everybody was the fact

53
00:02:45,990 --> 00:02:43,810
that it went down

54
00:02:48,600 --> 00:02:46,000
we actually penetrated down to about two

55
00:02:52,199 --> 00:02:48,610
and a half vehicle lengths before we had

56
00:02:56,039 --> 00:02:52,209
a stall out at the vacuum seal where the

57
00:02:57,569 --> 00:02:56,049
rod goes into the chamber but nothing

58
00:02:58,710 --> 00:02:57,579
appears to be stopping at what we did

59
00:03:01,619 --> 00:02:58,720
see however it was something very

60
00:03:05,729 --> 00:03:01,629
similar to a dlr saw which is a trumpet

61
00:03:07,470 --> 00:03:05,739
shaped radiation ablated zone going in

62
00:03:12,119 --> 00:03:07,480
where you're wasting a lot of energy

63
00:03:15,089 --> 00:03:12,129

just trying to get started if you plot

64
00:03:17,970 --> 00:03:15,099
this up you can see the the curve here

65
00:03:20,099 --> 00:03:17,980
of depth versus energy in a watt hours

66
00:03:23,009 --> 00:03:20,109
that we're putting in here there was a

67
00:03:25,259 --> 00:03:23,019
stall point in the middle where the the

68
00:03:26,699 --> 00:03:25,269
vacuum seal bound up we had to jiggle it

69
00:03:28,819 --> 00:03:26,709
to get it to keep going the reason we

70
00:03:32,069 --> 00:03:28,829
were doing this is because we had a

71
00:03:34,140 --> 00:03:32,079
edged marker on the rod to let us know

72
00:03:36,659 --> 00:03:34,150
how far the vehicle had gone down per

73
00:03:38,520 --> 00:03:36,669
watt hour of descent so once it started

74
00:03:40,199 --> 00:03:38,530
back up and we were below the hole

75
00:03:42,629 --> 00:03:40,209
closure rate and and by the way the

76
00:03:43,890 --> 00:03:42,639
supposition that the hole closes is no

77
00:03:46,650 --> 00:03:43,900
longer conjecture

78
00:03:48,780 --> 00:03:46,660
we saw it it's real and after a certain

79
00:03:51,180 --> 00:03:48,790
point it will bind around anything that

80
00:03:54,120 --> 00:03:51,190
is holding that probe up so anything

81
00:03:56,580 --> 00:03:54,130
that goes below a vehicle length or two

82
00:03:59,129 --> 00:03:56,590
is going to have to be free controlled

83
00:04:00,870 --> 00:03:59,139
from this point forward the nice thing

84
00:04:03,390 --> 00:04:00,880
about it was that green line that you

85
00:04:06,869 --> 00:04:03,400
see there was our thermal modeling that

86
00:04:10,140 --> 00:04:06,879
was built around the a mod equation for

87
00:04:11,729 --> 00:04:10,150
a traveling vehicle and so that was kind

88
00:04:14,210 --> 00:04:11,739

of reassuring to know that we're on

89
00:04:18,060 --> 00:04:14,220
target with our simulations as well

90
00:04:21,060 --> 00:04:18,070
looking at cryovac behavior the other

91
00:04:23,310 --> 00:04:21,070
nice thing is we had designed the

92
00:04:24,659 --> 00:04:23,320
chamber to be large enough so that the

93
00:04:27,210 --> 00:04:24,669
boundary conditions would maintain

94
00:04:29,460 --> 00:04:27,220
Europa ice and we tracked that

95
00:04:32,120 --> 00:04:29,470
performance over more than a kilowatt

96
00:04:34,500 --> 00:04:32,130
hour of energy being pumped into the ice

97
00:04:35,879 --> 00:04:34,510
from that probe and you can see from

98
00:04:38,159 --> 00:04:35,889
that the middle plot they

99
00:04:41,159 --> 00:04:38,169
we had some minor changes in vacuum why

100
00:04:43,469 --> 00:04:41,169
because you're sublimating ice out into

101
00:04:46,110 --> 00:04:43,479
the atmosphere and the three-state pumps

102
00:04:48,300 --> 00:04:46,120
have to pull that back down the bottom

103
00:04:49,980 --> 00:04:48,310
line there the green solid line is the

104
00:04:51,240 --> 00:04:49,990
temperature of the ice near all the

105
00:04:52,740 --> 00:04:51,250
chamber it's sitting down there at

106
00:04:55,679 --> 00:04:52,750
liquid nitrogen temperature not doing

107
00:04:57,420 --> 00:04:55,689
much the dotted line is a string of

108
00:04:59,580 --> 00:04:57,430
thermocouples that was immediately

109
00:05:02,129 --> 00:04:59,590
adjacent to the probe itself so you can

110
00:05:05,670 --> 00:05:02,139
see that we are radiating energy out

111
00:05:08,700 --> 00:05:05,680
into the ice and it's picking that up so

112
00:05:10,379 --> 00:05:08,710
the real test was what is going to

113
00:05:13,499 --> 00:05:10,389

happen if we change the game here

114
00:05:17,969 --> 00:05:13,509
instead of using a passive probe we pump

115
00:05:20,129 --> 00:05:17,979
optical power down to the system on a

116
00:05:21,959 --> 00:05:20,139
spacecraft this would be a card a board

117
00:05:24,300 --> 00:05:21,969
level laser for the test that we did

118
00:05:27,860 --> 00:05:24,310
this was an industrial 10 70 nanometer

119
00:05:31,499 --> 00:05:27,870
laser which we sent by fiber optic

120
00:05:34,939 --> 00:05:31,509
thread it's about a 200 micron device

121
00:05:37,890 --> 00:05:34,949
and there were optics inside a Tyrolean

122
00:05:39,689 --> 00:05:37,900
tellurium copper head here we had two

123
00:05:41,670 --> 00:05:39,699
different types that we wanted to look

124
00:05:45,420 --> 00:05:41,680
at to kind of bracket the a mod equation

125
00:05:49,079 --> 00:05:45,430
one was where we had the portion of the

126
00:05:52,079 --> 00:05:49,089
beam about 54% of the power being dumped

127
00:05:53,490 --> 00:05:52,089
into the sidewalls of the vehicle to

128
00:05:55,740 --> 00:05:53,500
make sure that the vehicle didn't freeze

129
00:05:57,809 --> 00:05:55,750
in and then the rest of that was going

130
00:06:00,779 --> 00:05:57,819
out optically into the ice depositing

131
00:06:04,260 --> 00:06:00,789
over a distance of about a vehicle and a

132
00:06:06,420 --> 00:06:04,270
half length ahead of the system allowing

133
00:06:09,059 --> 00:06:06,430
it to move through that Isis it went

134
00:06:11,850 --> 00:06:09,069
forward and so here's a there's a video

135
00:06:13,499 --> 00:06:11,860
of this you see all the the refreeze on

136
00:06:16,670 --> 00:06:13,509
the outside of the probe is dropping off

137
00:06:19,649 --> 00:06:16,680
now it's turned up we're pumping about

138
00:06:21,540 --> 00:06:19,659

340 watts through this right now and

139
00:06:24,059 --> 00:06:21,550
interestingly not the thing that we

140
00:06:26,399 --> 00:06:24,069
conjectured for a long time is that it

141
00:06:29,999 --> 00:06:26,409
is sublimating out and forming a nice

142
00:06:33,540 --> 00:06:30,009
little crystal cone on the outside of

143
00:06:36,209 --> 00:06:33,550
the of the hole the one thing that was

144
00:06:38,610 --> 00:06:36,219
kind of a surprise is that we were

145
00:06:41,129 --> 00:06:38,620
getting extremely high efficiency out of

146
00:06:42,899 --> 00:06:41,139
this thing okay honeybee can go back and

147
00:06:44,309 --> 00:06:42,909
check these numbers if you wish but we

148
00:06:47,010 --> 00:06:44,319
were getting three watt hours per

149
00:06:49,270 --> 00:06:47,020
centimeter of descent this was for a

150
00:06:52,870 --> 00:06:49,280
three point 2 centimeter diameter of

151
00:06:54,879 --> 00:06:52,880
probe extremely efficient about sixteen

152
00:06:58,300 --> 00:06:54,889
times better than what we were seeing

153
00:07:00,430 --> 00:06:58,310
with the the passive probe we tried a

154
00:07:02,500 --> 00:07:00,440
shorter version the idea here was okay

155
00:07:04,360 --> 00:07:02,510
what happens if you dump all the energy

156
00:07:06,909 --> 00:07:04,370
into the Ison so because we're doing

157
00:07:09,520 --> 00:07:06,919
this optically we can actually determine

158
00:07:12,430 --> 00:07:09,530
how far ahead of the vehicle we want to

159
00:07:14,470 --> 00:07:12,440
deposit the the energy and so here's a

160
00:07:15,790 --> 00:07:14,480
here's a version of this test here again

161
00:07:18,129 --> 00:07:15,800
this is sped up about thirty times

162
00:07:19,900 --> 00:07:18,139
you'll notice our little Lego helicopter

163
00:07:22,450 --> 00:07:19,910

is moving that's because sublimate is

164
00:07:25,150 --> 00:07:22,460
flashing out of the hole and creating a

165
00:07:26,680 --> 00:07:25,160
bit of pressure which is sensed not that

166
00:07:28,900 --> 00:07:26,690
we put it in there to do that but it was

167
00:07:32,320 --> 00:07:28,910
a side product you'll notice that you

168
00:07:35,740 --> 00:07:32,330
can still see just the rear rim of the

169
00:07:38,370 --> 00:07:35,750
the vehicle in there the reason for that

170
00:07:41,770 --> 00:07:38,380
is because the backend of the vehicle

171
00:07:45,790 --> 00:07:41,780
froze down to a temperature at allowed

172
00:07:47,980 --> 00:07:45,800
it to bind in the hole once we got deep

173
00:07:50,740 --> 00:07:47,990
enough and so the answer is we had

174
00:07:53,380 --> 00:07:50,750
correctly bracketed the a mod equation

175
00:07:54,940 --> 00:07:53,390
what needs to be done now is to tune how

176
00:07:56,950 --> 00:07:54,950
much of the energy you want to pump into

177
00:07:59,350 --> 00:07:56,960
the sidewall how you distribute that

178
00:08:01,930 --> 00:07:59,360
through bimetallic and heat pump systems

179
00:08:04,600 --> 00:08:01,940
and then how much you put into the the

180
00:08:06,850 --> 00:08:04,610
nose to get the fastest descent for the

181
00:08:08,770 --> 00:08:06,860
least amount of energy so we just looks

182
00:08:12,460 --> 00:08:08,780
for some quick comparison here the red

183
00:08:14,920 --> 00:08:12,470
line is the passive probe the blue line

184
00:08:16,270 --> 00:08:14,930
is the longer probe in which we're

185
00:08:18,190 --> 00:08:16,280
putting a little bit of the heat into

186
00:08:20,290 --> 00:08:18,200
the sidewalls we're looking at about

187
00:08:24,990 --> 00:08:20,300
three watt hours per centimeter for the

188
00:08:29,560 --> 00:08:25,000

laser probe versus about 24 watt hours

189
00:08:33,159 --> 00:08:29,570
for the the passive probe and the speed

190
00:08:35,829 --> 00:08:33,169
is about actually nine times faster with

191
00:08:37,779 --> 00:08:35,839
the the laser probe so we're in the

192
00:08:39,909 --> 00:08:37,789
limits of what we would expect for

193
00:08:41,560 --> 00:08:39,919
example to be comparison comparing

194
00:08:44,110 --> 00:08:41,570
ourselves with a mechanical drill at the

195
00:08:45,820 --> 00:08:44,120
surface also the interesting thing here

196
00:08:48,160 --> 00:08:45,830
is that while many people have thought

197
00:08:50,260 --> 00:08:48,170
there would be a starting problem for

198
00:08:52,720 --> 00:08:50,270
this class of instrument both the laser

199
00:08:58,640 --> 00:08:52,730
and the passive probe we've not seen

200
00:09:04,820 --> 00:09:01,580
okay last slide here before conclusions

201
00:09:08,090 --> 00:09:04,830
this is comparing the laser probe in

202
00:09:10,430 --> 00:09:08,100
blue long version versus the short

203
00:09:13,970 --> 00:09:10,440
version again the issue was that

204
00:09:15,380 --> 00:09:13,980
eventually we had a lock-up in the

205
00:09:17,090 --> 00:09:15,390
vehicle in the case of the blue one it

206
00:09:18,500 --> 00:09:17,100
was not the probe itself it was the

207
00:09:21,470 --> 00:09:18,510
support rod that we were using to

208
00:09:23,230 --> 00:09:21,480
measure the descent rate so from this

209
00:09:26,690 --> 00:09:23,240
point forward what we're doing is

210
00:09:28,610 --> 00:09:26,700
putting a deployable fiber on the back

211
00:09:30,980 --> 00:09:28,620
of the vehicle a small fibrous board

212
00:09:32,870 --> 00:09:30,990
carries about five meters worth the

213
00:09:35,510 --> 00:09:32,880

fiber and the next tests that are

214
00:09:38,570 --> 00:09:35,520
scheduled now for September will be free

215
00:09:41,420 --> 00:09:38,580
fall tests with the probe spooling out

216
00:09:43,010 --> 00:09:41,430
the fiber as it goes down and hopefully

217
00:09:45,140 --> 00:09:43,020
we'll get probably on the order of two

218
00:09:47,690 --> 00:09:45,150
and a half meters worth of penetration

219
00:09:49,700 --> 00:09:47,700
data so just a couple things for the

220
00:09:51,650 --> 00:09:49,710
takeaway we have an operational chamber

221
00:09:54,200 --> 00:09:51,660
right now that is effectively the

222
00:09:58,520 --> 00:09:54,210
surface of Europa we've got good vacuum

223
00:10:01,070 --> 00:09:58,530
sitting at 77 Kelvin and 2.3 meters of

224
00:10:04,250 --> 00:10:01,080
ice that you can go through if anybody

225
00:10:07,910 --> 00:10:04,260
needs that kind of facility let us know

226
00:10:09,950 --> 00:10:07,920
we'd be happy to collaborate when we

227
00:10:12,530 --> 00:10:09,960
look at Europa surface conditions we now

228
00:10:14,960 --> 00:10:12,540
have hard data showing what some of

229
00:10:17,780 --> 00:10:14,970
these probes do the hot penny probe

230
00:10:19,670 --> 00:10:17,790
actually works it's just very slow and

231
00:10:22,550 --> 00:10:19,680
energy inefficient certainly for the

232
00:10:24,680 --> 00:10:22,560
initial stage the good news is there

233
00:10:28,100 --> 00:10:24,690
that several different types of probes

234
00:10:30,350 --> 00:10:28,110
that are possible candidates for getting

235
00:10:32,600 --> 00:10:30,360
all the way through the ice cap are now

236
00:10:33,860 --> 00:10:32,610
enabled by that piece of data it'll take

237
00:10:35,360 --> 00:10:33,870
a little while to get a couple of

238
00:10:37,100 --> 00:10:35,370

vehicle lanes through but once you do

239
00:10:39,290 --> 00:10:37,110
the hole is going to close we saw that

240
00:10:41,720 --> 00:10:39,300
that's real and then you're going to

241
00:10:43,430 --> 00:10:41,730
build up vapor pressure to allow melt

242
00:10:46,010 --> 00:10:43,440
probes to actually work in that

243
00:10:48,020 --> 00:10:46,020
environment we have a test coming up

244
00:10:50,870 --> 00:10:48,030
it's called prometheus under the sesame

245
00:10:54,320 --> 00:10:50,880
program in which we're building a micro

246
00:10:56,870 --> 00:10:54,330
closed cycle hot-water drill to take off

247
00:11:00,500 --> 00:10:56,880
once it achieves passive mode descent

248
00:11:03,590 --> 00:11:00,510
and locks into the ice and then this law

249
00:11:07,340 --> 00:11:03,600
we're looking at onboard fiber spooling

250
00:11:09,500 --> 00:11:07,350
for the the Archimedes probe the utility

251
00:11:11,960 --> 00:11:09,510
of that approach is that if you're

252
00:11:15,979 --> 00:11:11,970
looking at trying to get information

253
00:11:18,199 --> 00:11:15,989
in the 1 to 10 even 25 meter descent

254
00:11:20,839 --> 00:11:18,209
range into ice this is an extremely

255
00:11:23,179 --> 00:11:20,849
energy efficient approach using the

256
00:11:26,529 --> 00:11:23,189
laser in fact it it's something that

257
00:11:30,129 --> 00:11:26,539
would work off a battery powered non RTG

258
00:11:32,779 --> 00:11:30,139
lander and so for us these were

259
00:11:39,649 --> 00:11:32,789
surprising pieces of data that have now

260
00:11:41,479 --> 00:11:39,659
come out of the chamber everyone one

261
00:11:49,429 --> 00:11:41,489
quick question while we're transitioning

262
00:11:51,949 --> 00:11:49,439
here Oh super cold bill Sam Howell JPL

263
00:11:53,929 --> 00:11:51,959

my question is right now you have

264
00:11:56,629 --> 00:11:53,939
relatively narrow diameter probe and I

265
00:11:59,239 --> 00:11:56,639
wonder if the ratio of the diameter of

266
00:12:00,799 --> 00:11:59,249
the column ated beam to the diameter of

267
00:12:02,689 --> 00:12:00,809
the probe matters where you're actually

268
00:12:04,159 --> 00:12:02,699
dumping that optical energy into if you

269
00:12:06,229 --> 00:12:04,169
scale it to the size of something that

270
00:12:09,229 --> 00:12:06,239
can be instrumented you have to scale up

271
00:12:11,629 --> 00:12:09,239
the size of the collimated beam

272
00:12:13,579 --> 00:12:11,639
minnesota's you know the energy required

273
00:12:16,639 --> 00:12:13,589
to get the optical energy into the

274
00:12:18,499 --> 00:12:16,649
iscope with like r-squared or something

275
00:12:21,139 --> 00:12:18,509
we've played with both of these the

276
00:12:23,960 --> 00:12:21,149
original probe that we developed in warm

277
00:12:26,210 --> 00:12:23,970
ice had a much bigger lens this was more

278
00:12:28,129 --> 00:12:26,220
about trying to compare it with an

279
00:12:30,679 --> 00:12:28,139
existing passive probe that we had so we

280
00:12:31,999 --> 00:12:30,689
had apples to apples comparison and so

281
00:12:36,199 --> 00:12:32,009
those are those are experimental

282
00:12:39,169 --> 00:12:36,209
variables that we are looking at this is

283
00:12:40,429 --> 00:12:39,179
not really a cryo bot okay in the sense

284
00:12:41,539 --> 00:12:40,439
that you're carrying an intelligent

285
00:12:43,159 --> 00:12:41,549
system with you and it's a

286
00:12:46,429 --> 00:12:43,169
self-contained device it requires a

287
00:12:48,739 --> 00:12:46,439
surface based laser power supply to do

288
00:12:50,960 --> 00:12:48,749

that however what I didn't have time to

289
00:12:54,979 --> 00:12:50,970
go into there is that it will carry a

290
00:12:57,379 --> 00:12:54,989
fiber Raman a probe that does a side

291
00:12:59,059 --> 00:12:57,389
look into the ice as it goes time this

292
00:13:02,569 --> 00:12:59,069
is being developed in parallel on this