



Dr. William Ailor
The Aerospace Corporation
Principal Investigator,
Reentry Breakup Recorder

1
00:00:01,266 --> 00:00:06,336
>> The ATV in the same
way as the Progress Ship

2
00:00:06,336 --> 00:00:09,236
and the Japanese H2
Transfer Vehicle,

3
00:00:09,586 --> 00:00:12,956
the Automated Transfer
Vehicle will be commanded

4
00:00:12,956 --> 00:00:15,596
to a destructive entry
into the atmosphere

5
00:00:15,856 --> 00:00:20,306
and the surviving pieces will
fall harmlessly into the ocean.

6
00:00:20,306 --> 00:00:23,486
It is used as a trash
disposal vehicle

7
00:00:23,636 --> 00:00:27,006
when its cargo delivery
work is complete.

8
00:00:27,966 --> 00:00:32,326
Now NASA TV viewers have heard
us use those words many times

9
00:00:32,326 --> 00:00:34,996
in discussing the
disposition of cargo vehicles,

10
00:00:35,246 --> 00:00:39,426
talking about a destructive
entry over the ocean.

11
00:00:40,176 --> 00:00:42,956
Well it turns out that
simply disposing of a vehicle

12
00:00:42,956 --> 00:00:46,056
in this way isn't
always good enough.

13
00:00:46,056 --> 00:00:49,516
Knowing how one of these
vehicles breaks apart while it

14
00:00:49,516 --> 00:00:51,946
plunges through the
atmosphere is of value too

15
00:00:52,546 --> 00:00:55,846
and the Space Station's Science
Program has an investigation

16
00:00:55,846 --> 00:00:57,776
that's designed to
learn more about that.

17
00:00:58,306 --> 00:01:00,746
It's called the ReEntry
Breakup Recorder

18
00:01:01,146 --> 00:01:07,026
and Aki Hoshide activated and
installed the REBER hardware

19
00:01:07,066 --> 00:01:10,906
in ATV-3 this morning
for the ride back

20
00:01:10,906 --> 00:01:14,966
down after the undocking
coming up tomorrow afternoon.

21
00:01:15,556 --> 00:01:16,876
The principle investigator

22
00:01:16,876 --> 00:01:20,526
for the ReEntry Breakup
Recorder is Dr. William Ailor

23
00:01:20,916 --> 00:01:23,076
and he joins us this
morning from his office

24
00:01:23,316 --> 00:01:25,786
at The Aerospace
Corporation in El Segundo,

25
00:01:25,786 --> 00:01:27,596
California to talk about it.

26
00:01:27,886 --> 00:01:30,906
Dr. Ailor, tell me when
and how you got interested

27
00:01:30,906 --> 00:01:34,486
in the question of finding
out how things break apart

28
00:01:34,486 --> 00:01:35,936
when they're coming in
through the atmosphere.

29
00:01:36,186 --> 00:01:37,646
>> Dr. Ailor: Certainly,
good morning.

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00:01:37,896 --> 00:01:42,646
I joined the company back in
1974 and shortly thereafter,

31
00:01:42,646 --> 00:01:47,846

we had the Cosmos 954 re-entry
that left some debris in Canada

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00:01:47,846 --> 00:01:52,446
and then some time after that
again, we had Skylab that came

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00:01:52,446 --> 00:01:54,726
down and that also
-- there was concern

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00:01:54,726 --> 00:01:56,466
with things breaking
up in the atmosphere.

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00:01:56,466 --> 00:02:00,446
So I got interested during
that period and have sort

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00:02:00,446 --> 00:02:03,486
of followed this particular
topic for a long time.

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00:02:04,406 --> 00:02:08,086
>> It's maybe a too simple a
question to ask why it matters.

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00:02:08,086 --> 00:02:11,676
I think it certainly matters
if this debris is falling

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00:02:11,676 --> 00:02:12,796
on my house as it entered.

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00:02:12,796 --> 00:02:14,816
But is there value in general

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00:02:14,816 --> 00:02:17,176
of knowing how a space
craft is destroyed?

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00:02:17,816 --> 00:02:18,436

>> Dr. Ailor: Yes, indeed.

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00:02:18,436 --> 00:02:22,966

Basically we have a number
of large object re-entries

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00:02:22,966 --> 00:02:25,936

that come in -- these objects
come in randomly every year

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00:02:26,366 --> 00:02:31,366

and these objects that come in
randomly can be large enough

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00:02:31,366 --> 00:02:35,996

to cause, you know, hazards
on the ground and the --

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00:02:36,866 --> 00:02:40,136

so that was one reason we want
to know why things break up is

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00:02:40,136 --> 00:02:42,096

to know how to assess
that hazard

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00:02:42,466 --> 00:02:44,896

and assessing the hazard
is interesting these days

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00:02:44,896 --> 00:02:47,996

because one of the ways for
removing space debris from orbit

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00:02:47,996 --> 00:02:50,676

or removing it as a concern is

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00:02:50,676 --> 00:02:52,236
to re-enter it into
the atmosphere.

53
00:02:52,696 --> 00:02:55,816
And there're basically two
ways to re-enter things.

54
00:02:55,816 --> 00:03:00,146
One is to do it like we're doing
with the ATV-3 which is direct

55
00:03:00,146 --> 00:03:02,396
into the ocean but
that can be expensive

56
00:03:02,396 --> 00:03:04,406
for somebody who's
operating a space craft.

57
00:03:04,476 --> 00:03:07,166
So if we can lower the
hazard sufficiently

58
00:03:07,166 --> 00:03:11,196
for these large objects,
they could be allowed

59
00:03:11,196 --> 00:03:16,656
to re-enter randomly and that
reduces the cost substantially

60
00:03:16,656 --> 00:03:18,016
for space craft operators.

61
00:03:18,776 --> 00:03:22,926
>> Generally speaking, how large
does an item have to be in order

62
00:03:22,966 --> 00:03:24,946

to survive all the
way to the ground?

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00:03:25,556 --> 00:03:29,616

>> Dr. Ailor: Well, basically
the way we assess this is

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00:03:29,616 --> 00:03:33,416

experience tells us that
anywhere from 10 to 40%

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00:03:33,416 --> 00:03:37,366

of an object's dry mass on orbit
will survive to hit the ground.

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00:03:37,716 --> 00:03:40,936

So that means that, you know,
you have to have an object

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00:03:40,936 --> 00:03:44,866

of sufficient size that has
big enough surviving fragments

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00:03:44,866 --> 00:03:45,886

to be a hazard.

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00:03:46,256 --> 00:03:48,386

I would say the general
rule of thumb is anything

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00:03:48,386 --> 00:03:52,446

that weighs more than about 800
kilograms is probably something

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00:03:52,446 --> 00:03:53,746

that we would be
concerned about.

72

00:03:54,586 --> 00:03:56,776

>> And so -- and some

pieces have survived.

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00:03:56,776 --> 00:03:58,706

Does studying them
tell you anything

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00:03:58,706 --> 00:04:02,196

about how the space
craft disintegrated?

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00:04:02,536 --> 00:04:03,286

>> Dr. Ailor: It does indeed.

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00:04:03,286 --> 00:04:06,176

As a matter of fact, we
have a program working

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00:04:06,176 --> 00:04:09,936

with our local Air Force to
bring back surviving things

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00:04:09,936 --> 00:04:12,676

that are found on the ground
that have survived re-entry

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00:04:12,676 --> 00:04:15,146

and we do a metallurgical
analysis on those to try

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00:04:15,146 --> 00:04:18,046

to understand how hot they got
and we compare those results

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00:04:18,046 --> 00:04:19,796

to what our models predict.

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00:04:21,176 --> 00:04:24,716

>> So you can learn some things
but I take it not as much

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00:04:24,716 --> 00:04:25,456
as you'd like to know.

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00:04:25,926 --> 00:04:26,946
>> Dr. Ailor: That's
exactly right.

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00:04:26,946 --> 00:04:29,716
Basically what we'd like
to know is, you know,

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00:04:29,716 --> 00:04:32,416
what altitude do things
come apart, you know,

87

00:04:32,496 --> 00:04:36,286
what is the heating -- there's
some evidence that the models

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00:04:36,286 --> 00:04:40,356
at least prior to this time have
been over predicting the heating

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00:04:40,356 --> 00:04:42,316
at high altitude which
means that you would predict

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00:04:42,316 --> 00:04:44,826
that less survives than
actually does and so one

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00:04:44,826 --> 00:04:47,116
of our objectives with this
ReEntry Breakup Recorder is

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00:04:47,116 --> 00:04:50,216
to get some definitive
data on how objects respond

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00:04:50,216 --> 00:04:51,366
as they re-enter the atmosphere.

94

00:04:51,876 --> 00:04:53,136
>> Okay, let's talk
about the hardware.

95

00:04:53,136 --> 00:04:56,786
Can you describe the REBER,
ReEntry Breakup Recorder?

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00:04:57,556 --> 00:04:57,916
>> Dr. Ailor: Sure.

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00:04:57,916 --> 00:05:00,826
Basically, REBER is
about a foot in diameter,

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00:05:00,826 --> 00:05:02,436
about nine inches tall.

99

00:05:02,436 --> 00:05:07,236
It weighs about four kilograms
or about nine pounds and the way

100

00:05:07,236 --> 00:05:10,186
to think of it is it's basically
a cell phone with a heat shield

101

00:05:10,336 --> 00:05:13,316
and its own little
instrument suite.

102

00:05:13,656 --> 00:05:18,316
So basically, the way REBER
works is it sits inside the

103

00:05:18,466 --> 00:05:19,296
host vehicle.

104
00:05:20,106 --> 00:05:21,796
It's in a copper shell.

105
00:05:21,986 --> 00:05:24,686
As the host vehicle re-enters,

106
00:05:24,686 --> 00:05:28,796
the aerodynamic heating will
break apart the host vehicle,

107
00:05:28,906 --> 00:05:30,996
expose the copper
shell to heating.

108
00:05:31,046 --> 00:05:33,756
When that copper shell gets
hot, there's some plastic bolts

109
00:05:33,756 --> 00:05:37,156
that melt away and it
releases our little device,

110
00:05:37,156 --> 00:05:38,076
the ReEntry Recorder

111
00:05:38,596 --> 00:05:42,056
which through the re-entry
process records things

112
00:05:42,056 --> 00:05:46,076
like accelerations and rates and
attitude rates, temperatures,

113
00:05:46,446 --> 00:05:48,856
pressures, those
types of things.

114
00:05:48,856 --> 00:05:52,606
And so when we get released

and after we're free flying,

115

00:05:52,986 --> 00:05:56,816
around 60,000 feet or so, we're
basically falling straight down

116

00:05:56,816 --> 00:05:58,686
and at that time,
we make a phone call

117

00:05:58,686 --> 00:06:00,236
in the Iridium system
and dump our data.

118

00:06:00,836 --> 00:06:05,016
>> And when you say
released, your thing turns

119

00:06:05,016 --> 00:06:08,686
into a satellite and is
left flying on its own

120

00:06:08,686 --> 00:06:11,956
because the vehicle it was in
has destroyed itself around it.

121

00:06:12,216 --> 00:06:12,906
>> Dr. Ailor: That's correct.

122

00:06:12,906 --> 00:06:14,776
Exactly. Yes, we're
buried inside --

123

00:06:14,776 --> 00:06:17,526
in that trash pile you
described, not quite like that.

124

00:06:17,526 --> 00:06:20,556
We're actually strapped
up near the hatch

125

00:06:20,796 --> 00:06:24,986
but as the vehicle breaks apart,
we basically count on the fact

126

00:06:24,986 --> 00:06:28,086
that everything inside is
going to be released due

127

00:06:28,086 --> 00:06:29,136
to the aerodynamic heating

128

00:06:29,136 --> 00:06:32,936
as the outside structure is
melted away and then of course,

129

00:06:32,936 --> 00:06:36,026
then we get the release as
you say and we fly separately.

130

00:06:36,446 --> 00:06:37,486
>> Thrown clear of the wreckage.

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00:06:37,486 --> 00:06:38,696
>> Dr. Ailor: Thrown
clear, exactly.

132

00:06:38,906 --> 00:06:41,196
>> And the data is
delivered how?

133

00:06:42,076 --> 00:06:45,406
>> Dr. Ailor: It's all
on the Iridium system.

134

00:06:45,406 --> 00:06:48,966
It's basically a satellite
telephone basically

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00:06:49,376 --> 00:06:52,466
and we make a phone call, it
goes up through the satellite,

136

00:06:52,466 --> 00:06:55,506
comes down to a web page that
we can access from our desk.

137

00:06:56,926 --> 00:06:59,386
>> Does the REBER
itself survive?

138

00:07:00,086 --> 00:07:01,076
>> Dr. Ailor: REBER does.

139

00:07:01,076 --> 00:07:04,766
As it turns out, we didn't
design it to survive impact

140

00:07:04,846 --> 00:07:08,296
but in the last several
re-entries, it's actually landed

141

00:07:08,296 --> 00:07:11,586
in the water in the South
Pacific and it's continued

142

00:07:11,586 --> 00:07:13,126
to broadcast for
a number of hours.

143

00:07:13,126 --> 00:07:14,886
Those can be expensive
telephone calls.

144

00:07:15,756 --> 00:07:16,846
>> [Chuckle] You
haven't recovered one?

145

00:07:16,956 --> 00:07:19,266

>> Dr. Ailor: No, they're not
really designed for recovery

146

00:07:19,266 --> 00:07:22,266
and where they come down right
now is in a very remote location

147

00:07:22,266 --> 00:07:27,196
but we do have information on
the back of contact information

148

00:07:27,196 --> 00:07:28,606
so if somebody finds
one on a beach

149

00:07:28,606 --> 00:07:30,496
or something, they can tell us.

150

00:07:30,836 --> 00:07:32,336
>> You -- you say
that they come --

151

00:07:32,336 --> 00:07:33,546
how many have you flown so far?

152

00:07:34,076 --> 00:07:35,216
>> Dr. Ailor: We've flown three.

153

00:07:35,826 --> 00:07:39,106
We flew one on HTV-2,
that was successful,

154

00:07:39,106 --> 00:07:40,046
that was our first one.

155

00:07:40,406 --> 00:07:43,236
We flew one on ATV-2,
that was not successful

156

00:07:43,566 --> 00:07:49,006
and so we flew one on HTV-3
just recently this month.

157
00:07:49,006 --> 00:07:51,426
It came in earlier this
month, worked beautifully

158
00:07:51,526 --> 00:07:56,186
and we're hoping the one on
ATV-3 will be successful.

159
00:07:56,846 --> 00:08:00,616
>> You simply didn't get the
data from the last ATV or -- ?

160
00:08:00,616 --> 00:08:02,256
>> Dr. Ailor: That's
correct, we simply didn't

161
00:08:02,256 --> 00:08:05,856
and we have a number of theories
as to why that might be.

162
00:08:05,986 --> 00:08:09,756
We were located near the
propulsion system on that one.

163
00:08:09,756 --> 00:08:13,566
Previous re-entries of that
particular one had a fairly

164
00:08:13,566 --> 00:08:16,216
violent breakup with
including an explosion

165
00:08:16,586 --> 00:08:18,246
that could have damaged
our systems.

166

00:08:18,526 --> 00:08:20,906

We did a lot of testing
this time to make sure

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00:08:20,906 --> 00:08:23,006

that we're rugged, to
look for any falls.

168

00:08:23,006 --> 00:08:24,346

We did fix a few little things

169

00:08:24,346 --> 00:08:25,516

that could have caused
trouble too,

170

00:08:25,516 --> 00:08:27,776

so we think these are
much more robust this time

171

00:08:27,776 --> 00:08:29,086

and we're hoping for success.

172

00:08:29,676 --> 00:08:31,836

>> What have you
learned from the two sets

173

00:08:31,836 --> 00:08:33,026

of data that you did get?

174

00:08:33,566 --> 00:08:35,796

>> Dr. Ailor: Well, we
got very good information

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00:08:35,796 --> 00:08:39,436

on the attitude during
the breakup process,

176

00:08:39,436 --> 00:08:41,416

how the space craft
itself responded.

177

00:08:41,926 --> 00:08:44,216

We have good information
now on the breakup altitude

178

00:08:44,216 --> 00:08:47,006

which has always been something
that's of great interest

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00:08:47,006 --> 00:08:48,366

because the breakup altitude

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00:08:48,366 --> 00:08:50,916

in a sense defines the
ground footprint which is

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00:08:50,916 --> 00:08:52,166

where all the debris will land.

182

00:08:52,166 --> 00:08:53,846

Again, that's another
important factor

183

00:08:54,316 --> 00:08:58,776

and we basically were able

184

00:08:58,776 --> 00:09:01,386

to detect a few events
as we were coming in.

185

00:09:01,686 --> 00:09:03,766

One of the problems
with our current device

186

00:09:03,766 --> 00:09:05,656

or limitations I should say is

187

00:09:05,656 --> 00:09:08,516

that it really has its

own internal sensors.

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00:09:08,576 --> 00:09:13,506

We're working on a device
now which would record data

189

00:09:13,506 --> 00:09:17,316

from a number of small wireless
sensors that would be placed

190

00:09:17,316 --> 00:09:19,126

in various locations
in the host vehicle.

191

00:09:19,196 --> 00:09:21,246

That will really
provide superb data

192

00:09:21,246 --> 00:09:22,836

for doing the type
of work we do.

193

00:09:23,706 --> 00:09:25,756

>> And with an eye
toward applying this

194

00:09:25,756 --> 00:09:30,756

to future space craft or better
designs at existing ones?

195

00:09:30,836 --> 00:09:32,456

>> Dr. Ailor: Indeed,
yes, exactly right.

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00:09:32,456 --> 00:09:35,536

We basically would be able
to do something called design

197

00:09:35,536 --> 00:09:38,826

for demise which it means you

could design a space craft

198

00:09:38,826 --> 00:09:40,836

with features in it so
that it would come apart

199

00:09:40,836 --> 00:09:44,586

in controlled ways
hopefully limiting the hazard

200

00:09:44,586 --> 00:09:45,326

on the ground.

201

00:09:45,636 --> 00:09:48,286

And you would have some
confidence in those designs

202

00:09:48,286 --> 00:09:50,596

because you can have a
nice way of testing those.

203

00:09:50,846 --> 00:09:53,726

As a matter of fact, one of the
potential uses for these types

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00:09:53,726 --> 00:09:55,746

of devices is as a black box

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00:09:55,746 --> 00:09:57,806

for commercial space
transportation systems

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00:09:57,806 --> 00:09:59,996

so that you can record
what happens

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00:09:59,996 --> 00:10:02,366

in case there's an accident.

208

00:10:02,366 --> 00:10:03,856
You can also use these devices

209
00:10:03,856 --> 00:10:06,546
for testing heat shield
materials which in fact,

210
00:10:06,546 --> 00:10:08,646
we have sensors in our
heat shields on this one

211
00:10:08,646 --> 00:10:10,816
and they provide
some very nice data

212
00:10:10,816 --> 00:10:14,396
on the temperature distributions
in the heat shield.

213
00:10:14,496 --> 00:10:17,096
>> You have one that's
flying as it were tomorrow.

214
00:10:17,256 --> 00:10:19,566
Are there more in line?

215
00:10:19,566 --> 00:10:21,346
>> Dr. Ailor: Yes,
well let's see.

216
00:10:21,346 --> 00:10:24,156
We have an internal
research project

217
00:10:24,156 --> 00:10:27,106
on this wireless version I was
talking about and we're trying

218
00:10:27,106 --> 00:10:29,306
to find the funding to

build and fly those.

219

00:10:29,306 --> 00:10:31,926

There's a lot of interest
in flying them but we need

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00:10:31,926 --> 00:10:33,496

to build a few so
hopefully we will be able

221

00:10:33,496 --> 00:10:34,676

to get some funding to do that.

222

00:10:35,476 --> 00:10:40,086

>> But everything is now
set for this one to come

223

00:10:40,086 --> 00:10:41,306

down with the ATV tomorrow?

224

00:10:42,036 --> 00:10:42,726

>> Dr. Ailor: Yes, indeed.

225

00:10:42,726 --> 00:10:45,166

We're all set and I think
it will be a very nice --

226

00:10:45,166 --> 00:10:46,466

I believe it's Wednesday
night though.

227

00:10:46,926 --> 00:10:49,976

But yes, we are looking forward
to that particular re-entry