WEBVTT

1
00:00:01.075 --> 00:00:01.885
Welcome back.

2
00:00:01.985 --> 00:00:03.365
Uh, I hope you all had, uh,

3
00:00:03.365 --> 00:00:04.965
good conversations during the break.

4
00:00:05.265 --> 00:00:08.565
Uh, as many of us, uh, have, uh, similar backgrounds,

5
00:00:08.915 --> 00:00:10.725
it's fun to sometimes catch up

6
00:00:10.725 --> 00:00:12.125
with people you haven't seen for a while.

7
00:00:12.545 --> 00:00:15.285
And I ran into a test pilot school classmate of mine,

8
00:00:15.285 --> 00:00:18.245
Nick Bista, who, uh, Bob mentioned earlier

9
00:00:18.245 --> 00:00:20.845
that I played in a, uh, national chess tournament.

10
00:00:21.065 --> 00:00:22.885
Uh, Nick won that chess tournament.

11
00:00:23.065 --> 00:00:25.285
His team, his team did anyway,

12
00:00:25.285 --> 00:00:28.565
and we had no idea, uh, until, uh, until just now.

13
00:00:28.665 --> 00:00:30.205
So hopefully you guys had just

14
00:00:30.205 --> 00:00:32.045
as fruitful conversations during the break.

15
00:00:32.745 --> 00:00:34.445
Uh, 'cause it is a small community as a,

16
00:00:34.445 --> 00:00:35.565
it is a small world.

17
00:00:35.785 --> 00:00:39.725
Um, and that, uh, as one of my instructors once told me

18
00:00:39.725 --> 00:00:42.165
that, uh, big sky little airplane breaks down when

19
00:00:42.165 --> 00:00:43.325
you're all going to the same place.

20
00:00:43.385 --> 00:00:44.845
So it's not such a small world

21
00:00:44.845 --> 00:00:47.485
that we have our next presenter from the Boeing Company, uh,

22
00:00:47.665 --> 00:00:49.685
and Tom Esser is gonna be talking

23
00:00:49.685 --> 00:00:50.965
to us about Deterrent Buffet

24
00:00:51.105 --> 00:00:54.605
and quantifying that, uh, what that which can sometimes be,

25
00:00:54.945 --> 00:00:57.525
uh, a little bit of a subjective, uh, feature.

26
00:00:57.585 --> 00:01:00.045
Mm-Hmm. Tom started, uh, at Aerotech, uh,

27
00:01:00.045 --> 00:01:02.565

where he worked on the, uh, Mitsubishi Regional Jet

28
00:01:02.625 --> 00:01:04.205
and the, uh, MD 87.

29
00:01:04.705 --> 00:01:07.525
Uh, he's a private pilot working on his instrument rating

30
00:01:07.585 --> 00:01:09.605
as well, and he's joined us at the Boeing Company

31
00:01:09.625 --> 00:01:10.925
and the Stability and Control Group.

32
00:01:11.385 --> 00:01:15.565
Uh, his most proud achievement was probably,

33
00:01:15.565 --> 00:01:16.885
is most stressful as well.

34
00:01:16.905 --> 00:01:18.965
And that was the 7 37 return to service.

35
00:01:19.185 --> 00:01:21.605
So a lot of what you're gonna hear about, uh,

36
00:01:21.665 --> 00:01:24.085
you're gonna hear about that schedule piece, uh,

37
00:01:24.085 --> 00:01:25.165
coming to the forefront.

38
00:01:25.625 --> 00:01:28.565
Uh, you're gonna hear about, um, a lot of testing

39
00:01:28.565 --> 00:01:30.845
that we weren't quite, uh, expecting

40
00:01:31.025 --> 00:01:34.525
or, uh, in some cases a hundred percent prepared to do.

41
00:01:34.745 --> 00:01:37.885
Uh, but we'd, uh, we worked together as a team, uh,

42
00:01:38.105 --> 00:01:40.445
and, uh, worked together with our partners at the FAA

43
00:01:40.545 --> 00:01:43.125
as well who were as, uh, important to that program

44
00:01:43.305 --> 00:01:46.325
and to the safety of that program, uh, as we were.

45
00:01:46.625 --> 00:01:47.805
And, uh, we figured it out.

46
00:01:47.985 --> 00:01:50.565
So without further ado, Tom Messer.

47
00:01:58.195 --> 00:02:00.135
All right. Hello everyone.

48
00:02:00.275 --> 00:02:02.215
Uh, it's an incredible honor to be here.

49
00:02:02.395 --> 00:02:03.415
Uh, welcome to Seattle.

50
00:02:03.695 --> 00:02:04.815
I hope that you guys are enjoying it,

51
00:02:04.835 --> 00:02:06.655
and I hope to see you again in October

52
00:02:06.875 --> 00:02:08.535
for the SFT International Symposium.

53
00:02:08.795 --> 00:02:10.195
That's gonna be a lot of fun.

54
00:02:11.695 --> 00:02:12.875

So, uh, I guess I'll start

55
00:02:12.875 --> 00:02:15.635
with the bottom line up first, quantifying buffet.

56
00:02:16.135 --> 00:02:19.755
Uh, this is a, a cool, nifty mathematical algorithm

57
00:02:19.755 --> 00:02:23.475
that we've come up with that I wanna tell the story about

58
00:02:23.575 --> 00:02:25.955
how this really is indicative of a mindset

59
00:02:26.105 --> 00:02:28.035
that we have in flight test of

60
00:02:28.705 --> 00:02:31.015
constantly pushing the boundaries

61
00:02:31.195 --> 00:02:33.135
and improving how we are doing things.

62
00:02:33.775 --> 00:02:36.755
Uh, if we are able to simplify the analysis

63
00:02:37.705 --> 00:02:41.025
workload onboard, the crew has the ability to

64
00:02:41.575 --> 00:02:44.905
have more workload available for situational awareness

65
00:02:45.365 --> 00:02:48.505
and decision making, and that increases safety.

66
00:02:48.605 --> 00:02:52.485
So if we're able to take a lot of these lower level math and

67
00:02:52.665 --> 00:02:56.325
and algorithm work out of the engineer's brain, they're able

68
00:02:56.325 --> 00:02:58.525
to think a lot more about the entire test

69
00:02:58.705 --> 00:03:00.355
and how to keep us safe in the air.

70
00:03:02.195 --> 00:03:04.215
So let's get at it. Uh, everybody's favorite slide.

71
00:03:04.265 --> 00:03:05.575
We've got some copyright stuff.

72
00:03:07.465 --> 00:03:08.605
And, uh, Claude, I'll mention,

73
00:03:08.725 --> 00:03:10.645
I don't have the slides on the screen down here.

74
00:03:11.755 --> 00:03:13.775
So we'll start out with a little bit

75
00:03:13.775 --> 00:03:14.975
of a brief overview on Buffet.

76
00:03:15.085 --> 00:03:16.535
I'll level set everyone, we'll,

77
00:03:16.535 --> 00:03:18.015
we'll brief everyone on the terms that we're going

78
00:03:18.015 --> 00:03:21.415
to be discussing today, and then I'll get into why Buffet is

79
00:03:21.415 --> 00:03:22.855
important to us and some

80
00:03:22.855 --> 00:03:25.055
of the traditional method methods we've used for

81
00:03:25.615 --> 00:03:27.415

identifying it, uh, up until this point.

82
00:03:28.005 --> 00:03:29.225
And then I'll get into the fun part.

83
00:03:29.235 --> 00:03:30.905
We're gonna, we're gonna do some calculus today.

84
00:03:30.945 --> 00:03:33.225
I hope you guys are ready for that. And then I'll talk about

85
00:03:33.225 --> 00:03:35.105
some of the capabilities that this is unlocked for us,

86
00:03:35.125 --> 00:03:36.185
and we're really excited about those.

87
00:03:36.645 --> 00:03:40.795
So, what is Buffet airplane?

88
00:03:40.795 --> 00:03:44.515
Buffet is a vibration that you feel in the airframe

89
00:03:45.225 --> 00:03:48.355
that is primarily caused by airflow, the interaction

90
00:03:48.355 --> 00:03:49.875
between airflow and the airframe.

91
00:03:50.095 --> 00:03:53.395
Uh, if you feel vibration from a hi, like a hydraulic pump

92
00:03:53.815 --> 00:03:55.315
or gear reactions on the ground,

93
00:03:55.315 --> 00:03:56.515
that's not what we're talking about.

94
00:03:56.845 --> 00:03:59.075
We're talking specifically about vibration

95
00:03:59.075 --> 00:04:01.115
that is induced on the airframe from

96
00:04:01.115 --> 00:04:02.195
the airflow that is surrounding it.

97
00:04:03.735 --> 00:04:06.415
What is initial buffet? That is the first indication

98
00:04:06.435 --> 00:04:08.685
to a pilot that something

99
00:04:08.685 --> 00:04:10.005
you're, you're approaching a limit.

100
00:04:10.105 --> 00:04:11.965
You're, you're getting close to stall.

101
00:04:12.015 --> 00:04:13.125
Maybe you're overspeeding.

102
00:04:13.435 --> 00:04:16.765
It's that first cue to a pilot that maybe you shouldn't

103
00:04:17.325 --> 00:04:19.465
be continuing to do what you're doing in

104
00:04:19.545 --> 00:04:20.625
an operational sense anyway.

105
00:04:22.195 --> 00:04:24.475
And deterrent buffet is quite violent.

106
00:04:24.815 --> 00:04:27.555
Um, for those of us that that ride along on the,

107
00:04:27.555 --> 00:04:30.795
the transport category, airplanes, you're going in a lot

108
00:04:30.795 --> 00:04:32.675

of different directions at a lot

109
00:04:32.675 --> 00:04:34.475
of different frequencies, and it's very violent.

110
00:04:34.735 --> 00:04:36.835
Uh, you're unable to read your screens.

111
00:04:37.375 --> 00:04:39.435
Uh, and ideally that level

112
00:04:39.435 --> 00:04:42.715
of buffet is deterring any pilot from continuing

113
00:04:42.715 --> 00:04:43.915
to do what they're doing.

114
00:04:45.675 --> 00:04:47.875
Identifying initial and deter buffet is really important

115
00:04:47.875 --> 00:04:49.835
to us in flight tests for a number of different reasons.

116
00:04:50.585 --> 00:04:51.965
So why would we want to quantify it?

117
00:04:53.105 --> 00:04:56.325
We use initial buffet for a lot of design factors,

118
00:04:56.325 --> 00:04:59.665
including, uh, we have regulations that set

119
00:04:59.665 --> 00:05:02.345
where certain operational speeds need to be, um,

120
00:05:02.525 --> 00:05:03.825
in regards to initial buffet.

121
00:05:04.095 --> 00:05:05.945
Initial buffet helps us understand the maneuver

122
00:05:05.945 --> 00:05:07.185
margin of our aircraft.

123
00:05:07.845 --> 00:05:10.305
And there's a, a few other performance metrics in there

124
00:05:10.305 --> 00:05:13.425
that all are based on where you're identifying

125
00:05:13.425 --> 00:05:14.825
and placing that initial buffet point.

126
00:05:16.865 --> 00:05:18.395
Deterrent buffet is the endpoint

127
00:05:18.395 --> 00:05:19.595
for some of the highest risks.

128
00:05:19.985 --> 00:05:23.035
Risk maneuvers we do in flight tests, stalls, wind up turns,

129
00:05:23.465 --> 00:05:26.105
says right there in the test procedure, go

130
00:05:26.105 --> 00:05:27.505
until you hit deterrent buffet.

131
00:05:27.965 --> 00:05:30.135
And depending on the pilot you get,

132
00:05:30.445 --> 00:05:32.935
that could very drastically change

133
00:05:32.935 --> 00:05:34.055
the endpoint of the maneuver.

134
00:05:34.395 --> 00:05:35.415
Uh, as an engineer,

135
00:05:35.685 --> 00:05:37.655

that makes me a little bit nervous knowing that there's

136
00:05:37.655 --> 00:05:40.375
that much, uh, variability in there.

137
00:05:41.075 --> 00:05:44.055
And that's what we're trying to, to help with this process.

138
00:05:45.935 --> 00:05:47.875
So I know we have some of the, some regulators in the room,

139
00:05:47.875 --> 00:05:50.075
so let's talk about why this is important in that sense.

140
00:05:50.735 --> 00:05:53.355
25 2 0 1 D stall ID regulations

141
00:05:54.375 --> 00:05:57.480
deterrent buffet is an acceptable indication of, of stall.

142
00:05:57.625 --> 00:06:00.925
Uh, but one person's deterrent buffet could very well be

143
00:06:01.005 --> 00:06:02.085
a different person's deterrent.

144
00:06:02.085 --> 00:06:04.845
Buffet. I've been on flight test campaigns where we flew

145
00:06:05.075 --> 00:06:07.765
with five pilots, two in the seats and three in the back,

146
00:06:07.825 --> 00:06:09.085
and we swapped people out

147
00:06:09.305 --> 00:06:12.645
to understand if we were getting a consistent deterrent

148
00:06:12.645 --> 00:06:13.885
buffet determination or not.

149
00:06:14.195 --> 00:06:15.845
That was before we had this algorithm.

150
00:06:16.305 --> 00:06:18.205
Um, and maybe that would've come in handy.

151
00:06:19.065 --> 00:06:22.375
No one wants to take the risk that one person saying,

152
00:06:22.375 --> 00:06:24.975
deterrent buffet is your stall id, and then you go

153
00:06:24.975 --> 00:06:26.295
and have the regulators fly.

154
00:06:26.485 --> 00:06:30.575
Well, past that windup turns, uh,

155
00:06:30.575 --> 00:06:30.975
you'll notice

156
00:06:31.005 --> 00:06:32.575
deterrent buffet there at the end of the chart.

157
00:06:32.575 --> 00:06:35.175
Everybody's favorite stick force per g uh,

158
00:06:35.175 --> 00:06:36.735
chart from AC 25 7.

159
00:06:37.485 --> 00:06:40.535
Something I wanna point out though is this buffet onset,

160
00:06:40.535 --> 00:06:42.375
initial buffet, that line

161
00:06:42.395 --> 00:06:45.735
and where you locate that line can affect your pass fail

162
00:06:46.055 --> 00:06:47.535

criteria for that, for that maneuver.

163
00:06:47.795 --> 00:06:51.285
Uh, if your buffet onset is too early, uh,

164
00:06:51.985 --> 00:06:53.685
or sorry if your buffet onset is too late,

165
00:06:53.955 --> 00:06:55.965
then maybe you've had a stick force reversal

166
00:06:56.105 --> 00:06:58.205
and you need to think about improving your design.

167
00:06:59.135 --> 00:07:01.795
So where you locate initial buffet is very important

168
00:07:01.795 --> 00:07:02.955
from a regulatory standpoint.

169
00:07:05.015 --> 00:07:08.055
So have we done it up until this point for initial buffet?

170
00:07:08.585 --> 00:07:11.655
There is a, I would say a, a generally accepted, uh,

171
00:07:11.895 --> 00:07:13.255
standard of 0.1 G peak to peak.

172
00:07:13.875 --> 00:07:16.815
Uh, that's only looking in the normal vertical

173
00:07:16.995 --> 00:07:18.015
up and down direction.

174
00:07:18.715 --> 00:07:19.935
And it doesn't look at frequency

175
00:07:19.935 --> 00:07:21.015
content or anything like that.

176
00:07:21.015 --> 00:07:23.575
You're just looking at pilot seat accelerometer,

177
00:07:23.575 --> 00:07:24.935
trace 0.1 g, peak to peak.

178
00:07:25.125 --> 00:07:28.755
There's initial buffet deterrent.

179
00:07:28.755 --> 00:07:31.795
Buffet, as I mentioned, is very subjective and inconsistent.

180
00:07:32.135 --> 00:07:33.235
Um, some challenges

181
00:07:33.235 --> 00:07:36.635
that we have been encountering more recently, for example,

182
00:07:37.215 --> 00:07:38.835
is maybe you have a flight test program

183
00:07:39.185 --> 00:07:41.035
that spans for multiple years.

184
00:07:41.125 --> 00:07:44.835
Maybe you've done a stall a handful of years ago with, uh,

185
00:07:44.935 --> 00:07:48.155
one pilot, and now several years later you're with

186
00:07:48.155 --> 00:07:49.795
that same airplane doing a bunch of stalls

187
00:07:49.795 --> 00:07:50.875
with a different pilot.

188
00:07:51.415 --> 00:07:53.605
And that's a very inconsistent data set.

189
00:07:54.065 --> 00:07:57.565

Um, as an engineer, I, it would be much more satisfying

190
00:07:57.565 --> 00:07:59.565
to me to have something that is quantifiable

191
00:07:59.585 --> 00:08:01.685
and kind of putting that line in the sand.

192
00:08:01.905 --> 00:08:04.685
Um, we do, as I just showed at the regulations,

193
00:08:05.415 --> 00:08:06.915
the pilot has the final authority.

194
00:08:07.145 --> 00:08:09.155
This really is just providing context for us

195
00:08:09.155 --> 00:08:11.835
to have better conversations on board to think about

196
00:08:12.025 --> 00:08:14.715
what we're doing and if we're doing the right thing,

197
00:08:14.735 --> 00:08:17.145
and if we should continue to,

198
00:08:17.205 --> 00:08:18.225
to keep doing what we're doing.

199
00:08:19.585 --> 00:08:22.005
So the key takeaway here is that a more scientific,

200
00:08:22.535 --> 00:08:24.525
consistent and objective method

201
00:08:24.905 --> 00:08:27.445
for quantifying buffet would be helpful in this space.

202
00:08:28.845 --> 00:08:30.745
So how do we do that? Now, this is for the, the fun part.

203
00:08:31.205 --> 00:08:34.565
If we want to quantify buffet, we have

204
00:08:34.565 --> 00:08:36.205
to understand the humans, the human

205
00:08:36.225 --> 00:08:37.325
body's reaction to buffet.

206
00:08:37.625 --> 00:08:41.005
Uh, this is not A-A-U-A-V flying around un crude.

207
00:08:41.105 --> 00:08:44.225
Uh, there is a pilot in the loop and their opinion matters.

208
00:08:45.155 --> 00:08:48.295
And understanding how the human body reacts

209
00:08:48.295 --> 00:08:50.335
to vibrations is the key to this whole thing.

210
00:08:50.755 --> 00:08:53.655
So we'll go back to, uh, the eighties with turbo.

211
00:08:53.655 --> 00:08:54.695
Here I've got a slinky.

212
00:08:55.325 --> 00:08:57.505
And if you wanna think about the slinky, like your spine,

213
00:08:59.185 --> 00:09:00.365
you can shake it up and down,

214
00:09:01.255 --> 00:09:02.955
and we are sensitive

215
00:09:02.975 --> 00:09:05.635
to certain frequencies in the normal direction.

216
00:09:05.845 --> 00:09:09.525

Maybe this is 0.1 g peak to peak initial buffet. Cool.

217
00:09:10.205 --> 00:09:11.495
What happens if I start doing this?

218
00:09:11.995 --> 00:09:15.615
Oh, we've introduced an entirely separate axi axis here.

219
00:09:16.365 --> 00:09:19.385
And if you ever feel not too good when you're on an airplane

220
00:09:19.385 --> 00:09:21.425
shaking side to side, this is why our,

221
00:09:21.525 --> 00:09:23.625
our spines aren't set up very well for it.

222
00:09:24.385 --> 00:09:26.885
And our 0.1 g peak to peak

223
00:09:28.145 --> 00:09:29.605
is not considering that effect.

224
00:09:30.145 --> 00:09:32.325
So in addition to just the amplitude

225
00:09:32.325 --> 00:09:36.065
of the vibration in one axis, one axes, one axis, we need

226
00:09:36.065 --> 00:09:38.025
to also be considering the frequency content

227
00:09:39.125 --> 00:09:41.225
and the direction that that vibration is occurring.

228
00:09:42.855 --> 00:09:44.585
This chart is the bread and butter of the algorithm.

229
00:09:44.845 --> 00:09:48.585
Uh, this ISO study was done, uh, in the nineties by nasa.

230
00:09:49.465 --> 00:09:51.675
They put a whole bunch of people on shaker tables,

231
00:09:52.125 --> 00:09:55.485
shook them in various directions, different frequencies,

232
00:09:55.515 --> 00:09:56.765
different amplitudes.

233
00:09:57.575 --> 00:09:58.635
And these are their findings,

234
00:09:58.635 --> 00:09:59.955
which I think are pretty interesting.

235
00:10:00.095 --> 00:10:02.915
Uh, the curve on the left, the the blue solid line,

236
00:10:03.325 --> 00:10:04.395
those are the frequencies

237
00:10:04.425 --> 00:10:06.235
that the human body is more sensitive

238
00:10:06.235 --> 00:10:07.915
to in the lateral direction.

239
00:10:08.795 --> 00:10:11.175
The red dash line is the vertical up and down direction,

240
00:10:11.175 --> 00:10:13.055
and those are the frequencies that human body is more

241
00:10:13.815 --> 00:10:15.055
sensitive to in the vertical direction.

242
00:10:15.055 --> 00:10:16.335
You'll notice that they don't align

243
00:10:16.335 --> 00:10:17.775

with each other perfectly.

244
00:10:19.485 --> 00:10:20.945
We take these frequency weights

245
00:10:21.325 --> 00:10:22.705
and we pump them into our algorithm,

246
00:10:22.885 --> 00:10:25.425
and we account for this so that we know, oh,

247
00:10:25.845 --> 00:10:27.385
the pilot is being subjected

248
00:10:27.385 --> 00:10:29.065
to this buffet at this frequency.

249
00:10:29.455 --> 00:10:30.825
Well, we don't care about that frequency.

250
00:10:30.885 --> 00:10:32.425
It, it doesn't bother the human body that much.

251
00:10:32.425 --> 00:10:34.295
Well weigh it much lower. Oh,

252
00:10:34.475 --> 00:10:37.175
the pilot's getting shaken side to side at one hertz.

253
00:10:37.445 --> 00:10:39.655
Yeah, that's gonna be a high metric on the buffet scale

254
00:10:39.925 --> 00:10:40.935
that is not comfortable.

255
00:10:43.075 --> 00:10:44.495
So the key takeaway here is

256
00:10:44.495 --> 00:10:46.815
that we're sensitive in into different

257
00:10:46.815 --> 00:10:48.015
frequencies in different directions.

258
00:10:50.205 --> 00:10:51.665
So now time for some map.

259
00:10:52.945 --> 00:10:55.325
The way that we di that we distill this data down is

260
00:10:55.345 --> 00:10:58.045
by doing an FFT with a moving window.

261
00:10:58.385 --> 00:11:00.845
Uh, all you calculus people out there will know

262
00:11:00.875 --> 00:11:03.285
that is A DFT discreet for your transform.

263
00:11:04.305 --> 00:11:06.685
We move that window over our accelerometer data.

264
00:11:06.825 --> 00:11:08.885
Uh, typically that's a high sample rate, uh,

265
00:11:08.885 --> 00:11:11.325
maybe 200 hertz accelerometer that's, uh, attached

266
00:11:11.325 --> 00:11:14.085
to the seat track, uh, in the, the, the flight deck.

267
00:11:14.465 --> 00:11:17.135
And that moving window is

268
00:11:17.935 --> 00:11:20.135
sized based on the maneuvers that we are doing.

269
00:11:21.395 --> 00:11:23.615
So now I have a, a fun little walk around chart here.

270
00:11:24.125 --> 00:11:27.415

This chart in the top left is, uh, a zoomed in view

271
00:11:27.415 --> 00:11:29.855
of the data I had in our window from the previous slide.

272
00:11:31.075 --> 00:11:33.345
After we do our discrete four year transform, you end up

273
00:11:33.345 --> 00:11:35.185
with the red dash line there.

274
00:11:35.725 --> 00:11:38.305
Uh, what I would point out is that a lot

275
00:11:38.305 --> 00:11:39.585
of our rigid body dynamics

276
00:11:39.585 --> 00:11:42.705
and the lower frequencies there, uh, kind of below one hert,

277
00:11:43.335 --> 00:11:44.605
those are all, uh,

278
00:11:44.815 --> 00:11:47.445
after you apply the weighting, those are all squashed down.

279
00:11:47.865 --> 00:11:49.685
The black line is the results of all

280
00:11:49.685 --> 00:11:51.845
of the frequency weighting that we do from that ISO study.

281
00:11:52.145 --> 00:11:54.760
So rigid body body dynamics, we're not concerned with that.

282
00:11:54.925 --> 00:11:56.625
The, the pilot is not sensitive

283
00:11:56.625 --> 00:11:58.025
to those or queuing off of those.

284
00:11:58.525 --> 00:11:59.705
But you may notice that some

285
00:11:59.705 --> 00:12:01.465
of those intermediate frequencies between one

286
00:12:01.465 --> 00:12:03.405
and 10 hertz, there are some peaks

287
00:12:03.405 --> 00:12:05.085
that are accentuated after the waiting.

288
00:12:05.265 --> 00:12:08.125
And there are some peaks that are kind of, uh,

289
00:12:08.125 --> 00:12:09.525
damped down after the waiting.

290
00:12:10.075 --> 00:12:12.735
And this is the, like I said, kind of the bread

291
00:12:12.735 --> 00:12:14.455
and butter of how we're understanding

292
00:12:15.165 --> 00:12:17.295
the human in this environment.

293
00:12:18.755 --> 00:12:20.055
But a frequency chart isn't very

294
00:12:20.055 --> 00:12:21.215
helpful to someone in flight test.

295
00:12:21.475 --> 00:12:23.775
So you have to do an inverse DFT

296
00:12:23.775 --> 00:12:25.095
to get it back into the time domain.

297
00:12:25.805 --> 00:12:27.225

And after we do all of that,

298
00:12:27.285 --> 00:12:29.305
we have a very nice buffet metric

299
00:12:29.305 --> 00:12:30.705
that we're tracking on condition.

300
00:12:32.135 --> 00:12:33.155
And this is what that would look like.

301
00:12:33.215 --> 00:12:34.595
So this is a time history

302
00:12:34.815 --> 00:12:38.185
of a frequency weighted vertical acceleration, uh,

303
00:12:38.685 --> 00:12:39.865
metric buffet metric.

304
00:12:40.205 --> 00:12:42.745
Uh, during maybe a, a stall maneuver,

305
00:12:42.885 --> 00:12:44.425
you start at a low buffet level

306
00:12:44.845 --> 00:12:48.065
and as you increase time into the maneuver, you notice

307
00:12:48.065 --> 00:12:49.145
that the buffet level is rising.

308
00:12:50.755 --> 00:12:54.665
Maybe you can plot, take this and plot vertical acceleration

309
00:12:54.665 --> 00:12:56.385
and lateral acceleration in the same plot.

310
00:12:56.565 --> 00:12:59.625
Now you have kind of this overall view of, of

311
00:12:59.645 --> 00:13:01.985
how the pilot is getting shaken around up there.

312
00:13:02.205 --> 00:13:04.745
And the higher number you see, the more uncomfortable it is.

313
00:13:05.935 --> 00:13:08.395
So that's kind of our, our sandbox, if you will.

314
00:13:08.415 --> 00:13:10.915
We figured out a way to quantify buffet,

315
00:13:11.575 --> 00:13:14.205
but it's still not very useful for us yet if,

316
00:13:14.265 --> 00:13:15.285
if we fly a stall

317
00:13:15.425 --> 00:13:18.525
and on the buffet meter I see a 0.8, like, great,

318
00:13:18.545 --> 00:13:19.805
that's not very helpful to me.

319
00:13:20.265 --> 00:13:23.085
You need training data. And boy do we

320
00:13:23.085 --> 00:13:24.165
have a lot of training data.

321
00:13:24.785 --> 00:13:27.425
We pumped, uh, a lot

322
00:13:27.425 --> 00:13:30.225
of data from several previous Boeing programs,

323
00:13:30.805 --> 00:13:33.425
big commercial tube and wing airplane programs.

324
00:13:34.475 --> 00:13:36.985

Every single time we flew a stall on those programs,

325
00:13:36.985 --> 00:13:39.385
we wrote down the time at which the pilot called

326
00:13:39.385 --> 00:13:40.465
Initial and deterrent buffet.

327
00:13:41.405 --> 00:13:43.985
We pumped those times into our algorithm

328
00:13:44.245 --> 00:13:46.185
and developed a set of envelopes

329
00:13:46.535 --> 00:13:49.865
that help us determine if we are experiencing a low buffet

330
00:13:49.865 --> 00:13:53.185
level, if we are experiencing an initial buffet level

331
00:13:53.245 --> 00:13:55.065
or if we're experiencing a deterrent buffet level.

332
00:13:56.325 --> 00:13:58.825
So the combination of our buffet quantification

333
00:13:59.375 --> 00:14:01.585
with this robust set of data

334
00:14:01.585 --> 00:14:04.145
that we've collected over a number of years, uh,

335
00:14:04.235 --> 00:14:06.345
helps us understand the airplanes

336
00:14:06.655 --> 00:14:08.435
and continue to understand the future

337
00:14:08.435 --> 00:14:09.515
products that we'll be testing.

338
00:14:09.975 --> 00:14:14.345
So how would that look if you're looking at this chart

339
00:14:14.345 --> 00:14:16.805
during a stall start out

340
00:14:16.805 --> 00:14:18.965
and trim, we're right there near the origin,

341
00:14:19.945 --> 00:14:22.185
very low buffet level.

342
00:14:24.125 --> 00:14:26.025
As the pilot decelerates begins

343
00:14:26.025 --> 00:14:27.505
to pull up, we hit initial buffet.

344
00:14:27.845 --> 00:14:29.665
So you can see that we've now crossed into

345
00:14:29.665 --> 00:14:31.545
that initial buffet region there.

346
00:14:34.315 --> 00:14:36.175
As the pilot continues to increase a OA,

347
00:14:36.175 --> 00:14:37.935
the buffet level increases, and that's shown.

348
00:14:40.125 --> 00:14:41.985
And then we hit stall ID deterrent buffet,

349
00:14:42.195 --> 00:14:43.345
looks like we hit, uh,

350
00:14:43.365 --> 00:14:45.385
or we got a very big lateral hit there.

351
00:14:48.415 --> 00:14:52.515

How are we using this? This has been used on a few previous

352
00:14:52.555 --> 00:14:53.755
programs, uh,

353
00:14:54.015 --> 00:14:56.555
but it was only initially, it only initially started out

354
00:14:56.555 --> 00:14:58.115
as a post-flight data thing.

355
00:14:58.415 --> 00:15:00.875
Um, and it was still, it had a a lot of value.

356
00:15:01.085 --> 00:15:02.475
We're able to take this algorithm

357
00:15:03.015 --> 00:15:04.675
and take all of the windup turns.

358
00:15:04.675 --> 00:15:06.035
We've flown over the course of a program

359
00:15:06.055 --> 00:15:08.715
and our cert report, we can pump them through that algorithm

360
00:15:09.255 --> 00:15:12.595
and we get our AC 25 70 stick force per g chart

361
00:15:12.825 --> 00:15:14.115
with our initial buffet line.

362
00:15:14.375 --> 00:15:17.315
So an engineer can very quickly assess a plot

363
00:15:17.615 --> 00:15:20.355
and say, okay, these are compliant characteristics.

364
00:15:20.495 --> 00:15:24.185
I'm happy with this, or we need to go and something.

365
00:15:25.305 --> 00:15:27.485
Uh, one of the cool, uh, benefits

366
00:15:27.485 --> 00:15:29.445
that we've seen more recently is ride quality.

367
00:15:29.905 --> 00:15:31.925
Uh, it's out of the scope of this presentation,

368
00:15:32.685 --> 00:15:36.185
but we also have a method for quantifying turbulence.

369
00:15:36.875 --> 00:15:38.615
You can compare your turbulence metric

370
00:15:38.615 --> 00:15:41.015
and your buffet metric to understand ride quality.

371
00:15:41.305 --> 00:15:42.815
Maybe turbulence is really high,

372
00:15:43.005 --> 00:15:44.335
have a really high turbulence score,

373
00:15:44.715 --> 00:15:46.335
but our buffet score is really low.

374
00:15:46.835 --> 00:15:49.505
So that must mean that the stiffness of the aircraft,

375
00:15:49.685 --> 00:15:51.065
our modal suppression software,

376
00:15:51.325 --> 00:15:53.905
the overall overall ride quality is,

377
00:15:54.085 --> 00:15:55.545
is good in that condition.

378
00:15:55.765 --> 00:15:57.225

You could also imagine the opposite.

379
00:15:57.235 --> 00:16:00.265
Maybe turbulence isn't very high, but our buffet levels

380
00:16:00.365 --> 00:16:02.185
and our uncomfortability rating is high.

381
00:16:02.835 --> 00:16:05.255
So maybe that's a, there's room for improvement there.

382
00:16:05.925 --> 00:16:09.105
And in the this new big data space that we're in,

383
00:16:09.105 --> 00:16:10.905
now you can pump all of the data

384
00:16:10.905 --> 00:16:12.585
that we're gathering on all these flights

385
00:16:12.585 --> 00:16:15.545
through this metric and, you know, set a comparison.

386
00:16:15.735 --> 00:16:19.185
Show me all the times where Buffett was really high

387
00:16:19.445 --> 00:16:20.735
and turbulence is really high,

388
00:16:20.915 --> 00:16:23.145
and find your design space

389
00:16:23.145 --> 00:16:24.305
for the problems you're trying to fix.

390
00:16:24.805 --> 00:16:28.575
We saw a lot of benefits

391
00:16:28.725 --> 00:16:32.635
with this in our post data analysis world, which led

392
00:16:32.635 --> 00:16:34.715
to us wondering if we could do the same thing on board.

393
00:16:34.935 --> 00:16:36.755
Uh, it's a little tough with, uh,

394
00:16:37.015 --> 00:16:38.715
the four year transforms that we're doing.

395
00:16:38.715 --> 00:16:41.155
There is a little bit of a lag incurred just from the,

396
00:16:41.175 --> 00:16:43.995
the processing, but it's less than a second,

397
00:16:43.995 --> 00:16:45.435
maybe on the order of half a second

398
00:16:45.535 --> 00:16:46.955
behind when you're actually

399
00:16:46.955 --> 00:16:48.125
experiencing those buffet levels.

400
00:16:48.505 --> 00:16:51.045
So we created the tool for onboard buffet,

401
00:16:51.045 --> 00:16:54.985
ident buffet identification to this thing's pretty nifty.

402
00:16:55.045 --> 00:16:56.385
Uh, it allows the FTE

403
00:16:56.385 --> 00:16:58.105
to monitor the buffet environment in real

404
00:16:58.105 --> 00:16:59.145
time on the aircraft.

405
00:17:01.505 --> 00:17:02.685

Here's the live data tab.

406
00:17:02.795 --> 00:17:04.725
This is mostly for situational awareness

407
00:17:05.065 --> 00:17:07.285
and, uh, running the tool, the

408
00:17:07.945 --> 00:17:09.315
operation of the tool is pretty easy.

409
00:17:09.335 --> 00:17:10.875
You hit trim at the beginning of the maneuver,

410
00:17:11.025 --> 00:17:12.395
calculate during the recovery.

411
00:17:12.855 --> 00:17:15.155
The math happens so quickly that you have the answer

412
00:17:15.155 --> 00:17:16.355
before you've even recovered

413
00:17:16.355 --> 00:17:17.995
from whatever test maneuver you're doing.

414
00:17:19.015 --> 00:17:21.035
Uh, a future improvement that I'm really looking forward

415
00:17:21.035 --> 00:17:23.595
to when I have the time is to automate all of this so

416
00:17:23.595 --> 00:17:25.275
that it's automatically picking out trims.

417
00:17:25.275 --> 00:17:27.155
It's automatically detecting, oh, you just stall

418
00:17:27.535 --> 00:17:28.835
and you have that answer again

419
00:17:28.935 --> 00:17:31.045
before you've even finished covering from your maneuver.

420
00:17:33.235 --> 00:17:34.405
This is the results tab,

421
00:17:34.625 --> 00:17:36.525
and this is what I like to refer to

422
00:17:36.585 --> 00:17:40.005
as we're turning raw data into actionable information

423
00:17:40.595 --> 00:17:42.205
that the engineer can use

424
00:17:42.465 --> 00:17:44.205
to increase their situational awareness,

425
00:17:44.695 --> 00:17:46.005
understand the test better,

426
00:17:46.385 --> 00:17:50.095
and inform their decision making to improve efficiency

427
00:17:50.095 --> 00:17:51.855
and safety over the course of a test day

428
00:17:51.875 --> 00:17:52.915
and over a test program,

429
00:17:54.095 --> 00:17:55.875
you recognize the big chart in the middle

430
00:17:56.415 --> 00:17:57.715
is our quantified buffet.

431
00:17:57.935 --> 00:18:00.315
You have vertical and lateral accelerations there,

432
00:18:00.415 --> 00:18:04.785

and our red and uh, yellow buffet cur or buffet envelopes.

433
00:18:04.975 --> 00:18:08.785
This looks like it was a, a stall where they had a lot of,

434
00:18:09.005 --> 00:18:11.705
uh, frequency content down there at the,

435
00:18:11.885 --> 00:18:12.945
the lower alpha region.

436
00:18:13.165 --> 00:18:14.985
And then as they got towards stall, they kind

437
00:18:14.985 --> 00:18:16.665
of hung out at one vertical load

438
00:18:16.665 --> 00:18:18.785
and looks like they were getting good lateral side

439
00:18:18.785 --> 00:18:19.865
to side at that time

440
00:18:20.125 --> 00:18:21.645
and that there was one lateral kick

441
00:18:21.645 --> 00:18:23.165
that pushed them into the deterrent buffet region.

442
00:18:23.305 --> 00:18:25.615
And we have some other tools in here that helped

443
00:18:25.615 --> 00:18:26.655
with situational awareness

444
00:18:26.755 --> 00:18:29.515
and again, helped the engineer understand the test.

445
00:18:31.815 --> 00:18:33.435
So how's this helping us? One, one

446
00:18:33.435 --> 00:18:35.915
of my favorite features from this tool is the event markers.

447
00:18:36.585 --> 00:18:39.525
As I said, uh, previously, this tool runs all the math

448
00:18:39.545 --> 00:18:40.685
for you and gives you an answer

449
00:18:40.685 --> 00:18:42.885
before the maneuver is even finished.

450
00:18:43.465 --> 00:18:46.725
So you have way more time after the maneuver and

451
00:18:46.725 --> 00:18:48.525
after you're done getting comments to think about

452
00:18:48.725 --> 00:18:50.645
how it went to think about if you need

453
00:18:50.645 --> 00:18:52.205
to adjust test techniques

454
00:18:52.305 --> 00:18:54.765
or is this a characteristic of the airplane?

455
00:18:55.665 --> 00:18:59.165
Uh, and having that line on the aircraft really saves us,

456
00:18:59.465 --> 00:19:00.925
uh, in a test efficiency sense

457
00:19:00.925 --> 00:19:04.005
because we're no longer collecting data landing the next

458
00:19:04.025 --> 00:19:06.685
day, doing some analysis, then making decisions

459
00:19:06.685 --> 00:19:08.605

to possibly go and launch another flight.

460
00:19:08.975 --> 00:19:10.245
We're now doing all of this live

461
00:19:10.245 --> 00:19:11.365
on the aircraft in real time.

462
00:19:12.625 --> 00:19:14.665
We also have the ability to remove background noise,

463
00:19:14.665 --> 00:19:15.825
which you can kind of think of

464
00:19:15.965 --> 00:19:17.905
as noise canceling on your headphones.

465
00:19:18.545 --> 00:19:21.555
Initial buffet is often described as uh,

466
00:19:21.745 --> 00:19:24.595
that buffet indication above the baseline,

467
00:19:25.455 --> 00:19:26.555
but the baseline is changing.

468
00:19:26.575 --> 00:19:29.435
If you're in a clean, you know, your flaps are up,

469
00:19:29.435 --> 00:19:31.555
your gear is up, you're not in any turbulent air,

470
00:19:31.945 --> 00:19:33.475
your baseline can be pretty smooth.

471
00:19:33.575 --> 00:19:35.475
And so any little buffet you feel on top of

472
00:19:35.475 --> 00:19:36.675
that is going to be noticeable.

473
00:19:37.535 --> 00:19:40.595
But if you're trimmed at flap sporty gear down,

474
00:19:41.025 --> 00:19:44.315
there's going to be a buffet environment there by default.

475
00:19:45.105 --> 00:19:47.755
This remove background noise function considers

476
00:19:47.955 --> 00:19:51.355
that background noise and shows you when your buffet level

477
00:19:51.415 --> 00:19:54.595
has reached an initial, an initial buffet quantity above

478
00:19:54.625 --> 00:19:55.915
what that background noise is.

479
00:19:56.305 --> 00:19:58.645
So that's why you see those two events there on the bottom

480
00:19:58.645 --> 00:20:00.365
chart, initial buffet, and then the tear

481
00:20:00.875 --> 00:20:02.805
from the re removing of the background noise.

482
00:20:04.145 --> 00:20:07.575
I also love using this tool during stalls.

483
00:20:07.575 --> 00:20:10.375
Again, we get the event markers, uh, again,

484
00:20:10.515 --> 00:20:12.775
during the recovery I'm able to assess, oh,

485
00:20:12.835 --> 00:20:14.775
it looks like the pilot only held full left

486
00:20:14.775 --> 00:20:16.175

column for one second there.

487
00:20:16.735 --> 00:20:20.215
I wonder why. I wonder what compelled them to not go

488
00:20:20.215 --> 00:20:21.375
to full stall ID there.

489
00:20:21.925 --> 00:20:24.105
And then Toby pops up this deterrent buffet line right

490
00:20:24.105 --> 00:20:25.625
where the column, uh, force

491
00:20:25.845 --> 00:20:28.185
or the column position starts to turn.

492
00:20:28.905 --> 00:20:30.565
Oh, well maybe that's an indicator to me

493
00:20:30.795 --> 00:20:32.165
that the pilot was deterred

494
00:20:32.385 --> 00:20:33.565
and they didn't want to go any further.

495
00:20:34.185 --> 00:20:36.445
So now I already know that I can talk to them about

496
00:20:36.445 --> 00:20:37.685
that when we're collecting comments.

497
00:20:38.115 --> 00:20:40.335
And it makes those discussions so much more fruitful

498
00:20:40.335 --> 00:20:42.255
and productive and it helps 'em along

499
00:20:42.435 --> 00:20:43.975
so it helps 'em along quicker so

500
00:20:43.975 --> 00:20:46.175
that we can get more done in one test day.

501
00:20:48.505 --> 00:20:49.885
Uh, a very important part of this

502
00:20:49.885 --> 00:20:51.525
that I wanna touch on is we're not trying

503
00:20:51.545 --> 00:20:53.365
to replace a a pilot here.

504
00:20:53.385 --> 00:20:55.245
The pilot determination is very important from

505
00:20:55.245 --> 00:20:56.325
a regulatory standpoint.

506
00:20:57.205 --> 00:20:58.905
So really all of this is situational awareness

507
00:20:58.905 --> 00:21:01.265
for us in the back and to help inform our conversations.

508
00:21:01.995 --> 00:21:04.205
This tool has the ability to compare the time

509
00:21:04.205 --> 00:21:05.725
that Toby picked initial

510
00:21:05.725 --> 00:21:08.125
and deterrent buffet with the time that the pilot picked.

511
00:21:08.465 --> 00:21:09.765
So we can understand, okay,

512
00:21:09.765 --> 00:21:12.485
maybe the vibration environment on this model

513
00:21:12.485 --> 00:21:14.565

of airplane is a little bit different from previously

514
00:21:14.565 --> 00:21:15.885
and we can kind of tune our model

515
00:21:16.305 --> 00:21:18.965
to better predict when we are hitting deterrent Buffett.

516
00:21:19.805 --> 00:21:21.145
And another thing that I really like is

517
00:21:21.145 --> 00:21:22.185
the automatic notification.

518
00:21:22.305 --> 00:21:24.825
I can have all of my screens up for data monitoring

519
00:21:24.925 --> 00:21:25.945
during a stall

520
00:21:26.325 --> 00:21:28.345
and I can kind of have Toby behind all of that.

521
00:21:28.805 --> 00:21:31.065
And because it turns Amber when we're in deterrent buffet,

522
00:21:31.665 --> 00:21:33.465
I can just kind of include that in my scan

523
00:21:33.805 --> 00:21:36.945
and know that okay, now Toby is saying

524
00:21:36.945 --> 00:21:37.945
that we're in deterrent buffet.

525
00:21:38.595 --> 00:21:39.765
Sometimes it's hard to tell

526
00:21:39.765 --> 00:21:40.845
when you're shaking around that much.

527
00:21:43.315 --> 00:21:47.895
So in conclusion, uh, those ISO standard, uh, Buffett,

528
00:21:47.995 --> 00:21:51.665
or sorry, those ISO standards really helped us come up

529
00:21:51.665 --> 00:21:53.025
with a way to quantify buffet

530
00:21:53.045 --> 00:21:54.465
and I'm pretty excited about it.

531
00:21:54.645 --> 00:21:56.905
Uh, when you combine that with the robust set

532
00:21:56.905 --> 00:22:00.345
of training data from all of the pilot's, opinions from all

533
00:22:00.345 --> 00:22:02.425
of the stalls and wind up turns that we've done

534
00:22:03.055 --> 00:22:06.015
over a number of decades, we have a pretty robust tool

535
00:22:06.015 --> 00:22:09.775
that has been very helpful in having scientific objective

536
00:22:10.155 --> 00:22:11.335
and a consistent standard

537
00:22:11.755 --> 00:22:13.335
for analyzing and quantifying buffet.

538
00:22:14.165 --> 00:22:15.305
We have seen improvements in

539
00:22:15.305 --> 00:22:16.585
onboard workflow because of this.

540
00:22:16.925 --> 00:22:20.265

And our post data processing is way easier because of this.

541
00:22:20.265 --> 00:22:21.425
Like I said, you can hit a button

542
00:22:21.525 --> 00:22:23.745
and it gives you all of your charts with that line on there.

543
00:22:24.045 --> 00:22:25.345
So you're no longer spending a bunch

544
00:22:25.345 --> 00:22:27.105
of time fighting a plotting program.

545
00:22:27.725 --> 00:22:29.625
Now you're thinking about the results

546
00:22:29.805 --> 00:22:31.065
and you're thinking about the airplane

547
00:22:31.085 --> 00:22:32.385
and you're thinking about is it safe?

548
00:22:33.585 --> 00:22:34.645
And the key takeaway here,

549
00:22:34.825 --> 00:22:37.005
and the thing that I'm the most excited to share today

550
00:22:37.625 --> 00:22:41.005
is this is just one small nifty thing,

551
00:22:41.875 --> 00:22:43.775
but I think it's really indicative of a culture

552
00:22:43.775 --> 00:22:44.975
that we're trying to foster

553
00:22:46.255 --> 00:22:47.825
that is looking towards the future.

554
00:22:48.765 --> 00:22:51.665
How can we make the engineer's workload

555
00:22:51.665 --> 00:22:52.905
during a flight test easier?

556
00:22:52.905 --> 00:22:54.185
Whether they're on the airplane,

557
00:22:54.185 --> 00:22:56.625
whether they're in a control room, it doesn't matter.

558
00:22:57.145 --> 00:22:59.775
How can we make it easier? We don't wanna be spending time

559
00:22:59.825 --> 00:23:03.755
doing math in a spreadsheet, whatever computers can do that.

560
00:23:04.895 --> 00:23:07.395
The computers can't make good decisions on board,

561
00:23:07.455 --> 00:23:11.745
the computers can't be situationally aware, but we can.

562
00:23:12.005 --> 00:23:14.745
And so if we put in a bunch of work on the ground

563
00:23:14.845 --> 00:23:17.345
to build these tools up to increase our capability,

564
00:23:17.715 --> 00:23:19.825
we're just freeing our brain space up on the airplane

565
00:23:19.885 --> 00:23:20.905
and I'm really excited about that.

566
00:23:22.715 --> 00:23:23.715
All right, and that's it.

567
00:23:39.135 --> 00:23:41.955

So where I can see where this would really help safety is

568
00:23:42.435 --> 00:23:44.915
possibly using this as a knock it off call

569
00:23:45.055 --> 00:23:47.315
so they don't go too deep into deterrent Buffett.

570
00:23:48.115 --> 00:23:49.655
Uh, have you thought about that?

571
00:23:49.755 --> 00:23:52.095
Or, you know, putting a light on the,

572
00:23:52.715 --> 00:23:55.555
on the cockpit somewhere that they go, okay,

573
00:23:55.665 --> 00:23:58.635
that the computer says they think it's deterrent Buffett and

574
00:23:58.815 --> 00:23:59.815
We have considered it.

575
00:24:00.385 --> 00:24:04.335
Um, I like numbers.

576
00:24:04.995 --> 00:24:06.255
And so usually for me,

577
00:24:06.615 --> 00:24:09.295
a OA is the go-to knock it off for a stall.

578
00:24:09.965 --> 00:24:13.335
Um, we're hesitant to use this as an indication to the pilot

579
00:24:13.365 --> 00:24:15.135
that they should stop doing anything

580
00:24:15.135 --> 00:24:16.895
because again, we do trust the pilot

581
00:24:16.955 --> 00:24:18.575
as the final authority on

582
00:24:18.575 --> 00:24:20.695
that situation up in the point OHS of the airplane.

583
00:24:21.395 --> 00:24:24.755
Um, but if we are doing a number of stalls

584
00:24:24.755 --> 00:24:27.235
and we see that we're pulling way further than

585
00:24:27.235 --> 00:24:29.235
what the tool is saying, that's a conversation

586
00:24:29.235 --> 00:24:30.835
that we can have on board to see if we need to be

587
00:24:42.465 --> 00:24:43.465
Excellent presentation. Tom,

588
00:24:43.465 --> 00:24:46.995
thanks. Would love to have had this tool over the years

589
00:24:47.055 --> 00:24:48.275
of, uh, my job.

590
00:24:49.595 --> 00:24:52.875
I can tell you that early on in my career, deterrent Buffett

591
00:24:54.255 --> 00:24:56.955
was a hell of a lot higher than

592
00:24:56.955 --> 00:24:58.475
what we say is deterrent Buffett.

593
00:24:58.475 --> 00:25:01.175
Now, if you weren't being picked up out of the seat

594
00:25:01.315 --> 00:25:04.215

and dropped on your butt, it wasn't deterrent.

595
00:25:05.345 --> 00:25:06.805
And, uh, we all know

596
00:25:06.825 --> 00:25:08.085
and have discovered over time

597
00:25:08.115 --> 00:25:11.485
that NY is far more significant than NZ with respect to

598
00:25:11.485 --> 00:25:14.075
that detection and deter.

599
00:25:14.535 --> 00:25:16.155
I'm far deterred by him. Why?

600
00:25:16.415 --> 00:25:18.875
And it, uh, 'cause the airplane is doing a whole lot

601
00:25:18.875 --> 00:25:20.235
of stuff structurally behind you

602
00:25:20.865 --> 00:25:24.005
and you need to know what's going on back in

603
00:25:24.005 --> 00:25:26.085
that tail section, that 41 section.

604
00:25:26.225 --> 00:25:29.545
It is, uh, that's where the damage is. Yeah,

605
00:25:29.845 --> 00:25:30.765
Definitely agree. Yeah.

606
00:25:30.865 --> 00:25:32.385
Thank you Tom. Yeah, Thanks Jerry.

607
00:25:35.555 --> 00:25:38.215
All right. Bob Stoney, FAA retired.

608
00:25:41.425 --> 00:25:43.415
We've been talking about this for a long time

609
00:25:43.415 --> 00:25:46.335
and I I was glad that you, uh, you know, stated

610
00:25:46.365 --> 00:25:48.015
that you're gonna depend on the pilot.

611
00:25:48.355 --> 00:25:50.535
You know, I think that's an important thing

612
00:25:50.535 --> 00:25:51.895
to continually emphasize.

613
00:25:52.015 --> 00:25:53.775
'cause that's the first thing I think about is you're gonna

614
00:25:53.805 --> 00:25:56.375
replace me as, you know, with a auto pull

615
00:25:57.155 --> 00:25:58.335
and you won't need me anymore.

616
00:25:58.515 --> 00:26:00.375
And which is okay for me.

617
00:26:00.435 --> 00:26:02.335
I'm retired, but some of the younger guys might not.

618
00:26:03.035 --> 00:26:06.335
So, um, as this is a great presentation, um,

619
00:26:07.365 --> 00:26:09.745
as you think about the future, uh, you know,

620
00:26:09.745 --> 00:26:11.465
future Boeing designs might be a little

621
00:26:11.465 --> 00:26:12.625

different looking than they are now.

622
00:26:12.685 --> 00:26:15.185
You know, you've got concepts that are different

623
00:26:15.685 --> 00:26:18.385
and of course for other part 25 manufacturers

624
00:26:18.385 --> 00:26:20.945
that have different looking airplanes, smaller, more dense,

625
00:26:21.205 --> 00:26:23.635
uh, composite ver I don't know.

626
00:26:23.635 --> 00:26:26.875
But have you considered how to generalize this?

627
00:26:27.235 --> 00:26:29.115
'cause the, I'm thinking of other sources

628
00:26:29.175 --> 00:26:31.195
of vibration, you know, just sitting here.

629
00:26:31.615 --> 00:26:35.175
Um, a glare shield might dance, you know,

630
00:26:35.175 --> 00:26:37.495
with the hula girl on top, whereas the seat's not,

631
00:26:37.595 --> 00:26:40.695
or perhaps even the control system might have some.

632
00:26:41.395 --> 00:26:44.085
How do you, are you thinking about how to generalize it

633
00:26:44.085 --> 00:26:46.725
or is it just kind of at this point Boeing focused?

634
00:26:47.255 --> 00:26:48.645
Thank you. That's a really good question.

635
00:26:48.645 --> 00:26:50.685
Something that I've been thinking about a bit lately.

636
00:26:52.035 --> 00:26:56.215
The way that it's set up right now really capitalizes on the

637
00:26:58.045 --> 00:26:59.855
very consistent design trend of a lot

638
00:26:59.855 --> 00:27:01.175
of larger Boeing aircraft.

639
00:27:01.815 --> 00:27:03.465
I think that you're definitely right on

640
00:27:03.695 --> 00:27:06.825
that the buffet environment is going to change when you're

641
00:27:07.555 --> 00:27:09.855
flying a very differently shaped airplane.

642
00:27:11.195 --> 00:27:13.275
I don't, I'm curious to see if, if the data

643
00:27:13.275 --> 00:27:15.875
that we have would be, I'm curious to see

644
00:27:15.895 --> 00:27:18.355
how relevant the data set now that we have would be.

645
00:27:19.185 --> 00:27:20.985
I I think that I wouldn't want to just go

646
00:27:20.985 --> 00:27:22.265
and fly a stall on a new plane

647
00:27:23.095 --> 00:27:27.635
and expect this Deterrent buffet event

648
00:27:27.815 --> 00:27:30.525

to line up with what a pilot is saying.

649
00:27:30.765 --> 00:27:32.205
I, I think that we would need to fly,

650
00:27:32.585 --> 00:27:34.525
get our training data on that new airframe

651
00:27:34.835 --> 00:27:36.015
before we plugged it into this

652
00:27:40.005 --> 00:27:41.005
Tool. A

653
00:27:41.005 --> 00:27:44.765
question, uh, Tom Emrick retired, um, in a lot

654
00:27:44.765 --> 00:27:46.605
of your data points up there, I'm sure.

655
00:27:47.465 --> 00:27:51.005
Um, the question is how does it, how do the operators,

656
00:27:51.025 --> 00:27:53.125
how do they, do you think they're gonna respond to this?

657
00:27:53.125 --> 00:27:56.135
Because Deterrent Buffet to a pilot

658
00:27:56.155 --> 00:27:58.335
that's flown 300 night traps in a horn,

659
00:27:58.335 --> 00:28:00.575
it's very different than a young lady flying a colgan

660
00:28:01.125 --> 00:28:04.455
dash eight whose recovery from a stall is the slow down on

661
00:28:04.455 --> 00:28:06.935
your track flaps 'cause it's a tail plane stall.

662
00:28:07.685 --> 00:28:10.585
So the question is, what's Alex Serini think about this at

663
00:28:10.585 --> 00:28:14.285
Qantas or David Hathaway at WestJet or any of the people

664
00:28:14.305 --> 00:28:17.045
and the operators because there's such a wide range

665
00:28:17.065 --> 00:28:18.365
of pilot experience.

666
00:28:18.905 --> 00:28:21.485
Uh, how is this gonna correlate operationally to the fleet?

667
00:28:21.535 --> 00:28:22.645
Thank you. Yeah,

668
00:28:22.785 --> 00:28:23.785
That's a great question.

669
00:28:23.985 --> 00:28:26.285
And that's one of the reasons that I like this tool the most

670
00:28:26.605 --> 00:28:27.885
actually, is it's able

671
00:28:27.905 --> 00:28:31.405
to help you compare two different pilots on any given day.

672
00:28:31.625 --> 00:28:34.805
You know, maybe you have one pilot that's feeling super full

673
00:28:34.805 --> 00:28:36.285
of themselves that day and really macho,

674
00:28:36.285 --> 00:28:37.365
and they wanna show the other pilot

675
00:28:37.365 --> 00:28:39.645

that they can pull way further into a stall than they

676
00:28:39.805 --> 00:28:40.685
normally would 'cause they're not afraid

677
00:28:41.185 --> 00:28:42.035
of the deterrent buffet.

678
00:28:42.815 --> 00:28:45.545
This tool gives us that line in the sand to assess that.

679
00:28:46.115 --> 00:28:48.855
Um, and conversely, if we have a pilot that

680
00:28:49.895 --> 00:28:51.445
maybe there's some issues

681
00:28:51.445 --> 00:28:54.005
that are preventing them from wanting to go into

682
00:28:54.005 --> 00:28:57.855
that intense buffet, we can have conversations to say, well,

683
00:28:57.855 --> 00:28:59.695
look, this historically doesn't seem

684
00:28:59.695 --> 00:29:00.815
to be a very high level of buffet.

685
00:29:00.815 --> 00:29:03.495
We need to talk about it. I don't know

686
00:29:03.495 --> 00:29:05.775
how much I would be willing to override a pilot's opinion on

687
00:29:05.775 --> 00:29:06.775
board, but that is a

688
00:29:06.775 --> 00:29:07.855
conversation we could have on the ground.

689
00:29:08.905 --> 00:29:09.905
And for further testing.

690
00:29:13.855 --> 00:29:17.635
Rod Witte, FAA retired, uh, so,

691
00:29:18.815 --> 00:29:21.155
so Boeing 7 47 versus

692
00:29:21.775 --> 00:29:24.165
RJ Business Jet.

693
00:29:24.665 --> 00:29:27.525
And when I came into the FAA in 1995,

694
00:29:28.265 --> 00:29:29.655
there was a big controversy

695
00:29:29.655 --> 00:29:32.495
because, uh, Bombardier had determined, uh,

696
00:29:32.515 --> 00:29:35.655
on their company test that they had reached

697
00:29:35.765 --> 00:29:37.775
what they thought was a deterrent.

698
00:29:38.155 --> 00:29:43.095
So we brought a pilot from the Seattle, a CO,

699
00:29:43.925 --> 00:29:46.425
and uh, he said, no, no, that's not even close.

700
00:29:47.505 --> 00:29:50.445
You gotta go way up here at Mount Bros.

701
00:29:50.445 --> 00:29:51.565
Everything has to shake.

702
00:29:51.715 --> 00:29:54.405

Well, maybe in a 7 47, not in an rj.

703
00:29:54.705 --> 00:29:56.325
So the question is the same.

704
00:29:57.585 --> 00:30:01.325
How does that apply between a big airplane like a 7 47

705
00:30:01.465 --> 00:30:05.975
or 7 37 in, in an RJ or, or a Gulf Stream or,

706
00:30:06.155 --> 00:30:07.375
or, or a business jet?

707
00:30:07.565 --> 00:30:08.975
Yeah, that's a very good question.

708
00:30:09.315 --> 00:30:13.215
Um, and I, I got the privilege to present this topic, uh,

709
00:30:13.235 --> 00:30:14.815
at the European conference last year,

710
00:30:15.405 --> 00:30:16.665
and I had a hepo, uh,

711
00:30:16.665 --> 00:30:18.065
helicopter pilot ask me the same thing.

712
00:30:19.455 --> 00:30:21.895
I would be, I would be busting the deterrent buffet metric

713
00:30:21.895 --> 00:30:22.895
in straight level flight.

714
00:30:23.715 --> 00:30:27.215
So I, I think that having, I think that training data

715
00:30:28.325 --> 00:30:29.525
specific to the airframes,

716
00:30:29.585 --> 00:30:33.565
and if, if not that particular model, a similarly designed

717
00:30:34.125 --> 00:30:36.295
airplane, you know, tube and a wing big tube

718
00:30:36.295 --> 00:30:38.325
and a wing versus a RJ size tube

719
00:30:38.325 --> 00:30:39.245
and a wing, I think that that

720
00:30:39.445 --> 00:30:40.525
training data is really important.

721
00:30:41.225 --> 00:30:42.325
We don't have a lot of that training

722
00:30:42.325 --> 00:30:43.565
data on the smaller aircraft.

723
00:30:43.705 --> 00:30:46.365
So I am hesitant as an engineer to say

724
00:30:46.365 --> 00:30:47.405
that I have confidence in that model.

725
00:30:49.095 --> 00:30:51.515
You would need to do testing of your own to categorize it.

726
00:30:51.845 --> 00:30:53.185
And I, I think that the,

727
00:30:53.445 --> 00:30:56.375
the point you made about having different pilots from

728
00:30:56.375 --> 00:30:59.665
different backgrounds is a very good one.

729
00:30:59.805 --> 00:31:02.225

And I, I think that that kind of outlines the challenge

730
00:31:02.225 --> 00:31:03.465
that we have going forward with

731
00:31:03.465 --> 00:31:04.665
the certification environment.

732
00:31:05.365 --> 00:31:07.225
You can have your company pilot saying one thing,

733
00:31:07.945 --> 00:31:10.045
you can have your regulators saying another thing,

734
00:31:10.545 --> 00:31:12.765
and then maybe you get regulators that are used

735
00:31:12.765 --> 00:31:14.445
to flying other things come in

736
00:31:14.445 --> 00:31:15.565
and say a completely different thing.

737
00:31:16.615 --> 00:31:18.555
The nice thing about having this metric in this line in the

738
00:31:18.555 --> 00:31:22.245
sand allows you to kind of locate yourselves relative to

739
00:31:22.245 --> 00:31:25.085
that and then have a conversation about what is in

740
00:31:25.085 --> 00:31:27.955
between there and kind of come together and answer.

741
00:31:31.065 --> 00:31:34.255
Tyler Wilhelm, Tyler Wilhelm, Boeing, uh, Bob stole most

742
00:31:34.255 --> 00:31:36.175
of my question, although, uh,

743
00:31:36.565 --> 00:31:38.975
your deterrent buffet was okay when Gene Arnold was

744
00:31:38.975 --> 00:31:40.135
like, I think I can get a little more.

745
00:31:40.155 --> 00:31:44.695
We knew we were in for something, uh, in that determination

746
00:31:44.695 --> 00:31:47.095
of the boundaries on the NYNZ chart.

747
00:31:47.315 --> 00:31:49.415
Uh, was that just Boeing pilots

748
00:31:49.435 --> 00:31:51.375
or did we have cert pilots in there as well?

749
00:31:51.435 --> 00:31:52.435
Do you remember?

750
00:31:54.195 --> 00:31:55.195
I believe that certification

751
00:31:55.195 --> 00:31:56.315
data is included in the models.

752
00:31:56.905 --> 00:31:58.555
Okay. I'm just curious about the scope

753
00:31:58.555 --> 00:32:00.715
and if we want to revisit that, uh,

754
00:32:00.715 --> 00:32:02.755
as we learn more about these other things.

755
00:32:02.895 --> 00:32:03.895
Mm-Hmm.

756
00:32:15.395 --> 00:32:16.975

Steven Thomas, Boeing.

757
00:32:17.845 --> 00:32:19.425
Um, so would you say

758
00:32:19.425 --> 00:32:21.985
that the pilots are validating the algorithm

759
00:32:22.045 --> 00:32:25.225
or is the algorithm validating the pilot's decisions?

760
00:32:25.805 --> 00:32:27.265
It is a little bit of a, a chicken

761
00:32:27.285 --> 00:32:28.665
or the egg situation, isn't it?

762
00:32:29.045 --> 00:32:31.625
Uh, I would say to start out, the

763
00:32:32.365 --> 00:32:33.745
pilots are validating the model,

764
00:32:34.245 --> 00:32:35.995
and once we are comfortable with the model,

765
00:32:36.345 --> 00:32:38.115
then it's a little bit of the other way around.

766
00:32:38.335 --> 00:32:40.195
But again, as someone

767
00:32:40.195 --> 00:32:42.635
that is constantly working on improving the tool,

768
00:32:43.195 --> 00:32:45.435
I always have that question mark of is it good enough?

769
00:32:45.445 --> 00:32:47.075
Where are the improvements? How can we get better?

770
00:32:47.585 --> 00:32:49.895
There are certain stalls that we need to fly

771
00:32:50.035 --> 00:32:51.775
to understand the space better.

772
00:32:51.845 --> 00:32:53.415
Something that we didn't discuss here,

773
00:32:53.435 --> 00:32:56.055
but the vibration environment I've noticed is different at

774
00:32:56.055 --> 00:32:58.535
15,000 feet versus 35,000 feet.

775
00:32:59.585 --> 00:33:02.165
Same configuration, it's different altitude.

776
00:33:02.165 --> 00:33:04.285
The B environment is different. How do you account for that?

777
00:33:05.655 --> 00:33:08.045
Constantly thinking of ways that we can improve.

778
00:33:08.555 --> 00:33:10.575
But to answer your question, I it's definitely a circular

779
00:33:14.825 --> 00:33:15.825
Situation. Kind of a follow up

780
00:33:15.825 --> 00:33:16.065
to that.

781
00:33:16.165 --> 00:33:18.825
And also to what John had asked about the, for,

782
00:33:18.825 --> 00:33:22.475
from a safety perspective, um, I was always,

783
00:33:23.015 --> 00:33:24.035

uh, not clear.

784
00:33:24.315 --> 00:33:26.475
'cause you know, you'd be pulling in and boom

785
00:33:27.135 --> 00:33:28.835
and you'd go, mark, you know,

786
00:33:28.835 --> 00:33:31.435
that's my deterrent buffet point call.

787
00:33:31.985 --> 00:33:34.155
Have you thought about presenting the model

788
00:33:34.265 --> 00:33:35.755
information to the pilot?

789
00:33:35.995 --> 00:33:37.715
I don't mean, you know, having a graph of it,

790
00:33:37.735 --> 00:33:39.475
but just a light coming on saying,

791
00:33:39.475 --> 00:33:42.675
this is when Toby says this is deterrent buffet so that

792
00:33:43.255 --> 00:33:47.195
the cert pilot can go, yeah, that, uh, I that checks kind

793
00:33:47.195 --> 00:33:49.675
of thing, or No, I was later or maybe earlier.

794
00:33:50.505 --> 00:33:53.395
Have you thought about, uh, that it's, uh, you know,

795
00:33:53.395 --> 00:33:54.515
you don't wanna lead the witness,

796
00:33:54.735 --> 00:33:56.755
but uh, it might be a really easy way

797
00:33:56.755 --> 00:33:58.755
to confirm it, if you will. Mm-Hmm.

798
00:33:59.255 --> 00:34:02.285
That's, I would say that that's been my key concern

799
00:34:02.865 --> 00:34:04.325
is exactly to use the words

800
00:34:04.325 --> 00:34:05.525
that you said of leading the witness.

801
00:34:06.725 --> 00:34:09.665
Um, I think it is good situational awareness, um,

802
00:34:10.005 --> 00:34:11.025
and certainly something

803
00:34:11.025 --> 00:34:14.585
that we could very easily roll into a test display, um, or,

804
00:34:14.805 --> 00:34:16.625
or anything that is available in a pilot scan.

805
00:34:17.105 --> 00:34:18.565
I think that the maturity

806
00:34:18.565 --> 00:34:20.485
of the tool at this point is at a spot

807
00:34:20.605 --> 00:34:21.645
where we could have discussions

808
00:34:21.645 --> 00:34:23.125
with our pilots to see if they'd be interested in that.

809
00:34:27.675 --> 00:34:29.015
One. One more question, if you don't mind.

810
00:34:29.155 --> 00:34:30.215

Uh, Doug Schmidt,

811
00:34:30.315 --> 00:34:33.015
new hire at the fa a very long way from retirement.

812
00:34:33.595 --> 00:34:37.375
Uh, so now that you have this tool,

813
00:34:37.375 --> 00:34:39.255
and I, I realize we're just starting out with this,

814
00:34:39.255 --> 00:34:41.655
but you have this tool that is an onboard diagnostic

815
00:34:41.655 --> 00:34:43.415
for unusual vibrations.

816
00:34:43.455 --> 00:34:45.455
I thought it was really interesting how you can filter out,

817
00:34:46.125 --> 00:34:47.505
uh, background noise

818
00:34:47.685 --> 00:34:48.745
and detect something

819
00:34:48.935 --> 00:34:51.425
that normally the pilot would detect is this is unusual,

820
00:34:51.485 --> 00:34:53.025
but now you have this additional tool.

821
00:34:53.525 --> 00:34:55.825
Has there been any thought about the applications of that

822
00:34:55.825 --> 00:34:58.465
for identifying to the, to the crew, uh,

823
00:34:58.525 --> 00:35:00.625
an anomaly on board a mechanical failure

824
00:35:00.805 --> 00:35:03.585
or just something unusual aero mechanically

825
00:35:03.585 --> 00:35:06.585
with the aircraft as an additional crew alerting system

826
00:35:06.605 --> 00:35:08.265
and maybe commercial applications for that?

827
00:35:09.115 --> 00:35:13.355
Yeah, I will say that this tool was originally created

828
00:35:13.895 --> 00:35:15.995
to help us during stall and windup turn testing.

829
00:35:17.445 --> 00:35:19.465
It has been very helpful for a lot more than that.

830
00:35:20.005 --> 00:35:23.275
Uh, and we've we're constantly finding new fun ways

831
00:35:23.375 --> 00:35:26.475
and features to, to add in to help us with exactly that.

832
00:35:39.675 --> 00:35:42.765
Yeah. Great questions, great presentation. Tom.

833
00:35:42.765 --> 00:35:44.565
Thank you very much, uh, for all of that.

834
00:35:44.845 --> 00:35:46.925
I do think that there's a lot of different ways

835
00:35:46.955 --> 00:35:49.405
that this could go and, uh, whether we love it

836
00:35:49.405 --> 00:35:51.285
or hate it, data is here to stay.

837
00:35:51.465 --> 00:35:53.845

Uh, it's, the question is how do we incorporate it

838
00:35:53.845 --> 00:35:57.205
to be a productive partner in the, uh,

839
00:35:57.205 --> 00:35:58.565
in the flight test operation?

840
00:35:58.665 --> 00:36:01.685
Not to replace anyone onboard the aircraft,

841
00:36:01.785 --> 00:36:02.965
but to augment them.

842
00:36:03.345 --> 00:36:05.645
Uh, one of the, some of the questions that, you know,

843
00:36:05.895 --> 00:36:08.445
since I have the privilege of standing up here, I will, uh,

844
00:36:08.735 --> 00:36:10.205
chime in that I think that this could be

845
00:36:10.205 --> 00:36:11.285
a great training aid, right?

846
00:36:11.285 --> 00:36:13.045
When I flew my first windup turns,

847
00:36:13.145 --> 00:36:16.645
my first stalls in Boeing aircraft, uh, I was sitting next

848
00:36:16.645 --> 00:36:17.925
to somebody who'd done it for years.

849
00:36:18.265 --> 00:36:20.645
Uh, and I got feedback, Hey, that was a little too much,

850
00:36:20.645 --> 00:36:21.685
or That was a little too little.

851
00:36:21.795 --> 00:36:23.445
This gives us something objective

852
00:36:23.445 --> 00:36:25.765
where we're all speaking off the same sheet of music,

853
00:36:25.765 --> 00:36:28.685
whether we're talking internally as a, uh, OEM

854
00:36:28.785 --> 00:36:31.685
or whether we're having a conversation with a regulator, uh,

855
00:36:31.825 --> 00:36:35.685
or maybe even a partner, uh, in, uh, in future applications.

856
00:36:35.945 --> 00:36:39.325
So I think this is a, not just a great, uh, application

857
00:36:39.985 --> 00:36:41.605
for flight test and flight safety,

858
00:36:41.785 --> 00:36:44.365
but also, um, maybe a template for

859
00:36:44.385 --> 00:36:47.355
how other things could be, uh, quantification, uh,

860
00:36:47.555 --> 00:36:50.035
quantification could help other aspects of flight test

861
00:36:50.335 --> 00:36:51.995
and uh, and aircraft development.

862
00:36:51.995 --> 00:36:53.715
So well done. Another round of pause please.