WEBVTT

1
00:00:07.105 --> 00:00:07.365
All right.

2
00:00:07.365 --> 00:00:09.685
Next up we have, uh, Marty Schubert with Bell.

3
00:00:10.275 --> 00:00:12.525
He's going to talk to us today about strategies

4
00:00:12.525 --> 00:00:15.125
for risk management and proof of concept flight tests.

5
00:00:15.555 --> 00:00:16.555
Come on up, Marty.

6
00:00:24.805 --> 00:00:27.095
Okay. I will start out with an admin announcement.

7
00:00:27.565 --> 00:00:28.615
I've got a lot of slides

8
00:00:28.835 --> 00:00:31.375
and I'm gonna brush on many of these points.

9
00:00:31.515 --> 00:00:33.015
I'm not gonna hit everything verbatim.

10
00:00:33.875 --> 00:00:35.895
Um, it is publicly available

11
00:00:36.035 --> 00:00:38.575
so you can look at it, uh, afterward.

12
00:00:38.905 --> 00:00:43.695
There will be a, uh, I've included a checklist in the back.

13
00:00:44.075 --> 00:00:45.215
I'm not gonna talk to it,

14
00:00:45.235 --> 00:00:46.495
but I think it's of value

15
00:00:46.525 --> 00:00:48.655
that you review that after the fact.

16
00:00:49.515 --> 00:00:52.335
Um, proof of concept testing, the V 22

17
00:00:52.995 --> 00:00:54.535
is pretty mature now.

18
00:00:54.535 --> 00:00:56.815
We're in production, we're doing great things out there,

19
00:00:56.915 --> 00:00:59.975
but as an aircraft, it's still relatively new concept.

20
00:01:01.075 --> 00:01:02.895
So we're getting plenty of opportunities

21
00:01:03.195 --> 00:01:05.255
to improve the capabilities of the airplane.

22
00:01:05.505 --> 00:01:09.735
We're looking at various kind of fixes, uh, with the V 22,

23
00:01:10.155 --> 00:01:13.095
things like improving, uh, reduced visibility, landings,

24
00:01:13.095 --> 00:01:16.055
improving performance, that sort of thing.

25
00:01:16.275 --> 00:01:18.975
And in the, in the last couple years, we've been doing more

26
00:01:18.975 --> 00:01:20.415
and more proof of concept tests,

27
00:01:21.075 --> 00:01:25.015

and those have led the team to kind of develop an approach

28
00:01:25.075 --> 00:01:27.295
to how we attack these proof of concept tests.

29
00:01:27.315 --> 00:01:28.455
And that's what I'm gonna talk about.

30
00:01:28.765 --> 00:01:31.855
Much of it is common sense. Some of it maybe not.

31
00:01:32.195 --> 00:01:35.135
Uh, some of it you might disagree with our approach there.

32
00:01:37.815 --> 00:01:39.635
I'm gonna start out with just a couple examples

33
00:01:39.635 --> 00:01:40.795
of proof of concept tests.

34
00:01:40.975 --> 00:01:44.595
Uh, this is one, Frank Conway was the lead on this one.

35
00:01:44.615 --> 00:01:46.115
We learned a lot on this test.

36
00:01:46.665 --> 00:01:48.195
This is one of our first big proof

37
00:01:48.195 --> 00:01:49.835
of concept tests in the cell sales.

38
00:01:49.855 --> 00:01:53.195
We put these winglets on the outside of the N cell

39
00:01:53.455 --> 00:01:55.675
to improve, uh, L over D

40
00:01:55.675 --> 00:01:57.915
and get better range performance in airplane mode.

41
00:01:58.675 --> 00:02:00.115
A good concept, it worked,

42
00:02:00.495 --> 00:02:02.395
but there was a lot of negatives to it,

43
00:02:02.815 --> 00:02:04.715
and it's kind of died a quiet death.

44
00:02:05.015 --> 00:02:07.995
Um, we also looked at split flapper on cruise performance.

45
00:02:08.775 --> 00:02:13.155
Um, but from these we started to develop kind of a,

46
00:02:13.255 --> 00:02:16.435
an attack on how we do these concept tests.

47
00:02:17.465 --> 00:02:18.875
Some VTO concepts.

48
00:02:20.105 --> 00:02:23.525
We looked at a opposed lateral cyclic where we tilt the, uh,

49
00:02:23.705 --> 00:02:26.045
the rotors inboard with the flight controls

50
00:02:26.045 --> 00:02:27.285
to relieve download.

51
00:02:28.145 --> 00:02:31.765
The, the V 22 has like a 12 to 13% download.

52
00:02:31.765 --> 00:02:34.245
Pretty significant amount of thrust dedicated to that

53
00:02:34.805 --> 00:02:35.845
OLC worked well.

54
00:02:35.945 --> 00:02:39.245

We integrated it vortex generators on the wing

55
00:02:39.865 --> 00:02:41.565
to improve per on, on a, uh,

56
00:02:41.565 --> 00:02:43.125
prop rotor to improve performance.

57
00:02:43.125 --> 00:02:47.045
Didn't work so well. We played around with flap on position,

58
00:02:47.745 --> 00:02:49.405
you know, the BLO and flap concept

59
00:02:49.585 --> 00:02:51.285
to see if we could get a little bit better lift.

60
00:02:51.825 --> 00:02:54.765
Uh, we ended up staying with our nominal flap setting all,

61
00:02:54.825 --> 00:02:57.685
all the way down, uh, for download alleviation.

62
00:02:57.685 --> 00:02:59.750
And then what I'm gonna talk about today, as an example,

63
00:02:59.785 --> 00:03:01.045
is bonded blade tabs.

64
00:03:01.045 --> 00:03:02.485
We're right in the throes of this test.

65
00:03:03.385 --> 00:03:05.285
Um, the concept here is just

66
00:03:05.285 --> 00:03:08.525
to attach a tab on the trailing edge of the production blade

67
00:03:09.025 --> 00:03:10.525
and get better hover performance.

68
00:03:10.625 --> 00:03:14.565
Simple concept, very simple application, uh,

69
00:03:14.665 --> 00:03:15.885
not such a simple test.

70
00:03:16.585 --> 00:03:20.685
Uh, and that's where we're gonna talk about some

71
00:03:20.685 --> 00:03:22.725
of the lessons and some of the approaches we developed.

72
00:03:23.745 --> 00:03:26.445
The bonded tabs were designed to give us hot

73
00:03:26.445 --> 00:03:27.565
and high hover performance,

74
00:03:28.705 --> 00:03:30.965
but they didn't want to give up too much on the,

75
00:03:31.265 --> 00:03:32.885
on the fixed wing side.

76
00:03:33.345 --> 00:03:36.125
So we didn't want to have major impacts to our range.

77
00:03:36.705 --> 00:03:39.205
We didn't want to have loads, impacts aeros,

78
00:03:39.275 --> 00:03:40.405
elastic impacts.

79
00:03:40.505 --> 00:03:43.565
So that was kind of what drove the sizing of the tabs,

80
00:03:46.525 --> 00:03:49.215
Just some of the size constraints they played with,

81
00:03:49.595 --> 00:03:52.375

you know, uh, span, taper cord, um,

82
00:03:52.475 --> 00:03:53.695
the deflection of the tab.

83
00:03:54.035 --> 00:03:57.055
And they, they ran these through a sensitivity analysis

84
00:03:57.075 --> 00:04:00.095
to come up against those impacts that we're talking about,

85
00:04:00.675 --> 00:04:04.735
uh, the airplane mode versus, uh, helicopter mode.

86
00:04:05.355 --> 00:04:08.935
And then they came up with their optimal tab design.

87
00:04:10.005 --> 00:04:11.815
This is kind of a notional concept of

88
00:04:11.815 --> 00:04:13.695
that analytical approach we did

89
00:04:14.425 --> 00:04:16.335
after the initial down select.

90
00:04:16.365 --> 00:04:19.615
Then we started to do a lot more analysis of that design,

91
00:04:20.365 --> 00:04:23.215
went in, ran performance studies, aero server,

92
00:04:23.215 --> 00:04:27.975
elastic studies, um, loads analysis using our various tools.

93
00:04:28.635 --> 00:04:32.295
And that yellow lightning bolt is about the time the test

94
00:04:32.295 --> 00:04:34.535
team was, was integrated into the plan.

95
00:04:35.725 --> 00:04:39.095
This is a little bit late, frankly, we learned on the,

96
00:04:39.155 --> 00:04:42.495
the cell sales that very lesson early integration helps.

97
00:04:43.395 --> 00:04:46.095
Um, the way the system works right now

98
00:04:46.095 --> 00:04:48.375
where it's a Bell Boeing team under a government

99
00:04:48.915 --> 00:04:53.575
led test team, when we have a proof of concept test,

100
00:04:53.595 --> 00:04:55.655
it comes to us as a request for test

101
00:04:56.125 --> 00:04:57.575
with an analysis package

102
00:04:58.395 --> 00:05:02.015
and, uh, a test matrix of what the guys who want, who, uh,

103
00:05:02.285 --> 00:05:04.015
want the data, what they think they need.

104
00:05:04.475 --> 00:05:08.015
And then it's for us to divine if anything else is needed.

105
00:05:08.395 --> 00:05:10.735
And then we, we feed that back to them.

106
00:05:11.155 --> 00:05:13.895
We develop the test plan on the government team

107
00:05:13.915 --> 00:05:14.935
and then we execute.

108
00:05:18.045 --> 00:05:21.945

So with this proof of concept test, we started to develop

109
00:05:22.525 --> 00:05:26.385
an approach where we do our homework, we get that RFT,

110
00:05:26.385 --> 00:05:30.065
we do our homework, we determine what we as a test team need

111
00:05:30.375 --> 00:05:34.465
with respect to analysis, um, modeling that sort of thing.

112
00:05:34.465 --> 00:05:35.505
And we feed that back

113
00:05:35.505 --> 00:05:37.345
to the engineering on both Bell and Boeing.

114
00:05:38.205 --> 00:05:41.985
And then we go after testing that positive attribute.

115
00:05:42.805 --> 00:05:46.425
The best way to call this, uh, to a good name

116
00:05:46.545 --> 00:05:48.185
for this approach is fail fast.

117
00:05:48.885 --> 00:05:50.985
We have a negative hypothesis basically

118
00:05:50.985 --> 00:05:52.665
that it's not going to work.

119
00:05:53.605 --> 00:05:56.105
So we go after that attribute that this is supposed

120
00:05:56.105 --> 00:05:59.405
to help us, namely in the bonded tabs, hover performance,

121
00:05:59.425 --> 00:06:01.005
and we prove it doesn't give us that.

122
00:06:01.545 --> 00:06:03.245
And we do that as quickly as we can.

123
00:06:04.105 --> 00:06:06.605
And then by doing that, you save time,

124
00:06:06.905 --> 00:06:09.085
you save schedule, you save risk.

125
00:06:10.105 --> 00:06:12.005
So that's our risk management strategy here.

126
00:06:13.185 --> 00:06:16.805
And then if that proves good, then we go

127
00:06:16.805 --> 00:06:19.485
after the next attribute, the next showstopper

128
00:06:19.915 --> 00:06:21.725
that we think is gonna fail the design.

129
00:06:24.165 --> 00:06:27.585
But to do this, you have to have incremental data reviews

130
00:06:27.975 --> 00:06:29.865
with the guys, the decision makers

131
00:06:29.865 --> 00:06:32.065
and the engineering authorities in there.

132
00:06:32.125 --> 00:06:33.585
And that's kind of a hard sell.

133
00:06:34.755 --> 00:06:37.665
We're lucky in that we have a separate organization

134
00:06:37.885 --> 00:06:41.505
for flight test, uh, not underneath the program office.

135
00:06:41.725 --> 00:06:44.825

So we can dictate this kind of stuff to some degree,

136
00:06:45.325 --> 00:06:46.825
but it's still a very hard sell.

137
00:06:49.125 --> 00:06:51.265
One of the things I wanna talk about is in

138
00:06:51.265 --> 00:06:55.145
that optimization, that sensitivity analysis, we identified

139
00:06:55.615 --> 00:06:57.265
that swash plate loads,

140
00:06:57.425 --> 00:06:59.785
swash plate actuator loads were gonna be a constraint.

141
00:07:00.565 --> 00:07:03.785
The basic sizing of that tab was driven by this.

142
00:07:04.095 --> 00:07:08.505
This particular aspect in the V 22 swash plate

143
00:07:08.965 --> 00:07:11.945
is used in VTO mode to tilt the rotors.

144
00:07:12.365 --> 00:07:15.905
And in aircraft airplane mode, it's purely

145
00:07:16.045 --> 00:07:19.225
for collective pitch with a secondary mission

146
00:07:19.285 --> 00:07:21.945
of just keeping your flapping zeroed out

147
00:07:22.125 --> 00:07:23.585
to make it act like a prop.

148
00:07:24.905 --> 00:07:28.525
So we found through the analysis, they designed us right to

149
00:07:29.185 --> 00:07:32.725
the limit dive point where we have to do loads demonstration

150
00:07:33.075 --> 00:07:35.165
that limit dive point 310 knots,

151
00:07:35.665 --> 00:07:39.525
and we are gonna do load maneuvers like rolling pullups,

152
00:07:39.595 --> 00:07:43.085
wind up turns, symmetric poles at that condition,

153
00:07:43.865 --> 00:07:46.325
and that's where they designed it to work.

154
00:07:47.545 --> 00:07:50.525
The problem is, if they missed by any amount,

155
00:07:51.185 --> 00:07:54.645
we were now gonna be in a scenario if we had a critical

156
00:07:54.645 --> 00:07:55.805
failure and

157
00:07:55.805 --> 00:07:58.845
that swatch plate went into single boost operation, that it,

158
00:07:58.915 --> 00:08:00.565
it's basically a two fail scenario.

159
00:08:01.305 --> 00:08:02.605
We were gonna potentially have a

160
00:08:02.605 --> 00:08:04.245
catastrophic situation on our hands.

161
00:08:04.945 --> 00:08:07.045
So definitely identified that as a risk.

162
00:08:07.045 --> 00:08:08.925

That was one of those things we we're gonna go

163
00:08:08.925 --> 00:08:11.845
after very early in this fail fast scenario.

164
00:08:13.405 --> 00:08:15.785
Um, part of that homework I was talking about,

165
00:08:15.785 --> 00:08:17.185
we do a lot of brainstorming.

166
00:08:17.525 --> 00:08:18.865
We get this test matrix,

167
00:08:18.965 --> 00:08:21.945
but as a test team, we still sit down and brainstorm

168
00:08:21.965 --> 00:08:24.345
and see if we think they missed anything.

169
00:08:24.845 --> 00:08:29.185
And, and we look at loads flight controls hq,

170
00:08:29.975 --> 00:08:32.105
just our experience with developing

171
00:08:32.285 --> 00:08:35.425
and optimizing this highly optimized flight control design,

172
00:08:35.965 --> 00:08:38.025
we did come up with, with some things

173
00:08:38.025 --> 00:08:40.025
that we thought should be included.

174
00:08:40.825 --> 00:08:44.905
Additionally, uh, in the test matrix, some

175
00:08:44.905 --> 00:08:46.305
of those things we asked for

176
00:08:46.395 --> 00:08:48.305
after this brainstorming, we asked

177
00:08:48.325 --> 00:08:50.385
for more refined performance

178
00:08:50.385 --> 00:08:52.785
and loads predictions from the analysis group.

179
00:08:53.555 --> 00:08:55.765
Aeros elastics, we wanted better trending

180
00:08:55.765 --> 00:08:57.285
for all the air speeds involved.

181
00:08:57.395 --> 00:08:58.645
They had some for high speed,

182
00:08:58.645 --> 00:09:00.605
we needed some for the conversion.

183
00:09:01.585 --> 00:09:04.805
Um, and then on the flight control side,

184
00:09:05.305 --> 00:09:07.525
we thought there was a lot that a lot more needed.

185
00:09:07.745 --> 00:09:09.405
So we asked for some analysis there.

186
00:09:10.405 --> 00:09:12.085
Specifically, we asked for structural

187
00:09:12.085 --> 00:09:13.445
load limiting analysis.

188
00:09:14.025 --> 00:09:17.045
We knew that in certain areas we had very little margin in

189
00:09:17.045 --> 00:09:19.125

our optimization on the V 22

190
00:09:19.585 --> 00:09:20.885
for the structural load limiting.

191
00:09:21.145 --> 00:09:24.125
Uh, specifically one of those would be the application

192
00:09:24.125 --> 00:09:26.365
of roll con control in VTO mode

193
00:09:26.425 --> 00:09:27.925
to differential collective pitch

194
00:09:28.625 --> 00:09:32.525
and how we use that to avoid over torquing our gear boxes.

195
00:09:33.585 --> 00:09:37.405
So, uh, with that we came in,

196
00:09:38.155 --> 00:09:40.765
this is a, this slide shows the loads

197
00:09:40.765 --> 00:09:42.605
matrix that was provided.

198
00:09:43.665 --> 00:09:46.285
Um, you can see, lemme see if I can do it.

199
00:09:46.435 --> 00:09:48.605
Yeah, here you go. There's

200
00:09:48.605 --> 00:09:51.085
that swash plate single boost the guys had already thought

201
00:09:51.085 --> 00:09:54.725
about, and then they had some historical loads demonstration

202
00:09:55.165 --> 00:09:57.805
analysis, so demonstration points,

203
00:09:58.125 --> 00:09:59.165
structural demonstration points,

204
00:09:59.185 --> 00:10:02.285
and then a bunch of flight load survey, uh, for

205
00:10:02.505 --> 00:10:04.645
as a technical risk reduction effort.

206
00:10:05.685 --> 00:10:08.785
And then we integrated this

207
00:10:09.585 --> 00:10:12.545
SL some SLL points from structural load limiting points.

208
00:10:13.045 --> 00:10:15.025
And we finally had a final loads plan.

209
00:10:15.485 --> 00:10:17.745
The majority of this test plan was loads testing.

210
00:10:18.125 --> 00:10:20.305
So the higher risk, higher risk stuff.

211
00:10:22.965 --> 00:10:24.545
Now, the general approach we're talking about,

212
00:10:24.755 --> 00:10:26.465
we're gonna go after that first attribute.

213
00:10:26.635 --> 00:10:27.945
We're gonna try to fail it.

214
00:10:28.645 --> 00:10:33.305
So what we did, we developed a limited envelope expansion.

215
00:10:33.775 --> 00:10:35.665
This is something we used in the cell sales,

216
00:10:36.415 --> 00:10:38.425

just enough envelope to get you out there,

217
00:10:38.425 --> 00:10:41.825
collect the performance data that you need and then execute.

218
00:10:42.125 --> 00:10:44.145
So in doing that, you still have

219
00:10:44.145 --> 00:10:46.665
to take into consideration flying qualities.

220
00:10:46.665 --> 00:10:48.265
You have to treat this as a new rotor.

221
00:10:48.265 --> 00:10:49.425
That's the way we did anyway.

222
00:10:49.885 --> 00:10:52.905
Flying qualities a SE loads,

223
00:10:54.115 --> 00:10:56.885
collect our tethered hover data at sea level.

224
00:10:57.305 --> 00:10:59.365
If it failed there, we weren't even gonna bother going

225
00:10:59.365 --> 00:11:00.925
to high altitude where they really wanted the

226
00:11:01.125 --> 00:11:02.725
demonstration, but it passed.

227
00:11:02.905 --> 00:11:05.925
So then we went, took the blades off the airplane,

228
00:11:06.545 --> 00:11:09.365
put the legacy blades on, flew it out to Logan, Utah,

229
00:11:10.185 --> 00:11:12.965
put new blades on, and executed the tether hover out there.

230
00:11:14.905 --> 00:11:17.195
Then we went into our first plan data review.

231
00:11:18.335 --> 00:11:20.275
Um, just to give you an example of how

232
00:11:20.275 --> 00:11:22.395
that limited envelope expansion goes.

233
00:11:23.295 --> 00:11:26.475
Uh, your, within your envelope, in this case,

234
00:11:26.495 --> 00:11:30.155
the hover envelope, we're looking at controllability A SC

235
00:11:30.155 --> 00:11:31.715
and then performance very limited.

236
00:11:32.015 --> 00:11:34.755
And then we would expand out and pick up other loads data

237
00:11:35.295 --> 00:11:38.155
and, and, uh, ancillary flying quality data,

238
00:11:39.045 --> 00:11:40.995
continuous loads, monitoring throughout all that.

239
00:11:45.265 --> 00:11:47.845
So that first data review,

240
00:11:47.845 --> 00:11:49.725
there's an incremental data review process.

241
00:11:50.065 --> 00:11:52.285
We started, I borrowed heavily

242
00:11:52.795 --> 00:11:56.405
from a discussion two years ago, uh, by Ben Luther.

243
00:11:56.645 --> 00:11:59.205

I thought he had an excellent discussion about incremental

244
00:11:59.205 --> 00:12:01.405
flight test and, and data review,

245
00:12:01.505 --> 00:12:06.085
and being able to adapt based on discovery, adapt your test,

246
00:12:06.585 --> 00:12:07.685
and continue planning.

247
00:12:08.425 --> 00:12:10.605
So this in the proof of concept test to,

248
00:12:10.885 --> 00:12:13.005
I thought was a perfect opportunity for that.

249
00:12:13.395 --> 00:12:16.565
That checklist we use is at the end of this, uh,

250
00:12:16.915 --> 00:12:19.125
this briefing for you guys to review on your own.

251
00:12:20.335 --> 00:12:22.475
The beauty of this is it really does allow

252
00:12:22.475 --> 00:12:23.795
for a comprehensive review.

253
00:12:23.795 --> 00:12:25.115
These data reviews tend

254
00:12:25.115 --> 00:12:29.275
to be technically oriented on the production decision,

255
00:12:30.405 --> 00:12:34.385
but there needs to be a flight test process review also.

256
00:12:34.405 --> 00:12:36.265
And that's what this checklist does for us.

257
00:12:37.565 --> 00:12:39.505
To do that, you still have to have a very

258
00:12:40.345 --> 00:12:41.465
flexible test plan review

259
00:12:41.465 --> 00:12:45.625
and amendment process, which we had to convince HX 21 our

260
00:12:46.505 --> 00:12:49.305
overhead agency, that that's what we needed to do on this.

261
00:12:49.965 --> 00:12:51.505
And they, they, they were amenable.

262
00:12:56.165 --> 00:12:58.225
The hover performance results were excellent.

263
00:12:59.125 --> 00:13:02.585
The dash line there indicates the baseline air airplane.

264
00:13:03.395 --> 00:13:06.575
The solid line was the new bonded tabs.

265
00:13:06.575 --> 00:13:10.455
We had 5.7% increase in hover performance,

266
00:13:10.455 --> 00:13:12.415
which is a substantial amount.

267
00:13:13.255 --> 00:13:15.615
A lot of troupes more that we could put on there.

268
00:13:16.685 --> 00:13:20.015
That's the good news on this slide.

269
00:13:20.045 --> 00:13:21.935
This is kind of a review of the data review.

270
00:13:22.115 --> 00:13:25.255

The first two are the good, the red is the bad.

271
00:13:26.515 --> 00:13:30.215
We achieved our, our hover performance goals, the loads

272
00:13:30.215 --> 00:13:31.735
and a SC and the VOL mode.

273
00:13:31.735 --> 00:13:33.855
During our envelope expansion was great,

274
00:13:34.875 --> 00:13:38.005
but, uh, in airplane mode now,

275
00:13:38.005 --> 00:13:41.805
because this was better than expected hover performance,

276
00:13:42.345 --> 00:13:46.445
now we have a worry about worse than expected swash plate,

277
00:13:46.445 --> 00:13:48.725
single boost actuator loads in high speed dive.

278
00:13:50.245 --> 00:13:52.785
So that percolated up to our main concern.

279
00:13:53.655 --> 00:13:56.305
Also, we saw a little bit of non-optimal flying qualities.

280
00:13:56.575 --> 00:13:57.705
What we originally thought

281
00:13:57.705 --> 00:13:59.345
with this small solidity change in the

282
00:13:59.345 --> 00:14:00.385
rotor wasn't gonna give us much.

283
00:14:00.765 --> 00:14:04.545
We saw a lot highly optimized V 22 fly controls,

284
00:14:04.855 --> 00:14:06.745
very sensitive to a solidity change.

285
00:14:07.925 --> 00:14:09.665
We got high focus roll mode.

286
00:14:09.885 --> 00:14:11.745
We, uh, made it slightly more sensitive.

287
00:14:11.745 --> 00:14:14.825
That's, uh, it's taunted us for years on the V 22,

288
00:14:14.895 --> 00:14:19.025
it's just a pilot, uh, assisted oscillation with respect

289
00:14:19.025 --> 00:14:21.865
to the gear and your lateral sticker ergonomics.

290
00:14:22.405 --> 00:14:24.465
So it was slightly more sensitive, not a,

291
00:14:24.525 --> 00:14:25.665
not a showstopper at all.

292
00:14:25.695 --> 00:14:27.505
Lateral response was a little hotter.

293
00:14:28.245 --> 00:14:30.505
We noticed the directional response had a little bit

294
00:14:30.505 --> 00:14:33.905
of jerk in it, indicating maybe our lead, uh, lead shaping

295
00:14:34.005 --> 00:14:36.665
of our controls could be improved with this.

296
00:14:37.125 --> 00:14:41.505
And then, uh, on one of the men descent, uh, uh,

297
00:14:42.085 --> 00:14:45.345

men power descent points in 60, the cell we ended up with,

298
00:14:45.365 --> 00:14:47.105
uh, governor saturation.

299
00:14:47.525 --> 00:14:50.745
Not a big deal, but something we can optimize.

300
00:14:51.115 --> 00:14:52.925
Frankly, all of these things pointed

301
00:14:53.465 --> 00:14:55.725
to maybe a software change that would go

302
00:14:55.725 --> 00:14:58.485
with the bonded tabs, with some software work.

303
00:14:58.505 --> 00:15:00.485
We could make all these things better than

304
00:15:00.485 --> 00:15:01.525
the baseline airplane.

305
00:15:01.595 --> 00:15:05.845
That was the good news. And then we saw a potential

306
00:15:06.445 --> 00:15:10.485
acoustic impact that we, we laid on the investigation for.

307
00:15:12.385 --> 00:15:15.765
So the good news, okay, hover looked good, let's go

308
00:15:15.765 --> 00:15:17.725
after the next showstopper.

309
00:15:18.705 --> 00:15:20.965
In this case, airplane mode performance.

310
00:15:21.065 --> 00:15:22.565
We wanna show that it's gonna fail,

311
00:15:22.955 --> 00:15:24.045
that it's gonna fail badly,

312
00:15:24.425 --> 00:15:28.215
and then we're done with the test and we want to, right

313
00:15:28.215 --> 00:15:29.495
after that, we're gonna use

314
00:15:29.495 --> 00:15:32.255
that airplane mode performance testing in a limited envelope

315
00:15:32.265 --> 00:15:35.855
again to get out and, and do a high speed dive and, and,

316
00:15:35.955 --> 00:15:38.775
and take a sniff at those swash plate loads.

317
00:15:39.515 --> 00:15:41.535
Uh, and we were gonna actually do a dive

318
00:15:41.595 --> 00:15:44.415
and then a wind up turn as build up, uh,

319
00:15:44.515 --> 00:15:46.655
toward 310 knots.

320
00:15:49.355 --> 00:15:52.135
The good news airplane mode performance was,

321
00:15:52.915 --> 00:15:54.255
was hardly impacted at all.

322
00:15:54.325 --> 00:15:58.535
Less than 1% change in range. That was good news.

323
00:15:59.355 --> 00:16:01.615
So all the decision makers, you know,

324
00:16:01.615 --> 00:16:03.855

the nav cognizant authorities and,

325
00:16:04.195 --> 00:16:07.335
and class desk, they're all thumbs up, looks great,

326
00:16:07.785 --> 00:16:10.295
hover performance is good, range impacts low.

327
00:16:12.265 --> 00:16:16.045
Uh, we saw some a SE differences from what our analysis was,

328
00:16:16.105 --> 00:16:17.485
but all the damping on the,

329
00:16:17.545 --> 00:16:19.725
on the aero server elastic modes was good.

330
00:16:20.225 --> 00:16:21.445
But we did have a switch up.

331
00:16:21.905 --> 00:16:25.245
Uh, symmetric wing beam was typically the,

332
00:16:25.625 --> 00:16:28.165
the least damped when we went to the bonded tabs,

333
00:16:28.165 --> 00:16:31.045
symmetric wing cord now was the least damped,

334
00:16:31.255 --> 00:16:32.885
still both good damping

335
00:16:34.265 --> 00:16:37.845
and then flying qualities in airplane mode and vitol

336
00:16:37.905 --> 00:16:38.925
and conversion mode.

337
00:16:38.925 --> 00:16:43.735
Pretty much unaffected Problem was we exceeded the boost

338
00:16:43.785 --> 00:16:47.175
limit before we even got to 310 knots.

339
00:16:47.875 --> 00:16:49.615
So now that was something to wrestle with.

340
00:16:50.625 --> 00:16:52.015
There was a lot of questions there,

341
00:16:52.015 --> 00:16:53.615
whether the boost limit was real,

342
00:16:54.285 --> 00:16:57.295
whether the flight controls would respond if you started

343
00:16:57.295 --> 00:16:58.895
to back drive a swash plate actuary

344
00:16:58.895 --> 00:17:00.015
or how they'd respond to it

345
00:17:00.515 --> 00:17:03.055
and whether we had time to respond to it.

346
00:17:03.115 --> 00:17:06.415
It is a failure mode, a dual failure mode, probably 10

347
00:17:06.415 --> 00:17:08.855
to the minus seventh kind of an issue.

348
00:17:09.435 --> 00:17:10.815
So is that a showstopper?

349
00:17:10.835 --> 00:17:13.775
We asked Nair, they said, no, not at this time.

350
00:17:13.805 --> 00:17:15.735
This is the only thing really hanging us up.

351
00:17:16.595 --> 00:17:19.415

So they went and changed the test from, uh, proof

352
00:17:19.435 --> 00:17:20.735
of concept risk reduction

353
00:17:21.115 --> 00:17:24.095
to a production qualification type test.

354
00:17:24.195 --> 00:17:26.175
Now they're saying those,

355
00:17:26.785 --> 00:17:28.935
those tabs are production representative.

356
00:17:29.355 --> 00:17:32.495
We wanna put more load points on you and,

357
00:17:32.595 --> 00:17:35.095
and, uh, full qualification effort, load survey

358
00:17:35.155 --> 00:17:36.255
and demonstration points.

359
00:17:38.165 --> 00:17:40.095
Problem was, we still had this unanswered.

360
00:17:40.875 --> 00:17:43.655
Uh, so we went into a lot of simulation.

361
00:17:44.075 --> 00:17:47.615
Uh, we put patches into our, our GTR modeling.

362
00:17:48.315 --> 00:17:51.405
We went and looked at the original specification, talked to

363
00:17:52.025 --> 00:17:55.125
the vendor, and we started to develop a plan

364
00:17:55.135 --> 00:17:57.645
where we thought, we thought we could move

365
00:17:57.645 --> 00:17:59.725
that boundary out a little bit and,

366
00:17:59.825 --> 00:18:01.765
and regain that 310 knots.

367
00:18:02.295 --> 00:18:04.885
We're right now in the middle of that big research project,

368
00:18:05.585 --> 00:18:06.725
and it's been an up

369
00:18:06.725 --> 00:18:09.005
and down rollercoaster ride while we're

370
00:18:09.005 --> 00:18:10.045
trying to get that decision.

371
00:18:10.505 --> 00:18:12.085
In the meantime, they're asking us

372
00:18:12.085 --> 00:18:14.965
to do a qualification test matrix on these tabs.

373
00:18:16.745 --> 00:18:18.325
So here's where we are right now.

374
00:18:18.325 --> 00:18:20.125
We're down in the lower left corner here.

375
00:18:20.935 --> 00:18:22.685
We've done all of this. We're down here.

376
00:18:22.685 --> 00:18:25.125
We're, we're asked to do a flight loads survey,

377
00:18:26.625 --> 00:18:28.605
um, qualification matrix.

378
00:18:29.195 --> 00:18:31.565

Instead, we're doing those points.

379
00:18:31.655 --> 00:18:34.125
We're assuming that this thing's gonna fail this swatch

380
00:18:34.125 --> 00:18:35.125
plate single boost thing,

381
00:18:35.345 --> 00:18:38.245
and we prioritize all the risk reduction points.

382
00:18:38.675 --> 00:18:40.245
Once we get them done, then we'll go into

383
00:18:40.245 --> 00:18:41.325
the qualification points.

384
00:18:42.185 --> 00:18:46.165
And while we're doing this review, and, and

385
00:18:46.165 --> 00:18:49.645
before we even hit this plan data review, we ended up with,

386
00:18:49.705 --> 00:18:51.325
uh, uh, some surprises.

387
00:18:54.325 --> 00:18:58.185
One of those was that where we attached the, the tabs

388
00:18:58.185 --> 00:18:59.625
to the blades was cracking.

389
00:19:00.325 --> 00:19:03.905
The tabs actually added rigidity to, to the blade,

390
00:19:04.525 --> 00:19:06.745
and now they were flexing right at those joints,

391
00:19:07.005 --> 00:19:09.225
and we were starting to crack the skins of the blades.

392
00:19:10.045 --> 00:19:12.425
So the upshot of

393
00:19:12.425 --> 00:19:15.865
that was the way they were attaching it was, was gonna have

394
00:19:15.865 --> 00:19:17.025
to change in production.

395
00:19:17.485 --> 00:19:21.345
So now the blades structurally are not represented of the,

396
00:19:21.345 --> 00:19:22.865
of the production design.

397
00:19:23.195 --> 00:19:25.705
We're no longer in production qualification.

398
00:19:25.715 --> 00:19:27.265
We're back to risk reduction.

399
00:19:28.125 --> 00:19:29.905
The outer mold line of the blades

400
00:19:30.285 --> 00:19:32.225
of the blade tabs remain the same.

401
00:19:32.365 --> 00:19:35.185
So anything downstream of the rotor is still representative.

402
00:19:35.685 --> 00:19:38.065
We can still collect good risk reduction data.

403
00:19:39.165 --> 00:19:41.225
So the prioritization logic we used

404
00:19:41.465 --> 00:19:42.505
previously still applies.

405
00:19:43.245 --> 00:19:44.385

So we're looking good there.

406
00:19:44.895 --> 00:19:47.905
Another one that came up is, um,

407
00:19:48.055 --> 00:19:50.425
that differential collective pitch that I was talking about

408
00:19:50.425 --> 00:19:52.945
with SLL was, uh, structural load limiting.

409
00:19:53.365 --> 00:19:55.945
We were starting to get some pretty high loads in wind up

410
00:19:55.945 --> 00:19:57.065
turns at 90 the cell.

411
00:19:57.885 --> 00:20:02.185
So our hunch there was kinda right this, this thing,

412
00:20:02.485 --> 00:20:04.425
the SLL might have to be backed down.

413
00:20:05.005 --> 00:20:06.505
So we're gonna collect some of that data.

414
00:20:06.915 --> 00:20:08.465
Right now it's not a showstopper

415
00:20:08.465 --> 00:20:10.785
because it's simply a fatigue impact.

416
00:20:11.015 --> 00:20:14.265
It's a dynamic component with an unlimited endurance life.

417
00:20:14.925 --> 00:20:18.625
Now, we may have to fatigue track it if we go with it as is

418
00:20:18.685 --> 00:20:20.865
and don't make any kind of corrections

419
00:20:20.865 --> 00:20:21.905
to the flight controls.

420
00:20:22.975 --> 00:20:25.995
Bottom line though, we went back to a risk reduction effort

421
00:20:26.015 --> 00:20:27.915
for the remaining test points on the plan.

422
00:20:30.735 --> 00:20:32.195
And that's where we are right now.

423
00:20:32.535 --> 00:20:35.155
We are just about to get a final date of review

424
00:20:35.335 --> 00:20:37.955
of the swash plate, single boost operations.

425
00:20:38.815 --> 00:20:39.875
If that looks good.

426
00:20:40.095 --> 00:20:43.355
If it looks like we have margins, we're gonna go out

427
00:20:43.815 --> 00:20:45.195
and finish off those points

428
00:20:45.855 --> 00:20:47.685
and then do our loads points there.

429
00:20:48.025 --> 00:20:49.365
And then we're gonna do cleanup

430
00:20:49.385 --> 00:20:51.605
for this risk reduction effort and,

431
00:20:51.745 --> 00:20:52.765
and preparation

432
00:20:52.865 --> 00:20:56.605

for the final production design decision of the tabs.

433
00:20:57.065 --> 00:20:58.565
We still have a whole bunch.

434
00:20:58.715 --> 00:21:03.405
Once they put the new tabs on the, with the new, um,

435
00:21:04.145 --> 00:21:06.565
new attachment, we still get to go

436
00:21:06.565 --> 00:21:09.085
and repeat most of this stuff again, regrettably.

437
00:21:09.785 --> 00:21:12.885
But that's been our goal. We're gonna fail fast.

438
00:21:13.705 --> 00:21:14.845
And we've used that approach.

439
00:21:15.025 --> 00:21:19.405
It takes a little bit if, uh, if it had failed at any point,

440
00:21:19.405 --> 00:21:20.605
we would've been done and probably

441
00:21:20.605 --> 00:21:21.685
saved the government some time.

442
00:21:21.945 --> 00:21:24.765
And in fact, it's working.

443
00:21:25.305 --> 00:21:28.645
So we got a full up, uh, test almost done here.

444
00:21:29.765 --> 00:21:32.505
To do this though, you gotta ensure the team understands it,

445
00:21:32.505 --> 00:21:33.905
management understands it.

446
00:21:34.055 --> 00:21:35.545
Your engineering authority does.

447
00:21:36.455 --> 00:21:39.925
This may be a hard sell for, for other, other companies.

448
00:21:41.025 --> 00:21:45.485
Um, early engagement of the test team was a real must

449
00:21:46.345 --> 00:21:48.165
in this design and other designs

450
00:21:48.825 --> 00:21:50.445
of these proof of concept tests.

451
00:21:50.445 --> 00:21:52.885
Sometimes they're, they, they're, they're given to us

452
00:21:53.185 --> 00:21:57.045
as an asymmetric configuration or a time limited information

453
00:21:57.705 --> 00:22:00.565
and, uh, a a time limited component

454
00:22:01.385 --> 00:22:05.085
and a quick, you get a test team involved in that planning,

455
00:22:05.185 --> 00:22:06.285
the better off you are.

456
00:22:06.785 --> 00:22:09.245
For instance, on the sales, we had major,

457
00:22:09.375 --> 00:22:11.725
major maintenance impacts on the n cell sales.

458
00:22:12.345 --> 00:22:13.965
And had they got us in there earlier,

459
00:22:14.185 --> 00:22:16.525

we could have told them that the, the life

460
00:22:16.545 --> 00:22:19.085
of the components they were putting on there was not enough.

461
00:22:19.785 --> 00:22:23.125
And that our schedule was gonna be about four times as long

462
00:22:23.125 --> 00:22:25.565
as they thought, uh, the,

463
00:22:25.825 --> 00:22:28.485
the guys hadn't factored in envelope expansion,

464
00:22:28.485 --> 00:22:30.285
for instance, with, with the sales

465
00:22:32.545 --> 00:22:35.585
and, uh, socialize the test team needs.

466
00:22:35.695 --> 00:22:37.385
This is something we're always trying to do.

467
00:22:38.205 --> 00:22:40.825
The guys come with us, come to us with an RFT,

468
00:22:41.485 --> 00:22:43.465
and then we say, this is what we need

469
00:22:43.685 --> 00:22:45.905
to execute the flight test in a safe, uh,

470
00:22:46.015 --> 00:22:47.105
safe, efficient manner.

471
00:22:47.725 --> 00:22:49.185
Uh, we need a little more analysis.

472
00:22:49.285 --> 00:22:52.185
We need A-G-T-R-A patch to our GTR modeling

473
00:22:52.285 --> 00:22:55.025
so we can rehearse in the sim, that sort of thing.

474
00:22:56.205 --> 00:22:58.625
And, uh, limited envelope expansion

475
00:22:58.655 --> 00:23:01.745
that we used in the cell sales we use here in bonded tabs.

476
00:23:01.745 --> 00:23:04.905
It's great. It does require continuous tracking.

477
00:23:05.415 --> 00:23:10.345
It's a self-imposed, um, restriction on, on the testing,

478
00:23:10.485 --> 00:23:12.625
but you need to know when you're pushing out beyond that

479
00:23:13.285 --> 00:23:14.945
pre-established envelope.

480
00:23:15.725 --> 00:23:18.065
So, um, we had some good metrics.

481
00:23:18.205 --> 00:23:21.305
We came up with incell sales that were,

482
00:23:21.395 --> 00:23:23.785
we've used in the bonded tabs testing and that's helped.

483
00:23:24.685 --> 00:23:26.705
And then finally, understand the difference

484
00:23:26.705 --> 00:23:29.905
between risk reduction and this is technical risk reduction.

485
00:23:30.375 --> 00:23:32.865
It's not the risk management process that I'm talking about

486
00:23:34.005 --> 00:23:35.825

and a qualification effort.

487
00:23:36.625 --> 00:23:38.205
We definitely focused on that

488
00:23:38.465 --> 00:23:42.885
and we continually pounded our loads guys about prioritizing

489
00:23:42.885 --> 00:23:45.005
those loads maneuvers to

490
00:23:45.125 --> 00:23:47.525
where we had those organized properly for

491
00:23:47.755 --> 00:23:49.205
with those aspects in mind.

492
00:23:50.595 --> 00:23:52.855
That's all I have. Any questions

493
00:23:54.895 --> 00:23:55.895
Question back here?

494
00:23:56.875 --> 00:23:58.775
Yes. Um, maybe you answered it

495
00:23:58.775 --> 00:24:00.455
or maybe you mentioned it earlier in the presentation

496
00:24:00.675 --> 00:24:03.095
and, uh, government people don't take this the wrong way,

497
00:24:03.395 --> 00:24:05.375
but how much was the government involved?

498
00:24:05.445 --> 00:24:07.615
Were you doing this, uh, at PAX

499
00:24:07.615 --> 00:24:09.375
or was this at Arlington here at your test center?

500
00:24:09.675 --> 00:24:10.855
No, this was, in fact,

501
00:24:10.875 --> 00:24:14.775
at PAX River we were under the umbrella of HX 21.

502
00:24:15.275 --> 00:24:19.535
So it's a government run test team, but we've got Bell

503
00:24:19.535 --> 00:24:21.175
and Boeing highly integrated into it.

504
00:24:21.965 --> 00:24:25.175
Yeah, one of the interesting things here though was in

505
00:24:25.175 --> 00:24:29.335
that RFT process, a lot of the expertise that Bell had

506
00:24:29.365 --> 00:24:30.655
with respect to loads

507
00:24:30.655 --> 00:24:33.535
and aero server elastics, that analysis was done solid.

508
00:24:34.275 --> 00:24:38.735
But, but the Boeing side still had only been touched upon.

509
00:24:38.915 --> 00:24:40.295
So the handling qualities,

510
00:24:40.295 --> 00:24:42.295
Boeing is responsible for flight controls.

511
00:24:43.035 --> 00:24:44.895
The flight controls designed the V 22.

512
00:24:45.515 --> 00:24:48.895
We had to bring them in when the team, um, plugged into it.

513
00:24:48.895 --> 00:24:50.735

And that's where we came up with these SLL

514
00:24:50.775 --> 00:24:54.695
concerns. Any other questions? Yeah,

515
00:24:54.695 --> 00:24:55.695
I got a question back here. Um,

516
00:24:55.695 --> 00:24:57.895
you, I, this may be, uh, just my ignorance

517
00:24:57.895 --> 00:24:59.815
of your process, but, uh, when,

518
00:24:59.815 --> 00:25:01.535
when you talk about flexible test planning

519
00:25:01.555 --> 00:25:04.735
and a flexible test team, uh, when you're making discoveries

520
00:25:04.735 --> 00:25:05.935
that may drive additional testing

521
00:25:06.035 --> 00:25:07.575
or additional points you have to add to the plan,

522
00:25:07.675 --> 00:25:09.495
how high up the chain do you have to go

523
00:25:09.495 --> 00:25:11.575
before you get to somebody who says you can go do that?

524
00:25:12.055 --> 00:25:13.775
I mean, can your test team get together with the design guys

525
00:25:13.775 --> 00:25:14.735
and just decide to go out

526
00:25:15.015 --> 00:25:16.055
tomorrow and apply some new points?

527
00:25:16.055 --> 00:25:17.095
Maybe not tomorrow, but

528
00:25:17.875 --> 00:25:20.295
No, we're, we're pretty, pretty constrained under,

529
00:25:20.295 --> 00:25:21.975
under the government contract.

530
00:25:22.585 --> 00:25:26.135
We've got to go through the squadron commander basically

531
00:25:26.155 --> 00:25:27.255
of HX 21.

532
00:25:27.275 --> 00:25:30.895
So we have a, uh, a test team, the V 22 test team.

533
00:25:31.025 --> 00:25:33.255
We'll do it inside the V 22 test team

534
00:25:33.255 --> 00:25:37.055
with our lead government and contractor review.

535
00:25:37.635 --> 00:25:39.855
And then we take there to the squadron.

536
00:25:39.905 --> 00:25:42.095
Oftentimes though, it's just a meeting with,

537
00:25:42.445 --> 00:25:44.815
with the project officer, the project engineer

538
00:25:45.515 --> 00:25:49.695
and the, the co of the squadron and his technical director,

539
00:25:50.035 --> 00:25:52.775
and you sit down and pen and ink the change in.

540
00:25:53.235 --> 00:25:55.255

So when you set out to do this,

541
00:25:55.255 --> 00:25:56.695
and you talked about your risk reduction

542
00:25:56.695 --> 00:26:00.015
or whatever, did you level set everybody that you wanted

543
00:26:00.015 --> 00:26:01.495
to be more nimble on this project

544
00:26:01.525 --> 00:26:03.255
than you had been in the past? And was that

545
00:26:03.255 --> 00:26:04.255
Helpful? Yeah, we did not

546
00:26:04.255 --> 00:26:05.615
do that with the earlier proof

547
00:26:05.615 --> 00:26:07.735
of concept test, but on the bonded tabs,

548
00:26:08.075 --> 00:26:09.215
we kinda learned our lesson

549
00:26:09.835 --> 00:26:12.095
and that very first data review, we tried

550
00:26:12.095 --> 00:26:14.575
to make sure everybody understood where we were coming from,

551
00:26:14.575 --> 00:26:16.495
that we're looking to fail the system.

552
00:26:16.555 --> 00:26:19.775
You know, we're trying to, we need decision makers in

553
00:26:19.775 --> 00:26:22.215
that data review, not just technical guys.

554
00:26:22.835 --> 00:26:26.055
And, and that's, that's tough pulling the Nair decision

555
00:26:26.295 --> 00:26:28.775
maker and, uh, and the class desk kind

556
00:26:28.775 --> 00:26:30.215
of guy into those kind of reviews.

557
00:26:30.485 --> 00:26:32.055
It's, it's not an easy process,

558
00:26:32.315 --> 00:26:34.855
but as we went on, it got a little easier.

559
00:26:35.875 --> 00:26:36.295
Thanks.

560
00:26:53.345 --> 00:26:55.925
All right. Thank you Marty. Good.