WEBVTT

1
00:00:00.535 --> 00:00:02.045
Which is what I know.

2
00:00:02.425 --> 00:00:07.205
I'm, I, I flew V 22 for 23 years through EMD.

3
00:00:08.245 --> 00:00:10.325
I was the chief pilot on the cv,

4
00:00:11.545 --> 00:00:15.765
and then I also did army tests on the Chinook, um,

5
00:00:16.235 --> 00:00:19.485
with Al Wilson, wherever he is at that back here somewhere.

6
00:00:20.015 --> 00:00:24.005
There he is. So, um, currently I,

7
00:00:24.125 --> 00:00:25.365
I retired in 2020

8
00:00:25.665 --> 00:00:29.445
and I'm currently a consultant now of on flight test and,

9
00:00:29.985 --> 00:00:32.565
and flight controls, design and handling quality stuff.

10
00:00:33.465 --> 00:00:38.405
So I'm gonna talk about you, you probably heard me

11
00:00:38.405 --> 00:00:39.965
before, the head hands and heart.

12
00:00:40.025 --> 00:00:41.205
I'm gonna talk about the head here.

13
00:00:41.875 --> 00:00:44.325
This is how to build a risk management program,

14
00:00:45.025 --> 00:00:48.725
and I'm gonna use what RJ talked about with

15
00:00:49.365 --> 00:00:52.565
Wicker's paper, beaker's paper, all, I'm gonna refer to 'em

16
00:00:52.565 --> 00:00:57.405
as beaker and, uh, walk you through the ideas there

17
00:00:57.465 --> 00:01:00.285
and how we on the V 22 team did it.

18
00:01:01.105 --> 00:01:03.965
And for this, I'm gonna talk, uh,

19
00:01:04.975 --> 00:01:06.365
about flight loads.

20
00:01:06.755 --> 00:01:09.245
Something that all aircraft have to do, something

21
00:01:09.245 --> 00:01:11.685
that is really not emphasized in test pilot school.

22
00:01:12.225 --> 00:01:13.885
So I'm gonna give you a little flight loads.

23
00:01:13.885 --> 00:01:18.755
Course first risk management.

24
00:01:19.415 --> 00:01:22.875
If, uh, an interesting fact here I went, um,

25
00:01:23.065 --> 00:01:27.515
I've been updating this brief periodically since 2016.

26
00:01:28.335 --> 00:01:30.075
And each flight test safety workshop,

27
00:01:30.235 --> 00:01:31.715

I walk away with something different.

28
00:01:32.015 --> 00:01:33.355
And a couple of these papers

29
00:01:34.305 --> 00:01:36.555
that we've talked about really influenced,

30
00:01:37.055 --> 00:01:38.315
uh, update on this.

31
00:01:39.295 --> 00:01:41.315
Claude, can you, I don't need the notes.

32
00:01:41.735 --> 00:01:45.755
Can you just gimme the slide? Show me the slide.

33
00:01:45.755 --> 00:01:50.635
Yeah, that's fine. There you go. Um, risk management.

34
00:01:51.065 --> 00:01:54.915
Okay, uh, back in 2018,

35
00:01:55.575 --> 00:01:59.915
the 40 40 26 B used the traditional,

36
00:02:00.695 --> 00:02:04.275
uh, view of risk management as just, you know, we,

37
00:02:04.335 --> 00:02:08.075
we remember that little chart we have in our THA development

38
00:02:08.775 --> 00:02:12.155
as, as basically severity and probability.

39
00:02:12.385 --> 00:02:15.115
There's a big assumption there that you have some sort

40
00:02:15.115 --> 00:02:17.715
of experience in, in assessing that,

41
00:02:17.855 --> 00:02:20.635
and you can assess it in a, a reasonable fashion.

42
00:02:21.295 --> 00:02:25.355
In Wicker's paper, he brought out uncertainty, uncertainty

43
00:02:25.415 --> 00:02:28.395
and figuring out severity and probability uncertainty,

44
00:02:28.395 --> 00:02:31.235
and exactly what kind of hazards you're gonna run into.

45
00:02:32.335 --> 00:02:36.555
And that evolved into the new definition

46
00:02:36.555 --> 00:02:39.435
of 40, 40, 26 that you see here.

47
00:02:40.235 --> 00:02:42.355
I still think it could probably be written a little better,

48
00:02:43.095 --> 00:02:44.675
and I have a suggestion there.

49
00:02:45.855 --> 00:02:50.345
And the, the thing in my suggestion is

50
00:02:51.215 --> 00:02:53.705
it's the risk of running into that hazard

51
00:02:54.405 --> 00:02:58.745
and the uncertainty in realizing that hazard

52
00:02:59.665 --> 00:03:00.725
and realizing it.

53
00:03:00.825 --> 00:03:05.045
Now, we factor in what sort of severity

54
00:03:05.345 --> 00:03:09.125

or probability and the variability of both of those things.

55
00:03:13.135 --> 00:03:15.225
Something else out of 40, 40, 26.

56
00:03:15.735 --> 00:03:18.585
This is kind of the big principles that they put in.

57
00:03:19.525 --> 00:03:21.065
And I agree with these.

58
00:03:21.485 --> 00:03:25.785
Um, number one, except no unnecessary risk, you're gonna see

59
00:03:25.785 --> 00:03:27.345
that a couple times in my brief.

60
00:03:27.655 --> 00:03:29.865
It's gonna guide a lot of decisions

61
00:03:30.485 --> 00:03:32.065
in your risk mitigation plan.

62
00:03:32.765 --> 00:03:36.425
The second one, where you're going to reduce your risk

63
00:03:36.425 --> 00:03:37.705
to an acceptable level.

64
00:03:38.265 --> 00:03:41.865
I like to talk about this as a balancing act.

65
00:03:42.645 --> 00:03:45.745
The value of the data you're collecting versus

66
00:03:46.445 --> 00:03:48.705
the risk associated with collecting that data.

67
00:03:49.745 --> 00:03:54.215
So it's not just working on this side of the equation

68
00:03:54.215 --> 00:03:56.495
where you're trying to reduce risk to.

69
00:03:57.075 --> 00:03:58.895
You have to understand the value

70
00:03:58.895 --> 00:04:00.135
of the data you're collecting.

71
00:04:00.355 --> 00:04:04.135
At some point, you're gonna get to where in a test plan,

72
00:04:04.195 --> 00:04:06.535
you're collecting data you really don't need.

73
00:04:06.675 --> 00:04:09.215
And you need to know that, recognize it

74
00:04:09.275 --> 00:04:10.695
and say, I'm out of balance.

75
00:04:11.725 --> 00:04:15.335
Even if it is a, a less risky point, if there's no need

76
00:04:15.335 --> 00:04:18.255
to go do it, you're still accepting risk you don't need.

77
00:04:18.795 --> 00:04:21.575
And item number one there is gonna apply.

78
00:04:24.155 --> 00:04:27.535
So here's my view of the basics for risk mitigation,

79
00:04:28.815 --> 00:04:31.795
and I started out with risk analysis, use

80
00:04:31.795 --> 00:04:32.955
of expected results.

81
00:04:33.215 --> 00:04:35.555

That's kind of that thing that we were talking about.

82
00:04:35.915 --> 00:04:39.835
Reducing ignorance, bringing knowledge to the left,

83
00:04:41.215 --> 00:04:43.995
and then, uh, multidisciplinary execution,

84
00:04:44.005 --> 00:04:45.995
especially an envelope expansion.

85
00:04:46.495 --> 00:04:48.515
But even after envelope expansion,

86
00:04:48.615 --> 00:04:51.915
multidisciplinary execution really can save your bacon.

87
00:04:53.135 --> 00:04:56.035
And, uh, obviously the buildup

88
00:04:56.035 --> 00:04:57.515
concept as we've talked about.

89
00:04:57.935 --> 00:05:01.635
And in that buildup, real time trending to limits,

90
00:05:02.585 --> 00:05:04.715
also trending to expected results,

91
00:05:05.385 --> 00:05:07.235
that is something they are different.

92
00:05:08.255 --> 00:05:11.715
And then finally, use of a cessation of test protocols.

93
00:05:11.735 --> 00:05:14.195
And there's various flavors of this that I'll talk to.

94
00:05:14.975 --> 00:05:16.955
So these are the basics in my mind.

95
00:05:17.535 --> 00:05:22.235
And then we can enhance them like, um, RJ was talking about,

96
00:05:22.295 --> 00:05:23.795
and I have a couple things here.

97
00:05:23.905 --> 00:05:27.515
This is Marty's view of how to enhance them, how

98
00:05:27.515 --> 00:05:29.915
to operate in that random uncertainty area

99
00:05:29.915 --> 00:05:31.275
that we're talking about.

100
00:05:31.665 --> 00:05:34.675
Keeping your aperture open with a multidisciplinary team,

101
00:05:35.545 --> 00:05:38.675
assessing the margins almost real time.

102
00:05:39.465 --> 00:05:41.875
Know when you're about your, you've got no slack,

103
00:05:42.815 --> 00:05:46.725
and then increasing redundancy in your aircraft system,

104
00:05:46.745 --> 00:05:49.685
but not in that, but in your people processes.

105
00:05:50.595 --> 00:05:53.165
Make sure if you, you don't have single point failures

106
00:05:53.865 --> 00:05:55.085
and, and those sort of things.

107
00:05:55.145 --> 00:05:58.245
And we'll talk a little bit more about that at, at length.

108
00:05:59.685 --> 00:06:01.275

Let's talk about the V 22 first.

109
00:06:01.575 --> 00:06:03.355
Uh, I'm gonna talk about loads.

110
00:06:03.495 --> 00:06:05.035
So it's kind of important to understand.

111
00:06:05.105 --> 00:06:07.875
It's a partial, uh, authority.

112
00:06:08.425 --> 00:06:09.635
Flyable wire aircraft

113
00:06:10.625 --> 00:06:14.075
with blended controls has airplane controls like flap,

114
00:06:14.135 --> 00:06:16.755
perons and rudders and elevator, and,

115
00:06:16.815 --> 00:06:19.515
and then it has cyclic controls of the rotor.

116
00:06:20.045 --> 00:06:24.515
Collective pitch is used for thrust, whether you're in VTO

117
00:06:24.535 --> 00:06:25.635
or in airplane mode.

118
00:06:28.025 --> 00:06:30.205
The interesting thing that makes loads testing on this

119
00:06:30.755 --> 00:06:33.125
very complex aircraft, very interesting,

120
00:06:33.125 --> 00:06:37.205
is we have structural load limiting throughout the software.

121
00:06:38.745 --> 00:06:41.645
We, we control, we sense and control flapping.

122
00:06:42.465 --> 00:06:46.405
We control a OA, we control, uh, conversion.

123
00:06:47.465 --> 00:06:50.645
We have many aspects. We control torque.

124
00:06:53.145 --> 00:06:56.885
So all those things make loads.

125
00:06:57.075 --> 00:07:00.725
Testing on this aircraft, particularly interesting.

126
00:07:00.905 --> 00:07:04.485
You can see it still has a decent, uh, normal load, uh,

127
00:07:04.585 --> 00:07:07.285
factor envelope minus 0.5 to four.

128
00:07:08.185 --> 00:07:09.765
And you're talking about testing

129
00:07:10.965 --> 00:07:13.205
multiple different aircraft in the same airframe.

130
00:07:13.385 --> 00:07:16.645
So there is a lot to do with loads here.

131
00:07:18.315 --> 00:07:19.885
There's that beaker paper.

132
00:07:20.905 --> 00:07:23.445
I'm gonna talk about the first two bullets of his paper.

133
00:07:23.885 --> 00:07:26.405
I think, uh, RJ went over that just fine.

134
00:07:27.545 --> 00:07:28.885
Now I'm gonna take this

135
00:07:29.065 --> 00:07:32.365

and I'm gonna talk about each one of those sections

136
00:07:32.705 --> 00:07:35.085
and how our flight test principles support that.

137
00:07:36.925 --> 00:07:40.345
So the first three, the, the three

138
00:07:40.345 --> 00:07:43.545
that I've highlighted here, we do a traditional flight test.

139
00:07:46.645 --> 00:07:49.955
First of all, risk analysis kind of operates in that

140
00:07:50.825 --> 00:07:52.475
left hand side of the chart.

141
00:07:52.945 --> 00:07:54.235
This is from experience.

142
00:07:54.235 --> 00:07:57.435
This is the tpha, the ft, rws, whatever you want

143
00:07:57.435 --> 00:07:59.435
to use your terminology for.

144
00:08:00.025 --> 00:08:01.475
This is our severity

145
00:08:01.535 --> 00:08:03.995
and probability estimations, uh,

146
00:08:03.995 --> 00:08:05.515
the things we know about the aircraft.

147
00:08:06.295 --> 00:08:11.175
Um, and then we pull

148
00:08:12.335 --> 00:08:14.215
material to the left on this chart.

149
00:08:14.875 --> 00:08:19.055
We reduce ignorance by using expected results, ground tests,

150
00:08:19.615 --> 00:08:22.215
modeling, simulation, previous flight tests.

151
00:08:24.995 --> 00:08:28.415
And from that we're also, if you're building the airplane

152
00:08:28.475 --> 00:08:31.375
or new or whatever, you're gonna develop limitations,

153
00:08:31.375 --> 00:08:33.655
restrictions, and emergency procedures

154
00:08:34.385 --> 00:08:35.975
under this expected results.

155
00:08:37.775 --> 00:08:41.035
And then you're gonna apply your margins for flight tests.

156
00:08:41.415 --> 00:08:43.275
So you're gonna take those limits and you're gonna apply

157
00:08:43.275 --> 00:08:46.035
certain margins on those, on those limits

158
00:08:47.095 --> 00:08:49.835
to keep you safe based on your hazard analysis.

159
00:08:52.675 --> 00:08:56.805
And then the lower right, how do we handle uncertainty?

160
00:08:57.035 --> 00:08:59.765
This is where we start with the multidisciplinary team.

161
00:09:00.075 --> 00:09:02.725
Even for loads testing on the V 22,

162
00:09:03.305 --> 00:09:07.925

we have handle qualities, guys, we have ISTs in the room.

163
00:09:08.705 --> 00:09:11.525
We cover all the bases with a multidisciplinary team

164
00:09:11.525 --> 00:09:14.285
because we just don't know where things are gonna go.

165
00:09:14.945 --> 00:09:17.805
And oftentimes our margins are

166
00:09:17.805 --> 00:09:19.765
so thin in all of those regions.

167
00:09:19.795 --> 00:09:21.605
Performance handling qualities

168
00:09:21.705 --> 00:09:22.765
and flight controls

169
00:09:22.765 --> 00:09:27.455
that we need all those guys Build up concept.

170
00:09:29.035 --> 00:09:31.055
The thing we're talking about, you learn in test pilot

171
00:09:31.055 --> 00:09:33.295
school where we're gonna build up

172
00:09:33.295 --> 00:09:37.535
and maneuver type maneuver inputs and in test conditions.

173
00:09:38.835 --> 00:09:42.775
And then finally use of realtime trending to limits.

174
00:09:43.475 --> 00:09:44.895
You do that with the buildup,

175
00:09:45.835 --> 00:09:49.295
and you do it not only to limits, but to expected results.

176
00:09:49.595 --> 00:09:51.935
You don't have to hit a limit to knock it off.

177
00:09:52.195 --> 00:09:55.255
If you start to diverge from your expected results.

178
00:09:55.435 --> 00:09:58.775
Say, you know, you've previously tested an aircraft.

179
00:09:58.955 --> 00:10:01.495
We do this in V 22 with software loads a lot.

180
00:10:01.555 --> 00:10:02.895
We get a software change

181
00:10:03.245 --> 00:10:04.855
that may affect structural load limiting.

182
00:10:05.305 --> 00:10:07.335
We'll go out there, we'll be doing our loads testing

183
00:10:07.465 --> 00:10:11.615
where we're tracking our previous tests of loads,

184
00:10:11.875 --> 00:10:13.455
and we start to diverge from that.

185
00:10:13.635 --> 00:10:15.295
We stop before we hit any limits

186
00:10:15.295 --> 00:10:18.375
because we may go really non-linear very fast

187
00:10:18.965 --> 00:10:21.895
because the structural load limiting interactions

188
00:10:22.325 --> 00:10:23.455
tend to be non-linear.

189
00:10:26.905 --> 00:10:28.045

And then we use knock it off.

190
00:10:28.915 --> 00:10:32.085
This is, gets back to that very first principle

191
00:10:32.085 --> 00:10:33.925
that's in 40 40, 26.

192
00:10:34.305 --> 00:10:36.205
Accept no unnecessary risk.

193
00:10:37.355 --> 00:10:41.325
Have rules in place to tell you, stop

194
00:10:42.075 --> 00:10:45.485
this test point is not gonna get us the data that we need,

195
00:10:46.665 --> 00:10:48.525
and we don't want to accept that risk.

196
00:10:51.305 --> 00:10:52.325
So let's go a little deeper.

197
00:10:52.555 --> 00:10:57.405
Risk analysis tpha, um, the big deal here, you know,

198
00:10:57.405 --> 00:11:00.445
I've got two bullets here that covers some of the details.

199
00:11:01.465 --> 00:11:05.245
The big thing to remember is the THA is test specific.

200
00:11:06.225 --> 00:11:10.025
So think test technique, the system under test

201
00:11:10.045 --> 00:11:11.785
and the environment, you're testing it in.

202
00:11:12.035 --> 00:11:15.825
Those three things. Feed that hazard analysis.

203
00:11:19.695 --> 00:11:21.555
And then you have some of these other issues.

204
00:11:22.415 --> 00:11:24.355
You know, the, the maturity

205
00:11:24.355 --> 00:11:27.355
of the aircraft early on when you're just starting

206
00:11:27.355 --> 00:11:29.115
with an aircraft, you're gonna have all sorts

207
00:11:29.115 --> 00:11:31.595
of different things that could, could inform this.

208
00:11:31.655 --> 00:11:35.555
The FIA analysis, the FTAs, FHAs,

209
00:11:35.945 --> 00:11:37.195
yeah, all that.

210
00:11:37.245 --> 00:11:40.395
Those things that are just, they're really painful to go

211
00:11:40.395 --> 00:11:44.595
through, but they can inform your testing, especially on,

212
00:11:44.775 --> 00:11:47.475
on a, a first, first of a kind prototype.

213
00:11:48.545 --> 00:11:52.315
Also, there's STPA, which you, we hear about a lot.

214
00:11:52.375 --> 00:11:53.765
The systems theoretical process.

215
00:11:54.945 --> 00:11:56.245
It, it has,

216
00:11:56.345 --> 00:11:58.845

it is a little different than than the first three in

217
00:11:58.845 --> 00:12:03.005
that it brings in the control loops, the human control loops

218
00:12:03.105 --> 00:12:04.125
and examines them.

219
00:12:04.945 --> 00:12:09.005
The others really focus on the aircraft. So STPA is tough.

220
00:12:09.565 --> 00:12:12.805
I i, I am not smart on it

221
00:12:12.985 --> 00:12:14.645
and I have not used it much,

222
00:12:15.425 --> 00:12:19.125
but guys that have done it really swear by it.

223
00:12:19.665 --> 00:12:22.285
Uh, but it takes a little bit to get there.

224
00:12:22.995 --> 00:12:24.725
There's a lot of work to be done there.

225
00:12:25.935 --> 00:12:27.365
Other resources, frankly,

226
00:12:27.395 --> 00:12:30.365
this is the way you do t HHAs mostly experience.

227
00:12:31.385 --> 00:12:34.685
Um, and you bring in other things.

228
00:12:34.945 --> 00:12:37.645
You know, we have the database that we have

229
00:12:37.645 --> 00:12:40.925
with the flight test safety workshop, um, you,

230
00:12:41.565 --> 00:12:43.245
industry guidance, whatever you can,

231
00:12:43.565 --> 00:12:46.245
wherever you can glean anything on that hazard

232
00:12:47.505 --> 00:12:49.365
or develop the hazards associated

233
00:12:49.365 --> 00:12:51.125
with the test technique that you're gonna do.

234
00:12:52.225 --> 00:12:54.925
Um, cut and paste is not a bad thing here.

235
00:12:56.035 --> 00:12:58.445
Just understand that after you do the cut

236
00:12:58.445 --> 00:13:00.005
and paste, you do the next step.

237
00:13:00.005 --> 00:13:01.525
Number three, brainstorming.

238
00:13:01.525 --> 00:13:04.645
You sit down and you say, is that correct

239
00:13:05.025 --> 00:13:07.805
for the current configuration of our aircraft?

240
00:13:08.745 --> 00:13:11.165
And do I have this hazard nailed down?

241
00:13:11.305 --> 00:13:15.485
Is there anything else I'm missing with this test technique?

242
00:13:19.495 --> 00:13:22.985
And again, can't emphasize this is enough

243
00:13:22.985 --> 00:13:24.225

multidisciplinary approach.

244
00:13:24.325 --> 00:13:26.745
Too often, even in the V 22,

245
00:13:27.515 --> 00:13:29.345
we've got one guy writing the test plan,

246
00:13:29.805 --> 00:13:31.545
one guy drafting the ths,

247
00:13:32.045 --> 00:13:33.665
and then he sends it out for a review

248
00:13:34.285 --> 00:13:36.585
and nobody, no comments come back on the review.

249
00:13:37.075 --> 00:13:40.465
Wrong answer. This is a multidisciplinary approach.

250
00:13:41.365 --> 00:13:44.465
And, and if you're doing it right, it,

251
00:13:44.525 --> 00:13:47.585
you can see these hazards coming from different directions.

252
00:13:47.595 --> 00:13:49.545
We're doing loads testing, but guess what?

253
00:13:50.125 --> 00:13:52.705
We have different kind of hazards that we have to deal

254
00:13:52.705 --> 00:13:54.265
with while we're doing the loads testing.

255
00:13:55.125 --> 00:13:59.945
So let's take a look. Here's, here's our list

256
00:14:00.045 --> 00:14:04.345
of flight loads, test hazards for the test event

257
00:14:04.345 --> 00:14:05.385
that I'm gonna talk to.

258
00:14:06.045 --> 00:14:10.305
The one I'm looking at is a rolling pull up at 55 knots.

259
00:14:10.975 --> 00:14:14.065
It's a really ugly point for the V 22,

260
00:14:14.965 --> 00:14:16.745
and we're doing it at high altitude.

261
00:14:18.485 --> 00:14:19.825
So we have a couple of things here.

262
00:14:20.765 --> 00:14:22.585
The the first one is kind of obvious.

263
00:14:23.105 --> 00:14:25.105
I mean, it's, you know, it's a loads test.

264
00:14:25.245 --> 00:14:28.385
You, you fail it and you end up bending something.

265
00:14:29.285 --> 00:14:31.905
Um, but the others are a little less obvious.

266
00:14:32.755 --> 00:14:36.625
These are some of the maneuvers that we build up to

267
00:14:36.625 --> 00:14:38.305
that rolling pole, like the wind up turn.

268
00:14:38.305 --> 00:14:40.385
You can get some special disorientation.

269
00:14:41.285 --> 00:14:44.705
We have loss of longitudinal control if you get too slow.

270
00:14:45.685 --> 00:14:49.705

And, um, and then divergent oscillation.

271
00:14:50.435 --> 00:14:53.605
These, if you look at 'em, they are multidisciplinary.

272
00:14:53.995 --> 00:14:56.805
It's not loads related. This is, this is outta the box.

273
00:14:56.955 --> 00:15:01.805
It's it's aerodynamics handling qualities, performance, all

274
00:15:01.805 --> 00:15:04.085
of those things start to figure in.

275
00:15:05.765 --> 00:15:07.185
So multidisciplinary.

276
00:15:08.245 --> 00:15:10.505
And then those three things that I talked about,

277
00:15:10.535 --> 00:15:12.265
test technique system under test

278
00:15:12.285 --> 00:15:15.545
and flight condition caused it.

279
00:15:15.985 --> 00:15:18.945
Identification. If, if you're doing a loads test, one

280
00:15:18.945 --> 00:15:20.745
of your first things you should put down is

281
00:15:20.745 --> 00:15:22.425
failing that loads test.

282
00:15:22.805 --> 00:15:25.545
So that's an obvious, uh, root cause.

283
00:15:26.325 --> 00:15:29.105
You, you bent something here, we have it in different forms.

284
00:15:29.205 --> 00:15:33.705
We have critical flapping, we have, uh, over torque

285
00:15:34.005 --> 00:15:36.865
of the gear boxes, and then we have all

286
00:15:37.485 --> 00:15:40.425
actual structural load exceedance on the

287
00:15:40.435 --> 00:15:41.545
rotor or the airframe.

288
00:15:43.045 --> 00:15:45.025
And the other thing is, you have

289
00:15:45.025 --> 00:15:48.425
to consider maybe the pilot messing it up.

290
00:15:49.765 --> 00:15:52.145
He could contribute to any of those other causes

291
00:15:53.035 --> 00:15:54.695
or do something else.

292
00:15:55.275 --> 00:15:59.255
So make sure you include that failure, if you will,

293
00:15:59.355 --> 00:16:02.255
in your cause identification effect.

294
00:16:02.285 --> 00:16:05.375
There's, there's oftentimes you, we get the wrapped

295
00:16:05.375 --> 00:16:06.375
around the axle trying

296
00:16:06.375 --> 00:16:09.095
to figure out hazard versus effect and everything like that.

297
00:16:09.555 --> 00:16:13.175

An easy way to determine if it's an effect is can you grade

298
00:16:13.175 --> 00:16:14.895
it in order of severity?

299
00:16:15.795 --> 00:16:18.175
That's an effect. So, you know,

300
00:16:18.175 --> 00:16:19.695
break it a little bit, break it a lot.

301
00:16:21.395 --> 00:16:22.655
So let's take the top one,

302
00:16:23.235 --> 00:16:25.055
and I'm gonna run down it real quick.

303
00:16:25.245 --> 00:16:27.575
This is the, the big one for flight loads.

304
00:16:28.435 --> 00:16:30.935
So there's a couple of best practices.

305
00:16:31.075 --> 00:16:34.415
I'm not gonna go through all the details of this, um,

306
00:16:35.525 --> 00:16:37.825
but I'm gonna show you some of the things

307
00:16:38.425 --> 00:16:40.425
a good THA should have in my opinion.

308
00:16:41.445 --> 00:16:44.825
Number one is avoid getting tangled up

309
00:16:45.325 --> 00:16:48.505
and trying to figure out, you know, chicken and egg here.

310
00:16:48.925 --> 00:16:52.345
If I, if, if the pilot say Misapply controls

311
00:16:52.345 --> 00:16:53.945
and does the wrong recovery procedure,

312
00:16:54.005 --> 00:16:55.385
he may over flap the rotor,

313
00:16:55.565 --> 00:16:58.625
but you may also over flap the rotor in in another way.

314
00:16:58.835 --> 00:17:01.705
Which one do you put in? Put 'em both in, just list 'em all.

315
00:17:02.325 --> 00:17:04.945
And, and then when you do the precautionary measures,

316
00:17:04.945 --> 00:17:07.225
you'll sort out, you know, all those,

317
00:17:07.285 --> 00:17:08.905
you'll make sure you address 'em all.

318
00:17:08.905 --> 00:17:10.985
And I think you're gonna find it works out just fine.

319
00:17:11.635 --> 00:17:13.385
Don't get too wrapped around the axle.

320
00:17:13.965 --> 00:17:17.505
Uh, the other thing is on the cause I start to number them

321
00:17:18.015 --> 00:17:19.185
because why?

322
00:17:19.185 --> 00:17:22.065
Because when I get to precautionary me measures,

323
00:17:22.625 --> 00:17:26.185
I wanna link those measures to the causes to make sure

324
00:17:26.185 --> 00:17:29.065

that I've addressed all of those causes.

325
00:17:34.705 --> 00:17:37.925
And then we're gonna put the initial risk assessment.

326
00:17:37.925 --> 00:17:39.965
This is the unmitigated risk assessment.

327
00:17:41.275 --> 00:17:45.365
This is how bad it can be if you don't do anything,

328
00:17:45.425 --> 00:17:47.365
if you don't use any of your control measures.

329
00:17:49.135 --> 00:17:51.355
And then you're gonna list your precautionary measures

330
00:17:52.095 --> 00:17:53.395
and I put 'em in order.

331
00:17:53.745 --> 00:17:56.715
This is, uh, a recommendation, uh,

332
00:17:57.465 --> 00:17:59.195
from Keith, wherever you are.

333
00:17:59.695 --> 00:18:02.875
And I like this idea, it's something we do is

334
00:18:03.655 --> 00:18:07.075
put it in order of this stuff that's been pre-planned,

335
00:18:07.195 --> 00:18:08.835
pre-done for your test.

336
00:18:09.545 --> 00:18:10.795
Then the stuff you're gonna brief

337
00:18:10.855 --> 00:18:12.795
and then the stuff you're gonna execute in flight.

338
00:18:13.615 --> 00:18:18.595
Too many times it's been death by THA reading in a, in a,

339
00:18:18.915 --> 00:18:22.875
a pre-test, uh, brief where we read everything.

340
00:18:23.205 --> 00:18:25.795
Don't do that. It's gonna kill everybody.

341
00:18:25.865 --> 00:18:28.115
They're, they're all gonna stop listening halfway

342
00:18:28.115 --> 00:18:31.155
through the second THA and, and you're getting nothing done.

343
00:18:32.135 --> 00:18:34.555
Figure out what you really need to brief.

344
00:18:34.785 --> 00:18:37.595
Everybody in the test team should have read

345
00:18:37.595 --> 00:18:41.635
that test plan should have, should already have, um,

346
00:18:41.945 --> 00:18:43.515
knowledge of those tpha.

347
00:18:43.535 --> 00:18:45.195
And you hit the high points, frankly.

348
00:18:45.855 --> 00:18:49.115
And, and it helps if you organize a precautionary, uh,

349
00:18:49.115 --> 00:18:50.115
measures in that order,

350
00:18:51.385 --> 00:18:53.635
then you have a corrective action beyond that.

351
00:18:53.945 --> 00:18:56.315

That is, if all your precautionary measures

352
00:18:56.385 --> 00:18:57.995
fail, what are you gonna do?

353
00:18:58.305 --> 00:18:59.995
Even if you've encountered that hazard

354
00:19:00.585 --> 00:19:02.435
probability now is a hundred percent.

355
00:19:02.615 --> 00:19:04.675
So you're not mitigating probability,

356
00:19:04.675 --> 00:19:07.115
you're mitigating severity at this point.

357
00:19:07.415 --> 00:19:09.035
So figure out if there's a way

358
00:19:09.575 --> 00:19:12.595
to get your aircraft back home in one piece.

359
00:19:15.195 --> 00:19:17.255
And then finally, residual hazard.

360
00:19:18.485 --> 00:19:22.375
This is after the pro precautionary measures

361
00:19:22.515 --> 00:19:24.735
and the corrective actions have been employed.

362
00:19:25.235 --> 00:19:28.735
What's your residual? And I like to list both of those.

363
00:19:30.365 --> 00:19:33.935
That tells you how many slices of Swiss cheese you have.

364
00:19:34.955 --> 00:19:38.015
You know, the old Swiss cheese model, if you've got a ton

365
00:19:38.015 --> 00:19:40.935
of control measures, um, that's tough.

366
00:19:41.355 --> 00:19:44.535
Uh, it's, it's making your test that much more complex

367
00:19:44.715 --> 00:19:47.735
and complexity can be deadly.

368
00:19:51.125 --> 00:19:54.425
So let's look at, uh, the aspect

369
00:19:54.485 --> 00:19:57.585
of pushing knowledge from the right to the left,

370
00:19:59.625 --> 00:20:01.525
that's expected results.

371
00:20:02.895 --> 00:20:04.515
So one of the things to understand here,

372
00:20:04.855 --> 00:20:07.595
and we we've seen it a lot on the V 22, was

373
00:20:07.595 --> 00:20:10.555
that the guys are out there doing the modeling,

374
00:20:10.695 --> 00:20:14.155
the simulation, the development of, of, of, uh, and,

375
00:20:14.175 --> 00:20:15.435
and the loads analysis.

376
00:20:15.895 --> 00:20:17.595
But they're doing it to specification.

377
00:20:17.785 --> 00:20:19.595
They're not doing it to help you

378
00:20:19.615 --> 00:20:21.235

as a flight tester necessarily.

379
00:20:21.855 --> 00:20:25.395
You need to understand that, that all of that stuff there is

380
00:20:25.775 --> 00:20:27.635
for them to make sure it meets spec

381
00:20:27.975 --> 00:20:31.075
and it's ready to go in the can and they give it to you.

382
00:20:31.175 --> 00:20:34.475
And then you'll turn around sometimes and say, I need more.

383
00:20:35.295 --> 00:20:36.435
And that's a tough sell.

384
00:20:38.295 --> 00:20:39.315
But one

385
00:20:39.315 --> 00:20:43.115
of the things the B 22 team guys here have heard me say

386
00:20:43.115 --> 00:20:46.475
many, many times is the flight test plan is a contract.

387
00:20:47.345 --> 00:20:49.365
We had the luxury on the V 22 team

388
00:20:50.105 --> 00:20:53.805
of being a government controlled test team that

389
00:20:54.785 --> 00:20:56.285
didn't work under engineering.

390
00:20:56.305 --> 00:20:59.245
We had Boeing and Bell Engineering feeding us our,

391
00:20:59.385 --> 00:21:01.245
our test matrices and that sort of thing.

392
00:21:01.705 --> 00:21:03.965
And we didn't even work under the program office.

393
00:21:04.265 --> 00:21:05.845
So we had that luxury.

394
00:21:06.065 --> 00:21:09.525
So our, our risk was being a little too conservative,

395
00:21:10.305 --> 00:21:14.765
but we always went into a negotiation with the guys

396
00:21:14.795 --> 00:21:16.405
that were asking for the data

397
00:21:16.995 --> 00:21:19.365
because we were the guys that had to collect the data.

398
00:21:20.225 --> 00:21:23.405
And, and it helps to start that way early.

399
00:21:24.465 --> 00:21:25.645
Um, even

400
00:21:25.645 --> 00:21:27.885
before the test matrix is finalized,

401
00:21:27.985 --> 00:21:29.885
you start learning what's coming your way.

402
00:21:30.255 --> 00:21:33.565
Start, start prepping engineering and management.

403
00:21:33.825 --> 00:21:35.765
Get 'em, get 'em used to the idea

404
00:21:35.765 --> 00:21:37.285
that you're gonna be asking for something.

405
00:21:37.285 --> 00:21:41.285

Sometimes we ask for more simulations, sometimes rehearsals

406
00:21:41.395 --> 00:21:44.085
with the test team, depending on what we were doing.

407
00:21:44.865 --> 00:21:47.245
So the big thing here is just coach engineering

408
00:21:47.245 --> 00:21:48.845
and management and,

409
00:21:49.025 --> 00:21:51.685
and let them know that there's something additional out

410
00:21:51.685 --> 00:21:53.285
there to the engineering.

411
00:21:56.345 --> 00:21:58.915
Some of the general stuff, the pre-test,

412
00:21:58.915 --> 00:22:02.835
general homework limitations, restrictions.

413
00:22:03.225 --> 00:22:04.715
This is just the V 22.

414
00:22:04.905 --> 00:22:08.795
There's a whole laundry list of things that we had to, to

415
00:22:09.465 --> 00:22:10.675
know what was going on.

416
00:22:10.705 --> 00:22:12.995
Each one of 'em had little different flavors,

417
00:22:12.995 --> 00:22:16.755
like the flight clearance was by tail number, often referred

418
00:22:16.755 --> 00:22:18.595
to a given test plan for

419
00:22:19.335 --> 00:22:22.115
relief on certain restrictions for that test plan.

420
00:22:22.815 --> 00:22:26.075
Um, but then you had, uh, an old placard document

421
00:22:26.105 --> 00:22:27.435
that we still referred to.

422
00:22:27.465 --> 00:22:29.675
That was what we operated under EMD

423
00:22:30.145 --> 00:22:32.795
that had the basic limitations that we came

424
00:22:32.795 --> 00:22:33.995
to the V 22 with.

425
00:22:34.655 --> 00:22:38.835
Uh, and eventually it got it, it got

426
00:22:39.475 --> 00:22:42.115
replaced entirely by the Nair flight clearance.

427
00:22:42.255 --> 00:22:45.515
But at one point we had both of those documents in play.

428
00:22:46.135 --> 00:22:48.795
And then each team, uh, had their own

429
00:22:49.305 --> 00:22:53.115
emergency type adjustments for, you know, short notice.

430
00:22:53.175 --> 00:22:54.275
And that's the cares

431
00:22:54.275 --> 00:22:56.915
and flash grams that we had cares from Boeing,

432
00:22:56.935 --> 00:23:00.435

the flash grams from Bell, we had to manage that.

433
00:23:00.935 --> 00:23:04.915
And that was often by tail number, sometimes software load.

434
00:23:05.735 --> 00:23:09.945
Uh, our aircrew checklists we were responsible for,

435
00:23:10.845 --> 00:23:15.025
but the checklist often had certain components in them

436
00:23:15.025 --> 00:23:16.825
that were software specific

437
00:23:16.925 --> 00:23:21.545
or configuration specific that we, we had to, to control.

438
00:23:22.365 --> 00:23:24.425
And then finally there was a software, SOP

439
00:23:24.425 --> 00:23:26.185
that which was this massive document

440
00:23:26.185 --> 00:23:29.105
of all these little things that can, can crop up.

441
00:23:29.485 --> 00:23:32.745
Um, eventually we ended up with a flight manual.

442
00:23:33.325 --> 00:23:35.905
And so the flight clearance would refer to the flight manual

443
00:23:35.965 --> 00:23:37.065
and then tell you where you had

444
00:23:37.065 --> 00:23:38.145
relief from the flight manual.

445
00:23:38.285 --> 00:23:40.145
But this can be

446
00:23:40.785 --> 00:23:43.545
a monumental problem when you start stacking all this stuff

447
00:23:43.685 --> 00:23:45.845
up and, and having to brief it.

448
00:23:46.225 --> 00:23:49.405
Um, it's important. A couple things to remember there.

449
00:23:49.655 --> 00:23:52.045
Understand the precedence, understand

450
00:23:52.045 --> 00:23:53.405
what you can and can't do.

451
00:23:53.875 --> 00:23:56.405
Generally as a test team, with all

452
00:23:56.405 --> 00:23:59.685
of these guidance sent our way, we could not make it.

453
00:24:00.345 --> 00:24:03.845
Uh, we less stringent. We could only make it more stringent.

454
00:24:05.225 --> 00:24:07.285
And then it's important to understand the basis

455
00:24:07.705 --> 00:24:10.765
of your limitations so you can gain relief on them.

456
00:24:11.435 --> 00:24:12.725
Some are hard to gain relief.

457
00:24:12.885 --> 00:24:14.645
I mean, some are are hard limits.

458
00:24:14.785 --> 00:24:17.485
You cross that line, something really bad happens to you.

459
00:24:17.705 --> 00:24:20.525

Others are out there because you just don't have enough test

460
00:24:20.555 --> 00:24:24.165
data and nav air hasn't approved an, uh,

461
00:24:24.275 --> 00:24:25.645
that much more envelope.

462
00:24:25.745 --> 00:24:27.845
So it's important to understand where you are

463
00:24:28.105 --> 00:24:31.605
and what it takes to move that limitation a little bit.

464
00:24:33.505 --> 00:24:37.475
Emergency procedures, uh, every startup gets

465
00:24:37.475 --> 00:24:38.555
to try to develop this.

466
00:24:38.555 --> 00:24:42.795
This is a painful process. This is the process we used.

467
00:24:43.225 --> 00:24:44.675
This is the process we used

468
00:24:44.845 --> 00:24:48.755
after we had multiple accidents in the 2000,

469
00:24:49.095 --> 00:24:50.435
2001 regime.

470
00:24:51.535 --> 00:24:55.915
We went back, we had a 24 month, uh, pause, and we went back

471
00:24:55.935 --> 00:24:57.475
and looked at single double

472
00:24:57.535 --> 00:24:59.755
and triple fails compound failures.

473
00:25:00.575 --> 00:25:03.315
We had multidisciplinary team that sat down

474
00:25:03.935 --> 00:25:08.395
and we analyzed the system, how it was gonna accommodate

475
00:25:08.395 --> 00:25:13.235
that failure and, uh, what kind of indications the crew had.

476
00:25:13.655 --> 00:25:17.235
We went into a simulation environment and looked at that

477
00:25:17.335 --> 00:25:19.995
and tried to make sure we understood it.

478
00:25:20.375 --> 00:25:23.675
And then we built our checklist to work with,

479
00:25:25.105 --> 00:25:28.355
work with those annunciations In that accommodation.

480
00:25:28.355 --> 00:25:31.075
The aircraft had huge improvement in

481
00:25:31.075 --> 00:25:32.115
our emergency procedures.

482
00:25:32.175 --> 00:25:33.515
It was monstrous, the change

483
00:25:33.515 --> 00:25:36.155
that occurred once we started doing the process.

484
00:25:36.365 --> 00:25:39.395
Right. I really can't emphasize enough

485
00:25:39.395 --> 00:25:41.275
that this is really important to do.

486
00:25:41.545 --> 00:25:42.635

It's hard, it's painful.

487
00:25:43.345 --> 00:25:46.155
It's especially painful to get a multidisciplinary team

488
00:25:46.175 --> 00:25:48.475
to work out, uh, work on this.

489
00:25:48.615 --> 00:25:52.085
But, um, I recommend it. Yeah.

490
00:25:52.985 --> 00:25:54.885
Can you define system accommodation?

491
00:25:55.235 --> 00:25:57.885
Yeah. How the system reacts, how it fault reacts.

492
00:25:58.545 --> 00:26:03.125
So on on the B 22, we had a hydraulic system that was,

493
00:26:03.665 --> 00:26:05.245
was high pressure, low volume.

494
00:26:05.705 --> 00:26:07.605
So it had a leak detection algorithm,

495
00:26:07.905 --> 00:26:10.285
and it had all these isolation algorithms.

496
00:26:10.745 --> 00:26:13.125
So when you had a leak for instance, all sorts of stuff

497
00:26:13.645 --> 00:26:16.765
happened under, and you had to understand what you were left

498
00:26:16.765 --> 00:26:17.805
with after that.

499
00:26:18.545 --> 00:26:19.805
So it, and, and,

500
00:26:20.105 --> 00:26:23.365
and sometimes it was a gradual degradation,

501
00:26:23.465 --> 00:26:26.085
you may say a leak detected and then it,

502
00:26:26.345 --> 00:26:29.845
and you know, what is gonna come next, those sort of things.

503
00:26:30.545 --> 00:26:33.685
In the early days, we didn't differentiate hydraulic

504
00:26:33.685 --> 00:26:36.045
failures from, uh, flight control failures.

505
00:26:36.305 --> 00:26:38.725
It was all the same. And we had A-P-F-C-S reset

506
00:26:39.155 --> 00:26:40.245
cost us an aircraft.

507
00:26:40.945 --> 00:26:45.565
Uh, so we learned how to better do that

508
00:26:45.565 --> 00:26:47.165
through this kind of process.

509
00:26:51.675 --> 00:26:53.485
Some other stuff with expected results,

510
00:26:53.835 --> 00:26:55.165
application of margins.

511
00:26:55.785 --> 00:26:58.325
The important thing here is you gotta know

512
00:26:58.325 --> 00:27:00.805
what parameter you're really tracking for that buildup.

513
00:27:01.505 --> 00:27:04.325

You know, uh, we generally in test planning,

514
00:27:04.625 --> 00:27:05.805
put a big target band,

515
00:27:05.805 --> 00:27:07.445
you we're gonna build up a gross weight

516
00:27:07.445 --> 00:27:09.925
and we're gonna build up in density altitude, for instance.

517
00:27:10.715 --> 00:27:14.245
Well, is that really the parameter that's controlling loads?

518
00:27:14.465 --> 00:27:18.085
No, not really. For flight loads that for us rotor loads,

519
00:27:18.835 --> 00:27:22.365
it's, it's load factor times gross weight divided

520
00:27:22.505 --> 00:27:24.325
by the density altitude ratio.

521
00:27:24.505 --> 00:27:27.365
That's the proper parameter for, for load.

522
00:27:27.985 --> 00:27:32.715
And then if you're pushing up against, uh, say, uh, um,

523
00:27:32.725 --> 00:27:34.235
retreating blade stall, now you have

524
00:27:34.235 --> 00:27:37.435
to include advanced ratio, which is basically the,

525
00:27:37.455 --> 00:27:39.715
the rotor speed versus your velocity.

526
00:27:41.775 --> 00:27:44.875
So it's understanding those parameters that you need.

527
00:27:45.815 --> 00:27:50.235
And then one thing I always like to ask the engineers was,

528
00:27:51.295 --> 00:27:52.665
where's your analysis weak?

529
00:27:52.895 --> 00:27:55.385
Because I need to know where I have high confidence

530
00:27:55.385 --> 00:27:57.025
and low confidence on parameters.

531
00:27:57.965 --> 00:27:59.585
And if a guy says he doesn't know,

532
00:27:59.585 --> 00:28:02.185
because a lot of engineers are using these fancy tools

533
00:28:02.205 --> 00:28:04.025
and they just don't understand the assumptions,

534
00:28:04.025 --> 00:28:07.025
underlying assumptions of those, it's important to ask that

535
00:28:07.045 --> 00:28:08.945
and say, where's your weak?

536
00:28:09.555 --> 00:28:13.305
Where are you weak? So I understand where my confidence, uh,

537
00:28:13.365 --> 00:28:14.825
should be down a little bit.

538
00:28:15.685 --> 00:28:17.465
And that leads to that next bullet.

539
00:28:17.925 --> 00:28:20.585
And then the last bullet's kind of a no brainer.

540
00:28:21.565 --> 00:28:23.145

Can you really track that parameter

541
00:28:23.145 --> 00:28:24.425
to the accuracy you need?

542
00:28:24.735 --> 00:28:27.225
It's important to ask that we've, we got,

543
00:28:27.565 --> 00:28:29.305
we got burned on a flight test one time

544
00:28:29.305 --> 00:28:31.985
because we just weren't tracking the right parameter

545
00:28:32.205 --> 00:28:34.665
and we didn't have the fidelity we needed on it.

546
00:28:35.085 --> 00:28:36.785
We just wasted some time out there.

547
00:28:41.415 --> 00:28:43.835
So let's use that, those concepts

548
00:28:43.895 --> 00:28:45.835
and look at load margin as an example.

549
00:28:46.015 --> 00:28:49.155
Now you're getting it to my, my primer on loads testing.

550
00:28:50.335 --> 00:28:54.395
Um, on the V 22, we set static alert limits

551
00:28:54.695 --> 00:28:55.995
for our flight test limits.

552
00:28:57.055 --> 00:29:01.275
And they're based on various things that are, we're fed for,

553
00:29:01.775 --> 00:29:03.555
for failure analysis, all the way down

554
00:29:03.555 --> 00:29:05.715
to actual cycle failures.

555
00:29:06.775 --> 00:29:11.355
And, and then on that static alert limit, we're gonna set

556
00:29:12.465 --> 00:29:15.865
a warning below that to tell us we're getting close,

557
00:29:16.975 --> 00:29:18.585
typically about 80%,

558
00:29:19.365 --> 00:29:21.985
but we're gonna adjust that warning level according to our

559
00:29:22.585 --> 00:29:24.025
expected nominal operation.

560
00:29:24.045 --> 00:29:26.025
So if we're gonna be operating way high, close

561
00:29:26.025 --> 00:29:27.745
to the warning, we might bump it up a little bit

562
00:29:27.745 --> 00:29:29.065
to give ourselves a little more margin.

563
00:29:30.165 --> 00:29:32.065
Um, if we're gonna operate way low,

564
00:29:32.085 --> 00:29:33.825
we might wanna lower it a little bit

565
00:29:34.485 --> 00:29:36.825
so we know we're starting to move,

566
00:29:37.055 --> 00:29:38.185
move in the wrong direction.

567
00:29:38.885 --> 00:29:39.985

I'm sorry, that's my phone.

568
00:29:44.225 --> 00:29:48.045
Thanks Jude. Probably my mom.

569
00:29:49.665 --> 00:29:52.085
So, so knowing that,

570
00:29:52.275 --> 00:29:55.165
then we can apply knockdowns on our flight test limits,

571
00:29:55.225 --> 00:29:57.825
and that's what we do, you know, so

572
00:29:59.655 --> 00:30:01.225
less confidence, more knockdown.

573
00:30:01.525 --> 00:30:03.385
Say you knock it down by 50%,

574
00:30:04.565 --> 00:30:08.065
and we're talking on not just a couple of parameters,

575
00:30:08.065 --> 00:30:11.465
we're talking on a thousand parameters, 2000 parameters

576
00:30:11.605 --> 00:30:14.545
of the aircraft, but we have to look at the ones

577
00:30:14.545 --> 00:30:16.985
that really are impacting us for loads

578
00:30:16.985 --> 00:30:18.385
and make sure we understand them.

579
00:30:18.615 --> 00:30:23.305
Then this is static limits. Guess what? V 22 is rotorcraft.

580
00:30:23.685 --> 00:30:26.425
We got this device up there pumping

581
00:30:27.435 --> 00:30:28.745
loads into our system.

582
00:30:29.365 --> 00:30:31.545
So we have oscillatory limits also.

583
00:30:32.525 --> 00:30:34.625
And with that comes fatigue.

584
00:30:35.285 --> 00:30:38.595
So fatigue, you, you,

585
00:30:38.595 --> 00:30:42.835
anybody who's bent a a paperclip knows that you know,

586
00:30:42.975 --> 00:30:45.435
one bend, you don't break it, but multiple times

587
00:30:45.695 --> 00:30:47.395
and you can break it with a light load.

588
00:30:47.975 --> 00:30:49.435
That's what happens with fatigue.

589
00:30:49.895 --> 00:30:53.115
So we have to understand our fatigue loads.

590
00:30:53.115 --> 00:30:56.035
We have to understand the components in the aircraft

591
00:30:56.035 --> 00:30:57.955
that are undergoing fatigue.

592
00:30:58.265 --> 00:31:01.515
Potentially. The way to do that is they,

593
00:31:01.545 --> 00:31:04.875
this is a fancy little, uh, chart here, the SN curve.

594
00:31:05.815 --> 00:31:10.035

It simply shows you, um, load on the left hand side

595
00:31:10.035 --> 00:31:11.955
and then cycles down below,

596
00:31:13.295 --> 00:31:16.915
and it predicts when something's gonna fail on that.

597
00:31:17.415 --> 00:31:19.035
And so you take your SN curve

598
00:31:19.095 --> 00:31:22.275
and they, uh, have that dash line to add a little, uh,

599
00:31:22.275 --> 00:31:23.435
safety margin to it.

600
00:31:23.435 --> 00:31:26.395
And then you pump that into what you want

601
00:31:26.455 --> 00:31:27.915
as your oscillatory limit.

602
00:31:28.575 --> 00:31:32.555
And, uh, so your oscillator are different than your statics,

603
00:31:33.175 --> 00:31:35.875
and that complicates the heck out of things.

604
00:31:36.865 --> 00:31:40.395
What I like is on the far right of that, um,

605
00:31:40.725 --> 00:31:43.035
curve is the point where it doesn't matter

606
00:31:43.135 --> 00:31:47.435
how many times you oscillate, you're not gonna fail it.

607
00:31:47.435 --> 00:31:48.675
That's called the endurance limit.

608
00:31:49.135 --> 00:31:51.275
And that is music to my ears

609
00:31:51.495 --> 00:31:53.315
as a flight tester when I had no,

610
00:31:53.475 --> 00:31:56.755
a fatigue measure is operating below endurance limit.

611
00:31:57.665 --> 00:32:02.195
Good. So something simple to remember,

612
00:32:02.265 --> 00:32:05.315
endurance limits if you're operating below 'em are good.

613
00:32:06.215 --> 00:32:08.275
Now the thing with fatigue calculations

614
00:32:08.295 --> 00:32:09.515
is we don't do 'em real time.

615
00:32:09.935 --> 00:32:11.835
So we don't calculate fatigue life on

616
00:32:11.835 --> 00:32:12.955
our components real time.

617
00:32:12.985 --> 00:32:14.275
It's done after the fact.

618
00:32:15.175 --> 00:32:18.075
So you have to be somewhat conservative in setting your

619
00:32:18.075 --> 00:32:21.035
limits, uh, based on the amount of time

620
00:32:21.215 --> 00:32:22.475
or many, um, amount

621
00:32:22.475 --> 00:32:24.315

of cycles you might expect in your flight test.

622
00:32:24.315 --> 00:32:27.395
Otherwise, you could get an ugly surprise later on.

623
00:32:27.395 --> 00:32:29.955
If I have time, I'll tell you about one of those.

624
00:32:33.215 --> 00:32:36.255
So I talked about pretest

625
00:32:37.455 --> 00:32:38.735
reducing, uh, ignorance.

626
00:32:38.985 --> 00:32:42.005
How about during test? This is important.

627
00:32:42.315 --> 00:32:45.125
This is something RJ talked about, making sure

628
00:32:45.195 --> 00:32:47.725
that you pay attention to the data you're collecting

629
00:32:47.725 --> 00:32:49.285
and just don't throw it over the fence.

630
00:32:49.305 --> 00:32:52.685
As RJ said with us, when we're doing loads,

631
00:32:52.685 --> 00:32:54.485
we have quick look plots that we're looking at

632
00:32:54.905 --> 00:32:57.845
and we are reviewing right

633
00:32:57.845 --> 00:33:00.125
after flight what it looked like.

634
00:33:01.175 --> 00:33:03.405
We're doing that primarily to look at some

635
00:33:03.405 --> 00:33:06.005
of our procedures like our, our our, uh,

636
00:33:06.015 --> 00:33:07.725
knock it off recovery procedures,

637
00:33:08.255 --> 00:33:11.725
which I'm gonna go into depth here on, which are fairly,

638
00:33:12.425 --> 00:33:13.725
um, involved.

639
00:33:14.825 --> 00:33:18.165
And then also to look at whether everything's behaving

640
00:33:18.165 --> 00:33:20.725
right, whether we were on our structural load limits,

641
00:33:20.725 --> 00:33:23.085
whether we're starting to tickle 'em, what what kind

642
00:33:23.085 --> 00:33:24.685
of nonlinearity is starting to build

643
00:33:25.265 --> 00:33:28.605
so we can inform our our next, uh, test evolution.

644
00:33:29.635 --> 00:33:32.365
It's tough to do this, A lot of people don't want to do it,

645
00:33:32.365 --> 00:33:35.805
but it really has paid dividends, uh, for us.

646
00:33:36.585 --> 00:33:37.965
Uh, especially when you're,

647
00:33:38.275 --> 00:33:39.645
when you're doing software changes

648
00:33:39.785 --> 00:33:41.565

and you're doing a baseline software

649
00:33:41.565 --> 00:33:44.045
and you're looking at, at a new software

650
00:33:44.505 --> 00:33:46.765
and, uh, maybe that structural load limiting

651
00:33:46.995 --> 00:33:48.565
that envelope protection is not,

652
00:33:49.145 --> 00:33:50.965
not exactly the same as before.

653
00:33:52.265 --> 00:33:57.045
Um, and then these others talk about what it takes to,

654
00:33:57.825 --> 00:33:59.445
to slow down a little bit.

655
00:33:59.785 --> 00:34:03.245
Um, pausing tests, overrunning data.

656
00:34:03.785 --> 00:34:06.205
If you're doing fatigue, if, uh, if you're doing tests

657
00:34:06.205 --> 00:34:07.765
where there's fatigue, life involved,

658
00:34:08.145 --> 00:34:10.405
you don't overrun data, that's a bad thing.

659
00:34:10.945 --> 00:34:12.485
You need to do those fatigue life

660
00:34:12.485 --> 00:34:14.165
calculations at the end of the day.

661
00:34:14.235 --> 00:34:17.805
Make sure you're tracking before you go out on the next day.

662
00:34:17.805 --> 00:34:22.405
Because like we got burned on one, we ran a bunch

663
00:34:22.405 --> 00:34:24.725
of fatigue life out of, out of some components.

664
00:34:24.865 --> 00:34:26.565
One time we overrun our data.

665
00:34:27.945 --> 00:34:32.245
Um, tracking progress toward your exit criteria, this is

666
00:34:32.245 --> 00:34:34.485
that accept no unnecessary risk.

667
00:34:34.635 --> 00:34:39.165
Back to principle number one. And then unexpected results.

668
00:34:39.235 --> 00:34:41.205
Have a plan. Um,

669
00:34:42.315 --> 00:34:45.685
make sure you have a way to pump the brakes

670
00:34:46.725 --> 00:34:50.105
and make sure that everybody has, uh,

671
00:34:51.135 --> 00:34:53.745
that built in culture when things start

672
00:34:53.745 --> 00:34:55.025
to look a little different.

673
00:34:57.045 --> 00:34:59.225
And then last for flight tests.

674
00:34:59.225 --> 00:35:00.465
If you're doing a long program

675
00:35:00.605 --> 00:35:02.065

or you're running up against something

676
00:35:02.065 --> 00:35:04.745
that's particularly ticklish, they want the data,

677
00:35:04.805 --> 00:35:06.865
but you feel it's too risky sometimes.

678
00:35:07.645 --> 00:35:09.665
Is there a plan for modeling and update?

679
00:35:09.965 --> 00:35:12.665
We had this happen when we were doing some tests

680
00:35:12.675 --> 00:35:16.185
where we were running a single boost limit, uh, as far as

681
00:35:16.635 --> 00:35:20.505
above a single boost limit, um, for high speed dives.

682
00:35:20.965 --> 00:35:22.945
And we wanted to know how fast we had

683
00:35:22.945 --> 00:35:26.105
to react if we had a hydraulic failure, um,

684
00:35:26.445 --> 00:35:29.025
before the flight controls would destroy the aircraft.

685
00:35:29.845 --> 00:35:32.665
Uh, so we paused test, we didn't do it.

686
00:35:32.665 --> 00:35:34.945
They went out and did the analysis. It was too thin.

687
00:35:35.445 --> 00:35:39.955
We stopped, uh, incremental data review.

688
00:35:40.055 --> 00:35:41.115
I'm not gonna go through this,

689
00:35:41.175 --> 00:35:42.915
but this is something I developed

690
00:35:42.915 --> 00:35:47.555
after listening to Ben Luther's, uh, paper in, uh,

691
00:35:47.775 --> 00:35:49.995
2016 on critical thinking.

692
00:35:50.275 --> 00:35:51.555
I think this is really valuable.

693
00:35:51.975 --> 00:35:56.035
Too often when you get an expected result, you go to try

694
00:35:56.035 --> 00:35:59.755
to fix the issue and not look at the processes

695
00:35:59.815 --> 00:36:02.435
and how that issue now cascades down into your

696
00:36:02.435 --> 00:36:03.995
processes and your risk assessment.

697
00:36:04.675 --> 00:36:05.875
I think it's important to do that.

698
00:36:06.185 --> 00:36:08.435
This is my personal checklist that I developed

699
00:36:08.495 --> 00:36:09.955
for our incremental data reviews.

700
00:36:10.105 --> 00:36:13.835
Sometimes it was just a regular scheduled data review.

701
00:36:13.835 --> 00:36:17.835
Oftentimes it was unexpected results works for both.

702
00:36:18.535 --> 00:36:20.675

So something maybe you can use

703
00:36:20.735 --> 00:36:22.355
and I recommend reading this paper

704
00:36:25.295 --> 00:36:28.075
now we're operating over in the right hand side.

705
00:36:28.135 --> 00:36:29.195
Now, uncertainty.

706
00:36:29.685 --> 00:36:32.675
We've done all of our analysis for the left hand side of,

707
00:36:33.255 --> 00:36:35.875
of beaker's, uh, chart here.

708
00:36:36.375 --> 00:36:38.315
Now, how do we handle uncertainty?

709
00:36:38.665 --> 00:36:41.555
This is where you get into the blocks blocking

710
00:36:41.615 --> 00:36:42.915
and tackling of flight test.

711
00:36:42.945 --> 00:36:46.835
This is buildup, real-time monitoring and trending.

712
00:36:49.165 --> 00:36:51.185
So what does it look like? Again,

713
00:36:51.555 --> 00:36:53.185
trend the appropriate parameters.

714
00:36:53.695 --> 00:36:57.345
Make sure you track it, uh, in flight and between flights.

715
00:36:57.615 --> 00:36:58.825
Another lesson learned.

716
00:36:59.405 --> 00:37:01.505
You know, tho those target bands

717
00:37:01.505 --> 00:37:03.265
that you put in the test plan for buildup,

718
00:37:03.535 --> 00:37:05.545
they don't translate to the way you do it.

719
00:37:05.645 --> 00:37:08.665
If you're tracking a particular parameter for loads,

720
00:37:08.845 --> 00:37:11.665
you need to pick up where your buildup left off,

721
00:37:11.765 --> 00:37:13.065
be on the next flight.

722
00:37:13.195 --> 00:37:16.865
Don't just jump into that band at, uh, a higher gross weight

723
00:37:16.865 --> 00:37:18.545
and a higher density altitude, for instance.

724
00:37:18.565 --> 00:37:20.945
Now you got a step change in your load parameter,

725
00:37:20.945 --> 00:37:22.905
and you might have an ugly surprise.

726
00:37:24.645 --> 00:37:26.425
Um, buildup increments.

727
00:37:26.425 --> 00:37:27.465
This is an interesting one

728
00:37:27.465 --> 00:37:32.295
because, uh, if you have a lot of slices in buildup

729
00:37:33.155 --> 00:37:36.615

that's exposure, you're taking a lot of risk unnecessarily.

730
00:37:37.315 --> 00:37:41.215
You may not need little short slices early.

731
00:37:41.475 --> 00:37:43.815
You know, say, say you, you know you're gonna go

732
00:37:43.815 --> 00:37:45.015
to a full stick deflection.

733
00:37:45.585 --> 00:37:47.535
Don't go at it at half inch increments.

734
00:37:47.535 --> 00:37:49.655
Maybe that first one is at one inch

735
00:37:50.125 --> 00:37:53.655
because it saves you on, uh, every, every time you do one

736
00:37:53.655 --> 00:37:55.135
of these buildup, it's exposure

737
00:37:55.555 --> 00:37:58.295
for us in flight loads at 55 knots,

738
00:37:58.705 --> 00:38:00.015
we're hanging on the rotor,

739
00:38:00.345 --> 00:38:02.655
we're heating the elastomers in the rotor.

740
00:38:03.115 --> 00:38:06.175
We had to be very judicious as in how we did our buildup.

741
00:38:06.175 --> 00:38:08.655
Otherwise, we ended up just chewing up all the time in

742
00:38:08.655 --> 00:38:10.295
buildup and never got to the end point

743
00:38:10.295 --> 00:38:12.055
before the elastomer overheated.

744
00:38:12.995 --> 00:38:17.295
So, and then you have to take those thin slices at the end,

745
00:38:17.665 --> 00:38:19.455
right up close to your limit.

746
00:38:19.955 --> 00:38:22.015
And if you're talking about structural load limiting

747
00:38:22.725 --> 00:38:24.615
that when it's, when you start hitting that

748
00:38:25.845 --> 00:38:27.945
you behavior starts to go nonlinear.

749
00:38:28.005 --> 00:38:31.625
So you have to really maybe take thin slices

750
00:38:31.625 --> 00:38:35.565
until you can characterize how the SLL is performing.

751
00:38:39.265 --> 00:38:41.125
Lastly, well, the next one,

752
00:38:41.125 --> 00:38:43.325
termination criteria I've talked to you about.

753
00:38:44.225 --> 00:38:47.525
And we have, there's basically three, um,

754
00:38:48.295 --> 00:38:49.765
three termination criteria.

755
00:38:49.825 --> 00:38:53.205
We have. We have the exit criteria,

756
00:38:53.205 --> 00:38:55.125

which is the big test plant criteria.

757
00:38:55.355 --> 00:38:57.685
There's termination criteria that we use

758
00:38:57.685 --> 00:39:00.285
for individual test points, that's before or

759
00:39:00.285 --> 00:39:03.965
after the test points, and then knock it off criteria,

760
00:39:03.965 --> 00:39:05.525
which is during the test point.

761
00:39:06.585 --> 00:39:08.525
If you don't have that, you might want to rethink it.

762
00:39:08.615 --> 00:39:11.565
It'll, it'll help you, uh, in

763
00:39:12.645 --> 00:39:14.205
avoiding unnecessary risk.

764
00:39:18.245 --> 00:39:19.785
And what is that exit criteria?

765
00:39:20.285 --> 00:39:23.505
Way back to that second principle in the 40, 40 26,

766
00:39:23.525 --> 00:39:26.425
you're evaluating the balance between the knowledge gained

767
00:39:26.845 --> 00:39:28.305
and the risk associated with that.

768
00:39:28.775 --> 00:39:32.385
It's a constant, uh, battle to, to do that.

769
00:39:32.725 --> 00:39:36.185
So it's important to understand in your test matrix the

770
00:39:36.185 --> 00:39:38.185
value of every individual point.

771
00:39:38.525 --> 00:39:40.465
At some point, you're gonna meet your exit criteria.

772
00:39:40.765 --> 00:39:43.585
You'll have a handful of points left on the test matrix,

773
00:39:43.725 --> 00:39:45.305
and you can say, no, I don't need it.

774
00:39:46.125 --> 00:39:47.625
It helps to have the, the loads

775
00:39:47.625 --> 00:39:48.905
guys involved in that decision.

776
00:39:49.045 --> 00:39:52.665
Of course, limit checking.

777
00:39:53.415 --> 00:39:56.465
Like I said, we have like two 3000 parameters on the

778
00:39:56.625 --> 00:39:59.825
aircraft where we've got all sorts of good stuff going on.

779
00:39:59.885 --> 00:40:01.145
You need protocols for it.

780
00:40:01.145 --> 00:40:03.745
Here I'm just showing some of the various things

781
00:40:03.775 --> 00:40:06.505
that then create, can create havoc with,

782
00:40:07.015 --> 00:40:08.265
with our limit checking.

783
00:40:08.765 --> 00:40:12.905

And, uh, if you have a lot of this TM spikes

784
00:40:12.965 --> 00:40:16.985
or loss of lock, uh, it'll really slow down your effort in,

785
00:40:16.985 --> 00:40:19.585
in a, in a ter to, uh, loads test.

786
00:40:20.485 --> 00:40:21.585
And so you have

787
00:40:21.585 --> 00:40:25.065
to have some really sharp guys on, on top of it.

788
00:40:25.205 --> 00:40:27.745
And frankly, if you're getting a lot of this,

789
00:40:29.085 --> 00:40:30.105
you need to address it.

790
00:40:30.325 --> 00:40:31.865
You need to control it in some fashion.

791
00:40:32.485 --> 00:40:35.745
You need to rethink, uh, your instrumentation set up.

792
00:40:36.765 --> 00:40:40.625
Um, all of those factors in influence TM reliability,

793
00:40:41.005 --> 00:40:43.745
and bottom line, they should be considered a control factory

794
00:40:43.805 --> 00:40:44.945
for risk mitigation.

795
00:40:46.295 --> 00:40:49.505
This, uh, bad TM can create risk.

796
00:40:50.745 --> 00:40:52.245
So understand that

797
00:40:52.945 --> 00:40:56.965
and understand that if you are really on a high risk test,

798
00:40:57.305 --> 00:40:59.725
you can't afford all of this garbage occurring.

799
00:40:59.825 --> 00:41:01.765
You need everything clean and,

800
00:41:02.145 --> 00:41:05.365
and, uh, make sure you do control it rigorously.

801
00:41:06.785 --> 00:41:09.805
For us aspect ratio, there were certain parts in the, uh,

802
00:41:10.425 --> 00:41:14.045
um, out, out over the bay where we would operate

803
00:41:14.045 --> 00:41:15.965
that we knew we had good clean tm

804
00:41:16.825 --> 00:41:18.725
and there were others where we didn't.

805
00:41:18.995 --> 00:41:23.005
Yeah, and that, so when we had a really high risk test,

806
00:41:23.065 --> 00:41:24.605
we wanted to get it into an area

807
00:41:25.015 --> 00:41:26.765
where we had really cleaned tm.

808
00:41:28.215 --> 00:41:31.565
Let's talk about the buildup now, uh, flight loads test.

809
00:41:31.755 --> 00:41:33.725
This is how we did it in V 22.

810
00:41:34.305 --> 00:41:37.045

Um, we'd typically start with symmetrical

811
00:41:37.265 --> 00:41:40.565
and single axis inputs, you know, the rolling, uh,

812
00:41:40.625 --> 00:41:43.525
we would do a symmetric pushovers and pull-ups

813
00:41:43.745 --> 00:41:46.565
and then roll reversals, dynamic yas,

814
00:41:46.565 --> 00:41:49.565
and they would feed our

815
00:41:50.385 --> 00:41:53.925
or, um, the windup, turn the rolling pull-up.

816
00:41:54.155 --> 00:41:57.645
They would inform what our targets were for those maneuvers.

817
00:41:58.235 --> 00:42:00.605
Then we generally did the windup turn next

818
00:42:01.235 --> 00:42:03.485
because it was kind of a steady state maneuver,

819
00:42:04.335 --> 00:42:05.525
asymmetric steady state.

820
00:42:05.665 --> 00:42:07.445
And then we would do the rolling pull-up,

821
00:42:07.445 --> 00:42:08.485
which is the most dynamic.

822
00:42:08.705 --> 00:42:10.205
And that's what I'm gonna talk about here.

823
00:42:11.305 --> 00:42:14.085
And I'm gonna talk about how we analyzed it

824
00:42:14.085 --> 00:42:15.605
and how we try to make it safe.

825
00:42:16.865 --> 00:42:18.365
So here's the point.

826
00:42:19.075 --> 00:42:22.915
This is a, this is a power required chart.

827
00:42:23.055 --> 00:42:24.635
It shows three different curves.

828
00:42:25.385 --> 00:42:28.155
That one on the left is 85 in the cell,

829
00:42:28.155 --> 00:42:29.475
then you have 60 in the cell,

830
00:42:29.475 --> 00:42:30.515
and then airplane mode,

831
00:42:30.855 --> 00:42:34.475
the 55 knot point lies at on an 85 in the cell.

832
00:42:35.135 --> 00:42:39.115
And then that green line above is our power available.

833
00:42:39.265 --> 00:42:42.835
There's a little bump in it because we are at a hundred.

834
00:42:43.375 --> 00:42:47.155
Uh, we, we have a, a higher level of torque

835
00:42:47.275 --> 00:42:50.955
and RPM, uh, in the, in the low speed region

836
00:42:51.015 --> 00:42:52.355
to give us a little more oomph.

837
00:42:52.975 --> 00:42:57.075

And then it ramps out with speed as as we accelerate.

838
00:42:58.095 --> 00:43:00.855
So this is for 45,000.

839
00:43:01.325 --> 00:43:04.095
Some of the, the really hairy points we were doing were much

840
00:43:04.095 --> 00:43:07.095
higher than this, where our margins were very thin

841
00:43:07.275 --> 00:43:08.495
on performance.

842
00:43:11.015 --> 00:43:12.875
So I already talked a little bit

843
00:43:12.875 --> 00:43:14.755
to the parameter for the loads test.

844
00:43:15.185 --> 00:43:18.395
It's this fancy thing NZ gross weight over sigma

845
00:43:19.415 --> 00:43:21.875
or thrust coefficient over sigma, however you wanna turn it.

846
00:43:22.335 --> 00:43:25.675
So we have to have a way of tracking that, modeling it,

847
00:43:26.025 --> 00:43:27.395
keep keeping an eye on it,

848
00:43:27.735 --> 00:43:29.395
but that's not the only thing to worry about.

849
00:43:30.855 --> 00:43:32.235
But here's the rolling pull up.

850
00:43:32.415 --> 00:43:37.395
We start out 30 to 45 degree angle a bank, say to the right,

851
00:43:38.055 --> 00:43:40.555
and then we put max thrust in,

852
00:43:41.455 --> 00:43:45.875
and then we incrementally build up in

853
00:43:46.065 --> 00:43:49.315
lateral input until we get a full roll input.

854
00:43:49.575 --> 00:43:52.115
So now you've got two controls on the stops,

855
00:43:52.625 --> 00:43:54.795
full power, full lat stick.

856
00:43:55.335 --> 00:43:58.755
And then once you've achieved that safely, then

857
00:43:59.205 --> 00:44:03.595
after we hit the stop laterally, we apply an afec

858
00:44:04.105 --> 00:44:07.355
step to, to achieve our max NZ

859
00:44:07.355 --> 00:44:08.675
as we're going through wings level.

860
00:44:09.815 --> 00:44:13.075
And that's the rolling pull up a lot going on.

861
00:44:14.015 --> 00:44:17.555
And it, that is in other rotorcraft,

862
00:44:17.575 --> 00:44:20.515
you would never dare do these things

863
00:44:20.705 --> 00:44:24.195
because in some of these rolling pull-ups, you had three,

864
00:44:24.895 --> 00:44:27.115

you know, you, you had your, your lat stick

865
00:44:27.135 --> 00:44:30.475
and long stick on, on the stop along with full power.

866
00:44:31.305 --> 00:44:34.885
So, but that's what it takes to test the, uh,

867
00:44:35.125 --> 00:44:36.965
structural load limine according to nav air.

868
00:44:38.305 --> 00:44:40.645
So very dynamic maneuver.

869
00:44:41.185 --> 00:44:44.485
And the important thing here is to understand that

870
00:44:46.515 --> 00:44:50.365
once that maneuver is done, IE you've got that load.

871
00:44:51.365 --> 00:44:52.705
You don't have to be so dynamic.

872
00:44:53.325 --> 00:44:56.665
So the recovery becomes very important here.

873
00:44:56.765 --> 00:44:58.465
No need to make any things worse

874
00:44:58.565 --> 00:45:00.745
by doing the wrong recovery on the aircraft.

875
00:45:01.125 --> 00:45:02.785
And we're gonna go into detail on that.

876
00:45:03.325 --> 00:45:04.865
But first we're gonna look at the hazards.

877
00:45:05.165 --> 00:45:06.505
Um, well, one other thing here.

878
00:45:07.445 --> 00:45:09.665
Um, we, we determined

879
00:45:09.665 --> 00:45:13.505
that we hit max nz when we're either full aft on the stop

880
00:45:13.645 --> 00:45:18.465
or we have repeat points at increasing af stick mar uh,

881
00:45:18.645 --> 00:45:21.425
af stick inputs that aren't giving us any higher nz.

882
00:45:22.285 --> 00:45:26.635
So now what we're up against,

883
00:45:27.365 --> 00:45:30.675
those hazards I talked about before, let's map 'em here.

884
00:45:31.615 --> 00:45:34.955
So I got the list of the hazard root causes

885
00:45:36.535 --> 00:45:39.035
and then some complicating issues that feed those.

886
00:45:40.015 --> 00:45:42.275
Um, in the maneuver, if you get slow,

887
00:45:42.275 --> 00:45:44.995
that's this number one, you

888
00:45:45.615 --> 00:45:48.795
can decelerate from 55 knots below 30 knots,

889
00:45:48.795 --> 00:45:50.675
and now you have no airspeed indication.

890
00:45:51.855 --> 00:45:55.395
You're in that nasty region where vortex ring state occurs.

891
00:45:55.855 --> 00:45:58.275

You can see that your power required goes up.

892
00:45:58.295 --> 00:45:59.875
So you could be in a power deficit

893
00:46:00.935 --> 00:46:04.835
and you could even be in a, a side slip to where you start

894
00:46:04.835 --> 00:46:08.635
to risk running into pitch up with side slip from the floor,

895
00:46:08.635 --> 00:46:10.715
your rotor impinging on your empina,

896
00:46:11.095 --> 00:46:14.475
and that'll just erase in a forward stick, which is

897
00:46:14.475 --> 00:46:17.475
what you need to get back to 55 knots.

898
00:46:17.655 --> 00:46:19.555
So you don't want to go slow.

899
00:46:20.295 --> 00:46:23.195
So, but we're in a maneuver that deliberately

900
00:46:23.865 --> 00:46:25.635
make moves you in that direction.

901
00:46:27.915 --> 00:46:30.295
You don't want to go fast either, though, too fast,

902
00:46:30.295 --> 00:46:31.775
because if you go too fast,

903
00:46:31.865 --> 00:46:34.255
we're leaving the nelle set at 85.

904
00:46:34.355 --> 00:46:36.815
If you go too fast, you run into the conversion corridor,

905
00:46:37.535 --> 00:46:40.975
structural load limiting, which says, Hey, I don't want you

906
00:46:41.275 --> 00:46:43.015
to run into retreating blade stall,

907
00:46:43.015 --> 00:46:45.095
so I'm gonna move the nielle for you.

908
00:46:45.875 --> 00:46:48.215
Uh, but if you're in a dynamic maneuver

909
00:46:48.235 --> 00:46:49.815
and the nielle moves, guess what?

910
00:46:49.815 --> 00:46:52.055
The rotor flaps, that's not a good thing either.

911
00:46:52.315 --> 00:46:53.655
So we don't want to hit that.

912
00:46:55.245 --> 00:46:59.335
Another complicating factor is we have that RPM change.

913
00:46:59.475 --> 00:47:01.615
How is it affected? It's affected

914
00:47:01.795 --> 00:47:04.655
by increasing collective pitch on the rotor.

915
00:47:05.395 --> 00:47:07.855
Um, if that occurs at the same time you got

916
00:47:08.395 --> 00:47:12.015
max torque applied for your role, that's not a good thing

917
00:47:12.325 --> 00:47:14.735
because now you can risk, it can add

918
00:47:14.755 --> 00:47:18.535

to your over torque risk, uh, on your gear boxes.

919
00:47:19.395 --> 00:47:23.575
And then just so happens that in the V 22,

920
00:47:23.635 --> 00:47:26.495
you have the weakest lateral control power in the aircraft

921
00:47:26.545 --> 00:47:27.775
right around this speed

922
00:47:28.445 --> 00:47:31.205
because flap ons are not very useful.

923
00:47:31.625 --> 00:47:33.765
And lateral swash plate gearing,

924
00:47:33.765 --> 00:47:36.005
which we use in the near hover, is not there.

925
00:47:36.265 --> 00:47:39.205
You're just on differential collective pitch with the rotors

926
00:47:39.585 --> 00:47:41.605
and it's limited by gearbox limits.

927
00:47:42.205 --> 00:47:45.485
Structural load limiting is keeping you from using it.

928
00:47:45.945 --> 00:47:50.365
So we have a mushy control of, uh,

929
00:47:50.435 --> 00:47:51.845
lateral at the same time.

930
00:47:52.785 --> 00:47:55.165
And then finally, you're just

931
00:47:55.165 --> 00:47:58.765
above the turn coordination threshold for the V 22

932
00:47:59.375 --> 00:48:01.965
above 60 knots turn coordination is on,

933
00:48:02.915 --> 00:48:04.775
and you don't have to mess with the pedals

934
00:48:05.035 --> 00:48:09.095
and the pedal's back drive, um, below

935
00:48:09.095 --> 00:48:10.655
that you're in charge.

936
00:48:11.635 --> 00:48:14.415
So basically you have to treat it

937
00:48:14.415 --> 00:48:16.255
as I'm in charge on this one.

938
00:48:16.275 --> 00:48:19.215
And you, you can, uh, if you're at higher,

939
00:48:19.215 --> 00:48:20.895
you'll feel the back drive and you'll know you're

940
00:48:20.895 --> 00:48:21.935
in turn coordination.

941
00:48:22.115 --> 00:48:26.145
So, so what does this mean?

942
00:48:26.355 --> 00:48:30.665
We're not only having to trend our NZW over sigma,

943
00:48:30.665 --> 00:48:33.305
we're having to trend rotor flapping gearbox torque,

944
00:48:33.885 --> 00:48:36.345
and at the same time rotor elastomer heating

945
00:48:36.345 --> 00:48:37.665

because we're hanging on the rotor for

946
00:48:37.665 --> 00:48:38.825
so long during buildup.

947
00:48:39.445 --> 00:48:42.865
So oftentimes between points, we'll run the new cells down

948
00:48:42.865 --> 00:48:45.305
to, to say 40 or

949
00:48:45.525 --> 00:48:48.105
or so, so we can cool the elastomers down

950
00:48:48.105 --> 00:48:49.145
and continue testing.

951
00:48:52.135 --> 00:48:54.395
So now let's look at those complicating issues

952
00:48:54.455 --> 00:48:57.995
and how they figure in to knock it off procedures.

953
00:48:59.295 --> 00:49:00.635
Hey Marty, how's the speed?

954
00:49:03.105 --> 00:49:06.555
Good point. It sucks. Thanks, Frank.

955
00:49:07.445 --> 00:49:08.635
Frank and I were, uh,

956
00:49:10.015 --> 00:49:13.635
did this 0.1 day, multiple days, in fact.

957
00:49:14.105 --> 00:49:16.195
Yeah, it's terrible. The speed stability's terrible.

958
00:49:16.895 --> 00:49:19.075
So, and that figures into some of our, uh,

959
00:49:19.455 --> 00:49:21.315
our recovery procedures.

960
00:49:22.615 --> 00:49:27.195
So like I said, you're, you're collecting the data to

961
00:49:27.195 --> 00:49:28.475
where you get max nz,

962
00:49:28.475 --> 00:49:31.955
but when you're done, you're done recover in a,

963
00:49:32.015 --> 00:49:33.115
in a slower fashion.

964
00:49:33.295 --> 00:49:36.275
So our mantra on the V 22 is fast and slow out.

965
00:49:37.375 --> 00:49:39.075
No need complicating your life

966
00:49:39.175 --> 00:49:41.635
by doing a rapid control reversal.

967
00:49:42.335 --> 00:49:45.115
Um, we fix the thrust, we leave it there.

968
00:49:45.935 --> 00:49:49.195
That's to keep flapping from, uh, getting high.

969
00:49:50.535 --> 00:49:53.795
We, uh, maintain the Noelle where it is to keep flapping.

970
00:49:54.735 --> 00:49:57.315
And then we go to an outside scan for the very thing

971
00:49:57.345 --> 00:50:00.275
that Frank just mentioned, our speed stability's terrible.

972
00:50:00.745 --> 00:50:04.235

What you're doing is you, you're setting your, your trim

973
00:50:05.155 --> 00:50:06.555
attitude, you're doing the maneuver

974
00:50:06.615 --> 00:50:09.395
and you're going back to that trim attitude using visual.

975
00:50:09.985 --> 00:50:11.635
It's quicker, it's more efficient,

976
00:50:12.015 --> 00:50:15.595
and at the same time, you can pick up any kind of, uh, yaw

977
00:50:15.695 --> 00:50:18.555
that's occurring from the, the maneuver.

978
00:50:20.425 --> 00:50:23.525
And then we stress a sequential recovery of controls

979
00:50:23.585 --> 00:50:25.525
to avoid gearbox over torques and,

980
00:50:25.825 --> 00:50:27.005
and, uh, that sort of thing.

981
00:50:27.915 --> 00:50:31.965
Very complicated maneuver. So how do you do this?

982
00:50:31.965 --> 00:50:35.045
How do you memorize this? You don't. You teach it.

983
00:50:35.745 --> 00:50:38.205
You teach, you teach your body to do this.

984
00:50:38.345 --> 00:50:41.985
We simulate the heck out of it. We simulate a lot.

985
00:50:42.125 --> 00:50:44.665
We have a training program for this for our pilots.

986
00:50:45.085 --> 00:50:47.425
We make sure when they're operating

987
00:50:47.645 --> 00:50:49.145
and doing these kinda loads tests,

988
00:50:49.145 --> 00:50:52.265
they're always recovering in the same fashion, even if it's

989
00:50:52.285 --> 00:50:54.625
for a point that's not as critical,

990
00:50:55.245 --> 00:50:58.265
you'll recover in the same fashion you practice every time

991
00:50:58.965 --> 00:51:01.905
and you get feedback from TM if you're not doing

992
00:51:01.925 --> 00:51:02.985
the recovery, right?

993
00:51:03.295 --> 00:51:05.145
Make sure you get that kind of coaching.

994
00:51:05.165 --> 00:51:06.385
Hey, you forgot to do this.

995
00:51:06.645 --> 00:51:11.185
You know, so that is building that heuristic

996
00:51:11.535 --> 00:51:12.985
that RJ was talking about.

997
00:51:12.985 --> 00:51:17.505
You're building a rule of thumb, a feel, an experience base

998
00:51:17.615 --> 00:51:19.905
that you can rely on and,

999
00:51:20.165 --> 00:51:23.345

and it comes into play if something else goes wrong there.

1000
00:51:25.485 --> 00:51:27.945
Uh, I talked about cessation of test criteria.

1001
00:51:28.695 --> 00:51:30.025
There's the exit criteria,

1002
00:51:30.085 --> 00:51:33.065
but then we have maneuver termination guidelines.

1003
00:51:33.175 --> 00:51:37.905
This is, hey, yeah, um, you're not in the proper condition

1004
00:51:38.125 --> 00:51:41.345
or configuration to do that test point, terminate, stop

1005
00:51:41.345 --> 00:51:44.945
what you're doing, reconfigure, get, get your stuff in a row

1006
00:51:45.565 --> 00:51:48.305
or you've done it to completion

1007
00:51:48.725 --> 00:51:50.985
or you're starting to run into loads implications.

1008
00:51:51.885 --> 00:51:55.585
Um, and finally, the uh,

1009
00:51:56.075 --> 00:51:57.745
pilot can always say, I'm done.

1010
00:51:58.425 --> 00:52:02.945
I on, I did that one time, uh, doing,

1011
00:52:03.685 --> 00:52:05.825
we were doing, um, vertical landings.

1012
00:52:06.165 --> 00:52:10.185
We had to hit 12 foot per second, uh, at, um,

1013
00:52:10.285 --> 00:52:14.305
and we were at 10 foot per second hitting the ground at 10

1014
00:52:14.305 --> 00:52:16.465
foot per second at a hundred knots and bouncing.

1015
00:52:16.485 --> 00:52:19.585
And, and the cockpit was between the Elles doing this

1016
00:52:19.725 --> 00:52:20.865
and you're doing this.

1017
00:52:20.885 --> 00:52:23.065
And I finally said, no, we're done, you guys.

1018
00:52:23.365 --> 00:52:25.105
And I just told the guys, you can,

1019
00:52:25.285 --> 00:52:26.785
you can extrapolate that one.

1020
00:52:27.195 --> 00:52:28.345
We're not interpolating.

1021
00:52:28.565 --> 00:52:31.905
So, um, there are times when you get to say no,

1022
00:52:33.925 --> 00:52:35.545
um, not, and,

1023
00:52:35.545 --> 00:52:38.985
and those general maneuver termination criteria are

1024
00:52:38.985 --> 00:52:40.225
what I call slow thinking.

1025
00:52:40.605 --> 00:52:42.305
That's the stuff in between test points.

1026
00:52:42.405 --> 00:52:43.825

That's before, that's after.

1027
00:52:44.805 --> 00:52:46.625
Now you're going into test execution.

1028
00:52:46.645 --> 00:52:48.865
Now we have specific knock it off criteria.

1029
00:52:48.975 --> 00:52:50.025
This is fast thinking.

1030
00:52:50.215 --> 00:52:53.745
This is your TM room and you try, uh, knowing when, when,

1031
00:52:53.745 --> 00:52:56.345
and knock the maneuver off when you knock it off.

1032
00:52:56.605 --> 00:52:59.345
You use that very elaborate knock it off procedure

1033
00:52:59.345 --> 00:53:01.345
that we're talking about that you've memorized.

1034
00:53:06.385 --> 00:53:11.105
Now let's talk about the upper right random uncertainty.

1035
00:53:11.405 --> 00:53:14.665
The where the black swan nests, if you will.

1036
00:53:15.005 --> 00:53:17.345
Uh, this is a tough one.

1037
00:53:17.415 --> 00:53:19.105
This is where we talk about heuristics.

1038
00:53:19.105 --> 00:53:20.665
We talk about a couple other things.

1039
00:53:20.775 --> 00:53:25.365
I've got a couple things I suggest here. Um, one aperture.

1040
00:53:25.475 --> 00:53:28.565
This is, this is where multidisciplinary teams help.

1041
00:53:28.905 --> 00:53:30.765
You know, you may be doing a performance test,

1042
00:53:30.785 --> 00:53:32.925
but having a handling qualities guy in the room

1043
00:53:33.425 --> 00:53:36.125
or a dynamics guy in the room, you may pick up something

1044
00:53:36.125 --> 00:53:37.125
that's starting to go wrong.

1045
00:53:37.745 --> 00:53:41.245
Um, it's expensive, it's painful, but it pays off.

1046
00:53:42.025 --> 00:53:46.085
Um, just keep, uh, there's a tendency always

1047
00:53:46.105 --> 00:53:49.045
to focus on the parameters that you're working on,

1048
00:53:50.385 --> 00:53:51.805
but don't just do that.

1049
00:53:51.995 --> 00:53:55.085
Have a wider view of the aircraft in the telemetry room.

1050
00:53:55.785 --> 00:53:59.215
Uh, also part of this aperture is

1051
00:53:59.635 --> 00:54:00.975
who you got in the cockpit.

1052
00:54:01.115 --> 00:54:02.415
We have a dual cockpit,

1053
00:54:02.915 --> 00:54:05.415

so sometimes if you've got a newbie in there,

1054
00:54:05.875 --> 00:54:08.295
his aperture's way down, he's not seeing anything.

1055
00:54:08.915 --> 00:54:11.455
Um, maybe on a high risk test point,

1056
00:54:11.555 --> 00:54:12.655
you put two guys in there

1057
00:54:12.655 --> 00:54:13.975
that really know what they're doing.

1058
00:54:14.315 --> 00:54:15.975
So one guy can pick up stuff

1059
00:54:15.975 --> 00:54:17.175
that's, that's starting to change.

1060
00:54:18.675 --> 00:54:22.095
Um, assess margins. This is a biggie for me.

1061
00:54:22.835 --> 00:54:26.575
Um, it's important. This is kind of like real time ORM.

1062
00:54:27.635 --> 00:54:31.455
Uh, are we stacking up the things against us real bad?

1063
00:54:31.675 --> 00:54:35.575
You know, uh, the next three come from the, the,

1064
00:54:35.595 --> 00:54:36.815
the book, the Black Swan.

1065
00:54:36.815 --> 00:54:38.775
It's a tough read, don't recommend it.

1066
00:54:38.995 --> 00:54:41.495
But there were three things that came out of that.

1067
00:54:41.795 --> 00:54:43.655
And this is the first one, slack.

1068
00:54:44.405 --> 00:54:47.495
What makes you robust to that random uncertainty out there

1069
00:54:47.495 --> 00:54:48.775
that that crazy event

1070
00:54:48.775 --> 00:54:52.135
that you haven't thought about is having slack, having

1071
00:54:52.645 --> 00:54:53.935
some margin, if you will.

1072
00:54:53.995 --> 00:54:56.295
And that's what we talk about in in flight tests.

1073
00:54:56.295 --> 00:54:57.935
We talk about stability, margins,

1074
00:54:58.175 --> 00:55:01.055
performance margins, time margin.

1075
00:55:01.395 --> 00:55:06.135
That's a big deal. So those kind of margins, um, it's,

1076
00:55:06.365 --> 00:55:07.695
it's important to track them,

1077
00:55:07.785 --> 00:55:11.015
understand when you're lean thin on 'em,

1078
00:55:11.395 --> 00:55:13.655
and then take extra control at that point,

1079
00:55:14.005 --> 00:55:17.495
because even the simplest thing completely unrelated

1080
00:55:17.495 --> 00:55:20.415

to flight test can put you over the edge and,

1081
00:55:20.555 --> 00:55:22.375
and make, make for a bad day.

1082
00:55:23.835 --> 00:55:26.385
So, and then redundancy,

1083
00:55:26.385 --> 00:55:30.625
this is another one from the black swan margins, slack

1084
00:55:31.185 --> 00:55:33.985
redundancy, you know, redundant systems help

1085
00:55:34.835 --> 00:55:36.745
complexity is, is tough.

1086
00:55:36.885 --> 00:55:38.785
So it helps to have redundant systems.

1087
00:55:40.345 --> 00:55:42.595
Talk about this in the way of

1088
00:55:43.225 --> 00:55:45.635
control processes for people.

1089
00:55:46.615 --> 00:55:49.835
The TM room don't have a single point failure in the TM room

1090
00:55:50.295 --> 00:55:51.635
on your critical parameters.

1091
00:55:52.265 --> 00:55:53.475
Have that guy backed up.

1092
00:55:53.525 --> 00:55:55.955
Maybe have a second person doing that,

1093
00:55:56.485 --> 00:56:00.835
maybe offload the loads guy in, in other duties.

1094
00:56:01.645 --> 00:56:03.715
Maybe have the handling qualities guys do that

1095
00:56:03.735 --> 00:56:05.155
for him or something like that.

1096
00:56:05.295 --> 00:56:07.715
We, we do that on, in, in our telemetry room.

1097
00:56:08.175 --> 00:56:09.875
The guys really help each other out.

1098
00:56:10.495 --> 00:56:13.835
So we try not to be that single point failure,

1099
00:56:16.025 --> 00:56:18.595
then simplify it.

1100
00:56:18.815 --> 00:56:22.525
Um, this really helps simplify your limits,

1101
00:56:22.595 --> 00:56:24.285
your processes, your procedures.

1102
00:56:24.675 --> 00:56:28.965
Complex systems fail in complex ways, so keep your

1103
00:56:29.475 --> 00:56:31.445
control measures as simple as you can

1104
00:56:31.665 --> 00:56:33.045
and still be effective.

1105
00:56:33.415 --> 00:56:36.725
Think of the Swiss cheese model, not having a lot of, of,

1106
00:56:36.825 --> 00:56:40.165
of, uh, a layers of Swiss cheese with a lot of holes.

1107
00:56:40.315 --> 00:56:44.645

Have a, a few Swiss cheese, uh, with less holes.

1108
00:56:45.265 --> 00:56:47.605
So just do it, do it that way.

1109
00:56:47.905 --> 00:56:51.195
Um, and this will,

1110
00:56:51.525 --> 00:56:53.395
those three things can kind of

1111
00:56:53.905 --> 00:56:57.835
help you enhance being more robust to the unexpected.

1112
00:56:58.615 --> 00:57:01.275
And then finally, what we've talked about developing

1113
00:57:01.365 --> 00:57:05.275
heuristics, and this is, this is what I talk about with

1114
00:57:05.275 --> 00:57:08.315
that robust knock it off call that knock it off call

1115
00:57:08.315 --> 00:57:09.755
that works for our loads test,

1116
00:57:10.295 --> 00:57:13.155
but you've trained your body to respond to that.

1117
00:57:13.335 --> 00:57:14.835
And if something else happens out there,

1118
00:57:15.095 --> 00:57:17.675
that's probably the most likely way you're gonna get out

1119
00:57:17.675 --> 00:57:20.075
of the, out of that situation.

1120
00:57:20.135 --> 00:57:24.155
The idea with, with the, the heuristic is

1121
00:57:24.975 --> 00:57:27.515
to use a, a good positive rule of thumb

1122
00:57:27.775 --> 00:57:30.115
to give you a little bit of time to sort out

1123
00:57:30.115 --> 00:57:31.235
what the heck is happening

1124
00:57:31.375 --> 00:57:34.635
and then troubleshoot it effectively, not to jump

1125
00:57:34.695 --> 00:57:36.595
to conclusions that are gonna burn you.

1126
00:57:38.015 --> 00:57:40.875
So let's look at margin awareness then on that point.

1127
00:57:41.605 --> 00:57:43.435
Guess what we've got?

1128
00:57:43.435 --> 00:57:46.195
We have low margins on that 55 knot point,

1129
00:57:46.695 --> 00:57:50.075
and in pretty much everything performance,

1130
00:57:50.535 --> 00:57:51.875
we have very little performance.

1131
00:57:51.875 --> 00:57:56.395
We get slow, we fall out of the sky handling qualities where

1132
00:57:57.285 --> 00:57:59.915
we're at the worst control power laterally.

1133
00:58:00.335 --> 00:58:01.555
And when you do this maneuver,

1134
00:58:01.575 --> 00:58:04.875

you hear this big whooshing sound in the, in the rotors

1135
00:58:05.225 --> 00:58:07.075
that tells you they're right at their limit.

1136
00:58:07.375 --> 00:58:10.795
Uh, it just, uh, it's unnerving the first time you hear it.

1137
00:58:11.055 --> 00:58:14.275
Um, and then you're obviously pushing

1138
00:58:14.415 --> 00:58:15.555
up against your loads limits.

1139
00:58:15.695 --> 00:58:17.795
So those three things can kind of interact

1140
00:58:17.815 --> 00:58:20.715
and really make for a bad day if you don't do things right.

1141
00:58:21.335 --> 00:58:24.195
And the other thing to consider on margins is time.

1142
00:58:25.055 --> 00:58:28.355
You know, here I have some of them time, yeah, we're,

1143
00:58:28.355 --> 00:58:32.835
we're pressed on time knocking through our, our buildup

1144
00:58:32.915 --> 00:58:34.715
because our elastomers are heating.

1145
00:58:35.295 --> 00:58:38.115
Uh, we time to avoid hazards.

1146
00:58:38.115 --> 00:58:42.335
There's not much, uh, um, you because you're on your limits.

1147
00:58:42.515 --> 00:58:45.855
And then we find ourselves sometimes at

1148
00:58:45.855 --> 00:58:46.935
low altitude on this one.

1149
00:58:46.935 --> 00:58:48.695
So we don't even have time to bail out hardly.

1150
00:58:49.355 --> 00:58:50.655
So we have to consider that.

1151
00:58:52.965 --> 00:58:54.905
So when you see all of this, what do you do?

1152
00:58:55.205 --> 00:58:56.705
You employ the other aspects.

1153
00:58:57.165 --> 00:59:00.945
You exercise the controls that you have control over

1154
00:59:02.645 --> 00:59:04.025
TM reliability.

1155
00:59:04.295 --> 00:59:07.625
Make sure you've got solid tm, uh, continuity.

1156
00:59:07.885 --> 00:59:09.265
We use a continuity pilot

1157
00:59:09.325 --> 00:59:12.065
for the loads buildup on the really high risk points.

1158
00:59:12.115 --> 00:59:14.105
We'll put two experienced pilots in there.

1159
00:59:14.765 --> 00:59:18.325
Um, just various controls

1160
00:59:18.325 --> 00:59:20.325
that we have control over.

1161
00:59:20.435 --> 00:59:22.485

Make sure they're, they're implemented.

1162
00:59:22.655 --> 00:59:24.045
Don't go out in bad weather.

1163
00:59:25.065 --> 00:59:28.655
Um, you know, you go out with a, uh, you have

1164
00:59:28.655 --> 00:59:30.455
to have a really strong visible horizon.

1165
00:59:30.595 --> 00:59:31.615
You don't want turbulence,

1166
00:59:31.615 --> 00:59:32.815
you don't want any of that kind of stuff.

1167
00:59:32.845 --> 00:59:36.695
Just put everything in your favor when your ORM here says

1168
00:59:37.085 --> 00:59:41.525
your, you got no slack lack, um,

1169
00:59:41.895 --> 00:59:44.845
heuristics experience counts here.

1170
00:59:44.845 --> 00:59:46.205
Test pilot school training.

1171
00:59:47.415 --> 00:59:50.515
Um, we use continuity pilots that I talked about.

1172
00:59:51.625 --> 00:59:56.515
Um, it helps if you don't have

1173
00:59:56.515 --> 00:59:59.115
that experience to develop it.

1174
01:00:00.135 --> 01:00:04.395
And, uh, you have to argue with management for this.

1175
01:00:04.695 --> 01:00:08.235
Uh, a lot of times you need to convince management

1176
01:00:08.335 --> 01:00:12.095
to buy the insurance and, uh, that's tough.

1177
01:00:13.085 --> 01:00:15.695
It's a tough sell. But take that chart

1178
01:00:15.715 --> 01:00:17.375
and say, random uncertainty.

1179
01:00:17.495 --> 01:00:19.455
I, I'm working on that area, man.

1180
01:00:19.715 --> 01:00:21.735
You know, tell 'em you need to do that

1181
01:00:22.515 --> 01:00:25.095
and, uh, maybe it'll help you in

1182
01:00:25.095 --> 01:00:26.775
that unforeseen circumstances.

1183
01:00:28.495 --> 01:00:31.595
So this is what I covered on the left,

1184
01:00:31.615 --> 01:00:32.635
the traditional metrics

1185
01:00:32.815 --> 01:00:34.675
and some of the things I've offered here.

1186
01:00:35.575 --> 01:00:37.915
How am I doing on time? I got about 10 minutes.

1187
01:00:38.415 --> 01:00:41.875
So I've told you how we did it right now,

1188
01:00:41.875 --> 01:00:43.035

I'm gonna tell you how we did it wrong.

1189
01:00:44.135 --> 01:00:45.955
So I'm gonna jump ahead.

1190
01:00:48.375 --> 01:00:49.395
Bonded blade tabs.

1191
01:00:49.545 --> 01:00:50.955
This was a proof of concept test

1192
01:00:52.055 --> 01:00:54.995
and we were gonna go out

1193
01:00:55.095 --> 01:00:59.555
and show that by gluing these tabs on the trailing edge

1194
01:00:59.555 --> 01:01:02.115
of the blade, we were gonna gain better hover performance.

1195
01:01:02.255 --> 01:01:06.235
We did that worked good. Then came loads.

1196
01:01:06.615 --> 01:01:08.915
We knew it was gonna drive loads up on the rotor.

1197
01:01:09.135 --> 01:01:12.915
So we went out and we, we slowly built out an envelope

1198
01:01:13.215 --> 01:01:15.395
and went out and started doing loads

1199
01:01:15.395 --> 01:01:17.475
testing and we got burned.

1200
01:01:17.955 --> 01:01:19.555
A team that had been doing loads testing

1201
01:01:19.695 --> 01:01:22.595
for a long time had all our procedures nailed down,

1202
01:01:23.415 --> 01:01:27.275
and we made a mistake, a couple of mistakes in one day.

1203
01:01:28.215 --> 01:01:31.715
It was a wind up turn, guess where it was? Same dang speed.

1204
01:01:31.825 --> 01:01:33.035
I've just been talking about.

1205
01:01:34.015 --> 01:01:35.795
Um, we knew the loads were,

1206
01:01:35.815 --> 01:01:37.395
the static loads were gonna be higher.

1207
01:01:37.735 --> 01:01:40.515
We assumed that the oscillator would go with them.

1208
01:01:41.575 --> 01:01:43.595
Um, second sort of the test day,

1209
01:01:44.175 --> 01:01:45.755
we jumped up into the test band.

1210
01:01:47.975 --> 01:01:51.355
Um, same test band, gross weight

1211
01:01:51.495 --> 01:01:55.875
and, uh, density alte band, but we were heavier.

1212
01:01:56.225 --> 01:01:57.275
It's later in the day.

1213
01:01:58.015 --> 01:02:01.835
Jumped up there, it was a step change in our

1214
01:02:02.785 --> 01:02:05.515
load parameter, went into the windup turn

1215
01:02:06.535 --> 01:02:10.755

and immediately got a massive oscillatory exceedance.

1216
01:02:11.455 --> 01:02:16.375
Um, so then in the data

1217
01:02:16.695 --> 01:02:19.605
re review, we, we realized we overran the, our data.

1218
01:02:20.025 --> 01:02:24.045
We did not do the fatigue calculation from previous day.

1219
01:02:25.305 --> 01:02:28.085
And lo and behold, we were eating up the life on,

1220
01:02:28.305 --> 01:02:30.525
on the gimbal and a couple other components

1221
01:02:30.625 --> 01:02:31.845
faster than expected.

1222
01:02:32.985 --> 01:02:35.915
And there was other things

1223
01:02:35.915 --> 01:02:37.595
that were telling us it was different.

1224
01:02:38.375 --> 01:02:42.635
Our a SE points in airplane mode, we had shifted, um,

1225
01:02:43.615 --> 01:02:46.075
our, um, two of our a SE modes.

1226
01:02:46.175 --> 01:02:47.715
One became more critical than the other.

1227
01:02:47.735 --> 01:02:48.995
And that wasn't forecast.

1228
01:02:49.655 --> 01:02:52.395
We were bottoming out the governor at 60 in the,

1229
01:02:52.395 --> 01:02:55.435
in the cell, um, dissents.

1230
01:02:55.495 --> 01:02:57.555
And we had hotter roll response

1231
01:02:57.655 --> 01:02:59.635
and, uh, ya response in the aircraft.

1232
01:02:59.695 --> 01:03:00.715
So there's a lot telling us.

1233
01:03:01.455 --> 01:03:04.195
We blame most of that on just the effectiveness

1234
01:03:04.215 --> 01:03:05.595
of the bonded tabs.

1235
01:03:06.975 --> 01:03:09.235
But then on data review, we realized

1236
01:03:09.775 --> 01:03:12.795
we had changed the whole, um, the, the, uh,

1237
01:03:13.455 --> 01:03:15.715
the whole torsional response of the rotor

1238
01:03:15.855 --> 01:03:17.555
by putting those tabs off like that.

1239
01:03:18.255 --> 01:03:19.435
And so that static

1240
01:03:20.055 --> 01:03:23.275
and oscillatory load went like this

1241
01:03:24.215 --> 01:03:27.795
and the oscillatory just took off and buried itself.

1242
01:03:27.815 --> 01:03:29.235

And in this maneuver, I think we,

1243
01:03:29.345 --> 01:03:30.515
what did we get down to Mike?

1244
01:03:30.515 --> 01:03:34.875
28% of the fatigue life of the gimbal in one maneuver.

1245
01:03:35.175 --> 01:03:39.915
So we got the aircraft back on, on the ground,

1246
01:03:39.935 --> 01:03:42.755
but we took a very hard long look at what we

1247
01:03:42.755 --> 01:03:44.475
as a test team had done.

1248
01:03:44.615 --> 01:03:46.955
We had drifted away from our own principles

1249
01:03:47.535 --> 01:03:49.515
and kind of blew off a couple of our,

1250
01:03:49.975 --> 01:03:51.235
the things that I just talked about.

1251
01:03:52.575 --> 01:03:55.995
So lessons learned and that was ours.

1252
01:03:56.895 --> 01:04:01.195
Um, and here's some of the various things that we saw

1253
01:04:01.385 --> 01:04:02.995
that were telling us that this

1254
01:04:02.995 --> 01:04:04.155
thing was definitely different.

1255
01:04:05.665 --> 01:04:07.275
With that, any

1256
01:04:07.595 --> 01:04:11.435
questions, suggestions?

1257
01:04:12.775 --> 01:04:16.515
My view of risk mitigation anyway. Yeah,

1258
01:04:37.615 --> 01:04:38.615
There we go.

1259
01:04:39.975 --> 01:04:43.725
Check, check. Ali Sultan. Uh, FAA flight test.

1260
01:04:43.725 --> 01:04:44.845
Thank you for the presentation.

1261
01:04:45.345 --> 01:04:48.125
Um, you touched earlier on, um, uh,

1262
01:04:48.145 --> 01:04:50.525
on the beaker chart again, uh,

1263
01:04:50.525 --> 01:04:52.765
as in the previous presentation.

1264
01:04:52.765 --> 01:04:54.165
And, and I really liked that chart.

1265
01:04:54.305 --> 01:04:58.325
And, um, in, in my experience that left

1266
01:04:58.425 --> 01:05:03.085
and right windows, uh, are not objectively where,

1267
01:05:03.095 --> 01:05:05.205
where they really are, they can move based on,

1268
01:05:05.765 --> 01:05:07.365
I guess the knowledge of the flight

1269
01:05:07.395 --> 01:05:08.645

test team and the company.

1270
01:05:09.585 --> 01:05:12.885
Uh, the more knowledge that the company has, um,

1271
01:05:13.945 --> 01:05:16.285
the less risk there is.

1272
01:05:16.505 --> 01:05:19.045
So that right window kind of narrows down a little bit.

1273
01:05:19.435 --> 01:05:23.525
Yeah. Um, one thing I've noticed working with a lot

1274
01:05:23.525 --> 01:05:27.925
of applicants is that there is certainly a range to

1275
01:05:27.925 --> 01:05:29.925
that window between the different applicants.

1276
01:05:29.945 --> 01:05:34.765
And a lot of that stems from, uh, sometimes the lack

1277
01:05:34.765 --> 01:05:37.765
of knowledge on the flight test team regarding, uh,

1278
01:05:37.985 --> 01:05:39.845
the expected hazards from the test

1279
01:05:39.905 --> 01:05:41.245
that's about to be conducted.

1280
01:05:42.105 --> 01:05:46.325
Um, and and this is, this is to to to the group and, and,

1281
01:05:46.345 --> 01:05:49.325
and for discussion and suggestions, uh, one thing

1282
01:05:49.325 --> 01:05:54.165
that I see can be beneficial is even evening out, uh,

1283
01:05:54.345 --> 01:05:55.765
the playing field for everyone

1284
01:05:55.785 --> 01:05:59.845
and getting everyone to a higher baseline of knowledge

1285
01:06:00.225 --> 01:06:02.365
of the possible test hazards.

1286
01:06:02.745 --> 01:06:04.685
Uh, you, you mentioned in there the,

1287
01:06:04.685 --> 01:06:06.845
the NASA flight test, uh, database.

1288
01:06:07.385 --> 01:06:09.925
Um, I think unfortunately, that site is down,

1289
01:06:09.945 --> 01:06:12.045
so if anybody would go on there now

1290
01:06:12.145 --> 01:06:14.085
and tries to actually get some information

1291
01:06:14.145 --> 01:06:15.725
out, they won't be able to.

1292
01:06:16.585 --> 01:06:19.805
Um, I spoke to different applicants in the past, uh,

1293
01:06:19.865 --> 01:06:22.365
in regards to maybe acquiring

1294
01:06:22.425 --> 01:06:25.845
and putting together maybe a master database

1295
01:06:26.625 --> 01:06:30.965
of t ha's, and we run into issues of proprietary information

1296
01:06:31.305 --> 01:06:33.925

and a lot of things that kind of complicates that.

1297
01:06:34.025 --> 01:06:36.005
So my, my question to you, sir

1298
01:06:36.025 --> 01:06:40.005
and the group is how can we come up with a way to

1299
01:06:40.675 --> 01:06:45.525
make testing safer for everybody by giving, giving everyone

1300
01:06:46.185 --> 01:06:48.405
access, uh, to those ths

1301
01:06:48.405 --> 01:06:51.925
and maybe finding a way to sterilize that data out

1302
01:06:51.925 --> 01:06:53.245
of proprietary information while,

1303
01:06:53.245 --> 01:06:56.205
while keeping some benefit in those tpha? Thank you.

1304
01:06:56.515 --> 01:07:00.685
Yeah. Um, we tried a couple workshops back to, uh,

1305
01:07:00.705 --> 01:07:03.725
we had a THA development workshop, which was really good.

1306
01:07:04.465 --> 01:07:08.365
Um, but we only just touched on what we needed.

1307
01:07:08.825 --> 01:07:12.045
And one of the problems with th a is they are so

1308
01:07:13.245 --> 01:07:17.325
aircraft specific and, uh, you can cut and paste and,

1309
01:07:17.385 --> 01:07:18.845
and look at others,

1310
01:07:19.465 --> 01:07:21.845
but you have to understand, uh, what pieces

1311
01:07:21.905 --> 01:07:23.525
and parts apply and what's missing.

1312
01:07:24.115 --> 01:07:28.165
It's still, that process is really the more important thing.

1313
01:07:28.925 --> 01:07:32.525
I, I would love to have a big bigger database out there.

1314
01:07:32.825 --> 01:07:36.605
Um, I think maybe a future flight test safety workshop,

1315
01:07:36.665 --> 01:07:38.405
we should endeavor to do it again,

1316
01:07:38.405 --> 01:07:40.365
break up in groups like we did on that one

1317
01:07:40.385 --> 01:07:43.285
and crank out some more, uh, ts.

1318
01:07:44.225 --> 01:07:47.165
Uh, but there's nothing like getting

1319
01:07:47.165 --> 01:07:49.005
that multidisciplinary team there

1320
01:07:49.065 --> 01:07:50.605
and just brainstorming through it,

1321
01:07:50.955 --> 01:07:52.205
that that's the hard part.

1322
01:07:52.395 --> 01:07:54.845
There's some good tools, the bow tie analysis

1323
01:07:54.945 --> 01:07:58.165

and things like that, that are out there that really help in

1324
01:07:58.165 --> 01:08:01.225
that process for, for the start.

1325
01:09:55.305 --> 01:09:59.605
So, uh, the, the analogy that makes sense to me is

1326
01:10:00.135 --> 01:10:01.805
robustness is like a sea wall.

1327
01:10:02.315 --> 01:10:06.005
Like you build up a really thick, you know, strong,

1328
01:10:07.505 --> 01:10:10.045
uh, thing that protect you from the elements.

1329
01:10:11.005 --> 01:10:13.565
Resilience is a swamp marsh, like a salt marsh.

1330
01:10:14.625 --> 01:10:18.565
So if your, if your house is like 50 feet from the sea wall

1331
01:10:19.145 --> 01:10:21.285
and the sea wall gives way

1332
01:10:21.385 --> 01:10:25.045
and the storm's still going, your house is gone, right?

1333
01:10:25.705 --> 01:10:28.805
But if your, if your house is a kilometer from the sea

1334
01:10:28.805 --> 01:10:30.885
and there's a salt marsh in the middle,

1335
01:10:32.185 --> 01:10:33.765
that's a lot more resilient.

1336
01:10:33.985 --> 01:10:37.245
Uh, it can absorb all those,

1337
01:10:37.625 --> 01:10:39.845
uh, those differences. So

1338
01:10:39.925 --> 01:10:40.925
I think that's a good point.

1339
01:10:41.205 --> 01:10:43.285
I, I tend to use the term robust

1340
01:10:43.425 --> 01:10:47.605
and I think, uh, the guy who wrote the Black Swan Tale,

1341
01:10:47.905 --> 01:10:52.405
he actually uses resilience, I think as a, as a term there.

1342
01:10:52.405 --> 01:10:55.765
That's probably the better term to use, frankly, in,

1343
01:10:55.785 --> 01:10:56.805
in what I'm talking about.

1344
01:11:02.205 --> 01:11:05.385
Any other questions? Yeah.

1345
01:11:06.405 --> 01:11:10.025
So one bullet you had in there was assess the probability

1346
01:11:10.285 --> 01:11:12.905
of failure, remove that bullet,

1347
01:11:17.225 --> 01:11:18.965
So assess the probability of failure

1348
01:11:19.115 --> 01:11:20.125
with one of your bullets.

1349
01:11:20.235 --> 01:11:23.485
Yeah, and I'm going that, that can be,

1350
01:11:24.475 --> 01:11:25.925

give you a false sense of confidence.

1351
01:11:25.925 --> 01:11:27.965
How do you assess the probability of failure?

1352
01:11:31.925 --> 01:11:35.215
When, well, when we're, we're,

1353
01:11:36.405 --> 01:11:37.475
which slide was that?

1354
01:11:37.575 --> 01:11:39.515
Was that on the THA slide?

1355
01:11:42.455 --> 01:11:45.895
I think it was, yeah, on that you're,

1356
01:11:45.895 --> 01:11:48.895
you're looking at individual failures that might occur

1357
01:11:48.895 --> 01:11:50.335
that would affect your test.

1358
01:11:51.695 --> 01:11:55.865
So, so say, um, say, uh,

1359
01:11:56.005 --> 01:11:59.465
engine failure when you're in the HV avoid region would be

1360
01:11:59.465 --> 01:12:02.505
one of those things that you would assess there and,

1361
01:12:02.565 --> 01:12:04.545
and you would say it's likely.

1362
01:12:05.125 --> 01:12:09.785
Um, another example there would be a dual engine failure,

1363
01:12:10.605 --> 01:12:12.265
uh, highly improbable.

1364
01:12:12.645 --> 01:12:16.065
Do we really put together anything on against

1365
01:12:16.255 --> 01:12:17.745
that as an issue?

1366
01:12:18.785 --> 01:12:22.685
Um, it does figure in, it brings to to mind.

1367
01:12:23.065 --> 01:12:27.365
Um, a, a lesson I learned this was,

1368
01:12:28.005 --> 01:12:29.845
I was one of the senior guys

1369
01:12:30.025 --> 01:12:34.125
and the guys out at Bell were doing some flight tests, uh,

1370
01:12:34.665 --> 01:12:36.765
and they were doing throttle boaties where you're,

1371
01:12:36.765 --> 01:12:40.605
you're slamming the thrust command lever three times,

1372
01:12:40.955 --> 01:12:41.965
boom, boom, boom.

1373
01:12:42.705 --> 01:12:45.765
And, uh, well, the upshot is if you fail that test,

1374
01:12:45.785 --> 01:12:48.285
you're gonna get probably a compressor stall.

1375
01:12:49.305 --> 01:12:50.965
You may end up with an engine failure.

1376
01:12:51.345 --> 01:12:54.045
Uh, the problem is you're doing both engines simultaneously.

1377
01:12:54.385 --> 01:12:56.245

So for me it was like, oh man,

1378
01:12:56.565 --> 01:12:58.285
I could get both engines at the same time.

1379
01:12:58.465 --> 01:13:00.325
So I was like, Hey, you know,

1380
01:13:00.505 --> 01:13:02.685
if you're doing those points still about 10,000 feet,

1381
01:13:02.825 --> 01:13:05.325
you know, because, you know, that's about high key

1382
01:13:05.325 --> 01:13:07.485
for our aircraft with a dual engine failure

1383
01:13:08.815 --> 01:13:10.525
where it's a lifting body approach.

1384
01:13:11.105 --> 01:13:14.645
Uh, but the guys chose not to do that,

1385
01:13:15.225 --> 01:13:17.805
and they did it at pattern altitude and lo

1386
01:13:17.805 --> 01:13:19.165
and behold, it saved their butt

1387
01:13:19.165 --> 01:13:22.725
because they got a single engine failure

1388
01:13:24.225 --> 01:13:27.445
caught on fire, blew up, uh, the engine

1389
01:13:27.865 --> 01:13:31.765
and it racked the gear boxes of the aircraft to

1390
01:13:31.765 --> 01:13:34.605
where the cell blowers, uh, got disconnected

1391
01:13:34.705 --> 01:13:36.565
and the gear boxes started to overheat.

1392
01:13:37.185 --> 01:13:38.765
By the time they got it on the ground,

1393
01:13:38.825 --> 01:13:40.285
the gear boxes were melted down.

1394
01:13:40.345 --> 01:13:42.365
Had they been at 10,000 feet that had been toast.

1395
01:13:42.705 --> 01:13:44.925
So, um, you know, it's,

1396
01:13:44.955 --> 01:13:47.285
it's the big alligator versus the little alligator.

1397
01:13:48.225 --> 01:13:51.525
And, and sometimes that's a, a judgment call,

1398
01:13:52.145 --> 01:13:54.925
but Dan Wells, uh, he's still around today.

1399
01:13:55.525 --> 01:13:57.045
I think he's still flying 6 0 9.

1400
01:13:57.225 --> 01:13:58.925
He was in that aircraft when that happened.

1401
01:13:59.625 --> 01:14:03.005
Uh, pretty, pretty much a black swan kind of thing.

1402
01:14:03.105 --> 01:14:04.965
And he was, they were up against it.

1403
01:14:05.265 --> 01:14:08.045
And later on we learned the hard way.

1404
01:14:08.045 --> 01:14:11.445

In V 22 we had some gear, we had some drive train issues,

1405
01:14:11.555 --> 01:14:13.405
hard clutches that would, would do that.

1406
01:14:13.505 --> 01:14:16.205
They'd just cascade through the drive train

1407
01:14:16.265 --> 01:14:18.085
and just wreak havoc.

1408
01:14:18.585 --> 01:14:20.045
And we learned how to deal with that.

1409
01:14:20.665 --> 01:14:23.325
But being at high altitude was not necessarily the best

1410
01:14:23.325 --> 01:14:24.405
thing if that occurred.

1411
01:14:25.185 --> 01:14:27.285
So probability of failure, that's a failure

1412
01:14:27.285 --> 01:14:28.565
that we're talking about there.

1413
01:14:29.105 --> 01:14:33.885
Uh, um, not failing the test condition necessarily.

1414
01:14:34.665 --> 01:14:37.765
Uh, there's not a probability in, in that regard,

1415
01:14:38.065 --> 01:14:41.365
but you need to plan on failing the test condition.

1416
01:14:41.685 --> 01:14:43.565
I think that's a better way of wording that.

1417
01:14:43.865 --> 01:14:48.445
If I'm doing loads test plan on exceeding loads, you know,

1418
01:14:48.635 --> 01:14:51.565
plan on busting, bending the aircraft

1419
01:14:51.905 --> 01:14:53.365
and having to get it home.

1420
01:14:55.065 --> 01:14:55.285
So

1421
01:15:06.515 --> 01:15:07.915
I think we're done. Oh, I

1422
01:15:07.915 --> 01:15:09.355
Have a quick question if we have time.

1423
01:15:09.625 --> 01:15:14.075
Yeah. Um, I've noticed in a lot of

1424
01:15:14.625 --> 01:15:17.115
tpha they focus on single causes

1425
01:15:18.015 --> 01:15:22.515
and when it comes to accident debriefs, it always seems like

1426
01:15:23.575 --> 01:15:27.235
it, what ends up happening is a system level failure

1427
01:15:27.415 --> 01:15:28.555
or a multiple failure

1428
01:15:28.735 --> 01:15:31.115
or a cascading failure like you just described.

1429
01:15:32.055 --> 01:15:34.915
So I'm wondering what tips you have on kind

1430
01:15:34.915 --> 01:15:38.115
of taking a bigger mindset and assessing against those,

1431
01:15:39.375 --> 01:15:41.755

you know, empirical low probability failures,

1432
01:15:41.755 --> 01:15:44.715
but the ones that are, you know, always getting us. Yeah,

1433
01:15:44.715 --> 01:15:47.795
That's tough because a lot of times they are interrelated,

1434
01:15:48.055 --> 01:15:50.155
you know, when I was talking root cause there

1435
01:15:50.695 --> 01:15:54.075
pilots screwing up over torquing or over flapping the rotor.

1436
01:15:54.615 --> 01:15:57.915
Um, it's, uh, it still helps

1437
01:15:58.375 --> 01:15:59.835
to list all the root causes

1438
01:16:00.655 --> 01:16:02.635
and then that compounding kind

1439
01:16:02.635 --> 01:16:05.075
of gets worked out in the precautionary measures.

1440
01:16:05.155 --> 01:16:10.115
I think, um, uh, what you do need to

1441
01:16:10.645 --> 01:16:12.675
worry about is when, again,

1442
01:16:12.675 --> 01:16:16.195
when you're operating on very low margins on multiple

1443
01:16:16.255 --> 01:16:20.515
fronts, um, stepping across a boundary can go

1444
01:16:21.335 --> 01:16:23.035
all all ways, all at once.

1445
01:16:23.295 --> 01:16:24.955
And then that's a really bad thing.

1446
01:16:24.975 --> 01:16:27.195
If you lose performance analytic qualities and,

1447
01:16:27.575 --> 01:16:31.635
and exceed loads all at the same time, you're, uh, that can

1448
01:16:32.175 --> 01:16:33.835
set you up for a catastrophic event.

1449
01:16:34.415 --> 01:16:38.635
So you just need to be sensitive, I think during flight

1450
01:16:39.535 --> 01:16:42.835
to how close you are to that, that compounding

1451
01:16:43.735 --> 01:16:46.075
and that, that ORM process

1452
01:16:46.185 --> 01:16:47.995
that I'm talking about really helps there.

1453
01:16:48.155 --> 01:16:49.155
I think

1454
01:16:49.935 --> 01:16:51.935
I, I would say too, if your th

1455
01:16:52.235 --> 01:16:55.815
A's if your th a's routinely have just a single cause,

1456
01:16:56.395 --> 01:16:59.255
you probably not need to widen that aperture a little bit

1457
01:16:59.435 --> 01:17:01.015
and go back to the drawing board.

1458
01:17:01.615 --> 01:17:02.895

'cause there's stuff that's probably

1459
01:17:02.895 --> 01:17:04.015
out there that you're not seeing.

1460
01:17:09.205 --> 01:17:11.005
I, I'll just add to that too.

1461
01:17:11.425 --> 01:17:13.525
The, i I think there's a bit of culture that comes in too.

1462
01:17:13.725 --> 01:17:16.325
'cause when you look at those causes that you have

1463
01:17:16.945 --> 01:17:18.405
and you take a look at how you're,

1464
01:17:18.405 --> 01:17:20.485
how you're mitigating them, if you find

1465
01:17:20.485 --> 01:17:22.565
that you're mitigating with procedurally

1466
01:17:22.945 --> 01:17:25.565
and not taking the time to design out some of those,

1467
01:17:26.065 --> 01:17:28.685
you may have a culture that's leaving large

1468
01:17:28.685 --> 01:17:29.805
holes in the Swiss cheese.

1469
01:17:29.985 --> 01:17:31.965
So if you can close a couple of those,

1470
01:17:31.965 --> 01:17:34.085
then they don't add up downstream.

1471
01:17:34.505 --> 01:17:37.805
So it's, it's important to have a culture that, that seeks

1472
01:17:37.805 --> 01:17:39.725
to design out the problem first

1473
01:17:40.465 --> 01:17:42.285
and not, um, leave it all to

1474
01:17:42.915 --> 01:17:45.085
operational risk management. Yeah,

1475
01:17:45.085 --> 01:17:48.685
That's, that's another, um, that's another thing

1476
01:17:48.685 --> 01:17:51.085
that's mentioned in the 40 40 26.

1477
01:17:51.235 --> 01:17:52.685
It's also a NASA protocol.

1478
01:17:53.665 --> 01:17:58.445
Design it out first if you can add safety, add warnings

1479
01:17:58.585 --> 01:18:00.965
and then procedures, procedures are last

1480
01:18:00.965 --> 01:18:03.565
because that's, those are human control measures

1481
01:18:03.565 --> 01:18:06.205
and they are the most susceptible to screwing up.

1482
01:18:07.745 --> 01:18:11.765
You were talking about THA overload

1483
01:18:12.235 --> 01:18:16.565
that also if you're doing tpha all day, all time, every

1484
01:18:17.165 --> 01:18:20.365
briefing 'em all over and they're too detailed, that leads

1485
01:18:20.365 --> 01:18:23.005

to complacency and that leads to drift.

1486
01:18:23.665 --> 01:18:26.085
So like Dave and, and,

1487
01:18:26.265 --> 01:18:30.365
and Marty are saying, you also want to back up from your ths

1488
01:18:30.365 --> 01:18:32.645
and say, okay, is there a fundamental thing that we need

1489
01:18:32.645 --> 01:18:34.565
to change in the design

1490
01:18:34.585 --> 01:18:36.285
or how we're doing things to prevent

1491
01:18:36.285 --> 01:18:38.165
that drift and complacency.

1492
01:18:38.425 --> 01:18:41.285
And I have gone over that complacency line in the past.

1493
01:18:41.505 --> 01:18:45.965
So you, you, you said last night, no tough questions.

1494
01:18:46.225 --> 01:18:49.125
Uh, what is the flying airspeed of an unladen swallow

1495
01:18:50.105 --> 01:18:51.485
of the African variety European

1496
01:18:51.485 --> 01:18:55.685
African coffee?

1497
01:18:55.715 --> 01:18:56.715
Everybody.

1498
01:18:58.825 --> 01:18:59.805
Thanks guys.