WEBVTT

1
00:00:05.335 --> 00:00:05.805
Thank you.

2
00:00:09.275 --> 00:00:11.645
Good morning. So I've got for you today a pretty, uh,

3
00:00:11.675 --> 00:00:15.165
classic example of a fundamental meeting between fly

4
00:00:15.165 --> 00:00:16.725
by wire flight controls and physics.

5
00:00:17.305 --> 00:00:19.125
Uh, before I start, I wanna thank, uh,

6
00:00:19.205 --> 00:00:21.245
Colonel Hank Vanderberg at PMA 2 61

7
00:00:21.265 --> 00:00:22.685
for authorizing this presentation

8
00:00:22.685 --> 00:00:24.365
and Sikorsky for allowing me to speak.

9
00:00:24.515 --> 00:00:26.805
They've let me be pretty frank with my comments today,

10
00:00:26.805 --> 00:00:28.165
so I think that's probably a good thing in terms

11
00:00:28.165 --> 00:00:29.205
of flight test lessons learned.

12
00:00:31.265 --> 00:00:32.925
So today I'll take you through the, uh, background

13
00:00:32.925 --> 00:00:33.925
of 53 K initially.

14
00:00:34.345 --> 00:00:36.565
Uh, talk about the ground test that we did leading up

15
00:00:36.565 --> 00:00:38.765
to first, uh, initial ground runs

16
00:00:38.765 --> 00:00:40.485
with blades on and then to first flight.

17
00:00:40.945 --> 00:00:42.165
Uh, pretty major discovery

18
00:00:42.165 --> 00:00:45.245
that we found on the ground test vehicle, uh,

19
00:00:45.395 --> 00:00:47.885
what the design error was, how we missed it in flight test,

20
00:00:47.905 --> 00:00:49.485
and that's gonna be the focus of the brief.

21
00:00:49.625 --> 00:00:51.685
I'm not a design engineer on this, on this aircraft,

22
00:00:51.685 --> 00:00:52.685
but I was a tester involved.

23
00:00:52.685 --> 00:00:54.005
So I'm gonna talk mostly about test

24
00:00:55.305 --> 00:00:56.365
and we'll talk about recovery

25
00:00:56.745 --> 00:00:58.245
and our flight test progress since then.

26
00:00:58.245 --> 00:00:59.445
So you'll see this has a happy ending.

27
00:00:59.445 --> 00:01:00.445

Like some of the other briefs.

28
00:01:03.535 --> 00:01:07.485
53 K was specified as a replacement for the CH 53 echo.

29
00:01:07.945 --> 00:01:09.445
Its mission is mostly heavy cargo,

30
00:01:09.465 --> 00:01:10.685
but also for troop transport.

31
00:01:11.105 --> 00:01:14.525
Uh, the idea is to deliver a heavy payload at 110 nautical

32
00:01:14.525 --> 00:01:16.405
miles, double the 47 F

33
00:01:16.405 --> 00:01:18.805
and about triple what the V 22 can do at that range.

34
00:01:19.385 --> 00:01:21.365
You hear a lot of people say that it has tripled the

35
00:01:21.525 --> 00:01:23.565
external load lift capability of the 53 echo.

36
00:01:23.565 --> 00:01:26.485
That's not really right. They can lift about the same thing,

37
00:01:26.505 --> 00:01:28.325
but again, it's a range, uh, factor.

38
00:01:28.345 --> 00:01:30.365
So we have much more range with, with the heavy load.

39
00:01:31.025 --> 00:01:33.005
So for this mission that we, that's depicted here,

40
00:01:33.005 --> 00:01:35.725
it's a 27,000 pound external load lift from

41
00:01:35.765 --> 00:01:36.805
a, uh, from a ship.

42
00:01:37.345 --> 00:01:39.085
And then, uh, the idea is fly it at

43
00:01:39.085 --> 00:01:40.525
marine high hot conditions.

44
00:01:40.585 --> 00:01:41.805
So 91.5 degrees

45
00:01:41.805 --> 00:01:45.845
and 3000 feet pressure, 110 nautical miles, drop it off

46
00:01:45.945 --> 00:01:47.525
and then come home, uh, from

47
00:01:47.525 --> 00:01:48.685
that, uh, external load mission.

48
00:01:49.105 --> 00:01:50.285
So again, quite a bit more

49
00:01:50.285 --> 00:01:51.765
capability than what the Echo has.

50
00:01:52.385 --> 00:01:55.045
And, um, you'll see how we can achieve that in terms of our,

51
00:01:55.065 --> 00:01:56.205
uh, uh, performance.

52
00:01:57.465 --> 00:02:00.005
So 88,000 pounds is our max hover gross weight.

53
00:02:00.005 --> 00:02:01.125
That's with an external load,

54
00:02:01.385 --> 00:02:04.245

and that external load can be as heavy as 36,000 pounds.

55
00:02:05.025 --> 00:02:06.725
On the, on the right there is a picture from our

56
00:02:06.725 --> 00:02:08.005
first external loads flight test.

57
00:02:08.425 --> 00:02:09.685
So the objective of that test was

58
00:02:09.685 --> 00:02:11.245
to pick up a 12,000 pound load

59
00:02:11.245 --> 00:02:13.605
and, uh, demonstrate our emergency jettison functionality

60
00:02:13.915 --> 00:02:15.685
that set us off into external loads.

61
00:02:15.805 --> 00:02:17.485
Envelope expansion on the K, um,

62
00:02:17.485 --> 00:02:19.725
having flown just about six months ago for the first time,

63
00:02:20.555 --> 00:02:21.685
with all the power you need

64
00:02:21.685 --> 00:02:24.085
to carry a 36,000 pound external load, you happen

65
00:02:24.085 --> 00:02:25.045
to have a lot of excess power

66
00:02:25.045 --> 00:02:26.205
when you don't have the external.

67
00:02:26.225 --> 00:02:28.285
So 196 knots is our max dive speed.

68
00:02:28.905 --> 00:02:32.085
Um, pretty fast for a helicopter, we can do about one 70 vh.

69
00:02:32.545 --> 00:02:34.885
So, uh, again, a pretty, pretty good capability.

70
00:02:34.885 --> 00:02:38.085
In terms of performance, we talk about 53 KA lot

71
00:02:38.085 --> 00:02:39.725
as an upgrade to the 53 echo,

72
00:02:39.945 --> 00:02:42.165
but in reality, this is an entirely new aircraft.

73
00:02:42.505 --> 00:02:45.085
The only component that is common between the 53 echo

74
00:02:45.085 --> 00:02:47.405
and 53 K is the refueling probe.

75
00:02:47.785 --> 00:02:50.765
So, uh, entirely new composite fuselage, uh,

76
00:02:50.785 --> 00:02:52.165
new engines, new rotor systems.

77
00:02:52.185 --> 00:02:54.605
So 19,000 shaft horsepower is our, uh,

78
00:02:54.945 --> 00:02:56.245
is our gearbox capability.

79
00:02:56.245 --> 00:02:57.245
We've got a little bit more engine than

80
00:02:57.245 --> 00:02:58.085
that for high altitude.

81
00:02:59.825 --> 00:03:02.285

Our flight control system is a full authority fly by wire.

82
00:03:02.305 --> 00:03:04.125
So this is the first full authority fly

83
00:03:04.125 --> 00:03:06.205
by wire rotorcraft in the Marine Corps

84
00:03:06.205 --> 00:03:08.325
and Navy inventory B 22 fly

85
00:03:08.325 --> 00:03:09.685
by wire also, but not full authority.

86
00:03:09.685 --> 00:03:10.805
So this is a little bit new to us.

87
00:03:11.245 --> 00:03:12.845
I think in terms of, uh, F 35,

88
00:03:12.845 --> 00:03:14.245
we would be considered a legacy system,

89
00:03:14.545 --> 00:03:17.805
but like the F 35 B with our seven main rotor blades

90
00:03:17.805 --> 00:03:19.685
and four tail rotor blades, I will also claim

91
00:03:19.685 --> 00:03:21.205
that we have 11 control effectors.

92
00:03:24.185 --> 00:03:26.365
We have an explicit model following control law

93
00:03:26.365 --> 00:03:29.645
architecture, uh, rigidly enforced by our feedback.

94
00:03:29.865 --> 00:03:31.925
Uh, three pilot selectable control law modes.

95
00:03:32.225 --> 00:03:34.565
Uh, this thing is designed for level one handling qualities

96
00:03:34.565 --> 00:03:36.645
with a DS 33, but it's designed for

97
00:03:36.645 --> 00:03:38.205
that in both good visual environments

98
00:03:38.205 --> 00:03:39.605
and degraded visual environments.

99
00:03:39.605 --> 00:03:41.485
We operate a lot in the dust, so

100
00:03:41.585 --> 00:03:44.445
that's driven multiple modes that are pilot selectable so

101
00:03:44.445 --> 00:03:45.885
that depending on the ambient conditions

102
00:03:45.885 --> 00:03:47.965
and the visual environment, he can get what he needs.

103
00:03:48.825 --> 00:03:50.845
We also a unique trim active side, uh,

104
00:03:50.845 --> 00:03:52.245
side stick cyclic incept.

105
00:03:52.705 --> 00:03:54.885
So you've seen a few aircraft with side six this week.

106
00:03:55.225 --> 00:03:56.845
Uh, again, this is the first one for us.

107
00:03:56.945 --> 00:03:59.085
Uh, you know, the, the H ones have them,

108
00:03:59.185 --> 00:04:00.485

but, uh, for a heavy helicopter,

109
00:04:00.485 --> 00:04:01.565
it's kind of a new thing for us.

110
00:04:04.705 --> 00:04:07.205
We built up to flight test with a lot of ground test,

111
00:04:07.205 --> 00:04:08.285
and I have pictured here a couple

112
00:04:08.285 --> 00:04:09.525
of pictures of our ground test vehicle.

113
00:04:10.105 --> 00:04:12.005
Uh, this was really intended for a bunch

114
00:04:12.005 --> 00:04:13.245
of risk reduction testing.

115
00:04:13.545 --> 00:04:15.645
We started off in the bare head configuration, which is

116
00:04:15.645 --> 00:04:17.205
what I have pictured, no rotor blades installed,

117
00:04:17.625 --> 00:04:19.845
and, uh, then built up to testing with blades on

118
00:04:20.425 --> 00:04:21.925
the GTV obviously was expensive.

119
00:04:21.925 --> 00:04:24.205
It's an entire CH 53 K bolted to the ground.

120
00:04:24.345 --> 00:04:26.365
So there's a hole cut in the bottom of this aircraft

121
00:04:26.665 --> 00:04:29.085
and a very large steel pedestal that is,

122
00:04:29.085 --> 00:04:30.405
uh, attached to the main gear box.

123
00:04:30.835 --> 00:04:32.845
This allows us to pull all of the power

124
00:04:32.845 --> 00:04:34.445
that the aircraft has on the ground

125
00:04:34.465 --> 00:04:36.165
and achieve all of the hub moment that we've got.

126
00:04:36.235 --> 00:04:39.565
Also, uh, in order to fully ring out the, uh, drive, train,

127
00:04:39.665 --> 00:04:42.285
and the rotor system, one of the reasons we needed

128
00:04:42.285 --> 00:04:44.485
to do rotor system testing on this air on this, uh,

129
00:04:44.485 --> 00:04:46.045
ground vehicle is that there wasn't a,

130
00:04:46.525 --> 00:04:48.005
a whirl tower in existence

131
00:04:48.005 --> 00:04:50.085
that could take our seven main rotor blades

132
00:04:50.265 --> 00:04:52.405
and spin them together to the speeds it needed to get to.

133
00:04:52.825 --> 00:04:54.485
So we needed to build an aircraft to do it

134
00:04:54.485 --> 00:04:55.605
with our, uh, three engines.

135
00:04:56.875 --> 00:04:58.565

This also allowed us quite a bit of time

136
00:04:58.785 --> 00:05:00.845
and opportunity to conduct flight control

137
00:05:00.845 --> 00:05:01.965
system and avionics testing.

138
00:05:02.115 --> 00:05:04.085
Because this was built as a full aircraft

139
00:05:04.085 --> 00:05:06.805
and not as a propulsion system test bed, we were able

140
00:05:06.805 --> 00:05:09.165
to check out all of the avionics, do quite a bit

141
00:05:09.165 --> 00:05:11.045
of flight controls work, and actually incorporate several

142
00:05:11.045 --> 00:05:13.285
flight control software versions on the ground vehicle

143
00:05:13.615 --> 00:05:14.725
prior to going to flight tests.

144
00:05:15.795 --> 00:05:18.925
This ended up being a very, uh, useful tool for us

145
00:05:18.925 --> 00:05:20.405
and very fortunate that we had bought it in

146
00:05:20.405 --> 00:05:21.445
terms of the flight control system.

147
00:05:22.145 --> 00:05:24.525
We also had, uh, something that is a little bit, um, new,

148
00:05:24.525 --> 00:05:25.645
at least in terms of its depth.

149
00:05:25.745 --> 00:05:28.485
We have a fully integrated test team between the, uh,

150
00:05:28.645 --> 00:05:30.045
Sikorsky engineers and the government.

151
00:05:30.345 --> 00:05:32.605
So, uh, the picture here is, uh, one Sikorsky pilot

152
00:05:32.625 --> 00:05:34.565
and one marine test pilot in there for bear head.

153
00:05:34.985 --> 00:05:37.045
And, uh, our flight test engineers monitor

154
00:05:37.045 --> 00:05:38.325
identically on their stations.

155
00:05:38.325 --> 00:05:40.845
So it's a, a very, uh, close knit, uh, tight working team.

156
00:05:42.745 --> 00:05:43.965
So, like I said, it was fortunate

157
00:05:43.965 --> 00:05:45.125
that we had the ground test vehicle

158
00:05:45.385 --> 00:05:46.485
for the flight control system.

159
00:05:46.545 --> 00:05:48.645
It wasn't really a system that we expected to get a lot

160
00:05:48.645 --> 00:05:49.965
of discovery out of, but we did.

161
00:05:50.505 --> 00:05:53.485
Um, so after the very first bladed ground run in, uh,

162
00:05:53.485 --> 00:05:56.245

April a couple of years ago, the structures engineers noted

163
00:05:56.245 --> 00:05:58.485
that their tail rotor loads were higher than they expected.

164
00:05:58.985 --> 00:06:01.405
So initially, of course, we blamed this on instrumentation

165
00:06:01.715 --> 00:06:03.645
that clearly the loads must have been wrong.

166
00:06:04.105 --> 00:06:06.685
Uh, instrumentation asked us, Hey, what are the loads on

167
00:06:06.685 --> 00:06:08.085
that tiedown strut there?

168
00:06:08.385 --> 00:06:10.525
So we found that the loads on the tiedown strut agreed

169
00:06:10.525 --> 00:06:12.485
with the tail rotor, uh, measured strains.

170
00:06:12.705 --> 00:06:13.805
So obviously something was real.

171
00:06:14.425 --> 00:06:16.725
Um, we saw the high compressive loads and,

172
00:06:16.725 --> 00:06:18.005
and in a way that we wouldn't have expected.

173
00:06:18.005 --> 00:06:19.965
Obviously we're doing everything in a buildup approach.

174
00:06:20.385 --> 00:06:22.805
So, uh, we began with very low power on the aircraft,

175
00:06:22.805 --> 00:06:23.805
and you wouldn't have expected a lot

176
00:06:23.805 --> 00:06:25.125
of tail rotor for that configuration.

177
00:06:27.025 --> 00:06:28.725
Our flight controls team speculated, well,

178
00:06:28.725 --> 00:06:29.925
maybe we're not getting the tail rotor

179
00:06:29.925 --> 00:06:31.165
angles that we are asking for.

180
00:06:32.025 --> 00:06:33.965
Um, so, you know, obviously we,

181
00:06:33.985 --> 00:06:36.805
we get the tail rotor blade commands outta the flight

182
00:06:36.805 --> 00:06:39.165
controls, and we've sort of made the mistake of assuming

183
00:06:39.195 --> 00:06:40.925
that what the flight controls call is,

184
00:06:40.925 --> 00:06:42.565
my tail rotor blade angle is actually

185
00:06:42.565 --> 00:06:43.605
the tail rotor blade angle.

186
00:06:44.105 --> 00:06:45.525
Uh, the team jumped on the aircraft

187
00:06:45.545 --> 00:06:46.845
and measured the commanded

188
00:06:46.845 --> 00:06:49.325
and, uh, versus achieved angles with a digital protractor.

189
00:06:49.785 --> 00:06:52.085

And we showed that we weren't getting the correct polarity

190
00:06:52.085 --> 00:06:53.725
of, uh, tailwater command

191
00:06:53.825 --> 00:06:55.685
or we weren't achieving what was being commanded.

192
00:06:56.225 --> 00:06:59.285
So, uh, there's a plot of, in green is what the mixing ought

193
00:06:59.285 --> 00:07:01.685
to have looked at, looked like versus collective position.

194
00:07:01.785 --> 00:07:03.005
Red was what we were actually getting.

195
00:07:03.705 --> 00:07:05.165
So obviously a problem there.

196
00:07:06.405 --> 00:07:07.445
I made the question, which one was

197
00:07:07.515 --> 00:07:08.685
left, which one was right.

198
00:07:10.665 --> 00:07:12.085
Uh, so where did the problem come from?

199
00:07:12.395 --> 00:07:15.165
Well, the, uh, the initial kinematics on the tail rotor

200
00:07:15.165 --> 00:07:18.045
and the simulator were based on 53 Echo, um, and,

201
00:07:18.045 --> 00:07:19.925
and other aircraft with a similar configuration.

202
00:07:20.465 --> 00:07:22.845
So that's a slight difference between Echo

203
00:07:22.845 --> 00:07:24.085
and K that we'll see pretty soon.

204
00:07:24.225 --> 00:07:28.085
Uh, during development, the rotors team updated the, uh, ICD

205
00:07:28.425 --> 00:07:29.565
for the tail rotor,

206
00:07:29.785 --> 00:07:32.205
but the, those, uh, that kinematic update wasn't then

207
00:07:32.205 --> 00:07:33.405
reflected in the simulator.

208
00:07:33.785 --> 00:07:35.925
So you're flying a simulator, uh, you know,

209
00:07:35.925 --> 00:07:37.605
pilot input goes into a mixer.

210
00:07:37.875 --> 00:07:40.245
That mixer makes a command in terms of, uh,

211
00:07:40.245 --> 00:07:41.605
degrees over to the servos.

212
00:07:41.625 --> 00:07:44.725
The kinematic in the sim turn that command in terms

213
00:07:44.725 --> 00:07:45.925
of degrees into inches.

214
00:07:46.105 --> 00:07:47.485
And then we have a model of the servos.

215
00:07:48.025 --> 00:07:50.085
Uh, but then here's where fancy control

216
00:07:50.085 --> 00:07:51.165

system meets physics, right?

217
00:07:51.225 --> 00:07:53.525
So we have a model, the actuator position,

218
00:07:53.525 --> 00:07:55.045
and then we have a model of the swash plate,

219
00:07:55.045 --> 00:07:56.845
or in this case just the control rigging.

220
00:07:57.105 --> 00:07:59.765
And then that makes a tail roter angle in the sim.

221
00:08:00.385 --> 00:08:02.005
So again, everything works fine in the sim.

222
00:08:02.005 --> 00:08:04.685
You can make these almost arbitrary, uh, mappings,

223
00:08:04.785 --> 00:08:06.965
and it'll work because you've modeled everything

224
00:08:06.965 --> 00:08:08.045
and you're just inverting the model.

225
00:08:08.585 --> 00:08:09.925
The moment you take that to an aircraft,

226
00:08:10.225 --> 00:08:11.405
uh, you can see problems.

227
00:08:11.665 --> 00:08:13.925
So here's a picture of the 53 echoes tail rotor,

228
00:08:14.065 --> 00:08:17.245
and here's a picture of the 53 Ks model of the tail rotor.

229
00:08:17.545 --> 00:08:19.085
Uh, you can see the pitch horns here.

230
00:08:19.265 --> 00:08:20.565
Uh, the pitch control rods here are

231
00:08:20.565 --> 00:08:21.605
on the leading edge of the blade here.

232
00:08:21.605 --> 00:08:23.005
They're on the trailing edge of the blade.

233
00:08:23.425 --> 00:08:25.845
So on identical servo command to the tail rotor

234
00:08:25.845 --> 00:08:28.205
between the two aircraft yields an opposite, uh,

235
00:08:28.255 --> 00:08:29.445
blade angle change.

236
00:08:30.505 --> 00:08:33.085
So that a fairly small modeling difference

237
00:08:33.085 --> 00:08:35.805
between the two obviously had, uh, pretty big results.

238
00:08:38.065 --> 00:08:39.965
So we do do a lot of work leading up to flight tests.

239
00:08:39.965 --> 00:08:41.645
We had a representative from NRC here this week.

240
00:08:41.645 --> 00:08:43.245
We also did a lot of testing on Rascal,

241
00:08:43.265 --> 00:08:44.365
but it's the same problem.

242
00:08:44.785 --> 00:08:47.725
So you put a model of your aircraft into their aircraft

243
00:08:47.825 --> 00:08:48.925

and then invert that model

244
00:08:49.105 --> 00:08:52.485
and use their dynamics, uh, to pretend that you're a 53 K

245
00:08:52.485 --> 00:08:53.965
and not a Bell four 12 or an H 60.

246
00:08:54.385 --> 00:08:55.525
So again, that's not a place

247
00:08:55.525 --> 00:08:56.925
that you're going to find an error like this.

248
00:08:56.925 --> 00:08:58.605
You do a bunch of simulator testing, you do a bunch

249
00:08:58.605 --> 00:09:00.805
of surrogate aircraft testing, and nowhere do you have the

250
00:09:00.805 --> 00:09:02.085
opportunity to find this problem.

251
00:09:02.505 --> 00:09:05.005
So it's really, really comes down to us in flight tests to,

252
00:09:05.225 --> 00:09:07.285
you know, that once the error has made it to that point,

253
00:09:07.345 --> 00:09:09.005
it comes to us in flight tests to find it.

254
00:09:09.625 --> 00:09:13.485
So, uh, so there I was, uh, so I was out there on a,

255
00:09:13.485 --> 00:09:15.845
on a Saturday with my digital protractor measuring tail

256
00:09:15.935 --> 00:09:19.005
blade angles, and I had a had an opportunity to notice that,

257
00:09:19.105 --> 00:09:21.365
hey, when the guy in the cockpit's calling right pedal,

258
00:09:21.385 --> 00:09:23.005
the servo isn't moving in the right direction,

259
00:09:23.065 --> 00:09:24.445
and let's talk about why it didn't.

260
00:09:25.545 --> 00:09:27.765
Uh, so there's several reasons, uh, how it was missed.

261
00:09:27.945 --> 00:09:29.565
You know, obviously there's a lot of layers

262
00:09:29.565 --> 00:09:30.645
of Swiss cheese here happening,

263
00:09:31.145 --> 00:09:34.125
but in general, I ca I came down to five, uh,

264
00:09:34.405 --> 00:09:35.445
contributing factors that led

265
00:09:35.445 --> 00:09:37.245
to not catching this on the ground test vehicle.

266
00:09:38.015 --> 00:09:39.325
We'll go through each of those in detail.

267
00:09:39.785 --> 00:09:41.365
So the first one is the flight control system

268
00:09:41.365 --> 00:09:42.405
acceptance test procedure.

269
00:09:42.505 --> 00:09:45.605
We have ATPs for, you know, every system on the aircraft,

270
00:09:45.605 --> 00:09:47.005

and they all get performed on each aircraft

271
00:09:47.025 --> 00:09:48.285
as it's delivered to flight test.

272
00:09:48.945 --> 00:09:52.005
So this F-C-S-A-T-P was done as part of the build,

273
00:09:52.345 --> 00:09:54.205
but it was done before the blades were installed.

274
00:09:54.545 --> 00:09:57.685
So the team who was doing the A TP was just looking at a

275
00:09:57.805 --> 00:09:59.725
servo and, you know, some rigging

276
00:09:59.745 --> 00:10:02.005
and didn't have the, the opportunity to look at the thing

277
00:10:02.005 --> 00:10:03.805
and see where the blade would go in response

278
00:10:03.805 --> 00:10:05.725
to the servo movement, unfortunately.

279
00:10:05.745 --> 00:10:07.485
So this, this did specifically check

280
00:10:07.485 --> 00:10:08.485
for the correct railroad

281
00:10:08.485 --> 00:10:10.125
or servo movement in response to pedal

282
00:10:10.125 --> 00:10:11.125
and collective inputs.

283
00:10:11.505 --> 00:10:13.765
The unfortunate thing is that the expected results from the

284
00:10:13.765 --> 00:10:15.205
A TP were based on the sim.

285
00:10:15.705 --> 00:10:17.365
So the sim that had the error in it is

286
00:10:17.365 --> 00:10:18.565
what generated the a TP

287
00:10:18.635 --> 00:10:20.325
that we followed when we installed the

288
00:10:20.325 --> 00:10:21.365
thing on, on the pedestal.

289
00:10:22.185 --> 00:10:24.045
Here's an, here's a picture of that, uh,

290
00:10:24.045 --> 00:10:25.245
tail rotor without blades.

291
00:10:25.545 --> 00:10:27.605
So again, you can imagine that all you're looking at is

292
00:10:27.685 --> 00:10:29.125
servo extender, server retract.

293
00:10:29.745 --> 00:10:31.565
You know, all of us have seen the design

294
00:10:31.565 --> 00:10:33.685
and knew which direction the blades were facing, uh,

295
00:10:33.685 --> 00:10:35.845
in the design, but without them in front of you is I think,

296
00:10:35.885 --> 00:10:37.525
a difficult thing for the team to, to check.

297
00:10:38.105 --> 00:10:41.045

So there I was, I wasn't actually there conducting the A TPI

298
00:10:41.045 --> 00:10:42.245
was conducting a follow on check

299
00:10:42.245 --> 00:10:43.445
of the tail rotor blade angles.

300
00:10:43.725 --> 00:10:45.565
I knew though that this a TP had been conducted.

301
00:10:45.905 --> 00:10:47.085
So I assumed, well,

302
00:10:47.275 --> 00:10:49.485
there's no major discovery to be had here.

303
00:10:49.545 --> 00:10:51.165
I'm just trying to check an angle on a blade,

304
00:10:51.505 --> 00:10:54.245
and I think limited the scope of my investigation

305
00:10:54.385 --> 00:10:56.165
and didn't allow, it didn't, uh, set me up

306
00:10:56.165 --> 00:10:57.885
to critically think about, you know,

307
00:10:57.885 --> 00:10:59.085
what, what there was to be learned.

308
00:11:01.665 --> 00:11:05.205
The next one up, we had a full check of the main rotor

309
00:11:05.205 --> 00:11:06.885
and tail rotor blade angles planned.

310
00:11:07.345 --> 00:11:08.845
But, uh, what we were out there, uh,

311
00:11:08.845 --> 00:11:10.205
that day conducting was really a,

312
00:11:10.225 --> 00:11:11.965
an abbreviated blade angle check.

313
00:11:12.465 --> 00:11:13.925
We had a big milestone coming up,

314
00:11:13.925 --> 00:11:16.085
which was the bladed light off of our ground test vehicle.

315
00:11:16.625 --> 00:11:18.285
And, uh, you know, big deal for the program,

316
00:11:18.345 --> 00:11:19.525
we put blades on a 53 K

317
00:11:19.525 --> 00:11:20.925
for the first time and, and spun it up.

318
00:11:21.305 --> 00:11:23.965
So, as you can imagine, there was some desire to get to that

319
00:11:23.965 --> 00:11:26.325
as quickly as possible and to minimize prerequisite tests.

320
00:11:26.865 --> 00:11:29.525
So we decided, well, this isn't really a prerequisite test

321
00:11:29.525 --> 00:11:30.565
to that bladed light off.

322
00:11:30.575 --> 00:11:32.045
We're, we're gonna stay at low pitch.

323
00:11:32.255 --> 00:11:33.885
We're not gonna put a lot of torque on the aircraft.

324
00:11:33.885 --> 00:11:36.885

So if I have small differences in rigging between my, um,

325
00:11:36.885 --> 00:11:38.765
between my rotor blades, it shouldn't be a big deal.

326
00:11:38.765 --> 00:11:40.565
We get some vibrations, but let's not worry about that.

327
00:11:41.305 --> 00:11:42.645
So instead, we went out there

328
00:11:42.645 --> 00:11:44.245
and did a very initial, uh,

329
00:11:44.245 --> 00:11:46.045
blade angle check just to check the rig.

330
00:11:46.425 --> 00:11:47.485
You know, we had, uh,

331
00:11:47.585 --> 00:11:49.885
pre tracks on all the main rotor blades, uh,

332
00:11:49.885 --> 00:11:51.165
coming out of the whirl tower.

333
00:11:51.325 --> 00:11:53.610
I mentioned before that we can't whirl all seven rotor

334
00:11:53.610 --> 00:11:56.125
blades together, but we can whirl three of them together.

335
00:11:56.545 --> 00:11:58.285
So what they did was we had a, a master blade,

336
00:11:58.285 --> 00:12:00.645
and then we whirl two blades against the master

337
00:12:00.745 --> 00:12:03.085
and just iterate through the, the set that way.

338
00:12:03.665 --> 00:12:06.325
Um, one of our worries with was that this would allow errors

339
00:12:06.325 --> 00:12:07.485
to propagate in the rigging,

340
00:12:07.545 --> 00:12:09.725
and we would get dramatically differently raid

341
00:12:09.915 --> 00:12:10.925
main rotor blades.

342
00:12:11.265 --> 00:12:13.805
We were able to whirl the entire tail rotor together.

343
00:12:13.825 --> 00:12:15.645
So there was somewhat less focus on the tail

344
00:12:15.645 --> 00:12:16.805
rotor during this investigation.

345
00:12:16.805 --> 00:12:19.085
This was mostly on main rotor, uh, issue.

346
00:12:19.525 --> 00:12:22.685
I note here that I wasn't talking very effectively

347
00:12:22.685 --> 00:12:23.845
with the FTE and the cockpit.

348
00:12:23.845 --> 00:12:25.285
We were on radios and it was hard to hear him.

349
00:12:25.585 --> 00:12:28.245
So he was making pedal inputs, making collective inputs.

350
00:12:28.325 --> 00:12:30.405
I wasn't paying very much attention to what he was saying.

351
00:12:30.705 --> 00:12:32.965

Uh, 'cause again, I was up there expecting measuring tail

352
00:12:32.965 --> 00:12:34.525
rotor blade angles, and that was it.

353
00:12:35.345 --> 00:12:38.445
Um, we also found, so remember the objective of this was

354
00:12:38.445 --> 00:12:41.605
to compare the rigging of each of the blades to one another.

355
00:12:42.085 --> 00:12:43.005
I measured two of the tail

356
00:12:43.005 --> 00:12:44.165
rotor blades, and they were identical.

357
00:12:44.165 --> 00:12:45.445
We measured the other two. They were identical.

358
00:12:45.865 --> 00:12:48.205
So from that perspective, I thought, oh, good, nothing

359
00:12:48.205 --> 00:12:49.445
to worry about on the tail rotor.

360
00:12:49.445 --> 00:12:51.285
This was after we had conducted all the checks on the main

361
00:12:51.285 --> 00:12:52.325
rotor and found some differences.

362
00:12:52.825 --> 00:12:55.205
Um, so that, again, degraded attention to detail and,

363
00:12:55.205 --> 00:12:58.645
and test, uh, because I wasn't expecting to be surprised.

364
00:12:59.085 --> 00:13:01.245
I was focusing on only one very narrow objective.

365
00:13:01.665 --> 00:13:03.485
And, uh, I was not attentive to discovery.

366
00:13:05.025 --> 00:13:08.005
So, uh, that, that's, that's a thing to keep in mind is

367
00:13:08.005 --> 00:13:11.405
that, you know, surprises are surprises, right?

368
00:13:11.405 --> 00:13:12.925
You can't, unless you're expecting

369
00:13:12.925 --> 00:13:14.205
to be surprised, you won't notice it.

370
00:13:14.865 --> 00:13:16.525
Uh, the other thing, this is probably new to a lot

371
00:13:16.525 --> 00:13:17.885
of people in flight test schedule pressure.

372
00:13:18.095 --> 00:13:20.085
Never heard of that, right? So, uh, I mentioned

373
00:13:20.085 --> 00:13:22.725
that we had delayed the, mentioned

374
00:13:22.725 --> 00:13:24.805
that we had delayed the blade angle check to the full thing

375
00:13:24.805 --> 00:13:25.805
to after the milestone.

376
00:13:26.225 --> 00:13:27.885
Um, we were conducting this initial check

377
00:13:27.885 --> 00:13:29.085
on second shift on a Saturday.

378
00:13:29.625 --> 00:13:31.285

Uh, so we had very few people there,

379
00:13:31.285 --> 00:13:32.885
and we didn't have extra sets of eyes with us.

380
00:13:32.885 --> 00:13:34.445
It was just the two of us, one on the cockpit,

381
00:13:34.445 --> 00:13:35.445
one back on the tail rotor.

382
00:13:35.785 --> 00:13:37.525
And as you can imagine, second shift on a Saturday,

383
00:13:37.585 --> 00:13:40.045
we didn't do a lot of rigorous data review after the fact.

384
00:13:40.105 --> 00:13:42.045
We did write down angles and,

385
00:13:42.145 --> 00:13:43.765
and in fact, in, in retrospect,

386
00:13:43.765 --> 00:13:46.165
the angles I had written down were sufficient, obviously,

387
00:13:46.165 --> 00:13:48.245
to prove to myself that the tail was backwards,

388
00:13:48.385 --> 00:13:51.085
but didn't look at them in enough detail, uh, in order

389
00:13:51.085 --> 00:13:52.165
to understand that real time.

390
00:13:52.705 --> 00:13:54.285
The next thing is, so why didn't I do it on Sunday?

391
00:13:54.285 --> 00:13:55.165
Well, Sunday we were doing

392
00:13:55.165 --> 00:13:56.565
instrumentation safety and clearance checks.

393
00:13:56.825 --> 00:13:59.365
So, uh, again, didn't spend the next day looking at data.

394
00:13:59.365 --> 00:14:01.325
We instead spent it checking, uh, for,

395
00:14:01.505 --> 00:14:03.245
for tight wires and for chafing.

396
00:14:03.625 --> 00:14:05.805
Uh, we then spent the next, you know, we,

397
00:14:05.805 --> 00:14:07.685
this is like a 13 day straight stretch of work.

398
00:14:07.825 --> 00:14:09.845
So we spent the next week getting ready

399
00:14:09.845 --> 00:14:10.765
for the bladed light off and

400
00:14:10.765 --> 00:14:11.765
conducting the bladed light off.

401
00:14:11.765 --> 00:14:13.725
So it wasn't until after that very first run

402
00:14:13.955 --> 00:14:15.085
that we actually looked at the data

403
00:14:15.085 --> 00:14:16.245
in any detail from this test.

404
00:14:17.025 --> 00:14:19.485
Uh, again, that day on Saturday, we were under pressure

405
00:14:19.485 --> 00:14:20.725

to get off the aircraft and let maintenance

406
00:14:20.725 --> 00:14:22.285
and instrumentation continue putting it together.

407
00:14:23.025 --> 00:14:25.965
Um, however, even with the pressure, I had plenty of time

408
00:14:25.985 --> 00:14:28.045
to, to do this and understand what I was looking at

409
00:14:28.065 --> 00:14:30.485
and find the issue rather than, um,

410
00:14:31.075 --> 00:14:32.245
punting it for the next day.

411
00:14:32.745 --> 00:14:35.285
So this is one of those where even under time pressure,

412
00:14:35.285 --> 00:14:37.685
there's opportunity to, to learn things in flight test.

413
00:14:39.025 --> 00:14:40.285
The other thing, I mentioned this before,

414
00:14:40.385 --> 00:14:42.765
but we were very focused on the main rotor.

415
00:14:42.985 --> 00:14:44.285
Uh, because of the, the fact

416
00:14:44.285 --> 00:14:45.685
that we couldn't whirl the blades together,

417
00:14:46.465 --> 00:14:48.365
we did find some big pre track differences.

418
00:14:48.365 --> 00:14:49.965
So we spent quite a lot of time on that Saturday

419
00:14:49.965 --> 00:14:52.045
and Sunday talking about ELAs, hysteresis

420
00:14:52.045 --> 00:14:53.245
and elastomeric bearings,

421
00:14:53.245 --> 00:14:55.885
and why, why else might there be a difference in the rig

422
00:14:55.885 --> 00:14:57.685
between the blades when otherwise we wouldn't have expected

423
00:14:57.685 --> 00:14:59.125
very much coming out of the world tower.

424
00:14:59.675 --> 00:15:01.325
That ended up actually not being a problem.

425
00:15:01.395 --> 00:15:03.445
This was all correctly set on the world tower,

426
00:15:03.445 --> 00:15:04.965
and we didn't have a lot of, uh, track

427
00:15:04.965 --> 00:15:06.285
and balance changes to make initially.

428
00:15:06.665 --> 00:15:07.885
So the thing that we were measuring,

429
00:15:07.885 --> 00:15:09.965
that we were focusing on didn't really end up mattering.

430
00:15:10.155 --> 00:15:12.685
Like I said before, the tail angles were identical

431
00:15:12.685 --> 00:15:15.405
between all of the blades, so not a lot to be found there.

432
00:15:16.185 --> 00:15:17.965

Uh, however, we focused on a red herring

433
00:15:18.185 --> 00:15:19.925
and, uh, again, a pretty classic mistake.

434
00:15:20.465 --> 00:15:22.845
The we had a, a real problem hiding right in front of us

435
00:15:22.845 --> 00:15:23.845
and instead focused on something that

436
00:15:23.845 --> 00:15:24.685
was completely irrelevant.

437
00:15:25.385 --> 00:15:27.685
Um, you know, Ben Lutheran, his paper, uh,

438
00:15:27.685 --> 00:15:29.805
yesterday talked about what time pressure does

439
00:15:29.805 --> 00:15:31.445
to people, and, uh, it said two things.

440
00:15:31.445 --> 00:15:33.285
He said that it decreases their performance

441
00:15:33.385 --> 00:15:36.165
and that you react by, uh, constraining your inputs.

442
00:15:36.225 --> 00:15:38.365
So this is one where, you know, in a,

443
00:15:38.365 --> 00:15:39.605
in a pressurized environment,

444
00:15:39.665 --> 00:15:41.245
we definitely constrained our inputs.

445
00:15:41.245 --> 00:15:43.005
And in instead of, uh, thinking about everything

446
00:15:43.005 --> 00:15:44.965
that was in front of us, we, we focus on one thing and,

447
00:15:44.965 --> 00:15:46.165
and lost everything else.

448
00:15:47.825 --> 00:15:49.045
The other, the last thing, uh,

449
00:15:49.045 --> 00:15:51.965
the last causal factor was a lack of expected results.

450
00:15:52.305 --> 00:15:55.045
So, you know, we have fairly complicated tail rotor blade

451
00:15:55.045 --> 00:15:57.285
geometry, and we were up there measuring on that, you know,

452
00:15:57.315 --> 00:15:58.765
very inboard cuff.

453
00:15:59.425 --> 00:16:02.645
Um, the guy in the cockpit was calling out FCC

454
00:16:03.295 --> 00:16:04.565
blade angle commands,

455
00:16:04.565 --> 00:16:05.805
but that actually didn't correlate

456
00:16:05.805 --> 00:16:07.205
to the number on the protractor.

457
00:16:07.545 --> 00:16:10.645
And the number on the protractor had sort of a, uh, uh,

458
00:16:10.645 --> 00:16:12.285
arbitrary sign convention depending on

459
00:16:12.285 --> 00:16:13.365

where the tail rotor blade was.

460
00:16:13.365 --> 00:16:15.765
We have a canted tail rotor, so depending on where,

461
00:16:15.765 --> 00:16:17.605
where the blade is in terms of azimuth, that,

462
00:16:17.605 --> 00:16:18.685
uh, changes what the sign is.

463
00:16:18.685 --> 00:16:21.645
So it wasn't easy to hear a tail rotor blade angle command

464
00:16:22.025 --> 00:16:24.525
and, and translated into the number I was seeing

465
00:16:24.545 --> 00:16:25.765
on the inclinometer.

466
00:16:26.345 --> 00:16:28.285
Um, mentioned the complicated geometry.

467
00:16:28.785 --> 00:16:29.965
And, uh, we didn't have it with us.

468
00:16:30.065 --> 00:16:31.965
So we, we could have had prior to it.

469
00:16:32.065 --> 00:16:34.325
Here's the number I will see on the protractor if

470
00:16:34.325 --> 00:16:35.485
everything is matching correctly.

471
00:16:35.665 --> 00:16:37.045
Didn't bother with that. We just went out there

472
00:16:37.045 --> 00:16:38.485
and measured it and then took the measurements home.

473
00:16:38.985 --> 00:16:41.645
Um, so again, expect results would've been in a great way

474
00:16:41.645 --> 00:16:43.925
to, uh, to found this issue while

475
00:16:43.925 --> 00:16:45.045
we were conducting the test.

476
00:16:45.545 --> 00:16:48.205
So how do we recover? Uh, pretty major issue.

477
00:16:48.205 --> 00:16:50.485
We talked a lot about this this week about how we need many,

478
00:16:50.485 --> 00:16:52.085
many software drops in order to get

479
00:16:52.085 --> 00:16:53.285
through a developmental test program.

480
00:16:54.105 --> 00:16:56.645
Uh, well, so the structural loads engineers

481
00:16:56.645 --> 00:16:57.685
were the ones who pointed us to this.

482
00:16:57.685 --> 00:16:59.605
Again, they, they had a independent data source,

483
00:16:59.605 --> 00:17:02.405
which is their, uh, tail rotor, uh, blade strains

484
00:17:02.405 --> 00:17:04.365
and the compressive load on the support strut.

485
00:17:04.705 --> 00:17:05.965
So that was what called it out.

486
00:17:05.965 --> 00:17:07.765

And then some critical thinking from others on the flight

487
00:17:07.765 --> 00:17:09.885
controls team, uh, pointed us in this direction.

488
00:17:10.425 --> 00:17:13.085
So the design team, uh, in concert with the test team,

489
00:17:13.085 --> 00:17:14.925
conducted a end-to-end review of the control system.

490
00:17:14.925 --> 00:17:16.845
We were looking for any other errors like this

491
00:17:16.845 --> 00:17:19.085
that could have made their way through, um,

492
00:17:19.315 --> 00:17:21.125
that was conducted fairly successfully.

493
00:17:21.145 --> 00:17:22.365
We didn't find any other problems.

494
00:17:23.065 --> 00:17:24.805
And the results were, uh, submitted

495
00:17:24.805 --> 00:17:26.125
to the model design safety committee

496
00:17:26.125 --> 00:17:27.765
that we talked a bit about a couple of days ago.

497
00:17:28.105 --> 00:17:30.525
Uh, Dave Walsh, who I think was here at least yesterday,

498
00:17:30.595 --> 00:17:33.605
chaired the, uh, investigatory board into this issue.

499
00:17:33.605 --> 00:17:35.805
So we had a lot of senior help on, uh, trying

500
00:17:35.805 --> 00:17:37.165
to make sure we didn't have any other problems,

501
00:17:37.185 --> 00:17:39.245
and then investigating how we made this error.

502
00:17:40.785 --> 00:17:43.205
Uh, we then conducted what we had planned to do all along,

503
00:17:43.205 --> 00:17:45.685
which was the full main rotor, uh, cube check,

504
00:17:45.685 --> 00:17:48.925
measuring blade angles across the control envelope in order

505
00:17:48.925 --> 00:17:50.165
to look for, again, other problems.

506
00:17:50.165 --> 00:17:52.165
And we compare the measured results to what we achieved.

507
00:17:52.185 --> 00:17:53.285
And except for the tailer,

508
00:17:53.285 --> 00:17:54.565
like I said, everything went, went well.

509
00:17:55.345 --> 00:17:57.845
Um, then we use these flight test variables.

510
00:17:57.845 --> 00:17:59.965
So I know a lot of, uh, the advanced programs have these,

511
00:17:59.985 --> 00:18:03.245
but we have a, a wide variety of flight test adjustable, uh,

512
00:18:03.245 --> 00:18:05.605
parameters that we can add into the controls

513
00:18:05.605 --> 00:18:06.765

without a software drop.

514
00:18:07.145 --> 00:18:08.325
So the designers were able

515
00:18:08.325 --> 00:18:10.285
to invert the entire tail mixing matrix

516
00:18:10.545 --> 00:18:13.925
and correct the sign error, uh, using just FTDs.

517
00:18:13.925 --> 00:18:15.485
We actually did not need a software

518
00:18:15.485 --> 00:18:16.725
drop in order to fix this problem.

519
00:18:16.855 --> 00:18:18.805
Eventually we did, but not during ground test.

520
00:18:20.185 --> 00:18:22.485
So we resumed normal testing in nine business days.

521
00:18:22.905 --> 00:18:24.005
Uh, pretty major error.

522
00:18:24.065 --> 00:18:27.645
We did a, an extensive review of the entire system design

523
00:18:28.105 --> 00:18:30.285
and less than two weeks later we were back into test.

524
00:18:30.745 --> 00:18:33.565
So a pretty big win, I think on the recovery side of this,

525
00:18:33.715 --> 00:18:36.405
that, you know, Hey, let's, let's stop, let's think about

526
00:18:36.405 --> 00:18:39.285
what the problems are and where we're at in terms of safety.

527
00:18:39.585 --> 00:18:41.125
And then once you prove you're safe, let's get back to work.

528
00:18:41.345 --> 00:18:44.245
You know, uh, so quite, quite useful, uh, use

529
00:18:44.245 --> 00:18:46.965
of flight test variables that,

530
00:18:46.965 --> 00:18:48.205
that got us through ground test.

531
00:18:48.265 --> 00:18:51.645
So we, um, we did all of our planned, uh,

532
00:18:51.645 --> 00:18:53.645
ground test vehicle testing with that, uh,

533
00:18:53.645 --> 00:18:54.685
flight test variable set

534
00:18:54.695 --> 00:18:56.765
until we got our final first flight software bill

535
00:18:56.765 --> 00:18:57.605
and then put that on, which

536
00:18:57.605 --> 00:18:58.885
obviously had the correct mixing in it.

537
00:18:59.385 --> 00:19:00.765
Uh, we've flown quite a bit since then.

538
00:19:00.765 --> 00:19:03.765
So first flight was on, uh, October 27th of last year,

539
00:19:04.035 --> 00:19:05.205
just about six months ago.

540
00:19:05.825 --> 00:19:08.645

Our, uh, second test aircraft, EDM three flew in January,

541
00:19:09.345 --> 00:19:11.245
and since then we've had 45 flights.

542
00:19:11.425 --> 00:19:12.925
So, uh, we'll see if they fly in today,

543
00:19:12.945 --> 00:19:14.085
but, uh, doing quite well.

544
00:19:14.085 --> 00:19:17.125
So 45 flights in, in six months on two aircraft is, uh,

545
00:19:17.125 --> 00:19:18.565
I think pretty good progress for a developmental

546
00:19:18.565 --> 00:19:19.685
program on a new design.

547
00:19:20.685 --> 00:19:21.845
I mentioned the ground test.

548
00:19:21.845 --> 00:19:23.725
So we've, we've been conducting hundreds of hours

549
00:19:23.745 --> 00:19:25.005
of ground test over about two

550
00:19:25.005 --> 00:19:26.445
and a half years on the ground test vehicle,

551
00:19:27.065 --> 00:19:28.845
and we've been continuing envelope expansion.

552
00:19:28.905 --> 00:19:30.845
So we, um, a couple of weeks ago picked up our

553
00:19:30.845 --> 00:19:32.005
12,000 pound external load.

554
00:19:32.045 --> 00:19:33.565
A couple of press releases came out about that.

555
00:19:34.025 --> 00:19:36.085
And as it's the primary mission of this helicopter,

556
00:19:36.085 --> 00:19:37.485
quite a bit of our envelope expansion

557
00:19:38.135 --> 00:19:41.085
scope is gonna be dedicated to external envelope expansion

558
00:19:41.085 --> 00:19:43.525
and development, or I mentioned a DS 33.

559
00:19:43.525 --> 00:19:44.765
So all those standards apply

560
00:19:44.765 --> 00:19:46.965
to externally loaded configurations as well as internal.

561
00:19:46.985 --> 00:19:48.685
So there's a lot of maneuvering left to do for us.

562
00:19:50.025 --> 00:19:53.205
Uh, so in conclusion, we test for a reason and,

563
00:19:53.265 --> 00:19:55.125
and there are surprises out there to be had.

564
00:19:55.645 --> 00:19:57.045
I think sometimes it's tempting to think

565
00:19:57.045 --> 00:19:58.645
that we're just verifying a design

566
00:19:58.745 --> 00:20:01.045
or that there are only very minor, uh,

567
00:20:01.045 --> 00:20:03.525

developmental discoveries to be had during flight tests.

568
00:20:03.585 --> 00:20:05.405
But these are prototype vehicles

569
00:20:05.585 --> 00:20:08.245
and, uh, anything you can imagine is out there.

570
00:20:09.705 --> 00:20:11.405
The other thing is you make it a mistake early

571
00:20:11.585 --> 00:20:13.205
and it's very easy for that mistake to,

572
00:20:13.465 --> 00:20:15.925
to work its way into all of your documentation.

573
00:20:16.025 --> 00:20:20.725
So that one ICD miss years ago ended up in the simulator.

574
00:20:20.725 --> 00:20:21.965
It ended up in our surrogate aircraft.

575
00:20:21.985 --> 00:20:24.805
It ended up in the documentation that we used initially

576
00:20:24.805 --> 00:20:27.405
to check out this very characteristic on the aircraft.

577
00:20:27.905 --> 00:20:29.405
So, uh, question everything.

578
00:20:29.545 --> 00:20:31.765
And really the, the way to have avoided this would've been

579
00:20:31.765 --> 00:20:33.925
for someone standing there looking at the tail rotor blade

580
00:20:33.985 --> 00:20:35.885
to say, Hey, he stepped on the right pedal.

581
00:20:36.105 --> 00:20:38.685
Did that railroad blade move in the right direction

582
00:20:38.685 --> 00:20:39.765
for me to ya to the right?

583
00:20:40.305 --> 00:20:42.445
And that is something that is un incontrovertible.

584
00:20:42.445 --> 00:20:45.085
That's where physics takes control over wires.

585
00:20:46.665 --> 00:20:48.805
Uh, fly by wire is powerful for good and bad.

586
00:20:48.865 --> 00:20:51.485
So we can make that sign error, but then we can also fix it.

587
00:20:51.825 --> 00:20:54.085
So that's a quick way to recover from a problem is

588
00:20:54.085 --> 00:20:55.885
to use our fly by wire features again, to,

589
00:20:55.905 --> 00:20:58.005
to get back on track even after there's been a problem.

590
00:20:59.745 --> 00:21:01.325
And, uh, the ground test vehicle is worth the cost.

591
00:21:01.325 --> 00:21:03.805
So you can imagine that buying an entire 53 K just

592
00:21:03.805 --> 00:21:05.445
for ground test was, uh,

593
00:21:05.605 --> 00:21:07.125
an expensive commitment by the program.

594
00:21:07.425 --> 00:21:09.085

But here's an, here's a case where we

595
00:21:09.845 --> 00:21:11.365
absolutely safe schedule because of it.

596
00:21:11.465 --> 00:21:14.925
So, I mean, forget about, we wouldn't have been unsafe.

597
00:21:14.985 --> 00:21:17.125
You know, you go out there for the very first taxi event

598
00:21:17.125 --> 00:21:18.925
and you try to make a taxi turn and you go the other way.

599
00:21:19.265 --> 00:21:20.445
It would've been apparent that it was

600
00:21:20.445 --> 00:21:21.685
wrong then before we flew.

601
00:21:21.945 --> 00:21:24.285
But the ground test vehicle, you don't wanna discover

602
00:21:24.285 --> 00:21:25.805
that the day before first flight, right?

603
00:21:25.905 --> 00:21:28.045
So, uh, from a programmatic cost

604
00:21:28.045 --> 00:21:29.525
and schedule perspective, I think that,

605
00:21:29.525 --> 00:21:31.045
that this thing was worth its weight in gold.

606
00:21:31.355 --> 00:21:33.485
This isn't actually the GTV, it's an EDM.

607
00:21:34.025 --> 00:21:35.485
Uh, and actually that's all I've got.

608
00:21:35.545 --> 00:21:36.725
So does anyone have questions?

609
00:21:41.955 --> 00:21:42.955
Thank you.

610
00:21:51.475 --> 00:21:53.445
Just a second. Wait the mic up here.

611
00:21:54.225 --> 00:21:58.845
Um, Okay, here we go.

612
00:21:59.275 --> 00:22:01.885
Done. So Claude, we gonna fix that.

613
00:22:02.225 --> 00:22:05.285
Um, basically what

614
00:22:05.285 --> 00:22:08.005
You pointed out to is something we all run into, which is,

615
00:22:08.065 --> 00:22:11.605
uh, uh, sculpt, uh, scheduled pressure.

616
00:22:12.345 --> 00:22:16.085
And you, your example was very, very, very relevant

617
00:22:16.085 --> 00:22:17.205
because we all see it.

618
00:22:17.965 --> 00:22:19.605
Saturdays minimum team,

619
00:22:20.585 --> 00:22:23.165
people got wanna see their families and wanna do stuff.

620
00:22:23.165 --> 00:22:24.805
You're in a hurry, you're trying to get stuff done.

621
00:22:24.805 --> 00:22:26.885

You gotta make that barbecue to get home at night.

622
00:22:27.125 --> 00:22:30.765
I know how things go. Yep. And, and so you, you miss stuff.

623
00:22:30.865 --> 00:22:34.625
And it's not by not on

624
00:22:34.625 --> 00:22:36.185
purpose, it's not by intent.

625
00:22:36.185 --> 00:22:38.545
It's just the reality of flight tests sometimes.

626
00:22:39.685 --> 00:22:41.505
And, and you have expected results

627
00:22:42.045 --> 00:22:44.545
and you're looking to, it's where you expect,

628
00:22:44.965 --> 00:22:47.945
and again, without good models

629
00:22:48.125 --> 00:22:51.545
or without good predictions in, in your, in your quiver,

630
00:22:51.545 --> 00:22:54.185
if you would, uh, it makes it very difficult to,

631
00:22:54.185 --> 00:22:55.345
to see those miscon compares.

632
00:22:55.425 --> 00:22:56.665
'cause you see everything's looking the same.

633
00:22:56.765 --> 00:22:58.145
So it must be good. Okay.

634
00:22:58.645 --> 00:23:02.145
So I think this is a very relevant, uh, presentation.

635
00:23:02.145 --> 00:23:04.425
Thank you for your frankness on this objection. Sure.

636
00:23:06.135 --> 00:23:07.135
Alright, Thank you.

637
00:23:17.745 --> 00:23:20.305
I, I certainly second, uh, Jerry's remarks there,

638
00:23:20.365 --> 00:23:22.185
really excellent presentation, uh,

639
00:23:22.185 --> 00:23:23.465
completely different than the one

640
00:23:23.465 --> 00:23:25.665
before it, you know, F 35, air on fire,

641
00:23:25.675 --> 00:23:27.825
white scarf, all that kind of stuff.

642
00:23:28.045 --> 00:23:31.585
Uh, and then the 197 knot, uh, CH 53 K,

643
00:23:31.585 --> 00:23:33.305
which is a remarkable vehicle in its own right.

644
00:23:33.305 --> 00:23:34.305
So, but totally different.

645
00:23:34.405 --> 00:23:36.905
Uh, that's the beauty of, uh, these kinds of symposiums

646
00:23:36.905 --> 00:23:38.425
to have, uh, uh,

647
00:23:38.425 --> 00:23:40.665
technical discussions about all kinds of different products.

648
00:23:40.925 --> 00:23:44.185

Um, in that presentation, I found it interesting that, uh,

649
00:23:44.335 --> 00:23:46.925
much like, uh, many of the military's predecessors

650
00:23:46.925 --> 00:23:51.605
with new airplanes, E 2D, uh, F 18 EFG, et cetera,

651
00:23:51.945 --> 00:23:55.605
um, and others, uh, I think it's a sign of the times that,

652
00:23:55.605 --> 00:23:58.045
uh, aircraft may be named the same as one

653
00:23:58.045 --> 00:23:59.445
of their predecessors, but they're largely

654
00:23:59.445 --> 00:24:00.725
completely new aircraft.

655
00:24:01.265 --> 00:24:02.965
Um, it's a sign of the times.