WEBVTT

1
00:00:00.105 --> 00:00:04.025
Uh, presentation this morning here is, uh,

2
00:00:04.685 --> 00:00:06.215
talking about whether

3
00:00:06.275 --> 00:00:11.245
or not following a proven process is always gonna result in

4
00:00:12.115 --> 00:00:14.205
success and what you think it will.

5
00:00:14.935 --> 00:00:17.435
Uh, so we have Bill fell from Sikorsky.

6
00:00:18.495 --> 00:00:22.075
He's, uh, worked on a lot of,

7
00:00:22.095 --> 00:00:24.175
uh, helicopters.

8
00:00:24.245 --> 00:00:26.735
He's been been in the, in the business

9
00:00:26.795 --> 00:00:28.695
for 26 years as a test pilot.

10
00:00:29.475 --> 00:00:34.455
Uh, everything from the SB one, defiant S 76, civil,

11
00:00:34.625 --> 00:00:39.025
civil, several military, uh, the fly by wire, black Hawk,

12
00:00:39.965 --> 00:00:43.185
uh, Comanches, several other Blackhawks.

13
00:00:43.185 --> 00:00:47.795
So he's, he's flown in everything that, uh, scares me.

14
00:00:48.215 --> 00:00:52.295
So he's also an avid road biker, spends a lot of time, uh,

15
00:00:53.095 --> 00:00:55.905
chasing the, uh, down his dream

16
00:00:55.905 --> 00:00:57.225
and becoming the next Tour de France.

17
00:00:57.285 --> 00:01:00.095
Uh, so come on up.

18
00:01:08.875 --> 00:01:10.895
And I learned something about Darren this morning.

19
00:01:11.085 --> 00:01:13.415
Also, I was a pole vaulter in high school,

20
00:01:13.635 --> 00:01:16.335
so we'll talk later about, uh, pole vaulting

21
00:01:16.395 --> 00:01:17.775
and, uh, and what to do there.

22
00:01:18.195 --> 00:01:22.095
Um, thanks for, uh, allowing me to talk to you about, uh,

23
00:01:22.195 --> 00:01:24.935
our first flight process at Sikorsky.

24
00:01:25.195 --> 00:01:28.855
Uh, before I get going into the, uh, presentation, uh,

25
00:01:29.075 --> 00:01:32.055
I'd like to say that this venue is fantastic, that the city

26
00:01:32.055 --> 00:01:33.175
of Seattle is awesome,

27
00:01:33.675 --> 00:01:36.255

and that the food here has been fantastic.

28
00:01:37.075 --> 00:01:38.495
And, uh, I learned a few

29
00:01:39.085 --> 00:01:42.295
food tidbits in the prior presentations here.

30
00:01:42.455 --> 00:01:45.135
I learned that eating crayons can be really good

31
00:01:45.195 --> 00:01:46.375
for your flight test team,

32
00:01:46.795 --> 00:01:51.375
and that, uh, probably reinforced what, uh, is true for,

33
00:01:51.635 --> 00:01:55.095
uh, most teams is that maybe drinking the Kool-Aid is not

34
00:01:55.095 --> 00:01:56.495
so good, uh, for your team.

35
00:01:56.755 --> 00:02:01.425
But, um, uh, Claude, can I get the notes version on the,

36
00:02:01.925 --> 00:02:03.585
the display down, the, thank you.

37
00:02:04.125 --> 00:02:07.905
Um, so I wanna contrast two first flights

38
00:02:07.975 --> 00:02:11.185
that we've had at Sikorsky Aircraft where I was the, uh,

39
00:02:11.185 --> 00:02:12.425
pilot at the controls.

40
00:02:12.905 --> 00:02:17.365
Uh, one of those events went perfectly according

41
00:02:17.425 --> 00:02:22.285
to plan, and the other one did not go perfectly according

42
00:02:22.345 --> 00:02:26.645
to plan, and yet they both followed the same process.

43
00:02:27.695 --> 00:02:30.895
Now, I'm gonna go through the first event

44
00:02:30.895 --> 00:02:31.895
that went very well,

45
00:02:32.145 --> 00:02:34.175
where I'll tell you a little bit about the aircraft.

46
00:02:34.285 --> 00:02:36.495
I'll go over the process that we followed

47
00:02:36.715 --> 00:02:38.175
and how that flight went,

48
00:02:39.145 --> 00:02:43.745
and then I didn't get approval to talk about the other one,

49
00:02:43.805 --> 00:02:45.385
so I've got no slides on it.

50
00:02:45.405 --> 00:02:48.305
But I'm gonna tell you how the first flight went

51
00:02:48.325 --> 00:02:51.185
and the events that happened on first flight such

52
00:02:51.185 --> 00:02:53.905
that the lessons learned, uh, makes sense.

53
00:02:55.225 --> 00:02:59.945
So, um, this picture has nothing to do

54
00:03:00.295 --> 00:03:01.505

with a first flight.

55
00:03:01.565 --> 00:03:04.865
If you found yourself at 70 degrees nose low, uh,

56
00:03:04.905 --> 00:03:08.065
a hundred feet off the ground with zero air speed, uh,

57
00:03:08.375 --> 00:03:10.345
that would be a pretty bad first flight.

58
00:03:10.445 --> 00:03:13.785
But this was a picture I took from the backseat of Comanche,

59
00:03:13.785 --> 00:03:15.465
which was a fantastic aircraft.

60
00:03:15.685 --> 00:03:19.305
And the first, uh, aircraft in my presentation is,

61
00:03:21.125 --> 00:03:23.985
is, um, uh, one of

62
00:03:23.985 --> 00:03:26.225
what we thought would be a good replacement for the mission

63
00:03:26.225 --> 00:03:27.705
that Comanche was designed for.

64
00:03:32.765 --> 00:03:37.385
So, S 97 first flight, the first aircraft, the S 97 Raider,

65
00:03:37.725 --> 00:03:42.715
um, Sikorsky has had, we're up

66
00:03:42.715 --> 00:03:46.035
to like S 1 0 3, S 1 0 4 at this point.

67
00:03:46.175 --> 00:03:48.635
So our process is robust in

68
00:03:48.635 --> 00:03:51.875
that we've had over a hundred aircraft that have gone

69
00:03:51.875 --> 00:03:52.955
through our flight process.

70
00:03:53.615 --> 00:03:56.035
Now, not all of those aircraft have flown,

71
00:03:56.095 --> 00:03:58.475
but most of those aircraft have flown.

72
00:03:59.095 --> 00:04:03.235
And, you know, some people think that, uh, the, uh,

73
00:04:04.075 --> 00:04:06.475
s number has something to do with the year that

74
00:04:06.475 --> 00:04:07.835
that aircraft first flew,

75
00:04:07.895 --> 00:04:09.995
or the year that that aircraft was designed.

76
00:04:10.505 --> 00:04:11.955
Nope, it's just sequential.

77
00:04:12.255 --> 00:04:16.035
And, uh, uh, so we're up over a hundred at this point.

78
00:04:16.495 --> 00:04:20.675
Now, we first flew Raider in May of 2015,

79
00:04:21.135 --> 00:04:25.435
and Kevin Rebeck had done the prior, uh,

80
00:04:25.825 --> 00:04:28.555
high profile first flight in the X two

81
00:04:28.555 --> 00:04:30.035

technology demonstrator.

82
00:04:30.735 --> 00:04:33.425
And it's not a written part of our process

83
00:04:33.735 --> 00:04:36.145
that you have somebody in the aircraft

84
00:04:36.165 --> 00:04:37.785
that's done a first flight,

85
00:04:38.405 --> 00:04:41.945
but we like to include, uh, as the pilot,

86
00:04:42.165 --> 00:04:45.185
not on the controls, somebody who has, uh,

87
00:04:45.345 --> 00:04:46.825
accomplished a first flight.

88
00:04:46.925 --> 00:04:49.665
And it was, it, it provided confidence for me,

89
00:04:49.765 --> 00:04:52.505
and it made it easier to go through the process by virtue

90
00:04:52.565 --> 00:04:56.025
of the fact that, uh, Kevin was, uh, was there with me

91
00:04:56.045 --> 00:04:57.625
and working with me through the process.

92
00:05:00.755 --> 00:05:03.295
So, a little bit about the aircraft. Here's the aircraft.

93
00:05:03.695 --> 00:05:07.055
S 97 Raider, uh, 11,000 pound machine.

94
00:05:07.635 --> 00:05:10.775
Uh, it had 34 foot diameter rotor, uh,

95
00:05:11.225 --> 00:05:13.295
about 2,500 horsepower.

96
00:05:13.675 --> 00:05:17.215
And we went, uh, 210 knots in level flight.

97
00:05:17.215 --> 00:05:21.455
Eventually, we've been over 75 degrees angle a bank about

98
00:05:21.555 --> 00:05:22.815
2.7 Gs,

99
00:05:22.815 --> 00:05:25.975
which I know are my fixed wing brothern in the room are

100
00:05:25.975 --> 00:05:27.095
thinking that's not very much,

101
00:05:27.115 --> 00:05:30.175
but it's pretty respectable for a, uh, for a helicopter

102
00:05:30.915 --> 00:05:34.015
and, uh, a robust low speed envelope.

103
00:05:34.865 --> 00:05:37.965
Now, the aircraft also has the ability to fly

104
00:05:38.275 --> 00:05:40.245
with the prop uninstalled.

105
00:05:40.495 --> 00:05:42.845
We've been almost 160 knots

106
00:05:42.875 --> 00:05:45.045
with the prop not even installed on the machine.

107
00:05:45.625 --> 00:05:48.885
And there's also a clutch, uh, in the prop.

108
00:05:49.025 --> 00:05:53.765

So the prop is connected to the drive train that's connected

109
00:05:53.765 --> 00:05:56.085
to the rotor, and if you have a heart over

110
00:05:56.225 --> 00:05:59.125
or something like that in your pusher prop, uh,

111
00:05:59.235 --> 00:06:01.965
it's effectively slowing down your wing potentially.

112
00:06:02.105 --> 00:06:04.605
So, uh, system safety wise, like, ah,

113
00:06:04.605 --> 00:06:05.965
why don't we put a clutch in there

114
00:06:05.965 --> 00:06:07.805
and we can just disengage it from the system.

115
00:06:07.905 --> 00:06:10.605
And then you maintain your rotor, RPM and you're flying.

116
00:06:10.635 --> 00:06:13.085
Similar to the fact that if it were uninstalled.

117
00:06:17.855 --> 00:06:19.715
So what is our process?

118
00:06:20.485 --> 00:06:24.795
First off, the S 97 was a company funded program,

119
00:06:25.735 --> 00:06:30.095
and, uh, you know, I, I think great on the company that, uh,

120
00:06:30.265 --> 00:06:32.175
we're, we decided to spend some research

121
00:06:32.175 --> 00:06:35.015
and development money to, uh, develop this aircraft.

122
00:06:35.155 --> 00:06:37.295
But the first slide, I think is there

123
00:06:37.375 --> 00:06:41.175
because, uh, the Army had canceled Comanche,

124
00:06:41.635 --> 00:06:44.255
and on the cancellation of Comanche, they went

125
00:06:44.315 --> 00:06:47.615
to armed Aerial Scout and armed reconnaissance helicopter.

126
00:06:48.085 --> 00:06:51.055
Both of those programs were subsequently canceled,

127
00:06:51.275 --> 00:06:53.695
and at this point, we decided to design

128
00:06:53.835 --> 00:06:56.935
and build the S 97 Raider as

129
00:06:56.935 --> 00:06:59.335
what we thought would be the next, uh,

130
00:06:59.965 --> 00:07:02.175
awesome scout attack helicopter.

131
00:07:02.715 --> 00:07:07.575
And arguably that, uh, um, risk that we took

132
00:07:07.595 --> 00:07:10.655
to build that aircraft led to the Army's, uh,

133
00:07:11.335 --> 00:07:14.935
starting the future attack reconnaissance aircraft program.

134
00:07:15.675 --> 00:07:18.975
And so we have another prototype sitting in our hangar in

135
00:07:18.975 --> 00:07:21.535

Florida that's, uh, that's a part of that program

136
00:07:23.045 --> 00:07:25.095
that the Army canceled about two months ago.

137
00:07:25.765 --> 00:07:28.905
So it's pretty frustrating that you spend that much time

138
00:07:28.925 --> 00:07:32.665
and effort and, uh, now it's, uh, four strikes on

139
00:07:32.775 --> 00:07:34.425
that particular mission,

140
00:07:34.805 --> 00:07:37.925
but that's a different, uh, a different story.

141
00:07:38.625 --> 00:07:41.805
So how do we, how do we get to that,

142
00:07:41.985 --> 00:07:43.845
uh, that first flight?

143
00:07:44.105 --> 00:07:46.685
So we had to set our own requirements,

144
00:07:46.705 --> 00:07:48.405
our own key performance parameters,

145
00:07:48.425 --> 00:07:49.725
and hold ourselves to 'em.

146
00:07:50.105 --> 00:07:53.505
And so we, before we get to, uh,

147
00:07:53.715 --> 00:07:55.905
where we're really manufacturing parts

148
00:07:56.245 --> 00:07:59.545
and writing contracts with vendors, we have three design,

149
00:08:00.235 --> 00:08:05.185
three design reviews of, uh, of increasing, uh,

150
00:08:05.405 --> 00:08:06.825
detail on the machine.

151
00:08:07.285 --> 00:08:08.385
And some of the parts

152
00:08:08.485 --> 00:08:12.585
and pieces that, uh, we have, we know about

153
00:08:12.725 --> 00:08:16.345
before that we're, we're in parallel competing,

154
00:08:16.345 --> 00:08:18.545
completing the analysis on those parts

155
00:08:18.605 --> 00:08:19.865
to see how strong they are.

156
00:08:20.165 --> 00:08:22.665
But in general, we get through the three design reviews

157
00:08:22.685 --> 00:08:25.105
before we write contracts with all of our vendors

158
00:08:25.175 --> 00:08:28.625
that are making all of the parts that are not in house,

159
00:08:28.765 --> 00:08:30.905
but we're all the time talking to 'em upfront

160
00:08:31.245 --> 00:08:33.825
to help refine those design reviews.

161
00:08:34.735 --> 00:08:37.115
Now, once we go into parts manufacturing

162
00:08:37.495 --> 00:08:38.915

and then we start getting parts,

163
00:08:38.965 --> 00:08:41.195
we're doing the analytical work on all

164
00:08:41.195 --> 00:08:42.835
of those individual parts.

165
00:08:43.715 --> 00:08:48.255
And the, the flight test process is such

166
00:08:48.255 --> 00:08:51.215
that we want to have as robust a limits

167
00:08:51.515 --> 00:08:53.575
as we can on each of those parts.

168
00:08:54.365 --> 00:08:56.965
And if we just do the math on it,

169
00:08:57.035 --> 00:08:59.925
then we take a significant knockdown, uh,

170
00:09:00.185 --> 00:09:01.885
by our process in terms of

171
00:09:01.915 --> 00:09:03.925
what loads we allow that part to see.

172
00:09:04.465 --> 00:09:06.555
Whereas if we put it through ground test,

173
00:09:06.735 --> 00:09:09.115
we wait till the part's made and we get one of them,

174
00:09:09.375 --> 00:09:11.275
and we'll put a million cycles on it,

175
00:09:11.335 --> 00:09:14.235
or whatever it takes with increasing loads

176
00:09:14.835 --> 00:09:15.855
to break that part.

177
00:09:16.195 --> 00:09:18.495
And ideally, we do break the part so that we know

178
00:09:18.495 --> 00:09:20.415
how strong it's, and then we can take less

179
00:09:20.415 --> 00:09:22.975
of a knockdown on, uh, on that component

180
00:09:23.115 --> 00:09:25.535
and then allow more envelope on the aircraft.

181
00:09:25.995 --> 00:09:30.775
Now, on a prototype program, we're probably only putting the

182
00:09:31.775 --> 00:09:34.335
critical components through that sort of a ground test,

183
00:09:34.725 --> 00:09:36.975
whereas on a production program,

184
00:09:37.185 --> 00:09:38.415
we're putting more components

185
00:09:38.755 --> 00:09:42.095
and we're also on the critical components doing several

186
00:09:42.195 --> 00:09:45.615
of them, such that we have statistics on exactly where

187
00:09:45.615 --> 00:09:46.695
that component fails,

188
00:09:46.835 --> 00:09:50.415
and you have higher, uh, uh, confidence in that part,

189
00:09:50.915 --> 00:09:54.215

and that allows you to take less of a knockdown in

190
00:09:54.215 --> 00:09:57.335
what you're able to, uh, achieve, uh, on that part.

191
00:09:57.955 --> 00:10:02.545
Now, after that, the picture here is our iron bird,

192
00:10:03.085 --> 00:10:05.825
uh, and this had the engines, the gear boxes,

193
00:10:06.205 --> 00:10:08.545
the rotor blades, and the prop blades.

194
00:10:09.085 --> 00:10:13.185
And you're seeing how all of those parts work together

195
00:10:13.725 --> 00:10:15.825
in this, uh, in this test stand.

196
00:10:16.285 --> 00:10:20.545
Now, interesting on, on this, uh, particular configuration

197
00:10:20.655 --> 00:10:21.785
with our pusher prop

198
00:10:21.855 --> 00:10:25.185
that is maybe wasn't our wheelhouse, uh, before this point.

199
00:10:25.685 --> 00:10:27.925
Um, the,

200
00:10:28.105 --> 00:10:33.005
the X two aircraft are designed with, uh, by

201
00:10:33.185 --> 00:10:36.325
for how much power the machine needs based on

202
00:10:36.385 --> 00:10:38.605
how fast you want the aircraft to go.

203
00:10:38.875 --> 00:10:42.925
Whereas typically a helicopter you size the power by,

204
00:10:43.405 --> 00:10:46.285
I wanna hover in this atmospheric condition

205
00:10:46.515 --> 00:10:50.365
with a given payload, so quite a bit different, uh,

206
00:10:50.545 --> 00:10:54.005
by sizing for speed, the power you end up with excess power

207
00:10:54.005 --> 00:10:55.485
and a hover, but long.

208
00:10:55.485 --> 00:10:59.045
And the short of that is that, uh, we have to put a lot

209
00:10:59.045 --> 00:11:02.885
of power through the prop gearbox on the test stand in order

210
00:11:02.905 --> 00:11:06.245
to qualify the, uh, machine

211
00:11:06.385 --> 00:11:07.565
and the torque to get

212
00:11:07.565 --> 00:11:09.725
to the high speeds we want to get to in flight.

213
00:11:10.115 --> 00:11:13.575
Well, the Mach test stands not going

214
00:11:13.575 --> 00:11:15.255
through the air at 200 knots.

215
00:11:15.595 --> 00:11:18.215
And, uh, it's also getting buffeted by, uh,

216
00:11:18.405 --> 00:11:19.495

main rotor blades.

217
00:11:19.835 --> 00:11:23.035
So we were hitting prop blade loads

218
00:11:23.655 --> 00:11:26.355
before, uh, we were able to get

219
00:11:26.355 --> 00:11:28.755
to the torque on the gearbox that we wanted.

220
00:11:28.935 --> 00:11:32.155
So we put trip strips on the prop blades, and that helped.

221
00:11:32.215 --> 00:11:34.075
We were able to get to some higher torques.

222
00:11:34.255 --> 00:11:36.315
We even removed the main rotor blades

223
00:11:36.375 --> 00:11:38.675
to get the torque on the prop gearbox that,

224
00:11:38.735 --> 00:11:39.835
uh, that we wanted to get.

225
00:11:40.375 --> 00:11:44.805
And then on the subsequent aircraft that was, uh, bigger,

226
00:11:45.225 --> 00:11:47.765
uh, we did all of that and that didn't work.

227
00:11:48.105 --> 00:11:50.205
And so we spent a lot of money and time

228
00:11:50.585 --> 00:11:52.205
and installed a water break.

229
00:11:52.505 --> 00:11:55.765
We removed the prop blades, attached the water break

230
00:11:55.825 --> 00:11:57.205
to the prop output shaft,

231
00:11:57.585 --> 00:12:00.605
and got all of the power through the gearbox in order to get

232
00:12:00.625 --> 00:12:03.845
to the, uh, uh, torques that we wanted to get to on,

233
00:12:03.905 --> 00:12:04.925
uh, on that.

234
00:12:05.425 --> 00:12:08.005
Um, and the thing is that this is also,

235
00:12:08.005 --> 00:12:11.725
this is an incremental process that you get just enough

236
00:12:11.725 --> 00:12:15.605
through that machine that you need to for, uh, first flight.

237
00:12:16.185 --> 00:12:20.255
Um, because there's schedule pressures.

238
00:12:20.255 --> 00:12:22.135
People want you to get going and,

239
00:12:22.195 --> 00:12:25.895
and you can achieve a certain amount of success on your, uh,

240
00:12:25.995 --> 00:12:27.015
on your test stand

241
00:12:27.155 --> 00:12:30.215
and get enough done so that you can do some

242
00:12:30.215 --> 00:12:31.975
of the early envelope expansion

243
00:12:32.315 --> 00:12:35.895

and then keep running the machine as you incrementally, uh,

244
00:12:36.035 --> 00:12:37.135
expand the envelope.

245
00:12:37.975 --> 00:12:40.755
Um, beyond the test stand, we have a, uh,

246
00:12:40.935 --> 00:12:42.555
system integration lab.

247
00:12:43.055 --> 00:12:47.045
And that system integration lab has a, uh,

248
00:12:47.115 --> 00:12:51.285
like a 200 degree field of view, non motion simulator

249
00:12:51.285 --> 00:12:52.885
with a representative cockpit.

250
00:12:52.905 --> 00:12:55.245
And I spent hundreds of hours in there

251
00:12:55.385 --> 00:12:58.765
before first flight, developing the flight control laws,

252
00:12:59.015 --> 00:13:01.805
developing, uh, emergency procedures,

253
00:13:02.045 --> 00:13:04.245
experiencing emergency procedures,

254
00:13:04.545 --> 00:13:09.365
and, um, uh, uh, getting as comfortable as I could

255
00:13:09.795 --> 00:13:11.685
with the, uh, with the aircraft.

256
00:13:12.385 --> 00:13:17.355
Now, we don't always build the, uh, iron Bird

257
00:13:17.575 --> 00:13:19.035
for all of our programs,

258
00:13:19.335 --> 00:13:21.835
but for me it's the preferred method

259
00:13:21.835 --> 00:13:24.995
because on that method, you are able

260
00:13:25.015 --> 00:13:29.035
to run the test stand at higher loads than you're ever going

261
00:13:29.035 --> 00:13:30.315
to run through the aircraft

262
00:13:31.055 --> 00:13:35.195
and put lots of hours on it more than you're going

263
00:13:35.195 --> 00:13:36.635
to put on the aircraft.

264
00:13:36.975 --> 00:13:39.635
And then when you go to run your aircraft

265
00:13:39.735 --> 00:13:41.755
or fly your aircraft, uh,

266
00:13:42.055 --> 00:13:44.475
you have confidence in the pristine components

267
00:13:44.475 --> 00:13:47.755
that you're running at lower loads than you did on the Iron

268
00:13:47.865 --> 00:13:50.635
Bird, but we don't always do that.

269
00:13:50.895 --> 00:13:52.675
And so on X two tech demonstrator,

270
00:13:52.695 --> 00:13:54.715

we used a different method where

271
00:13:55.495 --> 00:13:58.795
we chained the X two tech demonstrator to the ground.

272
00:13:59.215 --> 00:14:00.995
We ran it at high power.

273
00:14:01.175 --> 00:14:06.155
And, uh, uh, the expenditure for the Iron Bird

274
00:14:06.715 --> 00:14:09.435
resonates with me because I was in the, uh, X two,

275
00:14:09.435 --> 00:14:13.875
running it hard one day, heard a pop called the telemetry

276
00:14:13.975 --> 00:14:15.795
and said, what do you got?

277
00:14:16.215 --> 00:14:18.955
And, uh, he's like, nothing. What do you think?

278
00:14:19.085 --> 00:14:21.595
Maybe one of the turn buckles on the chain twisted.

279
00:14:21.595 --> 00:14:25.075
Maybe that's what you heard. And, um, I'm like,

280
00:14:25.095 --> 00:14:26.435
all right, I'm totally buying it.

281
00:14:26.615 --> 00:14:29.235
And about 10 seconds later, the uh,

282
00:14:29.235 --> 00:14:30.875
transmission oil pressure went

283
00:14:30.875 --> 00:14:34.315
to zero transmission chip light came on all sorts

284
00:14:34.315 --> 00:14:37.515
of red lights, and the gearbox was essentially coming apart

285
00:14:38.285 --> 00:14:40.025
and, uh, emergency shut down.

286
00:14:40.365 --> 00:14:44.015
And we got to, uh, we didn't really do much damage

287
00:14:44.015 --> 00:14:45.655
to the box, and so we were able

288
00:14:45.655 --> 00:14:49.335
to relatively quickly fix the gear box and subsequent tests.

289
00:14:49.435 --> 00:14:51.325
But my point there is that

290
00:14:52.515 --> 00:14:55.725
that failure would've been undetectable in our inspection

291
00:14:55.795 --> 00:14:58.565
process in between the ground test,

292
00:14:58.565 --> 00:15:00.525
where we're using our flight test vehicle

293
00:15:00.745 --> 00:15:03.485
as our ground test vehicle and going to flight test.

294
00:15:03.785 --> 00:15:07.565
So if your failure mode is at X minus one, as it was in

295
00:15:07.565 --> 00:15:12.125
that case, awesome problem detected and safety achieved.

296
00:15:14.225 --> 00:15:17.325
If your failure is at x plus one relative

297
00:15:17.325 --> 00:15:19.845

where x is the number of hours you're going to ground test,

298
00:15:21.155 --> 00:15:23.375
you're in the air when that failure happens.

299
00:15:23.555 --> 00:15:26.335
And so there's a certain amount of risk in using that, uh,

300
00:15:26.595 --> 00:15:30.375
uh, flight test asset as your ground test asset as well.

301
00:15:31.675 --> 00:15:34.695
So we, um, do incremental flight releases.

302
00:15:34.755 --> 00:15:36.975
We use this model development safety committee

303
00:15:37.025 --> 00:15:40.775
where we have, uh, a group of smart people, uh,

304
00:15:40.975 --> 00:15:43.775
I could say gray beards or silverbacks.

305
00:15:43.835 --> 00:15:46.135
But, uh, I don't think those terms are particularly

306
00:15:46.285 --> 00:15:48.615
endearing to the women that are on that committee.

307
00:15:48.955 --> 00:15:50.775
So, uh, I'm not sure.

308
00:15:50.835 --> 00:15:52.615
Uh, they're just a bunch of smart people,

309
00:15:52.955 --> 00:15:55.695
and the team has to go open kimono, right?

310
00:15:55.695 --> 00:15:56.895
Like they have to tell them

311
00:15:56.925 --> 00:15:58.735
what they've seen in the development.

312
00:15:59.275 --> 00:16:02.535
And, uh, it, it relies on an honest relationship

313
00:16:02.535 --> 00:16:04.095
between the committee and the team.

314
00:16:04.315 --> 00:16:05.415
And then, uh, the,

315
00:16:05.595 --> 00:16:07.935
the model development safety committee will provide

316
00:16:08.295 --> 00:16:09.575
homework, uh, to the team

317
00:16:09.675 --> 00:16:11.815
and then write them flight releases.

318
00:16:14.775 --> 00:16:17.715
So how did it go? Couldn't have been better.

319
00:16:17.975 --> 00:16:19.995
It flew exactly like the simulator.

320
00:16:20.255 --> 00:16:23.795
And so, uh, I think that's an awesome, uh, testament

321
00:16:23.815 --> 00:16:25.395
to the process that, uh,

322
00:16:25.475 --> 00:16:27.835
I was completely comfortable and confident.

323
00:16:28.615 --> 00:16:32.555
One of the, the one of the things that I said, um,

324
00:16:32.825 --> 00:16:35.595

that wasn't a policy or a part of the process

325
00:16:35.775 --> 00:16:39.315
or procedure was that look like keep these photographers

326
00:16:39.315 --> 00:16:41.635
and videographers out of my briefing room.

327
00:16:42.055 --> 00:16:44.075
And I don't want those guys dancing around me

328
00:16:44.175 --> 00:16:45.835
as I'm walking to the aircraft.

329
00:16:45.905 --> 00:16:48.995
Like, if you want to do that, go ahead and do it.

330
00:16:48.995 --> 00:16:51.075
As I'm walking away from the aircraft

331
00:16:51.125 --> 00:16:54.115
after the flight, if you want to video my briefing room,

332
00:16:54.495 --> 00:16:56.995
go ahead and do it on one of the, uh, missions

333
00:16:56.995 --> 00:17:00.235
where we're chained to the earth or prior to first flight or

334
00:17:00.235 --> 00:17:01.275
after first flight.

335
00:17:01.455 --> 00:17:05.155
But, uh, on first flight, just leave us alone until, uh,

336
00:17:05.325 --> 00:17:06.835
until after the flight.

337
00:17:07.455 --> 00:17:11.625
Um, I, I had three landings on the test card

338
00:17:11.625 --> 00:17:13.745
because I thought, ah, you know, maybe,

339
00:17:14.385 --> 00:17:15.575
maybe I'm gonna be stressed.

340
00:17:15.675 --> 00:17:18.615
And we, we actually flew first flight with a degraded, uh,

341
00:17:18.615 --> 00:17:19.615
flight control mode.

342
00:17:19.635 --> 00:17:23.785
We did that on purpose, and, um, you'd need

343
00:17:23.785 --> 00:17:26.945
to be attentive on the flight controls when, uh, in

344
00:17:27.065 --> 00:17:28.065
that degraded mode.

345
00:17:28.125 --> 00:17:29.545
And I thought, maybe I'll be stressed

346
00:17:29.645 --> 00:17:31.025
and I'll be able to put it on the ground

347
00:17:31.045 --> 00:17:32.705
and just stretch my hands and sort of thing.

348
00:17:32.705 --> 00:17:34.905
And it turns out I wasn't stressed at all,

349
00:17:35.205 --> 00:17:37.265
and I thought, I got three landings

350
00:17:37.265 --> 00:17:38.505
and takeoffs on the card here.

351
00:17:38.525 --> 00:17:40.545

I'm totally gonna do 'em because this is pretty easy.

352
00:17:40.725 --> 00:17:42.465
And so it was nice to, to do that.

353
00:17:42.565 --> 00:17:44.585
Not for the reason I wanted to, but just

354
00:17:44.585 --> 00:17:46.225
because they were on the card.

355
00:17:46.975 --> 00:17:48.615
Um, now

356
00:17:48.885 --> 00:17:51.625
before I get into the next aircraft, um,

357
00:17:53.625 --> 00:17:56.585
I lost this aircraft in a flight test accident,

358
00:17:57.345 --> 00:18:00.325
and, uh, it was related to

359
00:18:01.645 --> 00:18:06.085
a software error in the fly by wire software that, um, uh,

360
00:18:06.715 --> 00:18:10.005
made it through our level a software qualification process,

361
00:18:10.405 --> 00:18:13.805
a version that happened after, uh, first flight

362
00:18:14.705 --> 00:18:19.125
and, uh, ended up in pretty significant, um,

363
00:18:19.845 --> 00:18:21.885
170 degree per second roll rate.

364
00:18:22.105 --> 00:18:23.565
Uh, 60 to 70 degrees

365
00:18:23.565 --> 00:18:25.325
of roll attitude two feet off the ground.

366
00:18:25.635 --> 00:18:29.405
Luckily, uh, landed at level and uh,

367
00:18:29.745 --> 00:18:30.885
but we didn't fly it again

368
00:18:30.905 --> 00:18:34.005
and we subsequently rebuilt the second aircraft.

369
00:18:34.765 --> 00:18:39.455
And, um, I think a couple of things taken away from that.

370
00:18:39.595 --> 00:18:40.615
We improved our process.

371
00:18:40.915 --> 00:18:42.975
Our process got better because of that.

372
00:18:43.435 --> 00:18:45.855
And maybe I learned that, uh, my

373
00:18:46.485 --> 00:18:50.295
Jedi test pilot force is not some exponential function

374
00:18:50.295 --> 00:18:51.455
that's always going up.

375
00:18:51.595 --> 00:18:54.615
But I had a, a ripple in the force where, uh,

376
00:18:54.705 --> 00:18:56.215
where it went down a bit,

377
00:18:56.635 --> 00:19:00.255
but moving on to the, uh, second aircraft, um,

378
00:19:03.215 --> 00:19:05.075

it went bad from the takeoff.

379
00:19:05.775 --> 00:19:09.875
So the fly by wire, we have ground mode and air mode.

380
00:19:10.015 --> 00:19:12.995
And so it did not transition from ground mode

381
00:19:12.995 --> 00:19:14.475
to air mode on lift off one

382
00:19:14.475 --> 00:19:16.715
of the weight on wheels sensors stuck in ground

383
00:19:16.745 --> 00:19:18.415
mode, not a big deal.

384
00:19:18.595 --> 00:19:21.935
The machine flies pretty good in, uh, ground mode.

385
00:19:22.475 --> 00:19:24.375
And so, uh, uh,

386
00:19:24.995 --> 00:19:28.255
but the rotor was mis rigged also.

387
00:19:28.435 --> 00:19:32.295
And so the aircraft wanted to yaw to the right on liftoff,

388
00:19:33.205 --> 00:19:34.215
also not a big deal.

389
00:19:34.215 --> 00:19:37.455
Helicopter pilots are used to, uh, yawing

390
00:19:37.455 --> 00:19:38.615
and they just step on the pedal.

391
00:19:39.585 --> 00:19:44.205
Uh, back to that incremental, uh, ground test qualification.

392
00:19:44.825 --> 00:19:49.095
We didn't have the limits that we really needed

393
00:19:49.275 --> 00:19:52.575
to step very aggressively on the pedal, and I knew that.

394
00:19:53.215 --> 00:19:56.475
So the aircraft yard, 90 to a hundred degrees to the right

395
00:19:56.615 --> 00:19:59.995
before I was able to really slowly ease in some pedal

396
00:20:00.135 --> 00:20:01.315
to stop the YA rate.

397
00:20:01.335 --> 00:20:03.955
And of course, there's a thousand people watching this on

398
00:20:03.955 --> 00:20:05.395
livestream, probably more.

399
00:20:05.735 --> 00:20:08.075
And I'm thinking to myself, oh my God, they,

400
00:20:08.075 --> 00:20:10.235
they must think I'm a terrible pilot.

401
00:20:10.695 --> 00:20:14.555
And, uh, the reality was that, uh, it took good restraint

402
00:20:14.615 --> 00:20:16.435
to slowly, uh, feed in that pedal

403
00:20:16.435 --> 00:20:19.595
because, um, uh, it could have tripped the limits

404
00:20:19.695 --> 00:20:21.395
and it could, the flight would've been over there.

405
00:20:22.005 --> 00:20:26.675

Maybe a bit of serendipity also that, uh, um,

406
00:20:27.175 --> 00:20:30.515
the, we had those two failures together.

407
00:20:30.615 --> 00:20:33.475
The weight on wheel sensor failed to go to air mode

408
00:20:33.735 --> 00:20:37.485
and the aircraft being mis rigged together.

409
00:20:37.665 --> 00:20:41.325
If the aircraft immediately transitioned to flight mode,

410
00:20:41.385 --> 00:20:45.165
the feedback in the flight controls would've immediately fed

411
00:20:45.185 --> 00:20:46.805
in that pedal, and that could have driven

412
00:20:46.865 --> 00:20:48.125
the aircraft over the limit.

413
00:20:48.265 --> 00:20:49.725
So a bit of luck there.

414
00:20:50.585 --> 00:20:54.045
Um, this aircraft had a tendency to dance a little bit left

415
00:20:54.045 --> 00:20:55.125
and right, the second one,

416
00:20:55.385 --> 00:20:57.805
and it was a very smooth fuselage.

417
00:20:57.985 --> 00:21:02.005
And the, uh, um, the wake would shed intermittently

418
00:21:02.145 --> 00:21:05.205
and cause the aircraft didn't necessarily move right

419
00:21:05.205 --> 00:21:06.725
and left, but it provided a right

420
00:21:06.725 --> 00:21:08.445
and left acceleration sensation

421
00:21:08.445 --> 00:21:09.685
that was a little unsettling.

422
00:21:10.575 --> 00:21:15.195
And then the aircraft also had, um, when I landed,

423
00:21:16.075 --> 00:21:19.415
uh, the flight controls, the lateral stick

424
00:21:19.415 --> 00:21:24.345
and the pedals were felt far more sensitive than they did on

425
00:21:24.345 --> 00:21:26.185
the ground prior to takeoff.

426
00:21:26.365 --> 00:21:29.985
And I think the landing gear took a little bit different set

427
00:21:30.255 --> 00:21:32.425
than it did, uh, prior to liftoff.

428
00:21:32.485 --> 00:21:33.505
And so we ended up having

429
00:21:33.505 --> 00:21:36.425
to make some pretty significant changes to, uh, help, uh,

430
00:21:36.575 --> 00:21:38.505
help resolve, uh, that issue.

431
00:21:39.525 --> 00:21:41.545
But in the end, we went on

432
00:21:41.605 --> 00:21:44.705

and we put a full envelope on that second aircraft

433
00:21:44.775 --> 00:21:46.185
that is undefined.

434
00:21:49.415 --> 00:21:51.225
Alright, so why, um,

435
00:21:52.745 --> 00:21:57.085
why was the pilot effort higher in that second, uh, event?

436
00:21:57.805 --> 00:22:01.385
So some of that complex aerodynamic interactions,

437
00:22:01.445 --> 00:22:05.945
the dancing left and right, uh, we saw that on Raider,

438
00:22:06.165 --> 00:22:09.385
but the second aircraft weighed about three times as much

439
00:22:09.525 --> 00:22:14.465
and was, uh, maybe a bit further from any of our experience

440
00:22:14.495 --> 00:22:15.985
with this type of aircraft.

441
00:22:16.765 --> 00:22:20.405
Um, human error, the, uh,

442
00:22:20.735 --> 00:22:23.845
rotor rig being wrong, shame on us, right?

443
00:22:23.845 --> 00:22:26.405
Like that was just lack of attention to detail.

444
00:22:26.905 --> 00:22:31.295
We knew the fact that, uh, you know, that also two rotors,

445
00:22:31.555 --> 00:22:34.295
um, that there's some interplay between them.

446
00:22:34.355 --> 00:22:37.455
And so you don't necessarily rig each rotor the same way.

447
00:22:38.155 --> 00:22:42.135
Um, I threw up their team and organizational differences.

448
00:22:42.675 --> 00:22:46.935
Uh, there were more than just Sikorsky involved in the

449
00:22:46.935 --> 00:22:50.085
second aircraft, and so person to person,

450
00:22:50.685 --> 00:22:52.565
I think we had awesome relationships.

451
00:22:53.145 --> 00:22:57.605
Uh, but there were some organizational pulling that, uh,

452
00:22:58.325 --> 00:23:00.365
I don't know, a little bit of an us and them

453
00:23:00.505 --> 00:23:03.965
and independent meetings where some were excluded

454
00:23:04.185 --> 00:23:07.405
and did it, did it influence that first flight?

455
00:23:07.965 --> 00:23:10.685
I don't know. Is it good? Nope, not at all.

456
00:23:11.105 --> 00:23:12.205
So, um,

457
00:23:12.985 --> 00:23:15.125
and then the part failure, we knew these weight on wheel

458
00:23:15.405 --> 00:23:18.805
switches were finicky and, uh, we've since, uh, come up

459
00:23:18.805 --> 00:23:20.445

with some better solutions there.

460
00:23:20.705 --> 00:23:23.725
But, uh, uh, we even put a switch in the cockpit

461
00:23:23.725 --> 00:23:25.845
that you could force it from, uh, air mode

462
00:23:25.905 --> 00:23:28.765
or from air mode to ground mode or ground mode to air mode.

463
00:23:29.105 --> 00:23:31.205
If we needed to, we could have voted out one

464
00:23:31.205 --> 00:23:32.765
of those weight on wheel sensors

465
00:23:33.025 --> 00:23:35.045
and, uh, we were just reaching for

466
00:23:35.045 --> 00:23:37.085
that switch when it transitioned on its own.

467
00:23:43.065 --> 00:23:46.035
So CFD, right?

468
00:23:46.035 --> 00:23:48.155
Like you could do some detailed analysis

469
00:23:48.575 --> 00:23:51.995
and it's, it's kind of impractical for the entire operation.

470
00:23:52.575 --> 00:23:57.175
And, um, I I say you don't know where

471
00:23:57.195 --> 00:24:00.415
to do that detailed analysis always until you go

472
00:24:00.415 --> 00:24:03.055
through flight test and then you find some cliff

473
00:24:03.195 --> 00:24:06.175
for some point where you need to really do the deep dive.

474
00:24:06.275 --> 00:24:09.465
And so we're flying the second Raider aircraft,

475
00:24:09.485 --> 00:24:11.665
and I was flying it a couple of months ago

476
00:24:11.885 --> 00:24:14.185
and I had a data point where, you know,

477
00:24:14.195 --> 00:24:15.825
we're wrapped into a turn

478
00:24:16.285 --> 00:24:19.265
and, uh, it ya about 10 degrees one way

479
00:24:19.525 --> 00:24:23.745
and then 30 well side slipped 10 degrees one direction,

480
00:24:23.845 --> 00:24:27.305
and then about 30 degrees of side slip the other direction.

481
00:24:27.485 --> 00:24:30.985
And it's supposed to be full-time, uh, turn coordination

482
00:24:31.125 --> 00:24:32.985
or, uh, heading hold in mobile flight.

483
00:24:33.125 --> 00:24:37.545
And I think the co-pilot mused that, uh, um,

484
00:24:38.695 --> 00:24:40.475
ooh, it's gonna be pretty terrible if this

485
00:24:40.475 --> 00:24:41.515
thing reverses ends.

486
00:24:42.385 --> 00:24:46.885

And, uh, so we used this tool Helios to uh, do the analysis

487
00:24:46.985 --> 00:24:48.525
and we looked at that exact point

488
00:24:49.065 --> 00:24:53.365
and the interaction of the rotor wake from the two rotors

489
00:24:53.465 --> 00:24:58.035
and the pusher prop were pushing on the rudders such that,

490
00:24:58.255 --> 00:25:00.975
um, one

491
00:25:00.975 --> 00:25:03.415
of the rudders was providing a force in the opposite

492
00:25:03.415 --> 00:25:06.695
direction that we expected it to be providing a force.

493
00:25:07.275 --> 00:25:11.975
And so, uh, did we know to look there, we knew it was a,

494
00:25:11.975 --> 00:25:14.015
maybe a problem part of the envelope,

495
00:25:14.195 --> 00:25:16.895
but it, it used to take weeks

496
00:25:17.235 --> 00:25:19.735
to run a Helios test point.

497
00:25:19.735 --> 00:25:21.055
And we can do it in days now,

498
00:25:21.155 --> 00:25:23.895
but like, you can't afford to do that everywhere.

499
00:25:23.915 --> 00:25:25.135
And so it's complicated.

500
00:25:25.905 --> 00:25:30.305
Um, I think our models

501
00:25:30.535 --> 00:25:34.145
require real world validation also, right?

502
00:25:34.175 --> 00:25:37.865
Like you, your model is never solid until you take it

503
00:25:37.865 --> 00:25:39.585
through flight test and you refine the model

504
00:25:39.605 --> 00:25:41.305
and that's, uh, incremental as well.

505
00:25:41.365 --> 00:25:44.985
But the bottom line, high risk, but high risk for what?

506
00:25:45.445 --> 00:25:48.575
Are we gonna have an accident? I don't think so, right?

507
00:25:48.575 --> 00:25:50.535
Like we've done this a hundred plus times,

508
00:25:51.075 --> 00:25:54.645
but I think it's high risk for discovery.

509
00:25:55.105 --> 00:25:57.325
You're gonna learn something on that flight.

510
00:25:57.985 --> 00:26:01.975
And, uh, to, uh, quote, uh, one

511
00:26:01.975 --> 00:26:05.255
of the other presentations I saw prepare for the unexpected

512
00:26:05.515 --> 00:26:07.255
and expect to be unprepared.

513
00:26:07.945 --> 00:26:12.245

Uh, i, I think the unexpected is what there's high risk for

514
00:26:12.355 --> 00:26:15.245
that that's going to happen, but unprepared.

515
00:26:15.965 --> 00:26:17.765
I think if you go through the robust process,

516
00:26:18.185 --> 00:26:21.645
you spend the time as a team going

517
00:26:21.645 --> 00:26:24.125
through the ground test stand, spending all

518
00:26:24.125 --> 00:26:27.725
of those hundreds of hours in the system integration lab,

519
00:26:28.015 --> 00:26:29.285
doing the ground test

520
00:26:29.625 --> 00:26:32.365
and working through the emergency procedures

521
00:26:32.505 --> 00:26:34.925
and going through the model development safety committee,

522
00:26:35.465 --> 00:26:37.565
uh, and letting them know all of your issues

523
00:26:37.665 --> 00:26:39.365
and getting feedback from them.

524
00:26:39.795 --> 00:26:44.645
When you do all of that accurately, um, it's gonna allow you

525
00:26:44.825 --> 00:26:49.405
to respond as, as best you can leading

526
00:26:49.465 --> 00:26:51.525
to the success of that first flight.

527
00:26:51.865 --> 00:26:56.005
So I, I believe that our proven process is going to lead

528
00:26:56.005 --> 00:26:58.925
to success, but you're probably going to learn something

529
00:26:58.945 --> 00:27:00.855
and find something new in sis.

530
00:27:01.275 --> 00:27:01.905
Thank you.

531
00:27:13.425 --> 00:27:13.775
Right.

532
00:27:18.905 --> 00:27:19.905
He's the one coming,

533
00:27:21.165 --> 00:27:22.345
Uh, Joel Baden from Bell.

534
00:27:22.725 --> 00:27:25.005
Um, I noticed that, you know,

535
00:27:25.005 --> 00:27:26.725
obviously you can't talk a hundred percent about

536
00:27:26.725 --> 00:27:27.805
your second operation.

537
00:27:28.065 --> 00:27:30.325
You talked about using the same process in both,

538
00:27:31.195 --> 00:27:32.415
but the objective was

539
00:27:32.715 --> 00:27:35.295
how do you ensure a successful first flight?

540
00:27:35.975 --> 00:27:38.265

What defines success on a first flight for you?

541
00:27:39.875 --> 00:27:43.615
Yeah, honestly, like, um, the,

542
00:27:43.765 --> 00:27:46.775
that second aircraft first flight, uh,

543
00:27:46.915 --> 00:27:48.855
we were also limited on some

544
00:27:48.855 --> 00:27:50.815
of the air speeds that we achieved.

545
00:27:50.875 --> 00:27:52.255
We had relatively low limits.

546
00:27:52.395 --> 00:27:54.855
We found that the loads were higher than, uh,

547
00:27:55.335 --> 00:27:56.815
expected in many places.

548
00:27:57.435 --> 00:28:02.375
And, uh, we did probably 50% of the,

549
00:28:02.395 --> 00:28:05.535
uh, data card on that, uh, on that second, first flight.

550
00:28:05.635 --> 00:28:10.615
And we landed and, uh, the chief engineer came up to me

551
00:28:10.665 --> 00:28:12.455
after the flight and, um,

552
00:28:14.665 --> 00:28:17.355
everybody else kind of thought it was successful,

553
00:28:17.575 --> 00:28:22.435
but I was, um, I told him we have a lot

554
00:28:22.435 --> 00:28:25.875
of work to do and, uh, that, uh, we're gonna need

555
00:28:25.875 --> 00:28:27.835
to dive into the details on this.

556
00:28:27.935 --> 00:28:31.075
So I think that the team believed it was successful

557
00:28:31.135 --> 00:28:34.515
and it was successful in the fact that, uh, we, we didn't,

558
00:28:34.535 --> 00:28:39.165
uh, have any sort of significant incident, but right.

559
00:28:39.165 --> 00:28:40.605
There are degrees of success

560
00:28:40.945 --> 00:28:42.325
and whereas the first

561
00:28:43.005 --> 00:28:46.495
aircraft I talked about its success on first flight was like

562
00:28:46.535 --> 00:28:50.055
a hundred percent, we were like 50% success on the, uh,

563
00:28:50.055 --> 00:28:51.455
second air vehicle, I believe.

564
00:29:05.595 --> 00:29:09.025
Alright, yeah, it's always a good reminder in

565
00:29:09.025 --> 00:29:10.305
that distinction, right?

566
00:29:10.305 --> 00:29:13.495
Between, uh, successful performance

567
00:29:13.495 --> 00:29:15.135

of a test doesn't necessarily mean

568
00:29:15.135 --> 00:29:16.375
that the test article passed.

569
00:29:19.165 --> 00:29:20.745
Having that distinction there

570
00:29:20.805 --> 00:29:24.705
and, uh, important thing is making sure we've got a process

571
00:29:24.815 --> 00:29:26.745
that makes sure that our test is successful.

572
00:29:28.225 --> 00:29:28.515
Okay.