WEBVTT

1
00:00:00.000 --> 00:00:01.125
Development chief,

2
00:00:01.685 --> 00:00:04.205
I can either confirm nor deny that I have access to.

3
00:00:11.555 --> 00:00:14.325
Okay. Uh, coming up next we have Mr. Patrick

4
00:00:14.955 --> 00:00:16.765
Shan from Archer Aviation.

5
00:00:17.275 --> 00:00:20.685
Patrick is a staff flight test engineer.

6
00:00:21.265 --> 00:00:23.405
He, um, has eight years in flight test.

7
00:00:23.905 --> 00:00:27.445
He has an aerospace engineering degree from Ryerson,

8
00:00:28.585 --> 00:00:30.565
and, uh, with a focus on avionics and,

9
00:00:30.585 --> 00:00:33.725
and systems experienced in bringing conceptual design all

10
00:00:33.725 --> 00:00:36.165
the way up to flight tests on large STC programs

11
00:00:36.265 --> 00:00:37.445
and TC programs.

12
00:00:37.965 --> 00:00:40.805
Programs worked on include military, the C one 30

13
00:00:41.525 --> 00:00:43.965
PZL Sky Truck missionized,

14
00:00:43.995 --> 00:00:46.565
part 25 aircraft include the dash eight.

15
00:00:47.425 --> 00:00:51.085
Um, maritime SUR surveillance, CRJ Cargo,

16
00:00:51.865 --> 00:00:52.925
the water bomber,

17
00:00:53.265 --> 00:00:57.445
and EVO e, um, vit, a TC

18
00:00:58.325 --> 00:01:00.645
midnight, while most experienced

19
00:01:00.645 --> 00:01:02.965
as an onboarded FTE is also spent quite a bit

20
00:01:02.965 --> 00:01:04.685
of time in a TM room.

21
00:01:06.705 --> 00:01:09.525
Is Patrick available? Here we go.

22
00:01:13.545 --> 00:01:17.725
Oh, I'm sorry. You are with, uh, Benjamin from Archer.

23
00:01:18.045 --> 00:01:21.925
Benjamin is, uh, a helicopter pilot,

24
00:01:21.955 --> 00:01:24.805
graduated from the, uh, United un,

25
00:01:25.625 --> 00:01:29.125
the Navy test pilot school class 1 24 development test tour

26
00:01:29.225 --> 00:01:32.765
at HX 21 operational tour at VX one

27
00:01:32.825 --> 00:01:36.565

and last A-N-T-P-S instructor tour

28
00:01:38.015 --> 00:01:41.165
civil work at Sikorsky Palm Beach, work in Seahawk programs.

29
00:01:41.165 --> 00:01:45.165
Then project pilot for the CH 1 48 Cyclone first production

30
00:01:45.165 --> 00:01:48.685
pilot, US built fly by wire military helicopter,

31
00:01:49.315 --> 00:01:51.485
then flight controlled development on the

32
00:01:52.055 --> 00:01:53.925
optionally piloted Black Hawk,

33
00:01:53.975 --> 00:01:56.845
converting medical mechanical controls to fly by wire

34
00:01:57.225 --> 00:02:01.125
and culminating a fully autonomous external cargo mission,

35
00:02:01.745 --> 00:02:04.805
non external experimental pilot for archer's midnight

36
00:02:05.725 --> 00:02:08.925
E-V-T-O-L aircraft focused on flight control development

37
00:02:09.025 --> 00:02:11.845
and beginning with autonomous midnight zero

38
00:02:11.945 --> 00:02:13.685
and now piloted midnight one.

39
00:02:15.075 --> 00:02:16.075
Welcome.

40
00:02:24.795 --> 00:02:25.805
Well, thank you for having us.

41
00:02:25.835 --> 00:02:27.685
This is my first time at one of these events

42
00:02:27.945 --> 00:02:29.605
and my first time talking to you guys.

43
00:02:30.705 --> 00:02:33.045
So today we'll be, uh, comparing piloting options

44
00:02:33.185 --> 00:02:34.925
for prototype flight test vehicles.

45
00:02:37.985 --> 00:02:39.565
And you've already heard my introduction.

46
00:02:39.665 --> 00:02:41.725
The main thing to note here is, uh, well I used to have

47
00:02:41.725 --> 00:02:42.805
to endure the conditions

48
00:02:42.805 --> 00:02:44.005
on board the aircraft with the pilot.

49
00:02:44.205 --> 00:02:46.085
I now get the set in an air conditioned room.

50
00:02:46.945 --> 00:02:49.045
Um, and I have a big mute button for the pilot.

51
00:02:49.225 --> 00:02:51.325
So, um, I'm a happy camper.

52
00:02:54.195 --> 00:02:58.485
Alright, uh, I say, uh, already stated, uh, my tour

53
00:02:58.505 --> 00:03:00.325
as a test pilot started with that tech eval

54
00:03:00.325 --> 00:03:02.525

that Kevin was talking about, all the stress involved in

55
00:03:02.525 --> 00:03:04.325
that, uh, but focused

56
00:03:04.415 --> 00:03:07.285
after I left the Navy on fly by wire, uh,

57
00:03:07.345 --> 00:03:10.245
and then culminated in being the pilot of that Black Hawk

58
00:03:10.245 --> 00:03:12.085
with no pilots on board carrying external load.

59
00:03:12.585 --> 00:03:15.085
And now I'm experi or experimental test pilot for Archer.

60
00:03:16.425 --> 00:03:17.685
So from the beginning,

61
00:03:17.835 --> 00:03:21.325
test pilots were the main way we did flight test from

62
00:03:21.325 --> 00:03:24.605
Orville, uh, was test bot had to get in the aircraft,

63
00:03:24.795 --> 00:03:26.525
take it up for the first time, hope

64
00:03:26.525 --> 00:03:28.045
to get all the data about the bad things

65
00:03:28.045 --> 00:03:29.685
before the bad thing actually happened.

66
00:03:30.875 --> 00:03:32.085
That worked. It worked forever.

67
00:03:32.425 --> 00:03:33.645
And the reality is it still works.

68
00:03:33.755 --> 00:03:34.965
Lots of companies still use that.

69
00:03:35.275 --> 00:03:37.125
However, in the, in the modern days,

70
00:03:37.125 --> 00:03:38.205
there's a couple other options.

71
00:03:38.585 --> 00:03:40.565
Uh, and we're gonna investigate that both Patrick

72
00:03:40.585 --> 00:03:43.005
and I have had experience in both traditional test

73
00:03:43.305 --> 00:03:44.965
and some of these, uh, alternate tests.

74
00:03:45.015 --> 00:03:46.765
There are a lot of different definitions out there.

75
00:03:46.765 --> 00:03:48.005
These are the ones we chose.

76
00:03:48.115 --> 00:03:50.925
Obviously traditional onboard is the pilot is onboard using

77
00:03:51.165 --> 00:03:53.485
physical inceptors to manipulate the aircraft

78
00:03:54.605 --> 00:03:56.645
remotely piloted the pilot's on the ground,

79
00:03:56.705 --> 00:03:58.525
but is still using a physical interceptor

80
00:03:58.745 --> 00:04:00.285
to directly control the aircraft.

81
00:04:00.445 --> 00:04:02.605

I change the attitude of the aircraft, change the air speed

82
00:04:02.605 --> 00:04:04.285
of the, of the aircraft, uh,

83
00:04:04.325 --> 00:04:06.565
autonomously piloted the pilot's still on the ground,

84
00:04:06.585 --> 00:04:08.645
but now the pilot is using some sort of software,

85
00:04:08.645 --> 00:04:11.245
essentially a keyboard and a mouse to set way points,

86
00:04:11.355 --> 00:04:14.325
goal points, commands like takeoff land, things like that,

87
00:04:14.665 --> 00:04:16.885
but doesn't have physical inceptors is not commanding

88
00:04:16.885 --> 00:04:18.125
the attitude of the aircraft.

89
00:04:18.665 --> 00:04:21.245
Uh, but in all three cases there's still a pilot in control.

90
00:04:21.245 --> 00:04:23.045
There's still pilot responsible for the aircraft,

91
00:04:23.045 --> 00:04:24.885
the safe conduct, conduct of the flight test.

92
00:04:25.235 --> 00:04:26.565
It's just exactly how they do it.

93
00:04:26.565 --> 00:04:28.405
And where they're physically located is what varies.

94
00:04:31.025 --> 00:04:34.445
So the choices of, of which one of these is all comes down

95
00:04:34.505 --> 00:04:36.005
to competing priorities.

96
00:04:36.005 --> 00:04:38.645
We all know these competing priorities cost.

97
00:04:38.745 --> 00:04:40.205
We all know flight test is expensive.

98
00:04:40.465 --> 00:04:42.405
Uh, any way you do it, it's gonna be expensive.

99
00:04:42.865 --> 00:04:44.725
Uh, one of the things to look about in these different

100
00:04:44.725 --> 00:04:46.325
options is there way to use some of the capital

101
00:04:46.385 --> 00:04:47.645
for your initial test investment

102
00:04:47.905 --> 00:04:49.405
to be able to continue to be used.

103
00:04:49.405 --> 00:04:51.645
Things like a telemetry state system use,

104
00:04:51.645 --> 00:04:53.045
have a telemetry system that's capable

105
00:04:53.045 --> 00:04:54.205
of doing both autonomous tests

106
00:04:54.205 --> 00:04:55.965
and in the future also do, uh,

107
00:04:56.075 --> 00:04:57.525
piloted test if that's your goal.

108
00:04:58.545 --> 00:05:02.205

Key is obviously scope, uh, performance, eye on the prize.

109
00:05:02.205 --> 00:05:03.285
What is the point of the data?

110
00:05:03.285 --> 00:05:05.805
What is it that you're looking for, uh, to advance

111
00:05:05.805 --> 00:05:08.645
to the next stage, to take it to customer acceptance

112
00:05:08.645 --> 00:05:09.685
to get certification.

113
00:05:09.985 --> 00:05:12.365
And then that last bullet, what if for the media message,

114
00:05:12.515 --> 00:05:13.965
none of us like that reality,

115
00:05:14.065 --> 00:05:15.485
but in today's world, you have

116
00:05:15.485 --> 00:05:17.685
to constantly feed the information to be able

117
00:05:17.685 --> 00:05:19.725
to get the business development and the investors to keep

118
00:05:19.725 --> 00:05:21.925
that runway in front of you, as RJ said.

119
00:05:22.265 --> 00:05:24.685
Um, and so that's part of our need to, is the data required

120
00:05:24.685 --> 00:05:26.165
to keep that me media message going

121
00:05:26.425 --> 00:05:29.245
so the company can continue doing to eventually get to

122
00:05:29.245 --> 00:05:30.805
that product time.

123
00:05:30.945 --> 00:05:32.365
Always gotta move the ball forward.

124
00:05:32.785 --> 00:05:34.845
So in flight tests, you want to continually move forward.

125
00:05:34.845 --> 00:05:37.365
Might be tiny little bit, you know, inches at a time, um,

126
00:05:37.385 --> 00:05:39.645
but it's always moving forward so you're always progressing,

127
00:05:39.645 --> 00:05:41.405
which again, keeps everybody happy that the,

128
00:05:41.405 --> 00:05:42.525
the process is continuing.

129
00:05:43.505 --> 00:05:47.045
Uh, one of the initial quick initial capability does feed

130
00:05:47.045 --> 00:05:48.085
that media investor,

131
00:05:48.105 --> 00:05:50.525
but it also may make the long-term goal much, much longer.

132
00:05:50.905 --> 00:05:53.205
Uh, if you just wanna get something in the air just to show

133
00:05:53.205 --> 00:05:54.725
that the proof of concept exists,

134
00:05:54.875 --> 00:05:56.885
that may make it years onto the final product

135
00:05:56.885 --> 00:05:59.845

to get something that is actually certifiable, uh,

136
00:06:00.185 --> 00:06:02.245
and focus on the, uh, what is the data

137
00:06:02.245 --> 00:06:03.685
that's most critical to make that goal.

138
00:06:03.825 --> 00:06:04.845
So what system

139
00:06:04.905 --> 00:06:07.085
or method of flight test is gonna give you that piece

140
00:06:07.085 --> 00:06:09.485
of data you need to get to the end goal.

141
00:06:09.905 --> 00:06:12.245
And then safety, obviously, that's the point of all of this.

142
00:06:12.745 --> 00:06:15.365
How are we gonna do what we need to do safely?

143
00:06:15.665 --> 00:06:18.445
Uh, we know risk is required there. That's nothing new.

144
00:06:18.705 --> 00:06:20.485
Uh, we know resources are limited

145
00:06:20.665 --> 00:06:22.205
and the safety is a question.

146
00:06:22.355 --> 00:06:24.245
It's not a we are gonna be safe or not safe.

147
00:06:24.315 --> 00:06:27.285
It's a matter of cho choosing the resources, uh, to be able

148
00:06:27.285 --> 00:06:28.405
to determine how you're gonna do that.

149
00:06:28.625 --> 00:06:30.685
And the last bill is really the reason for this brief.

150
00:06:30.915 --> 00:06:33.005
It's not always clear which method is safer.

151
00:06:33.395 --> 00:06:34.885
It's pretty everybody. Oh, if there's no pilot

152
00:06:34.905 --> 00:06:36.045
on board, you can't kill the pilot.

153
00:06:36.425 --> 00:06:38.365
That's true. But what about the people on the ground?

154
00:06:38.465 --> 00:06:40.485
Are you possibly putting people on the ground more in danger

155
00:06:40.485 --> 00:06:42.285
because there's not a pilot on board the aircraft?

156
00:06:42.705 --> 00:06:43.805
Uh, and I'm not saying there's a right

157
00:06:43.805 --> 00:06:46.125
or wrong answer to that, but which method is safer is

158
00:06:46.125 --> 00:06:47.165
not a black and white answer.

159
00:06:48.995 --> 00:06:51.575
So a pilot on board benefits, uh, override over there.

160
00:06:52.035 --> 00:06:54.575
Um, probably the biggest one in my mind is

161
00:06:54.575 --> 00:06:55.935
that unknown, unknown tolerant.

162
00:06:55.935 --> 00:06:57.815

If something happens that you didn't know was gonna happen

163
00:06:58.115 --> 00:07:00.935
and you don't know how to deal with it, a pilot has a shot,

164
00:07:00.935 --> 00:07:03.295
maybe not a great shot, but a pilot has a shot to try

165
00:07:03.295 --> 00:07:05.975
and figure out how to fly this disabled aircraft in a mode

166
00:07:05.975 --> 00:07:08.415
that was never designed and safely get it back on the

167
00:07:08.415 --> 00:07:10.215
ground, or at least get it on the ground as safely

168
00:07:10.275 --> 00:07:13.295
as possible, risking the, the fewest lives in the process.

169
00:07:14.235 --> 00:07:16.175
So, uh, you can have a procedure for that.

170
00:07:16.175 --> 00:07:17.775
An autonomous aircraft, if something happens

171
00:07:17.875 --> 00:07:18.935
and it's not programmed,

172
00:07:19.165 --> 00:07:20.775
it's probably not gonna deal with it very well.

173
00:07:21.445 --> 00:07:22.455
More flexible planning.

174
00:07:22.795 --> 00:07:24.895
Uh, fa is pretty restrictive on flying aircraft

175
00:07:24.895 --> 00:07:26.055
without a pilot on board.

176
00:07:26.235 --> 00:07:27.735
So there's rules about where you can do that,

177
00:07:27.735 --> 00:07:29.095
which is gonna interfere with your,

178
00:07:29.275 --> 00:07:30.855
you know, the flexibility.

179
00:07:31.395 --> 00:07:32.855
And then having a pilot makes it pretty easy

180
00:07:32.855 --> 00:07:34.175
to say, Hey, can you go five knots faster?

181
00:07:34.685 --> 00:07:35.855
Yeah, if it's in the envelope,

182
00:07:35.855 --> 00:07:37.495
if you know in within our envelope, sure,

183
00:07:37.495 --> 00:07:39.335
I can go five knots faster autonomy, oh,

184
00:07:39.335 --> 00:07:40.575
I gotta go back and program that in.

185
00:07:40.575 --> 00:07:42.655
Change all the parameters to allow it to go faster.

186
00:07:43.195 --> 00:07:45.255
If the aircraft's eventually going to be directly piloted,

187
00:07:45.595 --> 00:07:47.255
um, then you have direct relevance.

188
00:07:47.275 --> 00:07:48.735
You start with a piloted aircraft

189
00:07:48.755 --> 00:07:50.575

and you're testing from the beginning in that mode.

190
00:07:51.115 --> 00:07:53.215
And then I would argue faster and cheaper to prototype.

191
00:07:53.235 --> 00:07:55.655
If your goal is to get something in the air to show

192
00:07:55.655 --> 00:07:57.255
that this concept is possible,

193
00:07:57.475 --> 00:07:59.335
having a pilot on board is gonna be

194
00:07:59.335 --> 00:08:00.495
faster and cheaper to get there.

195
00:08:00.795 --> 00:08:02.975
Uh, and that's, you know, I'm not part of boom obviously,

196
00:08:02.975 --> 00:08:04.295
but I think that's part of the reason for that,

197
00:08:04.295 --> 00:08:06.415
that got them in the air to be able to show that proof

198
00:08:06.535 --> 00:08:08.615
of concept and to kind of prove that fact.

199
00:08:08.615 --> 00:08:10.775
Here are a couple examples where they took aircraft

200
00:08:10.775 --> 00:08:12.655
that were going to be UASs, but the fastest

201
00:08:12.755 --> 00:08:14.175
and cheapest way to get them in there was

202
00:08:14.175 --> 00:08:15.975
to have a pilot sit on top of the aircraft

203
00:08:17.035 --> 00:08:18.735
or have a pilot climb in, you know,

204
00:08:18.795 --> 00:08:20.455
and have his head sticking up outta the top

205
00:08:20.455 --> 00:08:21.575
of a, of the fire scout.

206
00:08:21.635 --> 00:08:23.655
Was how both of those aircraft were initially flown.

207
00:08:25.735 --> 00:08:28.265
Some limitations, obviously the inherent human risk.

208
00:08:28.325 --> 00:08:29.705
If you have a pilot on board the aircraft,

209
00:08:29.705 --> 00:08:31.345
you are inherently, uh, risking that.

210
00:08:31.725 --> 00:08:33.825
Uh, one of example for that,

211
00:08:33.825 --> 00:08:35.105
when we were flying the Black Hawk

212
00:08:35.105 --> 00:08:36.825
and we wanted to fly the Black Hawk, nobody on board,

213
00:08:37.165 --> 00:08:38.625
we said, well, if we put it on the edge of a,

214
00:08:38.625 --> 00:08:41.945
of a military airfield fly directly into a gunnery range

215
00:08:41.945 --> 00:08:43.345
where there's nobody allowed to be there.

216
00:08:43.565 --> 00:08:45.105

And we come back to that airfield,

217
00:08:45.275 --> 00:08:47.065
there is zero chance we can hurt anybody.

218
00:08:47.275 --> 00:08:48.305
Could we lose the aircraft?

219
00:08:48.305 --> 00:08:50.305
Certainly could we have a fireball? Would it look ugly?

220
00:08:50.315 --> 00:08:51.505
Would it be bad for koi?

221
00:08:51.525 --> 00:08:53.465
All true, but we can't kill anybody.

222
00:08:53.525 --> 00:08:55.370
And so when we went to the THA when we went

223
00:08:55.370 --> 00:08:57.845
through the SRB process, it kind of wasn't a decision

224
00:08:57.845 --> 00:08:59.005
for the flight test team anymore.

225
00:08:59.145 --> 00:09:00.365
It went straight to the CEO.

226
00:09:00.675 --> 00:09:01.805
Like, we're not gonna hurt anybody,

227
00:09:01.905 --> 00:09:03.085
but you are risking the company

228
00:09:03.085 --> 00:09:04.725
and you're risking a certain amount of money in,

229
00:09:04.725 --> 00:09:06.005
in this one of a kind asset.

230
00:09:06.305 --> 00:09:08.285
So it was a different thought process than it was.

231
00:09:08.285 --> 00:09:12.645
If you, if you are have human risk involved payouts, um,

232
00:09:12.915 --> 00:09:14.525
it's a lot easier to program a robot

233
00:09:14.525 --> 00:09:15.525
to do exactly the same thing.

234
00:09:15.585 --> 00:09:16.805
US humans don't always do it

235
00:09:16.805 --> 00:09:18.045
exactly the same way every time.

236
00:09:18.705 --> 00:09:20.085
Uh, so that's one of the restrictions.

237
00:09:20.085 --> 00:09:21.765
And as I said, mishap impact the project.

238
00:09:22.225 --> 00:09:23.565
SpaceX has shown that over and over again,

239
00:09:23.565 --> 00:09:24.725
you can blow up a lot of rockets.

240
00:09:24.725 --> 00:09:27.085
If you don't hurt anybody, you get to blow up more rockets.

241
00:09:27.225 --> 00:09:29.205
So, and eventually lead to the, uh, the final product.

242
00:09:29.905 --> 00:09:31.245
Um, and then the gross weight

243
00:09:31.245 --> 00:09:32.845

and impact, obviously carrying a pilot on board.

244
00:09:33.285 --> 00:09:34.405
Interesting example there. That's the,

245
00:09:34.405 --> 00:09:35.925
the first space shuttle launch, you can tell

246
00:09:36.045 --> 00:09:38.965
'cause it's got the white, uh, external, uh, tank flew

247
00:09:38.965 --> 00:09:40.485
with the pilot two pilots on board.

248
00:09:40.615 --> 00:09:42.725
Eight years later, the Russians did the same exact thing.

249
00:09:42.725 --> 00:09:44.125
They chose to do it autonomously.

250
00:09:44.185 --> 00:09:46.085
So that whole, their entire shuttle from takeoff

251
00:09:46.085 --> 00:09:47.365
to landing was done with nobody on board,

252
00:09:47.705 --> 00:09:49.365
no human intervention from the ground.

253
00:09:49.865 --> 00:09:51.965
So kind of an different interesting example

254
00:09:52.025 --> 00:09:54.205
of one organization that shows one way

255
00:09:54.205 --> 00:09:57.335
and one that shows another remotely piloted,

256
00:09:57.335 --> 00:09:59.695
not something we have direct, uh, experience with, um,

257
00:09:59.695 --> 00:10:01.615
but is being used out there very successfully.

258
00:10:01.915 --> 00:10:03.015
Uh, the pilot's on the ground,

259
00:10:03.015 --> 00:10:05.135
using those physical inceptors to fly the aircraft,

260
00:10:05.355 --> 00:10:06.615
you have a lot of times have

261
00:10:06.615 --> 00:10:08.575
to have special sensors on board to provide the pilot,

262
00:10:08.575 --> 00:10:10.975
like a camera on the front of the aircraft to do takeoff

263
00:10:10.975 --> 00:10:12.335
and landings, things like that, that the

264
00:10:12.335 --> 00:10:13.455
normal aircraft wouldn't have.

265
00:10:13.875 --> 00:10:15.935
Uh, and then a two-way link for command and control.

266
00:10:15.955 --> 00:10:17.375
So you're both sending data down

267
00:10:17.555 --> 00:10:18.935
and then sending commands back up.

268
00:10:19.925 --> 00:10:21.665
Uh, some of the benefits you get

269
00:10:21.665 --> 00:10:23.625
to evaluate the planned inceptors on the ground

270
00:10:23.685 --> 00:10:24.785

before you go flying.

271
00:10:25.165 --> 00:10:26.745
Uh, so you get some real aircraft, uh,

272
00:10:26.745 --> 00:10:28.585
human factors, uh, testing.

273
00:10:29.245 --> 00:10:32.105
It removes that human on board risk lowers

274
00:10:32.105 --> 00:10:33.225
the mishap impact of the project.

275
00:10:33.225 --> 00:10:34.825
Obviously flexibility

276
00:10:34.825 --> 00:10:37.505
and pro profiles, you can kind of do a mixture of autonomous

277
00:10:37.525 --> 00:10:38.745
and, and the piloted.

278
00:10:38.745 --> 00:10:40.985
So you can have small, some small changes in real time.

279
00:10:41.325 --> 00:10:42.985
Uh, it's more unknown, unknown, tolerant.

280
00:10:42.985 --> 00:10:45.145
There's some things applied on board, uh, remotely could do

281
00:10:45.145 --> 00:10:48.345
to save the aircraft or at least co allow the, uh, issue

282
00:10:48.345 --> 00:10:49.745
to be less of a, of an impact.

283
00:10:50.285 --> 00:10:51.545
Um, and then you don't have

284
00:10:51.545 --> 00:10:52.105
to have every single

285
00:10:52.105 --> 00:10:53.705
contingency programmed into your autonomy.

286
00:10:54.055 --> 00:10:55.585
Some of the contingencies, if this happens,

287
00:10:55.605 --> 00:10:56.985
the pot's gonna take over and fly

288
00:10:56.985 --> 00:10:58.305
the aircraft, uh, manually.

289
00:10:59.135 --> 00:11:01.545
Some of the limitations that two, a link is expensive.

290
00:11:01.765 --> 00:11:04.305
Oh, talk to Patrick.

291
00:11:05.765 --> 00:11:07.585
All benefits. But there's, there's also a lot of,

292
00:11:07.585 --> 00:11:09.025
uh, limitations.

293
00:11:09.325 --> 00:11:11.825
So like Gman just alluded to, there's, uh,

294
00:11:11.895 --> 00:11:14.265
high bandwidth required that two-way link needs

295
00:11:14.265 --> 00:11:16.745
to also have very low latency for the pilot to be able

296
00:11:16.745 --> 00:11:17.825
to control the aircraft safely.

297
00:11:18.365 --> 00:11:20.225

The system has to be robust and failed safe.

298
00:11:21.085 --> 00:11:24.945
Um, any sort of failure needs to be, uh,

299
00:11:25.375 --> 00:11:27.065
handled from the pilot on the ground.

300
00:11:27.245 --> 00:11:28.265
So if you lose that link,

301
00:11:28.525 --> 00:11:30.145
you also lose the pilot on the ground

302
00:11:30.205 --> 00:11:31.985
and then you have an unsafe situation.

303
00:11:33.125 --> 00:11:35.825
You also have some cost in a ground control station.

304
00:11:35.825 --> 00:11:37.425
You're now building a cockpit on the ground

305
00:11:37.425 --> 00:11:38.465
that's only useful for

306
00:11:38.465 --> 00:11:39.705
that particular part of the flight test.

307
00:11:39.705 --> 00:11:40.905
And then it's useless afterwards.

308
00:11:41.885 --> 00:11:44.665
You require all these additional sensors, you have

309
00:11:44.665 --> 00:11:47.145
to put in cameras, maybe a gimbal on the front

310
00:11:47.145 --> 00:11:49.585
of the aircraft, um, additional antennas

311
00:11:49.815 --> 00:11:51.025
that could also interfere

312
00:11:51.025 --> 00:11:55.485
with your systems onboard the aircraft, as well as, uh, FA,

313
00:11:55.485 --> 00:11:58.485
a restrictions on flying the uninhabited aircraft.

314
00:12:01.825 --> 00:12:04.485
The other option will be autonomous piloting, uh,

315
00:12:04.485 --> 00:12:06.805
with an autonomous aircraft, the pilot is on the ground

316
00:12:06.945 --> 00:12:09.485
as well, but there's no real cockpit on the ground.

317
00:12:09.485 --> 00:12:11.285
There's no, um, inceptors.

318
00:12:11.745 --> 00:12:13.845
The pilot is using a keyboard and mouse.

319
00:12:14.225 --> 00:12:16.165
You're able to issue commands, uh,

320
00:12:16.165 --> 00:12:17.765
but you're very limited in what you can do.

321
00:12:18.465 --> 00:12:21.285
Um, you have a full telemetry team watching, uh,

322
00:12:21.285 --> 00:12:22.885
the aircraft at all times.

323
00:12:23.385 --> 00:12:26.645
The PIC generally will be sitting near the telemetry crew.

324
00:12:26.985 --> 00:12:28.325

Uh, so they're aware of, um,

325
00:12:28.995 --> 00:12:30.405
what everybody else is monitoring.

326
00:12:30.705 --> 00:12:32.125
But the pilot is very limited control.

327
00:12:32.155 --> 00:12:33.805
They can select a certain profile

328
00:12:33.905 --> 00:12:36.045
that's been pre-brief to fly.

329
00:12:36.585 --> 00:12:38.965
The profile will be exactly the same each time.

330
00:12:39.665 --> 00:12:43.765
Uh, the pilot is able to issue the takeoff command issue.

331
00:12:43.795 --> 00:12:46.965
Certain emergency, uh, commands such as land now

332
00:12:47.505 --> 00:12:51.165
or a return home come back to base or a divert.

333
00:12:51.405 --> 00:12:53.245
A divert would be to certain locations

334
00:12:53.245 --> 00:12:54.685
that were deemed safe to land in.

335
00:12:56.065 --> 00:12:58.645
The pilot can also spool down all engines in case the

336
00:12:58.805 --> 00:12:59.885
aircraft doesn't do it on its own.

337
00:13:00.465 --> 00:13:02.085
And our final fail safe, uh,

338
00:13:02.085 --> 00:13:04.525
we had a flight termination system in case

339
00:13:04.525 --> 00:13:05.845
of a flyaway situation.

340
00:13:06.065 --> 00:13:07.605
The pilot has a big red button

341
00:13:07.635 --> 00:13:10.085
that can open all the contactors on the aircraft

342
00:13:10.105 --> 00:13:11.405
and just drop it from the sky.

343
00:13:14.135 --> 00:13:16.635
So some of the background that, uh, we have experience

344
00:13:16.635 --> 00:13:20.275
with at Archer, um, we've flown two autonomous vehicles

345
00:13:20.295 --> 00:13:21.675
for the last four years.

346
00:13:22.455 --> 00:13:25.355
Um, maker is a 3,700 pound, um,

347
00:13:25.885 --> 00:13:27.915
three quarter scale model.

348
00:13:28.175 --> 00:13:30.475
Uh, six filters and six lifter engines.

349
00:13:31.135 --> 00:13:34.355
Uh, one battery pack with six independent strings.

350
00:13:34.455 --> 00:13:35.995
So it operates as, uh,

351
00:13:36.095 --> 00:13:38.195

six independent batteries, but they're all together.

352
00:13:38.335 --> 00:13:39.595
So in case of a failure

353
00:13:39.595 --> 00:13:40.955
with one, it could affect the others.

354
00:13:41.855 --> 00:13:44.795
Um, midnight Zero is a more representative prototype

355
00:13:44.795 --> 00:13:46.315
of our full size aircraft.

356
00:13:47.015 --> 00:13:48.795
Uh, that one is, uh, 6,500 pounds.

357
00:13:48.815 --> 00:13:52.275
So representative of our type type certificate aircraft.

358
00:13:52.935 --> 00:13:55.635
Um, same configuration six filter six lifters.

359
00:13:56.015 --> 00:13:57.835
We use the lessons we learned from Maker

360
00:13:58.495 --> 00:13:59.835
and, uh, put them into midnight.

361
00:13:59.835 --> 00:14:03.875
Zero. Um, midnight zero has representative engines

362
00:14:03.995 --> 00:14:05.675
and batteries to the type sort bird.

363
00:14:06.215 --> 00:14:09.235
Um, we call 'em like initial samples of both

364
00:14:09.235 --> 00:14:10.675
of, uh, those items.

365
00:14:10.895 --> 00:14:12.515
Uh, six independent battery packs.

366
00:14:13.895 --> 00:14:17.235
But the pilot, um, has the same control

367
00:14:17.615 --> 00:14:18.675
for both of these aircraft.

368
00:14:18.695 --> 00:14:20.635
And from a pilot's perspective, they're the same aircraft.

369
00:14:21.655 --> 00:14:24.275
Uh, the minimum flight crew that we use, uh, normally

370
00:14:24.275 --> 00:14:26.435
to conduct flight tests will be, uh, a pilot in command,

371
00:14:26.555 --> 00:14:30.075
a test director, um, someone monitoring GNC

372
00:14:30.075 --> 00:14:33.035
and flight controls, a propulsion responsible engineer

373
00:14:33.375 --> 00:14:36.035
and avionics responsible engineer that's looking at, um,

374
00:14:36.615 --> 00:14:39.155
the health of the systems as well as a visual observer,

375
00:14:39.155 --> 00:14:40.315
which is also our crew chief.

376
00:14:41.095 --> 00:14:44.155
And that is a requirement by, uh, through our KOA

377
00:14:44.175 --> 00:14:46.075
to always have visual, um,

378
00:14:46.135 --> 00:14:47.875

to always have the aircraft within visual site.

379
00:14:50.735 --> 00:14:52.285
Um, so to be able

380
00:14:52.285 --> 00:14:55.205
to expand the envelope on an eval aircraft, um,

381
00:14:55.925 --> 00:15:00.045
autonomously, we first decided to, uh,

382
00:15:00.045 --> 00:15:01.365
expand the hover envelope.

383
00:15:02.345 --> 00:15:05.565
Uh, we first did, uh, civility emergent chirps, uh,

384
00:15:05.565 --> 00:15:09.125
margin chirps at, um, every speed in the hover regime,

385
00:15:09.125 --> 00:15:10.965
which is up to about 40 knots.

386
00:15:11.585 --> 00:15:13.045
So force and moment chirps.

387
00:15:13.705 --> 00:15:15.325
We evaluated the performance in

388
00:15:15.325 --> 00:15:18.085
and out of ground effect, um, critical azimuth,

389
00:15:18.225 --> 00:15:20.445
we did pedal turns, we, uh,

390
00:15:20.445 --> 00:15:22.485
evaluated cooling in various wind conditions

391
00:15:23.605 --> 00:15:25.145
and, uh, climb and descent rates.

392
00:15:25.815 --> 00:15:27.745
This was very easy to do with an autonomous vehicle

393
00:15:27.745 --> 00:15:30.305
because we could run the same profile over and over again.

394
00:15:30.605 --> 00:15:32.425
Uh, we knew exactly what to expect.

395
00:15:32.525 --> 00:15:35.905
We didn't rely on a pilot, um, to be able

396
00:15:35.905 --> 00:15:36.985
to maintain a flight condition

397
00:15:36.985 --> 00:15:38.705
because the aircraft maintained it every single time.

398
00:15:41.505 --> 00:15:44.405
And, uh, this and the hover configuration, the, uh,

399
00:15:44.405 --> 00:15:45.885
control surfaces are disabled.

400
00:15:45.955 --> 00:15:47.085
They're just drooped.

401
00:15:47.505 --> 00:15:51.845
And the TILs are unlocked to allow for, uh, um, pedal turns

402
00:15:52.265 --> 00:15:53.845
and, uh, pitch attitude control.

403
00:15:56.465 --> 00:15:59.885
As we, uh, start moving forward, the, um,

404
00:16:00.625 --> 00:16:02.725
the aircraft will start a transition into a more

405
00:16:02.725 --> 00:16:03.925

conventional aircraft.

406
00:16:06.035 --> 00:16:09.775
For the transition, uh, phase we still ran, um,

407
00:16:10.195 --> 00:16:11.415
the forced a moment chirps,

408
00:16:11.415 --> 00:16:14.015
but now we also unlocked the control surfaces.

409
00:16:14.555 --> 00:16:15.975
So initially we'll start

410
00:16:15.975 --> 00:16:18.695
with control surface doublets evaluate, um,

411
00:16:18.695 --> 00:16:21.175
the aircraft stability before we move to the chirps.

412
00:16:22.155 --> 00:16:26.455
Um, as you go faster, you are using less current.

413
00:16:27.035 --> 00:16:28.735
Um, it's a lower power draw.

414
00:16:28.755 --> 00:16:31.455
So the hover portion, you tend to do more flights

415
00:16:31.715 --> 00:16:35.775
for less test points because you have a very high draw, um,

416
00:16:36.435 --> 00:16:38.615
energy inefficient, uh, flight phase.

417
00:16:39.075 --> 00:16:42.135
As you move into a more conventional aircraft,

418
00:16:42.355 --> 00:16:43.855
you become much more efficient

419
00:16:43.975 --> 00:16:45.855
and they're able to cram more test points into

420
00:16:45.935 --> 00:16:47.055
a certain flight.

421
00:16:47.235 --> 00:16:50.175
So as you go faster, it's less flights to achieve,

422
00:16:50.835 --> 00:16:52.655
um, all your data.

423
00:16:55.525 --> 00:16:57.665
So some of the efficiencies, like we already talked about,

424
00:16:57.725 --> 00:17:01.945
um, with autonomous, you get to, uh, flight faster,

425
00:17:02.865 --> 00:17:04.265
although a lot more software engineering involved.

426
00:17:04.285 --> 00:17:07.865
So for the company, it takes, it's a longer period to get

427
00:17:07.865 --> 00:17:10.825
to an autonomous vehicle, but getting the vehicle from, uh,

428
00:17:10.835 --> 00:17:13.465
built to in flight, um, is a lot faster

429
00:17:13.465 --> 00:17:15.305
because you can accept a little bit more risk.

430
00:17:15.305 --> 00:17:16.465
Having no pilot on board,

431
00:17:16.925 --> 00:17:19.705
we have a predictable path, uh, down the trim line.

432
00:17:19.705 --> 00:17:22.225

We know exactly how many flights it's gonna take us to get

433
00:17:22.225 --> 00:17:23.905
through the entire envelope.

434
00:17:24.215 --> 00:17:27.265
Expansion, uh, we know we don't have to repeat flights

435
00:17:27.265 --> 00:17:29.745
because of not being able to achieve that, uh,

436
00:17:29.745 --> 00:17:30.785
test condition every time.

437
00:17:30.785 --> 00:17:32.425
We know we're gonna achieve it every single time.

438
00:17:33.165 --> 00:17:36.105
Um, some of the examples where it saves us a lot of time,

439
00:17:36.205 --> 00:17:38.625
for example, as acoustics testing, that's one

440
00:17:38.625 --> 00:17:41.145
of the examples of the profiles we flew, uh,

441
00:17:41.145 --> 00:17:43.825
where the profile meets in the middle, that little, uh,

442
00:17:43.825 --> 00:17:46.785
middle dx, um, that's where our microphones were.

443
00:17:47.835 --> 00:17:49.605
And we're able to cram

444
00:17:49.605 --> 00:17:52.525
as many test points on a single battery charge, uh,

445
00:17:52.525 --> 00:17:53.725
because it's autonomous

446
00:17:53.745 --> 00:17:55.645
and we can get the exact

447
00:17:55.645 --> 00:17:56.805
flight conditions we're looking for.

448
00:17:56.865 --> 00:18:00.125
So let's say like 60 knots while doing a climb at a certain

449
00:18:00.525 --> 00:18:02.525
altitude, we can achieve it every single time.

450
00:18:03.025 --> 00:18:06.605
So if a noisy V 22 comes, uh, roaring by

451
00:18:06.985 --> 00:18:08.925
and we have to redo this flight, we,

452
00:18:09.145 --> 00:18:11.565
we know we can do it in a single, uh, single go.

453
00:18:14.895 --> 00:18:16.185
Some ways to mitigate risk

454
00:18:16.405 --> 00:18:18.865
and an autonomous vehicle is redundancy.

455
00:18:19.245 --> 00:18:22.545
Uh, so designing a redundant, robust architecture.

456
00:18:23.765 --> 00:18:25.985
Uh, we also do a lot of, uh, failure testing

457
00:18:26.045 --> 00:18:29.425
and Monte Carlo analysis on simulators, uh,

458
00:18:29.425 --> 00:18:30.585
with, uh, flight hardware.

459
00:18:31.245 --> 00:18:33.145

But we also have contingency plans in case

460
00:18:33.145 --> 00:18:34.185
of a failure in flight.

461
00:18:34.805 --> 00:18:35.825
So this kind of looks like

462
00:18:35.825 --> 00:18:37.265
spaghetti on the, uh, screen there.

463
00:18:37.285 --> 00:18:40.785
But, um, this shows you all the possible, um,

464
00:18:42.245 --> 00:18:45.705
uh, return home profiles that were evaluated

465
00:18:46.125 --> 00:18:48.345
for the profile you just saw for the acoustics plan.

466
00:18:49.125 --> 00:18:50.505
And every one

467
00:18:50.505 --> 00:18:52.585
of these profiles is evaluated on the simulator

468
00:18:52.725 --> 00:18:55.225
to ensure a safe landing back, uh, back at the base.

469
00:18:58.685 --> 00:18:59.985
So other ways to mitigate risk.

470
00:18:59.985 --> 00:19:01.985
We already talked about the fight termination system

471
00:19:01.985 --> 00:19:03.305
that's in the top right corner there.

472
00:19:03.415 --> 00:19:04.465
Nice big red button.

473
00:19:05.205 --> 00:19:07.425
Uh, but we also utilize a subscale aircraft,

474
00:19:07.425 --> 00:19:08.665
and we still use that to this day.

475
00:19:08.805 --> 00:19:10.785
Uh, we utilize the subscale aircraft

476
00:19:10.785 --> 00:19:12.145
to evaluate new software.

477
00:19:12.475 --> 00:19:15.385
We're able to go even higher risk with those, um,

478
00:19:15.795 --> 00:19:18.225
where we can evaluate the limitations

479
00:19:18.225 --> 00:19:19.305
of our flight control laws

480
00:19:19.765 --> 00:19:21.025
before putting them on the big bird.

481
00:19:21.025 --> 00:19:24.545
But we can also evaluate a certain profile if we need to.

482
00:19:25.365 --> 00:19:29.225
Um, the aircraft has some representative flight hardware,

483
00:19:29.225 --> 00:19:30.745
like an INS, uh,

484
00:19:30.745 --> 00:19:34.425
but has the same, uh, flight control laws and, uh, code.

485
00:19:36.815 --> 00:19:38.675
One of the ways that to mitigate, uh, risk

486
00:19:38.775 --> 00:19:40.595

of one wasting schedule time.

487
00:19:40.855 --> 00:19:44.515
We also, uh, create multiple variants of each profile.

488
00:19:45.095 --> 00:19:49.155
And that way in, in case like if we believe that we

489
00:19:50.225 --> 00:19:51.925
may need to increase speed for a profile

490
00:19:52.105 --> 00:19:55.445
or change the, um, the chirps for a certain profile,

491
00:19:55.495 --> 00:19:56.645
we'll create multiple variants

492
00:19:57.025 --> 00:19:59.205
and put them as part of that software load so

493
00:19:59.205 --> 00:20:00.965
that they're available for use in the

494
00:20:00.965 --> 00:20:02.205
future in case they were needed.

495
00:20:04.995 --> 00:20:08.085
Some of the, uh, lessons learned along the way.

496
00:20:08.425 --> 00:20:12.165
Um, early transition hover is tough,

497
00:20:12.505 --> 00:20:13.605
uh, tough on the aircraft.

498
00:20:14.015 --> 00:20:18.085
Hover is, uh, really strains the aircraft in terms

499
00:20:18.085 --> 00:20:21.125
of thermals, like that's for both battery and engines.

500
00:20:21.125 --> 00:20:23.245
And it also has a very high torque demand.

501
00:20:24.225 --> 00:20:27.165
Uh, mid transition is where we got our highest vibrations.

502
00:20:27.465 --> 00:20:28.925
So we try not to dwell in those areas.

503
00:20:29.345 --> 00:20:32.205
Um, however, for flight testing, we do, uh,

504
00:20:32.205 --> 00:20:34.125
dwell on those areas while we're conducting margin chirps,

505
00:20:34.125 --> 00:20:36.445
but we try to power through it for the transition.

506
00:20:37.505 --> 00:20:38.765
And then the late transition

507
00:20:38.765 --> 00:20:41.125
and cruise phase is a very efficient flight regime.

508
00:20:41.125 --> 00:20:44.245
So we try to push as many test points into that regime.

509
00:20:44.505 --> 00:20:46.965
Um, allows us to move a lot,

510
00:20:46.980 --> 00:20:48.725
lot faster at those higher speeds.

511
00:20:49.385 --> 00:20:51.125
But not all margin data is useful.

512
00:20:51.345 --> 00:20:55.125
So learning from the flight tests on Maker, we were able

513
00:20:55.125 --> 00:20:57.525

to reduce the test points required on midnight zero

514
00:20:57.945 --> 00:20:59.045
to allow us to move faster.

515
00:20:59.545 --> 00:21:01.805
And now using those learnings to move, um,

516
00:21:01.905 --> 00:21:03.845
faster on the piloted version, midnight.

517
00:21:03.845 --> 00:21:07.805
One Other efficiency improvements we already touched on was

518
00:21:07.965 --> 00:21:11.125
creating more profiles, but, um, one of the main things

519
00:21:11.125 --> 00:21:13.045
that helped us, uh, move a little faster was

520
00:21:13.275 --> 00:21:14.885
expanding the wind limit on the vehicle.

521
00:21:15.105 --> 00:21:18.645
And we did that by being able to, uh, change the profiles

522
00:21:18.665 --> 00:21:21.205
to take off and land in the same heading.

523
00:21:21.585 --> 00:21:24.205
So if you orient the aircraft into the wind for takeoff,

524
00:21:24.385 --> 00:21:25.405
you're hopefully back

525
00:21:25.825 --> 00:21:27.765
and landing into the wind again for landing.

526
00:21:28.545 --> 00:21:30.925
And that allowed us to increase the, uh, wind envelope.

527
00:21:31.665 --> 00:21:34.845
Um, unfortunately if the winds change during flight, um,

528
00:21:34.945 --> 00:21:37.365
it is an autonomous vehicle, we have no way of changing

529
00:21:37.365 --> 00:21:38.765
that heading on the return.

530
00:21:38.825 --> 00:21:40.405
So we have to accept some of that risk.

531
00:21:43.735 --> 00:21:46.115
Um, um, the other, um,

532
00:21:46.245 --> 00:21:48.555
efficiency improvement was flying in controlled

533
00:21:48.555 --> 00:21:49.795
airspace under a koa.

534
00:21:49.855 --> 00:21:51.075
We don't need chase.

535
00:21:51.365 --> 00:21:55.235
We're flying in, uh, controlled airspace that reduces cost

536
00:21:55.295 --> 00:21:56.395
and increases efficiency

537
00:21:56.555 --> 00:21:59.155
'cause we don't have to deal with having a second vehicle in

538
00:21:59.155 --> 00:22:00.155
the airspace as well.

539
00:22:03.655 --> 00:22:05.355
So some of these benefits we've already touched on,

540
00:22:05.375 --> 00:22:08.595

but in summary, uh, it's high risk tolerance allowing, uh,

541
00:22:08.595 --> 00:22:10.755
rapid development, especially in flight control laws.

542
00:22:11.615 --> 00:22:14.435
Um, flying and constrained airspace, um, allows us

543
00:22:14.435 --> 00:22:16.875
to move faster, um, and cheaper.

544
00:22:17.975 --> 00:22:20.315
We have precise inputs for each flight conditions.

545
00:22:20.435 --> 00:22:23.515
I don't have to rely on GEM in getting the exact flight

546
00:22:23.515 --> 00:22:24.915
condition for each test point.

547
00:22:25.075 --> 00:22:27.275
I know I'm gonna get it with an autonomous flight plan.

548
00:22:28.735 --> 00:22:32.315
And, um, we're able to evaluate the energy draw down

549
00:22:32.315 --> 00:22:34.755
to a percent of, uh, state of charge.

550
00:22:34.975 --> 00:22:38.395
So we know that our profile will, um, we'll be able

551
00:22:38.395 --> 00:22:39.555
to conduct all test points

552
00:22:40.055 --> 00:22:42.915
and we're able to maximize the amount of time in the air

553
00:22:43.625 --> 00:22:46.195
instead of having to get to a certain location

554
00:22:46.375 --> 00:22:47.435
before we can start testing.

555
00:22:48.695 --> 00:22:50.675
And especially useful for acoustics

556
00:22:50.675 --> 00:22:53.355
and down wash testing where we can conduct the same profile

557
00:22:53.355 --> 00:22:54.675
over and over again in different, uh,

558
00:22:54.675 --> 00:22:56.155
environmental conditions if required.

559
00:22:58.825 --> 00:23:02.995
Some of the limitations, um, were unknown, unknown failure

560
00:23:03.635 --> 00:23:06.995
failures are potentially catastrophic if we don't have, um,

561
00:23:08.255 --> 00:23:10.275
if we don't have it already programmed into the vehicle,

562
00:23:10.455 --> 00:23:12.235
the vehicle will try its best to come back.

563
00:23:12.655 --> 00:23:15.915
Um, but if there's something that's unknown that happens,

564
00:23:16.695 --> 00:23:19.715
our final ditch effort will be to just, uh,

565
00:23:19.775 --> 00:23:22.195
hit the big red button and watch it fall out of the sky.

566
00:23:23.945 --> 00:23:25.485
Um, there's an extensive effort

567
00:23:25.485 --> 00:23:27.205

to develop autonomous software.

568
00:23:27.825 --> 00:23:31.525
Um, this is something where you can throw more money

569
00:23:31.585 --> 00:23:34.845
and engineers at, uh, at the company level

570
00:23:35.265 --> 00:23:36.605
before you get into flight testing.

571
00:23:36.745 --> 00:23:38.765
So this does allow you to get into flight testing faster

572
00:23:38.865 --> 00:23:41.245
by being able to throw more band power at it early on.

573
00:23:42.175 --> 00:23:44.125
We're not able to change profiles easily.

574
00:23:44.275 --> 00:23:45.925
That does require a full software,

575
00:23:46.345 --> 00:23:47.485
uh, change on the aircraft.

576
00:23:47.485 --> 00:23:49.925
So that would require like a two to three day churn.

577
00:23:51.805 --> 00:23:53.865
Uh, landing direction we mentioned

578
00:23:53.865 --> 00:23:55.945
before could not be changed in real time,

579
00:23:56.365 --> 00:23:57.865
but we try to mitigate that by taking,

580
00:23:58.125 --> 00:24:01.465
by landing at the same, uh, heading as our takeoff.

581
00:24:02.205 --> 00:24:05.425
And we have very limited, uh, CN avoid, we can see,

582
00:24:05.425 --> 00:24:06.425
but we can't really avoid.

583
00:24:06.765 --> 00:24:09.505
So if there's a bird in the area, um, we'll go right

584
00:24:09.505 --> 00:24:10.665
through it, even if we see it

585
00:24:11.925 --> 00:24:14.985
and there's no human factors reviewed, um, for the intended,

586
00:24:15.085 --> 00:24:17.065
uh, flight scheme, but, uh, that's something

587
00:24:17.065 --> 00:24:18.705
that can be mitigated with a simulator.

588
00:24:21.625 --> 00:24:22.725
So, which is best, which

589
00:24:22.765 --> 00:24:23.765
Is best, I'm sure you're hoping

590
00:24:23.765 --> 00:24:24.845
that we were just gonna give you an answer.

591
00:24:25.145 --> 00:24:27.725
Um, the answer is if as always, it depends.

592
00:24:28.465 --> 00:24:30.845
So, um, there's no one size fits all approach.

593
00:24:30.985 --> 00:24:32.605
It depends on what your goals are

594
00:24:32.625 --> 00:24:34.125

for the project, short term, long term.

595
00:24:34.385 --> 00:24:37.485
And, uh, in the end, uh, one work may work

596
00:24:37.485 --> 00:24:38.605
for one project and not another.

597
00:24:38.605 --> 00:24:39.605
Like the spatial example,

598
00:24:39.675 --> 00:24:42.365
same exact mission flown very differently, um,

599
00:24:42.545 --> 00:24:44.125
for whatever reasons they thought.

600
00:24:44.385 --> 00:24:46.445
So it all depends on, on the data you seek.

601
00:24:46.705 --> 00:24:49.005
Um, it gets packed to that, you know, cost, schedule, scope,

602
00:24:49.005 --> 00:24:51.645
safety, um, measuring lows, looking at those,

603
00:24:51.645 --> 00:24:52.805
looking at what really matters.

604
00:24:53.225 --> 00:24:55.885
Um, and it really, it becomes that company-wide decision.

605
00:24:55.955 --> 00:24:57.325
It's not flight test. What's the most

606
00:24:57.325 --> 00:24:58.565
convenient thing for flight test?

607
00:24:58.585 --> 00:24:59.765
We all would like it to be,

608
00:25:00.105 --> 00:25:01.365
but this kind of decision of

609
00:25:01.365 --> 00:25:02.565
how you're gonna start flight test

610
00:25:02.665 --> 00:25:03.725
is a company-wide decision.

611
00:25:03.745 --> 00:25:05.445
It involves finance, it involves the,

612
00:25:05.625 --> 00:25:06.885
the business development people.

613
00:25:06.905 --> 00:25:08.685
It certainly involves the executive side.

614
00:25:08.985 --> 00:25:11.405
Uh, and that decision basically has to be made day one.

615
00:25:11.595 --> 00:25:13.605
Like, I wanna make this new kind of airplane.

616
00:25:13.695 --> 00:25:15.325
First thing you have to decide is, okay,

617
00:25:15.325 --> 00:25:17.205
am I gonna make a a piloted aircraft,

618
00:25:17.205 --> 00:25:18.845
an autonomous aircraft, or a

619
00:25:18.845 --> 00:25:20.205
remote aircraft somewhere in between?

620
00:25:20.625 --> 00:25:22.485
Um, because it's gonna take a lot of development

621
00:25:22.665 --> 00:25:24.445

and that has to happen from day one.

622
00:25:25.895 --> 00:25:27.915
So hopefully this gives you some of the, uh, the things

623
00:25:27.915 --> 00:25:30.555
to weigh and that analysis of alternatives, um, if

624
00:25:30.555 --> 00:25:32.235
that becomes something you are involved in.

625
00:25:32.915 --> 00:25:34.335
And with that, the yellow light comes on.

626
00:25:34.355 --> 00:25:36.175
So with your questions

627
00:25:42.015 --> 00:25:44.755
In your envelope expansion, have

628
00:25:45.665 --> 00:25:49.795
AELs or loads mentioned there, are you monitoring those

629
00:25:49.895 --> 00:25:52.835
or are you, or, or do you in, uh, have

630
00:25:53.055 --> 00:25:54.995
for instance, AEL injections?

631
00:25:56.815 --> 00:25:57.955
Let the engineers say that one.

632
00:25:58.815 --> 00:26:01.595
Uh, we are doing that now.

633
00:26:02.055 --> 00:26:03.915
So, um, we didn't do it in the past.

634
00:26:04.135 --> 00:26:05.555
We were monitoring vibrations.

635
00:26:06.335 --> 00:26:07.955
Um, but uh, there'll be more of

636
00:26:07.955 --> 00:26:09.155
that testing later this year.

637
00:26:10.465 --> 00:26:13.275
Okay. And to get it through the filters we had

638
00:26:13.275 --> 00:26:15.035
to most the technical content out of it.

639
00:26:15.255 --> 00:26:19.955
Oh, yeah. Um, with more

640
00:26:19.955 --> 00:26:21.875
and more autonomy in the loop, uh,

641
00:26:22.195 --> 00:26:24.435
software becomes increasingly important.

642
00:26:25.215 --> 00:26:28.435
So as flight tests, how do you approach software validation?

643
00:26:29.295 --> 00:26:32.155
And is flight tests in the future expected to become

644
00:26:33.075 --> 00:26:34.595
software experts as well?

645
00:26:35.135 --> 00:26:37.355
Um, and what, what is the test team's experience

646
00:26:37.355 --> 00:26:38.995
like on that front?

647
00:26:41.105 --> 00:26:42.925
So we rely heavily on our,

648
00:26:43.425 --> 00:26:45.805

on our teams doing, uh, the verification.

649
00:26:46.465 --> 00:26:47.805
Um, as flight test,

650
00:26:47.905 --> 00:26:50.805
we will evaluate the data coming from those data reviews.

651
00:26:51.465 --> 00:26:54.845
Um, the simulator sessions, for example, will go over

652
00:26:54.845 --> 00:26:56.165
that data and we'll actually brief

653
00:26:56.595 --> 00:26:59.125
that flight plan having flown on flight software

654
00:26:59.465 --> 00:27:03.325
or, sorry, uh, flight hardware, um, in our pretest briefs.

655
00:27:03.825 --> 00:27:06.085
And that's how we are able to

656
00:27:06.725 --> 00:27:08.565
recognize when something is abnormal happening.

657
00:27:08.565 --> 00:27:10.685
So for example, we'll also put, uh,

658
00:27:10.685 --> 00:27:11.885
different winds in a simulator.

659
00:27:12.465 --> 00:27:15.005
Uh, so when we are flying it in real life,

660
00:27:15.225 --> 00:27:17.725
we know we're gonna expect, let's say, um,

661
00:27:17.785 --> 00:27:20.765
an extra five degrees of pitch if we have a higher headwind.

662
00:27:21.305 --> 00:27:24.005
Um, and that's how we evaluate the software, just mainly

663
00:27:24.005 --> 00:27:25.365
through the simulator results.

664
00:27:28.685 --> 00:27:29.965
I got two questions for you.

665
00:27:30.545 --> 00:27:33.885
One, uh, you had, uh, a couple of risk mitigation

666
00:27:34.265 --> 00:27:35.325
or hazard mitigations.

667
00:27:35.385 --> 00:27:38.445
One was the, um, land now capability,

668
00:27:38.505 --> 00:27:40.325
and then the other one was your big red button.

669
00:27:40.745 --> 00:27:42.805
So those are, uh, mitigators,

670
00:27:42.825 --> 00:27:44.205
but they can also, uh,

671
00:27:44.675 --> 00:27:46.725
introduce risk I guess at some point as well.

672
00:27:46.745 --> 00:27:48.365
So how do you handle the risk

673
00:27:48.385 --> 00:27:50.285
that's introduced, uh, by those?

674
00:27:51.065 --> 00:27:52.405
And to me that that's a big part

675
00:27:52.405 --> 00:27:53.805

of this discussion of which one's safer.

676
00:27:54.265 --> 00:27:57.045
So land, now you knew roughly where it was gonna be,

677
00:27:57.065 --> 00:27:58.965
and we fly over farmland, which is, you know,

678
00:27:58.965 --> 00:28:00.885
there's no buildings, we don't fly over any houses,

679
00:28:01.385 --> 00:28:02.525
but it's not empty.

680
00:28:02.905 --> 00:28:04.885
Uh, and so there's always a chance with land now

681
00:28:04.885 --> 00:28:06.445
that it might end up in the wrong place

682
00:28:06.445 --> 00:28:08.085
where somebody's, you know, parked their tractor.

683
00:28:09.185 --> 00:28:11.645
Um, how we mitigated that is just, there was unlikely.

684
00:28:11.705 --> 00:28:13.365
The goal was always to bring the aircraft home.

685
00:28:13.865 --> 00:28:16.285
Uh, the flight termination system was simply a balance

686
00:28:16.285 --> 00:28:17.925
of if the aircraft is just gonna go off

687
00:28:17.985 --> 00:28:19.765
and refuses to turn around, it was better

688
00:28:19.765 --> 00:28:22.085
to stop it now than to see where it ran outta energy.

689
00:28:22.265 --> 00:28:25.005
And, uh, so the flight termination system was simply a

690
00:28:25.005 --> 00:28:27.045
better situation than the aircraft just departing

691
00:28:27.045 --> 00:28:29.765
and going, uh, into an uncontrolled environment.

692
00:28:30.105 --> 00:28:32.645
Uh, but the mitigations ends up being just a balance of,

693
00:28:32.705 --> 00:28:34.445
you know, we're gonna do everything, we're gonna do all this

694
00:28:34.445 --> 00:28:36.365
Monte Carlo testing and saying all the failures

695
00:28:36.365 --> 00:28:37.605
that we think are even possible,

696
00:28:37.605 --> 00:28:39.005
the aircraft's gonna safely come home.

697
00:28:39.235 --> 00:28:41.125
However, if it becomes something

698
00:28:41.125 --> 00:28:42.365
that the aircraft is only gonna be able

699
00:28:42.365 --> 00:28:43.565
to fly like a thermal runaway,

700
00:28:43.565 --> 00:28:46.245
which is extremely remote land now gave us an option

701
00:28:46.245 --> 00:28:47.365
to put it on the ground before it

702
00:28:47.365 --> 00:28:48.445

simply fell out of the sky.

703
00:28:48.585 --> 00:28:50.805
So that was a safer option than letting it literally just

704
00:28:50.805 --> 00:28:52.205
fall out of the sky out of control.

705
00:28:52.865 --> 00:28:55.925
And just to add onto that, we can escalate a response.

706
00:28:56.145 --> 00:28:58.565
So our initial response will always be return home.

707
00:28:58.985 --> 00:29:01.725
If it's not returning home, we can initiate a divert

708
00:29:01.725 --> 00:29:03.205
or a land now, and

709
00:29:03.615 --> 00:29:05.485
after that will be the flight termination system.

710
00:29:06.025 --> 00:29:08.445
That's great. And, uh, my second question was, uh,

711
00:29:08.625 --> 00:29:09.845
I'm assuming the answer's yes,

712
00:29:09.845 --> 00:29:11.405
but do you, you have a simulator

713
00:29:11.405 --> 00:29:13.405
and you, you rehearse these as a crew?

714
00:29:14.485 --> 00:29:15.525
Absolutely. Yeah. Great.

715
00:29:19.265 --> 00:29:20.765
Uh, two questions please.

716
00:29:20.905 --> 00:29:22.725
Uh, thank you for the presentation, first of all.

717
00:29:22.825 --> 00:29:27.205
Um, first question, um, do you plan on having the cap,

718
00:29:27.345 --> 00:29:31.045
the capability for the pilot to intervene even when the

719
00:29:31.605 --> 00:29:33.205
aircraft is flying autonomously?

720
00:29:33.945 --> 00:29:36.325
Um, and the second question is, as it comes

721
00:29:36.345 --> 00:29:39.085
to certification, how do you plan on approaching that?

722
00:29:39.455 --> 00:29:42.565
Would you run the, the certification, uh,

723
00:29:42.565 --> 00:29:45.925
flight test points autonomously or with pilot in the loop?

724
00:29:46.625 --> 00:29:48.405
Um, for us, for Archer, the,

725
00:29:48.425 --> 00:29:50.245
our end product is a piloted aircraft.

726
00:29:50.245 --> 00:29:51.725
So our choice to do autonomous was

727
00:29:51.725 --> 00:29:52.925
simply a flight test choice.

728
00:29:53.545 --> 00:29:55.925
So the next aircraft, the, the T one is it's called,

729
00:29:55.945 --> 00:29:57.565

or M1 is a piloted aircraft

730
00:29:57.565 --> 00:29:59.125
and will not be flown autonomously,

731
00:29:59.125 --> 00:30:00.245
it'll flown with a pilot on board.

732
00:30:00.245 --> 00:30:02.845
So this was simply an expeditious, expeditious route

733
00:30:02.845 --> 00:30:05.925
to get the data we needed to develop the piloted aircraft

734
00:30:06.305 --> 00:30:08.205
And reduce risk on the piloted aircraft.

735
00:30:09.025 --> 00:30:11.725
And we'll still continue to fly M zero even when we start

736
00:30:11.725 --> 00:30:13.965
flying M1, so that we can use that aircraft

737
00:30:13.965 --> 00:30:15.325
for those higher risk test points.

738
00:30:17.195 --> 00:30:20.125
Okay. And, and for the first question, do you, uh, is it,

739
00:30:20.125 --> 00:30:23.285
is it, is it, and this is outta ignorance, um, is it, is it

740
00:30:23.285 --> 00:30:25.125
that difficult to implement a process

741
00:30:25.175 --> 00:30:27.485
where the pilot can intervene when the,

742
00:30:27.635 --> 00:30:29.605
when the aircraft is flying autonomously

743
00:30:29.605 --> 00:30:30.605
or so that would be, or is

744
00:30:30.605 --> 00:30:31.845
that a conscious decision? So that would

745
00:30:31.845 --> 00:30:33.405
Be the remotely piloted, uh,

746
00:30:33.465 --> 00:30:36.565
so you would be at quite a bit of, um, development there.

747
00:30:37.035 --> 00:30:38.805
Okay, thank you. It also increases the amount of things

748
00:30:38.805 --> 00:30:40.565
that could happen once you, you know,

749
00:30:40.565 --> 00:30:42.045
if you say they can only fly this profile

750
00:30:42.065 --> 00:30:44.645
or come home, that was what the constrained airspace was.

751
00:30:44.645 --> 00:30:45.965
It was easy to go to tower and say,

752
00:30:45.965 --> 00:30:47.525
the aircraft will be in this bubble.

753
00:30:47.785 --> 00:30:49.085
It can't go above this altitude

754
00:30:49.085 --> 00:30:50.925
and will go from here to here and nowhere else.

755
00:30:51.235 --> 00:30:52.845
Once you open up remotely piloted,

756
00:30:52.845 --> 00:30:54.565

it's possible the pilot could fly over here

757
00:30:54.685 --> 00:30:56.445
or fly over there, not planned

758
00:30:56.445 --> 00:30:57.925
and not expected, but possible.

759
00:30:57.925 --> 00:30:58.805
Therefore, the tower

760
00:30:58.805 --> 00:31:00.045
would want to know where you're gonna go.

761
00:31:00.065 --> 00:31:01.365
How could you get there? What's the safety?

762
00:31:01.665 --> 00:31:02.685
It was very easy to say,

763
00:31:02.685 --> 00:31:05.445
this bubble is the only place the aircraft will fly, uh,

764
00:31:05.445 --> 00:31:07.445
which got us cl faster into the air and,

765
00:31:07.505 --> 00:31:09.085
and, uh, from ATCs perspective.

766
00:31:09.855 --> 00:31:10.285
Thank you.

767
00:31:17.195 --> 00:31:21.125
Yeah. With, uh, yeah, working with regards to as much

768
00:31:21.125 --> 00:31:24.125
as you can share about the test, uh, termination system

769
00:31:24.195 --> 00:31:28.325
that you use on that, is that a profile once the button,

770
00:31:28.505 --> 00:31:30.125
big red button is pushed or whatever,

771
00:31:30.125 --> 00:31:34.205
however it is engaged, is that a profile that's unique

772
00:31:34.265 --> 00:31:35.325
to the test area?

773
00:31:35.825 --> 00:31:37.085
The, um,

774
00:31:37.665 --> 00:31:38.965
It really is a last ditch effort.

775
00:31:39.225 --> 00:31:40.685
The, as as Patrick said,

776
00:31:40.685 --> 00:31:41.845
the intention is if something started

777
00:31:41.845 --> 00:31:43.205
to go wrong, we would tell it to come home.

778
00:31:43.585 --> 00:31:45.445
As it started to come home, we might choose to tell it

779
00:31:45.445 --> 00:31:47.965
to land, but the, the termination system was simply if the

780
00:31:48.205 --> 00:31:49.485
aircraft, everything failed

781
00:31:49.545 --> 00:31:52.365
and just start driving away in a straight direction towards

782
00:31:52.365 --> 00:31:54.605
like Salinas towards, you know, populated area.

783
00:31:54.985 --> 00:31:56.445

The flight termination system just opened

784
00:31:56.445 --> 00:31:57.485
up all the battery packs

785
00:31:57.585 --> 00:31:59.485
And it was, and it's an independent system,

786
00:31:59.625 --> 00:32:03.205
so it has its own antenna, own, uh, box on the aircraft.

787
00:32:03.825 --> 00:32:06.805
It will forcibly open the contactors on all batteries,

788
00:32:07.025 --> 00:32:10.845
but it'll also throw the, um, all the surfaces into a dive.

789
00:32:12.375 --> 00:32:14.195
So, so it would go into a spiral dive

790
00:32:14.455 --> 00:32:16.115
And crash, but not over my house

791
00:32:17.215 --> 00:32:18.215
Unless you're under us.

792
00:32:18.595 --> 00:32:20.515
I don't know. But that, that's why we had it so we could,

793
00:32:20.535 --> 00:32:22.435
it wouldn't, we could prevent it from going

794
00:32:22.435 --> 00:32:23.475
into populated terrain.

795
00:32:29.495 --> 00:32:31.035
All right. Thank you very much for your time. Thank you.