WEBVTT

1
00:00:03.840 --> 00:00:07.500
We continue, uh, to be amazed at, um, um,

2
00:00:07.680 --> 00:00:09.940
the thinking and the effort that goes into testing,

3
00:00:09.940 --> 00:00:14.540
whether it be flight testing or ground testing. Uh, it doesn't matter. Um,

4
00:00:14.560 --> 00:00:16.740
the elements that I take away from,

5
00:00:17.050 --> 00:00:21.980
from this particular presentation are the use of CRM among the test

6
00:00:21.980 --> 00:00:22.980
team. Uh,

7
00:00:23.010 --> 00:00:27.740
that can be a foot stomper for all of us based on what we saw yesterday. Um,

8
00:00:27.840 --> 00:00:32.180
the use of the FTI right there in, in front of the pilot, um,

9
00:00:32.340 --> 00:00:33.660
I found it, uh, uh,

10
00:00:33.660 --> 00:00:37.260
across the industry looking at different flight test programs that also has a

11
00:00:37.260 --> 00:00:42.260
very, very large benefit. Um, a uh, a sidebar on that is,

12
00:00:42.400 --> 00:00:47.200
is that if you install flight test instrumentation

13

00:00:47.300 --> 00:00:51.200
for the flight crew, it has to be right. It has to work in the proper manner.

14
00:00:51.700 --> 00:00:53.200
It looks to me like, uh,

15
00:00:53.210 --> 00:00:58.160
there is an opportunity to apply SST p a to that small system so that

16
00:00:58.160 --> 00:01:01.560
we make sure that there are no errors in what the flight crew is seeing.

17
00:01:02.580 --> 00:01:06.320
And then the last thing is, um, it's very difficult to, uh,

18
00:01:06.380 --> 00:01:10.080
go to an airfield and say, I would like your airfield for the next two hours.

19
00:01:10.980 --> 00:01:12.080
Uh, and, and by the way,

20
00:01:12.080 --> 00:01:15.000
we may close the runway if we have a blown tire or something like that.

21
00:01:15.070 --> 00:01:18.560
It's very difficult, um, to do that. And it,

22
00:01:19.470 --> 00:01:22.320
even though you have the time and you want to take your time,

23
00:01:22.380 --> 00:01:27.280
it does add to the stress level of doing test. So the next, uh,

24
00:01:27.280 --> 00:01:29.280
presentation that we have, uh,

25
00:01:29.280 --> 00:01:31.960
the last one for the morning before our panel discussion,

26

00:01:32.350 --> 00:01:37.200
it's optionally pilot vehicle as a means to de-risk autonomous

27
00:01:37.540 --> 00:01:41.680
UAS testing. It will be, um, presented by Marco Risotto.

28
00:01:42.460 --> 00:01:47.160
Um, it's uh, from PIP drill. You may have seen the pip stro aircraft out at the,

29
00:01:47.160 --> 00:01:51.240
uh, airfield on the first day. Marco is head of flight test and, uh,

30
00:01:51.320 --> 00:01:54.720
n an FTE at PIP stroll. He's a graduate, uh,

31
00:01:54.820 --> 00:01:59.560
of aerospace engineering from the Polytechnical Deno and the University of

32
00:01:59.630 --> 00:02:04.360
Stuttgart. He's been on EPI's flight test team, uh, since 2018.

33
00:02:04.940 --> 00:02:09.080
And he is also a general aviation pilot. He is joined by Dr.

34
00:02:09.250 --> 00:02:14.040
Simon shots of Emma Zia Aerospace. Um,

35
00:02:14.690 --> 00:02:15.640
Simon, uh,

36
00:02:15.680 --> 00:02:19.840
received his Bachelor of science degree and masters from aero in aerospace

37
00:02:20.080 --> 00:02:24.560
engineering at the Uni Technical University of Munich. And then, uh,

38
00:02:24.560 --> 00:02:25.680
even more interestingly,

39
00:02:25.740 --> 00:02:29.720
he attended the Georgia Institute of Technology and finished, uh,

40
00:02:29.740 --> 00:02:34.480
his PhD as a result at back at the Technical University of

41
00:02:34.500 --> 00:02:39.080
Munich. Tremendous academic qualifications, uh, in this room for sure.

42
00:02:39.980 --> 00:02:44.720
Um, he took the position as head of flight control at Azelia Aerospace in 2018

43
00:02:45.300 --> 00:02:49.280
and develops flight control laws and vehicle management functions to ground

44
00:02:49.280 --> 00:02:53.240
control software. So if you would please join me up here.

45
00:03:04.970 --> 00:03:05.803
Thank you.

46
00:03:12.120 --> 00:03:16.520
Thank you very much for the introduction today. We would like to,

47
00:03:16.940 --> 00:03:21.120
uh, tell you about, uh, flight test campaign. We've, uh, run, uh, uh,

48
00:03:21.740 --> 00:03:26.720
in the last, uh, couple of years, uh, um, about how we have, uh,

49
00:03:27.350 --> 00:03:32.320
converted one of our, uh, uh, legacy products into an augmented version.

50
00:03:32.550 --> 00:03:37.280
Here you see the, uh, what it looks like, uh, you,

51
00:03:37.420 --> 00:03:42.060
for those who have been the other day at the, um, at the tour,

52
00:03:42.600 --> 00:03:46.060
uh, we had there, the electric, uh, version of that.

53
00:03:46.210 --> 00:03:49.700
It's basically the same airframe. That's what it looks like from the outside.

54
00:03:49.730 --> 00:03:54.450
It's very similar aerodynamics. Um, and how, uh,

55
00:03:54.480 --> 00:03:57.530
most interestingly what we would like to talk to you about is, um,

56
00:03:57.710 --> 00:04:02.530
our test approach. How we have, uh, approached, uh, this, uh,

57
00:04:02.750 --> 00:04:06.530
um, by using an optional piloted vehicle to de-risk, uh,

58
00:04:06.790 --> 00:04:11.770
say the complexity and, uh, the unknowns of testing, uh, an Armand version,

59
00:04:12.670 --> 00:04:16.910
um, and, uh, the flight control system that's behind it, um,

60
00:04:18.750 --> 00:04:22.090
uh, through using manned, uh, version of it.

61
00:04:25.440 --> 00:04:30.260
Before we kick off just very quick, um, uh, facts about,

62
00:04:30.440 --> 00:04:34.060
uh, our organizations. It's not obvious that, uh, uh,

63
00:04:34.080 --> 00:04:37.860
we are so well known around here so far away. Uh, paper trail is, uh,

64
00:04:38.420 --> 00:04:42.860
a light aircraft manufacturer. We were, uh, founded in, uh, 1989.

65
00:04:43.200 --> 00:04:46.660
We build, uh, mostly two seaters, ultra light LSAs,

66
00:04:47.090 --> 00:04:51.700
also type certified versions. We are developing part 23, uh, aircraft. Um,

67
00:04:52.080 --> 00:04:55.500
we have, we are mostly known for our, uh, electric, uh,

68
00:04:55.780 --> 00:04:59.400
airplanes and work in the electric airplanes field. And, uh,

69
00:04:59.460 --> 00:05:04.120
we are also developing Amanda, um, platform and aircraft.

70
00:05:05.410 --> 00:05:09.950
Uh, we are also part of now Tetron, uh, family since the year. So,

71
00:05:11.450 --> 00:05:15.430
um, whereas Azelia, we've teamed up with Azelia, they're based in Munich,

72
00:05:16.490 --> 00:05:20.350
and they are, uh, just really, really smart about building, uh, uh,

73
00:05:20.350 --> 00:05:22.510
flight control systems for, uh,

74
00:05:22.610 --> 00:05:27.510
Amanda vehicle optional piloted vehicle vehicle management systems and all this

75
00:05:27.510 --> 00:05:30.150
sort of stuff that's absolutely crucial, you know,

76
00:05:30.150 --> 00:05:31.910
to make this type of product work,

77
00:05:33.460 --> 00:05:36.110
including ground control stations, as we will see.

78
00:05:37.680 --> 00:05:41.500
So a few key facts about the aircraft. It's, as I've said,

79
00:05:41.510 --> 00:05:45.260
based on a proven airframe and propulsion.

80
00:05:45.800 --> 00:05:49.820
So we know the airplane, we know it flies well open loop, it's out there,

81
00:05:49.980 --> 00:05:54.450
hundreds and hundred built, we know it flies quite well. Um, it has a hundred,

82
00:05:54.760 --> 00:05:58.330
oops, there you go. A hundred opower, uh,

83
00:05:58.460 --> 00:06:03.410
Rotax engine m t o w in this range of 600 to 750 kilo,

84
00:06:03.410 --> 00:06:04.450
depending on the version,

85
00:06:05.160 --> 00:06:09.730
a typical crew speed of 130 knots and a payload of 150,

86
00:06:09.730 --> 00:06:13.170
200 kilo, which should be around 400, 450 pounds.

87
00:06:15.200 --> 00:06:19.950
Few facts above the system itself, uh, it has, uh,

88
00:06:20.150 --> 00:06:24.710
redundant flight control system, triplex, fly con, uh, fly by wire, uh,

89
00:06:25.010 --> 00:06:28.750
fly control computers, um, supporting the fly by wire control system,

90
00:06:29.020 --> 00:06:32.070
vehicle and subsystem management to, uh,

91

00:06:32.070 --> 00:06:35.590
manage all the system that normally pilot would manage electrical system,

92
00:06:35.700 --> 00:06:40.230
circuit breakers, lights, pto, heat transponder, um, these kind of things.

93
00:06:40.620 --> 00:06:45.570
It's dedicated ground control station that we see here on the lower right. Um,

94
00:06:45.670 --> 00:06:50.330
it can be, um, controlled via either autopilot functions,

95
00:06:50.510 --> 00:06:53.850
remote control or automatic mission flight. And it's able also,

96
00:06:53.850 --> 00:06:57.650
it has an integrated geofencing, uh, um, function.

97
00:06:58.110 --> 00:07:02.450
So very quickly here, we can take a look at the, the ground control station, uh,

98
00:07:02.450 --> 00:07:05.250
that we have used during the testing. We have a pfd,

99
00:07:05.400 --> 00:07:08.730
some main information for the pilot or the operator, uh,

100
00:07:08.730 --> 00:07:12.090
in the main screen system, information on the left, uh,

101
00:07:12.290 --> 00:07:14.370
navigation and map information on the right.

102
00:07:14.370 --> 00:07:18.730
And we also had a cockpit camera stream, uh, live, uh, during our tests.

103
00:07:22.330 --> 00:07:26.270
Okay, so our concept is we want to de-risk this test,

104
00:07:27.290 --> 00:07:31.540
um, through the use of an optionally piloted vehicle. So the, the,

105
00:07:31.640 --> 00:07:34.140
the main idea is we want to, by doing this,

106
00:07:34.360 --> 00:07:39.060
we want to check and test to the flight control system performance using an

107
00:07:39.060 --> 00:07:42.610
identical aerodynamic and propulsion. Um,

108
00:07:43.260 --> 00:07:47.690
we're gonna test the closed loop population system hardware and software that it

109
00:07:47.690 --> 00:07:50.020
works properly. And, uh,

110
00:07:50.040 --> 00:07:54.900
we are also able to isolate certain system tests like GCs and data

111
00:07:54.970 --> 00:07:58.380
link and sensors without, uh,

112
00:07:58.860 --> 00:08:02.500
possible failures of these systems impacting, uh,

113
00:08:02.500 --> 00:08:06.540
the risk level of the test itself in a significant way. As we will see later,

114
00:08:07.700 --> 00:08:12.400
the limitations of this approach, mass imbalance wasn't fully representative,

115
00:08:12.620 --> 00:08:14.640
but close enough for the sake of these tests.

116
00:08:15.590 --> 00:08:19.610

And system redundancy was not representative of the surveyor. Basically.

117
00:08:19.630 --> 00:08:22.250
We didn't need the triplex redundancy on, on this,

118
00:08:22.590 --> 00:08:24.970
but also didn't affect the test results in any way

119
00:08:27.090 --> 00:08:29.220
high level benefits, um,

120
00:08:30.300 --> 00:08:33.600
of really why it was worthwhile for us to do this.

121
00:08:34.680 --> 00:08:37.820
So this allowed us, first of all to, uh, uh,

122
00:08:37.990 --> 00:08:42.420
adopt a buildup approach from simple autopilot function all the way up to

123
00:08:42.420 --> 00:08:46.890
automatic takeoff and landing a tool. We had a fly wire,

124
00:08:47.690 --> 00:08:52.330
a flight control system in parallel to the mechanical FCS that we,

125
00:08:52.510 --> 00:08:57.080
and, uh, by using a quick and reliable, uh,

126
00:08:57.080 --> 00:08:58.440
disconnection system,

127
00:08:58.940 --> 00:09:03.000
we gained the confidence that with a click above a button in 50 milliseconds,

128
00:09:03.000 --> 00:09:05.560
a hundred milliseconds, we would revert back to the,

129
00:09:05.580 --> 00:09:09.650
our normal known LSA airplane. So basically,

130
00:09:09.650 --> 00:09:13.050
the pilot was able to do his, his manual fly to and from the,

131
00:09:13.550 --> 00:09:17.970
the safe test area and start the test there in a known and, uh,

132
00:09:18.240 --> 00:09:20.890
predetermined condition, safe altitude, and so on.

133
00:09:21.770 --> 00:09:26.170
Simplified s and operating a UAV v of this size in integration in the airspace.

134
00:09:26.550 --> 00:09:28.610
And we were also quick in, uh,

135
00:09:28.630 --> 00:09:32.250
design test redesign cycles with the crew on board. This was very,

136
00:09:32.250 --> 00:09:34.090
very good for, uh, uh,

137
00:09:34.090 --> 00:09:38.050
understanding what was going on well or not well as predicted, uh,

138
00:09:38.050 --> 00:09:41.610
during the test, an obviously easier process to obtain a permit to fly,

139
00:09:41.710 --> 00:09:44.850
we were basically got a permit to fly for a manned aircraft with just a fancy

140
00:09:44.850 --> 00:09:49.410
autopilot. Couple of drawbacks as well. Uh, we're putting crew on board,

141
00:09:49.790 --> 00:09:54.010
so maybe not the best thing for safety. You might think, uh,

142
00:09:54.150 --> 00:09:58.650

we are derisking uav, but we're putting people in the U of V. That's true. Uh,

143
00:09:58.650 --> 00:10:01.330
but nonetheless, we think, uh, that, uh,

144
00:10:01.630 --> 00:10:05.730
we thought that we could do this by managing the risk in, uh, uh,

145
00:10:05.830 --> 00:10:07.570
so that the risk at the end of the day was,

146
00:10:07.630 --> 00:10:12.050
was acceptable because of all the benefits that we would get by by following

147
00:10:12.050 --> 00:10:16.570
this approach. And obviously we had to build two airplanes instead of one. Um,

148
00:10:16.570 --> 00:10:20.050
that's also another drawback, but, uh, for several other reasons, uh,

149
00:10:20.070 --> 00:10:23.770
it was worthwhile because we had other plans for the O P V platform. Anyway,

150
00:10:26.420 --> 00:10:27.840
and I'll end over to Simon,

151
00:10:29.460 --> 00:10:32.400
And thank you very much. Welcome everyone. Yeah,

152
00:10:32.400 --> 00:10:35.800
let's just talk a bit more about what we actually did to the aircraft.

153
00:10:35.980 --> 00:10:38.920
So I mean, just as an example here on the right hand side,

154
00:10:39.340 --> 00:10:42.480
you see basically behind the pilot seats, uh, we installed,

155
00:10:42.480 --> 00:10:46.720
this is like one actuator that here gears with an electromechanical clutch into

156
00:10:47.020 --> 00:10:48.080
the flag control system.

157
00:10:48.080 --> 00:10:53.000
So basically we have installed the primary for all primary

158
00:10:53.020 --> 00:10:56.840
access. We have installed this clutch, um, actuator mechanisms,

159
00:10:57.180 --> 00:11:01.480
and we also have installed actuators on throttle and brakes actually.

160
00:11:02.590 --> 00:11:06.810
Um, then of course, for all these things we have to have means to disconnect.

161
00:11:07.070 --> 00:11:11.330
So, um, there's of course the electromechanical clutch, okay,

162
00:11:11.360 --> 00:11:14.850
it's an electromechanical clutch. And then also for the throttle actuators,

163
00:11:14.910 --> 00:11:16.810
you have manual disconnect options.

164
00:11:16.810 --> 00:11:19.290
So you basically get rid of the connection to it.

165
00:11:20.430 --> 00:11:22.880
It's also if you have like brake pressure,

166
00:11:22.880 --> 00:11:26.480
you have the chance to have like a stuck brake basically in terms of actuation,

167
00:11:27.020 --> 00:11:30.320

you have the opportunity to release break pressure, um,

168
00:11:30.340 --> 00:11:34.280
so at least that that stops you from really tipping over or something like that.

169
00:11:34.740 --> 00:11:37.920
And then we have like a, like two-way power system.

170
00:11:37.940 --> 00:11:41.980
So first we have a power system that's really just for the actuators. Um,

171
00:11:41.980 --> 00:11:44.580
so basically you get rid of the power by a mean,

172
00:11:45.080 --> 00:11:49.580
and we also have the overall power, let's say for the mission autopilot.

173
00:11:49.680 --> 00:11:52.690
So for this all autopilot systems,

174
00:11:52.790 --> 00:11:55.660
everything is connected to one power supply.

175
00:11:55.720 --> 00:11:58.620
So basically if you cut this power supply, you really cut everything,

176
00:11:59.260 --> 00:12:03.180
computer sensors, x-ray, it's all gone. Um, and then, I mean,

177
00:12:03.180 --> 00:12:07.660
as a last means of something really went one wrong sufficiently high in air,

178
00:12:07.760 --> 00:12:10.380
at least, um, we have a ballistic rescue power shoot,

179
00:12:10.380 --> 00:12:13.380
so that's also on all the standard purpose aircraft.

180
00:12:13.440 --> 00:12:17.430

So we can make use of that to disconnect. I mean,

181
00:12:17.430 --> 00:12:22.220
basically there's also different ways to disconnect, um, the normal way, I mean,

182
00:12:22.220 --> 00:12:24.460
if you do a normal test and you're like,

183
00:12:24.460 --> 00:12:28.340
basically have the left hand seat safety pilot, right hand seat, flight test,

184
00:12:28.620 --> 00:12:33.110
engineer operator, however you want to call that on the right hand scene,

185
00:12:33.110 --> 00:12:37.110
you also have a direct law stick. So you can actually fly direct law, um,

186
00:12:37.140 --> 00:12:40.510
just for all the extra errors to really test what you want to test.

187
00:12:40.820 --> 00:12:44.270
There's a button on that to disconnect. This would be a software disconnect.

188
00:12:44.330 --> 00:12:46.790
So basically you tell the computer, please disconnect.

189
00:12:47.170 --> 00:12:49.550
So that opens the clutches by software,

190
00:12:50.270 --> 00:12:53.350
I mean as a pilot or also here in the middle,

191
00:12:53.690 --> 00:12:56.310
that's basically installed in the cockpit panel.

192
00:12:56.930 --> 00:13:00.390
You can also disconnect there by hardware. It's simple hardware.

193

00:13:00.450 --> 00:13:02.390
So basically pressing the red button,

194
00:13:02.390 --> 00:13:06.470
simple hardware will open the electromechanical clutches, disconnect all x-ray.

195
00:13:07.380 --> 00:13:10.320
Um, and of course, if all of these wouldn't be working,

196
00:13:10.500 --> 00:13:14.680
you still have the opportunity to, where is it here to have a switch where,

197
00:13:14.680 --> 00:13:16.920
where you take the whole power away from the system.

198
00:13:17.060 --> 00:13:19.720
So it's another way to make sure that you can,

199
00:13:20.340 --> 00:13:24.160
and also the x-ray eight have a certain limit that in channel it's possible to

200
00:13:24.240 --> 00:13:28.720
overrule, I mean, by force, uh, the x-ray, that's something you don't wanna do.

201
00:13:29.380 --> 00:13:33.510
It's also something we never, none of this were had to do. So in normal,

202
00:13:33.730 --> 00:13:35.270
the normal disconnect worked always,

203
00:13:35.330 --> 00:13:39.840
but that's just some means to ensure that we de-risk the, the flight.

204
00:13:39.910 --> 00:13:44.240
It's also if we basically lose, uh, computers or basically this,

205
00:13:44.410 --> 00:13:48.840
let's say the display functionality of our system, so you are unsure.

206
00:13:48.840 --> 00:13:53.280
We still also have here in the, in the panel, we basically have a status LEDs,

207
00:13:54.030 --> 00:13:57.810
and also that's the three main electromechanical clutches engaged.

208
00:13:57.950 --> 00:14:01.730
So you can also see it there, um, and disconnect the system.

209
00:14:02.770 --> 00:14:05.100
Yeah, in terms of design, we basically,

210
00:14:05.600 --> 00:14:10.370
of course also kind of ensure that we come with a safe software.

211
00:14:10.490 --> 00:14:13.770
I mean, in the end, the software is not part of surfing, vacation or anything,

212
00:14:13.790 --> 00:14:15.250
so we have the disconnect mechanism.

213
00:14:15.390 --> 00:14:19.810
So we really use this as a firewall and go easy on flight testing.

214
00:14:20.270 --> 00:14:24.530
But of course, we make sure that we have tested the software beforehand,

215
00:14:24.840 --> 00:14:28.440
that we have, um, verified, I mean, first of all,

216
00:14:28.440 --> 00:14:31.680
the whole safety system beforehand, but also that we,

217
00:14:31.810 --> 00:14:35.320
every time we go flying before that we recheck that the mechanisms work.

218
00:14:35.980 --> 00:14:38.480
And also, I mean, just maybe as a, as a feature, we, uh,

219
00:14:38.480 --> 00:14:41.360
don't have like a lot of re we have redundant computers,

220
00:14:41.360 --> 00:14:45.520
but not redundant functions in the end. So we basically have one main function.

221
00:14:45.520 --> 00:14:49.520
We, we don't do what we would do on the op, like the unmanned aircraft,

222
00:14:49.750 --> 00:14:53.450
just a bit more on our software development. So everything we do,

223
00:14:53.470 --> 00:14:57.340
we of course undergoes simulations, a lot of simulations before,

224
00:14:57.340 --> 00:14:59.860
and that we can rule out soft, uh,

225
00:14:59.860 --> 00:15:03.900
like logical errors that we can rule out in the hardware.

226
00:15:03.900 --> 00:15:05.580
The loop simulation that we also,

227
00:15:05.610 --> 00:15:08.460
when we bring the software onto the actual platform have issues.

228
00:15:08.880 --> 00:15:10.740
And especially on our unmanned watch,

229
00:15:10.800 --> 00:15:14.980
we also have the opportunity to put this simulation into our,

230
00:15:16.390 --> 00:15:16.960
uh,

231
00:15:16.960 --> 00:15:20.930
like basically to the aircraft and then move the extra x-ray of the aircraft to

232
00:15:20.930 --> 00:15:23.890
just make sure that the actual system still works. Of course,

233
00:15:23.890 --> 00:15:27.570
ultimately flight test, that's where we are. Why we are here.

234
00:15:28.250 --> 00:15:31.180
Just in terms of lightest operations, I mean,

235
00:15:31.360 --> 00:15:35.580
we have basically multi mechanisms. Let's first focus on the cockpit.

236
00:15:36.410 --> 00:15:39.790
The standard cockpit is still in there, so we have all the engine automation,

237
00:15:40.200 --> 00:15:43.590
everything a normal peoples to pilot would do is still in here.

238
00:15:44.210 --> 00:15:47.310
And then the right hand seat, we basically removed everything,

239
00:15:47.310 --> 00:15:51.490
which is like normal aircraft, and we install the fiber bio stick.

240
00:15:51.590 --> 00:15:56.510
We have the main tablet, which we can use to, um, yeah, observe,

241
00:15:56.510 --> 00:15:58.830
monitor the flight test, execute the flight test. And,

242
00:15:58.850 --> 00:16:02.590
and we have two different data links just from this aircraft.

243
00:16:02.590 --> 00:16:05.310
We have like six antenna pairs, but we can just two,

244
00:16:05.310 --> 00:16:07.670
use two data links at the same time. For line of site,

245
00:16:08.430 --> 00:16:11.730
we have a beyond line of site mobile network modem.

246
00:16:11.870 --> 00:16:14.490
So actually we are usually, um,

247
00:16:14.790 --> 00:16:18.850
flying sufficiently low that we actually can use that as well as additional data

248
00:16:18.880 --> 00:16:21.930
link. And we have a secure van connection.

249
00:16:22.510 --> 00:16:27.330
So basically we can have all data on all different ground control

250
00:16:27.330 --> 00:16:28.370
stations. This, for example,

251
00:16:28.470 --> 00:16:32.250
at one flight that was Munich and this one was a ster.

252
00:16:32.270 --> 00:16:35.130
We have also two of those. So we,

253
00:16:35.190 --> 00:16:38.690
we can really see the data on many different different ways. And, um,

254
00:16:39.460 --> 00:16:41.710
basically have a hot mic connection as well.

255
00:16:41.710 --> 00:16:44.870
So everything you the cockpit is saying is always coming down,

256
00:16:44.870 --> 00:16:48.190
and then all the others could all call our board if they see something

257
00:16:48.190 --> 00:16:50.710
monitoring. So basically the ground contrast station people,

258

00:16:51.340 --> 00:16:55.190
they're usually there for monitoring only, um, except we want to,

259
00:16:55.190 --> 00:16:58.430
to really a surrogate UAV V mission or something. Then you do it from ground,

260
00:16:58.930 --> 00:17:00.230
or you can also, for example,

261
00:17:00.230 --> 00:17:03.990
really theoretical if phenomenal or from ground if you wanted to. Um,

262
00:17:04.140 --> 00:17:05.990
also on the, on the other hand,

263
00:17:05.990 --> 00:17:10.910
the safety pilot is mainly there to also monitor traffic, fly to the flight,

264
00:17:10.910 --> 00:17:11.750
to site, engage,

265
00:17:12.360 --> 00:17:16.110
let's say the cockpit function that we didn't automate because especially we

266
00:17:16.110 --> 00:17:19.710
didn't automate the engine. So we are not a fully classically you, uh,

267
00:17:19.790 --> 00:17:22.870
O P V in the sense that you can really not fly with a pilot.

268
00:17:22.930 --> 00:17:26.710
The pilot could turn everything on and then jump out, and then you start flying,

269
00:17:26.710 --> 00:17:30.910
that would work. But it's not really as optional as a classical one. It's just,

270
00:17:31.840 --> 00:17:34.040

I mean, all functions are automated, but it's,

271
00:17:34.040 --> 00:17:38.590
there's still some calm or other functions that have to be done manual. Um,

272
00:17:38.650 --> 00:17:43.590
and also mean the on flight is the engineer is usually one that is operating the

273
00:17:44.130 --> 00:17:48.990
fcs and it can do whatever the ground contour station does in air and

274
00:17:49.000 --> 00:17:52.480
also could fly, fly by fly wire control. Um,

275
00:17:53.020 --> 00:17:56.990
just to make sure that all x-rays work. Just as an example here,

276
00:17:57.010 --> 00:17:59.960
one of our main interface pages is, in this case,

277
00:17:59.960 --> 00:18:02.360
it's for the inner control loop in air.

278
00:18:02.500 --> 00:18:06.360
So we really have the opportunity to play whatever

279
00:18:07.150 --> 00:18:10.480
automatic sequences we want to do. Flight test.

280
00:18:10.480 --> 00:18:14.600
This would now be actually a variety where you do have like roll angle,

281
00:18:14.630 --> 00:18:16.960
lateral acceleration, vertical acceleration,

282
00:18:17.580 --> 00:18:21.280
and basically can set here all the different parameters you want.

283
00:18:21.280 --> 00:18:25.440

You can define the doublet, you can give a constant side slip,

284
00:18:25.670 --> 00:18:28.350
lateral fo command, or you can, uh,

285
00:18:28.380 --> 00:18:32.160
also have like whatever roll angle dolets. Um,

286
00:18:33.250 --> 00:18:36.340
this is basically here. It always have a, has a small PFD as well.

287
00:18:36.400 --> 00:18:38.020
But of course we have the main pfd,

288
00:18:38.020 --> 00:18:41.300
you have the main interaction for all the nominal functions we want to test.

289
00:18:41.720 --> 00:18:44.220
And also, for example, here, we do it for ground testing as well.

290
00:18:44.920 --> 00:18:47.900
We were able to do asymmetric breaking. You can basically select,

291
00:18:47.900 --> 00:18:50.860
do you want to use asymmetric brakes or not? Do you want to do rather how,

292
00:18:51.050 --> 00:18:53.860
what kind of gain do you want? What's your lateral acceleration limit?

293
00:18:54.080 --> 00:18:57.070
That's all stuff you can set up here. Exactly.

294
00:18:57.490 --> 00:19:01.510
So that was on our interface. And let's now go today, build up

295
00:19:07.630 --> 00:19:11.780
About the, about the flight test buildup or first of all,

296
00:19:12.020 --> 00:19:16.140

actually the test philosophy. Um, we wanted to be fast,

297
00:19:16.630 --> 00:19:20.540
rapid in our design, uh, test, update,

298
00:19:20.540 --> 00:19:24.730
the model redesign cycles, and we managed,

299
00:19:25.470 --> 00:19:26.303
uh,

300
00:19:27.270 --> 00:19:32.110
we use the philosophy going from basic to more advanced FCS functions,

301
00:19:32.110 --> 00:19:35.310
as I mentioned earlier, and going from inner to outer loops testing,

302
00:19:37.090 --> 00:19:40.870
uh, for doing this. Basically then we structured the, uh,

303
00:19:40.870 --> 00:19:44.230
the test campaign with these, uh, in these phases. Uh,

304
00:19:44.230 --> 00:19:47.630
we started off with system tests. We started to, uh,

305
00:19:47.770 --> 00:19:51.790
tackle and treat every single system, especially activators, the
hardware,

306
00:19:52.010 --> 00:19:56.610
the sensors, using also direct law. Uh,

307
00:19:56.630 --> 00:20:00.690
we then moved on, includes the loops, testing the inner loops, uh,

308
00:20:00.690 --> 00:20:02.250
then moved on to the outer loops,

309
00:20:02.250 --> 00:20:05.930
basically autopilot functions and waypoint navigation of all the various

310
00:20:06.290 --> 00:20:10.970
functions of the system. Then, uh, uh, auto throttle that was,

311
00:20:11.110 --> 00:20:15.770
uh, took us quite some time, uh, to, um, to get to, let's say,

312
00:20:16.310 --> 00:20:21.090
uh, tune our controllers, uh, and the logic to make it work. Uh, lots of, uh,

313
00:20:21.090 --> 00:20:25.330
nonlinearities in that, uh, um, control chain, uh,

314
00:20:25.330 --> 00:20:30.210
took us possibly most of the, of the flight time to get it right.

315
00:20:30.800 --> 00:20:35.410
Then we moved on to the automatic, uh, taxi and braking. I have, uh,

316
00:20:36.110 --> 00:20:39.770
you could consider them, uh, potentially also together. But, um,

317
00:20:40.070 --> 00:20:44.450
at the end of the day, we were, uh, testing different, uh, um, actuators.

318
00:20:44.950 --> 00:20:49.440
Um, okay. Also then together at the same time, this was also quite, uh,

319
00:20:49.530 --> 00:20:52.640
quite important to build up the confidence, uh,

320
00:20:52.820 --> 00:20:57.440
to then move on to the automatic takeoff and then automatic landing and go

321
00:20:57.440 --> 00:20:58.273
around.

322
00:21:02.930 --> 00:21:04.190
Now, I'd like to, uh,

323
00:21:04.220 --> 00:21:08.950
show you a bit more in detail about the automatic landing test, uh,

324
00:21:08.950 --> 00:21:13.550
which was, uh, probably the most exciting test, uh, of this campaign. Um,

325
00:21:13.780 --> 00:21:16.750
this, uh, schematics shows a bit the idea,

326
00:21:16.850 --> 00:21:21.350
the logic behind how the system, um, of the automatic landing works.

327
00:21:21.650 --> 00:21:25.310
We see up here, uh, flight mode, enunciator, uh, style.

328
00:21:25.310 --> 00:21:29.750
And that's also what we saw in the cockpit, uh, of the very, uh, during the,

329
00:21:29.850 --> 00:21:33.670
the various phases of the auto landing. We see we start, uh, here, uh,

330
00:21:33.670 --> 00:21:38.430
basically in, in a normal auto pilot mode, vena and auto thrusts,

331
00:21:38.900 --> 00:21:42.600
then intercepting the approach path. Um,

332
00:21:43.880 --> 00:21:46.900
we do initiate the auto landing prior to this. Uh,

333
00:21:47.160 --> 00:21:49.180
and then we intercept the path.

334
00:21:49.640 --> 00:21:54.620
We continue being nav enough down to a certain threshold height where

335
00:21:54.970 --> 00:21:58.380
then the flare maneuver is initiated.

336
00:21:59.200 --> 00:22:03.260
So the vertical mode goes into vertical speed control.

337
00:22:03.650 --> 00:22:08.340
Lateral goes into the DECRA to compensate for any, uh,

338
00:22:08.340 --> 00:22:12.140
in case we were compensated for any crosswind and auto thrust, uh, uh,

339
00:22:12.140 --> 00:22:16.060
goes to idle. We are able actually, idle for us works, uh, quite well.

340
00:22:16.130 --> 00:22:20.300
It's a very aerodynamically sleek airplane. We don't need any more, uh,

341
00:22:20.500 --> 00:22:23.740
residual thrust, uh, all the way down to the ground from the flare. Actually,

342
00:22:23.840 --> 00:22:28.340
we had to manage quite well that, uh, that energy and not to,

343
00:22:28.720 --> 00:22:33.140
um, initiate the flare too abruptly or too early or, uh,

344
00:22:33.140 --> 00:22:37.660
or too quickly. Uh, we also have some, some protections here in this phase of,

345
00:22:37.720 --> 00:22:38.090
uh,

346
00:22:38.090 --> 00:22:42.780
bank and pitch after touchdown has been detected by the system.

347
00:22:42.840 --> 00:22:47.220
We enter the rotation phase where we have a feed forward, uh, command of, uh,

348
00:22:47.240 --> 00:22:50.620
pit rate to slowly, uh, put the nose gear down,

349
00:22:51.120 --> 00:22:54.580
and we maintain the ground heading at the moment of touchdown.

350
00:22:55.960 --> 00:22:57.280
Frost is obviously still idle.

351
00:22:57.340 --> 00:23:01.320
And then we move onto the rollout phase in which also auto brakes is, uh,

352
00:23:01.320 --> 00:23:04.940
is engaged, elevator goes to neutral,

353
00:23:05.120 --> 00:23:09.360
and then lateral mode goes into the central line tracking mode. Um,

354
00:23:12.490 --> 00:23:16.150
so, um, task goes for this test, uh,

355
00:23:16.250 --> 00:23:21.190
was obviously to consolidate the control logic, meaning when do we start, uh,

356
00:23:21.190 --> 00:23:25.870
when do we do, let's say, uh, flaps, reconfiguration, or under what conditions,

357
00:23:25.940 --> 00:23:30.030
when do we, uh, initiate the flare? Uh, what height there?

358
00:23:30.500 --> 00:23:33.070
When do we do all these, let's say,

359
00:23:33.430 --> 00:23:37.030
sequence of events that need to happen as a consequence of something else,

360
00:23:37.050 --> 00:23:41.270
of some other parameter? Uh, so that, uh, uh, it works the way it should.

361
00:23:43.320 --> 00:23:45.560

Uh, the, here obviously the, the, the,

362
00:23:45.580 --> 00:23:49.800
the input of the flight test pilot is absolutely crucial. And, uh, it's, um,

363
00:23:49.950 --> 00:23:51.440
many of these actions that you do,

364
00:23:51.440 --> 00:23:54.160
especially when you're flying this kind of aircraft, are, I would say almost,

365
00:23:54.220 --> 00:23:57.640
uh, uh, you know, maybe you don't have to think so much about them,

366
00:23:57.660 --> 00:23:59.640
but when you need to program them in an airplane,

367
00:23:59.640 --> 00:24:03.920
which needs to do it on its own in, uh, in, uh, a repeatable and safe, uh, way,

368
00:24:04.030 --> 00:24:08.800
then uh, we had to break it down, uh, to the very, uh, small details, let's say.

369
00:24:09.260 --> 00:24:12.760
And obviously we want to validate the clo uh, the controller performance, uh,

370
00:24:12.760 --> 00:24:15.360
from a approach path tracking. Uh,

371
00:24:15.360 --> 00:24:20.160
we wanted to be very precise during this approach. Path tracking, uh, dra uh,

372
00:24:20.360 --> 00:24:24.480
flare, obviously. When are we gonna start the flare? How are we gonna do it?

373

00:24:24.480 --> 00:24:29.100
What, uh, is it good enough? Uh, uh, do we end up with too much pitch?

374
00:24:29.240 --> 00:24:33.240
Not enough pitch? Do we get too slow? Uh,

375
00:24:33.240 --> 00:24:38.000
centerline tracking and braking, as I said, we, we tackle these last two points,

376
00:24:38.000 --> 00:24:41.640
central line tracking and braking before, but it needed to work nonetheless,

377
00:24:41.670 --> 00:24:46.640
with all the rest, just before, obviously we wanted to verify as robustness. Uh,

378
00:24:46.700 --> 00:24:49.800
we want that this works, uh, not just on a, on a perfect day,

379
00:24:49.940 --> 00:24:52.960
but also with different wind conditions, different flap settings.

380
00:24:52.960 --> 00:24:56.560
And also one thing that's, uh, not mentioned here, um, uh, different, uh,

381
00:24:56.560 --> 00:24:57.480
different approach speeds,

382
00:24:58.270 --> 00:25:03.080
some range of approach speeds for the very flat side things. And for this,

383
00:25:03.080 --> 00:25:05.880
we used the test buildup where we went on and, uh,

384
00:25:05.910 --> 00:25:10.630
simulated the auto land and auto flare initially at safe height. Obviously,

385
00:25:10.630 --> 00:25:14.470

this, uh, didn't allow us to, to, to, uh, catch the, the ground effect,

386
00:25:14.650 --> 00:25:17.670
but nonetheless, it gave us an idea that the FCS was not doing anything crazy,

387
00:25:17.770 --> 00:25:21.950
was doing what it was supposed to do, gave us the confidence then to, uh,

388
00:25:21.950 --> 00:25:25.990
go and perform, uh, uh, the, the, uh, maneuvers that, uh, the,

389
00:25:26.210 --> 00:25:30.470
the actual approach which were discontinuing at increasingly lower heights till

390
00:25:30.470 --> 00:25:33.350
we fell confident enough to actually go and perform the full auto land.

391
00:25:33.570 --> 00:25:35.430
And as I've said, we had, we wanted the,

392
00:25:35.430 --> 00:25:38.030
needed to have the high confidence in auto taxi, in auto brake.

393
00:25:39.100 --> 00:25:41.160
One interesting point I'd like to remark, uh,

394
00:25:41.160 --> 00:25:46.030
crew composition was an interesting topic of discussion where we had, uh,

395
00:25:46.210 --> 00:25:50.710
uh, test pilot and ft or actually the, the system expert on board.

396
00:25:51.370 --> 00:25:55.230
And we, uh, deemed it safer than just having the, the test pilot, uh,

397
00:25:55.230 --> 00:25:57.910
because the system complexity and the amount of,

398
00:25:58.050 --> 00:26:01.030

of things that he would've had to, to monitor on his own.

399
00:26:03.710 --> 00:26:06.410
Um, about the test analysis,

400
00:26:06.410 --> 00:26:09.530
we had a main hazard of loss of control near around ground.

401
00:26:09.530 --> 00:26:12.890
This was the main one, which causes could be basically the,

402
00:26:12.910 --> 00:26:16.290
the system not doing what it was supposed to do or some environmental factors

403
00:26:16.580 --> 00:26:18.810
which could have led to grand collision, crash landing,

404
00:26:18.880 --> 00:26:23.210
potentially loss of aircraft and crew. We, uh, put in place a few mitigations,

405
00:26:23.210 --> 00:26:26.530
obviously our buildup approach, the FCS disconnection system,

406
00:26:26.530 --> 00:26:30.930
which Simon has talked to you about, um, limited authority of the surfaces.

407
00:26:30.990 --> 00:26:31.670
At the beginning,

408
00:26:31.670 --> 00:26:35.490
the FCS could do only so much auto brakes initially was disengaged,

409
00:26:35.870 --> 00:26:40.100
so we decoupled that. We had strict wind limitations, no turbulence or gust.

410
00:26:40.480 --> 00:26:45.280
We went out to the longest and wide runway in Slovenia. Uh, and,

411
00:26:45.420 --> 00:26:49.560
uh, you, we were using helmets and we managed to, uh, obtain a residual risk,

412
00:26:49.620 --> 00:26:54.310
uh, of, uh, uh, which was me, uh, medium. Now we have, uh,

413
00:26:54.490 --> 00:26:58.170
uh, a bit of a video where, uh,

414
00:26:58.590 --> 00:27:01.650
we can take a look what it looked like. So this is the airplane.

415
00:27:01.830 --> 00:27:06.610
Now we line up on the runway with automatic taxi. We see on the up upper right,

416
00:27:06.750 --> 00:27:10.170
uh, the cockpit camera where we see the ft, the, the,

417
00:27:10.350 --> 00:27:13.130
the interface with the system, uh, on board.

418
00:27:13.190 --> 00:27:16.730
We see the ground control station at the test site here in a remote ground

419
00:27:16.730 --> 00:27:21.490
control station. Um, uh, in Munich actually we have com.

420
00:27:21.490 --> 00:27:26.010
This was, uh, uh, a full mission where we did an auto takeoff traffic pattern.

421
00:27:26.360 --> 00:27:28.810
Auto landing, which was commanded from Munich,

422
00:27:28.820 --> 00:27:32.410
could have been commanded from anywhere else, but just to, to make it fancier.

423

00:27:32.950 --> 00:27:37.930
We see we start the auto takeoff, uh, sequence. Um, interesting. We see one,

424
00:27:38.190 --> 00:27:42.850
1.5 meters, uh, of, uh, um, deviation from the center line.

425
00:27:43.550 --> 00:27:47.810
It was acceptable. Uh, and uh, then you see we enter the,

426
00:27:47.810 --> 00:27:51.930
the rotation and then from as soon as, uh, a few meters off the ground that the,

427
00:27:52.150 --> 00:27:56.810
uh, the system moves from the automatic take of, uh, mode to the normal,

428
00:27:56.990 --> 00:28:01.250
uh, auto loop, um, auto autopilot climb mode, and so on.

429
00:28:02.720 --> 00:28:07.140
Uh, automat reconfiguring of the, of the flaps. Um, of course.

430
00:28:08.710 --> 00:28:13.210
And now we have transitioned to the, to the final. We see here that we were,

431
00:28:13.220 --> 00:28:17.590
we're on final. Um, and uh, uh,

432
00:28:17.590 --> 00:28:21.790
as we get closer to the ground, we do enter the flare mode.

433
00:28:22.210 --> 00:28:25.670
We start increasing, going nose up a bit, touchdown,

434
00:28:25.780 --> 00:28:30.030
nice and smooth landing. Good job, Simon. And the rotation,

435
00:28:30.600 --> 00:28:33.670
retracting the flaps, engaging the auto brakes,

436
00:28:35.010 --> 00:28:38.750
and that's it. And they're cheering already. It wasn't the first one, so just,

437
00:28:41.910 --> 00:28:42.743
there we go.

438
00:28:42.980 --> 00:28:44.180
I just rushed,

439
00:28:44.500 --> 00:28:47.140
I just rushed through it because we are actually already out of time.

440
00:28:47.140 --> 00:28:49.860
But I mean, in the end, just to give, uh, some hints,

441
00:28:49.860 --> 00:28:52.900
we already did like 23 automatic takeouts, uh,

442
00:28:52.900 --> 00:28:57.180
65 automatic landing so far with this aircraft. And 28 in Port Portage.

443
00:28:57.330 --> 00:29:01.140
Very nice at the sea curved approaches in, you can see here,

444
00:29:01.140 --> 00:29:05.300
that's like basically red would be flare, blue would be the deportation,

445
00:29:05.300 --> 00:29:08.540
then it's roll out and you can see that they're pretty repeatable.

446
00:29:08.560 --> 00:29:11.300
The main thing is with this aircraft, you, it does want to stop,

447
00:29:11.300 --> 00:29:14.820
so you have very long flares and it's actually also one of the main risks.

448
00:29:14.820 --> 00:29:18.390
So we did a lot of flaps, we did a lot of, uh,

449
00:29:18.390 --> 00:29:20.910
like go around from one feet. We landed, uh,

450
00:29:21.100 --> 00:29:24.710
from the right and seat di fly by wire. So all that stuff we have done.

451
00:29:25.540 --> 00:29:28.520
And I mean, as like next things, I mean, this was,

452
00:29:28.660 --> 00:29:33.480
we are now really feeling safe to go, uh, testing this one here in flight. Um,

453
00:29:33.480 --> 00:29:34.880
this is going to happen this year.

454
00:29:35.650 --> 00:29:38.710
We have to just sort out which field in Europe it will be.

455
00:29:39.290 --> 00:29:42.530
And I mean with this one, we have done a lot of automatic taxi tests,

456
00:29:42.530 --> 00:29:44.400
center line tracking already in Munich.

457
00:29:44.500 --> 00:29:49.250
So it's basically we are directly before takeoff in the sense that

458
00:29:49.670 --> 00:29:53.520
now we are feel confident to continue with that one. So in the sense,

459
00:29:53.690 --> 00:29:54.840
thank you very much for that,

460
00:29:58.200 --> 00:30:02.730
Jill. One final remark, sec. Our lessons learned, uh, very quickly.

461
00:30:03.230 --> 00:30:04.210
Uh, for us, uh,

462

00:30:04.230 --> 00:30:07.610
the main lesson learned was that this was a viable and feasible approach.

463
00:30:07.910 --> 00:30:11.370
It worked for us. We were able to manage the risk. We were,

464
00:30:11.480 --> 00:30:15.610
were able to be very effective. We had a task campaign, which was, uh,

465
00:30:15.610 --> 00:30:20.610
was quite fast from initial first flight to auto landing. Um,

466
00:30:20.950 --> 00:30:22.850
and, uh, the other, uh,

467
00:30:22.850 --> 00:30:27.450
lesson learned was that having an integrated team with the developers of the fcs

468
00:30:27.640 --> 00:30:32.210
very close, integrated in the test team was absolutely crucial for, uh,

469
00:30:32.230 --> 00:30:36.250
for test success and uh, um, and the speed of testing. Thank you very much.

470
00:30:40.000 --> 00:30:40.490
Love that.