WEBVTT

1
00:00:00.475 --> 00:00:02.215
Thanks, Tiana for the presentation.

2
00:00:02.595 --> 00:00:04.775
I'm Nicola and, uh, together with Lorenzo.

3
00:00:04.775 --> 00:00:08.415
Today we want to tell you how we use simulation in, uh,

4
00:00:08.595 --> 00:00:10.975
our first flight campaign of the Nova 300.

5
00:00:11.715 --> 00:00:15.095
So we use those, uh, uh, simulation to manage uncertainties.

6
00:00:15.635 --> 00:00:17.975
Our talk, we will be dividing three parts.

7
00:00:18.475 --> 00:00:21.895
Uh, the first one, uh, I will address, uh, the problem

8
00:00:21.925 --> 00:00:25.375
that we're facing while in the second one, Lorenzo will deal

9
00:00:25.485 --> 00:00:28.375
with, uh, uh, the implementation of, uh, this, uh,

10
00:00:28.375 --> 00:00:31.375
simulation, uh, augmented, uh, flight testing approach.

11
00:00:31.795 --> 00:00:34.495
And then at the end, I will draw some conclusion based on,

12
00:00:34.715 --> 00:00:37.095
uh, the experience of the flight test campaign.

13
00:00:38.195 --> 00:00:41.495
So let's start with, uh, a brief introduction, uh, both

14
00:00:41.495 --> 00:00:43.095
to the context and the aircraft.

15
00:00:43.435 --> 00:00:45.895
Uh, you were able yesterday probably during, uh,

16
00:00:45.955 --> 00:00:49.895
the P Israel, uh, GOZA facility tour to see the aircraft.

17
00:00:50.395 --> 00:00:52.415
And, uh, so let's go through the context,

18
00:00:52.835 --> 00:00:53.855
uh, that we were facing.

19
00:00:54.275 --> 00:00:55.775
It was the first flight campaign

20
00:00:55.875 --> 00:00:57.855
of a completely new design for the company.

21
00:00:58.475 --> 00:01:01.775
Uh, it was an unmanned aircraft, a Vito aircraft, so capable

22
00:01:02.035 --> 00:01:03.175
of vertical takeoff

23
00:01:03.175 --> 00:01:06.255
and landing, uh, was full of new technologies.

24
00:01:06.685 --> 00:01:09.175
It's an aircraft with an automatic flight control system,

25
00:01:09.675 --> 00:01:11.455
uh, hybrid propulsion, uh,

26
00:01:11.725 --> 00:01:14.095
automatic flight control system in the way that

27
00:01:14.945 --> 00:01:16.855

everything is, uh, preplanned

28
00:01:17.195 --> 00:01:18.855
and, uh, inserted in the system

29
00:01:18.925 --> 00:01:21.775
with a predefined flight plan that, uh, at the command

30
00:01:21.775 --> 00:01:23.975
of the pilot, the aircraft automatically executes.

31
00:01:23.975 --> 00:01:27.495
So the pilot has, uh, limited to no capability to interact

32
00:01:27.495 --> 00:01:29.935
with the aircraft, and it's a force for the company.

33
00:01:30.085 --> 00:01:33.015
Also, we had previous experience with, uh, op visas,

34
00:01:33.015 --> 00:01:36.415
so optional piloted vehicles in which we were testing

35
00:01:36.415 --> 00:01:37.895
automatic flight control system,

36
00:01:37.955 --> 00:01:40.855
but with a person on board with the possibility

37
00:01:40.915 --> 00:01:43.335
to disengage the flight control system and take over

38
00:01:43.355 --> 00:01:45.815
and regain control manually on the aircraft.

39
00:01:46.195 --> 00:01:50.095
In this case, no. And also there was, uh, no subscale model

40
00:01:50.095 --> 00:01:51.615
that was flown of the aircraft.

41
00:01:52.195 --> 00:01:54.255
So the first time with loan, it was

42
00:01:54.255 --> 00:01:56.735
during the campaign only other mean to fly.

43
00:01:56.735 --> 00:01:58.415
It was, uh, through the simulations

44
00:01:58.565 --> 00:01:59.735
because we were, uh,

45
00:01:59.835 --> 00:02:02.455
we developed the aircraft following a model based approach.

46
00:02:02.635 --> 00:02:05.935
So models were available, uh, during the wool campaign

47
00:02:06.195 --> 00:02:07.575
and the design of the aircraft.

48
00:02:08.255 --> 00:02:10.535
I want to emphasize three elements of this list.

49
00:02:11.075 --> 00:02:13.095
It was the first flight campaign of the aircraft.

50
00:02:13.635 --> 00:02:15.735
It was, uh, full of advanced technologies,

51
00:02:16.195 --> 00:02:18.135
and it was, uh, limited pilot input.

52
00:02:18.595 --> 00:02:19.615
Why those three elements?

53
00:02:19.685 --> 00:02:23.015
Because, uh, uh, it creates a mix of complexity.

54
00:02:23.395 --> 00:02:26.375

Uh, we have a lot of data coming in the telemetry room

55
00:02:26.635 --> 00:02:28.295
and a disposal of the pilot

56
00:02:28.515 --> 00:02:30.815
and the flight test team that monitor the test.

57
00:02:31.345 --> 00:02:33.615
Everything is controlled by an automatic system,

58
00:02:33.875 --> 00:02:36.095
so it's faster than a human to think.

59
00:02:36.435 --> 00:02:39.455
And also it's high refresh rate with complex logics.

60
00:02:39.475 --> 00:02:43.135
So it's difficult for us to understand it, how it will react

61
00:02:43.195 --> 00:02:44.255
to certain situation.

62
00:02:44.595 --> 00:02:47.495
The pilot is not on board, so there's no direct feedback.

63
00:02:47.835 --> 00:02:50.815
As someone in the previous presentation were mentioning, uh,

64
00:02:50.915 --> 00:02:54.215
he has no direct feedback of the engine, uh, the attitude

65
00:02:54.215 --> 00:02:55.535
of the aircraft, nothing like this.

66
00:02:56.195 --> 00:02:58.335
And, uh, we have zero experience

67
00:02:58.475 --> 00:03:00.205
of a project like this in the company.

68
00:03:00.585 --> 00:03:01.725
So why this is a problem?

69
00:03:01.725 --> 00:03:04.325
Because it's difficult to understand the aircraft behavior,

70
00:03:04.705 --> 00:03:07.645
and also it's possible to lose the situational awareness

71
00:03:07.645 --> 00:03:08.805
because it's, uh,

72
00:03:08.805 --> 00:03:10.965
the aircraft can react in an unpredictable way.

73
00:03:11.305 --> 00:03:13.045
So it may be a complex situation.

74
00:03:15.385 --> 00:03:19.325
And then for, uh, the flight team, uh, propose a solution

75
00:03:19.385 --> 00:03:20.605
to cope with this problem.

76
00:03:21.105 --> 00:03:24.285
And, uh, we said if the aircraft is developed together

77
00:03:24.395 --> 00:03:26.605
with models following a model based approach,

78
00:03:26.865 --> 00:03:28.525
we have simulation model available.

79
00:03:29.065 --> 00:03:31.325
Uh, the mission is already predefined.

80
00:03:31.345 --> 00:03:33.765
So from the takeoff moment to the landing moment,

81
00:03:34.185 --> 00:03:36.925

we know exactly what the aircraft will do and

82
00:03:36.925 --> 00:03:38.645
therefore we, uh, decide

83
00:03:38.645 --> 00:03:41.885
to follow a simulation augmented flight testing approach.

84
00:03:42.625 --> 00:03:45.085
Uh, we use simulation at different, uh,

85
00:03:45.085 --> 00:03:46.525
moments of the test campaign.

86
00:03:46.825 --> 00:03:49.965
We use them of course, before flight to simulate the mission

87
00:03:50.065 --> 00:03:53.885
and to clear that to create mission limits based on the

88
00:03:54.085 --> 00:03:55.405
expected behavior of the aircraft.

89
00:03:55.865 --> 00:03:58.085
But we also use them during flight.

90
00:03:58.465 --> 00:04:02.525
Uh, we compared live, uh, the real data of the aircraft

91
00:04:02.595 --> 00:04:05.405
with the same offline simulation that we created

92
00:04:05.905 --> 00:04:07.085
for the pre-flight briefing.

93
00:04:07.345 --> 00:04:09.605
And we stream that in sync with the mission.

94
00:04:09.985 --> 00:04:12.565
We know that from the takeoff moment, every part

95
00:04:12.565 --> 00:04:14.085
of the mission is already known.

96
00:04:14.545 --> 00:04:18.165
So we can still stream, uh, those simulations together

97
00:04:18.165 --> 00:04:20.685
with the flight, but we can also use the same models

98
00:04:21.445 --> 00:04:23.045
together with, uh, real data.

99
00:04:23.385 --> 00:04:26.605
And therefore we add also real time simulations in which the

100
00:04:26.605 --> 00:04:29.805
same model we were fed with real data from the aircraft.

101
00:04:30.505 --> 00:04:33.605
And those mix of things of line simulation,

102
00:04:33.835 --> 00:04:34.965
real time simulation

103
00:04:35.185 --> 00:04:37.325
and flight data can be used together

104
00:04:37.385 --> 00:04:40.725
to create an interesting mix of deviation alerts

105
00:04:40.725 --> 00:04:43.365
that helps the flight test team in the decision making

106
00:04:43.365 --> 00:04:45.045
process during the test.

107
00:04:45.465 --> 00:04:48.325
And finally, we use them also afterwards, after the flight

108
00:04:48.715 --> 00:04:53.045

because, uh, knowing a priority, the simulation behavior

109
00:04:53.065 --> 00:04:56.765
of the aircraft and being able to compare it together

110
00:04:56.795 --> 00:04:59.685
with the flight, uh, results, uh, allow us

111
00:04:59.825 --> 00:05:02.165
to clear the flight, uh, in a quick way.

112
00:05:02.265 --> 00:05:05.245
If the aircraft bas in reality as in the simulation

113
00:05:05.465 --> 00:05:08.405
and that time before the flight to understand

114
00:05:08.405 --> 00:05:09.525
what the simulation was

115
00:05:09.705 --> 00:05:12.045
and decide that it was a correct behavior,

116
00:05:12.315 --> 00:05:15.005
then I can safely move quickly to the next test point.

117
00:05:16.645 --> 00:05:17.905
And now I will leave the stage

118
00:05:17.925 --> 00:05:19.545
to Lorenzo for the implementation.

119
00:05:20.155 --> 00:05:25.025
Thank you, Nicola. So this solution can be called, uh,

120
00:05:25.275 --> 00:05:27.985
simulation based monitoring and alerting system,

121
00:05:28.405 --> 00:05:30.985
but, uh, um, this is how we implement it.

122
00:05:30.985 --> 00:05:35.145
Essentially in the flight test process, we take a step back

123
00:05:35.325 --> 00:05:37.785
to the before the flight, what happens.

124
00:05:38.565 --> 00:05:40.025
So given flight plan

125
00:05:40.205 --> 00:05:43.825
and assumed initial conditions, we simulate the mission

126
00:05:43.855 --> 00:05:45.305
through our digital twin,

127
00:05:45.895 --> 00:05:50.345
then give us simulation results on attitude control loads,

128
00:05:50.345 --> 00:05:54.665
powertrain parameters, everything that can be used to

129
00:05:55.405 --> 00:05:57.805
not only give the clearance for the test,

130
00:05:58.305 --> 00:06:00.925
but also to define mission limitations.

131
00:06:01.345 --> 00:06:02.925
And we will get back to this later.

132
00:06:04.455 --> 00:06:08.755
So moving to the during phase, uh, during flight phase, uh,

133
00:06:08.935 --> 00:06:11.715
we started from a more traditional telemetry data

134
00:06:11.715 --> 00:06:12.955
visualization system,

135
00:06:13.495 --> 00:06:17.915

and we added a simulation layer, which was composed by

136
00:06:18.425 --> 00:06:19.595
offline simulations

137
00:06:19.745 --> 00:06:22.515
that are nothing more than the simulation results than

138
00:06:22.515 --> 00:06:25.675
before the flight that were streamed in

139
00:06:25.745 --> 00:06:26.795
sync with the mission.

140
00:06:27.655 --> 00:06:32.155
And then real time simulation, which are models

141
00:06:32.735 --> 00:06:34.555
fed by live telemetry data

142
00:06:34.945 --> 00:06:37.595
that simulates the nominal behavior

143
00:06:37.895 --> 00:06:39.675
of some systems components.

144
00:06:40.975 --> 00:06:45.435
Now all of this data need to be processed and synthesized.

145
00:06:45.695 --> 00:06:50.275
And for this, we use it tailor the human machine interface

146
00:06:51.845 --> 00:06:54.255
that maybe you had a grasp on, uh,

147
00:06:54.315 --> 00:06:56.615
during the visiting BP early telemetry room.

148
00:06:57.595 --> 00:07:01.575
So the final goal was to enhance situational awareness

149
00:07:02.665 --> 00:07:04.005
to ensure flight safety.

150
00:07:05.505 --> 00:07:09.245
So now we will have a first overview of how

151
00:07:09.265 --> 00:07:10.365
of flying simulation

152
00:07:10.385 --> 00:07:13.485
and real time simulation were implemented, so

153
00:07:13.485 --> 00:07:16.405
that if any one of you never saw this,

154
00:07:16.505 --> 00:07:19.365
but I, I pretty sure that you did.

155
00:07:19.385 --> 00:07:24.245
But I struggled to find, um, some guidelines in this, uh,

156
00:07:24.265 --> 00:07:26.965
as a publicly available data.

157
00:07:27.105 --> 00:07:30.485
So if anyone you wants to replicate this, a grasp of

158
00:07:30.505 --> 00:07:31.725
how you could do it,

159
00:07:32.545 --> 00:07:36.645
and then we will delve more into the human machine interface

160
00:07:36.735 --> 00:07:37.765
operations side.

161
00:07:39.965 --> 00:07:43.945
So most of telemetry softwares

162
00:07:44.465 --> 00:07:46.545

nowadays allow you, uh, to

163
00:07:47.685 --> 00:07:51.905
script your own code that interfaces with time channels.

164
00:07:52.445 --> 00:07:55.545
And this is what we use for offline simulation module.

165
00:07:56.165 --> 00:07:59.505
So there's nothing more that get a CS V file

166
00:07:59.505 --> 00:08:03.555
with simulation results, located memory for quick access,

167
00:08:03.775 --> 00:08:05.035
but then parses

168
00:08:05.035 --> 00:08:07.475
and stream streams, the results out

169
00:08:08.845 --> 00:08:11.705
as simulation, uh, telemetry channels.

170
00:08:11.925 --> 00:08:16.405
We have simulation channels, so the results stream sync

171
00:08:16.665 --> 00:08:18.165
and prediction channels,

172
00:08:18.165 --> 00:08:19.885
which are nothing more than the same data,

173
00:08:20.025 --> 00:08:23.565
but with an anticipation of site five seconds, for example.

174
00:08:24.565 --> 00:08:28.265
And of course, there's in the script an automatic start

175
00:08:28.355 --> 00:08:31.825
triggering logic to ensure this sync with the mission.

176
00:08:34.075 --> 00:08:38.845
Real time simulation, um, has a different building method.

177
00:08:39.465 --> 00:08:43.725
So we start from the digital twin models where we select

178
00:08:43.825 --> 00:08:47.325
and isolate, uh, the specific models

179
00:08:47.355 --> 00:08:48.885
that we are more interested in.

180
00:08:50.025 --> 00:08:51.805
We did some discretization

181
00:08:51.825 --> 00:08:53.365
and numerical stability assessment

182
00:08:53.435 --> 00:08:56.765
because, uh, we wanted them to be compatible

183
00:08:56.915 --> 00:08:58.125
with code generation.

184
00:08:58.835 --> 00:09:02.325
This is what allows us to deploy this code

185
00:09:02.385 --> 00:09:06.035
inside the telemetry software with its own execution,

186
00:09:06.035 --> 00:09:07.275
logic, and control script.

187
00:09:09.005 --> 00:09:10.865
Now, a really convenient characteristic

188
00:09:11.805 --> 00:09:13.305
of this real-time simulation

189
00:09:13.305 --> 00:09:16.545

that they don't require the same amount of maintenance

190
00:09:16.545 --> 00:09:17.585
as a flying simulation.

191
00:09:17.655 --> 00:09:20.625
That means that at every flight you don't need

192
00:09:20.625 --> 00:09:22.745
to load the new data load, okay?

193
00:09:23.325 --> 00:09:27.845
But unless you need to update the models,

194
00:09:28.395 --> 00:09:29.485
they're just ready to go.

195
00:09:30.385 --> 00:09:32.005
Now, in case you need,

196
00:09:32.065 --> 00:09:33.845
you actually do need to update the models.

197
00:09:35.015 --> 00:09:36.195
Uh, there's a fast way.

198
00:09:37.125 --> 00:09:39.355
There are settings in place, user settings

199
00:09:39.355 --> 00:09:42.675
where we can tune the models with characteristic parameters,

200
00:09:43.375 --> 00:09:47.995
or of course you can go back from the first uh,

201
00:09:48.465 --> 00:09:51.115
step and do all the process all over again.

202
00:09:54.165 --> 00:09:59.065
Now we delve into the most crucial part, the HMI, how

203
00:09:59.065 --> 00:10:00.465
to process, synthesize

204
00:10:00.565 --> 00:10:02.505
and present that to the crew during a test,

205
00:10:03.525 --> 00:10:07.265
but also understand the meaning of what we are seeing.

206
00:10:08.395 --> 00:10:10.855
So we start from the mission limitations.

207
00:10:11.635 --> 00:10:14.415
Uh, we set the simulated flight envelope for the mission.

208
00:10:14.955 --> 00:10:17.975
So we take these boundaries, we apply a little slack,

209
00:10:18.075 --> 00:10:21.255
and there you have the mission limitations together

210
00:10:21.285 --> 00:10:22.535
with the design limits

211
00:10:23.415 --> 00:10:25.515
as fixed limits on the basic indicator,

212
00:10:27.725 --> 00:10:31.385
the augmented version, essentially overlays

213
00:10:32.045 --> 00:10:35.625
of flight simulation indicators representing expected value

214
00:10:35.725 --> 00:10:38.705
at current time according to simulation results

215
00:10:38.765 --> 00:10:42.935
before the flight, real time simulations indicators

216
00:10:43.735 --> 00:10:47.815

representing the computed value at current time according

217
00:10:47.995 --> 00:10:50.175
to the model fed by telemetry data.

218
00:10:50.915 --> 00:10:54.255
And then we have offline prediction expected value

219
00:10:54.845 --> 00:10:56.215
with an anticipated time.

220
00:10:57.715 --> 00:11:00.335
Now, let's put this indicator for one moment aside

221
00:11:00.875 --> 00:11:05.735
and let's focus on a, just a general, uh, monitor parameter.

222
00:11:05.735 --> 00:11:08.455
Okay? We can see the evolution of this on a graph

223
00:11:08.885 --> 00:11:10.335
with its limitation.

224
00:11:10.715 --> 00:11:15.465
Uh, just mentioned. Now exceeding mission

225
00:11:15.735 --> 00:11:18.515
limitations presented like this

226
00:11:20.715 --> 00:11:22.925
implies for this flight test campaign,

227
00:11:23.275 --> 00:11:25.485
seizing test point and land.

228
00:11:26.225 --> 00:11:28.405
And this is a big difference with respect

229
00:11:28.405 --> 00:11:30.405
to traditional pilot in the loop.

230
00:11:30.535 --> 00:11:31.565
Knock it off response,

231
00:11:31.575 --> 00:11:34.085
which is just stop doing what you're doing.

232
00:11:35.265 --> 00:11:37.885
The this response in this case keeps

233
00:11:39.095 --> 00:11:43.035
stressing the aircraft and requires time, takes time.

234
00:11:43.815 --> 00:11:47.955
So this is why taking action here at this point may be too

235
00:11:47.955 --> 00:11:51.915
late to safety land without exceeding design limitations.

236
00:11:57.245 --> 00:12:00.265
So this is why we have offline simulation.

237
00:12:00.735 --> 00:12:03.225
This is the expected behavior for

238
00:12:03.225 --> 00:12:04.945
that gen monitor parameter.

239
00:12:06.325 --> 00:12:08.185
We set deviation threshold

240
00:12:08.685 --> 00:12:12.665
and as soon as we deviate from it, we get alert

241
00:12:12.895 --> 00:12:15.345
with this ember out outline box.

242
00:12:21.485 --> 00:12:24.185
Taking action here may be early enough

243
00:12:24.185 --> 00:12:26.545

to safely land without exceeding the sun limitations.

244
00:12:27.965 --> 00:12:32.345
And take note that this can be done just with the simple

245
00:12:32.405 --> 00:12:34.065
of flying simulation capability.

246
00:12:34.065 --> 00:12:37.265
There's no need for real time code generation, all the stuff

247
00:12:37.775 --> 00:12:39.665
this is achieved just by a simple script.

248
00:12:42.835 --> 00:12:45.175
Now of flight simulation deviation, of course,

249
00:12:45.245 --> 00:12:48.335
does not strictly mean aircraft is not behaving nominally.

250
00:12:48.555 --> 00:12:51.335
And that is why we implemented also the realtime simulation.

251
00:12:53.115 --> 00:12:56.135
If the realtime simulation matches measure data,

252
00:12:56.515 --> 00:12:59.935
as we can see here, there's the blue indicator just just

253
00:13:00.455 --> 00:13:02.335
matching the green level bar.

254
00:13:02.645 --> 00:13:07.395
Okay, they are matching then monitor parameter is likely

255
00:13:07.505 --> 00:13:09.075
nominal given the rare condition.

256
00:13:09.455 --> 00:13:12.115
And this deviation could led

257
00:13:12.135 --> 00:13:15.155
by errors in assumption in initial condition

258
00:13:15.695 --> 00:13:17.755
during the pre-flight simulation

259
00:13:18.375 --> 00:13:21.715
or error in assumption on the environmental condition,

260
00:13:21.775 --> 00:13:23.235
the real environment condition.

261
00:13:26.275 --> 00:13:29.565
When we do deviate from real time simulation, well,

262
00:13:29.565 --> 00:13:31.605
depending on the fidelity of the models, of course

263
00:13:32.235 --> 00:13:35.285
that could mean that anomaly or failure occurred.

264
00:13:38.265 --> 00:13:42.005
Now taking a look, for example, it's uh, like a version

265
00:13:42.105 --> 00:13:44.685
of some time ago of the test director in flight test

266
00:13:44.885 --> 00:13:46.725
engineer dashboard inside the telemetry room.

267
00:13:47.385 --> 00:13:52.005
Um, we can see that of course they can have a lot

268
00:13:52.005 --> 00:13:55.645
of parameters and they can have an overview on attitude,

269
00:13:55.655 --> 00:13:59.325
navigation, engine, RPMs, uh, system parameters,

270
00:13:59.425 --> 00:14:02.165

but they want to focus the attention only on

271
00:14:02.235 --> 00:14:04.005
this single panel.

272
00:14:04.845 --> 00:14:06.885
'cause here we have 32 parameters

273
00:14:07.115 --> 00:14:09.245
that can be monitored just with few indicators.

274
00:14:10.515 --> 00:14:13.165
This is achieved showing only the worst component data

275
00:14:13.915 --> 00:14:16.685
reporting below the component ID

276
00:14:18.715 --> 00:14:22.285
because the crew is automatically alerted when unexpected

277
00:14:22.645 --> 00:14:25.205
behavior is detected with December at line

278
00:14:25.225 --> 00:14:26.365
box, as you can see here.

279
00:14:29.825 --> 00:14:32.565
So how it went during the campaign,

280
00:14:32.565 --> 00:14:36.285
because it's interesting stuff, but practically how it was.

281
00:14:36.705 --> 00:14:39.245
So here are some lesson learned that we want to share.

282
00:14:39.295 --> 00:14:41.085
After the first polite campaign

283
00:14:41.345 --> 00:14:44.805
and the whole NOVA V one campaign, uh, the solution

284
00:14:44.805 --> 00:14:46.445
that we implemented proved to be effective.

285
00:14:46.905 --> 00:14:49.205
Uh, we compare the simulation reality

286
00:14:49.385 --> 00:14:52.285
and this allowed us to understand the behavior

287
00:14:52.385 --> 00:14:53.885
of the aircraft during the test point.

288
00:14:54.585 --> 00:14:58.245
Uh, we compared different type of simulation offline

289
00:14:58.545 --> 00:15:02.645
and real time, and this allowed us to, uh, have a faster

290
00:15:02.865 --> 00:15:04.525
and quick post flight analysis.

291
00:15:04.785 --> 00:15:07.045
So we were able to move in a quick way

292
00:15:07.075 --> 00:15:08.965
between a test point and the other one.

293
00:15:09.345 --> 00:15:11.325
And for us moving between at test point.

294
00:15:11.325 --> 00:15:13.485
And the other one means giving the endurance

295
00:15:13.485 --> 00:15:16.205
of the aircraft moving one, one flight to the other,

296
00:15:16.225 --> 00:15:19.485
one being an electric aircraft in that part of the campaign.

297
00:15:19.875 --> 00:15:23.405

Therefore, being able to move faster, uh, is important.

298
00:15:24.145 --> 00:15:26.725
And uh, also we compare the real time

299
00:15:27.145 --> 00:15:28.525
and offline simulations.

300
00:15:28.825 --> 00:15:31.645
And these, uh, gave us a lot of insights on,

301
00:15:31.645 --> 00:15:32.685
uh, what was going on.

302
00:15:32.945 --> 00:15:35.845
And I will share you with you an example here.

303
00:15:36.025 --> 00:15:38.565
Uh, we are looking at the voltage batteries of the aircraft.

304
00:15:39.105 --> 00:15:40.685
And, uh, in certain situations,

305
00:15:40.685 --> 00:15:42.285
having both the offline simulation

306
00:15:42.285 --> 00:15:46.085
and the real time one allowed us to understand better

307
00:15:46.085 --> 00:15:47.125
what was going on.

308
00:15:47.235 --> 00:15:50.285
Because, for example, during certain test points, we had

309
00:15:50.285 --> 00:15:53.125
to troubleshoot with the aircraft outside under the sun.

310
00:15:53.505 --> 00:15:54.885
So the initial temperature

311
00:15:54.885 --> 00:15:57.645
of the batteries were way different from the one

312
00:15:57.645 --> 00:16:00.405
that we had in the briefing, uh, simulation.

313
00:16:00.405 --> 00:16:03.445
So the offline, but the real time simulation were

314
00:16:03.445 --> 00:16:04.885
following real data.

315
00:16:05.105 --> 00:16:08.325
So they were, the initial condition were fed with, uh,

316
00:16:08.325 --> 00:16:10.645
real values, and we were able to track

317
00:16:10.665 --> 00:16:12.565
and monitor the behavior of the batteries

318
00:16:12.565 --> 00:16:15.165
during the test point, uh, understanding

319
00:16:15.165 --> 00:16:18.765
that the offline simulation were out of, uh, their, uh,

320
00:16:18.765 --> 00:16:20.325
reality because there was an

321
00:16:20.325 --> 00:16:21.645
offsetting the initial condition.

322
00:16:21.995 --> 00:16:25.965
Another example in which this would be proved helpful is in

323
00:16:25.965 --> 00:16:27.125
the attitude of the aircraft.

324
00:16:27.545 --> 00:16:29.085

As Lawrence explained, uh,

325
00:16:29.345 --> 00:16:33.045
we focused the real time simulations only on certain systems

326
00:16:33.825 --> 00:16:38.205
and, uh, uh, we didn't simulate real time, uh, the attitude

327
00:16:38.205 --> 00:16:40.645
of the aircraft and this flight dynamics parameters.

328
00:16:40.985 --> 00:16:44.285
And for example, during one test point, we were observing,

329
00:16:44.665 --> 00:16:48.125
uh, in over condition, uh, roll movement from the aircraft.

330
00:16:48.385 --> 00:16:50.485
And the offline simulation was of course telling

331
00:16:51.025 --> 00:16:53.045
for an over test condition with no wind,

332
00:16:53.345 --> 00:16:55.485
you do expect zero roll angle.

333
00:16:55.705 --> 00:16:58.565
And we were observing our roll angle that was due to, uh,

334
00:16:58.915 --> 00:17:00.285
gust coming from the side.

335
00:17:00.425 --> 00:17:02.045
The aircraft was correctly reacting

336
00:17:02.045 --> 00:17:03.085
to maintain the position,

337
00:17:03.425 --> 00:17:05.685
but in telemetry room, we had no indication

338
00:17:05.685 --> 00:17:07.085
of the wind coming in.

339
00:17:07.425 --> 00:17:09.685
And, uh, with only the offline simulation, we needed

340
00:17:09.685 --> 00:17:12.485
to stop the test to understand and investigate his behavior.

341
00:17:12.795 --> 00:17:14.885
That was, uh, not due to the aircraft behavior,

342
00:17:14.945 --> 00:17:17.365
but due to a response to an natural effect.

343
00:17:19.865 --> 00:17:23.245
And also we use the, uh, all the data collected, uh,

344
00:17:23.245 --> 00:17:25.005
to expand the validity of the models

345
00:17:25.005 --> 00:17:29.085
because if you, uh, put so much faith in your models,

346
00:17:29.425 --> 00:17:31.805
you need to start from a domain of validity,

347
00:17:31.805 --> 00:17:32.925
which they've been validated.

348
00:17:33.425 --> 00:17:36.605
We started from, uh, models validated using ground test.

349
00:17:37.025 --> 00:17:40.805
And then as, uh, the campaign progressed, we went through,

350
00:17:40.945 --> 00:17:43.885
uh, updates of the model comparing reality with

351
00:17:44.155 --> 00:17:46.325

what we were able to achieve in simulation.

352
00:17:47.185 --> 00:17:50.365
Uh, not everything was, uh, uh, correct

353
00:17:50.585 --> 00:17:51.765
and was, uh, perfect.

354
00:17:52.345 --> 00:17:55.245
For example, we discovered that the HMI of this system

355
00:17:55.245 --> 00:17:57.245
that Lorenzo presented, uh,

356
00:17:57.395 --> 00:17:59.045
must be simplified in certain cases.

357
00:17:59.545 --> 00:18:01.005
He showed an example for the,

358
00:18:01.075 --> 00:18:03.245
from the test director and FTE dashboard.

359
00:18:03.545 --> 00:18:06.045
And there we synthesized, uh,

360
00:18:06.145 --> 00:18:07.885
all the parameters of the powertrain.

361
00:18:07.905 --> 00:18:10.685
So eight batteries and motors in two simple indicators.

362
00:18:11.105 --> 00:18:12.925
But for example, the battery

363
00:18:12.985 --> 00:18:15.885
and VTU expert are looking at all the parameters.

364
00:18:15.885 --> 00:18:19.165
So an interface like this one may be too crowded for them.

365
00:18:19.385 --> 00:18:22.205
So instead of, uh, solving a problem of too many data

366
00:18:22.205 --> 00:18:25.285
to be monitored, we are adding an additional level of, uh,

367
00:18:25.425 --> 00:18:27.325
an additional layer of data,

368
00:18:27.665 --> 00:18:30.045
and they are not able to maintain this

369
00:18:30.045 --> 00:18:32.045
and analyze what they're seeing live

370
00:18:32.825 --> 00:18:36.605
and also can help solving this problem, an automatic system

371
00:18:36.835 --> 00:18:38.685
that, uh, synthesize all those data

372
00:18:38.945 --> 00:18:42.125
and simply show, uh, to, uh, whoever is in front

373
00:18:42.125 --> 00:18:43.725
of the station, uh,

374
00:18:43.835 --> 00:18:46.765
only the deviation from the parameters without the need

375
00:18:46.765 --> 00:18:49.365
of monitoring all the data, all the deviations.

376
00:18:49.515 --> 00:18:51.645
Because for example, for eight batteries,

377
00:18:51.645 --> 00:18:54.845
you have eight temperatures, eight voltages, eight uh,

378
00:18:55.085 --> 00:18:57.925

currents, and then you have the related simulation,

379
00:18:58.025 --> 00:18:59.925
the deviation, and also on.

380
00:18:59.925 --> 00:19:01.205
So a lot of parameters.

381
00:19:01.205 --> 00:19:03.085
We need something that synthesize

382
00:19:03.625 --> 00:19:05.405
and, uh, provide a custom message

383
00:19:05.505 --> 00:19:07.125
to the expert monitoring the system.

384
00:19:07.825 --> 00:19:10.645
And also all this framework is useful,

385
00:19:10.905 --> 00:19:13.885
but maybe, uh, problematic to be maintained under pressure

386
00:19:13.915 --> 00:19:15.085
because you need, uh,

387
00:19:15.465 --> 00:19:17.605
to prepare the simul flying simulations.

388
00:19:17.785 --> 00:19:20.325
And we usually do that to clear the mission

389
00:19:20.325 --> 00:19:21.965
during the briefing, but you need

390
00:19:21.965 --> 00:19:25.205
to upload those simulations in the telemetry stations.

391
00:19:25.465 --> 00:19:28.085
And it, it happened during a fast pace moment

392
00:19:28.105 --> 00:19:31.245
of the campaign that, for example, we had a flight

393
00:19:31.315 --> 00:19:32.925
with a wrong offline simulation

394
00:19:32.925 --> 00:19:34.565
because we were not able to update them

395
00:19:34.985 --> 00:19:37.605
and no one spotted it until we started the flight

396
00:19:37.865 --> 00:19:41.685
and we dis we monitored the, uh, real time simulation

397
00:19:41.685 --> 00:19:42.885
that we're showing correct data.

398
00:19:43.145 --> 00:19:46.965
So having both systems proved to be, uh, effective in.

399
00:19:46.965 --> 00:19:49.245
So also, uh, situation like this

400
00:19:51.875 --> 00:19:55.295
before concluding, uh, some ideas for improvement that, uh,

401
00:19:55.595 --> 00:19:59.375
we collected after using it for, uh, uh, the test campaign

402
00:19:59.575 --> 00:20:02.135
of the forced aircraft, uh, we need

403
00:20:02.135 --> 00:20:05.695
to extend the realtime simulation framework, not only

404
00:20:05.755 --> 00:20:07.495
to certain systems of the aircraft

405
00:20:07.495 --> 00:20:09.935

that were critical in the first part of the campaign,

406
00:20:10.155 --> 00:20:12.095
but also to the wool aircraft dynamics

407
00:20:12.095 --> 00:20:14.015
and aerodynamics more now that

408
00:20:14.555 --> 00:20:18.335
we are approaching the transition part of the campaign, and

409
00:20:18.335 --> 00:20:19.695
therefore there we will need

410
00:20:19.695 --> 00:20:21.655
to focus more on the aerodynamic part.

411
00:20:22.445 --> 00:20:24.935
Also, we need to improve the telemetry SMI

412
00:20:24.955 --> 00:20:27.295
for complex systems and, uh, uh,

413
00:20:27.295 --> 00:20:29.415
fast dynamics changing, uh, uh, systems.

414
00:20:30.205 --> 00:20:32.335
Also, the existing cast messages system

415
00:20:32.335 --> 00:20:34.975
that we used in the telemetry stations must be

416
00:20:35.215 --> 00:20:36.455
improved as mentioned before.

417
00:20:37.075 --> 00:20:39.375
And also we are considering instead of, uh, uh,

418
00:20:39.615 --> 00:20:42.735
starting from, uh, the simul model code, generating the code

419
00:20:42.915 --> 00:20:44.935
and implementing it in the simul in, uh,

420
00:20:44.955 --> 00:20:46.615
the telemetry stations to

421
00:20:47.125 --> 00:20:48.765
directly connect the simul model together

422
00:20:48.835 --> 00:20:51.685
with the telemetry stations to have an easier way

423
00:20:51.685 --> 00:20:53.085
to access the simulation model

424
00:20:53.425 --> 00:20:55.205
and follow the updates that engineering

425
00:20:55.205 --> 00:20:56.405
provide to those models.

426
00:20:58.755 --> 00:21:00.535
Uh, thanks for attending us

427
00:21:00.675 --> 00:21:02.495
and if you have any questions, we are here,

428
00:21:20.955 --> 00:21:21.955
Ted. Thank you. Uh,

429
00:21:21.955 --> 00:21:22.395
okay.

430
00:21:22.545 --> 00:21:23.835
From your presentation, you understood

431
00:21:23.835 --> 00:21:25.475
that you applied the method to the sub

432
00:21:25.895 --> 00:21:27.435

to only two subsystems. Uh,

433
00:21:28.175 --> 00:21:29.275
You not correct.

434
00:21:29.745 --> 00:21:32.435
Okay. But have you tuned the model some way

435
00:21:32.815 --> 00:21:35.555
before using it in, uh, during the flight testing?

436
00:21:36.705 --> 00:21:38.195
Because it,

437
00:21:38.335 --> 00:21:41.595
the model can highlight false positive in this case,

438
00:21:41.775 --> 00:21:44.675
you abor the flight testing, but also false negative,

439
00:21:45.015 --> 00:21:48.115
and in this case you can under evaluate the risk.

440
00:21:48.425 --> 00:21:52.115
Yeah, exactly. First, uh, we used the, the rule model

441
00:21:52.415 --> 00:21:53.675
for offline simulation.

442
00:21:53.815 --> 00:21:56.595
We were able to produce parameters of everything.

443
00:21:56.655 --> 00:21:58.915
So also the altitude, the position, and so on.

444
00:21:59.335 --> 00:22:02.195
And we used the realtime simulations only of the systems.

445
00:22:02.775 --> 00:22:04.635
So we add both layers.

446
00:22:05.655 --> 00:22:09.915
And the second part, of course, you, if you trust the model,

447
00:22:10.175 --> 00:22:11.235
you need to validate it,

448
00:22:11.235 --> 00:22:13.475
otherwise you are putting your faith in something

449
00:22:13.475 --> 00:22:15.235
that is not related to reality.

450
00:22:15.815 --> 00:22:18.555
And therefore, we based our domain

451
00:22:18.555 --> 00:22:21.395
of validity on the ground test campaign that we used.

452
00:22:21.935 --> 00:22:23.675
And on the design phase of the aircraft,

453
00:22:23.975 --> 00:22:26.715
we validated those models during the ground test campaign.

454
00:22:27.015 --> 00:22:29.715
And as soon as the campaign progressed, test by test,

455
00:22:29.855 --> 00:22:31.115
we validated the model.

456
00:22:31.375 --> 00:22:33.755
And in case of any discrepancy between reality

457
00:22:33.755 --> 00:22:35.515
and the models, we stopped testing

458
00:22:35.895 --> 00:22:38.115
and we checked if the model was wrong,

459
00:22:38.175 --> 00:22:41.715

or reality was for any reason, for example, like, uh,

460
00:22:41.735 --> 00:22:43.555
the over test with a side window

461
00:22:43.665 --> 00:22:45.275
different for those reasons.

462
00:22:45.975 --> 00:22:48.915
So it's a circle. Yeah. Yeah, it's a loop.

463
00:22:48.915 --> 00:22:51.355
And as soon as you test, you expand the validity

464
00:22:51.355 --> 00:22:53.195
of the domain of your models.

465
00:22:53.705 --> 00:22:54.835
Okay, welcome.

466
00:22:55.895 --> 00:22:58.755
If, if I can add also something, of course,

467
00:22:58.825 --> 00:23:00.475
this was something

468
00:23:00.475 --> 00:23:03.355
that we didn't explicitly in the presentation,

469
00:23:03.375 --> 00:23:05.475
but it's really important to stress this point,

470
00:23:05.975 --> 00:23:09.755
but also the reason why we choose to have this kind

471
00:23:09.755 --> 00:23:10.835
of trust is

472
00:23:10.835 --> 00:23:14.885
because with this kind of aircraft, there's no human that is

473
00:23:15.435 --> 00:23:19.285
able to look at the data, all this data

474
00:23:20.345 --> 00:23:23.755
and see yeah, say, okay, you know, it's normal,

475
00:23:23.985 --> 00:23:25.155
it's fine, we can continue.

476
00:23:26.095 --> 00:23:30.195
We are in a, in a, in a situation in which, uh,

477
00:23:30.815 --> 00:23:33.675
the best guesser of the, of, uh, an expected

478
00:23:33.775 --> 00:23:37.435
or nominal behavior for this, uh, machine is,

479
00:23:37.535 --> 00:23:40.275
are the models, which are the same ones that were used

480
00:23:40.275 --> 00:23:45.035
to design this same, uh, uh, aircraft used to, uh,

481
00:23:46.085 --> 00:23:48.765
validate, uh, during the ground test all the, that phase.

482
00:23:49.145 --> 00:23:52.325
So of course it's not, uh, the, the best solution,

483
00:23:52.325 --> 00:23:56.045
but it's, it's, uh, the best, uh, we could get.

484
00:23:59.775 --> 00:24:02.305
There's no other question I would have as mo a quick one.

485
00:24:02.645 --> 00:24:04.705
Um, oh yes. Actually,

486
00:24:07.075 --> 00:24:08.075

Quick question.

487
00:24:08.585 --> 00:24:12.865
I think that, uh, this computation introduce a delay between

488
00:24:13.135 --> 00:24:16.385
what is, uh, happening in the real world

489
00:24:16.385 --> 00:24:19.665
and what you, the time that you see in, uh, in control room.

490
00:24:20.205 --> 00:24:23.305
So do you experience this delay and have you manage it?

491
00:24:24.435 --> 00:24:27.125
It's microseconds, it's the way we take,

492
00:24:27.675 --> 00:24:32.645
it's a CC plus plus code, which is pretty fast, easy to,

493
00:24:33.225 --> 00:24:37.165
uh, you know, it's much lower level, uh, coding language.

494
00:24:37.265 --> 00:24:39.765
So, uh, it's much faster, for example,

495
00:24:40.115 --> 00:24:41.525
than Python, for example.

496
00:24:42.145 --> 00:24:44.165
Um, so for this reason, the delay,

497
00:24:44.215 --> 00:24:45.485
there is a delay of course.

498
00:24:45.985 --> 00:24:50.805
Um, but it's so, so short that even the,

499
00:24:51.665 --> 00:24:55.085
the, the frame per second of your display is, uh,

500
00:24:55.785 --> 00:24:57.045
is uh, is lower than that.

501
00:24:57.145 --> 00:24:58.805
So there is, of course you have the,

502
00:24:59.225 --> 00:25:00.805
the legal aid. But yeah, I

503
00:25:00.805 --> 00:25:02.285
Think that the computational time

504
00:25:02.865 --> 00:25:05.085
is faster than my eye looking at the display.

505
00:25:05.085 --> 00:25:06.605
Yeah. So you're not seeing that.

506
00:25:12.625 --> 00:25:13.115
Alright.