WEBVTT

1
00:00:06.385 --> 00:00:09.485
So, so that was a very shameless plug I did right now

2
00:00:10.025 --> 00:00:11.885
as a consultant flight test engineer,

3
00:00:11.995 --> 00:00:16.445
because I have history on the airplanes he's worked on.

4
00:00:16.825 --> 00:00:18.005
I'm pretty darn sure.

5
00:00:19.235 --> 00:00:23.415
And that's the benefit of coming to these, uh, workshops.

6
00:00:23.515 --> 00:00:26.535
You'll make a connection with somebody who might be able

7
00:00:26.535 --> 00:00:31.515
to tell you, oh, your stall angle of attack is X or Y or Z.

8
00:00:32.965 --> 00:00:36.065
And I'm really, really pleased to see Aerotech coming

9
00:00:36.085 --> 00:00:39.865
to more and more of these, uh, of Flight to Safety workshop,

10
00:00:40.105 --> 00:00:44.265
SETP and SFTE, where we're sharing some lessons learned.

11
00:00:44.485 --> 00:00:47.925
And without actually giving me any money,

12
00:00:48.025 --> 00:00:49.845
you might get some information

13
00:00:50.465 --> 00:00:53.965
and you share lessons learned, and we keep each other safe.

14
00:00:55.255 --> 00:00:57.715
On that note, I'm gonna switch up to our next presenters,

15
00:00:58.255 --> 00:01:02.195
and I've been trying to tease a thread out of each of our,

16
00:01:02.415 --> 00:01:04.195
uh, presenters on, you know, something

17
00:01:04.195 --> 00:01:05.195
that's not in their bio.

18
00:01:05.935 --> 00:01:08.675
And a lot of you, people are gonna ask you,

19
00:01:08.675 --> 00:01:10.195
what's the best airplane you ever flew?

20
00:01:10.965 --> 00:01:12.425
And out of these two gentlemen, I said,

21
00:01:12.425 --> 00:01:13.985
what's the worst airplane you ever flew?

22
00:01:15.195 --> 00:01:19.215
And, uh, uh, Colonel Kevin Hall, uh,

23
00:01:19.215 --> 00:01:22.575
from the Air Force said the worst thing he ever had was a

24
00:01:22.575 --> 00:01:26.945
stove F 35, where the, the, the door was failed full open.

25
00:01:27.705 --> 00:01:29.105
I bet that was an exciting ride.

26
00:01:29.405 --> 00:01:31.665
Um, and I've had one or two like that.

27
00:01:32.165 --> 00:01:35.705

And James Les, Jim Les from nasa, who's done a lot

28
00:01:35.705 --> 00:01:37.225
of other stuff, both of these guys,

29
00:01:37.225 --> 00:01:38.545
when I asked them, what are your hobbies?

30
00:01:38.565 --> 00:01:41.865
And they said, work. But Jim said the worst airplane

31
00:01:41.865 --> 00:01:42.905
he ever flew was the MQ.

32
00:01:42.905 --> 00:01:46.305
Nine Gentlemen. Stage is yours.

33
00:01:58.445 --> 00:02:00.665
Hey, thank you. Uh, good morning Sonar.

34
00:02:00.825 --> 00:02:03.585
And I are, uh, very pleased to be able to present, uh,

35
00:02:04.485 --> 00:02:05.905
to the, uh, workshop today.

36
00:02:06.205 --> 00:02:08.225
Um, the Pilot Breathing Assessment project

37
00:02:08.375 --> 00:02:10.705
that we've been working on for about the last year.

38
00:02:13.615 --> 00:02:15.335
I think most of you have seen the headlines

39
00:02:15.565 --> 00:02:16.575
over the last 10 years.

40
00:02:16.595 --> 00:02:19.255
The military has had a significant amount of problems with,

41
00:02:19.795 --> 00:02:23.775
uh, oxygen in their fighter aircraft and trainer aircraft.

42
00:02:24.075 --> 00:02:27.335
It gets, uh, national attention when the vice president's

43
00:02:27.355 --> 00:02:28.815
son can't start pilot training

44
00:02:28.815 --> 00:02:30.895
because the, the fleet is grounded.

45
00:02:33.075 --> 00:02:36.985
So this problem is affecting just about all the frontline

46
00:02:37.145 --> 00:02:39.745
fighters and trainers that the, uh, military is flying.

47
00:02:40.205 --> 00:02:41.265
And I think at one point

48
00:02:41.265 --> 00:02:44.025
or another, each of these aircraft here have been grounded

49
00:02:44.605 --> 00:02:47.105
for at least a brief period while they looked at the

50
00:02:47.125 --> 00:02:48.465
oxygen problems they were having.

51
00:02:49.485 --> 00:02:51.865
The common denominator is OGs.

52
00:02:52.005 --> 00:02:53.665
Uh, for those that aren't familiar with that,

53
00:02:53.665 --> 00:02:55.785
it's the onboard oxygen generation system.

54
00:02:55.885 --> 00:02:59.525

It takes oxygen out of the air instead of using a bottle

55
00:02:59.745 --> 00:03:02.525
of liquid oxygen to supply oxygen to the pilot.

56
00:03:02.985 --> 00:03:05.125
We are not really talking about OGs today,

57
00:03:05.385 --> 00:03:06.605
but, uh, that is the,

58
00:03:06.905 --> 00:03:08.725
the common denominator in all the problems

59
00:03:08.745 --> 00:03:10.005
the military's been having.

60
00:03:10.105 --> 00:03:12.455
And this is across the board,

61
00:03:12.455 --> 00:03:14.855
three different manufacturers making three different, uh,

62
00:03:15.235 --> 00:03:17.535
OGs systems all having similar problems.

63
00:03:19.615 --> 00:03:23.195
So in 2017, the US Navy asked the NASA Engineering

64
00:03:23.195 --> 00:03:24.755
and Safety Center to study

65
00:03:25.455 --> 00:03:27.915
the F 18 problems that they've been having.

66
00:03:27.945 --> 00:03:30.795
They put out this nice 258 page report

67
00:03:31.415 --> 00:03:34.905
and had a lot of good findings recommendations.

68
00:03:36.285 --> 00:03:39.625
One of those was that baseline data really do not exist

69
00:03:39.765 --> 00:03:42.185
as far as what the pilot needs in terms

70
00:03:42.185 --> 00:03:45.785
of an oxygen supply under different circumstances, uh, so

71
00:03:45.785 --> 00:03:48.265
that they can breathe and stay conscious.

72
00:03:50.285 --> 00:03:53.865
So in 2018, the NESC found money in their own budget

73
00:03:53.925 --> 00:03:57.105
and initiated on their own this pilot breathing assessment

74
00:03:57.205 --> 00:03:59.185
to try to go and get that baseline data.

75
00:03:59.445 --> 00:04:02.495
And that's what we're gonna talk about. So why are we here?

76
00:04:02.575 --> 00:04:05.575
A lot of you don't fly military aircraft probably don't fly

77
00:04:05.845 --> 00:04:07.255
obos even if you have in the past.

78
00:04:07.795 --> 00:04:09.815
Um, but we think this is unique enough.

79
00:04:09.815 --> 00:04:11.775
We wanna share our experiences on this project

80
00:04:12.125 --> 00:04:13.535
with the flight test community.

81
00:04:13.555 --> 00:04:15.615

And we are about halfway through the project.

82
00:04:16.225 --> 00:04:18.135
We're still a ways from having any kind

83
00:04:18.135 --> 00:04:19.295
of a report or results.

84
00:04:19.435 --> 00:04:21.975
So we just wanted to give you an update on what we're doing.

85
00:04:22.655 --> 00:04:24.965
There are other teams out there investigating these

86
00:04:24.965 --> 00:04:26.205
physiological episodes,

87
00:04:26.345 --> 00:04:27.765
and they've, a lot

88
00:04:27.765 --> 00:04:29.725
of them have had incidents while they're testing.

89
00:04:29.855 --> 00:04:31.885
We've even had some unexpected results,

90
00:04:31.885 --> 00:04:35.305
and we're gonna talk more about that, um,

91
00:04:35.385 --> 00:04:37.785
because the theme here of the workshop is safety assurance.

92
00:04:37.785 --> 00:04:39.185
We'll give you a few thoughts on that.

93
00:04:39.685 --> 00:04:42.145
Um, and then we hope we have some, uh, broader lessons

94
00:04:42.175 --> 00:04:43.945
that would apply to anybody's flight test.

95
00:04:45.525 --> 00:04:47.465
So I'm gonna talk about how we did the testing.

96
00:04:47.675 --> 00:04:49.305
Sonar is gonna talk about the results.

97
00:04:51.275 --> 00:04:54.305
First, I wanna give a little background theory to

98
00:04:54.305 --> 00:04:56.985
that we think underpins everything we're doing here.

99
00:04:57.245 --> 00:04:59.945
Uh, in that previous NESC report I talked about,

100
00:05:00.655 --> 00:05:04.185
they presented and developed the oxygen transport model.

101
00:05:05.065 --> 00:05:06.955
This is a system of systems.

102
00:05:07.585 --> 00:05:10.315
Look at the pilot breathing problem, if you will.

103
00:05:10.735 --> 00:05:12.715
Uh, the green bar there

104
00:05:13.315 --> 00:05:15.835
represents oxygen on the left where it's big.

105
00:05:15.835 --> 00:05:18.035
That's the supply that starts at the beginning,

106
00:05:18.575 --> 00:05:20.275
and then all the different interactions

107
00:05:20.275 --> 00:05:21.515
and losses that go on.

108
00:05:21.515 --> 00:05:23.835

And the, the little bar at the, uh, right side

109
00:05:23.835 --> 00:05:26.675
of your screen there is the oxygen reaching the pilot's

110
00:05:26.675 --> 00:05:29.905
brain physiological episodes though

111
00:05:29.905 --> 00:05:30.985
are not aircraft problems.

112
00:05:30.985 --> 00:05:32.545
They're, they happen to pee

113
00:05:33.325 --> 00:05:36.665
and hypoxia occurs when your brain doesn't get enough

114
00:05:36.685 --> 00:05:39.825
oxygen, regardless of what happened upstream of that,

115
00:05:40.245 --> 00:05:42.025
if your brain isn't getting the oxygen

116
00:05:42.405 --> 00:05:43.465
you're gonna pass out.

117
00:05:45.805 --> 00:05:49.095
Yesterday, uh, Ulu talked to us about, uh,

118
00:05:49.765 --> 00:05:52.825
what was the term he, he used, um,

119
00:05:54.105 --> 00:05:55.465
reductionism, I think it was.

120
00:05:55.685 --> 00:05:57.565
Um, yes, says yes.

121
00:05:57.745 --> 00:06:00.085
Um, if you look at just one part of the problem

122
00:06:00.185 --> 00:06:02.325
and think, if I just understand this component,

123
00:06:02.475 --> 00:06:03.805
I've got it figured out.

124
00:06:03.825 --> 00:06:05.125
Or if I look at each component

125
00:06:05.405 --> 00:06:06.525
separately, I've got it figured out.

126
00:06:06.835 --> 00:06:09.125
This is really a system of systems problems.

127
00:06:09.695 --> 00:06:11.645
Sonar is gonna talk later about some of the interactions

128
00:06:11.645 --> 00:06:13.405
that are pretty unexpected that

129
00:06:14.545 --> 00:06:16.405
result in the pilot not getting

130
00:06:16.405 --> 00:06:17.685
enough oxygen to their brain.

131
00:06:21.215 --> 00:06:25.505
Okay? So I said we, uh, there really was no data out there

132
00:06:26.045 --> 00:06:27.505
for pilot breathing needs.

133
00:06:27.605 --> 00:06:30.385
So we characterize the pilot's breathing needs

134
00:06:30.525 --> 00:06:33.945
by the respiratory rates, title volumes, that's a,

135
00:06:34.025 --> 00:06:35.305

a doctor term, um,

136
00:06:35.325 --> 00:06:36.705
and the air composition,

137
00:06:37.405 --> 00:06:39.825
all this is not very well understood or documented.

138
00:06:39.825 --> 00:06:41.745
So we set out to develop a standardized

139
00:06:41.745 --> 00:06:43.185
process to measure these things.

140
00:06:43.685 --> 00:06:45.985
We wanted to evaluate some of the instrumentation

141
00:06:45.985 --> 00:06:47.665
that's currently available to do that.

142
00:06:48.505 --> 00:06:51.285
And ultimately, we want to develop a physiological baseline

143
00:06:51.425 --> 00:06:54.005
so that if you're out testing a particular breathing system,

144
00:06:54.065 --> 00:06:55.725
you know what you're trying to test too.

145
00:06:58.175 --> 00:07:00.035
So into our methodology, we've,

146
00:07:00.245 --> 00:07:02.355
we're just now finishing up phase one.

147
00:07:02.815 --> 00:07:04.075
Uh, we call that the matrix.

148
00:07:04.775 --> 00:07:07.635
We just tried to cover the gamut of, uh, flight conditions.

149
00:07:07.635 --> 00:07:08.715
We had five pilots.

150
00:07:08.935 --> 00:07:11.035
We developed five different flight profiles

151
00:07:11.035 --> 00:07:12.315
and wanted to repeat each twice.

152
00:07:12.415 --> 00:07:13.915
So that gave us 50 flights.

153
00:07:13.995 --> 00:07:15.955
I think they're doing flight 49 today.

154
00:07:15.955 --> 00:07:17.515
And if I get home in time tonight,

155
00:07:18.035 --> 00:07:19.395
I might do flight 50 tomorrow.

156
00:07:20.055 --> 00:07:23.515
Um, out at Armstrong, we've got, uh, two F fifteens,

157
00:07:23.515 --> 00:07:24.635
two F eighteens.

158
00:07:24.975 --> 00:07:26.875
We can wear air force style gear

159
00:07:26.935 --> 00:07:29.075
or Navy gear in those aircraft.

160
00:07:29.415 --> 00:07:32.915
Um, because NASA only flies really old airplanes,

161
00:07:32.975 --> 00:07:34.155
we don't have OOGs.

162
00:07:34.535 --> 00:07:36.315

Uh, our systems are locks only.

163
00:07:36.335 --> 00:07:38.035
And that's actually a good thing for this test

164
00:07:38.035 --> 00:07:40.635
because we're taking the oxygen supply out of the equation.

165
00:07:40.695 --> 00:07:43.755
For the most part, locks is kind of a known good system.

166
00:07:44.265 --> 00:07:45.475
Turn it on, it works.

167
00:07:46.055 --> 00:07:48.955
Um, again, we're trying to develop a, a baseline

168
00:07:48.955 --> 00:07:50.475
for the pilot's breathing needs,

169
00:07:50.615 --> 00:07:51.915
and that hasn't been done before.

170
00:07:52.855 --> 00:07:55.595
We came up with, uh, you see a bunch of things up here.

171
00:07:55.665 --> 00:07:57.435
Five basic flight profiles.

172
00:07:57.715 --> 00:08:01.555
A, B, C, D, and FG was a ground only profile.

173
00:08:01.975 --> 00:08:03.275
We came up with some neat ways

174
00:08:03.295 --> 00:08:05.195
to remember which profiles is which,

175
00:08:05.335 --> 00:08:08.005
but we did one, uh, let's see.

176
00:08:08.005 --> 00:08:11.245
Profile A high altitude B was aerobatics.

177
00:08:11.245 --> 00:08:12.325
That was our most challenging.

178
00:08:12.385 --> 00:08:15.245
And, uh, so sonar is gonna talk a little bit about some

179
00:08:15.245 --> 00:08:16.325
of our results doing that.

180
00:08:16.345 --> 00:08:19.685
That's more of a high G, or I'll call it medium G.

181
00:08:20.105 --> 00:08:22.925
Um, sustained breathing effort, uh, control profile,

182
00:08:22.925 --> 00:08:24.045
which is a low breathing effort.

183
00:08:24.785 --> 00:08:28.765
Low altitude, you think, what are your oxygen requirements?

184
00:08:28.765 --> 00:08:30.205
Down low. There's actually good data

185
00:08:30.265 --> 00:08:33.005
to be found if the cabin doesn't pressurize.

186
00:08:33.105 --> 00:08:35.365
So in a fighter, if you stay below 8,000 feet,

187
00:08:35.365 --> 00:08:36.605
your cabin won't pressurize.

188
00:08:37.065 --> 00:08:39.605
And the pilot still does have breathing needs

189
00:08:39.825 --> 00:08:41.565

as they exert a moderate breathing effort.

190
00:08:44.255 --> 00:08:46.555
To do this test, we used a particular mask.

191
00:08:46.655 --> 00:08:48.555
The the 20 P that you see there.

192
00:08:48.615 --> 00:08:50.475
The red arrow is pointing out a key feature.

193
00:08:50.475 --> 00:08:53.835
There's a, an exhalation valve there that we were able

194
00:08:53.835 --> 00:08:56.125
to screw a second hose onto.

195
00:08:56.905 --> 00:08:59.365
Uh, you see that in the, the right side of the screen.

196
00:08:59.825 --> 00:09:02.365
And then we put these sensor blocks at the ends of the hose,

197
00:09:02.425 --> 00:09:04.845
and I'll, uh, talk about those in just a little bit.

198
00:09:06.075 --> 00:09:09.055
Um, we wear both air force style harnesses.

199
00:09:09.075 --> 00:09:11.335
We can wear that in our F 15 or our F 18.

200
00:09:11.475 --> 00:09:16.375
And then our F 18 can also be, um, cha swapped out so

201
00:09:16.375 --> 00:09:17.895
that we wear the Navy style harness.

202
00:09:18.235 --> 00:09:21.255
Um, air Force tends to use a diluter demand regulator.

203
00:09:21.795 --> 00:09:24.335
The, uh, Navy tends to use a pressure demand regulator,

204
00:09:24.335 --> 00:09:26.055
and we saw some differences with those.

205
00:09:26.925 --> 00:09:29.545
And interesting fact, a lot of this gear is not new.

206
00:09:29.645 --> 00:09:33.265
It actually, uh, got started a long time ago in a

207
00:09:33.405 --> 00:09:34.625
galaxy far, far away.

208
00:09:36.205 --> 00:09:39.335
There's a lot of re similarities there for some reason.

209
00:09:40.745 --> 00:09:42.435
Okay, so the, uh, instrumentation

210
00:09:42.455 --> 00:09:45.355
for measuring our breathing is a system called Vioxx.

211
00:09:45.375 --> 00:09:46.875
It was formerly amps.

212
00:09:47.215 --> 00:09:49.355
If, uh, you're familiar with some of the other work

213
00:09:49.355 --> 00:09:51.995
that's going on, this is produced by a company called Coum.

214
00:09:51.995 --> 00:09:53.555
That's that. Among other things,

215
00:09:53.555 --> 00:09:55.155
does life support equipment and gear.

216
00:09:56.085 --> 00:10:00.425

So the inhalation sensor block ISB measures what's,

217
00:10:00.425 --> 00:10:01.785
what the pilot's breathing in.

218
00:10:02.125 --> 00:10:04.065
And the exhalation sensor block measures

219
00:10:04.065 --> 00:10:05.385
what the pilot's breathing out.

220
00:10:05.685 --> 00:10:08.065
Um, no aircraft mod required to use this.

221
00:10:08.095 --> 00:10:09.385
It's battery operated.

222
00:10:09.385 --> 00:10:12.935
Self-contained has internal clocks in each of these.

223
00:10:12.935 --> 00:10:15.455
They're synced up to a laptop computer ahead of time.

224
00:10:15.915 --> 00:10:18.335
Uh, the clocks are not necessarily accurate enough

225
00:10:18.835 --> 00:10:20.855
for the level of work we're trying to do.

226
00:10:21.475 --> 00:10:24.015
So we have a sync, external sync cable

227
00:10:24.115 --> 00:10:25.135
that's connected to both.

228
00:10:25.135 --> 00:10:26.535
And then there's a button on it

229
00:10:26.535 --> 00:10:27.775
strapped to the pilot's front.

230
00:10:27.795 --> 00:10:30.535
And before every maneuver, we'll press the button,

231
00:10:30.965 --> 00:10:32.535
puts an event mark onto the data,

232
00:10:32.715 --> 00:10:34.695
and then when they analyze it, they're able to,

233
00:10:34.755 --> 00:10:35.855
to line everything up.

234
00:10:37.655 --> 00:10:39.945
From an aircraft standpoint, we wanted to measure

235
00:10:39.945 --> 00:10:41.065
what the aircraft was doing.

236
00:10:41.425 --> 00:10:45.865
Pressure altitude, airspeed, g pitch roll, heading, uh,

237
00:10:45.865 --> 00:10:48.385
throttle setting, INS velocity.

238
00:10:49.415 --> 00:10:50.715
If we had newer airplanes

239
00:10:50.715 --> 00:10:52.555
with better instrumentation in 'em, we would like

240
00:10:52.555 --> 00:10:53.555
to see cabin pressure

241
00:10:53.555 --> 00:10:57.115
and temperature as well as the ECS operating parameters.

242
00:10:57.595 --> 00:10:58.915
Remember, we're doing locks only.

243
00:10:59.655 --> 00:11:03.275

The intent is this data would be compared to Obox jets

244
00:11:03.575 --> 00:11:06.955
and what their ECS systems putting out into the obox

245
00:11:06.955 --> 00:11:08.195
system is very important.

246
00:11:08.295 --> 00:11:09.915
So we would wanna see all that recorded.

247
00:11:11.725 --> 00:11:12.975
Everybody's gotta have a survey.

248
00:11:13.155 --> 00:11:16.615
So we created some surveys, a pretest survey in order

249
00:11:16.675 --> 00:11:20.535
to get the pilot's backgrounds, any history they had with,

250
00:11:20.595 --> 00:11:22.135
uh, physiological incidents.

251
00:11:22.475 --> 00:11:24.135
And then the day of, we do a pre

252
00:11:24.195 --> 00:11:27.895
and a post survey covering standard things like rest

253
00:11:27.915 --> 00:11:30.015
and nutrition, and then anything unusual.

254
00:11:30.115 --> 00:11:32.175
We noted during the, uh, the sorting

255
00:11:32.435 --> 00:11:34.615
and we'll talk sonar will talk a little bit

256
00:11:34.615 --> 00:11:35.775
more about the pilot comments.

257
00:11:36.605 --> 00:11:37.825
The docs got involved.

258
00:11:38.005 --> 00:11:40.745
So we were doing spirometry, pulse oximetry.

259
00:11:40.965 --> 00:11:42.745
You may have done this stuff in your doctor's office.

260
00:11:43.085 --> 00:11:46.065
Um, the spirometry, you breathe into a tube in order

261
00:11:46.085 --> 00:11:48.265
to measure things like asthma.

262
00:11:48.685 --> 00:11:52.265
Um, and COPD, we did all this stuff both

263
00:11:52.265 --> 00:11:53.485
before and after flight.

264
00:11:53.495 --> 00:11:55.405
Every time we'd do it in the briefing room,

265
00:11:55.475 --> 00:11:57.205
just in our street clothes, we'd do it.

266
00:11:57.205 --> 00:12:01.135
Strapped into the jet fully, uh, suited up,

267
00:12:01.315 --> 00:12:02.455
uh, except for the mask.

268
00:12:03.235 --> 00:12:06.055
We did not take this stuff flying. We said no on that.

269
00:12:06.195 --> 00:12:07.855
We will, uh, give you all the data before and after,

270
00:12:07.875 --> 00:12:10.495

but we're not gonna have this stuff in the cockpit with us.

271
00:12:11.995 --> 00:12:14.645
Okay, so there's some obvious safety considerations when

272
00:12:14.645 --> 00:12:16.325
you're going out and testing a system

273
00:12:16.325 --> 00:12:18.005
that's critical to the pilot's health.

274
00:12:18.625 --> 00:12:20.765
Um, and also looking for conditions

275
00:12:20.765 --> 00:12:22.565
where you may degrade or fail that system.

276
00:12:25.015 --> 00:12:26.995
So how, how are we gonna do safety assurance?

277
00:12:27.165 --> 00:12:28.875
We're, we're very concerned about

278
00:12:28.875 --> 00:12:30.395
that at the test team level.

279
00:12:30.395 --> 00:12:33.755
We're not thinking system or safety management systems.

280
00:12:34.005 --> 00:12:37.075
We're not thinking safety climates or surveys like that.

281
00:12:37.695 --> 00:12:39.115
We just wanna make sure we're safe.

282
00:12:39.255 --> 00:12:41.995
So we're relying on our people and our processes.

283
00:12:42.805 --> 00:12:44.905
We put together a multidisciplinary team.

284
00:12:44.905 --> 00:12:46.385
We had engineers, scientists,

285
00:12:46.665 --> 00:12:49.425
a lot more flight surgeon involvement than you probably have

286
00:12:49.485 --> 00:12:50.745
in most of your programs.

287
00:12:51.135 --> 00:12:53.985
Test pilots. Our life support technicians we're very

288
00:12:54.265 --> 00:12:58.105
involved all through the project experts like Sonar.

289
00:12:58.525 --> 00:13:02.325
Um, part of our team, every time we changed something,

290
00:13:02.345 --> 00:13:03.965
we went back, reviewed what we were doing,

291
00:13:04.845 --> 00:13:06.005
represented it to our management.

292
00:13:06.625 --> 00:13:08.885
Um, the profiles we were flying,

293
00:13:09.095 --> 00:13:12.165
those are just standard maneuvers that pilots do every day.

294
00:13:12.165 --> 00:13:14.845
We did not create anything special or unique

295
00:13:15.225 --> 00:13:17.165
or silly for us to go out and do.

296
00:13:18.835 --> 00:13:21.695
And then, uh, because we're wearing a lot more stuff,

297
00:13:21.915 --> 00:13:24.535

ground egress, ejection, all

298
00:13:24.535 --> 00:13:25.975
that was a concern for the pilots.

299
00:13:25.975 --> 00:13:27.855
So we all went through additional egress

300
00:13:27.855 --> 00:13:29.895
and hanging harness training to make sure we were ready.

301
00:13:30.865 --> 00:13:33.015
Every time we changed something, we'd go back out

302
00:13:33.015 --> 00:13:36.495
to the jet, do a cockpit fit check, here's me making sure

303
00:13:36.495 --> 00:13:39.695
that I can look around and I'm not being constricted

304
00:13:39.695 --> 00:13:42.655
or restricted from my, uh, piloting duties by the equipment.

305
00:13:42.655 --> 00:13:43.855
You can see the hose is kind

306
00:13:43.855 --> 00:13:45.095
of stretching on the left there.

307
00:13:45.675 --> 00:13:49.855
Um, it had been worse and we, uh, changed the configuration

308
00:13:49.875 --> 00:13:52.495
and at least I could look over my shoulder at this point.

309
00:13:55.085 --> 00:13:58.385
So, uh, I had never really paid much attention to this,

310
00:13:58.485 --> 00:14:01.225
but, uh, this is all done for ejection seed aircraft.

311
00:14:01.225 --> 00:14:03.945
You need to do wind blast testing to make sure that

312
00:14:04.455 --> 00:14:06.385
when the pilot ejects into the slipstream,

313
00:14:06.765 --> 00:14:09.185
all this gear is not gonna become a flailing hazard.

314
00:14:09.765 --> 00:14:12.665
And so this is a, uh, this is the fun one.

315
00:14:12.665 --> 00:14:14.105
This is 450 knots.

316
00:14:14.105 --> 00:14:16.745
If you ever wondered what happened when you ejected into

317
00:14:16.745 --> 00:14:17.905
that kind of a slipstream.

318
00:14:26.895 --> 00:14:29.635
So even though the pilot's helmet did not stay on the, uh,

319
00:14:29.645 --> 00:14:31.315
vigil locks was securely attached

320
00:14:31.315 --> 00:14:32.715
to his harness all the way through.

321
00:14:36.415 --> 00:14:41.325
Okay? So in a nutshell, we're going out using locks.

322
00:14:41.325 --> 00:14:42.485
This is a known proven system

323
00:14:42.485 --> 00:14:43.885
that's worked reliably for years.

324
00:14:44.415 --> 00:14:46.085

We're gonna fly standard maneuvers.

325
00:14:47.815 --> 00:14:49.605
We're just out there gathering baseline data.

326
00:14:49.665 --> 00:14:50.925
So what could possibly go wrong?

327
00:14:51.145 --> 00:14:53.285
We really didn't expect to see anything interesting.

328
00:14:53.835 --> 00:14:55.495
So sonar will tell you what we saw.

329
00:14:57.445 --> 00:15:00.145
Thanks, clue. All right.

330
00:15:00.145 --> 00:15:02.025
We didn't expect to see anything, but we did.

331
00:15:02.645 --> 00:15:06.305
So once we saw something, we stepped back,

332
00:15:06.415 --> 00:15:08.945
stopped testing there, and, uh, took a deep dive.

333
00:15:09.165 --> 00:15:12.745
And after several months of really digging into it,

334
00:15:12.745 --> 00:15:14.945
we came up with some preliminary results that we presented

335
00:15:14.945 --> 00:15:16.225
to both the Air Force and the Navy.

336
00:15:16.765 --> 00:15:18.785
So the pilot breathing assessment is identified

337
00:15:18.785 --> 00:15:19.905
to design feature the mask

338
00:15:19.935 --> 00:15:22.265
that doesn't always function properly with safety pressure,

339
00:15:22.875 --> 00:15:24.605
with safety pressure regulators under dynamic

340
00:15:24.605 --> 00:15:26.325
conditions for proper function.

341
00:15:26.345 --> 00:15:28.885
The both valves basically need to sequence properly.

342
00:15:29.145 --> 00:15:32.605
And when they don't, um, bad things start happening.

343
00:15:32.625 --> 00:15:34.805
And the data suggests this is not always true in flight.

344
00:15:35.395 --> 00:15:37.775
In some cases, the degraded performance of the valve leads

345
00:15:37.775 --> 00:15:39.335
to both of them being open simultaneously.

346
00:15:39.595 --> 00:15:41.015
And you get a continuous flow,

347
00:15:41.425 --> 00:15:44.095
which disrupts the proctor regulator function

348
00:15:44.095 --> 00:15:45.415
and allows constant flow through the mask.

349
00:15:45.415 --> 00:15:49.295
And in other cases, the exhalation valve becomes over the

350
00:15:49.375 --> 00:15:51.035
difficult to unseat both

351
00:15:51.035 --> 00:15:53.155

of these conditions adversely affect the

352
00:15:53.155 --> 00:15:54.195
dynamics of breathing.

353
00:15:54.945 --> 00:15:57.525
And it's not something that you can detect just

354
00:15:57.545 --> 00:15:58.885
by checking things out on the ground.

355
00:15:59.385 --> 00:16:01.565
So we briefed this to both the Air Force and the Navy.

356
00:16:01.565 --> 00:16:02.645
It was very well received

357
00:16:02.945 --> 00:16:04.845
and one of our objectives was to hand it off so

358
00:16:04.845 --> 00:16:06.735
that they could take a look with their

359
00:16:07.295 --> 00:16:08.655
considerable, uh, assets.

360
00:16:09.005 --> 00:16:11.855
They have the two physiology, the the Pete teams,

361
00:16:12.115 --> 00:16:14.615
the physiological episode action teams.

362
00:16:15.235 --> 00:16:17.295
And so we brief both of them as well

363
00:16:17.295 --> 00:16:19.375
as the T six leadership on this.

364
00:16:19.955 --> 00:16:21.995
And they've been, uh, run them

365
00:16:21.995 --> 00:16:23.315
with this ball rather quickly.

366
00:16:23.895 --> 00:16:25.835
So what's going on?

367
00:16:25.935 --> 00:16:28.475
We, uh, take a step back and take a look at the mask.

368
00:16:28.655 --> 00:16:30.675
And we really wanna focus on the system interactions.

369
00:16:30.935 --> 00:16:33.555
Uh, it's, uh, for anybody who hasn't flown with these masks,

370
00:16:33.555 --> 00:16:34.715
they'll go through the basics here.

371
00:16:35.135 --> 00:16:37.235
Uh, and, uh,

372
00:16:37.485 --> 00:16:40.075
we'll talk a little bit later about the applicability to

373
00:16:40.855 --> 00:16:43.275
flight test in general for the civil and,

374
00:16:43.295 --> 00:16:44.715
and the business jets and whatnot.

375
00:16:44.875 --> 00:16:46.835
'cause, uh, for fighters

376
00:16:46.835 --> 00:16:48.955
who wearing these masks all the time, um,

377
00:16:49.375 --> 00:16:50.395
you know, we get used to it.

378
00:16:50.775 --> 00:16:53.155

But for the commercial, you know, you have the possibility

379
00:16:53.155 --> 00:16:55.315
of above 41 k operations

380
00:16:55.495 --> 00:16:57.835
and the emergency systems, which may

381
00:16:57.835 --> 00:16:58.875
or may not have these issues

382
00:16:58.895 --> 00:17:00.195
as well, that need to be looked at.

383
00:17:00.255 --> 00:17:01.995
So, so the mess is fairly straightforward.

384
00:17:02.455 --> 00:17:05.015
And if you look at the bottom, we've got the

385
00:17:06.445 --> 00:17:08.395
inhalation valve on the left hand side,

386
00:17:09.055 --> 00:17:11.155
and it's basically just a one-way valve, right?

387
00:17:11.395 --> 00:17:14.575
A little butterfly flap you breathe in opens

388
00:17:15.285 --> 00:17:17.375
with minimal resistance, let's the air come in

389
00:17:17.555 --> 00:17:20.575
and when you breathe out, it sets back down flat.

390
00:17:20.795 --> 00:17:22.575
And in theory, it shouldn't allow any air

391
00:17:22.575 --> 00:17:24.535
to go back out through that way.

392
00:17:25.675 --> 00:17:27.815
Now, the exhalation valve is also a one-way

393
00:17:27.815 --> 00:17:28.975
valve, but it's a little bit different.

394
00:17:28.975 --> 00:17:31.695
It's got a pressure compensation chamber in there.

395
00:17:31.795 --> 00:17:34.475
So obviously when you're at high altitudes,

396
00:17:34.475 --> 00:17:36.555
when you have pressure breathing for G pressure, breathing

397
00:17:36.555 --> 00:17:38.435
for altitude, you don't want the air

398
00:17:38.435 --> 00:17:41.555
to come in when it's pressurized in one side

399
00:17:41.655 --> 00:17:43.595
and right out the door on the right hand side

400
00:17:43.695 --> 00:17:45.115
and have this continuous flow.

401
00:17:45.735 --> 00:17:47.275
So in order to prevent that,

402
00:17:47.375 --> 00:17:50.005
you have this little compensation tube that runs

403
00:17:50.005 --> 00:17:51.245
between the two of them in there.

404
00:17:51.705 --> 00:17:54.245
And that just allows the safety pressure to be communicated

405
00:17:54.265 --> 00:17:55.485

to this compensation bladder.

406
00:17:55.605 --> 00:17:58.285
I call it a balloon. It basically blows up a little balloon

407
00:17:58.285 --> 00:18:03.185
in the exhalation valve that you can see kind of right here.

408
00:18:04.995 --> 00:18:07.595
And it works pretty elegantly to prevent

409
00:18:08.135 --> 00:18:09.755
the air from, you know, seals up.

410
00:18:09.755 --> 00:18:11.835
The exhalation valve prevents the air from coming out when

411
00:18:11.835 --> 00:18:13.195
you have this positive pressure coming in,

412
00:18:13.945 --> 00:18:15.555
then when you start to exhale,

413
00:18:16.005 --> 00:18:19.465
seals up the inhalation valve, opens up the exhalation valve

414
00:18:20.045 --> 00:18:23.105
and allows this kind of dual action swinging

415
00:18:23.285 --> 00:18:26.585
of pressures in two different domains back and forth.

416
00:18:27.915 --> 00:18:29.245
Flew with this for 20 years

417
00:18:29.245 --> 00:18:31.685
and didn't really understand, uh, how it,

418
00:18:32.575 --> 00:18:33.905
this delicate dance worked

419
00:18:33.905 --> 00:18:35.465
for every single breath that you have.

420
00:18:36.525 --> 00:18:38.465
And it's fairly robust from

421
00:18:39.165 --> 00:18:42.465
all my experience flying in the legacy aircraft sixteens one

422
00:18:42.665 --> 00:18:44.785
seventeens and non-safety pressure systems.

423
00:18:45.565 --> 00:18:47.065
And, but is it as robust

424
00:18:47.065 --> 00:18:51.705
as we thought When you add safety pressure, you have now,

425
00:18:52.285 --> 00:18:55.965
um, you,

426
00:18:55.985 --> 00:18:57.845
you're basically introducing, uh,

427
00:18:57.875 --> 00:18:59.285
I'll just ignore the safety pressure a second.

428
00:18:59.285 --> 00:19:00.805
So, so now you have a system

429
00:19:00.865 --> 00:19:03.765
that's got this pressure compensation chamber there

430
00:19:03.905 --> 00:19:05.725
and you have this interaction back

431
00:19:05.725 --> 00:19:07.325
and forth between the inhalation valve

432
00:19:07.585 --> 00:19:08.725

and the exhalation valve.

433
00:19:08.985 --> 00:19:12.845
And so you can see that it's subjected to some interactions

434
00:19:13.475 --> 00:19:14.805
both between the two valves

435
00:19:14.805 --> 00:19:17.245
that could be potentially unexpected as well

436
00:19:17.245 --> 00:19:20.165
as anything else that affects the pressure coming from the

437
00:19:20.165 --> 00:19:23.485
inhalation supply or outside in the cabinet pressure area.

438
00:19:25.135 --> 00:19:28.275
And one of the key things is most problems occur

439
00:19:28.815 --> 00:19:30.395
on the physiological, you know,

440
00:19:30.395 --> 00:19:33.235
the up so-called the unexplained physiological events.

441
00:19:33.625 --> 00:19:34.915
Most of the problems when we go back

442
00:19:34.915 --> 00:19:37.135
and look at the mask, nobody finds anything.

443
00:19:37.195 --> 00:19:39.495
You test 'em on the tester and it tests good

444
00:19:40.065 --> 00:19:42.365
and the same thing applied in our case, in our incident.

445
00:19:42.655 --> 00:19:44.525
Check the mask, everything is fine,

446
00:19:44.815 --> 00:19:46.445
check the regulator, everything's fine.

447
00:19:46.445 --> 00:19:48.485
Check the aircraft. We don't find anything.

448
00:19:49.095 --> 00:19:51.075
So what's going on with the systems interactions?

449
00:19:51.535 --> 00:19:52.595
So we take a look at the data,

450
00:19:53.255 --> 00:19:54.915
we finally have some good data coming in

451
00:19:55.055 --> 00:19:56.755
and, uh, 29 flights at this point,

452
00:19:57.215 --> 00:19:59.995
and we see some very unexpected data.

453
00:20:00.535 --> 00:20:02.415
So the first two, um,

454
00:20:02.875 --> 00:20:05.695
so we had a three hour long technical brief on this.

455
00:20:05.695 --> 00:20:07.135
At the risk of oversimplifying,

456
00:20:07.195 --> 00:20:10.255
I'm not gonna go completely down all the rabbit trails,

457
00:20:10.255 --> 00:20:12.175
but just give you an idea of some

458
00:20:12.175 --> 00:20:13.255
of the things we're looking at here.

459
00:20:13.895 --> 00:20:17.135

A and B are we have exhalation flow occurring

460
00:20:17.135 --> 00:20:18.575
during inhalation and inhalation flow

461
00:20:18.575 --> 00:20:19.655
occurring during exhalation.

462
00:20:19.655 --> 00:20:22.955
So those valves are not closed when they're supposed to be.

463
00:20:23.605 --> 00:20:25.785
And c and d on the pressure side,

464
00:20:26.445 --> 00:20:28.865
we have the pressure domains that are supposed

465
00:20:28.865 --> 00:20:31.305
to be separated by these one-way valves are not

466
00:20:31.305 --> 00:20:32.625
working like we expected.

467
00:20:33.205 --> 00:20:35.385
So when you breathe out, you would expect

468
00:20:35.385 --> 00:20:36.585
that the mass pressure to be higher

469
00:20:37.205 --> 00:20:40.865
and uh, it would be sealed off from the inhalation side.

470
00:20:40.865 --> 00:20:44.385
But we see at times that the pressures are the same,

471
00:20:44.675 --> 00:20:46.865
indicating that there's pressure being communicated back

472
00:20:46.865 --> 00:20:50.265
and forth across somewhere that it's not over.

473
00:20:50.285 --> 00:20:52.705
On E we've got kind of the worst case

474
00:20:52.705 --> 00:20:54.825
where you have inhalation pressure exceeding the mass

475
00:20:55.105 --> 00:20:56.585
pressure indicating a continuous flow.

476
00:20:56.605 --> 00:20:58.665
So those pressure domains are not separated at all.

477
00:20:59.085 --> 00:21:03.695
And then an f we would expect, uh, no oscillations

478
00:21:04.235 --> 00:21:08.595
and for testers,

479
00:21:08.595 --> 00:21:10.635
the whole oscillations and the dynamic response

480
00:21:10.635 --> 00:21:12.115
and frequentness response is something

481
00:21:12.115 --> 00:21:13.475
that they're not as familiar with.

482
00:21:14.135 --> 00:21:18.275
Not a terrible surprise to us to see for a system

483
00:21:18.275 --> 00:21:19.875
that has a pressure feedback loop.

484
00:21:20.065 --> 00:21:22.315
Some interactions at times in some oscillations,

485
00:21:22.655 --> 00:21:24.575
but that doesn't always occur.

486
00:21:30.695 --> 00:21:32.705

Okay, so we get to flight 29,

487
00:21:32.845 --> 00:21:36.025
and this was a profile B so that the acrobatics, um,

488
00:21:36.365 --> 00:21:41.195
and this is a medium altitude, high demanding profile.

489
00:21:41.215 --> 00:21:42.235
We have here the altitude

490
00:21:42.235 --> 00:21:43.795
and the velocity for the entire sorority.

491
00:21:43.795 --> 00:21:45.155
And you can see the squiggles in the metal.

492
00:21:45.735 --> 00:21:48.025
Um, points 10, 11

493
00:21:48.025 --> 00:21:49.065
and 13, there are

494
00:21:49.065 --> 00:21:50.865
what we affectionately call the scroll cages.

495
00:21:50.865 --> 00:21:54.505
So basically scripted, um, acrobatic maneuvers do a loop

496
00:21:55.165 --> 00:21:56.225
lin split s

497
00:21:57.215 --> 00:22:00.555
and several different scripted maneuvers in a, in a row

498
00:22:00.695 --> 00:22:03.395
to have a consistent repeatable, um,

499
00:22:03.465 --> 00:22:04.915
profile between the different pilots.

500
00:22:04.915 --> 00:22:06.755
So one of the keys in breathing testing is

501
00:22:06.995 --> 00:22:08.875
to know exactly what's going on

502
00:22:08.895 --> 00:22:10.555
and to try to isolate the variables.

503
00:22:10.815 --> 00:22:12.395
And so we did that. Um,

504
00:22:12.655 --> 00:22:16.195
and uh, of note, you know, the squiggles in the middle,

505
00:22:16.455 --> 00:22:18.915
you know, that's the, you can tell how dynamic it is

506
00:22:19.095 --> 00:22:20.275
and the pilot's breathing,

507
00:22:20.275 --> 00:22:23.995
you can actually see the respiration rate tick up each one

508
00:22:23.995 --> 00:22:25.235
of these demanding parts

509
00:22:25.255 --> 00:22:27.035
of the profile throughout the profile.

510
00:22:27.575 --> 00:22:29.505
But when we get the report back,

511
00:22:29.505 --> 00:22:31.105
the pilot said he couldn't exhale completely.

512
00:22:31.205 --> 00:22:33.225
It was more difficult than normal to exhale quickly

513
00:22:33.225 --> 00:22:34.425

through the mask and it felt

514
00:22:34.885 --> 00:22:37.625
as if exhaling against a partially closed valve

515
00:22:37.625 --> 00:22:39.385
or having to exhale against positive pressure.

516
00:22:39.655 --> 00:22:44.535
Well, that's not good. I'll read this one

517
00:22:44.535 --> 00:22:46.455
more on the next slide, but again, as he goes

518
00:22:46.455 --> 00:22:49.775
through on this time, uh, test 0.8,

519
00:22:50.335 --> 00:22:51.915
the level 360 degree turn,

520
00:22:52.215 --> 00:22:55.735
and again, talking about oxygen starvation,

521
00:22:58.995 --> 00:23:01.135
the squirrel occasion, the 5G wind up turn couldn't exhale

522
00:23:01.135 --> 00:23:02.375
completely in a short period of time

523
00:23:02.995 --> 00:23:05.455
and ran out of oxygen due to partial breaths due

524
00:23:05.455 --> 00:23:06.895
to trouble, exhaling it quickly.

525
00:23:07.595 --> 00:23:10.485
And then lastly,

526
00:23:10.725 --> 00:23:15.085
after four minutes of doing the 4G spiral descent,

527
00:23:15.265 --> 00:23:17.045
it was outta breath and could not complete further.

528
00:23:17.385 --> 00:23:20.285
So what's going on? When we take a look at the data, um,

529
00:23:20.545 --> 00:23:22.405
we have what we call fighting the machine.

530
00:23:22.465 --> 00:23:24.005
We see this repeatable pattern.

531
00:23:24.145 --> 00:23:27.045
So in the top left we have the inhalation in the

532
00:23:27.045 --> 00:23:28.445
exhalation flows.

533
00:23:28.905 --> 00:23:31.165
So the red on top is the inhalation,

534
00:23:31.225 --> 00:23:35.125
the blue on the bottom there is the exhalation flows.

535
00:23:35.125 --> 00:23:36.925
And you can see with the numbers, you know,

536
00:23:36.945 --> 00:23:39.965
1, 2, 3, 4, 5, 6, we have this repeating pattern kind of

537
00:23:39.965 --> 00:23:43.565
through the entire sort of the peak exhalation flow

538
00:23:45.205 --> 00:23:47.115
decreasing, and then a reset

539
00:23:47.455 --> 00:23:49.835
as the pilot was able to kind of get back to normal.

540
00:23:50.295 --> 00:23:52.475

And then this kind of repeats again, again,

541
00:23:52.475 --> 00:23:54.195
so the pilot is breathing normally,

542
00:23:54.195 --> 00:23:56.435
but the exhalation flows are continually decreasing.

543
00:23:57.055 --> 00:23:58.235
On the top right, you see the,

544
00:23:58.235 --> 00:24:00.755
just the three dimensional graph of what was going on.

545
00:24:01.055 --> 00:24:04.235
And the aircraft is supposed to be in an iso baric region

546
00:24:04.735 --> 00:24:07.235
of maintaining 8,000 feet the entire time.

547
00:24:08.065 --> 00:24:12.845
But you can actually see, uh, just below that the pressures

548
00:24:14.345 --> 00:24:17.205
in millimeters of mercury actually increase

549
00:24:17.425 --> 00:24:20.245
as the pilot's pulling GS by about 20, uh,

550
00:24:20.255 --> 00:24:21.695
20 millimeters of mercury.

551
00:24:21.915 --> 00:24:24.535
And the average swing in your mask is only, you know,

552
00:24:24.535 --> 00:24:25.695
four to five millimeters.

553
00:24:25.995 --> 00:24:28.535
So a fairly drastic change in the cabin pressure,

554
00:24:28.535 --> 00:24:30.695
which actually came as a surprise to us, um,

555
00:24:31.365 --> 00:24:32.495
when we were looking at this.

556
00:24:33.165 --> 00:24:35.985
And again, you've got a pressure compensated chamber in your

557
00:24:35.985 --> 00:24:38.585
mask and the entire system is driven by pressures

558
00:24:38.805 --> 00:24:39.865
and you have an environment

559
00:24:39.865 --> 00:24:41.985
that is also changing pressures at the same time.

560
00:24:44.855 --> 00:24:46.235
All right, so this was the where the pilot

561
00:24:46.345 --> 00:24:47.475
said he couldn't exhale completely.

562
00:24:47.495 --> 00:24:49.635
It was more difficult than normal to exhale quickly

563
00:24:49.635 --> 00:24:52.315
through the mask and he felt his effect exhaling against a

564
00:24:52.315 --> 00:24:54.115
partially closed valve or having

565
00:24:54.115 --> 00:24:55.635
to exhale against positive pressure.

566
00:24:55.815 --> 00:24:57.755
The surprising thing when we looked at the mask pressures is

567
00:24:57.755 --> 00:24:59.275

there was nothing terribly abnormal about them.

568
00:24:59.275 --> 00:25:00.755
They weren't extremely high

569
00:25:01.175 --> 00:25:02.595
and you would kind of expect that.

570
00:25:03.015 --> 00:25:04.395
Uh, and it appears

571
00:25:04.425 --> 00:25:07.395
that the human body is not terribly good at sensing force.

572
00:25:08.095 --> 00:25:11.395
Um, but what the pilot is probably sensing

573
00:25:11.395 --> 00:25:12.595
is the flow limitation.

574
00:25:13.175 --> 00:25:15.515
Um, you know, flow rate limits something

575
00:25:15.515 --> 00:25:16.515
that we don't usually think about,

576
00:25:16.575 --> 00:25:17.835
but apparently that the human body

577
00:25:17.945 --> 00:25:19.235
body is more sensitive to.

578
00:25:19.695 --> 00:25:22.675
So what the pilot feels may not always appear in

579
00:25:22.675 --> 00:25:23.795
the data is what you expect.

580
00:25:25.315 --> 00:25:26.655
So the pilot's fighting the machine.

581
00:25:27.075 --> 00:25:28.495
And here's one more example.

582
00:25:28.875 --> 00:25:32.615
Um, and again, at the risk of oversimplifying, you know,

583
00:25:32.615 --> 00:25:34.815
this very deep level of detail that we had to go in

584
00:25:34.875 --> 00:25:37.055
and analyze for months to really tease this out,

585
00:25:37.515 --> 00:25:41.925
you can see on the inhale side here as

586
00:25:41.925 --> 00:25:44.245
after the pilot's done with his inhalation,

587
00:25:44.385 --> 00:25:48.365
the inhalation flow doesn't return to zero even

588
00:25:48.505 --> 00:25:49.885
as the pilot's exhaling.

589
00:25:49.885 --> 00:25:51.565
So we have this interaction with the valves

590
00:25:51.565 --> 00:25:53.245
that took a long time to really understand.

591
00:25:53.625 --> 00:25:56.045
And in this case, you see the period over time

592
00:25:56.465 --> 00:26:00.005
as the inhalation flow continues to get higher and higher

593
00:26:00.025 --> 00:26:01.605
and higher in between his breaths

594
00:26:01.865 --> 00:26:05.565

and his exhalation flow, even during max effort is,

595
00:26:06.275 --> 00:26:07.975
you know, continually get lower

596
00:26:07.995 --> 00:26:09.695
and lower peak exhalation flows.

597
00:26:09.695 --> 00:26:12.095
So the pilot's losing out over time, finding the machine

598
00:26:12.095 --> 00:26:13.975
and losing the battle and cannot get a

599
00:26:14.135 --> 00:26:15.175
complete change over a breath.

600
00:26:18.385 --> 00:26:19.755
Alright, systems of systems,

601
00:26:20.825 --> 00:26:22.525
but everything checks good in isolation.

602
00:26:22.545 --> 00:26:25.325
We go back after regulator checks,

603
00:26:25.325 --> 00:26:27.045
good mass checks, good, can't find anything.

604
00:26:28.355 --> 00:26:32.665
So this is truly a complete system interaction

605
00:26:32.665 --> 00:26:34.105
that you can't find on the ground.

606
00:26:34.125 --> 00:26:36.345
And we see this time and time again on all the PEs.

607
00:26:36.685 --> 00:26:40.365
Um, but the linear systems model is still important.

608
00:26:40.505 --> 00:26:43.965
We still need oxygen to come from the source,

609
00:26:44.075 --> 00:26:45.405
whether it be locks

610
00:26:45.405 --> 00:26:49.645
or OGs through, you know, the regulator through the sensors,

611
00:26:49.645 --> 00:26:52.565
through the mask, into the lungs, into the oli,

612
00:26:52.915 --> 00:26:54.925
through the pulmonary system,

613
00:26:55.155 --> 00:26:56.765
through your circulation up to the brain.

614
00:26:56.765 --> 00:26:59.285
You know, it's gotta go all the way from beginning to end

615
00:26:59.285 --> 00:27:01.365
through all of these systems of the aircraft in the

616
00:27:01.365 --> 00:27:02.605
human successfully.

617
00:27:03.395 --> 00:27:06.215
But the important thing is that, um, you know,

618
00:27:06.215 --> 00:27:07.855
if you think about this as the node model

619
00:27:07.875 --> 00:27:10.095
as they showed the other day, every single one

620
00:27:10.095 --> 00:27:11.855
of these nodes interacts with every other node.

621
00:27:11.915 --> 00:27:16.735

So the cabin pressure, if it changes influences,

622
00:27:16.795 --> 00:27:18.615
that's the baseline for the regulator,

623
00:27:19.115 --> 00:27:21.295
for the mask and for the human.

624
00:27:21.835 --> 00:27:25.015
If you pull Gs that interacts with the springs

625
00:27:25.015 --> 00:27:26.855
and the bellows and the mask as well

626
00:27:26.855 --> 00:27:29.015
as in this case interacts with the cabin pressure

627
00:27:29.155 --> 00:27:30.735
and we saw a change of 20 millimeters

628
00:27:30.735 --> 00:27:32.935
of the cabin pressure just from pulling Gs.

629
00:27:33.685 --> 00:27:35.835
Every single node here on this linear systems

630
00:27:35.835 --> 00:27:37.395
model interacts with every other node.

631
00:27:37.395 --> 00:27:38.875
So it's kind of like an end-to-end problem.

632
00:27:40.195 --> 00:27:44.265
And so the only way to test that is by doing full end

633
00:27:44.265 --> 00:27:45.785
to end systems testing.

634
00:27:47.645 --> 00:27:50.745
So breathing dynamics a new paradigm.

635
00:27:51.285 --> 00:27:52.745
We took a look at everything

636
00:27:52.925 --> 00:27:56.235
and you see in the data, for lack of a better term,

637
00:27:56.235 --> 00:27:57.635
breathing dynamics, these flow

638
00:27:57.635 --> 00:27:59.675
and pressure interactions between the man

639
00:27:59.835 --> 00:28:02.195
and the machine that don't show up Otherwise,

640
00:28:03.015 --> 00:28:04.475
we want harmonious flow

641
00:28:04.475 --> 00:28:06.395
and pressure consistent with breathing physiology.

642
00:28:06.735 --> 00:28:10.195
And again, the physiological events happen to people, not

643
00:28:10.195 --> 00:28:12.675
to planes, and the human is one has to compensate

644
00:28:12.675 --> 00:28:14.875
for any disharmony that you have, any

645
00:28:14.915 --> 00:28:16.075
of those system interactions.

646
00:28:16.905 --> 00:28:18.285
Flight 29 is a good example

647
00:28:18.585 --> 00:28:20.325
and I'll leave you with, uh, another story.

648
00:28:20.425 --> 00:28:22.685

The, the infamous Dorito crumb.

649
00:28:23.145 --> 00:28:27.485
So it turns out that the system is so, um, interactive

650
00:28:27.875 --> 00:28:31.205
that even the smallest little crumb on the inhalation valve

651
00:28:31.205 --> 00:28:33.835
that prevents it from fully seeding, um,

652
00:28:33.935 --> 00:28:35.595
and they actually found the crumb

653
00:28:35.595 --> 00:28:37.795
after it got shipped to the lab, it survived

654
00:28:38.295 --> 00:28:39.435
and it made it to the lab.

655
00:28:39.935 --> 00:28:42.965
And when they tested it, the problem with the crumb there is

656
00:28:42.965 --> 00:28:46.045
that when it doesn't allow it deceit, the pressure's able

657
00:28:46.045 --> 00:28:47.725
to go back behind the inhalation valve

658
00:28:47.725 --> 00:28:48.965
through the compensation tube

659
00:28:49.625 --> 00:28:53.655
and keep the bladder on the exhalation side closed.

660
00:28:54.275 --> 00:28:57.925
So a problem with the inhalation valve manifests

661
00:28:57.945 --> 00:29:00.525
as a difficulty in unseating the exhalation valve

662
00:29:01.185 --> 00:29:03.525
and that ripples through the system

663
00:29:03.585 --> 00:29:06.125
and it also impacts the dynamics of the regulator.

664
00:29:06.955 --> 00:29:08.415
So completely unexpected

665
00:29:08.875 --> 00:29:11.655
and um, something that you'd only find

666
00:29:11.675 --> 00:29:13.215
by doing the end end systems testing.

667
00:29:13.755 --> 00:29:15.335
And there's an emerging consensus now,

668
00:29:15.515 --> 00:29:17.935
and this is a very big change from, uh,

669
00:29:17.935 --> 00:29:18.975
where we were a year ago.

670
00:29:19.235 --> 00:29:23.925
Um, they asked last week in the Navy F 18 Pete, who thinks

671
00:29:23.925 --> 00:29:27.605
that breathing dynamics can cause a physiological episode.

672
00:29:27.745 --> 00:29:29.245
And pretty much everybody raised their hand.

673
00:29:29.665 --> 00:29:32.405
So we're going down the path now, kind

674
00:29:32.405 --> 00:29:34.605
of the old paradigm was that just hypoxia

675
00:29:34.785 --> 00:29:36.805

and contamination are the major problems

676
00:29:36.805 --> 00:29:38.965
and they are still major issues that we need

677
00:29:38.965 --> 00:29:42.365
to be concerned about, but we now see

678
00:29:42.365 --> 00:29:43.925
that physiological episodes can happen

679
00:29:43.925 --> 00:29:46.165
with sufficient oxygen and no contamination.

680
00:29:46.705 --> 00:29:47.965
And we spent a lot of time and money

681
00:29:47.985 --> 00:29:50.085
to really rule out those two issues.

682
00:29:51.745 --> 00:29:54.525
All right, implications, unfavorable system interactions

683
00:29:54.545 --> 00:29:55.645
can disrupt pilot breathing.

684
00:29:55.645 --> 00:29:58.785
Far more than expected any testing, uh,

685
00:29:58.805 --> 00:30:00.545
of breathing systems needs

686
00:30:00.545 --> 00:30:02.585
to take these emerging safety issues into account.

687
00:30:03.895 --> 00:30:06.475
If you guys are looking at anything above 41 where you have

688
00:30:06.475 --> 00:30:08.235
to have an emergency mask, has that been tested,

689
00:30:08.505 --> 00:30:10.555
it's pressure compensated, it's probably subject

690
00:30:10.815 --> 00:30:12.235
to the same systems interactions

691
00:30:13.215 --> 00:30:15.795
and they seem to be at the center of our perplexing issues,

692
00:30:15.795 --> 00:30:18.195
which makes sense because systems of systems

693
00:30:19.175 --> 00:30:21.215
behave have emergent behavior

694
00:30:21.215 --> 00:30:24.055
that you wouldn't really expect from just the linear ideas

695
00:30:26.355 --> 00:30:27.695
and the subtlety of this mechanism

696
00:30:27.695 --> 00:30:28.895
cannot be over emphasized.

697
00:30:28.965 --> 00:30:29.895
It's important to get the

698
00:30:29.895 --> 00:30:31.135
pilots involved to get their comments.

699
00:30:31.515 --> 00:30:35.015
Um, initially the pilot thought that it was the jet and um,

700
00:30:35.595 --> 00:30:37.855
or sorry, the problem was them and not the jet.

701
00:30:37.855 --> 00:30:39.895
That's kinda one of the things we learned in test pilot

702
00:30:39.895 --> 00:30:42.135

that school is that it's always the jet, right?

703
00:30:42.135 --> 00:30:44.935
It's never your fault. Um, and that would apply here too.

704
00:30:45.355 --> 00:30:48.095
And it almost certainly would not have been found if it

705
00:30:48.215 --> 00:30:50.815
hadn't been a dedicated pilot breathing assessment

706
00:30:52.165 --> 00:30:54.015
that I'll turn it back over Tolu for the wrap up.

707
00:30:54.325 --> 00:30:56.615
Okay, so I think we've talked about most of these.

708
00:30:56.675 --> 00:31:00.415
The, the big takeaways are take an old proven system

709
00:31:00.415 --> 00:31:02.975
that you think works great and delve into it deeper.

710
00:31:03.035 --> 00:31:04.895
You're gonna find things you didn't expect.

711
00:31:05.355 --> 00:31:09.885
Um, the system of systems, um, effect there is,

712
00:31:10.625 --> 00:31:13.125
is critical subtle interactions can

713
00:31:13.125 --> 00:31:14.405
produce unexpected results.

714
00:31:16.255 --> 00:31:18.235
And so what's next? We're gonna keep going,

715
00:31:18.235 --> 00:31:19.555
gathering baseline data.

716
00:31:19.685 --> 00:31:22.355
We're going to keep working to develop a standard method.

717
00:31:22.535 --> 00:31:24.835
We are, we don't have the full answer here.

718
00:31:24.845 --> 00:31:26.955
We're halfway through. We're gonna keep working on this.

719
00:31:27.875 --> 00:31:28.895
Um, okay.

720
00:31:28.915 --> 00:31:31.615
And so I'll wrap up so we have maybe time for questions.

721
00:31:31.615 --> 00:31:33.975
Everybody has to have an iceberg slide, so there's ours.

722
00:31:36.515 --> 00:31:39.095
Any questions? We've got about 30 seconds.

723
00:31:40.965 --> 00:31:44.845
Alright. Oh, I guess they're going over there.

724
00:31:45.655 --> 00:31:47.405
Hello. Good morning. Thanks for the presentation.

725
00:31:47.925 --> 00:31:50.325
I have one question, actually, it's two questions. First.

726
00:31:51.105 --> 00:31:53.405
Uh, these systems have been flown, uh,

727
00:31:53.465 --> 00:31:54.725
for the past 20 years already.

728
00:31:55.145 --> 00:31:58.445
And is your report gonna address also the long-term effect

729
00:31:58.785 --> 00:32:03.085

of this new system comparison with the LOX systems?

730
00:32:03.545 --> 00:32:05.165
And the second question is, is your,

731
00:32:05.305 --> 00:32:07.005
or once it's finished, is it gonna be available?

732
00:32:09.075 --> 00:32:11.445
Okay, so I think the, the first question was are we going

733
00:32:11.445 --> 00:32:13.495
to address the, the problem?

734
00:32:13.565 --> 00:32:14.655
Yeah, the long-term effect

735
00:32:14.655 --> 00:32:16.335
of this system on the, on the body,

736
00:32:16.515 --> 00:32:17.895
The long-term effect of the system.

737
00:32:18.245 --> 00:32:21.335
Well, there's been a lot of efforts trying to, to solve well

738
00:32:21.335 --> 00:32:23.175
to even figure out what the problems are.

739
00:32:23.755 --> 00:32:26.975
As sonar mentioned, they've, they've looked at pieces of it

740
00:32:26.975 --> 00:32:29.215
and every piece they've looked at works fine.

741
00:32:29.315 --> 00:32:31.135
So I think we're, we're just getting to the point

742
00:32:31.135 --> 00:32:35.015
where we understand it's not one thing, um,

743
00:32:36.195 --> 00:32:39.445
OGs was, was implemented, my, my understanding

744
00:32:39.445 --> 00:32:43.525
of this is OGs was implemented as a logistics issue so

745
00:32:43.525 --> 00:32:45.285
that the military doesn't have

746
00:32:45.285 --> 00:32:47.325
to pre-position locks all around the world.

747
00:32:47.385 --> 00:32:49.485
So I don't think they're going away from OGs.

748
00:32:49.985 --> 00:32:52.925
So they're trying to solve this problem.

749
00:32:53.745 --> 00:32:56.805
Um, and there's little subtle pieces that they can fix.

750
00:32:56.805 --> 00:32:59.685
They've made a few changes that have appeared to help,

751
00:32:59.785 --> 00:33:02.365
but I, I don't know that we have the, the full solution.

752
00:33:02.825 --> 00:33:05.685
Um, as far as making the results available,

753
00:33:06.645 --> 00:33:08.725
anything NASA does that's gonna be freely available.

754
00:33:09.025 --> 00:33:10.645
Um, I can't speak for the military,

755
00:33:11.655 --> 00:33:13.325
thank you, but sonar can.

756
00:33:13.825 --> 00:33:14.825

So

757
00:33:15.425 --> 00:33:18.365
As far as the long-term effects, nothing, uh,

758
00:33:18.375 --> 00:33:20.005
we're not doing any longitudinal studies

759
00:33:20.065 --> 00:33:22.645
or anything like that, but we are addressing the spirometry.

760
00:33:22.745 --> 00:33:26.285
So you can tell when the lungs have a decrement in their

761
00:33:26.415 --> 00:33:28.445
capability, which is the reason why we're checking

762
00:33:28.505 --> 00:33:30.225
before, you know, so

763
00:33:30.225 --> 00:33:32.265
before you get dressed, once you put the equipment on,

764
00:33:32.285 --> 00:33:34.785
you know, your lung capacity drops a little bit due

765
00:33:34.785 --> 00:33:36.825
to all the gear you get in the jet, you know,

766
00:33:36.825 --> 00:33:39.465
in a constrained position it's even more.

767
00:33:39.845 --> 00:33:42.065
Uh, so, and then after flying for an hour,

768
00:33:42.275 --> 00:33:44.305
there are oftentimes effects of say,

769
00:33:44.345 --> 00:33:46.985
a hundred percent oxygen, which causes alysis of the,

770
00:33:46.985 --> 00:33:48.035
you know, the kind

771
00:33:48.035 --> 00:33:49.715
of reduced lung capacity just from the

772
00:33:49.715 --> 00:33:50.875
shrinking of the aveoli.

773
00:33:51.255 --> 00:33:54.795
So we are looking at the actual impact

774
00:33:54.855 --> 00:33:57.995
to the lung capacity in the, the context of this.

775
00:33:58.455 --> 00:34:01.595
But other than, uh, that we're not looking at, you know,

776
00:34:01.625 --> 00:34:03.795
obviously there's, if you're aware of some

777
00:34:03.795 --> 00:34:06.035
of the other things going on, there's studies showing the

778
00:34:06.195 --> 00:34:08.355
cerebral, uh, perfusion is impacted

779
00:34:08.355 --> 00:34:09.595
by the oxygen concentration

780
00:34:10.175 --> 00:34:14.325
and we're not tackling any of those questions, just the,

781
00:34:14.325 --> 00:34:16.085
just the one capacity of the spirometry

782
00:34:18.535 --> 00:34:19.535
Questions.

783
00:34:20.315 --> 00:34:21.605

Alright, thanks Jets.

784
00:34:21.845 --> 00:34:24.925
I do want to talk to you because my lighter altitude record

785
00:34:24.945 --> 00:34:29.285
was 28,000 feet in an un pressurized five P mask.

786
00:34:29.585 --> 00:34:34.405
And, uh, um, I got, I

787
00:34:34.565 --> 00:34:37.845
Got winded, so yeah, I'm sure your brain's okay.

788
00:34:40.225 --> 00:34:41.325
Not much drain bandage.

789
00:34:45.065 --> 00:34:48.805
So this morning we had a, a bit of a hodgepodge of papers.

790
00:34:49.165 --> 00:34:51.685
I hope you don't mind. I I grouped things in a logical

791
00:34:51.685 --> 00:34:52.965
fashion yesterday.

792
00:34:53.705 --> 00:34:55.765
I'm really impressed with the papers we've had today.

793
00:34:56.145 --> 00:34:59.125
Uh, we've got one more paper or one more presentation.

794
00:34:59.155 --> 00:35:03.765
It's turbo part due and, uh, it'll be after the break.

795
00:35:03.765 --> 00:35:05.565
And I'm gonna take away five minutes of your break.

796
00:35:05.985 --> 00:35:08.525
Please be back in your seats at 10 0 5

797
00:35:08.875 --> 00:35:10.445
because we gotta get on schedule.

798
00:35:10.665 --> 00:35:13.605
The bus will be out there at, at 1245

799
00:35:14.185 --> 00:35:16.605
and uh, Tom will talk more about that.

800
00:35:16.825 --> 00:35:18.285
Claude, let's roll the next video.