1
00:00:05,400 --> 00:00:05,500
(Music)

2
00:00:05,500 --> 00:00:07,567
Many pilots today
don't go out with an

3
00:00:07,567 --> 00:00:09,733
immediate concern on their
flight that they're going to

4
00:00:09,733 --> 00:00:11,267
run into the ground.

5
00:00:11,267 --> 00:00:13,300
There is a problem
in aviation

6
00:00:13,300 --> 00:00:15,533
of controlled flight
into the terrain.

7
00:00:15,533 --> 00:00:18,833
Controlled flight into the
terrain is a case where you

8
00:00:18,833 --> 00:00:21,800
have a perfectly healthy
aircraft that is

9
00:00:21,800 --> 00:00:23,567
what's called "under
controlled flight."

10
00:00:23,567 --> 00:00:25,600
In other words, it hasn't
stalled. The pilot has full

11
00:00:25,600 --> 00:00:29,467

control ability of
that aircraft. Yet,

12
00:00:29,467 --> 00:00:31,600
the aircraft ends up
running into the ground

13
00:00:31,600 --> 00:00:34,300
in some way.

14
00:00:34,300 --> 00:00:36,867
We're developing an
automatic system to avoid

15
00:00:36,867 --> 00:00:41,033
a ground collision in a case of
a fully functional aircraft.

16
00:00:41,033 --> 00:00:44,133
Which will automatically take
control of the aircraft

17
00:00:44,133 --> 00:00:47,700
and automatically fly that
aircraft away from the ground

18
00:00:47,700 --> 00:00:53,000
to save the pilot
and the vehicle.

19
00:00:53,000 --> 00:00:53,867
You don't need a
multi-million dollar fighter

20
00:00:53,867 --> 00:00:56,433
with digital fly-by-wire flight
controls and very expensive

21
00:00:56,433 --> 00:00:59,167
hardware to implement

a system like this.

22
00:00:59,167 --> 00:01:02,867
We can put these algorithms
that determine if there's a

23
00:01:02,867 --> 00:01:05,067
imminent ground collision, we
can put them on a phone, which

24
00:01:05,067 --> 00:01:09,033
we've demonstrated on the Droid,
and give out that application.

25
00:01:09,033 --> 00:01:12,433
When you go from an F-16 to
something like a small UAV,

26
00:01:12,433 --> 00:01:16,967
we unplug the F-16 model, we
plug in the small U-A-V model

27
00:01:16,967 --> 00:01:21,200
and the rest of the system
remains fairly much the same.

28
00:01:21,200 --> 00:01:23,733
The technology that we're
developing is important.

29
00:01:23,733 --> 00:01:25,967
We all have friends
And colleagues who

30
00:01:25,967 --> 00:01:28,700
aren't with us anymore because
they've run into the ground.

31
00:01:28,700 --> 00:01:31,833
Sound of of ejection seat

exploding.

32
00:01:31,833 --> 00:01:48,333
(Music)

33
00:01:48,333 --> 00:01:52,167
(Chatter)

34
00:01:52,167 --> 00:01:53,533
In the fighter area, there were

35
00:01:53,533 --> 00:01:56,867
about one or two people dying
a year in the Air Force alone

36
00:01:56,867 --> 00:01:59,767
due to this controlled flight
into terrain problem.

37
00:01:59,767 --> 00:02:02,633
And that is when an airplane

38
00:02:02,633 --> 00:02:05,933
in perfectly good health
crashes into the ground due

39
00:02:05,933 --> 00:02:10,967
to either pilot error or
possibly the pilot is

40
00:02:10,967 --> 00:02:13,933
unconscious as in fighter
jets pulling high Gs, they

41
00:02:13,933 --> 00:02:14,967
may lose consciousness.

42
00:02:14,967 --> 00:02:16,767
This is something that's not

just confined

43
00:02:16,767 --> 00:02:18,733
to military aircraft.
And it's not

44
00:02:18,733 --> 00:02:21,600
confined to UAVs. General
aviation aircraft have a big

45
00:02:21,600 --> 00:02:24,333
problem with running into
the ground. Pilots do for

46
00:02:24,333 --> 00:02:27,067
whatever reason, they're
distracted, they can't see,

47
00:02:27,067 --> 00:02:29,533
they're in a fog bank.
Another case is where they

48
00:02:29,533 --> 00:02:33,000
are spatially disoriented. A
good example of this is the

49
00:02:33,000 --> 00:02:35,967
J.F.K., Jr. mishap that
happened out on the East

50
00:02:35,967 --> 00:02:37,300
Coast a number of years ago.
They fly in, uh, sometimes

51
00:02:37,300 --> 00:02:42,733
extreme landing and take off
locations, up on mountains

52
00:02:42,733 --> 00:02:45,733
and things where aircrafts

don't have the aerodynamic

53
00:02:45,733 --> 00:02:48,433
ability to climb like
they think they should.

54
00:02:48,433 --> 00:02:51,833
A number of years ago, the
Defense Safety Oversight Council

55
00:02:51,833 --> 00:02:54,433
out of the Undersecretary
of Defense for Personnel
and Readiness

56
00:02:54,433 --> 00:02:57,600
saw this problem and
asked us to begin

57
00:02:57,600 --> 00:03:01,367
addressing it for fighters.
In conjunction with the Air

58
00:03:01,367 --> 00:03:04,500
Force, the Air Force
Research Lab and Lockhead,

59
00:03:04,500 --> 00:03:07,700
we went out and did an
intital program for, on the

60
00:03:07,700 --> 00:03:10,700
F-16 that would help address
the problem on all Air Force

61
00:03:10,700 --> 00:03:13,667
fighters. The ground
collision avoidance maneuver

62
00:03:13,667 --> 00:03:16,800

chosen for the F-16 is a
wings level climb. It climbs

63
00:03:16,800 --> 00:03:20,767
really well and it doesn't
turn very well. So we don't

64
00:03:20,767 --> 00:03:24,033
try to turn in front of an
obstacle, we try to climb up

65
00:03:24,033 --> 00:03:26,667
over the top of the
obstacles. So regardless of

66
00:03:26,667 --> 00:03:29,667
what position you are in, in
the F-16, if there's an

67
00:03:29,667 --> 00:03:32,333
impending collision, the
airplane will roll to wings

68
00:03:32,333 --> 00:03:35,800
level and begin a five to
six G wings level pull to

69
00:03:35,800 --> 00:03:37,667
clear the local terrain.

70
00:03:37,667 --> 00:03:46,100
(pilot)Okay. Gonna roll
inverted. Pull the nose down.

71
00:03:46,100 --> 00:03:48,067
It's going
to roll itself upright.

72
00:03:48,067 --> 00:03:53,133
And pull. Bingo.

That's all automatic.

73
00:03:53,133 --> 00:03:58,033
When you have that kind of
automatic computer actuation

74
00:03:58,033 --> 00:04:00,367
of a decision, you have to
take into consideration a

75
00:04:00,367 --> 00:04:04,300
few more things than a
warning system would. Don't

76
00:04:04,300 --> 00:04:07,300
make things worse is the
first requirement and the

77
00:04:07,300 --> 00:04:10,533
second one is don't get in
the way of normal piloting

78
00:04:10,533 --> 00:04:14,767
activities. And then the third
is, actually avoid collisions.

79
00:04:14,767 --> 00:04:16,800
You've got an auto
pilot that has the

80
00:04:16,800 --> 00:04:19,867
ability to really move this
airplane around. We have the

81
00:04:19,867 --> 00:04:23,800
ability to put six Gs on
this airplane. Six Gs is not

82
00:04:23,800 --> 00:04:26,700
an easy thing to withstand.

Fighter pilots get used to

83
00:04:26,700 --> 00:04:29,333
it but still, six G's when
you didn't ask for it is a

84
00:04:29,333 --> 00:04:33,167
surprise and it's really
gonna get somebody upset if

85
00:04:33,167 --> 00:04:34,767
it didn't have to happen.

86
00:04:34,767 --> 00:04:37,233
(Automated voice from cockpit)
Pull up. Pull up. Pull up.

87
00:04:37,233 --> 00:04:39,433
(Pilot) This is just
downright annoying.

88
00:04:39,433 --> 00:04:41,100
(Automated voice) Altitude.

89
00:04:41,100 --> 00:04:44,267
What ends up happening is after
a few false warnings in the

90
00:04:44,267 --> 00:04:48,433
cockpit, a pilot either
tunes out the warnings or

91
00:04:48,433 --> 00:04:51,333
turns the system off and now
that warning system provides

92
00:04:51,333 --> 00:04:54,933
no benefit. In a figher
aircraft, these collision

93
00:04:54,933 --> 00:04:57,600
avoidance maneuvers are very
aggressive so when they

94
00:04:57,600 --> 00:04:59,333
happen when they shouldn't
it's going to get in the way

95
00:04:59,333 --> 00:05:01,400
of the mission and it's
going to upset the pilot,

96
00:05:01,400 --> 00:05:04,067
severely. So avoiding
nuisances in a fighter

97
00:05:04,067 --> 00:05:06,700
airplane is extremely
important. Their concern was

98
00:05:06,700 --> 00:05:09,000
that they weren't going to
be able to carry out their

99
00:05:09,000 --> 00:05:10,933
mission and that the system
was going to interfere.

100
00:05:10,933 --> 00:05:13,567
When they were shown that they
could still do their mission

101
00:05:13,567 --> 00:05:17,800
and the system would wait
longer than they would

102
00:05:17,800 --> 00:05:21,067
before initiating a recovery
they realized that was not

103
00:05:21,067 --> 00:05:24,033
going to be a problem. We
believe that the system we

104
00:05:24,033 --> 00:05:26,400
developed in the ACAT
program that's being fielded

105
00:05:26,400 --> 00:05:30,967
in the F-16 now, will
prevent above 90%, maybe as

106
00:05:30,967 --> 00:05:33,867
much as 98% of the mishaps.

107
00:05:33,867 --> 00:05:36,433
We went out and tested
the system

108
00:05:36,433 --> 00:05:38,533
against every historical
category of

109
00:05:38,533 --> 00:05:41,133
controlled flight into
terrain mishap that the F-16

110
00:05:41,133 --> 00:05:45,433
has seen and based them on
actual mishap cases. And we

111
00:05:45,433 --> 00:05:50,433
showed that across the
envelope of operation of the

112
00:05:50,433 --> 00:05:53,400
system, it prevented
every single mishap.

113

00:05:53,400 --> 00:06:00,467
Music

114
00:06:00,467 --> 00:06:04,100
We wanted to set up a system
that would be easy to adapt to

115
00:06:04,100 --> 00:06:07,900
any different aircraft. At the
heart of that is a modular

116
00:06:07,900 --> 00:06:11,333
software architecture. These
pieces could be replaced

117
00:06:11,333 --> 00:06:15,000
like an F-16 piece could be
removed from the system and

118
00:06:15,000 --> 00:06:18,200
then a UAV piece inserted in
and then the rest of the

119
00:06:18,200 --> 00:06:22,467
algorithms could remain the
same. The F-16 represents

120
00:06:22,467 --> 00:06:26,400
the high-peformance top-end
of the performance spectrum.

121
00:06:26,400 --> 00:06:29,367
Airplanes that go real fast,
climb real well, have great

122
00:06:29,367 --> 00:06:32,167
climb performance, but
because they're going real

123
00:06:32,167 --> 00:06:35,767

fast, their lateral turn
performance is not as good.

124
00:06:35,767 --> 00:06:40,833
In the case of a small UAV
aircraft, like the DROID, we

125
00:06:40,833 --> 00:06:43,333
have a limited climb
performance, something very

126
00:06:43,333 --> 00:06:46,067
typical of a general
aviation aircraft. That

127
00:06:46,067 --> 00:06:48,833
performance model is very
different. And hopefully, by

128
00:06:48,833 --> 00:06:51,100
anchoring both ends of that
spectrum, we cover

129
00:06:51,100 --> 00:06:53,700
everything in between. I
think it makes it a lot more

130
00:06:53,700 --> 00:06:55,667
plausible that we could move
to a different aircraft all

131
00:06:55,667 --> 00:06:59,100
across the spectrum of
aviation. One of the main

132
00:06:59,100 --> 00:07:01,967
costs in bringing any kind
of a capability to an

133
00:07:01,967 --> 00:07:04,200

aircraft is the
actual hardware.

134
00:07:04,200 --> 00:07:07,433
A very small difference in where
the airplane actually goes.

135
00:07:07,433 --> 00:07:09,900
We had an eye on the future
and we recognized that

136
00:07:09,900 --> 00:07:11,767
eventually we wanted to get
this into the general

137
00:07:11,767 --> 00:07:15,133
aviation community. And, the
best way to get something

138
00:07:15,133 --> 00:07:17,600
into the general aviation
community would be to put

139
00:07:17,600 --> 00:07:19,733
something on tools that
would be readily accessible

140
00:07:19,733 --> 00:07:23,067
to them. So we moved the
software from high-dollar

141
00:07:23,067 --> 00:07:27,467
fighter hardware processors
to cell phones. And we've

142
00:07:27,467 --> 00:07:30,300
now migrated it onto a cell
phone app. At bare minimum,

143
00:07:30,300 --> 00:07:34,633

an app that would warn you.
The more advanced versions

144
00:07:34,633 --> 00:07:38,167
would tie into an auto-pilot
and actually take control

145
00:07:38,167 --> 00:07:41,467
and recover the aircraft. Not
all general aviation airplanes

146
00:07:41,467 --> 00:07:44,267
have aircraft have
the auto pilot

147
00:07:44,267 --> 00:07:46,833
that would be necessary,
but at the bare minimum

148
00:07:46,833 --> 00:07:48,367
it's an app that you can
put on your cell phone

149
00:07:48,367 --> 00:07:50,133
that you would get a warning
that you are about to run

150
00:07:50,133 --> 00:07:51,433
into something.

151
00:07:51,433 --> 00:07:53,833
(sound of airplane)

152
00:07:53,833 --> 00:07:55,800
And that has enabled this
technology to be potentially

153
00:07:55,800 --> 00:07:58,933
brought to the rest of the
public for a

154
00:07:58,933 --> 00:08:04,000
much broader application
and life savings.

155
00:08:04,000 --> 00:08:09,333
(voice on radio) I couldn't tell
on that very first run...

156
00:08:09,333 --> 00:08:12,133
The basic pieces that are

157
00:08:12,133 --> 00:08:14,967
needed to make this system
work are an understanding of

158
00:08:14,967 --> 00:08:18,633
where the aircraft is. This
is provided by GPS. You also

159
00:08:18,633 --> 00:08:21,667
need to know what the
terrain is around you. So we

160
00:08:21,667 --> 00:08:24,533
have a computer model of the
world that is a digital

161
00:08:24,533 --> 00:08:27,500
database of elevations. We
then, inside the software,

162
00:08:27,500 --> 00:08:31,000
have a model of well the
aircraft can perform. And

163
00:08:31,000 --> 00:08:34,233
that model is very precisely
tuned to that aircraft's

164
00:08:34,233 --> 00:08:36,000
performance capabilities.

165
00:08:36,000 --> 00:08:38,767
Even since they first started
developing this capability,

166
00:08:38,767 --> 00:08:42,333
back in the '90's, capabilities
of computers have gotten much,

167
00:08:42,333 --> 00:08:46,667
much better um, capabilities
of GPS navigation systems

168
00:08:46,667 --> 00:08:50,100
have become better, the uh
terrain database that allows

169
00:08:50,100 --> 00:08:53,700
the aircraft to know where,
where the ground is where

170
00:08:53,700 --> 00:08:55,233
the mountains and the
valleys are, um, have gotten

171
00:08:55,233 --> 00:08:58,633
a lot better. What we did
was, how we kind of overcame

172
00:08:58,633 --> 00:09:01,000
that was we had to go to
different sources, and we

173
00:09:01,000 --> 00:09:03,633
kind of had this mish-mash
of sources that were at

174

00:09:03,633 --> 00:09:05,800
different resolutions and
different accuracies, and we

175
00:09:05,800 --> 00:09:09,333
put that together in, you
know our, a custom database

176
00:09:09,333 --> 00:09:11,733
that really I think is
tailored more to what we are

177
00:09:11,733 --> 00:09:14,533
doing with auto GCAS than
the original databases were.

178
00:09:14,533 --> 00:09:18,567
We've built a utility that
compresses this terrain into

179
00:09:18,567 --> 00:09:21,667
a rather small file size,
such that we can carry the

180
00:09:21,667 --> 00:09:24,200
entire globe on a phone. So
we got a homogeneous, much

181
00:09:24,200 --> 00:09:29,000
more accurate digital
terrain database to use now.

182
00:09:29,000 --> 00:09:32,033
So by using improved digital
terrain, we get improved

183
00:09:32,033 --> 00:09:35,067
performance, and then by
using improved navigation

184

00:09:35,067 --> 00:09:38,033
system, we know where we are
over that terrain much

185
00:09:38,033 --> 00:09:41,267
better. So we can predict
the airplane to terrain

186
00:09:41,267 --> 00:09:44,733
collision geometry much better
than we could ten years ago.

187
00:09:44,733 --> 00:09:48,467
The system monitors
the approach of the

188
00:09:48,467 --> 00:09:51,033
ground and aircrafts ability
to maneuver to avoid it.

189
00:09:51,033 --> 00:09:53,000
It predicts an escape
trajectory that keeps the

190
00:09:53,000 --> 00:09:55,067
aircraft on a forward
trajectory but pulls it up

191
00:09:55,067 --> 00:09:57,967
away from the ground. But it
also computes a trajectory

192
00:09:57,967 --> 00:10:01,867
that moves the aircraft to
the right or to the left.

193
00:10:01,867 --> 00:10:05,400
It compares these two things,
the, the terrain, and the

194

00:10:05,400 --> 00:10:09,833
aircraft's ability to avoid
it. If the system thinks

195
00:10:09,833 --> 00:10:12,233
that the aircraft is
trouble, it will select the

196
00:10:12,233 --> 00:10:15,567
last possible option of
those three trajectories. It

197
00:10:15,567 --> 00:10:17,733
isn't forced to try and
climb over it. It can move

198
00:10:17,733 --> 00:10:20,900
to the side of it. That's
unique to the DROID system

199
00:10:20,900 --> 00:10:23,500
we've developed, and that is
a feature that will likely

200
00:10:23,500 --> 00:10:27,167
have, uh, a great advantage
when we take it and apply it

201
00:10:27,167 --> 00:10:29,767
to general aviation aircraft.

202
00:10:29,767 --> 00:10:36,367
(music)

203
00:10:36,367 --> 00:10:42,333
On a typical day of
flight, the team shows up
here, and at early in the

204
00:10:42,333 --> 00:10:44,767

morning, we gather all our
gear, we load it into our

205
00:10:44,767 --> 00:10:48,233
command-and-control van,
head out into the field,

206
00:10:48,233 --> 00:10:52,467
assemble the aircraft, set
up our systems, and then go

207
00:10:52,467 --> 00:10:55,233
through a series of tests.
Our first flight is going to

208
00:10:55,233 --> 00:10:57,933
be against that, that hill...
pilot flown, through the

209
00:10:57,933 --> 00:11:01,933
gap. And we're using two vhf
frequencies... What I've been

210
00:11:01,933 --> 00:11:04,800
doing is operating our user
interface which is the link

211
00:11:04,800 --> 00:11:07,833
really between us on the
ground, the test team, and

212
00:11:07,833 --> 00:11:12,167
the phone. We do a run, we
actually set up the

213
00:11:12,167 --> 00:11:15,100
auto-pilot through the
ground control station.

214
00:11:15,100 --> 00:11:19,233

We give it a point that that
it's going to fly to that's

215
00:11:19,233 --> 00:11:21,367
actually under the ground.
We're telling it to, you

216
00:11:21,367 --> 00:11:24,800
know, to really run into the
ground. The system is

217
00:11:24,800 --> 00:11:26,700
monitoring this and at the
last instance disengages

218
00:11:26,700 --> 00:11:29,200
that auto-pilot system and
uses the auto collision

219
00:11:29,200 --> 00:11:32,000
avoidance system to take
control of the aircraft and

220
00:11:32,000 --> 00:11:34,100
avoid hitting the ground.

221
00:11:34,100 --> 00:11:37,200
(voice on radio)
3...2...1... zero... fly up.

222
00:11:37,200 --> 00:11:40,433
(Music)

223
00:11:40,433 --> 00:11:42,533
Fly up right.

224
00:11:42,533 --> 00:11:47,667
(sound of plane engine)

225

00:11:47,667 --> 00:11:53,767
(Music)

226
00:11:53,767 --> 00:11:57,600
Just over the course of our
testing,

227
00:11:57,600 --> 00:12:00,533
and we went through our testing
as rapidly as we could,

228
00:12:00,533 --> 00:12:03,400
there were no fewer
than five fatalities

229
00:12:03,400 --> 00:12:05,467
and seven mishaps that we
could have prevented

230
00:12:05,467 --> 00:12:07,200
with that software on the

231
00:12:07,200 --> 00:12:10,700
very fighter aircraft we
were trying to design for.

232
00:12:10,700 --> 00:12:13,333
I think the system we're
fielding now with the F-16

233
00:12:13,333 --> 00:12:16,367
isn't perfect, uh, but I
think everyone in the field

234
00:12:16,367 --> 00:12:18,400
is going to love it and I think
it's going to save lives.

235
00:12:18,400 --> 00:12:21,400
Do we have the perfect answer?

236
00:12:21,400 --> 00:12:22,867
Of course we don't have
the perfect answer

237
00:12:22,867 --> 00:12:24,833
and that's something that's
going to evolve over time.

238
00:12:24,833 --> 00:12:26,700
But we're trying to save lives.

239
00:12:26,700 --> 00:12:28,933
We're trying to save pilots
and passengers lives

240
00:12:28,933 --> 00:12:31,633
from controlled
flight into terrain.

241
00:12:31,633 --> 00:12:33,867
NASA's taking the risk, and the
Air Force is taking the risk

242
00:12:33,867 --> 00:12:37,567
to put this system on, and I, I
think, I really do, that it'll,

243
00:12:37,567 --> 00:12:40,233
it'll be game changing
and save a lot of

244
00:12:40,233 --> 00:12:42,533
lives and really be a
benefit to society and

245
00:12:42,533 --> 00:12:44,800
really show what's possible.

246

00:12:44,800 --> 00:12:47,233
I think it's a system
whose time has come.

247
00:12:47,233 --> 00:12:49,967
There's no major obstacles from
a technology standpoint.

248
00:12:49,967 --> 00:12:52,333
Um, it does take, it does take

249
00:12:52,333 --> 00:12:53,867
work, it does take
development effort,

250
00:12:53,867 --> 00:12:55,833
it takes flight
testing to prove it.

251
00:12:55,833 --> 00:12:57,967
The technology is out
there to do this.

252
00:12:57,967 --> 00:13:01,200
It's a matter of bringing
all the pieces together

253
00:13:01,200 --> 00:13:02,667
and sewing it together
with software

254
00:13:02,667 --> 00:13:06,033
to make the capability
happen.