autonomy

1
00:00:00,734 --> 00:00:04,170
>>Flashing across California desert skies, the airplanes you see

2
00:00:04,170 --> 00:00:08,274
here are writing new chapters in the story
of man made flight....there she goes!

3
00:00:08,274 --> 00:00:12,812
>>This is my first opportunity
to greet you as deputy administrator

4
00:00:12,812 --> 00:00:16,483
of the National Aeronautics
and Space Administration.

5
00:00:16,816 --> 00:00:19,452
>>Together, you and I must make our new agency

6
00:00:19,452 --> 00:00:20,787
>>A most unusual place

7
00:00:20,820 --> 00:00:23,656
>>An organization that can challenge
conventional wisdom.

8
00:00:23,656 --> 00:00:27,260
>>We can engineer anything we can write the requirements for.

9
00:00:27,260 --> 00:00:28,661
>>We're going to make your idea work.

10
00:00:28,661 --> 00:00:31,231
This particular idea is quite disruptive.

11
00:00:31,898 --> 00:00:36,169
>>A typical flight, of course, starts
under the wing of the B-52 mothership.

12

00:00:36,336 --> 00:00:41,775
>>This sleek, high speed machine
would have made Rube Goldberg proud.

13
00:00:41,908 --> 00:00:44,778
>>The manner in which we fly
reentry from space,

14
00:00:44,778 --> 00:00:48,782
on the space shuttle was
pioneered on the X-15.

15
00:00:48,782 --> 00:00:54,387
>>The X-31 pretty much wrote the book on thurst vectoring, along with its sister program, the F-18 HARV.

16
00:00:54,387 --> 00:00:56,556
>>An observation of an occulation is

17
00:00:56,556 --> 00:00:59,526
one of the more challenging
missions that SOFIA can do.

18
00:01:00,326 --> 00:01:19,512
[Music/Background sound]

19
00:01:20,346 --> 00:01:24,717
>>Right now, we are looking
at the dawn of a new era of aviation.

20
00:01:27,754 --> 00:01:32,092
[Music/Background sound]

21
00:01:37,931 --> 00:01:39,632
[Music]

22
00:01:39,666 --> 00:01:41,201
>>Something has now emerged

23
00:01:41,201 --> 00:01:44,304

that might make even
our most elegant theories workable.

24
00:01:44,304 --> 00:01:47,440
>>Scientists developed equipment
which would be able to think...

25
00:01:47,440 --> 00:01:50,743
>>...machines that do things and make choices
without human beings,

26
00:01:50,977 --> 00:01:53,480
that uncanny spectacle is automation.

27
00:01:53,480 --> 00:01:56,082
>>...capable of storing, processing...

28
00:01:56,282 --> 00:01:59,953
>>>...calculations that would ordinarily
take hundreds of man hours;

29
00:01:59,953 --> 00:02:02,655
unique ability
to check itself on possible errors...

30
00:02:02,755 --> 00:02:05,458
>>>...cheaper and quicker and better.

31
00:02:05,758 --> 00:02:09,562
>>...electric eyes, limit switches, servo mechanisms...

32
00:02:09,562 --> 00:02:11,564
>>...secretary, librarian,

33
00:02:11,564 --> 00:02:16,169
banker, teacher, medical technician, bridge partner...

34
00:02:16,169 --> 00:02:20,340
>>...volumes of changing data

into a continuous flow of interpretations.

35
00:02:20,373 --> 00:02:23,042
>>Aladdin's lamp
couldn't do more.

36
00:02:23,042 --> 00:02:25,178
>>...jaws, loading machines, electric drills...

37
00:02:25,178 --> 00:02:26,446
...it's all automation.

38
00:02:26,446 --> 00:02:28,615
>>Computers have taken wing.

39
00:02:29,149 --> 00:02:33,486
>>By the late 1960s, digital computers
had become more available...

40
00:02:33,987 --> 00:02:36,422
>>...using data
about the aircraft's performance,

41
00:02:36,756 --> 00:02:39,893
the computers vote on the correct amount
of control deflection

42
00:02:39,893 --> 00:02:43,997
to make in response to the pilot's
stick and rudder movements.

43
00:02:44,130 --> 00:02:44,731
>>This system

44
00:02:44,731 --> 00:02:48,801
could make air travel of the future
smoother and safer by reducing aircraft

45
00:02:48,801 --> 00:02:53,373

vibrations through automatic response
from the computer to the aircraft controls.

46
00:02:54,774 --> 00:02:57,677
>>We did the digital engine control, we had an early

47
00:02:57,677 --> 00:03:01,781
large digital computer that ran the engine
and the inlet and exhaust system.

48
00:03:02,549 --> 00:03:06,219
>>We did an integrated control study
to provide digital control

49
00:03:06,219 --> 00:03:10,523
of the inlets, autopilot,
throttle, air data, and navigation system.

50
00:03:10,690 --> 00:03:12,292
...a digital computer here...

51
00:03:12,292 --> 00:03:14,327
...major improvement in the capability of the airplane...

52
00:03:14,794 --> 00:03:17,897
>>Test pilots are flying a plane
without having to leave the ground

53
00:03:18,231 --> 00:03:22,502
It's a new way of flight testing advanced
aircraft that's both more economical

54
00:03:22,569 --> 00:03:24,070
and less hazardous.

55
00:03:24,070 --> 00:03:27,207
A research pilot
in a realistically recreated cockpit

56

00:03:27,207 --> 00:03:31,344
on the ground, complete with flight
controls, flies the remotely piloted

57
00:03:31,344 --> 00:03:33,446
craft using computers and television.

58
00:03:33,634 --> 00:03:36,011
[Music/Background Noise]

59
00:03:36,149 --> 00:03:38,151
>>The airplane includes computers...

60
00:03:38,151 --> 00:03:40,753
...those computers take stick commands
and...

61
00:03:40,753 --> 00:03:42,422
>>...continuously monitor what

62
00:03:42,422 --> 00:03:47,193
the airplane is doing and compares it to
what the pilot wants the airplane to do.

63
00:03:47,860 --> 00:03:49,062
>>The computer signals the

64
00:03:49,062 --> 00:03:52,465
control surfaces
to not only execute the pilot's maneuver,

65
00:03:52,832 --> 00:03:56,069
but also to counter
any attempt by the X-29

66
00:03:56,202 --> 00:03:58,137
to veer out of control.

67
00:03:58,972 --> 00:04:01,941

[Music/Background sound]

68
00:04:05,378 --> 00:04:06,246
>>Fly up! Fly up!

69
00:04:06,246 --> 00:04:09,649
>>Yikes! No doubt about it, we didn't get a roll through on that one...

70
00:04:09,882 --> 00:04:11,251
>>You've got it.

71
00:04:11,251 --> 00:04:12,819
>>...a new initiative in the artificial

72
00:04:12,819 --> 00:04:16,055
intelligence area
and it's called aircraft automation.

73
00:04:16,356 --> 00:04:19,859
The technologies that end up coming out of
this would be autonomous flight

74
00:04:19,859 --> 00:04:21,828
vehicle technology.

75
00:04:21,828 --> 00:04:25,832
>>ERAST stands for Environmental Research
Aircraft and Sensor Technology...

76
00:04:25,932 --> 00:04:30,203
...platforms that could fly higher and longer
than the current piloted airplanes...

77
00:04:30,203 --> 00:04:33,172
...do science missions
and other commercial applications...

78
00:04:33,273 --> 00:04:35,308
>>Primarily the dull, dirty, and dangerous.

79
00:04:35,308 --> 00:04:38,344
>>We can go all the way up
to where the airplane can fly itself

80
00:04:38,344 --> 00:04:41,748
completely autonomously
with no input from anyone on the ground.

81
00:04:41,781 --> 00:04:45,118
>>Fly up to 50, 60 thousand
feet, fly a circle loop

82
00:04:45,151 --> 00:04:48,688
perhaps over a city,
providing the capability that a satellite now does.

83
00:04:49,155 --> 00:04:52,692
>>Now that we can fly for
on the order of 8 to 10 to 12 hours,

84
00:04:52,992 --> 00:04:56,429
we can look at long duration processes- biogeochemical cycling,

85
00:04:56,562 --> 00:04:59,232
looking at carbon and nitrogen
moving through an ecosystem...

86
00:04:59,232 --> 00:05:02,602
>>...to sort of kickstart
a commercial UAV industry.

87
00:05:02,602 --> 00:05:04,203
>>The technology that we've seen here in

88
00:05:04,203 --> 00:05:08,541
this test is what would be the foundation
for a follow-on program to really address

89

00:05:08,541 --> 00:05:12,845
the issue of how can UAVs routinely
operate in the national airspace system?

90
00:05:13,546 --> 00:05:14,514
>>The primary benefit of this

91
00:05:14,514 --> 00:05:17,650
technology is the ability of it
to adapt to the unknown,

92
00:05:17,950 --> 00:05:21,120
whether it be a system failure,
battle damage, icing on the wing,

93
00:05:21,120 --> 00:05:22,221
or flying in an unknown

94
00:05:22,221 --> 00:05:23,956
atmospheric environment.

95
00:05:23,956 --> 00:05:25,792
>>The aircraft
may be able to be flown but the pilot may

96
00:05:25,792 --> 00:05:28,795
or may not be able to find a solution
to how to fly that aircraft.

97
00:05:28,795 --> 00:05:32,799
>>Neural net control systems where
the controls are going to teach themselves

98
00:05:32,799 --> 00:05:34,934
and keep being smarter
from flight to flight.

99
00:05:34,934 --> 00:05:38,938
>>It can reconfigure the airplane
in an optimal way in order to give you

100
00:05:38,938 --> 00:05:40,606
the best flying qualities.

101
00:05:40,606 --> 00:05:41,507
>>...rotate..

102
00:05:41,841 --> 00:05:44,844
[Music/Background sound]

103
00:05:45,178 --> 00:05:47,080
>>There is no operator

104
00:05:47,080 --> 00:05:49,982
of the vehicle itself on the ground.

105
00:05:50,483 --> 00:05:54,587
Basically, the role that the human plays is
more in managing the mission...

106
00:05:54,587 --> 00:05:57,056
an orchestra director,
not the instrument player.

107
00:05:57,623 --> 00:06:00,960
>>...the vehicle
will complete all the autonomous actions

108
00:06:00,960 --> 00:06:05,264
necessary to release the weapon
optimally positioned to hit the target.

109
00:06:05,298 --> 00:06:06,265
>>One of the next things

110
00:06:06,265 --> 00:06:10,770
that we'll be demonstrating in UCAV
is the collaboration amongst aircraft...

111
00:06:10,970 --> 00:06:16,109
How do sets of aircraft interact
together in almost a social form?

112
00:06:16,342 --> 00:06:19,345
[Music/Background sound]

113
00:06:21,781 --> 00:06:22,715
>>We're going to examine

114
00:06:22,715 --> 00:06:27,153
the feasibility and technical utility
of actually being able to fly

115
00:06:27,186 --> 00:06:30,423
two airplanes or multiple aircraft
in formation with each other.

116
00:06:30,623 --> 00:06:34,527
>>Now, the trick to this is to make sure
that they fly in formation closely enough

117
00:06:34,527 --> 00:06:37,997
that they can extract the advantage
without obviously running into each other.

118
00:06:38,097 --> 00:06:40,466
>>The station keeping would be fairly close

119
00:06:40,466 --> 00:06:43,703
proximity for hours; the work load on
the flight crew would be quite high,

120
00:06:43,703 --> 00:06:47,106
so we started to develop autonomous
algorithms to do the station keeping,

121
00:06:47,106 --> 00:06:49,409
so you basically would have an autopilot

that you can engage.

122
00:06:49,409 --> 00:06:51,844
>>The computers are flying the airplane
without your stick

123
00:06:51,844 --> 00:06:55,314
input even in the system.
...to allow a piloted airplane

124
00:06:55,481 --> 00:06:59,952
to take two, three or four unpiloted
vehicles on a long distance trip.

125
00:07:00,186 --> 00:07:02,355
>>We're just getting started on this
technology.

126
00:07:02,355 --> 00:07:05,258
We'll use this technology
to refuel unoccupied combat

127
00:07:05,258 --> 00:07:07,660
air vehicles.

128
00:07:07,660 --> 00:07:09,295
>>...the basket is slightly moving...looks like it's going high...

129
00:07:10,596 --> 00:07:12,865
...ok it detected a miss and it came back on it's own...

130
00:07:13,366 --> 00:07:14,634
I did not do anything.

131
00:07:15,935 --> 00:07:15,301
She's got it.

132
00:07:15,935 --> 00:07:18,371
Congratulations, guys. That was fantastic.

133
00:07:18,438 --> 00:07:21,974
[Music/Background Noise]

134
00:07:23,109 --> 00:07:23,810
>>The Autonomous Soaring

135
00:07:23,810 --> 00:07:29,015
Project has one simple goal; it's to program
a small UAV to soar in thermals similar

136
00:07:29,015 --> 00:07:33,886
to the way a glider pilot or birds
do; it has been reprogramed to automatically

137
00:07:33,886 --> 00:07:37,790
detect that it's in an updraft
and then use that updraft by circling.

138
00:07:38,024 --> 00:07:40,793
There's a wide variety of applications
for this technology

139
00:07:40,793 --> 00:07:44,063
to help you UAVs do things
like forest fire detection,

140
00:07:44,530 --> 00:07:47,433
police surveillance, border patrol,
and weather monitoring.

141
00:07:48,134 --> 00:07:50,803
>>If the aircraft was damaged,
you don't have to necessarily

142
00:07:50,803 --> 00:07:54,140
just rely on the pilot to compensate
and fly the airplane...

143

00:07:54,540 --> 00:07:57,376
...adaptive flight controls,
autonomous flight controls,

144
00:07:57,643 --> 00:08:00,580
different things
where we're using the airplane

145
00:08:00,580 --> 00:08:02,348
to assist the pilot.

146
00:08:02,348 --> 00:08:06,052
>>It would take over basically the controls of the airplane as far as flight stability.

147
00:08:06,052 --> 00:08:08,621
>>The Platform Precision Autopilot is capable

148
00:08:08,621 --> 00:08:12,124
of staying on a given path
within about 15 feet.

149
00:08:12,291 --> 00:08:15,695
It allows the synthetic aperture
radar system

150
00:08:16,062 --> 00:08:19,765
to fly over
essentially the same path more than once.

151
00:08:19,899 --> 00:08:22,401
This obviously
has some potential applicability

152
00:08:22,401 --> 00:08:25,872
when you're looking at Earth surface
movements such as after an earthquake

153
00:08:25,872 --> 00:08:28,074
or if you're looking
at an ice pack melting.

154
00:08:30,510 --> 00:08:31,711
>>The F-16,

155
00:08:31,711 --> 00:08:36,682
we went out and tested the system
and based them on actual mishap cases.

156
00:08:36,849 --> 00:08:41,554
It prevented every single mishap. What
we're developing here is merely an aid

157
00:08:41,721 --> 00:08:44,490
should the pilot get distracted
or disoriented.

158
00:08:44,690 --> 00:08:49,095
By automating it, we can take out
the pilot reaction time entirely.

159
00:08:49,161 --> 00:08:52,398
>>The computer takes full control away
from the pilot for a very brief

160
00:08:52,398 --> 00:08:55,935
period of time and redirects the trajectory
of the aircraft

161
00:08:55,935 --> 00:08:57,169
to save the human.

162
00:08:57,470 --> 00:08:59,038
[Music/Background sound]

163
00:08:59,038 --> 00:09:00,106
>>ADSB is Automatic

164
00:09:00,106 --> 00:09:03,442
Dependent

Surveillance Broadcast, it's equipment on board

165
00:09:03,442 --> 00:09:07,346
an airplane that transmits its position
and velocity information twice per second.

166
00:09:07,380 --> 00:09:11,117
>>We were really trying to prove
that we could use ADSB

167
00:09:11,150 --> 00:09:15,421
as a way to do coordinated flight
between multiple vehicles.

168
00:09:15,488 --> 00:09:18,991
>>This system is present
on a lot of manned aircraft but we were

169
00:09:18,991 --> 00:09:23,062
one of the first UAS to perform
testing of it in the national airspace.

170
00:09:23,796 --> 00:09:26,832
NASA has a project for integrating UAS.

171
00:09:27,166 --> 00:09:30,269
>>So one day, UAS could hopefully fly

172
00:09:30,269 --> 00:09:34,874
with other commercial airlines
and everybody will fly together safely.

173
00:09:34,874 --> 00:09:38,711
>>There's various benefits
to integrating unmanned aircraft,

174
00:09:38,711 --> 00:09:42,315
being able to monitor
specific weather systems, monitor

175
00:09:42,648 --> 00:09:45,651
fires, delivering packages
to your doorstep...

176
00:09:46,018 --> 00:09:48,921
>>...operations to deliver medical emergency

177
00:09:49,188 --> 00:09:52,458
supplies, infrastructure
surveillance and monitoring...

178
00:09:52,725 --> 00:09:59,832
>>The technical side is a big challenge,
but being able to integrate them safely is maybe even a bigger challenge.

179
00:09:59,832 --> 00:10:01,334
>>To have thousands of these vehicles

180
00:10:01,334 --> 00:10:02,335
flying at the same time,

181
00:10:02,335 --> 00:10:03,069
you're going to have to have

182
00:10:03,069 --> 00:10:06,606
a lot more automation on the vehicle
and in the airspace system.

183
00:10:06,639 --> 00:10:08,274
>>Regulations for operations

184
00:10:08,274 --> 00:10:12,278
of the vehicle, regulations for airspace,
regulations for infrastructure.

185
00:10:12,445 --> 00:10:15,381
>>These aircraft are going to be
highly autonomous, piloted,

186
00:10:15,815 --> 00:10:18,417
optionally piloted, unpiloted vehicle.

187
00:10:18,451 --> 00:10:22,488
>>It's not just looking at the
UAM, it's actually integrating the small

188
00:10:22,488 --> 00:10:25,891
UAS, the package delivery, or even the
larger cargo delivery.

189
00:10:25,925 --> 00:10:30,262
>>Subscale aircraft, we use those for a variety of reasons
to test things like new technology,

190
00:10:30,463 --> 00:10:33,799
which could be hardware or software,
or even a completely new vehicle.

191
00:10:33,899 --> 00:10:36,969
You can do almost anything you want
without much risk,

192
00:10:37,570 --> 00:10:39,772
and you can realize those gains
very quickly.

193
00:10:39,839 --> 00:10:42,375
We're researching some level of autonomy.

194
00:10:42,375 --> 00:10:45,277
The aircraft in most cases are capable
of taking off,

195
00:10:45,745 --> 00:10:48,881
flying around, and landing
without any human intervention.

196
00:10:49,215 --> 00:10:52,385

Things like, ArduPilots and multi rotors

197
00:10:52,385 --> 00:10:55,688
and flying computers are allowing kids

198
00:10:55,688 --> 00:10:59,592
to play with research type tools
that they never had access to before.

199
00:10:59,925 --> 00:11:00,893
So it's sort of driving