
efficiency

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
00:01:39,933 --> 00:01:41,067
>>Can we get a fuel call?

22
00:01:41,067 --> 00:01:43,703
>>5.4...

23
00:01:43,837 --> 00:01:45,605

[Music/Background noise]

24
00:01:45,872 --> 00:01:50,143
>>Pollution was always something
we saw close up or not at all,

25
00:01:50,710 --> 00:01:55,849
until the National Aeronautics and Space
Administration gave us a global view

26
00:01:55,849 --> 00:01:57,150
from high above.

27
00:01:57,150 --> 00:01:59,652
>>As the world's population
continues to grow,

28
00:02:00,253 --> 00:02:05,258
our need to use our natural resources
wisely becomes more apparent and urgent.

29
00:02:05,825 --> 00:02:09,529
>>We're in an energy crisis
now and will be for some time to come.

30
00:02:09,863 --> 00:02:13,399
>>Attention all passengers, flight 307 is cancelled until further notice.

31
00:02:13,700 --> 00:02:17,437
>>We must change if we're going to have
the energy we need

32
00:02:17,437 --> 00:02:18,705
>>Until very recently,

33
00:02:18,705 --> 00:02:21,941
the priorities of aviation science
have remained unchanged.

34

00:02:21,941 --> 00:02:26,112
Only in the 1970s have the need for greater
efficiency of men and machines

35
00:02:26,112 --> 00:02:30,049
led to new and revised priorities
for aviation researchers.

36
00:02:30,316 --> 00:02:34,254
>>A new airfoil shape called
the supercritical wing is being flight

37
00:02:34,254 --> 00:02:37,657
tested aboard an extensively modified
F-8 jet aircraft.

38
00:02:37,957 --> 00:02:40,860
Almost the direct opposite of conventional
air foil shapes,

39
00:02:41,394 --> 00:02:44,030
the supercritical wing
has a flattened top surface-

40
00:02:44,297 --> 00:02:48,067
>>The new shape weakens
the shockwave that normally builds on top

41
00:02:48,067 --> 00:02:49,836
of conventional wings during flight,

42
00:02:49,836 --> 00:02:52,172
>>allowing the aircraft to fly faster,

43
00:02:52,305 --> 00:02:54,941
more smoothly and at lower
operating costs.

44
00:02:55,241 --> 00:02:58,978
>>And that concept ended up

making a significant contribution

45
00:02:58,978 --> 00:03:03,349
the supercritical wings are today used on almost every transport manufactured.

46
00:03:03,883 --> 00:03:08,688
>>We had the supercricial wing F-111, which did supercritical wing demonstration.

47
00:03:10,523 --> 00:03:11,191
>>The wings may be

48
00:03:11,191 --> 00:03:15,028
adjusted to various angles to achieve
optimum performance at different speeds.

49
00:03:15,261 --> 00:03:20,099
>>Studies indicate that if the design
features of the oblique wing were applied

50
00:03:20,099 --> 00:03:23,903
to full size jets, it would give them increased fuel economy.

51
00:03:24,137 --> 00:03:26,372
>>The piloted version
is now being built.

52
00:03:26,372 --> 00:03:27,707
>>The AD-1:

53
00:03:28,007 --> 00:03:29,576
During takeoff and landing,

54
00:03:29,576 --> 00:03:33,112
the wing can be positioned at right angles
to the body for maximum lift.

55
00:03:33,746 --> 00:03:35,882
But as the aircraft picks up speed,

56
00:03:36,649 --> 00:03:39,152
the wing can be pivoted to cut down drag

57
00:03:39,652 --> 00:03:41,754
and therefore fuel usage.

58
00:03:41,754 --> 00:03:42,956
[Music/Airplane flying]

59
00:03:42,956 --> 00:03:47,293
Another project geared to improve
aerodynamic efficiency was winglets

60
00:03:47,694 --> 00:03:51,231
engineers modified this KC-135 transport

61
00:03:51,231 --> 00:03:54,133
by mounting vertical extensions
on its wingtips.

62
00:03:54,667 --> 00:03:58,338
>>These winglets act to increase lift and
lower drag.

63
00:03:58,338 --> 00:04:00,340
>>Winglets cut wind resistance.

64
00:04:00,974 --> 00:04:05,979
NASA's scientists developed the advanced
winglet technology to cut wing drag,

65
00:04:06,379 --> 00:04:09,916
thereby increasing
air speed and cutting fuel consumption.

66
00:04:10,350 --> 00:04:14,287
>>Dryden researchers are using an F-111
to study ways of developing

67
00:04:14,287 --> 00:04:18,324
more efficient wing shapes.
In the natural laminar flow experiment,

68
00:04:18,391 --> 00:04:21,027
they modified the plane’s
outer wing panels.

69
00:04:21,160 --> 00:04:25,632
This new wing shape eliminated turbulent
air flow over much of the wing surface.

70
00:04:27,333 --> 00:04:29,202
>>For functional versatility,

71
00:04:29,202 --> 00:04:32,805
one of the most promising ideas tested
here is the tilt rotor.

72
00:04:33,106 --> 00:04:38,144
>>The XV-15 research aircraft combines
the vertical take off capability

73
00:04:38,144 --> 00:04:43,983
of the helicopter with the speed, range
and fuel economy of a turboprop airplane.

74
00:04:44,617 --> 00:04:48,054
These types of aircraft use less room
for takeoff and landing

75
00:04:48,254 --> 00:04:52,592
and keep noise and air pollution lower
than our present commercial planes.

76
00:04:52,592 --> 00:04:54,294
[Truck driving]

77
00:04:54,294 --> 00:04:56,362

>With the continuing fuel problems,

78
00:04:56,362 --> 00:04:59,599
engineers are attempting
to make the big trucks more efficient.

79
00:05:00,233 --> 00:05:04,003
It's believed that both trucks
and recreational vehicles can be made more

80
00:05:04,003 --> 00:05:05,638
economical to operate.

81
00:05:05,638 --> 00:05:08,641
>>Means of achieving
aerodynamic efficiency on aircraft

82
00:05:08,641 --> 00:05:11,577
isn't that different than it is
on automobiles and trucks.

83
00:05:11,878 --> 00:05:15,815
>>Starting with a small delivery van, Ed Saltzman and his team of engineers

84
00:05:15,815 --> 00:05:17,850
reshaped the vehicle with sheet metal.

85
00:05:18,217 --> 00:05:21,354
>>The aerodynamic improvements
that we've experienced so far

86
00:05:21,654 --> 00:05:26,459
are translatable into 15%,
perhaps 20%, savings in fuel.

87
00:05:26,492 --> 00:05:30,263
>>The researchers are hopeful
as they continue to apply aerodynamic

88

00:05:30,263 --> 00:05:33,833
techniques to help solve
a ground transportation problem.

89
00:05:36,836 --> 00:05:38,137
>>During the 1970s

90
00:05:38,137 --> 00:05:41,908
in the aviation field,
fuel rose from the least expensive

91
00:05:41,908 --> 00:05:45,678
operating costs for commercial airlines
to the most expensive.

92
00:05:45,945 --> 00:05:49,415
By 1979, the cost of fuel quadrupled.

93
00:05:49,615 --> 00:05:53,419
[Music/Background noise]

94
00:05:53,753 --> 00:05:56,789
>>A digital fly-by-wire
flight control system

95
00:05:57,023 --> 00:06:01,227
crucial to automation of the X-Wing’s
flight mode, conversion and circulation

96
00:06:01,227 --> 00:06:05,832
control aerodynamics has reached
the laboratory test phase.

97
00:06:05,832 --> 00:06:11,604
>>Has the dream of combining the best attributes of both
helicopter and airplane been realized?

98
00:06:11,938 --> 00:06:14,974
>>The X-Wing system will begin flight tests later

99
00:06:14,974 --> 00:06:18,378
this year to investigate
advanced rotor concepts.

100
00:06:18,711 --> 00:06:23,116
Its broad range of mission
capabilities capitalize on its ability

101
00:06:23,216 --> 00:06:27,053
to combine the unique
hovering qualities of a helicopter

102
00:06:27,453 --> 00:06:30,890
with the high cruise
speed and range of an airplane.

103
00:06:32,091 --> 00:06:34,727
>>The F-14 variable-sweep transition flight experiment

104
00:06:34,761 --> 00:06:38,464
was originated to obtain accurate
in-flight measurements of the boundary

105
00:06:38,464 --> 00:06:42,001
layer transition location
for wing airfoil pressure gradients,

106
00:06:42,068 --> 00:06:45,171
the wing panels of the F-14 were modified
to maintain laminar

107
00:06:45,171 --> 00:06:47,140
flow to a significant extent.

108
00:06:47,140 --> 00:06:49,142
[Music/Background noise]

109
00:06:49,142 --> 00:06:52,311
>>Because of the energy

crisis, I was working on the Jetstar,

110
00:06:52,378 --> 00:06:56,282
we took the wing tanks off the Jetstar
and we put an experiment

111
00:06:56,282 --> 00:06:59,685
for laminar flow control, this was like
subsonic laminar flow control.

112
00:06:59,886 --> 00:07:03,990
>>Birds change the shape of their wings
according to various flight conditions,

113
00:07:04,590 --> 00:07:08,895
>>The ideal wing
would have a smooth contour, upper surface

114
00:07:09,562 --> 00:07:14,267
and be able to rapidly
and precisely change its shape to provide

115
00:07:14,267 --> 00:07:17,837
minimum drag for the amount of lift
being commanded by the pilot.

116
00:07:18,371 --> 00:07:22,241
The Wright brothers
and their Wright Flier also used wing warping,

117
00:07:22,308 --> 00:07:25,711
so the idea is not new, it's
just that the technology

118
00:07:25,711 --> 00:07:29,382
has now developed to the point
where it is practical.

119
00:07:29,715 --> 00:07:32,084
>>This is the Mission Adaptive Wing.

120
00:07:33,019 --> 00:07:37,323
This flexibility is possible
because we now have composite materials

121
00:07:37,690 --> 00:07:41,260
that will withstand nearly
continuous bending without fatiguing

122
00:07:41,694 --> 00:07:45,331
and lightweight digital computers
that can operate at speeds

123
00:07:45,331 --> 00:07:47,166
sufficient to control the wing.

124
00:07:47,166 --> 00:07:48,968
Through in-flight contour changes,

125
00:07:49,268 --> 00:07:53,206
internal mechanisms bend flexible
leading and trailing edge surfaces

126
00:07:53,539 --> 00:07:56,642
to the appropriate
curvatures required to maintain

127
00:07:56,642 --> 00:07:59,712
the optimal aerodynamic
effectiveness at all times.

128
00:08:00,780 --> 00:08:02,682
The Mission Adaptive Wing:

129
00:08:02,682 --> 00:08:06,819
An attractive technology
for future military aircraft.

130
00:08:07,119 --> 00:08:10,189

>>It's really the first time
that a wing could actually provide

131
00:08:10,223 --> 00:08:13,392
optimum performance throughout
a very large part of the flight envelope.

132
00:08:14,327 --> 00:08:19,265
>>The C-140 Jetstar currently is test
flying an advanced propeller model,

133
00:08:19,398 --> 00:08:23,302
which should lead to considerable
fuel savings in future aircraft.

134
00:08:24,103 --> 00:08:27,673
>>Basically, a forward-swept wing
design is potentially more efficient

135
00:08:27,673 --> 00:08:29,609
in the transonic speed regime.

136
00:08:29,609 --> 00:08:32,712
The forward-swept
wing has a supercritical cross-section

137
00:08:33,079 --> 00:08:37,450
about one third the thickness of a typical
supercritical wing...a discreet

138
00:08:37,450 --> 00:08:40,953
variable camber device is installed
on the trailing edge of the wing.

139
00:08:44,891 --> 00:08:47,860
Set back on the fuselage,
the forward-swept wing

140
00:08:47,860 --> 00:08:51,697
configuration also affords a more flexible

payload distribution,

141
00:08:52,265 --> 00:08:55,234
which makes for a smaller,
lighter aircraft.

142
00:08:55,968 --> 00:08:58,404
Tactically tougher to see.

143
00:08:58,404 --> 00:09:02,575
Economically less costly
to build, operate and support.

144
00:09:02,575 --> 00:09:05,811
[Music/F-16s taking off]

145
00:09:05,811 --> 00:09:07,446
>>The F-16 XL aircraft

146
00:09:07,446 --> 00:09:11,384
is uniquely characterized
by its large cranked arrow wing.

147
00:09:11,484 --> 00:09:15,688
The aircraft can be used by NASA
as testbeds to evaluate aerodynamic

148
00:09:15,688 --> 00:09:20,493
concepts designed to improve wing airflow
during sustained supersonic flight.

149
00:09:20,860 --> 00:09:23,729
>>We know that we can get laminar flow
an inch or so back.

150
00:09:23,763 --> 00:09:24,830
Now we're trying to maintain it

151
00:09:24,830 --> 00:09:28,234

further aft, and in order to maintain
the laminar flow further aft, we have to

152
00:09:28,634 --> 00:09:31,971
come up with some method of augmentation
and that's why we're using

153
00:09:32,238 --> 00:09:35,975
suction, to actually
pull the boundary layer back down and

154
00:09:36,042 --> 00:09:37,109
re-laminarize the boundary layer.

155
00:09:37,109 --> 00:09:39,645
>>We’ve actually
perforated the surface of the wing

156
00:09:39,812 --> 00:09:42,348
with millions of microscopic holes,

157
00:09:42,715 --> 00:09:46,986
and we suck a portion of the airflow away
from the wing to help keep it stable.

158
00:09:47,153 --> 00:09:50,056
>>If you maintain laminar flow
for a larger distance,

159
00:09:50,056 --> 00:09:51,991
you can reduce the drag of an air foil.

160
00:09:51,991 --> 00:09:54,860
If you can reduce the drag,
you can increase your fuel efficiency.

161
00:09:54,860 --> 00:09:58,564
If you can increase your fuel efficiency,
you can increase your payload capability.

162
00:09:59,131 --> 00:10:01,200
And you know, it's
just a whole raft of things

163
00:10:01,200 --> 00:10:03,369
that come out of being
able to maintain laminar flow.

164
00:10:05,938 --> 00:10:07,340
>>Ailerons are normally used

165
00:10:07,340 --> 00:10:10,443
to roll the aircraft,
which is then used to turn the aircraft.

166
00:10:10,643 --> 00:10:11,978
We intend to use only

167
00:10:11,978 --> 00:10:16,382
the outboard ailerons
and move them together, both up or both down

168
00:10:16,649 --> 00:10:20,853
to change the tailoring of the wings so
as to optimize the flow characteristics.

169
00:10:20,853 --> 00:10:26,392
[Music/Background noise]

170
00:10:26,392 --> 00:10:28,060
>>I can deflect the inboard section

171
00:10:28,060 --> 00:10:31,330
downwards while deflecting the outward
section upwards.

172
00:10:31,731 --> 00:10:35,201
This will create an unbalanced force
on the wing, thereby

173
00:10:35,201 --> 00:10:39,372
twisting the structure in a new way-
different than we've seen before.

174
00:10:39,639 --> 00:10:42,675
>>These morphing structures of the future
are likely going to be able

175
00:10:42,675 --> 00:10:45,911
to sense the environment
and adapt, change their shape

176
00:10:46,212 --> 00:10:48,314
to particular flight conditions.

177
00:10:48,314 --> 00:10:50,149
>>The designer will be able to take material out,

178
00:10:50,149 --> 00:10:53,953
make the wing thinner ,
and it makes it a more efficient wing.

179
00:10:54,787 --> 00:10:57,623
>>This is a project that's trying to see

180
00:10:57,623 --> 00:11:01,727
if there's an advantage to flying two
or more aircraft in formation,

181
00:11:01,727 --> 00:11:03,262
much like flocks of birds.

182
00:11:04,263 --> 00:11:06,699
>>Every wing creates a wingtip vortex.

183
00:11:06,766 --> 00:11:09,902
And if you can put your airplane
on the part that's going up,

184
00:11:10,436 --> 00:11:12,338
then it's just like riding
a wave at the beach.

185
00:11:12,338 --> 00:11:15,975
>>The lead aircraft signals its position
to the follower with a wireless modem.

186
00:11:16,042 --> 00:11:18,010
You couldn't do this without fly-by-wire.

187
00:11:18,010 --> 00:11:19,745
The vortex can be so strong

188
00:11:19,745 --> 00:11:22,615
that a conventional flight control
system, it'll flip you out.

189
00:11:22,615 --> 00:11:26,519
>>But it's a high energy source,
and if we can properly map

190
00:11:26,519 --> 00:11:28,020
it and know where it is

191
00:11:28,020 --> 00:11:29,922
and then use that energy to our advantage...

192
00:11:29,922 --> 00:11:32,291
>>We're expecting to extract out

193
00:11:32,558 --> 00:11:35,961
a 10% drag reduction,
at least a 10% drag reduction...

194
00:11:36,962 --> 00:11:40,499
>>It's one of the first times that this has
ever been tried with a civilian airplane.

195
00:11:40,499 --> 00:11:43,836
>>What we wanted to
expand was to use production

196
00:11:43,836 --> 00:11:46,972
autopilots, the FAA mandated data link...

197
00:11:47,306 --> 00:11:48,474
>>Let's go ahead and try to step in

198
00:11:48,474 --> 00:11:49,542
toward the wake...

199
00:11:49,542 --> 00:11:52,411
>>...ways that you can improve the efficiency of vehicles

200
00:11:52,411 --> 00:11:54,113
by not changing the vehicles at all,

201
00:11:54,113 --> 00:11:57,950
but by changing how we use them,
or operational efficiencies.

202
00:11:58,117 --> 00:11:58,751
Even if you didn't

203
00:11:58,751 --> 00:12:01,821
want to fly in the wake, if you wanted
to, for instance, avoid the wake,

204
00:12:01,821 --> 00:12:04,690
you could still fly closer
than what is currently allowed.

205
00:12:04,690 --> 00:12:06,559
[Music/Background noise]

206

00:12:06,559 --> 00:12:11,130
>>BWB is a combination between
a regular aircraft and a flying wing

207
00:12:11,363 --> 00:12:14,467
>>It actually has a lower drag
than a conventional aircraft.

208
00:12:15,601 --> 00:12:18,237
>>It's like a hybrid car
compared to a regular car.

209
00:12:18,270 --> 00:12:21,841
You're getting 20 to 30%
better fuel efficiency.

210
00:12:22,808 --> 00:12:26,479
>>By understanding boundary layer transition,
we can increase our understanding

211
00:12:26,479 --> 00:12:27,780
and our predictive capability

212
00:12:27,780 --> 00:12:31,217
for all types of aircraft,
both for civil and for military aircraft.

213
00:12:31,917 --> 00:12:34,386
>>People take it for granted nowadays
that an airplane needs a rudder

214
00:12:34,386 --> 00:12:36,455
in order to turn.
Think of every bird you've ever seen.

215
00:12:36,455 --> 00:12:37,757
None of them have rudders.

216
00:12:37,757 --> 00:12:41,994
The PRANDTL-D aircraft is designed

with a certain twist in its wing...

217
00:12:42,027 --> 00:12:43,796
>>...a different lift distribution,

218
00:12:43,796 --> 00:12:45,364
>>... a new span load on the wings.

219
00:12:45,397 --> 00:12:48,501
>>What we're really looking for
is the positive correlation

220
00:12:48,501 --> 00:12:50,536
between roll and yaw.

221
00:12:50,536 --> 00:12:52,371
>>PRANDTL does not need winglets,

222
00:12:52,371 --> 00:12:54,507
It does not need a vertical tail...

223
00:12:54,573 --> 00:12:56,809
>>...and there's only two control surfaces.

224
00:12:56,809 --> 00:12:59,945
The design of PRANDTL minimizes drag.

225
00:13:00,946 --> 00:13:02,248
>>This doesn't have any hinges.

226
00:13:02,248 --> 00:13:05,384
It just bends. It morphs itself,
if you will, sort of like a bird flies.

227
00:13:05,384 --> 00:13:08,687
>>The efficiency of this technology
is very significant,

228

00:13:08,821 --> 00:13:10,689
and it results in a fuel savings up

229
00:13:10,689 --> 00:13:13,392
to hundreds of millions of dollars
of fuel savings a year.

230
00:13:13,392 --> 00:13:15,060
[Music/Background noise]

231
00:13:15,060 --> 00:13:17,863
>>A traditional wing has one flap
and one aileron per wing.

232
00:13:17,997 --> 00:13:21,534
We broke those up into segments
and that allows us to reshape the load

233
00:13:21,534 --> 00:13:25,104
using localized input or small inputs
rather than the whole control surface.

234
00:13:25,771 --> 00:13:29,909
>>We'd like to develop some research
that can be used to minimize the amount

235
00:13:29,909 --> 00:13:33,245
that structures deflect, minimize
the amount that structures vibrate.

236
00:13:34,113 --> 00:13:37,583
>>It's in an attempt to redistribute the
load into a more favorable configuration.

237
00:13:37,817 --> 00:13:40,953
That configuration will allow for
lighter weight structures in the future.

238
00:13:41,520 --> 00:13:42,688
>>The first step towards wing

239
00:13:42,688 --> 00:13:46,225
shape control is knowing
what the position of that wing is

240
00:13:46,592 --> 00:13:49,929
so that can be fed into a control system
to then control the shape.

241
00:13:50,429 --> 00:13:54,433
>>Conventional sensor technology allows you
to make a measurement every several feet.

242
00:13:55,034 --> 00:13:55,968
The FOSS technology

243
00:13:55,968 --> 00:13:59,672
allows you to have a sensor every quarter
inch along a single optical fiber

244
00:14:00,272 --> 00:14:04,343
that allows you to look more and more
like a biological system. If you can save

245
00:14:04,343 --> 00:14:07,613
a few pounds of instrumentation mass or lead wire mass,

246
00:14:08,080 --> 00:14:10,783
that's more fuel and less cost.

247
00:14:11,150 --> 00:14:14,019
That fiber can remain on the vehicle
throughout its life.

248
00:14:14,086 --> 00:14:18,691
>>Now, aircraft are taken out of service
and maintenance inspections are being

249
00:14:18,991 --> 00:14:21,527

applied to that at given intervals.

250
00:14:21,694 --> 00:14:24,830
Wouldn't it be better
to take an aircraft out of service

251
00:14:25,030 --> 00:14:30,169
when your management computer has told you
that it's time for service, and here’s why?

252
00:14:30,169 --> 00:14:33,072
The FOSS is capable
of measuring critical parameters

253
00:14:33,072 --> 00:14:38,310
such as temperature,
strain, liquid level, loads and deflection,

254
00:14:38,611 --> 00:14:42,781
>>I believe can really revolutionize
the way we do our business in aerospace.

255
00:14:42,781 --> 00:14:47,152
And it has that spillover effect
that can go into other types of industries

256
00:14:47,453 --> 00:14:50,990
like oil and gas, ship building and health
monitoring, high rise