1
00:00:00,000 --> 00:01:14,330
you

2
00:01:19,350 --> 00:01:17,430
at NASA Ames Research Center our basic

3
00:01:21,600 --> 00:01:19,360
product is information information is

4
00:01:24,210 --> 00:01:21,610
produced in the form of reports

5
00:01:27,780 --> 00:01:24,220
technical reports publications and also

6
00:01:29,370 --> 00:01:27,790
computer software we export hundreds of

7
00:01:31,469 --> 00:01:29,380
computer programs each year to the

8
00:01:33,360 --> 00:01:31,479
aerospace industry to be used by them to

9
00:01:35,520 --> 00:01:33,370
help them in their design process of

10
00:01:38,010 --> 00:01:35,530
various vehicle components or

11
00:01:39,719 --> 00:01:38,020
configurations the technology developed

12
00:01:41,520 --> 00:01:39,729
here at NASA Ames Research Center in the

13
00:01:43,109 --> 00:01:41,530

form of computational simulation

14
00:01:46,440 --> 00:01:43,119
software can benefit the aerospace

15
00:01:48,450 --> 00:01:46,450
industry by helping them produce safer

16
00:01:50,700 --> 00:01:48,460
and more fuel-efficient aircraft and

17
00:01:51,810 --> 00:01:50,710
also producing those aircraft at a

18
00:01:54,630 --> 00:01:51,820
reduced cost

19
00:01:57,450 --> 00:01:54,640
there are basically three aerodynamic

20
00:02:00,330 --> 00:01:57,460
simulation scientists that exist there's

21
00:02:02,430 --> 00:02:00,340
flight testing there's experimental

22
00:02:04,620 --> 00:02:02,440
testing and then there's computational

23
00:02:08,160 --> 00:02:04,630
fluid dynamics each has its advantages

24
00:02:10,229 --> 00:02:08,170
and disadvantages used together that's

25
00:02:12,840 --> 00:02:10,239
what we call computation to flight which

26
00:02:15,120 --> 00:02:12,850
is one of the visions at NASA's Ames

27
00:02:17,790 --> 00:02:15,130
Research Center computational fluid

28
00:02:20,820 --> 00:02:17,800
dynamics is used to complement both

29
00:02:22,680 --> 00:02:20,830
experimental and flight testing we can

30
00:02:25,410 --> 00:02:22,690
sometimes use computational fluid

31
00:02:27,120 --> 00:02:25,420
dynamics to do smart experimental

32
00:02:28,949 --> 00:02:27,130
testing in other words eliminate the

33
00:02:31,890 --> 00:02:28,959
need for doing a lot of repetitive

34
00:02:34,680 --> 00:02:31,900
testing and only test at very important

35
00:02:36,780 --> 00:02:34,690
or very critical test conditions we can

36
00:02:38,190 --> 00:02:36,790
do the same thing with flight testing as

37
00:02:40,320 --> 00:02:38,200
you know flight testing is a very

38
00:02:43,320 --> 00:02:40,330

expensive process we can use

39
00:02:45,330 --> 00:02:43,330
computational fluid dynamics to help

40
00:02:47,759 --> 00:02:45,340
augment that testing program and the

41
00:02:49,170 --> 00:02:47,769
data that it's produced the computers

42
00:02:51,150 --> 00:02:49,180
that are used to generate some of the

43
00:02:52,650 --> 00:02:51,160
results that you see today are contained

44
00:02:54,780 --> 00:02:52,660
in our NASA building the numerical

45
00:02:57,270 --> 00:02:54,790
aerodynamic simulation facility they

46
00:02:59,430 --> 00:02:57,280
included a crate to computer and a Cray

47
00:03:02,160 --> 00:02:59,440
ymp computer these are two of the

48
00:03:04,470 --> 00:03:02,170
fastest computers in the world today the

49
00:03:06,470 --> 00:03:04,480
process by which we perform CFD

50
00:03:08,910 --> 00:03:06,480
simulations involves first of all

51
00:03:11,190 --> 00:03:08,920
defining the geometry forgetting

52
00:03:12,930 --> 00:03:11,200
that geometry into the computer the next

53
00:03:15,570 --> 00:03:12,940
step involves discretizing the flow

54
00:03:17,190 --> 00:03:15,580
field about that configuration once that

55
00:03:19,589 --> 00:03:17,200
flow field is discretized then we can

56
00:03:22,740 --> 00:03:19,599
apply a flow solver in order to compute

57
00:03:24,870 --> 00:03:22,750
the flow about that configuration that's

58
00:03:28,440 --> 00:03:24,880
generates an enormous amount of data and

59
00:03:32,250 --> 00:03:28,450
we use graphics workstations to reduce

60
00:03:33,930 --> 00:03:32,260
that data and produce the results once

61
00:03:36,390 --> 00:03:33,940
that technology has been validated

62
00:03:38,070 --> 00:03:36,400
against experimental data and we

63
00:03:50,309 --> 00:03:38,080

disseminate that technology for

64
00:03:52,620 --> 00:03:50,319
industries use during launch of the

65
00:03:54,990 --> 00:03:52,630
space shuttle provisions have been made

66
00:03:57,780 --> 00:03:55,000
to employ an abort mode in case of

67
00:04:01,320 --> 00:03:57,790
emergency one of the elements of this

68
00:04:03,930 --> 00:04:01,330
abort mode is known as fast step fast

69
00:04:05,370 --> 00:04:03,940
SEP is the fast separation of Shuttle

70
00:04:08,250 --> 00:04:05,380
Orbiter from the rest of the launch

71
00:04:10,110 --> 00:04:08,260
vehicle as the shuttle goes through the

72
00:04:11,840 --> 00:04:10,120
launch sequence we will look at the

73
00:04:15,000 --> 00:04:11,850
results of two different numerical

74
00:04:18,300 --> 00:04:15,010
simulations the first occurs during

75
00:04:21,360 --> 00:04:18,310
ascent as the shuttle passes through the

76
00:04:23,070 --> 00:04:21,370
transonic range the external tanks of

77
00:04:25,760 --> 00:04:23,080
the rocket motors experience a

78
00:04:28,380 --> 00:04:25,770
hysteresis effect due to shock movement

79
00:04:32,310 --> 00:04:28,390
since the Mach number is changing from

80
00:04:34,980 --> 00:04:32,320
0.8 to 1.0 to over 6 seconds as shown

81
00:04:37,620 --> 00:04:34,990
here the unsteady flow field that

82
00:04:40,080 --> 00:04:37,630
evolves around the vehicle lags behind

83
00:04:53,280 --> 00:04:40,090
what it would be for steady flow or a

84
00:04:57,630 --> 00:04:55,920
notice the shock development shown by

85
00:05:28,650 --> 00:04:57,640
the pressure contours on the leading

86
00:05:58,260 --> 00:05:31,920
on the base of the tank we see a highly

87
00:06:03,150 --> 00:06:01,080
the second numerical simulation occurs

88
00:06:06,900 --> 00:06:03,160

at about two minutes into the flight at

89
00:06:09,600 --> 00:06:06,910
an elevation of about 50,000 meters at

90
00:06:12,180 --> 00:06:09,610
this time the solid rocket boosters or

91
00:06:15,390 --> 00:06:12,190
SRBs fall away from the tank and the

92
00:06:17,999 --> 00:06:15,400
orbiter these bodies moving relative to

93
00:06:22,129 --> 00:06:18,009
each other make analysis using other

94
00:06:28,499 --> 00:06:24,570
notice the interaction of the pressure

95
00:06:30,570 --> 00:06:28,509
contours as separation occurs visible

96
00:06:32,640 --> 00:06:30,580
under the body of the shuttle are the

97
00:06:35,610 --> 00:06:32,650
pressure contours created by shockwave

98
00:06:41,570 --> 00:06:35,620
interaction between the orbiter the

99
00:06:46,740 --> 00:06:44,700
Robert mecan research scientist and

100
00:06:49,680 --> 00:06:46,750
member of the NASA Ames space shuttle

101
00:06:52,710 --> 00:06:49,690
flow simulation team explains the work

102
00:06:55,740 --> 00:06:52,720
done with a solid rocket booster or SRB

103
00:06:58,649 --> 00:06:55,750
as a stepping stone to simulating fast

104
00:07:02,370 --> 00:06:58,659
set K the work that the Space Shuttle

105
00:07:05,939 --> 00:07:02,380
Group at Ames they interact with the

106
00:07:07,860 --> 00:07:05,949
Johnson Space Center and we're doing

107
00:07:09,839 --> 00:07:07,870
numerical simulations of various

108
00:07:12,510 --> 00:07:09,849
conditions of the shuttle during during

109
00:07:14,219 --> 00:07:12,520
the ascent of course there's a great

110
00:07:16,290 --> 00:07:14,229
deal of wind tunnel data that's

111
00:07:20,219 --> 00:07:16,300
available and also flight data that's

112
00:07:23,249 --> 00:07:20,229
been accumulated over the flight history

113
00:07:25,680 --> 00:07:23,259

of the shuttle and the shuttle group

114
00:07:27,510 --> 00:07:25,690
here at Ames is augmenting the data that

115
00:07:29,640 --> 00:07:27,520
there is they're filling in missing data

116
00:07:31,890 --> 00:07:29,650
and carrying out calculations that

117
00:07:34,680 --> 00:07:31,900
really aren't possible to model in any

118
00:07:36,809 --> 00:07:34,690
other way path SEP being one of those

119
00:07:46,060 --> 00:07:36,819
cases but really there's no other way to

120
00:07:50,270 --> 00:07:48,230
Computers now have primary controller

121
00:07:52,400 --> 00:07:50,280
critics like turbo pump is the main

122
00:07:54,350 --> 00:07:52,410
element in a rocket engine that supplies

123
00:07:57,350 --> 00:07:54,360
fuel from the fuel tank to the

124
00:07:59,000 --> 00:07:57,360
combustion chamber an important

125
00:08:02,870 --> 00:07:59,010
component in the turbo pump is the

126
00:08:05,660 --> 00:08:02,880
inducer a massive flow separation or

127
00:08:08,600 --> 00:08:05,670
cavitation in the inducer can block the

128
00:08:19,580 --> 00:08:08,610
fuel supply and result in total engine

129
00:08:22,070 --> 00:08:19,590
failure see kwan-yuen a senior research

130
00:08:25,400 --> 00:08:22,080
scientist of mcat institute at ames

131
00:08:27,560 --> 00:08:25,410
research center explains a computational

132
00:08:31,550 --> 00:08:27,570
study of this kind of problem was

133
00:08:33,500 --> 00:08:31,560
impractical even on supercomputers since

134
00:08:36,560 --> 00:08:33,510
the existing computer programs were not

135
00:08:39,080 --> 00:08:36,570
fast enough the objective of our project

136
00:08:41,510 --> 00:08:39,090
is to develop a very efficient computer

137
00:08:44,500 --> 00:08:41,520
program which can give a direct impact

138
00:08:47,780 --> 00:08:44,510

on the design of future rocket engines

139
00:08:50,720 --> 00:08:47,790
shown here is the actual hardware of the

140
00:08:53,420 --> 00:08:50,730
space shuttle main engine the turbo pump

141
00:08:55,430 --> 00:08:53,430
consists of an inducer with a stationary

142
00:09:01,820 --> 00:08:55,440
casing and a shrouded impeller with

143
00:09:04,670 --> 00:09:01,830
partial blades in this

144
00:09:06,980 --> 00:09:04,680
computer-generated image we remove the

145
00:09:08,780 --> 00:09:06,990
shroud and view the inducer and partial

146
00:09:11,730 --> 00:09:08,790
blades of the impeller

147
00:09:14,520 --> 00:09:11,740
we can see a pressure gradient across

148
00:09:21,990 --> 00:09:14,530
the blades as well as along the hub due

149
00:09:26,759 --> 00:09:24,840
the particle traces over the suction

150
00:09:29,819 --> 00:09:26,769
side of the blade and through the tip

151
00:09:31,800 --> 00:09:29,829
clearance are seen here particles over

152
00:09:34,439 --> 00:09:31,810
the pressure side of the blade shown in

153
00:09:38,519 --> 00:09:34,449
purple are sucked into the tip clearance

154
00:09:40,949 --> 00:09:38,529
and become the leakage flow the

155
00:09:45,420 --> 00:09:40,959
streamwise particle flow is shown in

156
00:09:48,509 --> 00:09:45,430
green the interaction of the leakage and

157
00:09:57,980 --> 00:09:48,519
screen wise flows results in a region of

158
00:10:00,179 --> 00:09:57,990
concentrated vorticity dough john kwok

159
00:10:02,280 --> 00:10:00,189
research scientist with the applied

160
00:10:04,379 --> 00:10:02,290
computation of fluids branch of Ames

161
00:10:07,230 --> 00:10:04,389
Research Center and group leader for

162
00:10:10,769 --> 00:10:07,240
this project continues the explanation

163
00:10:13,889 --> 00:10:10,779

power pump is especially one key area we

164
00:10:16,860 --> 00:10:13,899
can improve the performance aircraft

165
00:10:19,309 --> 00:10:16,870
engine normally performs in the

166
00:10:22,439 --> 00:10:19,319
efficiencies in the 90 percentile range

167
00:10:25,679 --> 00:10:22,449
typically total pumper operates in 80

168
00:10:28,410 --> 00:10:25,689
percentile efficiency range so there

169
00:10:32,280 --> 00:10:28,420
suddenly we can see lots of room to

170
00:10:37,019 --> 00:10:32,290
improve so shuttle can be benefited by

171
00:10:39,059 --> 00:10:37,029
this computational simulation and by

172
00:10:42,540 --> 00:10:39,069
improving the performance and improving

173
00:10:44,490 --> 00:10:42,550
their reliability and eventually we will

174
00:10:54,550 --> 00:10:44,500
meet the high launch capability in the

175
00:10:59,510 --> 00:10:57,590
recent advances in heart surgery have

176
00:11:01,820 --> 00:10:59,520
led to the development of the artificial

177
00:11:05,000 --> 00:11:01,830
heart and the use of artificial heart

178
00:11:07,130 --> 00:11:05,010
valves at the same time technology

179
00:11:08,870 --> 00:11:07,140
developed to compute the flow in

180
00:11:11,780 --> 00:11:08,880
components of the space shuttle main

181
00:11:13,940 --> 00:11:11,790
engine is being applied to simulate the

182
00:11:18,470 --> 00:11:13,950
unsteady flow in the Penn State

183
00:11:20,600 --> 00:11:18,480
artificial heart Joe John Kwok explains

184
00:11:23,810 --> 00:11:20,610
NASA's involvement in this spin-off

185
00:11:26,360 --> 00:11:23,820
technology in general we are interested

186
00:11:29,150 --> 00:11:26,370
in reapplying NASA develop technology

187
00:11:31,460 --> 00:11:29,160
especially the CFD technology can be

188
00:11:34,220 --> 00:11:31,470

reapplied in many different instances

189
00:11:36,560 --> 00:11:34,230
and artificial heart is that it it's

190
00:11:39,140 --> 00:11:36,570
particularly interesting because it will

191
00:11:41,270 --> 00:11:39,150
help national health problem and the

192
00:11:46,310 --> 00:11:41,280
demand for this type of mechanical

193
00:11:48,260 --> 00:11:46,320
device can really contribute to to human

194
00:11:49,480 --> 00:11:48,270
health and also animal health in the

195
00:11:52,580 --> 00:11:49,490
future

196
00:11:54,860 --> 00:11:52,590
Chetan Kyra's and Stuart Rogers research

197
00:11:56,140 --> 00:11:54,870
scientists were responsible for the flow

198
00:11:59,390 --> 00:11:56,150
code on this project

199
00:12:01,340 --> 00:11:59,400
Stewart Rogers further explains the data

200
00:12:02,990 --> 00:12:01,350
we started with in this case was

201
00:12:04,580 --> 00:12:03,000
basically taken straight off of

202
00:12:07,760 --> 00:12:04,590
blueprints which were used to build

203
00:12:10,910 --> 00:12:07,770
models of this heart which were tested

204
00:12:15,200 --> 00:12:10,920
by Penn State given the blueprints from

205
00:12:18,170 --> 00:12:15,210
that model we then generated a series of

206
00:12:20,180 --> 00:12:18,180
codes which would then describe that

207
00:12:22,400 --> 00:12:20,190
shape to the computer as a series of

208
00:12:24,230 --> 00:12:22,410
discrete points once we had those

209
00:12:26,600 --> 00:12:24,240
discrete points then our flow solver

210
00:12:39,310 --> 00:12:26,610
could take them and compute the flow

211
00:12:43,639 --> 00:12:41,900
here we see the main chamber of the

212
00:12:46,579 --> 00:12:43,649
heart and the particle traces which

213
00:12:49,040 --> 00:12:46,589

indicate the flow the color of the

214
00:13:07,490 --> 00:12:49,050
traces indicates the release height at

215
00:13:09,740 --> 00:13:07,500
the inflow valve opening this is the

216
00:13:13,040 --> 00:13:09,750
computer-generated image of the tilting

217
00:13:14,900 --> 00:13:13,050
disk heart valve this valve can be used

218
00:13:19,970 --> 00:13:14,910
in conjunction with an artificial heart

219
00:13:22,220 --> 00:13:19,980
or used as a separate device the inflow

220
00:13:24,320 --> 00:13:22,230
conditions are specified at the entrance

221
00:13:26,300 --> 00:13:24,330
for the valve opening and they are

222
00:13:30,470 --> 00:13:26,310
specified at the exit for the valve

223
00:13:33,100 --> 00:13:30,480
closing the tilting disk reacts from the

224
00:13:36,199 --> 00:13:33,110
force is applied to it by the blood flow

225
00:13:38,600 --> 00:13:36,209
the valve motion is made possible by

226
00:13:45,610 --> 00:13:38,610
using the chimera grid embedding

227
00:13:52,340 --> 00:13:48,740
we can view valve operation from

228
00:13:53,810 --> 00:13:52,350
different rotational views red particles

229
00:13:56,510 --> 00:13:53,820
are released from the vertical plane of

230
00:13:58,250 --> 00:13:56,520
the entrance and magenta particles are

231
00:14:00,860 --> 00:13:58,260
released from the sinus region of the

232
00:14:04,640 --> 00:14:00,870
aorta which is located just beyond the

233
00:14:06,950 --> 00:14:04,650
tilting disk the flow between the disk

234
00:14:10,280 --> 00:14:06,960
and the aortic wall is highly

235
00:14:12,380 --> 00:14:10,290
accelerated these kinds of changes in

236
00:14:26,280 --> 00:14:12,390
the local blood flow conditions can

237
00:14:30,970 --> 00:14:28,510
technology developments that result from

238
00:14:33,070 --> 00:14:30,980

solving this problem will yield spin

239
00:14:35,080 --> 00:14:33,080
back applications for other flow

240
00:14:38,110 --> 00:14:35,090
problems associated with the space

241
00:14:40,420 --> 00:14:38,120
shuttle main engine an important

242
00:14:42,610 --> 00:14:40,430
contribution made by NASA to medicine

243
00:14:46,180 --> 00:14:42,620
results in a contribution made by

244
00:14:47,650 --> 00:14:46,190
medicine back to NASA science aiding

245
00:15:05,759 --> 00:14:47,660
science through interdisciplinary

246
00:15:12,340 --> 00:15:09,430
the f-18 is a jet fighter currently used

247
00:15:14,769 --> 00:15:12,350
by the United States Navy it is used in

248
00:15:17,590 --> 00:15:14,779
air-to-air and air-to-ground fighter and

249
00:15:19,900 --> 00:15:17,600
attack roles by the fleet it has a great

250
00:15:22,769 --> 00:15:19,910
deal of maneuverability and performs at

251
00:15:25,540 --> 00:15:22,779
high G's and at high angles of attack

252
00:15:27,970 --> 00:15:25,550
Russell Cummings National Research

253
00:15:30,280 --> 00:15:27,980
Council research associate explains why

254
00:15:33,939 --> 00:15:30,290
the f-18 was chosen as a research

255
00:15:36,249 --> 00:15:33,949
vehicle the f-18 because it's capable of

256
00:15:39,610 --> 00:15:36,259
pulling such high manoeuvres and high

257
00:15:40,960 --> 00:15:39,620
G's gets into regimes of aerodynamics

258
00:15:43,059 --> 00:15:40,970
that other aircraft don't even

259
00:15:46,600 --> 00:15:43,069
experience because of that we're using

260
00:15:50,199 --> 00:15:46,610
it as a test bed and a computation basis

261
00:15:55,030 --> 00:15:50,209
for producing predictions for close over

262
00:15:57,389 --> 00:15:55,040
heinel attack aircraft the cfd process

263
00:16:00,009 --> 00:15:57,399

begins when the aircraft manufacturer

264
00:16:02,590 --> 00:16:00,019
supplies the surface geometry of the

265
00:16:05,139 --> 00:16:02,600
aircraft to be studied from this

266
00:16:08,620 --> 00:16:05,149
information a surface grid and a flow

267
00:16:10,900 --> 00:16:08,630
field grid is created then flow solving

268
00:16:14,110 --> 00:16:10,910
begins using the three-dimensional

269
00:16:17,710 --> 00:16:14,120
partially flux split time marching F 3d

270
00:16:20,499 --> 00:16:17,720
navier-stokes code predictions are made

271
00:16:24,220 --> 00:16:20,509
for turbulent flow by using the Baldwin

272
00:16:27,370 --> 00:16:24,230
Lomax turbulence model here we compare

273
00:16:30,249 --> 00:16:27,380
the flow visualization around the 1/32

274
00:16:32,439 --> 00:16:30,259
scale model of the f-18 in the eidetic

275
00:16:35,980 --> 00:16:32,449
international water tunnel with the

276
00:16:38,079 --> 00:16:35,990
computational results clearly vortices

277
00:17:04,550 --> 00:16:38,089
from the fore body and wing leading-edge

278
00:17:09,790 --> 00:17:06,500
we visualize our numerical predictions

279
00:17:12,410 --> 00:17:09,800
using a variety of methods including

280
00:17:14,360 --> 00:17:12,420
simulated surface oil flows which help

281
00:17:16,730 --> 00:17:14,370
us to see the primary and secondary

282
00:17:18,800 --> 00:17:16,740
cross flow separation lines on both the

283
00:17:21,580 --> 00:17:18,810
fuselage and the leading edge extension

284
00:17:24,830 --> 00:17:21,590
we also use felicity density contours

285
00:17:27,190 --> 00:17:24,840
which enable us to see both positive and

286
00:17:30,380 --> 00:17:27,200
negative senses of rotation of vortices

287
00:17:32,720 --> 00:17:30,390
we can further visualize vortices by

288
00:17:35,270 --> 00:17:32,730

passing particle traces back through the

289
00:17:37,070 --> 00:17:35,280
holistic on tours which help us see the

290
00:17:40,790 --> 00:17:37,080
vortices as they pass back over the

291
00:17:42,680 --> 00:17:40,800
fuselage the goal of the research is to

292
00:17:45,980 --> 00:17:42,690
be able to predict the flow over a full

293
00:17:48,320 --> 00:17:45,990
aircraft such as the f-18 so we can see

294
00:17:50,870 --> 00:17:48,330
the interaction of things such as the

295
00:17:53,150 --> 00:17:50,880
Lexx vortex as it comes up over on top

296
00:17:54,680 --> 00:17:53,160
of the Lex runs down the body and

297
00:17:59,180 --> 00:17:54,690
pinches on the vertical tail and

298
00:18:01,370 --> 00:17:59,190
possibly cause a structural damage in

299
00:18:04,190 --> 00:18:01,380
actual flight tests shown here on the

300
00:18:07,490 --> 00:18:04,200
fa-18 high alpha research vehicle or

301
00:18:10,130 --> 00:18:07,500
Harv note the effect of the Lex vortices

302
00:18:12,740 --> 00:18:10,140
on the vertical stabilizer as Russell

303
00:18:14,720 --> 00:18:12,750
Cummings continues there are flight

304
00:18:17,720 --> 00:18:14,730
tests being currently conducted done at

305
00:18:20,180 --> 00:18:17,730
Dryden and we're comparing our CFD

306
00:18:22,700 --> 00:18:20,190
predictions concurrently with them

307
00:18:24,800 --> 00:18:22,710
taking their data and it's very exciting

308
00:18:25,910 --> 00:18:24,810
since I don't believe that very many

309
00:18:28,190 --> 00:18:25,920
people have been able to do that before

310
00:18:30,470 --> 00:18:28,200
to actually have their CFD predictions

311
00:18:32,780 --> 00:18:30,480
hand in hand with flight test data and

312
00:18:35,900 --> 00:18:32,790
as we've compared the two side-by-side

313
00:18:38,120 --> 00:18:35,910

we've seen that the CFD has been able to

314
00:18:40,130 --> 00:18:38,130
very well predict the type of

315
00:18:56,050 --> 00:18:40,140
aerodynamics both for surface pressures

316
00:19:01,450 --> 00:18:59,260
a multi-stage compressor is used on jet

317
00:19:03,940 --> 00:19:01,460
aircraft engines to compress the air

318
00:19:07,030 --> 00:19:03,950
before it goes into the combustion phase

319
00:19:10,390 --> 00:19:07,040
a multi-stage compressor consists of

320
00:19:13,060 --> 00:19:10,400
many rotor stator pairs rotors are

321
00:19:15,970 --> 00:19:13,070
rotating air foils and stators are

322
00:19:17,800 --> 00:19:15,980
stationary air foils in a multi-stage

323
00:19:19,480 --> 00:19:17,810
compressor you may have as many as

324
00:19:21,600 --> 00:19:19,490
seventeen to twenty of these rotor

325
00:19:24,940 --> 00:19:21,610
stator pairs

326
00:19:27,400 --> 00:19:24,950
Karen Gundy Berlet research scientists

327
00:19:29,380 --> 00:19:27,410
at Ames Research Center explains the

328
00:19:29,830 --> 00:19:29,390
difficulty of doing research in this

329
00:19:33,310 --> 00:19:29,840
arena

330
00:19:35,710 --> 00:19:33,320
the goals of my project are to compute

331
00:19:38,530 --> 00:19:35,720
the three-dimensional flow within a

332
00:19:40,810 --> 00:19:38,540
multi-stage compressor and hopefully by

333
00:19:42,010 --> 00:19:40,820
doing this we can understand the fluid

334
00:19:43,990 --> 00:19:42,020
physics of the flow within the

335
00:19:46,690 --> 00:19:44,000
compressor see if we can design

336
00:19:49,810 --> 00:19:46,700
compressors that are much more efficient

337
00:19:51,310 --> 00:19:49,820
and much more reliable while reducing

338
00:19:55,450 --> 00:19:51,320

the weight and the size of the

339
00:19:58,090 --> 00:19:55,460
compressor here we see the results of

340
00:20:00,460 --> 00:19:58,100
this research these are the pressure

341
00:20:02,560 --> 00:20:00,470
contours within the aircraft engine

342
00:20:05,860 --> 00:20:02,570
compressor the flow is moving from left

343
00:20:08,410 --> 00:20:05,870
to right low pressure is indicated by

344
00:20:11,500 --> 00:20:08,420
blue whereas high pressure is indicated

345
00:20:13,900 --> 00:20:11,510
by red the pressure contours show the

346
00:20:15,400 --> 00:20:13,910
inviscid part of the flow field by

347
00:20:18,160 --> 00:20:15,410
seeing the pressure difference across

348
00:20:20,790 --> 00:20:18,170
each of the air foils you can see what

349
00:20:22,930 --> 00:20:20,800
forces are occurring on the airfoil

350
00:20:25,720 --> 00:20:22,940
notice that the pressure within the

351
00:20:28,150 --> 00:20:25,730
system is quite unsteady as the pressure

352
00:20:29,610 --> 00:20:28,160
rises from the first stage to the second

353
00:20:32,440 --> 00:20:29,620
stage

354
00:20:35,110 --> 00:20:32,450
these are the entropy contours within

355
00:20:37,390 --> 00:20:35,120
the two-and-a-half stage compressor the

356
00:20:40,900 --> 00:20:37,400
entropy shows that viscous part of the

357
00:20:42,640 --> 00:20:40,910
flow field it points out the slow fluid

358
00:20:43,530 --> 00:20:42,650
that sticks to the surface of the air

359
00:20:46,299 --> 00:20:43,540
force

360
00:20:48,520 --> 00:20:46,309
notice that the slow fluid is convected

361
00:20:51,340 --> 00:20:48,530
back through the system for three or

362
00:20:53,470 --> 00:20:51,350
four cord lengths in a multi-stage

363
00:20:56,080 --> 00:20:53,480

compressor the flow within the latter

364
00:20:58,570 --> 00:20:56,090
stages is much more complex than the

365
00:21:02,250 --> 00:20:58,580
flow for the initial stages easily seen

366
00:21:04,750 --> 00:21:02,260
here the entropy plot does a good job

367
00:21:06,850 --> 00:21:04,760
showing the wakes due to the viscous

368
00:21:09,790 --> 00:21:06,860
dissipation of the air next to the air

369
00:21:12,400 --> 00:21:09,800
fourth as the wakes progress along the

370
00:21:15,040 --> 00:21:12,410
surfaces of the airfoils note that there

371
00:21:18,130 --> 00:21:15,050
are varying forces applied that tend to

372
00:21:20,290 --> 00:21:18,140
twist and rotate the air ports in the

373
00:21:21,940 --> 00:21:20,300
latter stages where there are many wakes

374
00:21:25,900 --> 00:21:21,950
being conducted through the compressor

375
00:21:28,030 --> 00:21:25,910
the forces are even more severe the flow

376
00:21:30,549 --> 00:21:28,040
fields are very complicated and the

377
00:21:33,940 --> 00:21:30,559
unsteady forces appear to be varying

378
00:21:35,860 --> 00:21:33,950
quite rapidly there are is experimental

379
00:21:37,630 --> 00:21:35,870
data available for this compressor

380
00:21:40,120 --> 00:21:37,640
that's why we chose to can simulate the

381
00:21:42,490 --> 00:21:40,130
flow within this compressor so far the

382
00:21:44,140 --> 00:21:42,500
comparisons have been very good time

383
00:21:46,020 --> 00:21:44,150
average pressures on the surface are

384
00:21:48,970 --> 00:21:46,030
very close to the experimental values

385
00:21:51,730 --> 00:21:48,980
awake average data is in good comparison

386
00:21:53,590 --> 00:21:51,740
for computations where I have an

387
00:21:57,549 --> 00:21:53,600
extremely fine grid in the second stage

388
00:21:59,500 --> 00:21:57,559

of the compressor one of the directions

389
00:22:01,320 --> 00:21:59,510
I see for computational fluid dynamics

390
00:22:04,510 --> 00:22:01,330
in the future is in an area we call

391
00:22:07,030 --> 00:22:04,520
multidisciplinary physics in that area

392
00:22:08,970 --> 00:22:07,040
we combined not only the fluid equations

393
00:22:11,169 --> 00:22:08,980
but the equations governing

394
00:22:14,020 --> 00:22:11,179
electromagnetics or propulsions or

395
00:22:16,900 --> 00:22:14,030
controls into one software simulation

396
00:22:18,210 --> 00:22:16,910
tool in order to solve problems like

397
00:22:20,680 --> 00:22:18,220
that the problems of multidisciplinary

398
00:22:22,750 --> 00:22:20,690
fluid physics it's going to require

399
00:22:25,000 --> 00:22:22,760
computers a thousand times faster than

400
00:22:27,310 --> 00:22:25,010
the computers we have today computers on

401
00:22:29,290 --> 00:22:27,320
the speed of 1 teraflop that's one

402
00:22:32,049 --> 00:22:29,300
trillion floating-point operations per

403
00:22:33,850 --> 00:22:32,059
second in order to obtain the 1 teraflop

404
00:22:36,520 --> 00:22:33,860
capability that we'll need for

405
00:22:39,130 --> 00:22:36,530
performing multidisciplinary simulations

406
00:22:42,010 --> 00:22:39,140
it's going to require massively parallel

407
00:22:42,520 --> 00:22:42,020
computers computers that have thousands

408
00:22:46,180 --> 00:22:42,530
and thousands

409
00:22:48,970 --> 00:22:46,190
of processors as compared to the ymp

410
00:22:50,410 --> 00:22:48,980
which has eight processors the

411
00:22:52,930 --> 00:22:50,420
internationalization of the aerospace

412
00:22:55,150 --> 00:22:52,940
business is going to cause CFD to play

413
00:22:57,820 --> 00:22:55,160

an even greater role in the simulation

414
00:22:59,770 --> 00:22:57,830
sciences area our American aerospace

415
00:23:01,600 --> 00:22:59,780
manufacturers are going to rely have

416
00:23:03,670 --> 00:23:01,610
more heavily on computational fluid

417
00:23:05,230 --> 00:23:03,680
dynamics to produce better and more

418
00:23:07,000 --> 00:23:05,240
efficient aircraft in order to be