

ING AND WORKING IN SPACE

The Space Shuttle:
30 Years of Service

The reusable Space Shuttle carried out
more than 30 years of service, more than any other
vehicle in history.

John D. Anderson

National Air and Space Museum

1
00:00:05,269 --> 00:00:02,070
uh good morning ladies and gentlemen and

2
00:00:07,349 --> 00:00:05,279
welcome to day two of the naca centenni

3
00:00:09,030 --> 00:00:07,359
centenary symposium

4
00:00:11,110 --> 00:00:09,040
um i think we had a great day yesterday

5
00:00:12,470 --> 00:00:11,120
and i appreciate all your participation

6
00:00:14,150 --> 00:00:12,480
it's great questions and some great

7
00:00:15,509 --> 00:00:14,160
panels and i think we got a great lineup

8
00:00:17,430 --> 00:00:15,519
today as well

9
00:00:19,990 --> 00:00:17,440
but we started off this morning

10
00:00:22,790 --> 00:00:20,000
with a keynote address by dr john

11
00:00:25,029 --> 00:00:22,800
anderson uh curator of aerodynamics at

12
00:00:26,950 --> 00:00:25,039
the air and space museum here but also

13
00:00:29,269 --> 00:00:26,960

the legendary aerodynamicist any of you

14

00:00:30,790 --> 00:00:29,279

who are have studied aerodynamics

15

00:00:32,150 --> 00:00:30,800

probably have his textbook in one of its

16

00:00:35,590 --> 00:00:32,160

many versions on your bookshelf

17

00:00:36,709 --> 00:00:35,600

someplace so uh john's a legend in the

18

00:00:37,910 --> 00:00:36,719

aerodynamics world and he's going to

19

00:00:40,310 --> 00:00:37,920

talk to us about

20

00:00:42,549 --> 00:00:40,320

the naca in the 1930s trailblazing the

21

00:00:54,389 --> 00:00:42,559

technical world of aerodynamics so join

22

00:00:58,630 --> 00:00:56,549

well i want to start out by thanking

23

00:00:59,670 --> 00:00:58,640

bill berry

24

00:01:01,430 --> 00:00:59,680

and

25

00:01:03,910 --> 00:01:01,440

all of those who have organized this

26
00:01:06,230 --> 00:01:03,920
symposium for giving me the opportunity

27
00:01:07,590 --> 00:01:06,240
to share a few thoughts and say a few

28
00:01:09,510 --> 00:01:07,600
words with you

29
00:01:11,830 --> 00:01:09,520
uh

30
00:01:14,550 --> 00:01:11,840
in honor of this 100th anniversary of

31
00:01:17,270 --> 00:01:14,560
the creation of the naca and before i

32
00:01:18,230 --> 00:01:17,280
even get started i want to share with

33
00:01:19,510 --> 00:01:18,240
you

34
00:01:24,830 --> 00:01:19,520
for me

35
00:01:27,190 --> 00:01:24,840
the naca was all about aeronautical

36
00:01:29,590 --> 00:01:27,200
engineering the

37
00:01:33,910 --> 00:01:29,600
information the technology

38
00:01:38,310 --> 00:01:35,910

went around the world

39

00:01:41,109 --> 00:01:38,320

uh it was seminal in the field of

40

00:01:44,149 --> 00:01:41,119

aeronautical engineering extremely

41

00:01:46,870 --> 00:01:44,159

important and i wanted to emphasize that

42

00:01:50,870 --> 00:01:46,880

it's all about aeronautical engineering

43

00:01:52,310 --> 00:01:50,880

also the naca is all about

44

00:01:54,870 --> 00:01:52,320

the

45

00:01:57,350 --> 00:01:54,880

highly qualified intelligent

46

00:02:00,789 --> 00:01:57,360

hard-working individuals

47

00:02:03,990 --> 00:02:00,799

who work for the naca who produce this

48

00:02:06,830 --> 00:02:04,000

seminal information that made the united

49

00:02:09,589 --> 00:02:06,840

states and the naca world famous

50

00:02:11,589 --> 00:02:09,599

worldwide and i think that's important i

51
00:02:14,630 --> 00:02:11,599
want to i'm sort of giving them a shout

52
00:02:15,990 --> 00:02:14,640
out even before we start here

53
00:02:24,470 --> 00:02:16,000
the

54
00:02:34,070 --> 00:02:24,480
with you

55
00:02:40,390 --> 00:02:36,710
nope i keep on going back oh hey there's

56
00:02:43,030 --> 00:02:40,400
a preview man look at that

57
00:02:45,830 --> 00:02:43,040
let's keep on going back

58
00:02:48,790 --> 00:02:45,840
one more there

59
00:02:51,750 --> 00:02:48,800
i wanted that slide because it says the

60
00:02:53,830 --> 00:02:51,760
1930s this is the naca in the 1930s

61
00:02:57,030 --> 00:02:53,840
that's what i'm going to emphasize

62
00:02:59,350 --> 00:02:57,040
and what's magic about the 1930s but i

63
00:03:00,710 --> 00:02:59,360

by the way i watched every i wasn't

64

00:03:01,830 --> 00:03:00,720

physically present in this room

65

00:03:04,550 --> 00:03:01,840

yesterday

66

00:03:07,030 --> 00:03:04,560

but i watched every presentation in its

67

00:03:08,630 --> 00:03:07,040

entirety throughout the day on the

68

00:03:10,550 --> 00:03:08,640

computer at home

69

00:03:13,270 --> 00:03:10,560

and

70

00:03:16,470 --> 00:03:13,280

a number of the speakers emphasized the

71

00:03:17,990 --> 00:03:16,480

importance of the 1930s the 1930s was a

72

00:03:20,470 --> 00:03:18,000

period of what we call the design

73

00:03:22,070 --> 00:03:20,480

revolution that's when the nature and

74

00:03:25,110 --> 00:03:22,080

the configuration

75

00:03:26,229 --> 00:03:25,120

all aspects of the airplane changed

76

00:03:27,430 --> 00:03:26,239

due to

77

00:03:32,149 --> 00:03:27,440

major

78

00:03:33,990 --> 00:03:32,159

discoveries

79

00:03:36,949 --> 00:03:34,000

a lot of which were carried out by the

80

00:03:39,990 --> 00:03:36,959

naca 19 1930s

81

00:03:42,949 --> 00:03:40,000

i want before i go any further

82

00:03:46,710 --> 00:03:42,959

i want to share with you two quotes

83

00:03:49,670 --> 00:03:46,720

that bracket the 1930s first at the

84

00:03:51,430 --> 00:03:49,680

beginning and then at the end and these

85

00:03:54,390 --> 00:03:51,440

quotes

86

00:03:57,429 --> 00:03:54,400

are he'll come up here in a few seconds

87

00:03:59,670 --> 00:03:57,439

this man that's edward p warner

88

00:04:01,910 --> 00:03:59,680

now warner's name has been was mentioned

89

00:04:04,789 --> 00:04:01,920

yesterday several times debbie douglas

90

00:04:06,789 --> 00:04:04,799

for example in her presentation uh

91

00:04:10,470 --> 00:04:06,799

brought forth a contribution some of the

92

00:04:13,429 --> 00:04:10,480

contributions of ed warner but ed warner

93

00:04:15,670 --> 00:04:13,439

was graduated with with honors

94

00:04:17,990 --> 00:04:15,680

with a ba in

95

00:04:20,550 --> 00:04:18,000

in mathematics from harvard

96

00:04:21,749 --> 00:04:20,560

went to mit and the next year graduated

97

00:04:23,749 --> 00:04:21,759

with a bs

98

00:04:25,990 --> 00:04:23,759

in mechanical engineering and then the

99

00:04:28,629 --> 00:04:26,000

next year an m.a

100

00:04:29,830 --> 00:04:28,639

he after that immediately

101
00:04:32,870 --> 00:04:29,840
took a job

102
00:04:34,390 --> 00:04:32,880
with the naca langley memorial

103
00:04:36,150 --> 00:04:34,400
aeronautical laboratory and you were

104
00:04:39,030 --> 00:04:36,160
told this yesterday

105
00:04:40,390 --> 00:04:39,040
where he was the chief physicist and he

106
00:04:43,430 --> 00:04:40,400
took over he took charge of the

107
00:04:46,070 --> 00:04:43,440
aerodynamics program he

108
00:04:49,189 --> 00:04:46,080
helped to design and construct the first

109
00:04:51,670 --> 00:04:49,199
wind tunnel at the at langley you saw

110
00:04:54,469 --> 00:04:51,680
some pictures of that yesterday

111
00:04:57,350 --> 00:04:54,479
albeit it was basically a copy of a wind

112
00:05:01,189 --> 00:04:57,360
tunnel the national physical laboratory

113
00:05:03,510 --> 00:05:01,199

and then in 1920 he went back to mit

114

00:05:05,270 --> 00:05:03,520

becoming an associate professor of

115

00:05:07,350 --> 00:05:05,280

aeronautical engineering and he was

116

00:05:10,629 --> 00:05:07,360

there for six years

117

00:05:13,350 --> 00:05:10,639

in 1926 he took the job as assistant

118

00:05:17,270 --> 00:05:13,360

secretary of the navy for aeronautics

119

00:05:20,790 --> 00:05:17,280

and then in 1957 he became president of

120

00:05:21,749 --> 00:05:20,800

the icao the international congress of

121

00:05:23,749 --> 00:05:21,759

uh

122

00:05:29,749 --> 00:05:23,759

international

123

00:05:33,189 --> 00:05:29,759

civil aviation organization the icao

124

00:05:34,950 --> 00:05:33,199

ed warner was a mover and shaker

125

00:05:37,909 --> 00:05:34,960

in early aaron the first half of the

126

00:05:39,830 --> 00:05:37,919

century in aeronautics in this country

127

00:05:42,550 --> 00:05:39,840

and i'm i'm

128

00:05:44,390 --> 00:05:42,560

going to share with you two quotes

129

00:05:46,870 --> 00:05:44,400

one that was

130

00:05:49,029 --> 00:05:46,880

in a book that he wrote it was

131

00:05:52,629 --> 00:05:49,039

titled airplane design aerodynamics

132

00:05:54,710 --> 00:05:52,639

published by mcgraw-hill 1927. and in

133

00:05:57,350 --> 00:05:54,720

this textbook ed warner says the

134

00:06:00,390 --> 00:05:57,360

following and this is sort of the

135

00:06:02,870 --> 00:06:00,400

before the 1930s the pioneers of

136

00:06:05,189 --> 00:06:02,880

aircraft design traveled in a wilderness

137

00:06:06,790 --> 00:06:05,199

depended upon their own resources at

138

00:06:08,950 --> 00:06:06,800

every step

139

00:06:10,870 --> 00:06:08,960

no path was marked for them and the

140

00:06:14,150 --> 00:06:10,880

illumination along the way was only such

141

00:06:16,390 --> 00:06:14,160

as they themselves might provide

142

00:06:18,550 --> 00:06:16,400

of research in this application

143

00:06:20,390 --> 00:06:18,560

aeronautical engineering there had been

144

00:06:22,790 --> 00:06:20,400

hardly even a beginning

145

00:06:25,110 --> 00:06:22,800

in his place that often

146

00:06:28,070 --> 00:06:25,120

his place had often to be supplied by

147

00:06:31,270 --> 00:06:28,080

inspiration intuition or in person

148

00:06:33,350 --> 00:06:31,280

empiricism or go unsupplied and then

149

00:06:35,350 --> 00:06:33,360

that's sort of really describing the

150

00:06:37,110 --> 00:06:35,360

woeful state of the art particularly at

151

00:06:39,510 --> 00:06:37,120

the end of world war one and up into

152

00:06:42,390 --> 00:06:39,520

part of the 20s and then and then warner

153

00:06:43,990 --> 00:06:42,400

goes on in the same same paragraph

154

00:06:47,110 --> 00:06:44,000

the student who embarks upon

155

00:06:49,510 --> 00:06:47,120

aeronautical studies in 1927

156

00:06:50,710 --> 00:06:49,520

is subject to some degree to a contrary

157

00:06:53,830 --> 00:06:50,720

embarrassment

158

00:06:55,589 --> 00:06:53,840

experimental data inundate him

159

00:06:57,589 --> 00:06:55,599

the underbrush of obscurity has been

160

00:06:59,350 --> 00:06:57,599

cleared away the field is even more

161

00:07:01,430 --> 00:06:59,360

brightly illuminated by the fruits of

162

00:07:02,390 --> 00:07:01,440

governmental institutional and private

163

00:07:03,909 --> 00:07:02,400

research

164

00:07:06,390 --> 00:07:03,919

but listen to this

165

00:07:08,870 --> 00:07:06,400

yet the very uniformity with which

166

00:07:11,589 --> 00:07:08,880

enlightened enlightenment is being cast

167

00:07:13,189 --> 00:07:11,599

over the subject into several parts may

168

00:07:16,070 --> 00:07:13,199

prove confusing

169

00:07:19,589 --> 00:07:16,080

leaving the exact course to be followed

170

00:07:21,029 --> 00:07:19,599

still in dell that was 1927.

171

00:07:22,790 --> 00:07:21,039

now

172

00:07:25,350 --> 00:07:22,800

on the other side of that

173

00:07:27,430 --> 00:07:25,360

we have ed warner in a new book

174

00:07:29,350 --> 00:07:27,440

this entitled airplane design

175

00:07:31,189 --> 00:07:29,360

performance published by mcgraw-hill in

176
00:07:33,430 --> 00:07:31,199
1936

177
00:07:34,710 --> 00:07:33,440
and here is the other side of that

178
00:07:35,749 --> 00:07:34,720
period

179
00:07:38,629 --> 00:07:35,759
quote

180
00:07:40,950 --> 00:07:38,639
all this refinement

181
00:07:43,430 --> 00:07:40,960
what refinement well we'll see

182
00:07:45,510 --> 00:07:43,440
all this refinement becomes increasingly

183
00:07:48,070 --> 00:07:45,520
more important and engineers become

184
00:07:51,029 --> 00:07:48,080
increasingly excellent in their demands

185
00:07:53,670 --> 00:07:51,039
for it for two reasons first

186
00:07:56,390 --> 00:07:53,680
because as design becomes increasingly

187
00:07:58,550 --> 00:07:56,400
an exact science and as designers are

188
00:08:01,270 --> 00:07:58,560

required to subject themselves

189

00:08:04,070 --> 00:08:01,280

to ever closer specifications and

190

00:08:05,430 --> 00:08:04,080

advanced guarantees for their products

191

00:08:08,790 --> 00:08:05,440

performance

192

00:08:11,029 --> 00:08:08,800

errors are fo of 5 or 10 percent in

193

00:08:13,029 --> 00:08:11,039

aerodynamic data that might once have

194

00:08:16,469 --> 00:08:13,039

seemed too small to notice

195

00:08:18,469 --> 00:08:16,479

come to assume nightmare proportions so

196

00:08:20,070 --> 00:08:18,479

there's a big change now we have

197

00:08:21,909 --> 00:08:20,080

airplane designers

198

00:08:24,230 --> 00:08:21,919

getting up tight because the data is

199

00:08:26,710 --> 00:08:24,240

only five percent accurate what has

200

00:08:29,909 --> 00:08:26,720

changed one of the major things that has

201
00:08:32,149 --> 00:08:29,919
changed in between these two quotes

202
00:08:35,509 --> 00:08:32,159
is all the work that have been carried

203
00:08:38,709 --> 00:08:35,519
out by the naca at the langley memorial

204
00:08:40,310 --> 00:08:38,719
laboratory their technical contributions

205
00:08:41,509 --> 00:08:40,320
and so i'm going to share with you only

206
00:08:44,310 --> 00:08:41,519
three

207
00:08:46,150 --> 00:08:44,320
categories those contributions one is

208
00:08:47,670 --> 00:08:46,160
going to be the air foil work carried

209
00:08:50,070 --> 00:08:47,680
out uh

210
00:08:50,870 --> 00:08:50,080
at langley uh

211
00:08:53,350 --> 00:08:50,880
and

212
00:08:55,430 --> 00:08:53,360
the other second one is going to be the

213
00:08:57,190 --> 00:08:55,440

development of the naca cowling we'll

214

00:08:58,310 --> 00:08:57,200

say something about that and then

215

00:09:00,389 --> 00:08:58,320

finally

216

00:09:02,550 --> 00:09:00,399

shedding the some light on the

217

00:09:04,310 --> 00:09:02,560

intellectual understanding of what was

218

00:09:07,190 --> 00:09:04,320

called the compressibility problem for

219

00:09:09,110 --> 00:09:07,200

high-speed flight

220

00:09:11,910 --> 00:09:09,120

and debbie who just walked in you

221

00:09:13,590 --> 00:09:11,920

recognize that guy up there

222

00:09:15,269 --> 00:09:13,600

i was just quoting him as you were

223

00:09:17,829 --> 00:09:15,279

coming yet

224

00:09:19,990 --> 00:09:17,839

okay let's start

225

00:09:21,110 --> 00:09:20,000

let's start with airfoils

226
00:09:24,389 --> 00:09:21,120
and

227
00:09:25,509 --> 00:09:24,399
you know the naca right away when it was

228
00:09:27,829 --> 00:09:25,519
created

229
00:09:30,389 --> 00:09:27,839
recognized the

230
00:09:33,750 --> 00:09:30,399
the almost ad hoc state of the art of

231
00:09:38,070 --> 00:09:33,760
airfoil design in 1920

232
00:09:40,870 --> 00:09:38,080
the engine some engineers at the naca

233
00:09:42,550 --> 00:09:40,880
collected and categorized and and

234
00:09:44,790 --> 00:09:42,560
compiled

235
00:09:47,350 --> 00:09:44,800
airfoil data for hundreds of different

236
00:09:48,870 --> 00:09:47,360
airfoils around the world now what i'm

237
00:09:53,750 --> 00:09:48,880
showing you just one of these from this

238
00:09:57,110 --> 00:09:53,760

1920s in any naca tr 93

239

00:10:00,870 --> 00:09:57,120

this is a lift drag moment data

240

00:10:03,829 --> 00:10:00,880

for versus angle attack for the

241

00:10:07,030 --> 00:10:03,839

girding engine guardian 298 airfoil that

242

00:10:09,590 --> 00:10:07,040

was used for the fokker dr1

243

00:10:12,230 --> 00:10:09,600

and there are hundreds of these graphs

244

00:10:14,470 --> 00:10:12,240

and that the naca compiled

245

00:10:17,030 --> 00:10:14,480

just so that people could see ah this is

246

00:10:19,670 --> 00:10:17,040

the state of the art of airfoil

247

00:10:21,430 --> 00:10:19,680

knowledge airfoil design and it was a

248

00:10:27,269 --> 00:10:21,440

mess

249

00:10:32,310 --> 00:10:29,670

during the 1920s

250

00:10:34,630 --> 00:10:32,320

a person by the name of virginia's clark

251

00:10:35,829 --> 00:10:34,640

now clark i have to this is a group

252

00:10:37,990 --> 00:10:35,839

photo

253

00:10:39,670 --> 00:10:38,000

colonel clark is the man standing on the

254

00:10:41,990 --> 00:10:39,680

right in the back

255

00:10:43,430 --> 00:10:42,000

and as a matter of fact clark was a

256

00:10:46,870 --> 00:10:43,440

distinguished graduate of the naval

257

00:10:49,350 --> 00:10:46,880

academy in 1907. he went to san diego he

258

00:10:52,150 --> 00:10:49,360

learned to fly for the navy and then

259

00:10:53,829 --> 00:10:52,160

later on became part of the army

260

00:10:57,990 --> 00:10:53,839

during world war one

261

00:10:59,990 --> 00:10:58,000

he became the commander of the

262

00:11:01,030 --> 00:11:00,000

of the army research center at mccoak

263

00:11:02,790 --> 00:11:01,040

field

264

00:11:04,230 --> 00:11:02,800

that was mentioned uh every once in a

265

00:11:06,230 --> 00:11:04,240

while yesterday

266

00:11:07,750 --> 00:11:06,240

so there he is on the right

267

00:11:10,550 --> 00:11:07,760

now what's what's important about

268

00:11:12,790 --> 00:11:10,560

virginia's clark he designed airfoils a

269

00:11:14,550 --> 00:11:12,800

whole series of airfoils called

270

00:11:16,230 --> 00:11:14,560

for most famous being the clark y

271

00:11:17,269 --> 00:11:16,240

airfoil

272

00:11:19,750 --> 00:11:17,279

and

273

00:11:22,230 --> 00:11:19,760

by the way this photograph

274

00:11:24,069 --> 00:11:22,240

clark was sent to mit for one of the

275

00:11:25,670 --> 00:11:24,079

first classes in aeronautical

276

00:11:28,069 --> 00:11:25,680

engineering i think it was about nine i

277

00:11:30,230 --> 00:11:28,079

think the date on this photograph is

278

00:11:31,269 --> 00:11:30,240

1918

279

00:11:32,870 --> 00:11:31,279

and

280

00:11:34,550 --> 00:11:32,880

somewhere in the back i think is

281

00:11:37,269 --> 00:11:34,560

funsacker

282

00:11:38,870 --> 00:11:37,279

nevertheless

283

00:11:41,350 --> 00:11:38,880

clark

284

00:11:43,430 --> 00:11:41,360

design

285

00:11:44,630 --> 00:11:43,440

the clark y air force i'm going to put

286

00:11:46,790 --> 00:11:44,640

that on

287

00:11:49,190 --> 00:11:46,800

and

288

00:11:50,949 --> 00:11:49,200

here's what clark had to say

289

00:11:53,750 --> 00:11:50,959

about this aerofoil about the whole

290

00:11:56,069 --> 00:11:53,760

status of of airfoil design and this

291

00:11:58,870 --> 00:11:56,079

really shows the ad hoc nature of

292

00:12:00,870 --> 00:11:58,880

airfoil design this was a quote

293

00:12:03,110 --> 00:12:00,880

it was published in an interview that he

294

00:12:05,190 --> 00:12:03,120

had with aviation magazine now that was

295

00:12:08,710 --> 00:12:05,200

forerunner of what we call aviation week

296

00:12:10,870 --> 00:12:08,720

today it was in october 1927. colonel

297

00:12:12,629 --> 00:12:10,880

clark was asked

298

00:12:14,470 --> 00:12:12,639

how do you go about designing these

299

00:12:15,910 --> 00:12:14,480

airfoils of yours

300

00:12:18,230 --> 00:12:15,920

they've become famous by that time

301
00:12:21,350 --> 00:12:18,240
because so many airplanes were using the

302
00:12:23,110 --> 00:12:21,360
clark uh clark series of airfarms now

303
00:12:24,389 --> 00:12:23,120
colonel clark uh

304
00:12:27,190 --> 00:12:24,399
how do you go about designing these

305
00:12:28,550 --> 00:12:27,200
airfalls of yours what is the secret

306
00:12:30,069 --> 00:12:28,560
clark laughed

307
00:12:32,790 --> 00:12:30,079
and replied

308
00:12:34,389 --> 00:12:32,800
i would gladly tell you the secret if i

309
00:12:36,710 --> 00:12:34,399
knew of any

310
00:12:38,870 --> 00:12:36,720
the airfoil sections just seemed to lay

311
00:12:41,829 --> 00:12:38,880
themselves out and

312
00:12:44,230 --> 00:12:41,839
when good luck attends

313
00:12:46,550 --> 00:12:44,240

fair results are obtained

314

00:12:48,870 --> 00:12:46,560

when good luck attends

315

00:12:52,389 --> 00:12:48,880

fair results are attained that was the

316

00:12:54,550 --> 00:12:52,399

status of airfoil design and development

317

00:12:57,269 --> 00:12:54,560

in the even up at the towards the

318

00:13:03,590 --> 00:12:57,279

beginning of the 1930s

319

00:13:08,629 --> 00:13:07,269

in 1920s oh i should say

320

00:13:09,829 --> 00:13:08,639

if you just go out the hall and look

321

00:13:11,670 --> 00:13:09,839

down in the

322

00:13:13,829 --> 00:13:11,680

milestones of light gallery you see not

323

00:13:15,910 --> 00:13:13,839

hanging there but on the floor now the

324

00:13:18,550 --> 00:13:15,920

spirit of st louis the spirit of saint

325

00:13:20,389 --> 00:13:18,560

louis uses a clark y air force for

326
00:13:23,269 --> 00:13:20,399
example

327
00:13:27,829 --> 00:13:25,430
this person

328
00:13:29,670 --> 00:13:27,839
walked in the front gates

329
00:13:32,710 --> 00:13:29,680
of langley memorial aeronautical

330
00:13:33,829 --> 00:13:32,720
laboratory a year after he had graduated

331
00:13:35,509 --> 00:13:33,839
from

332
00:13:37,670 --> 00:13:35,519
university of california berkeley and

333
00:13:40,150 --> 00:13:37,680
mcken with a bachelor's degree in

334
00:13:42,550 --> 00:13:40,160
mechanical engineering this is eastman

335
00:13:45,670 --> 00:13:42,560
jacobs his name was mentioned several

336
00:13:47,509 --> 00:13:45,680
times in some presentations yesterday

337
00:13:50,310 --> 00:13:47,519
now jacobs

338
00:13:54,150 --> 00:13:50,320

within a few years became director of

339

00:13:56,389 --> 00:13:54,160

the variable density wind tunnel

340

00:13:57,350 --> 00:13:56,399

dick hellion said some interesting

341

00:13:59,350 --> 00:13:57,360

things

342

00:14:00,949 --> 00:13:59,360

about the variable density wind tunnel

343

00:14:03,670 --> 00:14:00,959

yesterday

344

00:14:05,350 --> 00:14:03,680

and in that tunnel

345

00:14:07,030 --> 00:14:05,360

there it is there's the variable density

346

00:14:09,350 --> 00:14:07,040

wind tunnel let me remind you what that

347

00:14:11,350 --> 00:14:09,360

is is a big pressure tank

348

00:14:13,509 --> 00:14:11,360

and inside that pressure tank is a is a

349

00:14:14,870 --> 00:14:13,519

wind tunnel complete wind tunnel inside

350

00:14:16,949 --> 00:14:14,880

that pressure tank

351
00:14:18,150 --> 00:14:16,959
and that tank was pressurized to 20

352
00:14:21,350 --> 00:14:18,160
atmospheres

353
00:14:23,269 --> 00:14:21,360
so that means that the air pressure

354
00:14:24,470 --> 00:14:23,279
in the airstream flowing over the model

355
00:14:27,829 --> 00:14:24,480
in that wind tunnel was at 20

356
00:14:28,629 --> 00:14:27,839
atmospheres high density air and that

357
00:14:31,030 --> 00:14:28,639
in

358
00:14:32,629 --> 00:14:31,040
aerodynamics parlance that means the

359
00:14:34,710 --> 00:14:32,639
reynolds number was high the reynolds

360
00:14:36,710 --> 00:14:34,720
number was almost equivalent to that

361
00:14:38,069 --> 00:14:36,720
encountered in free flight and so

362
00:14:42,710 --> 00:14:38,079
measurements

363
00:14:45,509 --> 00:14:42,720

this variable density tunnel

364

00:14:47,910 --> 00:14:45,519

were reasonable representations of what

365

00:14:50,470 --> 00:14:47,920

you could experience in full-scale

366

00:14:53,189 --> 00:14:50,480

flight particularly in those days so

367

00:14:56,710 --> 00:14:53,199

here we have eastman jacobs

368

00:14:58,949 --> 00:14:56,720

running that tunnel now and he begins a

369

00:15:01,269 --> 00:14:58,959

whole series

370

00:15:01,990 --> 00:15:01,279

of

371

00:15:07,509 --> 00:15:02,000

in

372

00:15:09,590 --> 00:15:07,519

designs now this is what was a if i had

373

00:15:11,910 --> 00:15:09,600

a laser pointer and i have a little red

374

00:15:14,629 --> 00:15:11,920

dot there but if if you look at the

375

00:15:17,350 --> 00:15:14,639

bottom picture that's an airfoil

376

00:15:20,310 --> 00:15:17,360

and you'll see that there's a curved

377

00:15:21,910 --> 00:15:20,320

line at midway in the middle of that

378

00:15:25,509 --> 00:15:21,920

airflow that's called the mean camera

379

00:15:30,389 --> 00:15:28,389

that airfoil is designed by first coming

380

00:15:32,629 --> 00:15:30,399

up with the camber line and then

381

00:15:34,710 --> 00:15:32,639

wrapping around it a symmetrical

382

00:15:37,110 --> 00:15:34,720

thickness distribution and that picture

383

00:15:39,670 --> 00:15:37,120

up on the top is the symmetrical

384

00:15:41,110 --> 00:15:39,680

thickness distribution so you combine

385

00:15:43,430 --> 00:15:41,120

the camber line with that thickness

386

00:15:46,069 --> 00:15:43,440

distribution and presto you've got an

387

00:15:46,949 --> 00:15:46,079

airfoil and you have an airfoil that is

388

00:15:50,150 --> 00:15:46,959

sort of

389

00:15:52,949 --> 00:15:50,160

designed in a systematic way

390

00:15:56,230 --> 00:15:52,959

this led to a whole series of airfoils

391

00:15:59,990 --> 00:15:56,240

which was called the naca

392

00:16:02,230 --> 00:16:00,000

four digit airfoil series

393

00:16:04,389 --> 00:16:02,240

which will come up here in a minute

394

00:16:06,870 --> 00:16:04,399

and there they are

395

00:16:08,790 --> 00:16:06,880

these airfoils not only were they

396

00:16:11,670 --> 00:16:08,800

systematically designed they were

397

00:16:14,389 --> 00:16:11,680

effective airflows the naca

398

00:16:16,949 --> 00:16:14,399

tested them extensively so there was a

399

00:16:19,749 --> 00:16:16,959

lot of experimental data available to

400

00:16:23,910 --> 00:16:19,759

airplane designers on these airfoils and

401
00:16:26,949 --> 00:16:23,920
so a very large number of airplanes

402
00:16:32,150 --> 00:16:26,959
during the 1930s used the naca

403
00:16:36,470 --> 00:16:33,829
for example

404
00:16:38,470 --> 00:16:36,480
not only just in the united states

405
00:16:40,470 --> 00:16:38,480
but

406
00:16:43,030 --> 00:16:40,480
when r.j mitchell was designing the

407
00:16:46,590 --> 00:16:43,040
spitfire

408
00:16:50,629 --> 00:16:46,600
that airplane uses an naca

409
00:16:53,829 --> 00:16:50,639
2213. it's a 13 thick aerofoil at the

410
00:16:55,910 --> 00:16:53,839
root tapers to a 22.05 five percent

411
00:16:58,550 --> 00:16:55,920
thick at the tip

412
00:16:59,829 --> 00:16:58,560
the spitfire used in naca four dision

413
00:17:02,550 --> 00:16:59,839

airfoil

414

00:17:05,990 --> 00:17:02,560

its major protagonist in the battle of

415

00:17:08,549 --> 00:17:06,000

britain the messerschmitt 109 also used

416

00:17:09,669 --> 00:17:08,559

an nac air foil it was sort of a strange

417

00:17:11,510 --> 00:17:09,679

one

418

00:17:13,029 --> 00:17:11,520

it was uh it was

419

00:17:16,870 --> 00:17:13,039

essentially called a

420

00:17:18,710 --> 00:17:16,880

2r comma 12 airfoil now you're gonna if

421

00:17:21,029 --> 00:17:18,720

you look for data for that airfoil it's

422

00:17:23,510 --> 00:17:21,039

hard to find because

423

00:17:25,990 --> 00:17:23,520

the naca felt that was not a very good

424

00:17:28,549 --> 00:17:26,000

airfoil very quickly after testing they

425

00:17:31,909 --> 00:17:28,559

found that that airfall it had low drag

426
00:17:33,830 --> 00:17:31,919
that was a big advantage it also had a

427
00:17:36,070 --> 00:17:33,840
low maximum lift coefficient and

428
00:17:38,549 --> 00:17:36,080
prematurely stolen

429
00:17:39,990 --> 00:17:38,559
so the naca

430
00:17:41,510 --> 00:17:40,000
recommended that

431
00:17:43,830 --> 00:17:41,520
here in the united states recommended

432
00:17:47,110 --> 00:17:43,840
people don't use it

433
00:17:49,590 --> 00:17:47,120
the engineers the designers the me109

434
00:17:53,190 --> 00:17:49,600
like that low drag feature and they use

435
00:17:57,029 --> 00:17:53,200
that airfoil on the 109. so i mean just

436
00:17:59,830 --> 00:17:57,039
it's just an example of how the airfoil

437
00:18:02,070 --> 00:17:59,840
were carried out by the naca by people

438
00:18:03,830 --> 00:18:02,080

like eastman jacobs and his

439

00:18:07,669 --> 00:18:03,840

and his colleagues

440

00:18:08,789 --> 00:18:07,679

provided a major change a major

441

00:18:09,750 --> 00:18:08,799

improvement

442

00:18:14,390 --> 00:18:09,760

in

443

00:18:15,590 --> 00:18:14,400

basically of air airfoil performance and

444

00:18:18,310 --> 00:18:15,600

giving

445

00:18:21,270 --> 00:18:18,320

airplane designers the opportunity to

446

00:18:24,230 --> 00:18:21,280

use effective airfoils on the airplane

447

00:18:27,510 --> 00:18:24,240

set this is one of the big deals during

448

00:18:33,669 --> 00:18:27,520

the 1930s from the naca well jacobs

449

00:18:37,750 --> 00:18:35,350

and i'm waiting for the next one to come

450

00:18:41,029 --> 00:18:39,029

i should say

451

00:18:43,669 --> 00:18:41,039

there is a jacob's had a colleague at

452

00:18:46,310 --> 00:18:43,679

langley theodore theodorsen theodores in

453

00:18:48,470 --> 00:18:46,320

the 1930s was the most respected

454

00:18:52,150 --> 00:18:48,480

theoretical aerodynamicist

455

00:18:54,390 --> 00:18:52,160

for the naca and theodorsen in parallel

456

00:18:55,830 --> 00:18:54,400

with these airfoil measurements being

457

00:18:57,669 --> 00:18:55,840

carried out in the variable density

458

00:19:00,789 --> 00:18:57,679

tunnel

459

00:19:02,150 --> 00:19:00,799

came up with a theoretical method

460

00:19:04,310 --> 00:19:02,160

for

461

00:19:07,990 --> 00:19:04,320

calculating the pressure distributions

462

00:19:09,990 --> 00:19:08,000

over airfoils of arbitrary shapes and

463

00:19:11,510 --> 00:19:10,000

arbitrary thickness that was a big that

464

00:19:13,190 --> 00:19:11,520

was a big improvement

465

00:19:15,350 --> 00:19:13,200

and it was i'll show you one of his

466

00:19:16,710 --> 00:19:15,360

results

467

00:19:19,590 --> 00:19:16,720

this is a result

468

00:19:21,430 --> 00:19:19,600

actually on a clark y airfoil showing uh

469

00:19:25,029 --> 00:19:21,440

pressure distributions or the bottom of

470

00:19:27,029 --> 00:19:25,039

the top of the airfoil and

471

00:19:29,190 --> 00:19:27,039

there are two curves shown there

472

00:19:31,190 --> 00:19:29,200

one is the theoretical measurement i

473

00:19:32,950 --> 00:19:31,200

mean the calculation of the pressure and

474

00:19:34,950 --> 00:19:32,960

one is the experimental measurement of

475

00:19:38,630 --> 00:19:34,960

the pressure distribution and you'll see

476

00:19:40,630 --> 00:19:38,640

that especially uh the uh over the top

477

00:19:43,430 --> 00:19:40,640

the lower pressures are plotted on the

478

00:19:45,430 --> 00:19:43,440

upper part of that graph and you'll see

479

00:19:47,590 --> 00:19:45,440

there's a little bit discrepancy there

480

00:19:50,150 --> 00:19:47,600

now to give you some idea of the kind of

481

00:19:51,990 --> 00:19:50,160

person theodorson was

482

00:19:53,590 --> 00:19:52,000

he looked at that and he said the

483

00:19:56,150 --> 00:19:53,600

trouble is with the experimental

484

00:19:57,669 --> 00:19:56,160

measurements the experimentals ought to

485

00:19:59,669 --> 00:19:57,679

take another look

486

00:20:00,789 --> 00:19:59,679

uh

487

00:20:02,950 --> 00:20:00,799

in my

488

00:20:05,830 --> 00:20:02,960

experience all the beginning you know

489

00:20:09,190 --> 00:20:05,840

right from the start even when i was

490

00:20:10,630 --> 00:20:09,200

educated in engineering

491

00:20:14,070 --> 00:20:10,640

you know

492

00:20:15,110 --> 00:20:14,080

you always accepted experimental data as

493

00:20:16,630 --> 00:20:15,120

the

494

00:20:21,909 --> 00:20:16,640

major

495

00:20:24,149 --> 00:20:21,919

any theoretical calculations if there

496

00:20:26,149 --> 00:20:24,159

was disagreement about that you would

497

00:20:28,230 --> 00:20:26,159

suspect the theoretical calculations but

498

00:20:30,470 --> 00:20:28,240

not theodore but i just wanted to throw

499

00:20:32,710 --> 00:20:30,480

this in that at the same time that these

500

00:20:35,270 --> 00:20:32,720

air form measurements were being made

501
00:20:38,310 --> 00:20:35,280
the naca had their most expert

502
00:20:40,070 --> 00:20:38,320
theoretician working on calculating

503
00:20:42,470 --> 00:20:40,080
particularly the pressure distributions

504
00:20:45,590 --> 00:20:42,480
over arbitrary airfalls of arbitrary

505
00:20:51,909 --> 00:20:49,190
one last aspect of this airfoil design

506
00:20:54,149 --> 00:20:51,919
eastman jacobs toured

507
00:20:55,590 --> 00:20:54,159
europe in 1935.

508
00:20:57,110 --> 00:20:55,600
he was over there for the volta

509
00:20:58,630 --> 00:20:57,120
conference which was mentioned yesterday

510
00:21:01,270 --> 00:20:58,640
and i'm going to talk about that later

511
00:21:03,669 --> 00:21:01,280
on but he was there and he took the

512
00:21:05,990 --> 00:21:03,679
opportunity over a space of a couple of

513
00:21:07,909 --> 00:21:06,000

months to tour various laboratories

514

00:21:12,870 --> 00:21:07,919

including in britain he visited

515

00:21:17,669 --> 00:21:15,270

g.i taylor who was the

516

00:21:20,149 --> 00:21:17,679

very noted fluid analysis

517

00:21:22,710 --> 00:21:20,159

and melvil jones who was a very noted

518

00:21:25,270 --> 00:21:22,720

aerodynamicist both at cambridge and

519

00:21:28,470 --> 00:21:25,280

they both told jacob said look

520

00:21:31,110 --> 00:21:28,480

you know we have discovered at cambridge

521

00:21:31,990 --> 00:21:31,120

in the wind tunnel that if you have a

522

00:21:37,590 --> 00:21:32,000

body

523

00:21:39,750 --> 00:21:37,600

pressure keeps going down over the

524

00:21:41,830 --> 00:21:39,760

surface of the body as you flow down the

525

00:21:43,190 --> 00:21:41,840

surface of the body pressure goes down

526

00:21:44,470 --> 00:21:43,200

it's called a favorable pressure

527

00:21:46,549 --> 00:21:44,480

gradient

528

00:21:48,870 --> 00:21:46,559

the boundary layer on that surface will

529

00:21:51,110 --> 00:21:48,880

tend to remain laminar

530

00:21:51,990 --> 00:21:51,120

and only when that pressure starts going

531

00:21:54,710 --> 00:21:52,000

up

532

00:21:56,789 --> 00:21:54,720

do you have a transition to a turbulent

533

00:21:59,909 --> 00:21:56,799

boundary layer now that's that's

534

00:22:03,190 --> 00:21:59,919

important because the skin friction for

535

00:22:05,029 --> 00:22:03,200

a laminar boundary layer is much lower

536

00:22:06,549 --> 00:22:05,039

than the skin friction for a turbulent

537

00:22:07,430 --> 00:22:06,559

boundary layer everything else being

538

00:22:10,830 --> 00:22:07,440

equal

539

00:22:13,590 --> 00:22:10,840

factor of 10 lower uh can be and so

540

00:22:16,789 --> 00:22:13,600

therefore uh there this was a pretty

541

00:22:19,590 --> 00:22:16,799

important uh piece of information that

542

00:22:20,549 --> 00:22:19,600

eastman jacobs took back to langley with

543

00:22:22,630 --> 00:22:20,559

him

544

00:22:26,549 --> 00:22:22,640

and then he sat down and said how in the

545

00:22:32,230 --> 00:22:26,559

world can i design an airfoil shape

546

00:22:34,149 --> 00:22:32,240

to create a long region a wide swath

547

00:22:35,830 --> 00:22:34,159

of favorable pressure grain and

548

00:22:39,110 --> 00:22:35,840

decreasing pressure over the surface of

549

00:22:40,789 --> 00:22:39,120

the airfall to encourage a large region

550

00:22:43,430 --> 00:22:40,799

of laminar flow over there fall and

551
00:22:45,830 --> 00:22:43,440
therefore uh encounter

552
00:22:47,430 --> 00:22:45,840
have a much lower skin friction

553
00:22:49,830 --> 00:22:47,440
coefficient well

554
00:22:52,710 --> 00:22:49,840
that was not easy uh there was there was

555
00:22:54,549 --> 00:22:52,720
no way of doing that and so jacobs took

556
00:22:56,310 --> 00:22:54,559
some of the work that theodorson had

557
00:22:58,390 --> 00:22:56,320
done theodores and said this is

558
00:23:00,549 --> 00:22:58,400
impossible you can't you can't take a

559
00:23:02,870 --> 00:23:00,559
pressure distribution and design an

560
00:23:05,190 --> 00:23:02,880
airfoil that's going to give you that

561
00:23:06,470 --> 00:23:05,200
pressure distribution jacobs went home

562
00:23:09,029 --> 00:23:06,480
for three days

563
00:23:11,750 --> 00:23:09,039

studied theodore since theory came up

564

00:23:13,590 --> 00:23:11,760

with a technique for designing an

565

00:23:16,149 --> 00:23:13,600

airfoil that indeed

566

00:23:17,990 --> 00:23:16,159

would create a given pressure

567

00:23:19,350 --> 00:23:18,000

distribution

568

00:23:20,789 --> 00:23:19,360

whoops

569

00:23:22,549 --> 00:23:20,799

i'm going to go back

570

00:23:24,149 --> 00:23:22,559

and what you see there

571

00:23:26,549 --> 00:23:24,159

and the top graph

572

00:23:29,510 --> 00:23:26,559

is a standard naca airflow and you see

573

00:23:31,350 --> 00:23:29,520

the pressure distribution uh it's uh

574

00:23:33,590 --> 00:23:31,360

starts at the front of the airfoil and

575

00:23:35,190 --> 00:23:33,600

it drops like a rock reaches a

576
00:23:36,870 --> 00:23:35,200
minimum

577
00:23:38,630 --> 00:23:36,880
just downstream the leading edge and

578
00:23:40,390 --> 00:23:38,640
then you have this big

579
00:23:41,830 --> 00:23:40,400
region of increasing pressure the

580
00:23:43,990 --> 00:23:41,840
adverse pressure gradient that

581
00:23:46,310 --> 00:23:44,000
encourages turbulent flow and that was

582
00:23:48,789 --> 00:23:46,320
what was encountered over all all these

583
00:23:51,750 --> 00:23:48,799
standard airfoils basically they had

584
00:23:53,510 --> 00:23:51,760
turbulent boundary layers on them

585
00:23:56,390 --> 00:23:53,520
the bottom graph

586
00:23:57,430 --> 00:23:56,400
is a different shaped air form

587
00:23:59,830 --> 00:23:57,440
and you can see the pressure

588
00:24:02,070 --> 00:23:59,840

distribution there drops like a rock or

589

00:24:05,269 --> 00:24:02,080

going going around the leading edge and

590

00:24:08,149 --> 00:24:05,279

then maintains a decreasing

591

00:24:09,590 --> 00:24:08,159

favorable pressure practically to you

592

00:24:11,510 --> 00:24:09,600

know further downstream and then the

593

00:24:13,190 --> 00:24:11,520

midpoint of the airfoil and then you get

594

00:24:16,950 --> 00:24:13,200

your pressure increase

595

00:24:21,269 --> 00:24:16,960

that airfoil experienced a large region

596

00:24:24,230 --> 00:24:21,279

of laminar flow and therefore had a much

597

00:24:27,269 --> 00:24:24,240

lower skin friction coefficient

598

00:24:28,630 --> 00:24:27,279

that airfoil was called a laminar flow

599

00:24:31,990 --> 00:24:28,640

airfoil

600

00:24:34,870 --> 00:24:32,000

the ana there was a whole series of naca

601
00:24:37,510 --> 00:24:34,880
laminar flow airfoils that were designed

602
00:24:39,830 --> 00:24:37,520
and investigated and measured total

603
00:24:41,750 --> 00:24:39,840
measurements made towards the end of the

604
00:24:45,350 --> 00:24:41,760
1930s

605
00:24:47,909 --> 00:24:45,360
and that work unlike almost all the

606
00:24:50,149 --> 00:24:47,919
previous work at the naca

607
00:24:51,830 --> 00:24:50,159
that work on the laminar flow airflow

608
00:24:53,830 --> 00:24:51,840
was considered to be

609
00:24:56,310 --> 00:24:53,840
so important that it was immediately

610
00:24:58,950 --> 00:24:56,320
classified and so the word didn't get

611
00:25:00,630 --> 00:24:58,960
around very much about these new laminar

612
00:25:03,990 --> 00:25:00,640
flow air falls

613
00:25:07,590 --> 00:25:04,000

but it did get to edgar smooth who was

614

00:25:09,830 --> 00:25:07,600

designing the p51 at north america

615

00:25:10,789 --> 00:25:09,840

and smood had an opportunity first he

616

00:25:14,470 --> 00:25:10,799

had designed

617

00:25:17,430 --> 00:25:14,480

using p51 using a standard airfoil and

618

00:25:19,990 --> 00:25:17,440

then he was visited by several naca

619

00:25:22,070 --> 00:25:20,000

engineers one one day this is what the

620

00:25:23,269 --> 00:25:22,080

naca did they sent people out they

621

00:25:25,830 --> 00:25:23,279

talked to

622

00:25:28,630 --> 00:25:25,840

important people in industry and smooth

623

00:25:30,710 --> 00:25:28,640

learned about this classified

624

00:25:33,190 --> 00:25:30,720

laminar flow airform

625

00:25:35,269 --> 00:25:33,200

he designed a different wing he took two

626

00:25:37,750 --> 00:25:35,279

models up to the wind tunnel at the

627

00:25:39,510 --> 00:25:37,760

university of washington tested

628

00:25:41,669 --> 00:25:39,520

standard wing and tested the wing with

629

00:25:43,990 --> 00:25:41,679

the laminar flow airfoil the laminar

630

00:25:48,230 --> 00:25:44,000

flow airfoil performed much better

631

00:25:49,669 --> 00:25:48,240

presto the p51 is the first airplane in

632

00:25:51,669 --> 00:25:49,679

history

633

00:25:55,510 --> 00:25:51,679

first production line airplane in

634

00:25:58,390 --> 00:25:55,520

history to use a laminar flow airflow

635

00:26:01,029 --> 00:25:58,400

now so this is a big deal is an

636

00:26:03,750 --> 00:26:01,039

important development

637

00:26:05,990 --> 00:26:03,760

a just another follow-on of the kind of

638

00:26:09,750 --> 00:26:06,000

referral work and the

639

00:26:12,870 --> 00:26:09,760

contributions being made by the naca

640

00:26:14,070 --> 00:26:12,880

in aerodynamics in the 1930s

641

00:26:15,990 --> 00:26:14,080

now

642

00:26:17,350 --> 00:26:16,000

the rest of that story by the way is

643

00:26:18,950 --> 00:26:17,360

that

644

00:26:20,710 --> 00:26:18,960

in real life

645

00:26:23,750 --> 00:26:20,720

the laminar flow airfoil didn't really

646

00:26:25,990 --> 00:26:23,760

produce much laminar flow because in the

647

00:26:28,070 --> 00:26:26,000

wind tunnel the variable density tunnel

648

00:26:28,789 --> 00:26:28,080

and other wind tunnels at langley

649

00:26:34,470 --> 00:26:28,799

the

650

00:26:36,310 --> 00:26:34,480

finely polished jewels nice and smooth

651
00:26:38,390 --> 00:26:36,320
in reality when you build something like

652
00:26:40,310 --> 00:26:38,400
a p-51 you have manufacturing

653
00:26:41,830 --> 00:26:40,320
irregularities

654
00:26:43,830 --> 00:26:41,840
you have the airplane flying through the

655
00:26:46,390 --> 00:26:43,840
air encountering all kinds of insects

656
00:26:48,950 --> 00:26:46,400
bug spots on the surface all of that

657
00:26:50,950 --> 00:26:48,960
produces roughness which encourages the

658
00:26:53,669 --> 00:26:50,960
turbulent boundary layer so for all

659
00:26:56,549 --> 00:26:53,679
practical purposes that laminar flow

660
00:26:58,230 --> 00:26:56,559
wing on the p51 did not create laminar

661
00:27:01,029 --> 00:26:58,240
flow but

662
00:27:02,870 --> 00:27:01,039
and here's a case of serendipity in the

663
00:27:05,110 --> 00:27:02,880

history of technology

664

00:27:06,789 --> 00:27:05,120

it turned out that that shape of the

665

00:27:09,750 --> 00:27:06,799

laminar flow airfoil

666

00:27:11,909 --> 00:27:09,760

also had what we call a higher critical

667

00:27:15,029 --> 00:27:11,919

mach number

668

00:27:17,110 --> 00:27:15,039

that wing that airplane could fly faster

669

00:27:18,630 --> 00:27:17,120

before encountering some adverse

670

00:27:21,110 --> 00:27:18,640

compressibility effects which i'm going

671

00:27:24,470 --> 00:27:21,120

to share with you in in just a few

672

00:27:26,630 --> 00:27:24,480

minutes but that was the deal that was

673

00:27:28,950 --> 00:27:26,640

all this airfoil work

674

00:27:30,389 --> 00:27:28,960

culminating in the laminar flow airfall

675

00:27:31,750 --> 00:27:30,399

even

676
00:27:34,549 --> 00:27:31,760
kelly johnson

677
00:27:36,389 --> 00:27:34,559
when he designed the p80

678
00:27:39,190 --> 00:27:36,399
in 1944

679
00:27:42,149 --> 00:27:39,200
used a laminar flow airfoil

680
00:27:44,870 --> 00:27:42,159
so that was that was very important okay

681
00:27:46,230 --> 00:27:44,880
that's it the airflow work being done at

682
00:27:48,789 --> 00:27:46,240
the naca

683
00:27:50,630 --> 00:27:48,799
the langley memorial laboratory was very

684
00:27:52,950 --> 00:27:50,640
important i'm going to quickly go to the

685
00:27:58,630 --> 00:27:52,960
next subject

686
00:27:59,830 --> 00:27:58,640
fred white

687
00:28:02,389 --> 00:27:59,840
took over

688
00:28:04,630 --> 00:28:02,399

a new facility in 1928

689

00:28:07,029 --> 00:28:04,640

at langley it was discussed yesterday

690

00:28:09,669 --> 00:28:07,039

jeremy kinney mentioned it several times

691

00:28:10,710 --> 00:28:09,679

the propeller research time

692

00:28:13,110 --> 00:28:10,720

and

693

00:28:17,750 --> 00:28:14,950

in that tunnel

694

00:28:20,389 --> 00:28:17,760

a new project was initiated and this

695

00:28:22,149 --> 00:28:20,399

this project was initiated really as a

696

00:28:24,950 --> 00:28:22,159

result of meeting the aircraft

697

00:28:27,350 --> 00:28:24,960

manufacturers at langley uh they

698

00:28:31,350 --> 00:28:27,360

encouraged some work on cowlings and

699

00:28:32,789 --> 00:28:31,360

you'll find the 1927 nac annual report

700

00:28:34,789 --> 00:28:32,799

the following quote

701
00:28:37,110 --> 00:28:34,799
one of the problems suggested the study

702
00:28:39,269 --> 00:28:37,120
the effect of cowling and fuselage shape

703
00:28:41,430 --> 00:28:39,279
on the resistance and

704
00:28:43,590 --> 00:28:41,440
and cooling characteristics of

705
00:28:45,990 --> 00:28:43,600
air-cooled engines was promptly

706
00:28:47,110 --> 00:28:46,000
incorporated in the committee's research

707
00:28:49,990 --> 00:28:47,120
program

708
00:28:51,350 --> 00:28:50,000
and so there you have fred weick

709
00:28:55,029 --> 00:28:51,360
in the

710
00:28:59,430 --> 00:28:57,190
see the fuselage there's a one of the

711
00:29:01,190 --> 00:28:59,440
cowlings they were testing on the future

712
00:29:03,830 --> 00:29:01,200
in that prt

713
00:29:05,590 --> 00:29:03,840

and the result of that work

714

00:29:08,789 --> 00:29:05,600

produced something that was called the

715

00:29:10,549 --> 00:29:08,799

number 10 naca cali

716

00:29:12,149 --> 00:29:10,559

there's the lockheed vega

717

00:29:14,549 --> 00:29:12,159

one of the first airplanes to

718

00:29:15,430 --> 00:29:14,559

incorporate the cal that's the that's

719

00:29:20,070 --> 00:29:15,440

that

720

00:29:23,190 --> 00:29:20,080

around the engine the the

721

00:29:24,310 --> 00:29:23,200

the cylinders of the engine and the naca

722

00:29:26,950 --> 00:29:24,320

cowling

723

00:29:28,149 --> 00:29:26,960

not only reduced the drag but also

724

00:29:28,950 --> 00:29:28,159

increased

725

00:29:31,110 --> 00:29:28,960

made

726

00:29:32,310 --> 00:29:31,120

and improved the cooling

727

00:29:36,710 --> 00:29:32,320

of the

728

00:29:39,750 --> 00:29:36,720

and here it is on the lockheed vega the

729

00:29:44,549 --> 00:29:42,070

before the cowling had a top speed of

730

00:29:46,430 --> 00:29:44,559

165 miles an hour

731

00:29:49,029 --> 00:29:46,440

after the cowling was added

732

00:29:50,710 --> 00:29:49,039

190 miles an hour is a top speed that

733

00:29:54,630 --> 00:29:50,720

was dramatic

734

00:29:57,190 --> 00:29:54,640

again another feather in the cap

735

00:29:58,470 --> 00:29:57,200

in the aerodynamic developments of the

736

00:30:01,110 --> 00:29:58,480

naca

737

00:30:02,789 --> 00:30:01,120

at the langley memorial laboratory and

738

00:30:05,510 --> 00:30:02,799

the final feather

739

00:30:10,950 --> 00:30:07,510

has to do with high speed

740

00:30:13,029 --> 00:30:10,960

compressibility problems

741

00:30:17,269 --> 00:30:13,039

we'll start here

742

00:30:18,389 --> 00:30:17,279

in 1918 at mccoook field in dayton ohio

743

00:30:20,070 --> 00:30:18,399

the army

744

00:30:21,750 --> 00:30:20,080

put together

745

00:30:23,430 --> 00:30:21,760

a new wind tunnel

746

00:30:24,630 --> 00:30:23,440

dick hallian mentioned that wind tunnel

747

00:30:26,389 --> 00:30:24,640

yesterday

748

00:30:28,149 --> 00:30:26,399

and in fact he even mentioned quite

749

00:30:31,350 --> 00:30:28,159

properly it's a pretty long one tall

750

00:30:34,830 --> 00:30:31,360

it's 18 feet it's a 14 inch test section

751

00:30:37,350 --> 00:30:34,840

uh it's so historic that uh it's

752

00:30:39,990 --> 00:30:37,360

uh belongs to the

753

00:30:42,070 --> 00:30:40,000

museum of the air force in dayton ohio

754

00:30:44,389 --> 00:30:42,080

on display the last time i was there

755

00:30:46,950 --> 00:30:44,399

sort of tucked in a corner but that wind

756

00:30:50,549 --> 00:30:46,960

tunnel you'll see here that wind tunnel

757

00:30:52,070 --> 00:30:50,559

had speeds from 25 to 406

758

00:30:55,310 --> 00:30:52,080

miles an hour

759

00:30:59,590 --> 00:30:55,320

now what airplane in 1918 would fly at

760

00:31:02,310 --> 00:30:59,600

465 miles an hour oh obviously none

761

00:31:04,870 --> 00:31:02,320

and there was nobody in that period of

762

00:31:07,350 --> 00:31:04,880

time who was even thinking about

763

00:31:09,269 --> 00:31:07,360

airplane speeds like that but

764

00:31:11,029 --> 00:31:09,279

they knew that the tip speeds of

765

00:31:13,909 --> 00:31:11,039

propellers

766

00:31:15,830 --> 00:31:13,919

came in in fact excite they exceeded

767

00:31:18,310 --> 00:31:15,840

that velocity

768

00:31:19,830 --> 00:31:18,320

and there were some really strange

769

00:31:22,789 --> 00:31:19,840

things happening

770

00:31:25,029 --> 00:31:22,799

when tip speeds got up close to the

771

00:31:27,830 --> 00:31:25,039

upper pillars got up close to the speed

772

00:31:30,310 --> 00:31:27,840

of sound and these guys frank caldwell

773

00:31:32,870 --> 00:31:30,320

elijah fails in that wind tunnel were

774

00:31:35,830 --> 00:31:32,880

the first to measure

775

00:31:39,350 --> 00:31:35,840

the effect of high speeds on lift prior

776

00:31:42,149 --> 00:31:39,360

to that ballisticians knew that

777

00:31:43,909 --> 00:31:42,159

for on projectiles if you fly up near

778

00:31:45,990 --> 00:31:43,919

the speed of sound suddenly there's a

779

00:31:47,909 --> 00:31:46,000

big increase in drag on the projectile

780

00:31:49,430 --> 00:31:47,919

but nobody had paid any attention to

781

00:31:52,149 --> 00:31:49,440

lift

782

00:31:54,789 --> 00:31:52,159

here's a strange looking graph

783

00:31:56,789 --> 00:31:54,799

as soon as it comes up

784

00:31:58,950 --> 00:31:56,799

from this result

785

00:32:00,870 --> 00:31:58,960

of a cook field what you see there on

786

00:32:03,029 --> 00:32:00,880

the vertical axis is something called

787

00:32:04,950 --> 00:32:03,039

lift coefficient on the horizontal axis

788

00:32:06,710 --> 00:32:04,960

is velocity speed

789

00:32:08,389 --> 00:32:06,720

measuring the wind tunnel and you can

790

00:32:10,310 --> 00:32:08,399

see just pay attention to the right hand

791

00:32:12,149 --> 00:32:10,320

side of that that picture

792

00:32:13,590 --> 00:32:12,159

you'll see that as the velocity

793

00:32:16,070 --> 00:32:13,600

increases

794

00:32:18,870 --> 00:32:16,080

all of a sudden the lift

795

00:32:22,230 --> 00:32:18,880

falls off the cliff it it just

796

00:32:24,549 --> 00:32:22,240

dramatically decreases

797

00:32:26,070 --> 00:32:24,559

an important observation they didn't

798

00:32:27,990 --> 00:32:26,080

have a clue

799

00:32:31,430 --> 00:32:28,000

as to what was causing it but it was an

800

00:32:33,909 --> 00:32:31,440

important observation

801
00:32:34,710 --> 00:32:33,919
a few years later oh by the way i should

802
00:32:38,549 --> 00:32:34,720
say

803
00:32:40,389 --> 00:32:38,559
this work is published in an naca tr

804
00:32:43,750 --> 00:32:40,399
because the naca

805
00:32:44,950 --> 00:32:43,760
funded this work at the cook field

806
00:32:47,909 --> 00:32:44,960
okay

807
00:32:50,070 --> 00:32:47,919
a few years later in the early 1920s the

808
00:32:52,070 --> 00:32:50,080
naca gave a contract in the national

809
00:32:54,230 --> 00:32:52,080
bureau of standards in

810
00:32:55,669 --> 00:32:54,240
a series of tests

811
00:32:57,830 --> 00:32:55,679
one of which

812
00:32:59,909 --> 00:32:57,840
was carried out uh one series carried

813
00:33:02,230 --> 00:32:59,919

out at the edgewood arsenal

814

00:33:06,149 --> 00:33:02,240

up here in maryland

815

00:33:13,190 --> 00:33:08,470

some measurements were made on air foils

816

00:33:16,389 --> 00:33:14,630

well yes

817

00:33:18,310 --> 00:33:16,399

measurements were made actually there

818

00:33:19,990 --> 00:33:18,320

they were made by

819

00:33:22,549 --> 00:33:20,000

hugh dryden

820

00:33:25,190 --> 00:33:22,559

uh and frank caldwell you've heard frank

821

00:33:27,909 --> 00:33:25,200

caldwell's name when jeremy yesterday

822

00:33:28,950 --> 00:33:27,919

talked about variable pitch propellers

823

00:33:33,110 --> 00:33:28,960

and

824

00:33:35,029 --> 00:33:33,120

those guys measured for example

825

00:33:37,269 --> 00:33:35,039

a pressure distribution on the surface

826

00:33:38,870 --> 00:33:37,279

of an airfoil when it was going through

827

00:33:41,029 --> 00:33:38,880

this period where the lift coefficient

828

00:33:42,870 --> 00:33:41,039

is dropping off the cliff

829

00:33:44,950 --> 00:33:42,880

and

830

00:33:46,710 --> 00:33:44,960

that was being called now the critical

831

00:33:47,990 --> 00:33:46,720

speed when the lift coefficient dropped

832

00:33:49,430 --> 00:33:48,000

off the cliff

833

00:33:51,190 --> 00:33:49,440

later on we would call that at a

834

00:33:53,830 --> 00:33:51,200

critical mach number

835

00:33:56,549 --> 00:33:53,840

and the nbs results

836

00:33:58,950 --> 00:33:56,559

showed pressure distribution that were

837

00:34:00,630 --> 00:33:58,960

rather strange you had your decreasing

838

00:34:02,470 --> 00:34:00,640

pressure as the flow expanded over the

839

00:34:05,190 --> 00:34:02,480

top surface of the airflow suddenly

840

00:34:09,190 --> 00:34:05,200

there is a jump in pressure and then a

841

00:34:10,790 --> 00:34:09,200

plateau a flat pressure a plateau in the

842

00:34:12,710 --> 00:34:10,800

pressure distribution

843

00:34:13,909 --> 00:34:12,720

now it was known at that time

844

00:34:17,349 --> 00:34:13,919

that

845

00:34:19,430 --> 00:34:17,359

distribution encountered on an airplane

846

00:34:21,510 --> 00:34:19,440

wing when the airplane was at high angle

847

00:34:24,869 --> 00:34:21,520

attack and the wing stalls and that was

848

00:34:26,869 --> 00:34:24,879

a clear indication of stalling stalling

849

00:34:28,550 --> 00:34:26,879

with a flow separating off the top

850

00:34:29,829 --> 00:34:28,560

surface of the wing

851
00:34:35,190 --> 00:34:29,839
these

852
00:34:36,389 --> 00:34:35,200
phenomena on an airfoil at zero degrees

853
00:34:38,230 --> 00:34:36,399
angle attack

854
00:34:40,389 --> 00:34:38,240
but it was happening at high speeds and

855
00:34:42,550 --> 00:34:40,399
they interpreted

856
00:34:44,069 --> 00:34:42,560
this very bad effect that you see there

857
00:34:46,310 --> 00:34:44,079
the lift coefficient falling off the

858
00:34:48,310 --> 00:34:46,320
cliff the that is called the can be

859
00:34:50,389 --> 00:34:48,320
called the adverse compressibility

860
00:34:52,389 --> 00:34:50,399
effects due to a compressibility burble

861
00:34:54,869 --> 00:34:52,399
they call

862
00:34:57,109 --> 00:34:54,879
that is associated with

863
00:34:58,630 --> 00:34:57,119

separated flow

864

00:35:00,470 --> 00:34:58,640

but again

865

00:35:02,390 --> 00:35:00,480

nobody had a clue

866

00:35:04,630 --> 00:35:02,400

why was the flow separating here you had

867

00:35:06,230 --> 00:35:04,640

a wing it's an airfoil at zero degrees

868

00:35:09,190 --> 00:35:06,240

angle of attack and the flow is

869

00:35:11,109 --> 00:35:09,200

separating at these high speeds what was

870

00:35:12,870 --> 00:35:11,119

going on

871

00:35:14,710 --> 00:35:12,880

well

872

00:35:17,109 --> 00:35:14,720

john stack

873

00:35:18,710 --> 00:35:17,119

1928 graduate of aeronautical

874

00:35:20,310 --> 00:35:18,720

engineering at mit walked through the

875

00:35:22,069 --> 00:35:20,320

doors of the langley memorial

876

00:35:24,950 --> 00:35:22,079

aeronautical laboratory

877

00:35:27,349 --> 00:35:24,960

he soon became involved in a small

878

00:35:28,790 --> 00:35:27,359

high-speed wind tunnel at langley

879

00:35:32,150 --> 00:35:28,800

and stack

880

00:35:35,910 --> 00:35:32,160

measured in 1934 for the first time

881

00:35:37,829 --> 00:35:35,920

really definitive the typical naca kind

882

00:35:39,990 --> 00:35:37,839

of definitive measurements

883

00:35:41,829 --> 00:35:40,000

of

884

00:35:44,630 --> 00:35:41,839

lift coefficient and drag coefficient a

885

00:35:46,950 --> 00:35:44,640

moment coefficient as a function

886

00:35:48,710 --> 00:35:46,960

of velocity

887

00:35:51,109 --> 00:35:48,720

and this happened to be a clockwise

888

00:35:54,150 --> 00:35:51,119

airfoil believe it or not

889

00:35:56,710 --> 00:35:54,160

and indeed it was absolute proof of

890

00:35:58,390 --> 00:35:56,720

these adverse compressibility effects

891

00:36:01,109 --> 00:35:58,400

because the lift as you see it dropping

892

00:36:03,829 --> 00:36:01,119

off when you get to high speed the drag

893

00:36:06,710 --> 00:36:03,839

is going up out of sight that that's the

894

00:36:08,710 --> 00:36:06,720

kind of data that gave rise to the myth

895

00:36:11,190 --> 00:36:08,720

of the sound barrier because you look at

896

00:36:13,190 --> 00:36:11,200

that data and say man we're never going

897

00:36:15,510 --> 00:36:13,200

to be able to fly faster than the speed

898

00:36:19,109 --> 00:36:15,520

of sound because

899

00:36:21,750 --> 00:36:19,119

the drag is going out of sight

900

00:36:24,630 --> 00:36:21,760

and they knew at that time it was due to

901
00:36:27,190 --> 00:36:24,640
flow separation but what was causing the

902
00:36:28,870 --> 00:36:27,200
flow to separate

903
00:36:31,030 --> 00:36:28,880
now i'm going to pass by this is what a

904
00:36:32,630 --> 00:36:31,040
chance john stack

905
00:36:34,390 --> 00:36:32,640
at this period of time

906
00:36:36,950 --> 00:36:34,400
theorized because they couldn't measure

907
00:36:38,950 --> 00:36:36,960
things properly at mach 1

908
00:36:40,790 --> 00:36:38,960
in a wind tunnel that the only way we

909
00:36:44,150 --> 00:36:40,800
could do that is with a real research

910
00:36:46,710 --> 00:36:44,160
airplane in 1934 he was he really was

911
00:36:48,870 --> 00:36:46,720
the first person to suggest

912
00:36:51,670 --> 00:36:48,880
a research airplane to prove this

913
00:36:53,430 --> 00:36:51,680

mysterious range around mach 1 and it

914

00:36:55,349 --> 00:36:53,440

didn't get anywhere that's a graph for

915

00:36:56,950 --> 00:36:55,359

those of you who

916

00:36:58,790 --> 00:36:56,960

have studied airplane performance that's

917

00:37:01,270 --> 00:36:58,800

called a power required curve power

918

00:37:02,630 --> 00:37:01,280

required versus velocity two curves one

919

00:37:04,710 --> 00:37:02,640

with compressibility one without

920

00:37:07,270 --> 00:37:04,720

compressibility only reason i'm showing

921

00:37:09,589 --> 00:37:07,280

this i found this graph in the john

922

00:37:12,950 --> 00:37:09,599

stock our archives

923

00:37:16,310 --> 00:37:12,960

at langley and it was in a manila folder

924

00:37:17,990 --> 00:37:16,320

was in between some of john stack's old

925

00:37:20,069 --> 00:37:18,000

irs forms

926

00:37:22,390 --> 00:37:20,079

and there's even a

927

00:37:24,470 --> 00:37:22,400

rusty paper clip mark on the top of that

928

00:37:27,190 --> 00:37:24,480

graph but he was thinking about these

929

00:37:29,190 --> 00:37:27,200

things even published a paper in the

930

00:37:31,910 --> 00:37:29,200

journal of aeronautical sciences about

931

00:37:34,230 --> 00:37:31,920

this but john stack the really big

932

00:37:35,750 --> 00:37:34,240

contribution came

933

00:37:36,630 --> 00:37:35,760

and

934

00:37:40,230 --> 00:37:36,640

when

935

00:37:43,829 --> 00:37:40,240

in 1934 working for eastman jacobs

936

00:37:45,829 --> 00:37:43,839

eastman jacobs was his boss

937

00:37:48,390 --> 00:37:45,839

jacob suggested since we don't know

938

00:37:50,870 --> 00:37:48,400

what's going on in this flow

939

00:37:53,349 --> 00:37:50,880

why don't we put a schlearn system

940

00:37:55,109 --> 00:37:53,359

across the wind tunnel

941

00:37:57,589 --> 00:37:55,119

at these high speeds

942

00:38:00,390 --> 00:37:57,599

and take a picture and see what is going

943

00:38:01,829 --> 00:38:00,400

on in the flow

944

00:38:04,950 --> 00:38:01,839

they did that

945

00:38:07,510 --> 00:38:04,960

and what you see there in 1934

946

00:38:09,109 --> 00:38:07,520

is the first ever

947

00:38:11,670 --> 00:38:09,119

visualization

948

00:38:13,109 --> 00:38:11,680

of shock waves occurring the flow is

949

00:38:15,430 --> 00:38:13,119

going from left to right over that

950

00:38:18,710 --> 00:38:15,440

airflow there's a shock wave off the top

951
00:38:20,230 --> 00:38:18,720
there's a shock wave off the bottom

952
00:38:22,870 --> 00:38:20,240
first ever

953
00:38:25,430 --> 00:38:22,880
that aerodynamicist had ever seen that

954
00:38:26,630 --> 00:38:25,440
and here this historic photograph is

955
00:38:29,910 --> 00:38:26,640
being taken

956
00:38:34,390 --> 00:38:29,920
by these dedicated intelligent

957
00:38:36,550 --> 00:38:34,400
engineers and scientists at naca langley

958
00:38:38,390 --> 00:38:36,560
this explained

959
00:38:40,790 --> 00:38:38,400
the cause of the separated flow the

960
00:38:42,630 --> 00:38:40,800
shock waves were separating the boundary

961
00:38:45,910 --> 00:38:42,640
layer

962
00:38:47,270 --> 00:38:45,920
flow separation resulted in higher drag

963
00:38:49,430 --> 00:38:47,280

lower lift

964

00:38:51,670 --> 00:38:49,440

that was the explanation it was that

965

00:38:54,710 --> 00:38:51,680

that was a major intellectual

966

00:38:57,829 --> 00:38:54,720

breakthrough in the understanding of the

967

00:38:59,030 --> 00:38:57,839

high-speed compressibility problem and

968

00:39:01,589 --> 00:38:59,040

uh

969

00:39:05,829 --> 00:39:01,599

know it's i don't think the naca gets

970

00:39:08,470 --> 00:39:05,839

enough credit for that now in part

971

00:39:12,390 --> 00:39:08,480

let me quote then this photograph

972

00:39:12,400 --> 00:39:16,790

when this measurement was made

973

00:39:21,510 --> 00:39:19,109

here's a quote from john becker who was

974

00:39:24,470 --> 00:39:21,520

uh became a leading aerodynamicist at

975

00:39:26,470 --> 00:39:24,480

langley later on he says the first tests

976
00:39:28,710 --> 00:39:26,480
were made on a circular cylinder not an

977
00:39:30,710 --> 00:39:28,720
airfoil but a circular cylinder about a

978
00:39:33,349 --> 00:39:30,720
half inch in diameter and the results

979
00:39:35,829 --> 00:39:33,359
were spectacular in spite of the poor

980
00:39:39,190 --> 00:39:35,839
quality of the optics the optics that

981
00:39:40,950 --> 00:39:39,200
they use celluloid for the windows

982
00:39:42,790 --> 00:39:40,960
across the wind tunnel test section so

983
00:39:44,950 --> 00:39:42,800
you're and those of you who've ever

984
00:39:47,270 --> 00:39:44,960
dealt with a certain system

985
00:39:49,990 --> 00:39:47,280
that sounds like heresy

986
00:39:52,069 --> 00:39:50,000
you need high quality optical windows

987
00:39:53,589 --> 00:39:52,079
here's celluloid being used but it was

988
00:39:55,430 --> 00:39:53,599

the beginning

989

00:39:58,230 --> 00:39:55,440

shock waves and intended flow

990

00:40:00,310 --> 00:39:58,240

separations were seen for the first time

991

00:40:02,550 --> 00:40:00,320

starting at subsonic stream speeds about

992

00:40:04,309 --> 00:40:02,560

six tenths times the speed of sound

993

00:40:07,109 --> 00:40:04,319

visitors from all over the laboratory

994

00:40:09,430 --> 00:40:07,119

from engineering charge hce read

995

00:40:11,030 --> 00:40:09,440

on down

996

00:40:12,710 --> 00:40:11,040

engineer in charge

997

00:40:15,430 --> 00:40:12,720

yesterday it was mentioned when jim

998

00:40:18,230 --> 00:40:15,440

hansen was here one of his first books

999

00:40:20,870 --> 00:40:18,240

is a history of the langley memorial

1000

00:40:22,829 --> 00:40:20,880

aeronautical laboratory the title is

1001
00:40:25,670 --> 00:40:22,839
engineer in charge and it's a double

1002
00:40:28,230 --> 00:40:25,680
entendre because engineer in charge was

1003
00:40:30,069 --> 00:40:28,240
what the director of the lab was called

1004
00:40:32,230 --> 00:40:30,079
and all these

1005
00:40:35,349 --> 00:40:32,240
dedicated intelligent

1006
00:40:39,430 --> 00:40:35,359
motivated engineers and scientists where

1007
00:40:41,030 --> 00:40:39,440
there were themselves in charge of the

1008
00:40:43,349 --> 00:40:41,040
work that they were doing they had the

1009
00:40:46,710 --> 00:40:43,359
professional freedom to do that and that

1010
00:40:47,990 --> 00:40:46,720
was important anyway i don't i i diverge

1011
00:40:49,829 --> 00:40:48,000
on that

1012
00:40:51,109 --> 00:40:49,839
reed came on down came to view the

1013
00:40:53,750 --> 00:40:51,119

phenomena

1014

00:40:56,230 --> 00:40:53,760

langley's ranking theorist theodore

1015

00:40:58,630 --> 00:40:56,240

theodorsen we saw him earlier

1016

00:41:00,870 --> 00:40:58,640

viewed the results skeptically

1017

00:41:02,630 --> 00:41:00,880

proclaiming that since the stream flow

1018

00:41:04,829 --> 00:41:02,640

was subsonic

1019

00:41:09,030 --> 00:41:04,839

what appeared to be shock

1020

00:41:11,589 --> 00:41:09,040

waves was an optical illusion an error

1021

00:41:12,950 --> 00:41:11,599

in judgment which he was never allowed

1022

00:41:15,829 --> 00:41:12,960

to forget

1023

00:41:17,510 --> 00:41:15,839

so sometimes you know everybody makes

1024

00:41:18,550 --> 00:41:17,520

misinterpretation

1025

00:41:21,589 --> 00:41:18,560

finally

1026

00:41:24,470 --> 00:41:21,599

this work the naca didn't sit on this

1027

00:41:26,630 --> 00:41:24,480

one year later eastman jacobs reported

1028

00:41:27,990 --> 00:41:26,640

on this at the fifth volta con

1029

00:41:30,950 --> 00:41:28,000

conference

1030

00:41:33,030 --> 00:41:30,960

for high-speed flight in rome

1031

00:41:34,630 --> 00:41:33,040

this conference was mentioned yesterday

1032

00:41:36,630 --> 00:41:34,640

in fact i think that callion mentioned

1033

00:41:39,109 --> 00:41:36,640

it because that's where adolf bushman

1034

00:41:40,790 --> 00:41:39,119

first suggested the idea of swept wings

1035

00:41:42,710 --> 00:41:40,800

and uh

1036

00:41:45,670 --> 00:41:42,720

also at that conference not so well

1037

00:41:48,790 --> 00:41:45,680

known as the father is the following

1038

00:41:51,270 --> 00:41:48,800

that jacobs gave a paper on this work at

1039

00:41:53,589 --> 00:41:51,280

the volta conference

1040

00:41:56,470 --> 00:41:53,599

and in that paper in keeping with the

1041

00:41:58,309 --> 00:41:56,480

naca's penchant for perfection

1042

00:42:00,150 --> 00:41:58,319

especially in his publications that was

1043

00:42:03,270 --> 00:42:00,160

another thing mentioned yesterday the

1044

00:42:05,510 --> 00:42:03,280

quality of the nac atr's they work they

1045

00:42:07,510 --> 00:42:05,520

strive for perfection so in keeping with

1046

00:42:09,910 --> 00:42:07,520

this pension for perfection

1047

00:42:12,390 --> 00:42:09,920

jacobs apologized for the quality of the

1048

00:42:14,069 --> 00:42:12,400

photographs a fault that detracted

1049

00:42:15,750 --> 00:42:14,079

little from their technical and

1050

00:42:17,990 --> 00:42:15,760

historical importance

1051
00:42:20,390 --> 00:42:18,000
unfortunately the photographs were

1052
00:42:22,150 --> 00:42:20,400
injured this is jacob's going on

1053
00:42:23,990 --> 00:42:22,160
unfortunately the photographs were

1054
00:42:25,829 --> 00:42:24,000
injured by the presence of bent

1055
00:42:27,829 --> 00:42:25,839
celluloid windows

1056
00:42:29,349 --> 00:42:27,839
forming the tunnel walls through which

1057
00:42:31,510 --> 00:42:29,359
the light passed

1058
00:42:33,990 --> 00:42:31,520
the pictures nevertheless

1059
00:42:36,950 --> 00:42:34,000
give fun here this is this is so laid

1060
00:42:40,069 --> 00:42:36,960
back the pictures nevertheless give

1061
00:42:41,910 --> 00:42:40,079
fundamental information in regard to the

1062
00:42:44,230 --> 00:42:41,920
nature of the flow

1063
00:42:46,150 --> 00:42:44,240

associated with the compressibility

1064

00:42:48,630 --> 00:42:46,160

verbal that was an intellectual

1065

00:42:50,309 --> 00:42:48,640

breakthrough in my mind which was a

1066

00:42:52,309 --> 00:42:50,319

first order

1067

00:42:55,190 --> 00:42:52,319

and with that

1068

00:42:58,309 --> 00:42:55,200

the naca high-speed research program was

1069

00:42:59,829 --> 00:42:58,319

not simply on the map it was leading the

1070

00:43:01,510 --> 00:42:59,839

pack

1071

00:43:02,470 --> 00:43:01,520

so this is uh

1072

00:43:05,670 --> 00:43:02,480

and

1073

00:43:08,630 --> 00:43:05,680

ultimately

1074

00:43:11,030 --> 00:43:08,640

helped us and led to the

1075

00:43:14,309 --> 00:43:11,040

the necessary information for the bell

1076

00:43:16,069 --> 00:43:14,319

engineers to to properly design the x1

1077

00:43:17,670 --> 00:43:16,079

which you heard about yesterday and

1078

00:43:20,150 --> 00:43:17,680

which is of course hanging in the

1079

00:43:22,790 --> 00:43:20,160

milestones of light gallery here

1080

00:43:25,030 --> 00:43:22,800

final comment on my own i want to wrap

1081

00:43:26,390 --> 00:43:25,040

this up with the following

1082

00:43:27,270 --> 00:43:26,400

i'm going to read this to make sure i

1083

00:43:28,950 --> 00:43:27,280

get the

1084

00:43:31,670 --> 00:43:28,960

all the words in

1085

00:43:34,470 --> 00:43:31,680

during the 1930s

1086

00:43:37,510 --> 00:43:34,480

no other research establishment

1087

00:43:38,710 --> 00:43:37,520

worldwide and that includes laboratories

1088

00:43:41,430 --> 00:43:38,720

in britain

1089

00:43:42,390 --> 00:43:41,440

prandtl's laboratory and germany the

1090

00:43:44,069 --> 00:43:42,400

labs

1091

00:43:46,390 --> 00:43:44,079

in france etc

1092

00:43:49,430 --> 00:43:46,400

no other research establishment

1093

00:43:51,430 --> 00:43:49,440

worldwide contributed more

1094

00:43:53,829 --> 00:43:51,440

to the advancement of aerodynamics as

1095

00:43:56,309 --> 00:43:53,839

applied to the airplane than did the

1096

00:43:59,030 --> 00:43:56,319

naca you know why did mesher schmidt use

1097

00:44:01,990 --> 00:43:59,040

an naca air force the germans did not

1098

00:44:04,950 --> 00:44:02,000

have any integrated logical airfare

1099

00:44:06,870 --> 00:44:04,960

program they used the naca data

1100

00:44:09,589 --> 00:44:06,880

the engineers and scientists at the

1101

00:44:11,510 --> 00:44:09,599

langley memorial aerodynamic laboratory

1102

00:44:13,829 --> 00:44:11,520

were among the best and i really

1103

00:44:17,349 --> 00:44:13,839

sincerely mean that they were among the

1104

00:44:19,829 --> 00:44:17,359

best and this is a legacy that today's

1105

00:44:22,870 --> 00:44:19,839

nasa engineers and scientists

1106

00:44:25,750 --> 00:44:22,880

can derive great pride from

1107

00:44:28,630 --> 00:44:25,760

and with that i'm going to wrap up this

1108

00:44:30,710 --> 00:44:28,640

discussion of the naca aerodynamic

1109

00:44:33,430 --> 00:44:30,720

contributions in the 1930s and how a