1
00:00:27,740 --> 00:00:26,060
hello and welcome to future path I'm

2
00:00:29,510 --> 00:00:27,750
amreeka forsteri director of external

3
00:00:32,840 --> 00:00:29,520
affairs at the NASA Lewis Research

4
00:00:35,060 --> 00:00:32,850
Center in Cleveland Ohio in NASA's goal

5
00:00:37,580 --> 00:00:35,070
is to try to fly higher further and

6
00:00:40,340 --> 00:00:37,590
faster new materials and structures are

7
00:00:41,720 --> 00:00:40,350
required to meet these goals in today's

8
00:00:43,220 --> 00:00:41,730
segment we're going to look at some of

9
00:00:45,049 --> 00:00:43,230
the things being done in our structures

10
00:00:47,119 --> 00:00:45,059
division structures for flight

11
00:00:58,759 --> 00:00:47,129
propulsion I think you'll find it

12
00:01:00,709 --> 00:00:58,769
interesting let's watch flight in the

13
00:01:03,649 --> 00:01:00,719

air or in space requires propulsion

14
00:01:06,050 --> 00:01:03,659
systems able to withstand extremes of

15
00:01:08,930 --> 00:01:06,060
mechanical stress vibration and

16
00:01:11,000 --> 00:01:08,940
temperatures designing these structures

17
00:01:13,190 --> 00:01:11,010
and matching available materials to the

18
00:01:16,210 --> 00:01:13,200
job has always been a complicated

19
00:01:18,980 --> 00:01:16,220
business and is becoming more so

20
00:01:20,860 --> 00:01:18,990
requiring safety and reliability from

21
00:01:23,990 --> 00:01:20,870
structures needing minimum maintenance

22
00:01:26,180 --> 00:01:24,000
having the least possible weight poses a

23
00:01:28,390 --> 00:01:26,190
basic contradiction which can be

24
00:01:32,210 --> 00:01:28,400
resolved only by the most sophisticated

25
00:01:33,920 --> 00:01:32,220
analytic methods the Lewis research

26
00:01:35,420 --> 00:01:33,930
structures division is dedicated to

27
00:01:38,060 --> 00:01:35,430
advancing the state of the art of

28
00:01:42,260 --> 00:01:38,070
structures technology or aeronautical

29
00:01:44,390 --> 00:01:42,270
space and terrestrial applications the

30
00:01:46,550 --> 00:01:44,400
principal product of the division is the

31
00:01:48,590 --> 00:01:46,560
development of validated analytic

32
00:01:51,170 --> 00:01:48,600
methods to predict the behavior of

33
00:01:55,000 --> 00:01:51,180
structural components and systems or

34
00:01:57,560 --> 00:01:55,010
aerospace propulsion and power machinery

35
00:01:59,090 --> 00:01:57,570
division provides not only solutions to

36
00:02:01,790 --> 00:01:59,100
problems encountered in current

37
00:02:03,650 --> 00:02:01,800
applications but also leadership in

38
00:02:06,290 --> 00:02:03,660

setting new directions for structures

39
00:02:10,309 --> 00:02:06,300
engineering to solve tomorrow's problems

40
00:02:12,140 --> 00:02:10,319
today the purpose of the structures

41
00:02:15,080 --> 00:02:12,150
division at Lewis research center is to

42
00:02:17,239 --> 00:02:15,090
develop advanced credible design tools

43
00:02:18,270 --> 00:02:17,249
these tools can then be used by

44
00:02:20,790 --> 00:02:18,280
designers

45
00:02:22,770 --> 00:02:20,800
to design advanced concepts for future

46
00:02:25,530 --> 00:02:22,780
missions both in aeronautics and in

47
00:02:27,570 --> 00:02:25,540
space we develop these methods for use

48
00:02:29,190 --> 00:02:27,580
on high-speed computers and they are

49
00:02:32,400 --> 00:02:29,200
validated with the state-of-the-art

50
00:02:34,470 --> 00:02:32,410
laboratory equipment we can predict the

51
00:02:36,449 --> 00:02:34,480
life that is the number of missions that

52
00:02:39,510 --> 00:02:36,459
can be flown by the advanced concept and

53
00:02:41,550 --> 00:02:39,520
we can optimize the design both from the

54
00:02:45,470 --> 00:02:41,560
point of view of minimum weight or from

55
00:02:50,460 --> 00:02:48,270
breakthroughs in flight usually follow

56
00:02:53,280 --> 00:02:50,470
developments in propulsion systems in

57
00:02:55,259 --> 00:02:53,290
the early days of flight structures

58
00:02:59,040 --> 00:02:55,269
design was a combination of art and

59
00:03:01,440 --> 00:02:59,050
trial and error if you are developing a

60
00:03:04,320 --> 00:03:01,450
rocket you built an engine derived from

61
00:03:07,880 --> 00:03:04,330
earlier designs to be sure it didn't

62
00:03:10,559 --> 00:03:07,890
fail you made it sturdier heavy as

63
00:03:12,780 --> 00:03:10,569

technology advanced lighter stronger

64
00:03:15,540 --> 00:03:12,790
materials and improve manufacturing

65
00:03:18,030 --> 00:03:15,550
methods made the impossible possible but

66
00:03:21,600 --> 00:03:18,040
mistakes were still made and the results

67
00:03:23,280 --> 00:03:21,610
were spectacular and costly failures the

68
00:03:25,140 --> 00:03:23,290
job of the structures division is to

69
00:03:28,410 --> 00:03:25,150
make sure such accidents will no longer

70
00:03:30,960 --> 00:03:28,420
occur they do this by applying the

71
00:03:33,330 --> 00:03:30,970
latest scientific analysis possible and

72
00:03:36,210 --> 00:03:33,340
by using the most up-to-date testing

73
00:03:38,039 --> 00:03:36,220
equipment and methods available to do

74
00:03:41,250 --> 00:03:38,049
this the staff of scientists engineers

75
00:03:43,680 --> 00:03:41,260
and technicians of the division perform

76
00:03:46,949 --> 00:03:43,690
work in structural mechanics structural

77
00:03:55,110 --> 00:03:46,959
dynamics fatigue fracture and on

78
00:03:56,880 --> 00:03:55,120
projects and applications some of the

79
00:03:59,009 --> 00:03:56,890
work in structural mechanics includes

80
00:04:02,340 --> 00:03:59,019
characterizing the properties of metals

81
00:04:04,560 --> 00:04:02,350
used in propulsion systems by subjecting

82
00:04:06,870 --> 00:04:04,570
specimens to stress and varying

83
00:04:08,789 --> 00:04:06,880
temperatures researchers can predict

84
00:04:11,880 --> 00:04:08,799
maximum loading and operating

85
00:04:14,069 --> 00:04:11,890
temperatures and testing is performed at

86
00:04:16,500 --> 00:04:14,079
very high temperatures on materials that

87
00:04:18,599 --> 00:04:16,510
will be used at places like the leading

88
00:04:26,689 --> 00:04:18,609

edge of the National aerospace plane

89
00:04:32,029 --> 00:04:29,730
the work in structural dynamics focuses

90
00:04:34,950 --> 00:04:32,039
on the forces affecting bodies in motion

91
00:04:37,680 --> 00:04:34,960
when the turbine in a jet engine loses a

92
00:04:40,200 --> 00:04:37,690
blade or even during a very hard landing

93
00:04:43,560 --> 00:04:40,210
the vibrations that occur can cause a

94
00:04:45,510 --> 00:04:43,570
propulsion system to fail tests in

95
00:04:48,390 --> 00:04:45,520
dynamics can simulate a blade boss

96
00:04:51,230 --> 00:04:48,400
condition to provide test data to

97
00:04:53,790 --> 00:04:51,240
compare with simulation models any

98
00:04:56,730 --> 00:04:53,800
rotating machine will tend to vibrate at

99
00:04:58,529 --> 00:04:56,740
certain critical speeds and since modern

100
00:05:00,750 --> 00:04:58,539
rotating equipment is required to

101
00:05:03,050 --> 00:05:00,760
operate at ever higher speeds this

102
00:05:05,520 --> 00:05:03,060
problem is increasingly important

103
00:05:07,560 --> 00:05:05,530
research in the division is developing

104
00:05:10,529 --> 00:05:07,570
methods for both active feedback and

105
00:05:12,689 --> 00:05:10,539
passive suppression to permit operation

106
00:05:16,740 --> 00:05:12,699
of equipment above critical speeds and

107
00:05:19,290 --> 00:05:16,750
to reduce bearing wear high-speed

108
00:05:21,600 --> 00:05:19,300
computer simulation is required for the

109
00:05:24,659 --> 00:05:21,610
full dynamic analysis of rotating

110
00:05:26,689 --> 00:05:24,669
machinery parallel computing developed

111
00:05:29,250 --> 00:05:26,699
in the division is making this possible

112
00:05:31,550 --> 00:05:29,260
by combining a large number of

113
00:05:34,020 --> 00:05:31,560

processors in one transfuser

114
00:05:36,750 --> 00:05:34,030
computations can be performed rapidly

115
00:05:40,170 --> 00:05:36,760
enough to study high speed vibrations of

116
00:05:40,180 --> 00:05:45,670
you

117
00:05:50,330 --> 00:05:48,650
studies in fatigue and fracture analysis

118
00:05:53,840 --> 00:05:50,340
are performed in many of the structures

119
00:05:56,030 --> 00:05:53,850
divisions labs both destructive and

120
00:05:58,460 --> 00:05:56,040
non-destructive methods are used to

121
00:06:01,160 --> 00:05:58,470
evaluate and characterize new materials

122
00:06:04,210 --> 00:06:01,170
and sometimes a combination of both are

123
00:06:06,680 --> 00:06:04,220
used to improve the analytical process

124
00:06:08,630 --> 00:06:06,690
much of this work is directed toward

125
00:06:12,410 --> 00:06:08,640
characterizing and understanding

126
00:06:15,740 --> 00:06:12,420
advanced material systems as an example

127
00:06:18,350 --> 00:06:15,750
researchers in the division sonic map a

128
00:06:21,500 --> 00:06:18,360
ceramic disc and send the data to a

129
00:06:24,580 --> 00:06:21,510
computer the computer outputs a color

130
00:06:27,050 --> 00:06:24,590
simulation showing variations in density

131
00:06:30,200 --> 00:06:27,060
defining areas where fractures should

132
00:06:32,740 --> 00:06:30,210
occur later the disc is placed in a

133
00:06:36,260 --> 00:06:32,750
hydrostatic chamber and fractured the

134
00:06:38,950 --> 00:06:36,270
actual fracture disk is then compared to

135
00:06:42,050 --> 00:06:38,960
the computer model for verification

136
00:06:44,270 --> 00:06:42,060
division researchers also test advanced

137
00:06:47,320 --> 00:06:44,280
fiber reinforced composite materials

138
00:06:50,450 --> 00:06:47,330

under varied loads expected in aerospace

139
00:06:53,090 --> 00:06:50,460
applications data collected from these

140
00:06:55,400 --> 00:06:53,100
tests are used to verify mathematical

141
00:06:57,650 --> 00:06:55,410
models which describe the material

142
00:07:00,020 --> 00:06:57,660
behavior these models are then

143
00:07:02,450 --> 00:07:00,030
incorporated into NASA computer codes

144
00:07:04,790 --> 00:07:02,460
used to predict the performance of

145
00:07:08,480 --> 00:07:04,800
composite structures in a variety of

146
00:07:10,730 --> 00:07:08,490
applications beyond solving the problems

147
00:07:12,500 --> 00:07:10,740
which can lead to failures the division

148
00:07:14,750 --> 00:07:12,510
provides leadership in developing new

149
00:07:17,780 --> 00:07:14,760
concepts and integrating information

150
00:07:21,140 --> 00:07:17,790
from many sources for application in

151
00:07:23,270 --> 00:07:21,150
areas ranging from windmills to the

152
00:07:25,910 --> 00:07:23,280
Space Shuttle main engines from

153
00:07:27,830 --> 00:07:25,920
fuel-efficient propellers to computer

154
00:07:31,280 --> 00:07:27,840
codes for production design and

155
00:07:32,870 --> 00:07:31,290
propulsion systems simulations the work

156
00:07:35,360 --> 00:07:32,880
of the division provides verified

157
00:07:37,640 --> 00:07:35,370
mathematical models and computer codes

158
00:07:40,460 --> 00:07:37,650
that are key elements of today's

159
00:07:42,710 --> 00:07:40,470
computer based design analyses for

160
00:07:45,310 --> 00:07:42,720
flight propulsion systems as well as

161
00:07:47,690 --> 00:07:45,320
many other systems with similar problems

162
00:07:50,270 --> 00:07:47,700
using the products of the structures

163
00:07:52,670 --> 00:07:50,280

division designers can better predict

164
00:07:55,400 --> 00:07:52,680
the life of a component by constructing

165
00:07:56,959 --> 00:07:55,410
it on the computer thereby saving time

166
00:08:00,109 --> 00:07:56,969
and material while

167
00:08:02,479 --> 00:08:00,119
venting costly failure future aerospace

168
00:08:05,559 --> 00:08:02,489
systems will require advanced capability

169
00:08:08,419 --> 00:08:05,569
on board computation and real-time

170
00:08:10,039 --> 00:08:08,429
sensors will combine to make it possible

171
00:08:12,319 --> 00:08:10,049
to monitor the health of advanced

172
00:08:14,299 --> 00:08:12,329
systems active elements could be

173
00:08:17,029 --> 00:08:14,309
included to make it possible to suppress

174
00:08:19,369 --> 00:08:17,039
dynamic instabilities structural

175
00:08:21,439 --> 00:08:19,379
tailoring to account for local stresses

176
00:08:23,299 --> 00:08:21,449
and local hot spots may be the only way

177
00:08:25,369 --> 00:08:23,309
to take advantage of the new lightweight

178
00:08:28,909 --> 00:08:25,379
high temperature yet very brittle

179
00:08:31,579 --> 00:08:28,919
materials computational simulation will

180
00:08:34,939 --> 00:08:31,589
allow designers to make rapid affordable

181
00:08:37,219 --> 00:08:34,949
and feasible designs probabilistic

182
00:08:39,639 --> 00:08:37,229
methods will allow designers to quantify

183
00:08:42,920 --> 00:08:39,649
risk and make trade-offs between

184
00:08:44,869 --> 00:08:42,930
performance and life combination these

185
00:08:47,240 --> 00:08:44,879
capabilities will allow those designers

186
00:08:50,840 --> 00:08:47,250
to operate and design closer to the

187
00:08:52,610 --> 00:08:50,850
limits such capability will allow us to

188
00:08:55,220 --> 00:08:52,620

build systems that we couldn't build

189
00:08:57,829 --> 00:08:55,230
before to carry out missions that

190
00:08:59,050 --> 00:08:57,839
conceivably couldn't be carried out with

191
00:09:01,400 --> 00:08:59,060
the development of these capabilities

192
00:09:04,509 --> 00:09:01,410
the structures division hopes to play a

193
00:09:07,160 --> 00:09:04,519
major part in bringing them about a

194
00:09:10,699 --> 00:09:07,170
special combination of experienced

195
00:09:13,699 --> 00:09:10,709
in-house staff and facilities in the

196
00:09:16,400 --> 00:09:13,709
Lewis research structures division has

197
00:09:19,009 --> 00:09:16,410
been tailored to meet the challenges and

198
00:09:22,429 --> 00:09:19,019
needs of a new age of spaceflight and

199
00:09:25,639 --> 00:09:22,439
aviation the work of the division

200
00:09:28,009 --> 00:09:25,649
continues to evolve technology and will

201
00:09:32,929 --> 00:09:28,019
take us into the next generations of

202
00:09:34,280 --> 00:09:32,939
flight our second segment is about a

203
00:09:36,379 --> 00:09:34,290
process developed at Lewis that we're

204
00:09:37,850 --> 00:09:36,389
very proud of an engineer in our

205
00:09:40,819 --> 00:09:37,860
materials division developed a process

206
00:09:51,810 --> 00:09:40,829
called arc sprayed mono tape let's find

207
00:09:58,120 --> 00:09:55,079
unfazed by extreme fire not temperatures

208
00:10:01,689 --> 00:09:58,130
possessing amazing strength a strength

209
00:10:04,180 --> 00:10:01,699
beyond belief its creation one of

210
00:10:07,269 --> 00:10:04,190
outstanding engineering achievement the

211
00:10:09,699 --> 00:10:07,279
new the ultra advanced composite

212
00:10:12,879 --> 00:10:09,709
materials being developed by NASA Lewis

213
00:10:15,040 --> 00:10:12,889

Research Center in Cleveland Ohio to

214
00:10:16,990 --> 00:10:15,050
understand this fascinating field we

215
00:10:20,430 --> 00:10:17,000
must start with basics and determine

216
00:10:23,019 --> 00:10:20,440
exactly what is a composite material

217
00:10:25,420 --> 00:10:23,029
possibly the easiest way to visualize a

218
00:10:28,360 --> 00:10:25,430
composite material is to offer the

219
00:10:30,400 --> 00:10:28,370
example of a tennis racquet the arm and

220
00:10:32,340 --> 00:10:30,410
frame part of the rocket is made by

221
00:10:34,840 --> 00:10:32,350
combining two distinct materials

222
00:10:37,540 --> 00:10:34,850
graphite fibers which give it strength

223
00:10:39,910 --> 00:10:37,550
and a low-temperature glue or binder

224
00:10:41,879 --> 00:10:39,920
which hold the fibers together that

225
00:10:45,309 --> 00:10:41,889
allows it to be fashioned into shape

226
00:10:47,499 --> 00:10:45,319
this is a composite material to

227
00:10:50,740 --> 00:10:47,509
different parts each with a different

228
00:10:53,590 --> 00:10:50,750
function research in this area began

229
00:10:55,480 --> 00:10:53,600
about 25 years ago when minut whiskers

230
00:10:58,420 --> 00:10:55,490
were discovered growing on electrical

231
00:11:00,910 --> 00:10:58,430
devices the whiskers were found to be

232
00:11:03,759 --> 00:11:00,920
single grain crystals that when tested

233
00:11:06,250 --> 00:11:03,769
proved to be very strong in later

234
00:11:09,009 --> 00:11:06,260
research work the whiskers were used in

235
00:11:12,370 --> 00:11:09,019
the making of bulk materials today

236
00:11:15,550 --> 00:11:12,380
instead of whiskers fibers like silicon

237
00:11:17,710 --> 00:11:15,560
carbide tungsten and graphite are used

238
00:11:19,569 --> 00:11:17,720

with a glue or binder to make such

239
00:11:22,480 --> 00:11:19,579
things as engineering and sports

240
00:11:24,759 --> 00:11:22,490
products there are some products though

241
00:11:25,660 --> 00:11:24,769
that need to be able to withstand higher

242
00:11:28,150 --> 00:11:25,670
temperatures

243
00:11:30,940 --> 00:11:28,160
at the same time it's also necessary

244
00:11:32,890 --> 00:11:30,950
that they be lightweight and stiff which

245
00:11:34,600 --> 00:11:32,900
incidentally are very important

246
00:11:37,750 --> 00:11:34,610
requirements for just about anything

247
00:11:40,180 --> 00:11:37,760
intended for use in space to meet the

248
00:11:42,940 --> 00:11:40,190
more demanding requirements a glue or

249
00:11:46,150 --> 00:11:42,950
binders such as aluminum or titanium may

250
00:11:47,710 --> 00:11:46,160
be used for other products that need to

251
00:11:51,010 --> 00:11:47,720
be heat-resistant at even higher

252
00:11:53,470 --> 00:11:51,020
temperatures a nickel or iron base alloy

253
00:11:56,620 --> 00:11:53,480
is combined with even certain carbide

254
00:11:58,840 --> 00:11:56,630
fibers or tungsten fibers there are

255
00:12:03,370 --> 00:11:58,850
several ways to do this and one of them

256
00:12:05,620 --> 00:12:03,380
is the arc spray process this method was

257
00:12:08,590 --> 00:12:05,630
developed right here at NASA but one of

258
00:12:10,450 --> 00:12:08,600
our engineers Leonard Westfall he works

259
00:12:14,590 --> 00:12:10,460
in the advanced metallic branch of

260
00:12:16,840 --> 00:12:14,600
NASA's materials division recently mr.

261
00:12:20,590 --> 00:12:16,850
Westfall described exactly how the arc

262
00:12:25,150 --> 00:12:20,600
process works the process works like

263
00:12:29,100 --> 00:12:25,160

this we have an arc spray gun which is

264
00:12:33,910 --> 00:12:29,110
attached to a large vacuum chamber

265
00:12:38,020 --> 00:12:33,920
inside the vacuum chamber is a drum that

266
00:12:43,420 --> 00:12:38,030
has our real strong fibers found on the

267
00:12:48,130 --> 00:12:43,430
surface at a very regular spacing the

268
00:12:51,250 --> 00:12:48,140
arc spray gun works by having two metal

269
00:12:53,050 --> 00:12:51,260
wires coming into the gun an electric

270
00:12:55,780 --> 00:12:53,060
arc is struck between the tips of the

271
00:12:58,030 --> 00:12:55,790
wires the electric arc is sufficient

272
00:13:02,080 --> 00:12:58,040
intensity to cause the water tips to

273
00:13:04,630 --> 00:13:02,090
melt I pressure stream of neutral gas

274
00:13:08,410 --> 00:13:04,640
and will usually use our gun very clean

275
00:13:11,080 --> 00:13:08,420
argon is sprayed on this molten on the

276
00:13:13,750 --> 00:13:11,090
mold and wire tips causing the molten

277
00:13:17,380 --> 00:13:13,760
metal to dislodge from the from the

278
00:13:21,340 --> 00:13:17,390
wires and to be vaporized into very very

279
00:13:23,820 --> 00:13:21,350
fine particles in sprayed and we aim it

280
00:13:28,110 --> 00:13:23,830
right on this drum surface

281
00:13:30,780 --> 00:13:28,120
thin sheet that's formed can be as big

282
00:13:33,150 --> 00:13:30,790
as two drum surface the thin sheet mr.

283
00:13:35,970 --> 00:13:33,160
Westfall was talking about is called a

284
00:13:38,730 --> 00:13:35,980
mono tape it comes off the drum very

285
00:13:41,670 --> 00:13:38,740
easily because a teflon spray is applied

286
00:13:44,070 --> 00:13:41,680
first the spray allows the material to

287
00:13:49,080 --> 00:13:44,080
get hard and yet not stick to the drum

288
00:13:51,540 --> 00:13:49,090

it simply peels off composite mono tapes

289
00:13:53,850 --> 00:13:51,550
are used to make composite shapes which

290
00:13:57,090 --> 00:13:53,860
are rather complex structures requiring

291
00:13:59,490 --> 00:13:57,100
extremely high strength in order to make

292
00:14:01,740 --> 00:13:59,500
the structure as strong as possible the

293
00:14:05,400 --> 00:14:01,750
mono tapes must be positioned in certain

294
00:14:07,860 --> 00:14:05,410
directions to do this the mono tape is

295
00:14:10,980 --> 00:14:07,870
cut into small pieces and stacked one on

296
00:14:14,010 --> 00:14:10,990
top of the other on the first piece all

297
00:14:16,530 --> 00:14:14,020
fibers are placed in one direction on

298
00:14:18,630 --> 00:14:16,540
the next piece the fibers are put in the

299
00:14:21,390 --> 00:14:18,640
opposite direction of those on the first

300
00:14:23,850 --> 00:14:21,400
piece this alternation of the fibers

301
00:14:25,980 --> 00:14:23,860
direction is continued on the pieces in

302
00:14:29,640 --> 00:14:25,990
order to maximize the structure strength

303
00:14:32,490 --> 00:14:29,650
in different directions the small pieces

304
00:14:35,270 --> 00:14:32,500
of composite mono tape usually are glued

305
00:14:38,040 --> 00:14:35,280
together by a method called hot pressing

306
00:14:39,960 --> 00:14:38,050
very heavy pressure is applied to the

307
00:14:42,150 --> 00:14:39,970
stack while it is subjected to a

308
00:14:45,420 --> 00:14:42,160
temperature of almost 2,000 degrees

309
00:14:48,120 --> 00:14:45,430
Fahrenheit as the metal gets squeezed

310
00:14:50,280 --> 00:14:48,130
together any small imperfections in the

311
00:14:52,770 --> 00:14:50,290
mono tape disappeared and the metal

312
00:14:56,250 --> 00:14:52,780
pieces blend together resulting in a

313
00:14:58,290 --> 00:14:56,260

perfectly solid plate cut into thin

314
00:15:02,010 --> 00:14:58,300
strips the plates are used extensively

315
00:15:04,260 --> 00:15:02,020
at NASA for testing purposes engineers

316
00:15:06,840 --> 00:15:04,270
have been able to make large tubes by

317
00:15:08,790 --> 00:15:06,850
using a pressing guide to shape it they

318
00:15:11,880 --> 00:15:08,800
have made demonstration turbine blades

319
00:15:14,400 --> 00:15:11,890
for jet engines these blades are located

320
00:15:17,250 --> 00:15:14,410
very close to the place where air mixed

321
00:15:19,980 --> 00:15:17,260
with fuel is burned as combustion takes

322
00:15:23,250 --> 00:15:19,990
place the expanding gases hit the blade

323
00:15:24,960 --> 00:15:23,260
causing it to turn it's easy to see why

324
00:15:29,070 --> 00:15:24,970
the blades must be able to withstand

325
00:15:31,650 --> 00:15:29,080
extremely high temperatures presently

326
00:15:34,920 --> 00:15:31,660
there are five NASA programs in which

327
00:15:38,220 --> 00:15:34,930
arc spray mono tape plays a major role

328
00:15:41,250 --> 00:15:38,230
our two programs deal specifically with

329
00:15:43,050 --> 00:15:41,260
the space shuttles main engine since the

330
00:15:45,139 --> 00:15:43,060
material now used to make the main

331
00:15:48,600 --> 00:15:45,149
engine is cracking due to thermal shock

332
00:15:51,240 --> 00:15:48,610
NASA is working with tungsten reinforced

333
00:15:54,210 --> 00:15:51,250
super alloys to replace it these

334
00:15:56,850 --> 00:15:54,220
composites in tests so far have proven

335
00:15:58,800 --> 00:15:56,860
to be more shock resistant stronger and

336
00:16:02,730 --> 00:15:58,810
able to withstand higher temperatures

337
00:16:05,100 --> 00:16:02,740
than the present material the second

338
00:16:07,340 --> 00:16:05,110

program deals with the reinforcement of

339
00:16:11,190 --> 00:16:07,350
a combustion liner in the space shuttle

340
00:16:19,019 --> 00:16:11,200
mr. Westfall explains a combustion liner

341
00:16:22,110 --> 00:16:19,029
is a contoured shape that is Hydra

342
00:16:24,300 --> 00:16:22,120
liquid hydrogen cold and it's the vessel

343
00:16:29,040 --> 00:16:24,310
that the liquid oxygen and liquid

344
00:16:31,400 --> 00:16:29,050
hydrogen burned in and you have very

345
00:16:33,810 --> 00:16:31,410
very high temperatures inside this

346
00:16:37,230 --> 00:16:33,820
combustion liner and typically it's made

347
00:16:39,210 --> 00:16:37,240
out of copper or strong copper alloy the

348
00:16:42,440 --> 00:16:39,220
problem this combustion liner is

349
00:16:45,960 --> 00:16:42,450
experiencing is the copper alloy is

350
00:16:48,019 --> 00:16:45,970
deforming due to the very high

351
00:16:50,970 --> 00:16:48,029
temperatures and the stresses that are

352
00:16:53,370 --> 00:16:50,980
generated in the thin inner wall causing

353
00:16:55,110 --> 00:16:53,380
in a while to deform and actually

354
00:16:57,900 --> 00:16:55,120
correct and the liquid hydrogen is

355
00:17:01,620 --> 00:16:57,910
leaking out we are putting tungsten

356
00:17:03,360 --> 00:17:01,630
fibers in the inside layer of the

357
00:17:05,460 --> 00:17:03,370
combustion liner to strengthen to

358
00:17:08,069 --> 00:17:05,470
selectively strengthen the inner wall of

359
00:17:11,520 --> 00:17:08,079
the combustion liner this is an example

360
00:17:13,860 --> 00:17:11,530
of one of the test specimens that we

361
00:17:16,620 --> 00:17:13,870
make and we have tungsten fibers

362
00:17:20,160 --> 00:17:16,630
reinforcing the inside surface of this

363
00:17:23,699 --> 00:17:20,170

specimen alright this specimen then will

364
00:17:25,470 --> 00:17:23,709
be tested in a rocket test chamber under

365
00:17:27,290 --> 00:17:25,480
conditions very very similar to the

366
00:17:32,490 --> 00:17:27,300
Space Shuttle main engine and the

367
00:17:34,919 --> 00:17:32,500
material will be tested to to failure we

368
00:17:36,870 --> 00:17:34,929
predict a much longer life with our

369
00:17:40,380 --> 00:17:36,880
tungsten reinforce copper than the

370
00:17:42,750 --> 00:17:40,390
current copper alloy that's being flown

371
00:17:45,200 --> 00:17:42,760
in space shuttle today also regarding

372
00:17:47,299 --> 00:17:45,210
space the third program has

373
00:17:49,820 --> 00:17:47,309
with the creation and development of

374
00:17:52,269 --> 00:17:49,830
very strong tools to hold liquid metals

375
00:17:54,980 --> 00:17:52,279
and heat pipes for nuclear reactors

376
00:17:57,169 --> 00:17:54,990
because of the tremendous pressure the

377
00:17:59,120 --> 00:17:57,179
tubes will have to withstand a new

378
00:18:02,600 --> 00:17:59,130
material is needed that is much stronger

379
00:18:05,269 --> 00:18:02,610
than the one now used using the

380
00:18:07,159 --> 00:18:05,279
composite process engineers are adding

381
00:18:11,090 --> 00:18:07,169
tungsten fibers to the present material

382
00:18:13,610 --> 00:18:11,100
to strengthen it and again in support of

383
00:18:16,190 --> 00:18:13,620
space power the next program is working

384
00:18:18,019 --> 00:18:16,200
to develop a specific container and will

385
00:18:20,180 --> 00:18:18,029
be able to take high temperatures and

386
00:18:23,419 --> 00:18:20,190
amounts of pressure which the current

387
00:18:25,340 --> 00:18:23,429
container cannot in this case the power

388
00:18:29,029 --> 00:18:25,350

being generated would be for a space

389
00:18:31,010 --> 00:18:29,039
station the composite material that has

390
00:18:34,130 --> 00:18:31,020
been developed is three to four times

391
00:18:35,930 --> 00:18:34,140
stronger than the present one surpassing

392
00:18:37,940 --> 00:18:35,940
the program's goal of finding a

393
00:18:40,490 --> 00:18:37,950
substitute container for present

394
00:18:42,889 --> 00:18:40,500
temperature and pressure levels the

395
00:18:45,049 --> 00:18:42,899
engineers at NASA have created one that

396
00:18:49,310 --> 00:18:45,059
can be used as power demands go up in

397
00:18:51,380 --> 00:18:49,320
the future the final program developing

398
00:18:54,039 --> 00:18:51,390
composite materials for use in space

399
00:18:57,139 --> 00:18:54,049
deals with the improvement of radiators

400
00:18:59,690 --> 00:18:57,149
again NASA engineer Leonard Westfall

401
00:19:03,740 --> 00:18:59,700
explains these tubes I talked about

402
00:19:06,399 --> 00:19:03,750
before have radiator panels hooked on on

403
00:19:10,970 --> 00:19:06,409
the back of them to get rid of the heat

404
00:19:14,299 --> 00:19:10,980
all right we're developing fiber

405
00:19:17,750 --> 00:19:14,309
reinforced radiator panels that are made

406
00:19:19,669 --> 00:19:17,760
out of graphite fibers that I have very

407
00:19:21,980 --> 00:19:19,679
very high thermal conductivity and

408
00:19:25,149 --> 00:19:21,990
thermal conductivity is the materials

409
00:19:27,440 --> 00:19:25,159
ability to conduct heat very quickly

410
00:19:30,320 --> 00:19:27,450
alright these fibers conduct heat

411
00:19:34,970 --> 00:19:30,330
extremely fast and we put them in and

412
00:19:37,419 --> 00:19:34,980
copper as a high-temperature glue copper

413
00:19:40,909 --> 00:19:37,429

also has very high thermal conductivity

414
00:19:44,240 --> 00:19:40,919
and so what we end up with is a

415
00:19:47,090 --> 00:19:44,250
structure that has higher thermal

416
00:19:52,519 --> 00:19:47,100
conductivity than copper is very very

417
00:19:54,500 --> 00:19:52,529
stiff and light and this saves weight it

418
00:19:56,870 --> 00:19:54,510
increases the efficiency of the radiator

419
00:19:59,010 --> 00:19:56,880
panels and makes the whole cooling

420
00:20:01,710 --> 00:19:59,020
scheme work much

421
00:20:04,170 --> 00:20:01,720
much better at NASA there is also very

422
00:20:07,290 --> 00:20:04,180
exciting work being done to support the

423
00:20:09,570 --> 00:20:07,300
national aerospace plane the plans for

424
00:20:11,670 --> 00:20:09,580
this remarkable plane call for it to

425
00:20:15,120 --> 00:20:11,680
take off from the ground and fly up

426
00:20:17,550 --> 00:20:15,130
right into orbit it would fly like an

427
00:20:19,920 --> 00:20:17,560
airplane but it's jet engine at higher

428
00:20:23,220 --> 00:20:19,930
altitudes and speeds would become like a

429
00:20:25,440 --> 00:20:23,230
rocket and boosted into space NASA's

430
00:20:27,600 --> 00:20:25,450
advanced metallics branch is working on

431
00:20:29,910 --> 00:20:27,610
developing a fiber-reinforced inner

432
00:20:33,060 --> 00:20:29,920
metallic material out of which to build

433
00:20:35,430 --> 00:20:33,070
the plane currently the plane severely

434
00:20:37,170 --> 00:20:35,440
lacks a suitable material there are

435
00:20:39,420 --> 00:20:37,180
three vital requirements that the

436
00:20:42,150 --> 00:20:39,430
material must have it must be

437
00:20:45,780 --> 00:20:42,160
lightweight highly resistant to extreme

438
00:20:48,120 --> 00:20:45,790

heat and very strong since it will be

439
00:20:50,520 --> 00:20:48,130
used primarily as a major structural

440
00:20:53,550 --> 00:20:50,530
component the composite material being

441
00:20:56,610 --> 00:20:53,560
tested and developed uses ceramic fibers

442
00:20:59,010 --> 00:20:56,620
the intermetallic matrix and ceramic

443
00:21:00,870 --> 00:20:59,020
fibers together form a material that

444
00:21:04,950 --> 00:21:00,880
could be the solution to one of the

445
00:21:07,860 --> 00:21:04,960
planes most pressing needs in all the

446
00:21:10,470 --> 00:21:07,870
research in all of these programs with

447
00:21:12,900 --> 00:21:10,480
all of the discoveries breakthroughs and

448
00:21:16,080 --> 00:21:12,910
amazing new products tested and those

449
00:21:19,110 --> 00:21:16,090
actually in use still according to mr.

450
00:21:21,060 --> 00:21:19,120
Westfall the present work is quote just

451
00:21:24,600 --> 00:21:21,070
scratching the surface in composite

452
00:21:26,910 --> 00:21:24,610
materials besides the fibers in

453
00:21:29,250 --> 00:21:26,920
existence today there are many many

454
00:21:33,540 --> 00:21:29,260
others with great potential that need to

455
00:21:35,730 --> 00:21:33,550
be developed and tested NASA's goal to

456
00:21:39,360 --> 00:21:35,740
develop even stronger fibers that can

457
00:21:41,070 --> 00:21:39,370
work at even higher temperatures some of

458
00:21:42,960 --> 00:21:41,080
the structures nASA has been working on

459
00:21:46,080 --> 00:21:42,970
will be used for the National aerospace

460
00:21:47,160 --> 00:21:46,090
plane or commonly known as nasp naspa

461
00:21:48,930 --> 00:21:47,170
when it is built will have a unique

462
00:21:50,670 --> 00:21:48,940
capability of taking off from any

463
00:22:03,840 --> 00:21:50,680

airport and fly directly into space

464
00:22:08,680 --> 00:22:06,160
imagine taking off from an airport

465
00:22:11,680 --> 00:22:08,690
runway flying at three to five times the

466
00:22:14,590 --> 00:22:11,690
speed of sound at altitudes of 20 miles

467
00:22:16,720 --> 00:22:14,600
or even higher a few short hours after

468
00:22:19,930 --> 00:22:16,730
departure you come to a stop halfway

469
00:22:21,850 --> 00:22:19,940
around the world or maybe you took off

470
00:22:24,250 --> 00:22:21,860
from a runway and flew directly into

471
00:22:26,080 --> 00:22:24,260
orbit to work in space and then you

472
00:22:29,890 --> 00:22:26,090
returned landing on a conventional

473
00:22:32,710 --> 00:22:29,900
Airport runway the National aerospace

474
00:22:35,920 --> 00:22:32,720
plane will try to make both scenarios a

475
00:22:38,440 --> 00:22:35,930
reality NASA and the Department of

476
00:22:41,950 --> 00:22:38,450
Defense have done research on hyper

477
00:22:44,710 --> 00:22:41,960
sonic technology for many years the NASP

478
00:22:47,710 --> 00:22:44,720
technology demonstrator will be a highly

479
00:22:50,170 --> 00:22:47,720
advanced explain a new member of the

480
00:22:54,160 --> 00:22:50,180
elite special research aircraft that

481
00:22:55,930 --> 00:22:54,170
includes the x1 which in 1947 was the

482
00:22:59,470 --> 00:22:55,940
first aircraft to break the speed of

483
00:23:02,470 --> 00:22:59,480
sound and fly supersonic in the early

484
00:23:05,830 --> 00:23:02,480
1960s the x-15 became one of the first

485
00:23:09,550 --> 00:23:05,840
manned hypersonic aircraft and reached

486
00:23:12,750 --> 00:23:09,560
speeds of Mach 7 for about 4,500 miles

487
00:23:16,930 --> 00:23:12,760
per hour one of the key technological

488
00:23:20,100 --> 00:23:16,940

developments of the x30 or NASA are in

489
00:23:22,600 --> 00:23:20,110
the propulsion area an air-breathing

490
00:23:27,280 --> 00:23:22,610
hydrogen-fueled supersonic combustion

491
00:23:29,410 --> 00:23:27,290
ramjet engine or scramjet engine is now

492
00:23:34,240 --> 00:23:29,420
being developed for speeds from about

493
00:23:36,910 --> 00:23:34,250
Mach 7 to Mach 25 the engine uses the

494
00:23:40,660 --> 00:23:36,920
velocity of the vehicle to compress air

495
00:23:42,730 --> 00:23:40,670
as it is rammed into the intake this

496
00:23:45,850 --> 00:23:42,740
compressed air is then mixed with

497
00:23:49,030 --> 00:23:45,860
gaseous hydrogen at this stage to

498
00:23:52,180 --> 00:23:49,040
generate high thrust a development on

499
00:23:54,290 --> 00:23:52,190
which we will focus is materials here to

500
00:23:56,780 --> 00:23:54,300
speak on that is Matt

501
00:24:00,710 --> 00:23:56,790
with the advent of the the aerospace

502
00:24:02,450 --> 00:24:00,720
plane there's become a need for a lot of

503
00:24:04,400 --> 00:24:02,460
new material development beyond a shadow

504
00:24:07,310 --> 00:24:04,410
of a doubt we need new materials all

505
00:24:09,620 --> 00:24:07,320
right and these new materials will most

506
00:24:12,800 --> 00:24:09,630
probably be composite materials but

507
00:24:16,700 --> 00:24:12,810
instead of using a metal matrix based

508
00:24:18,050 --> 00:24:16,710
composite will be using our epoxy based

509
00:24:21,430 --> 00:24:18,060
will be using a metal matrix based

510
00:24:23,930 --> 00:24:21,440
composite all right metal matrix being

511
00:24:26,390 --> 00:24:23,940
copper for instance one of the big

512
00:24:29,240 --> 00:24:26,400
problems NASA is facing with the advent

513
00:24:31,490 --> 00:24:29,250

of the National aerospace plane deals

514
00:24:34,550 --> 00:24:31,500
was not only finding the right materials

515
00:24:37,190 --> 00:24:34,560
to use but in cooling them as well we

516
00:24:38,930 --> 00:24:37,200
have to figure out some way of making a

517
00:24:40,280 --> 00:24:38,940
very strong material that's going to

518
00:24:43,190 --> 00:24:40,290
survive in a high temperature

519
00:24:46,460 --> 00:24:43,200
environment and what we're going to have

520
00:24:48,220 --> 00:24:46,470
to do is actively cool this material all

521
00:24:50,450 --> 00:24:48,230
right by putting some kind of a

522
00:24:52,130 --> 00:24:50,460
cryogenic fluid behind a gaseous

523
00:24:55,430 --> 00:24:52,140
hydrogen or liquid hydrogen which is

524
00:24:56,690 --> 00:24:55,440
very cold and X is a good heat transfer

525
00:25:00,260 --> 00:24:56,700
medium to take heat away from the

526
00:25:02,060 --> 00:25:00,270
leading edge so on on one side of the of

527
00:25:03,110 --> 00:25:02,070
the material on the inside of the wing

528
00:25:05,360 --> 00:25:03,120
for instance there'll be a lot of

529
00:25:07,220 --> 00:25:05,370
coolant rushing through to cool the

530
00:25:09,770 --> 00:25:07,230
inside down and on the outside you'll

531
00:25:11,390 --> 00:25:09,780
have a very hot surface and that is why

532
00:25:12,530 --> 00:25:11,400
we need the high heat conductivity with

533
00:25:14,750 --> 00:25:12,540
our instance you look at fighter jets

534
00:25:17,360 --> 00:25:14,760
that's travel Mach 1 or Mach 2 or even

535
00:25:18,950 --> 00:25:17,370
the Concorde which goes up to Mach 2 you

536
00:25:21,860 --> 00:25:18,960
see that their wings are very narrow at

537
00:25:23,270 --> 00:25:21,870
the leading edges okay and there's a

538
00:25:25,330 --> 00:25:23,280

problem with that because the smaller

539
00:25:28,400 --> 00:25:25,340
the leading edge gets the more difficult

540
00:25:30,950 --> 00:25:28,410
it is to cool and the hotter it gets

541
00:25:33,020 --> 00:25:30,960
because it's such a small it's just such

542
00:25:36,830 --> 00:25:33,030
a small point lying out there in the

543
00:25:39,770 --> 00:25:36,840
free stream that it gets it gets very

544
00:25:42,320 --> 00:25:39,780
warm very quickly the National aerospace

545
00:25:45,230 --> 00:25:42,330
plane is one of the projects being

546
00:25:48,290 --> 00:25:45,240
developed by NASA for future space use

547
00:25:50,810 --> 00:25:48,300
but we cannot expect it to do all of our

548
00:25:53,630 --> 00:25:50,820
work in space the National aerospace

549
00:25:57,710 --> 00:25:53,640
plane being something that will possibly

550
00:25:59,900 --> 00:25:57,720
be able to supplement the shuttle fleet

551
00:26:02,510 --> 00:25:59,910
or or maybe even replace it but

552
00:26:04,190 --> 00:26:02,520
obviously if you have an airplane that

553
00:26:07,010 --> 00:26:04,200
can take off from a runway and go to

554
00:26:08,510 --> 00:26:07,020
orbit with some people in it and go

555
00:26:11,780 --> 00:26:08,520
the space station for instance or

556
00:26:14,060 --> 00:26:11,790
something like that obviously it would

557
00:26:18,920 --> 00:26:14,070
have to be capable of shuttle type

558
00:26:20,600 --> 00:26:18,930
operations as far as payload goes I

559
00:26:22,580 --> 00:26:20,610
think moving big things like space

560
00:26:25,250 --> 00:26:22,590
station components or say for instance

561
00:26:26,600 --> 00:26:25,260
they want to go to Mars and they have to

562
00:26:28,220 --> 00:26:26,610
get some big boosters up there or

563
00:26:30,470 --> 00:26:28,230

something like that I don't see the

564
00:26:32,480 --> 00:26:30,480
national aerospace plane taking that

565
00:26:35,270 --> 00:26:32,490
kind of payload up there the National

566
00:26:37,790 --> 00:26:35,280
aerospace plane is expected to yield a

567
00:26:41,450 --> 00:26:37,800
high payoff for the United States in the

568
00:26:44,720 --> 00:26:41,460
early 21st century with reduced space

569
00:26:47,390 --> 00:26:44,730
launch costs vastly reduced transit time

570
00:26:49,700 --> 00:26:47,400
on long-haul air routes major

571
00:26:52,670 --> 00:26:49,710
investments by private enterprise in

572
00:26:56,090 --> 00:26:52,680
commercial space ventures and sustained

573
00:26:58,880 --> 00:26:56,100
us preeminence in aeronautics with all

574
00:27:02,270 --> 00:26:58,890
of the social and economic benefits that

575
00:27:03,680 --> 00:27:02,280
accompany it this is a Mariko forest

576
00:27:05,840 --> 00:27:03,690
area wishing you would buy and hope

577
00:27:07,880 --> 00:27:05,850
you've enjoyed our show I hope you walk

578
00:27:09,290 --> 00:27:07,890
along the future path again with me at