1
00:00:50,389 --> 00:00:48,549
the future

2
00:00:53,910 --> 00:00:50,399
ever wonder what it's going to be like

3
00:00:54,869 --> 00:00:53,920
20 30 or even 40 years from now

4
00:00:56,709 --> 00:00:54,879
hello

5
00:00:58,709 --> 00:00:56,719
and welcome to future path

6
00:01:00,389 --> 00:00:58,719
i'm amariko forrestery director of

7
00:01:03,590 --> 00:01:00,399
external affairs at the nasa lewis

8
00:01:05,509 --> 00:01:03,600
research center in cleveland ohio

9
00:01:07,830 --> 00:01:05,519
in the future we all know our clothes

10
00:01:09,350 --> 00:01:07,840
will change our hairstyles will change

11
00:01:10,230 --> 00:01:09,360
and even the music we listen to will

12
00:01:11,910 --> 00:01:10,240
change

13
00:01:13,910 --> 00:01:11,920

but how will the technology that's being

14
00:01:15,350 --> 00:01:13,920
developed today affect our lifestyles in

15
00:01:17,429 --> 00:01:15,360
the future

16
00:01:19,109 --> 00:01:17,439
for a long time nasa's been concerned

17
00:01:21,429 --> 00:01:19,119
with developing aircraft that will fly

18
00:01:23,350 --> 00:01:21,439
further higher and faster but more

19
00:01:24,950 --> 00:01:23,360
recently our concern has changed to

20
00:01:27,109 --> 00:01:24,960
flying aircraft with greater fuel

21
00:01:28,390 --> 00:01:27,119
efficiency and protecting our air

22
00:01:30,149 --> 00:01:28,400
quality

23
00:01:32,230 --> 00:01:30,159
nasa is developing a propulsion system

24
00:01:33,910 --> 00:01:32,240
which involves both the jet engine and

25
00:01:38,310 --> 00:01:33,920
advanced propellers it's called the

26
00:01:40,469 --> 00:01:38,320
advanced turboprop system and shown here

27
00:01:42,469 --> 00:01:40,479
the advanced turboprop project combines

28
00:01:44,469 --> 00:01:42,479
the efficiency of the propeller

29
00:01:46,149 --> 00:01:44,479
with the power of the turbine

30
00:01:47,590 --> 00:01:46,159
this technology base provides for the

31
00:01:50,149 --> 00:01:47,600
future development of the single

32
00:01:51,749 --> 00:01:50,159
rotation and counter rotation turboprop

33
00:01:53,670 --> 00:01:51,759
propulsion systems

34
00:01:56,310 --> 00:01:53,680
the idea is to reduce fuel consumption

35
00:01:57,910 --> 00:01:56,320
in both military and commercial aircraft

36
00:01:59,350 --> 00:01:57,920
the initial concept for the advanced

37
00:02:01,990 --> 00:01:59,360
turboprop system

38
00:02:04,389 --> 00:02:02,000

first came about in the mid-1970s due to

39
00:02:05,990 --> 00:02:04,399
the opec oil embargo and the sharp rise

40
00:02:09,270 --> 00:02:06,000
in fuel prices

41
00:02:12,630 --> 00:02:09,280
the fuel burned in a 727 or 737 jet

42
00:02:14,550 --> 00:02:12,640
aircraft can be reduced by as much as 50

43
00:02:16,390 --> 00:02:14,560
with a propeller driven aircraft

44
00:02:17,830 --> 00:02:16,400
advanced turboprop propellers are very

45
00:02:19,030 --> 00:02:17,840
different from traditional propeller

46
00:02:21,750 --> 00:02:19,040
designs

47
00:02:23,510 --> 00:02:21,760
they are very highly swept and very thin

48
00:02:25,110 --> 00:02:23,520
there are eight to ten blades rather

49
00:02:26,470 --> 00:02:25,120
than a three or four blades that we are

50
00:02:28,390 --> 00:02:26,480
used to seeing

51
00:02:29,670 --> 00:02:28,400
we therefore get more power in a smaller

52
00:02:32,150 --> 00:02:29,680
diameter

53
00:02:34,309 --> 00:02:32,160
it allows us to fly faster up to 600

54
00:02:35,430 --> 00:02:34,319
miles per hour and at a much higher

55
00:02:38,070 --> 00:02:35,440
altitude

56
00:02:40,390 --> 00:02:38,080
around 35 000 feet

57
00:02:41,750 --> 00:02:40,400
the noise levels of this new turboprop

58
00:02:44,790 --> 00:02:41,760
are much less than the traditional

59
00:02:46,229 --> 00:02:44,800
propeller or turboprop aircraft

60
00:02:49,110 --> 00:02:46,239
there have been three series of flight

61
00:02:51,509 --> 00:02:49,120
tests in the advanced turboprop project

62
00:02:54,270 --> 00:02:51,519
won the nasa ge boeing flight tests of

63
00:02:56,390 --> 00:02:54,280

the counter-rotating unducted fan on a

64
00:02:59,030 --> 00:02:56,400
b-727 aircraft

65
00:03:01,430 --> 00:02:59,040
two the nasa lockheed prop band tests of

66
00:03:04,229 --> 00:03:01,440
a single rotation advanced turboprop on

67
00:03:06,630 --> 00:03:04,239
a gulfstream two aircraft and three the

68
00:03:09,270 --> 00:03:06,640
ge mcdonald douglas tests on an md-80

69
00:03:12,710 --> 00:03:11,110
these tests verified the readiness of

70
00:03:14,630 --> 00:03:12,720
the advanced turboprop project for

71
00:03:16,630 --> 00:03:14,640
commercial engine development

72
00:03:19,910 --> 00:03:16,640
another way nasa is helping the aviation

73
00:03:21,990 --> 00:03:19,920
industry to a more efficient future

74
00:03:29,509 --> 00:03:22,000
another form of a propulsion system is

75
00:03:33,990 --> 00:03:31,589
when you think of diesel engines you

76
00:03:35,830 --> 00:03:34,000
probably think of certain types of cars

77
00:03:36,789 --> 00:03:35,840
or heavy trucks barreling down the

78
00:03:39,830 --> 00:03:36,799
highway

79
00:03:41,670 --> 00:03:39,840
but technology developed by nasa is

80
00:03:43,830 --> 00:03:41,680
currently creating breakthroughs in

81
00:03:46,070 --> 00:03:43,840
aircraft diesel engines

82
00:03:47,830 --> 00:03:46,080
nasa is also designing remarkable

83
00:03:49,270 --> 00:03:47,840
improvements for diesel engines and

84
00:03:51,509 --> 00:03:49,280
trucks

85
00:03:53,910 --> 00:03:51,519
enthusiasm for the development of diesel

86
00:03:54,949 --> 00:03:53,920
engines is reaching pre-world war two

87
00:03:57,110 --> 00:03:54,959
levels

88
00:03:59,270 --> 00:03:57,120

that's when diesel engine technology was

89
00:04:01,750 --> 00:03:59,280
very popular for its endurance and

90
00:04:03,350 --> 00:04:01,760
altitude records set on long distance

91
00:04:04,869 --> 00:04:03,360
flights

92
00:04:07,190 --> 00:04:04,879
although the war halted further

93
00:04:09,429 --> 00:04:07,200
development of aircraft diesel engines

94
00:04:10,869 --> 00:04:09,439
work on the engines continued again well

95
00:04:13,350 --> 00:04:10,879
after the war

96
00:04:16,310 --> 00:04:13,360
the united states army is developing and

97
00:04:18,710 --> 00:04:16,320
designing diesel engines for helicopters

98
00:04:21,189 --> 00:04:18,720
various industries throughout the world

99
00:04:23,430 --> 00:04:21,199
are planning to develop aircraft diesel

100
00:04:25,430 --> 00:04:23,440
and diesel engines used in heavy-duty

101
00:04:28,230 --> 00:04:25,440
trucks are being improved upon by the

102
00:04:30,950 --> 00:04:28,240
department of energy diesel engines are

103
00:04:33,670 --> 00:04:30,960
primarily used when high power is needed

104
00:04:36,390 --> 00:04:33,680
and fuel consumption and durability are

105
00:04:39,590 --> 00:04:36,400
of concern trucks stationary power

106
00:04:41,430 --> 00:04:39,600
plants large ships even tug boats use

107
00:04:43,830 --> 00:04:41,440
diesel engines

108
00:04:46,870 --> 00:04:43,840
a man who sees a bright future in diesel

109
00:04:49,510 --> 00:04:46,880
technology is mr william wintucky

110
00:04:51,909 --> 00:04:49,520
mr wintucky who has done much research

111
00:04:53,909 --> 00:04:51,919
on aviation diesel is involved with a

112
00:04:56,230 --> 00:04:53,919
number of projects at nasa lewis

113
00:04:58,150 --> 00:04:56,240

research center aimed at improving

114
00:05:00,469 --> 00:04:58,160
diesel engines

115
00:05:02,790 --> 00:05:00,479
joint research is underway involving

116
00:05:05,990 --> 00:05:02,800
nasa and the department of energy to

117
00:05:09,029 --> 00:05:06,000
make diesel engines more fuel efficient

118
00:05:11,670 --> 00:05:09,039
technology to redirect fuel exhaust back

119
00:05:14,310 --> 00:05:11,680
into the engine could result in reduced

120
00:05:16,230 --> 00:05:14,320
fuel consumption of long-haul trucks by

121
00:05:18,629 --> 00:05:16,240
up to 30 percent

122
00:05:21,110 --> 00:05:18,639
mr wintucky explains the difference

123
00:05:22,950 --> 00:05:21,120
between diesel engines and gasoline

124
00:05:26,870 --> 00:05:22,960
engines a

125
00:05:29,110 --> 00:05:26,880
diesel engine is basically the same as a

126
00:05:30,870 --> 00:05:29,120
gasoline engine except for the

127
00:05:34,550 --> 00:05:30,880
combustion process

128
00:05:35,430 --> 00:05:34,560
is that

129
00:05:38,469 --> 00:05:35,440
as

130
00:05:40,790 --> 00:05:38,479
the fuel is compressed by the piston

131
00:05:43,990 --> 00:05:40,800
the temperature is raised

132
00:05:47,350 --> 00:05:44,000
to a point where ignition

133
00:05:49,350 --> 00:05:47,360
is started by the heat of compression

134
00:05:50,390 --> 00:05:49,360
from the piston

135
00:05:51,350 --> 00:05:50,400
in

136
00:05:53,270 --> 00:05:51,360
the

137
00:05:55,189 --> 00:05:53,280
gasoline engine

138
00:05:56,230 --> 00:05:55,199

the combustion is controlled by a spark

139
00:05:57,909 --> 00:05:56,240
plug

140
00:06:00,629 --> 00:05:57,919
and ignition

141
00:06:02,309 --> 00:06:00,639
is controlled when you want it started

142
00:06:04,309 --> 00:06:02,319
by an electrical

143
00:06:05,590 --> 00:06:04,319
impulse which discharges through the

144
00:06:08,390 --> 00:06:05,600
spark plug

145
00:06:11,430 --> 00:06:08,400
in the case of the diesel engine

146
00:06:13,189 --> 00:06:11,440
when the fuel is raised to its auto

147
00:06:15,110 --> 00:06:13,199
ignition temperature

148
00:06:16,950 --> 00:06:15,120
the fuel ignites throughout the

149
00:06:19,749 --> 00:06:16,960
combustion chamber

150
00:06:22,150 --> 00:06:19,759
at the same time and therefore

151
00:06:24,150 --> 00:06:22,160
the pressure rises very rapidly just

152
00:06:26,150 --> 00:06:24,160
like an explosion and as a matter of

153
00:06:28,390 --> 00:06:26,160
fact is an explosion

154
00:06:30,550 --> 00:06:28,400
and that's why sometimes

155
00:06:32,070 --> 00:06:30,560
when you hear a diesel engine going down

156
00:06:33,909 --> 00:06:32,080
the street and it sounds like it's

157
00:06:37,350 --> 00:06:33,919
knocking you are actually hearing the

158
00:06:40,550 --> 00:06:37,360
explosions of the combustion process

159
00:06:44,309 --> 00:06:40,560
because of the

160
00:06:46,550 --> 00:06:44,319
explosions or very rapid pressure rises

161
00:06:49,510 --> 00:06:46,560
in the diesel combustion chamber the

162
00:06:52,469 --> 00:06:49,520
walls of the chamber have to be thicker

163
00:06:55,990 --> 00:06:52,479

and also the bearings have to be larger

164
00:06:59,029 --> 00:06:56,000
overall the engine must be much stronger

165
00:07:01,270 --> 00:06:59,039
to design for the explosions

166
00:07:03,830 --> 00:07:01,280
why develop better diesel engines and

167
00:07:06,629 --> 00:07:03,840
why create one for aircraft

168
00:07:09,430 --> 00:07:06,639
diesel fuel which is oil can be produced

169
00:07:12,550 --> 00:07:09,440
from a wide variety of sources such as

170
00:07:13,670 --> 00:07:12,560
of all things sunflower oil or peanut

171
00:07:16,390 --> 00:07:13,680
oil

172
00:07:20,469 --> 00:07:16,400
also diesel fuel is safer

173
00:07:23,029 --> 00:07:20,479
because it does not ignite on its own

174
00:07:25,670 --> 00:07:23,039
absence of an electrical ignition system

175
00:07:28,550 --> 00:07:25,680
eliminated radio interference another

176
00:07:30,710 --> 00:07:28,560
safety factor for aircraft diesels

177
00:07:34,710 --> 00:07:30,720
the desire to use the fuel-efficient

178
00:07:37,189 --> 00:07:34,720
diesel engine in aircraft is not new

179
00:07:40,070 --> 00:07:37,199
interest in aircraft diesel engines goes

180
00:07:42,309 --> 00:07:40,080
back as almost as far as internal

181
00:07:45,110 --> 00:07:42,319
combustion engine gasoline engines

182
00:07:46,710 --> 00:07:45,120
dating back to 1911.

183
00:07:47,909 --> 00:07:46,720
the main reason

184
00:07:50,230 --> 00:07:47,919
that

185
00:07:53,189 --> 00:07:50,240
diesel engines were considered for

186
00:07:55,350 --> 00:07:53,199
aircraft use very early on

187
00:07:58,150 --> 00:07:55,360
was at that time

188
00:07:59,510 --> 00:07:58,160

all of the gasoline engines were

189
00:08:01,589 --> 00:07:59,520
carbureted

190
00:08:03,110 --> 00:08:01,599
and one of the main problems that

191
00:08:04,070 --> 00:08:03,120
aircraft had

192
00:08:05,510 --> 00:08:04,080
was

193
00:08:06,390 --> 00:08:05,520
icing

194
00:08:09,189 --> 00:08:06,400
and

195
00:08:11,110 --> 00:08:09,199
with diesel fuel since the fuel was

196
00:08:12,869 --> 00:08:11,120
injected directly into the cylinder

197
00:08:15,350 --> 00:08:12,879
there was no problem with carburetor

198
00:08:17,430 --> 00:08:15,360
icing or ice forming in the carburetor

199
00:08:19,589 --> 00:08:17,440
stopping the fuel flow and of course

200
00:08:23,510 --> 00:08:19,599
stopping the engine

201
00:08:26,070 --> 00:08:23,520
a second and almost important reason was

202
00:08:27,270 --> 00:08:26,080
the fact that diesel fuel does not auto

203
00:08:30,629 --> 00:08:27,280
ignite

204
00:08:32,949 --> 00:08:30,639
which was a problem in the early days

205
00:08:34,550 --> 00:08:32,959
of aircraft

206
00:08:38,190 --> 00:08:34,560
auto ignition

207
00:08:41,430 --> 00:08:38,200
is the process where the fuel ignites

208
00:08:43,190 --> 00:08:41,440
spontaneously or without any external

209
00:08:45,670 --> 00:08:43,200
source

210
00:08:48,150 --> 00:08:45,680
in the case of gasoline gasoline

211
00:08:50,230 --> 00:08:48,160
vaporizes very easily

212
00:08:53,269 --> 00:08:50,240
and

213
00:08:55,590 --> 00:08:53,279

the vapors are very combustible

214
00:08:58,470 --> 00:08:55,600
with diesel fuel diesel fuel does not

215
00:09:00,949 --> 00:08:58,480
vaporize very easily and stays as a

216
00:09:02,550 --> 00:09:00,959
liquid so therefore it is a much safer

217
00:09:04,949 --> 00:09:02,560
fuel to use

218
00:09:07,829 --> 00:09:04,959
the diesel or compression ignition

219
00:09:09,670 --> 00:09:07,839
engine was first designed by dr rudolph

220
00:09:13,110 --> 00:09:09,680
diesel of germany

221
00:09:15,670 --> 00:09:13,120
by 1897 the first commercially practical

222
00:09:17,750 --> 00:09:15,680
diesel was put into use in the form of

223
00:09:21,269 --> 00:09:17,760
an industrial engine

224
00:09:24,230 --> 00:09:21,279
about 1910 the heavy slow speed diesel

225
00:09:26,389 --> 00:09:24,240
engines were replaced with higher speed

226
00:09:30,550 --> 00:09:26,399
lightweight engines which provided a

227
00:09:33,350 --> 00:09:30,560
major step toward aviation diesel use

228
00:09:36,630 --> 00:09:33,360
in nineteen thirty one the nine cylinder

229
00:09:38,870 --> 00:09:36,640
packard diesel built in the u.s set and

230
00:09:42,070 --> 00:09:38,880
still holds the world diesel flight

231
00:09:45,670 --> 00:09:42,080
endurance record of 84 hours and 35

232
00:09:47,430 --> 00:09:45,680
minutes without refueling

233
00:09:50,310 --> 00:09:47,440
credit for originating the diesel

234
00:09:52,070 --> 00:09:50,320
aircraft engine is given to germany's dr

235
00:09:55,509 --> 00:09:52,080
hugo junkers

236
00:09:56,630 --> 00:09:55,519
dr junkers was interested in development

237
00:09:58,310 --> 00:09:56,640
of

238
00:10:00,150 --> 00:09:58,320

a diesel engine

239
00:10:01,430 --> 00:10:00,160
to power

240
00:10:03,190 --> 00:10:01,440
commercial

241
00:10:04,630 --> 00:10:03,200
aircraft

242
00:10:07,350 --> 00:10:04,640
at the time

243
00:10:09,389 --> 00:10:07,360
there were no transatlantic flights

244
00:10:11,829 --> 00:10:09,399
because

245
00:10:14,310 --> 00:10:11,839
gasoline-powered aircraft could not

246
00:10:16,310 --> 00:10:14,320
carry enough fuel to cross the atlantic

247
00:10:18,870 --> 00:10:16,320
and still have enough

248
00:10:19,990 --> 00:10:18,880
room left for payload and the diesel

249
00:10:25,430 --> 00:10:20,000
engine

250
00:10:26,949 --> 00:10:25,440
to have the fuel efficiency that would

251
00:10:29,509 --> 00:10:26,959
allow

252
00:10:32,790 --> 00:10:29,519
transatlantic flight and still have room

253
00:10:36,630 --> 00:10:32,800
to carry either mail or payload

254
00:10:39,030 --> 00:10:36,640
so in conjunction with lufthansa

255
00:10:41,030 --> 00:10:39,040
the junkers joomla

256
00:10:44,230 --> 00:10:41,040
engine was developed

257
00:10:47,430 --> 00:10:44,240
and installed on

258
00:10:50,710 --> 00:10:47,440
a number of flying votes which lufthansa

259
00:10:55,110 --> 00:10:50,720
entered into transatlantic service from

260
00:10:57,509 --> 00:10:55,120
the azores to south america in 1936.

261
00:11:00,389 --> 00:10:57,519
the jumo continued operating until the

262
00:11:02,710 --> 00:11:00,399
outbreak of world war ii when production

263
00:11:04,870 --> 00:11:02,720

turned to the more easily designed and

264
00:11:07,509 --> 00:11:04,880
constructed gasoline engines from

265
00:11:09,829 --> 00:11:07,519
military aircraft

266
00:11:12,150 --> 00:11:09,839
the british developed the last major

267
00:11:14,550 --> 00:11:12,160
aircraft diesel engine which used a

268
00:11:16,949 --> 00:11:14,560
turbine to give it more power

269
00:11:18,870 --> 00:11:16,959
mr wintucky gives us some insight into

270
00:11:22,230 --> 00:11:18,880
the most fuel-efficient engine ever

271
00:11:23,670 --> 00:11:22,240
flown british napier nomad engine was

272
00:11:26,230 --> 00:11:23,680
very unique

273
00:11:29,910 --> 00:11:26,240
it was really a

274
00:11:31,190 --> 00:11:29,920
very high performance turbocharger

275
00:11:34,470 --> 00:11:31,200
in that

276
00:11:36,310 --> 00:11:34,480
the exhaust gases from the engine

277
00:11:38,710 --> 00:11:36,320
the diesel portion

278
00:11:41,110 --> 00:11:38,720
were ducted into

279
00:11:44,870 --> 00:11:41,120
a fan-like turbine

280
00:11:46,150 --> 00:11:44,880
which then drove the compressor

281
00:11:47,750 --> 00:11:46,160
which

282
00:11:50,629 --> 00:11:47,760
compressed air

283
00:11:52,470 --> 00:11:50,639
and put it into the inlet of the diesel

284
00:11:54,470 --> 00:11:52,480
engine

285
00:11:57,430 --> 00:11:54,480
this raised the

286
00:12:01,110 --> 00:11:57,440
overall pressure in the engine and

287
00:12:03,829 --> 00:12:01,120
allowed it to produce more power for

288
00:12:05,750 --> 00:12:03,839

the given size of engine that it was

289
00:12:08,230 --> 00:12:05,760
and in many cases

290
00:12:10,550 --> 00:12:08,240
engines will produce two three and even

291
00:12:13,990 --> 00:12:10,560
four times as much power when

292
00:12:16,790 --> 00:12:14,000
turbocharged versus when they just have

293
00:12:19,190 --> 00:12:16,800
a carburetor on them as would be in your

294
00:12:21,910 --> 00:12:19,200
normal automobile engine

295
00:12:23,590 --> 00:12:21,920
turbocharged diesel engines for aircraft

296
00:12:26,550 --> 00:12:23,600
are making a comeback

297
00:12:29,190 --> 00:12:26,560
nasa research has inspired the us army

298
00:12:31,190 --> 00:12:29,200
to develop the technology to use diesel

299
00:12:34,310 --> 00:12:31,200
engines in helicopters

300
00:12:35,670 --> 00:12:34,320
early in the 1980s the army did a number

301
00:12:37,350 --> 00:12:35,680
of studies

302
00:12:40,629 --> 00:12:37,360
in looking at

303
00:12:42,069 --> 00:12:40,639
engines for light helicopter use

304
00:12:42,870 --> 00:12:42,079
and they found

305
00:12:44,310 --> 00:12:42,880
that

306
00:12:46,710 --> 00:12:44,320
through the use of a very highly

307
00:12:49,430 --> 00:12:46,720
turbocharged diesel engine they could

308
00:12:52,069 --> 00:12:49,440
get an increase of up to 50 percent in

309
00:12:53,829 --> 00:12:52,079
range or a payload that a helicopter

310
00:12:54,949 --> 00:12:53,839
could carry

311
00:12:56,790 --> 00:12:54,959
and since

312
00:13:00,150 --> 00:12:56,800
for the army

313
00:13:03,670 --> 00:13:00,160

fuel represents up to 70 percent

314
00:13:06,629 --> 00:13:03,680
of the amount of supplies that has to be

315
00:13:08,389 --> 00:13:06,639
transported to the battlefield

316
00:13:13,190 --> 00:13:08,399
a 50

317
00:13:16,230 --> 00:13:13,200
increase in payload

318
00:13:19,430 --> 00:13:16,240
represents a tremendous savings to the

319
00:13:22,470 --> 00:13:19,440
army and a reduction in a logistics

320
00:13:24,150 --> 00:13:22,480
problem so the army was very much

321
00:13:26,870 --> 00:13:24,160
interested in

322
00:13:27,910 --> 00:13:26,880
the use of the diesel engine to

323
00:13:30,230 --> 00:13:27,920
lower

324
00:13:33,990 --> 00:13:30,240
part of its fuel requirements

325
00:13:36,949 --> 00:13:34,000
the army really took the expertise that

326
00:13:38,710 --> 00:13:36,959
nasa had developed

327
00:13:40,629 --> 00:13:38,720
during the time

328
00:13:42,069 --> 00:13:40,639
that it was looking at the aircraft

329
00:13:45,110 --> 00:13:42,079
diesel engine

330
00:13:47,750 --> 00:13:45,120
and is now using this expertise in its

331
00:13:50,150 --> 00:13:47,760
own program the engine being developed

332
00:13:53,350 --> 00:13:50,160
by the army for helicopters is expected

333
00:13:55,189 --> 00:13:53,360
to be operating by the mid 1990s

334
00:13:57,430 --> 00:13:55,199
and work is being done to develop

335
00:13:59,990 --> 00:13:57,440
materials and lubricants able to

336
00:14:02,710 --> 00:14:00,000
withstand the high temperatures high

337
00:14:04,150 --> 00:14:02,720
speed and high pressure of an aircraft

338
00:14:05,509 --> 00:14:04,160

diesel engine

339
00:14:07,910 --> 00:14:05,519
the

340
00:14:08,949 --> 00:14:07,920
oil that you use in your car

341
00:14:11,910 --> 00:14:08,959
runs

342
00:14:16,389 --> 00:14:15,350
about 350 degrees fahrenheit

343
00:14:18,230 --> 00:14:16,399
whereas

344
00:14:19,750 --> 00:14:18,240
in the engine

345
00:14:21,750 --> 00:14:19,760
for

346
00:14:24,629 --> 00:14:21,760
the helicopter we're talking about

347
00:14:26,470 --> 00:14:24,639
running as high as 800 degrees

348
00:14:28,150 --> 00:14:26,480
fahrenheit

349
00:14:29,430 --> 00:14:28,160
there is no

350
00:14:31,110 --> 00:14:29,440
oil now

351
00:14:33,590 --> 00:14:31,120
commercially available that will

352
00:14:35,509 --> 00:14:33,600
withstand these temperatures

353
00:14:38,310 --> 00:14:35,519
there are lubricants

354
00:14:40,310 --> 00:14:38,320
that can operate at these temperatures

355
00:14:42,389 --> 00:14:40,320
but they cost thousands of dollars and

356
00:14:43,670 --> 00:14:42,399
the goal of our program

357
00:14:46,150 --> 00:14:43,680
is to

358
00:14:48,230 --> 00:14:46,160
develop new lubricants that will be

359
00:14:49,750 --> 00:14:48,240
economically feasible

360
00:14:51,750 --> 00:14:49,760
and

361
00:14:54,870 --> 00:14:51,760
operate within the temperature

362
00:14:57,350 --> 00:14:54,880
limitations that are required to produce

363
00:14:59,350 --> 00:14:57,360

the power for this engine

364
00:15:01,829 --> 00:14:59,360
it is hoped the united states army's

365
00:15:04,470 --> 00:15:01,839
efforts with diesel technology will

366
00:15:07,670 --> 00:15:04,480
result in a safer more fuel efficient

367
00:15:10,150 --> 00:15:07,680
and economical helicopter fleet

368
00:15:12,870 --> 00:15:10,160
the diesel engine's low fuel consumption

369
00:15:15,829 --> 00:15:12,880
feature is valuable to countries such as

370
00:15:19,350 --> 00:15:15,839
italy and japan where fuel is very

371
00:15:21,910 --> 00:15:19,360
costly and also to the ussr where

372
00:15:24,629 --> 00:15:21,920
long-range flights abound

373
00:15:26,629 --> 00:15:24,639
decades ago scientists were able to see

374
00:15:27,829 --> 00:15:26,639
the promise of diesel engines in

375
00:15:30,389 --> 00:15:27,839
aircraft

376
00:15:33,189 --> 00:15:30,399
the previous work is the firm foundation

377
00:15:36,310 --> 00:15:33,199
on which today's research can stand

378
00:15:39,189 --> 00:15:36,320
research that nasa and people such as mr

379
00:15:42,150 --> 00:15:39,199
wintucky believe is important and could

380
00:15:43,590 --> 00:15:42,160
result in 21st century aircraft diesel

381
00:15:45,189 --> 00:15:43,600
engines

382
00:15:47,189 --> 00:15:45,199
now let's talk about another engine

383
00:15:55,350 --> 00:15:47,199
you've probably never even heard of the

384
00:16:00,389 --> 00:15:57,110
as part of the work being done in

385
00:16:02,710 --> 00:16:00,399
today's dynamic aerospace industry nasa

386
00:16:05,350 --> 00:16:02,720
lewis research center is further

387
00:16:07,990 --> 00:16:05,360
developing a rather remarkable engine

388
00:16:09,910 --> 00:16:08,000

which was invented surprisingly way back

389
00:16:12,870 --> 00:16:09,920
in 1816

390
00:16:14,949 --> 00:16:12,880
named after robert sterling its inventor

391
00:16:17,269 --> 00:16:14,959
the sterling engine very well could be

392
00:16:19,829 --> 00:16:17,279
the most exciting and efficient new type

393
00:16:22,870 --> 00:16:19,839
of energy conversion device in space

394
00:16:24,710 --> 00:16:22,880
within the foreseeable future already

395
00:16:27,110 --> 00:16:24,720
the engine has been developed and tested

396
00:16:29,350 --> 00:16:27,120
successfully as an automotive engine

397
00:16:30,550 --> 00:16:29,360
using less fuel than the car engines we

398
00:16:32,310 --> 00:16:30,560
use now

399
00:16:36,230 --> 00:16:32,320
and the sterling engine can use a

400
00:16:39,910 --> 00:16:36,240
variety of fuels gasoline diesel fuel

401
00:16:41,670 --> 00:16:39,920
alcohol kerosene and others

402
00:16:43,749 --> 00:16:41,680
during this report though we will

403
00:16:46,230 --> 00:16:43,759
explore this fascinating engine in its

404
00:16:49,030 --> 00:16:46,240
possible uses in space

405
00:16:51,110 --> 00:16:49,040
logically we begin by asking how does

406
00:16:53,670 --> 00:16:51,120
the sterling engine work

407
00:16:55,509 --> 00:16:53,680
simply put the engine works because of a

408
00:16:58,069 --> 00:16:55,519
difference in temperature

409
00:16:59,189 --> 00:16:58,079
one end is kept hot while the other is

410
00:17:01,509 --> 00:16:59,199
cold

411
00:17:03,509 --> 00:17:01,519
within the engine a displacer piston

412
00:17:05,350 --> 00:17:03,519
moves gas from the hot end to the cold

413
00:17:08,549 --> 00:17:05,360

end and back again

414
00:17:11,110 --> 00:17:08,559
as that gas moves its pressure changes

415
00:17:13,750 --> 00:17:11,120
when the pressure is high the gas pushes

416
00:17:14,949 --> 00:17:13,760
against a power piston causing an output

417
00:17:16,829 --> 00:17:14,959
of energy

418
00:17:19,189 --> 00:17:16,839
since the heat input is supplied

419
00:17:22,470 --> 00:17:19,199
externally anything that will burn or

420
00:17:25,510 --> 00:17:22,480
make heat such as solar or nuclear power

421
00:17:28,069 --> 00:17:25,520
fossil or gaseous fuels or even garbage

422
00:17:30,230 --> 00:17:28,079
will make the sterling engine run

423
00:17:31,990 --> 00:17:30,240
nasa is working to develop materials

424
00:17:33,669 --> 00:17:32,000
that can withstand extremely high

425
00:17:36,150 --> 00:17:33,679
temperatures to be used in the

426
00:17:38,549 --> 00:17:36,160
construction of the sterling engine

427
00:17:41,350 --> 00:17:38,559
there are two kinds of sterling engines

428
00:17:43,750 --> 00:17:41,360
the kinematic and the free piston

429
00:17:46,630 --> 00:17:43,760
the free piston shows the most promise

430
00:17:48,630 --> 00:17:46,640
as a source of electric power in space

431
00:17:51,270 --> 00:17:48,640
this concept is relatively new

432
00:17:53,750 --> 00:17:51,280
approximately 25 years old

433
00:17:55,909 --> 00:17:53,760
in their basic form both types have a

434
00:17:58,230 --> 00:17:55,919
piston and a displacer

435
00:18:00,390 --> 00:17:58,240
in the kinematic engine the piston and

436
00:18:01,590 --> 00:18:00,400
displacer are connected to other parts

437
00:18:03,909 --> 00:18:01,600
of the engine

438
00:18:05,990 --> 00:18:03,919

but in the free piston the piston and

439
00:18:08,549 --> 00:18:06,000
displacer are not physically connected

440
00:18:11,270 --> 00:18:08,559
to anything and move solely by forces

441
00:18:14,070 --> 00:18:11,280
and pressures within the engine

442
00:18:16,870 --> 00:18:14,080
at nasa's sterling engine project office

443
00:18:18,630 --> 00:18:16,880
jim dudenhofer special project manager

444
00:18:21,350 --> 00:18:18,640
had this to say about the sterling

445
00:18:24,150 --> 00:18:21,360
suitability for use in space

446
00:18:26,549 --> 00:18:24,160
so we have gas bearings

447
00:18:28,470 --> 00:18:26,559
to eliminate friction and wear

448
00:18:31,029 --> 00:18:28,480
we have a totally hermetically sealed

449
00:18:33,909 --> 00:18:31,039
unit which helps us with gas leakage and

450
00:18:35,510 --> 00:18:33,919
permeation in the long term bear in mind

451
00:18:37,750 --> 00:18:35,520
we're talking about an engine when we

452
00:18:39,510 --> 00:18:37,760
talk about space that must live out

453
00:18:41,669 --> 00:18:39,520
there without a mechanic for anywhere

454
00:18:43,830 --> 00:18:41,679
from seven to twenty years

455
00:18:45,430 --> 00:18:43,840
and so long life and and good

456
00:18:47,909 --> 00:18:45,440
maintainability

457
00:18:48,950 --> 00:18:47,919
uh are essential for a space power

458
00:18:51,590 --> 00:18:48,960
engine

459
00:18:53,830 --> 00:18:51,600
nasa lewis research center continues its

460
00:18:55,830 --> 00:18:53,840
work with the sterling engine as part of

461
00:18:58,070 --> 00:18:55,840
a project called the civil space

462
00:18:59,909 --> 00:18:58,080
technology initiative

463
00:19:02,950 --> 00:18:59,919

the purpose is to develop various

464
00:19:06,390 --> 00:19:02,960
technologies for future use in space

465
00:19:08,470 --> 00:19:06,400
until about 1985 there were free piston

466
00:19:10,630 --> 00:19:08,480
sterling machines that could generate

467
00:19:11,990 --> 00:19:10,640
only a maximum of three kilowatts of

468
00:19:14,870 --> 00:19:12,000
electricity

469
00:19:17,190 --> 00:19:14,880
nasa in trying to increase power output

470
00:19:19,909 --> 00:19:17,200
developed with mechanical technology

471
00:19:21,190 --> 00:19:19,919
incorporated a 25 kilowatt electric

472
00:19:23,909 --> 00:19:21,200
machine

473
00:19:26,630 --> 00:19:23,919
now nasa is trying to find out how much

474
00:19:28,870 --> 00:19:26,640
larger sterling engines can be made

475
00:19:31,830 --> 00:19:28,880
initial studies indicate power levels as

476
00:19:33,990 --> 00:19:31,840
high as 500 kilowatts per machine and

477
00:19:36,310 --> 00:19:34,000
possibly even higher

478
00:19:38,789 --> 00:19:36,320
and finally why develop the sterling

479
00:19:41,190 --> 00:19:38,799
engine now when already power has been

480
00:19:42,230 --> 00:19:41,200
generated in space in other ways for

481
00:19:45,510 --> 00:19:42,240
years

482
00:19:47,510 --> 00:19:45,520
jim dudenha for answers space technology

483
00:19:50,710 --> 00:19:47,520
is growing by leaps and bounds and

484
00:19:53,029 --> 00:19:50,720
instead of needing hundreds of watts

485
00:19:54,470 --> 00:19:53,039
in space we are now are going to be

486
00:19:56,070 --> 00:19:54,480
we're on the threshold of needing

487
00:19:58,710 --> 00:19:56,080
millions of watts

488
00:20:00,470 --> 00:19:58,720

if we're going to colonize mars if we're

489
00:20:02,950 --> 00:20:00,480
going to colonize the moon if we're

490
00:20:05,510 --> 00:20:02,960
going to manufacture in space

491
00:20:06,950 --> 00:20:05,520
we need tremendous amounts of electrical

492
00:20:10,390 --> 00:20:06,960
power

493
00:20:12,230 --> 00:20:10,400
photovoltaics simply become too large

494
00:20:14,710 --> 00:20:12,240
the great big solar panels that we're

495
00:20:17,990 --> 00:20:14,720
all accustomed to seeing simply become

496
00:20:19,990 --> 00:20:18,000
too large they're too difficult to move

497
00:20:22,390 --> 00:20:20,000
they have some limitations in polar

498
00:20:24,630 --> 00:20:22,400
orbits because of the the problems

499
00:20:27,110 --> 00:20:24,640
encountered with the van allen radiation

500
00:20:30,870 --> 00:20:29,430
solar dynamic machines of which sterling

501
00:20:33,270 --> 00:20:30,880
is one

502
00:20:36,789 --> 00:20:33,280
can operate any place that there is a

503
00:20:38,630 --> 00:20:36,799
source of heat be it the the sun

504
00:20:40,470 --> 00:20:38,640
be it nuclear

505
00:20:42,230 --> 00:20:40,480
a sterling engine wants its supplied

506
00:20:45,029 --> 00:20:42,240
heat can function

507
00:20:47,350 --> 00:20:45,039
and it can produce large amounts of of

508
00:20:49,990 --> 00:20:47,360
electrical power output in a relatively

509
00:20:51,909 --> 00:20:50,000
small and lightweight package

510
00:20:53,750 --> 00:20:51,919
and that's our purpose for being

511
00:20:56,070 --> 00:20:53,760
involved in this type of technology

512
00:20:58,549 --> 00:20:56,080
development work the amazing sterling

513
00:21:01,190 --> 00:20:58,559

engine one of the most efficient heat

514
00:21:03,669 --> 00:21:01,200
engines made and just one of the many

515
00:21:06,070 --> 00:21:03,679
technologies being developed today at

516
00:21:07,430 --> 00:21:06,080
nasa lewis research center

517
00:21:08,789 --> 00:21:07,440
now that we have a background on

518
00:21:09,750 --> 00:21:08,799
understanding how the sterling engine

519
00:21:11,669 --> 00:21:09,760
works

520
00:21:13,190 --> 00:21:11,679
let's view a short animated piece on the

521
00:21:14,950 --> 00:21:13,200
development of the sterling engine for

522
00:21:17,190 --> 00:21:14,960
its use in space

523
00:21:19,430 --> 00:21:17,200
the free piston sterling engine effort

524
00:21:22,950 --> 00:21:19,440
is directed at high efficiency

525
00:21:25,590 --> 00:21:22,960
long life and a high specific power

526
00:21:26,950 --> 00:21:25,600
to meet nasa's needs for future space

527
00:21:29,590 --> 00:21:26,960
missions

528
00:21:32,870 --> 00:21:29,600
the successful tests of the 25 kilowatt

529
00:21:35,430 --> 00:21:32,880
space power demonstrator engine at 650

530
00:21:38,710 --> 00:21:35,440
degrees k in 1985

531
00:21:41,190 --> 00:21:38,720
completed phase one

532
00:21:43,510 --> 00:21:41,200
phase two of the three-phase sterling

533
00:21:46,230 --> 00:21:43,520
program is now underway

534
00:21:49,510 --> 00:21:46,240
leading to the design fabrication and

535
00:21:51,750 --> 00:21:49,520
testing of a 1050 degree kelvin super

536
00:21:53,590 --> 00:21:51,760
alloy sterling engine

537
00:21:55,590 --> 00:21:53,600
this is one of several conceptual

538
00:21:57,909 --> 00:21:55,600

designs

539
00:21:59,830 --> 00:21:57,919
the successful development of the 1050k

540
00:22:02,789 --> 00:21:59,840
experimental sterling engine provides a

541
00:22:04,950 --> 00:22:02,799
low cost basis for the low risk future

542
00:22:09,190 --> 00:22:04,960
development of the phase three

543
00:22:10,950 --> 00:22:09,200
refractory alloy 1300k engine

544
00:22:13,750 --> 00:22:10,960
it will also provide a variable

545
00:22:16,630 --> 00:22:13,760
alternative power conversion system for

546
00:22:21,510 --> 00:22:16,640
an early flight demonstration of the s p

547
00:22:23,830 --> 00:22:21,520
100 nuclear space power reactor

548
00:22:26,789 --> 00:22:23,840
the performance objectives of a typical

549
00:22:29,750 --> 00:22:26,799
single cylinder design are

550
00:22:33,830 --> 00:22:29,760
alternator output 25 kilowatts of

551
00:22:41,590 --> 00:22:36,470
engine efficiency

552
00:22:47,590 --> 00:22:43,270
inlet temperature

553
00:22:54,310 --> 00:22:49,230
outlet temperature

554
00:23:00,070 --> 00:22:55,669
working fluid

555
00:23:07,190 --> 00:23:03,190
engine alternator frequency

556
00:23:12,149 --> 00:23:09,190
specific mass

557
00:23:14,630 --> 00:23:12,159
6.4 kilograms per kilowatt of

558
00:23:16,789 --> 00:23:14,640
electricity

559
00:23:20,070 --> 00:23:16,799
operational life

560
00:23:22,470 --> 00:23:20,080
over seven years

561
00:23:25,830 --> 00:23:22,480
with lessons learned in the 650 phase 1

562
00:23:28,710 --> 00:23:25,840
engine program the super alloy phase 2

563
00:23:31,750 --> 00:23:28,720

engine is being confidently designed for

564
00:23:35,590 --> 00:23:31,760
high performance and long life with

565
00:23:37,590 --> 00:23:35,600
current nickel base super alloys

566
00:23:40,149 --> 00:23:37,600
the free piston sterling engine achieves

567
00:23:43,350 --> 00:23:40,159
its high performance in part due to its

568
00:23:45,669 --> 00:23:43,360
simplicity of design and operation

569
00:23:48,070 --> 00:23:45,679
its major features are

570
00:23:51,110 --> 00:23:48,080
the heat exchanger assembly which will

571
00:23:53,110 --> 00:23:51,120
have only 40 heater cooler modules to

572
00:23:55,350 --> 00:23:53,120
significantly reduce the number of

573
00:23:59,190 --> 00:23:55,360
welded tube joints

574
00:24:02,149 --> 00:23:59,200
the displacer one of three moving parts

575
00:24:03,590 --> 00:24:02,159
is a five kilogram piston floating on a

576
00:24:05,669 --> 00:24:03,600
film of helium

577
00:24:08,230 --> 00:24:05,679
and shuttles the working fluid from the

578
00:24:11,909 --> 00:24:08,240
hot expansion space to the coal

579
00:24:13,830 --> 00:24:11,919
compression space and vice versa

580
00:24:16,310 --> 00:24:13,840
the reciprocating action of the 12

581
00:24:19,269 --> 00:24:16,320
kilogram power piston caused by the

582
00:24:21,909 --> 00:24:19,279
working fluid produces electrical power

583
00:24:23,990 --> 00:24:21,919
in the linear alternator

584
00:24:26,390 --> 00:24:24,000
the 12 kilogram balance piston

585
00:24:29,190 --> 00:24:26,400
oscillates to fully counteract the

586
00:24:31,110 --> 00:24:29,200
combined vibrations of the displacer and

587
00:24:33,750 --> 00:24:31,120
power pistons

588
00:24:36,230 --> 00:24:33,760

alternate engine designs employ opposed

589
00:24:40,310 --> 00:24:36,240
sets of pistons synchronized to

590
00:24:42,470 --> 00:24:40,320
eliminate the need for a balanced piston

591
00:24:44,549 --> 00:24:42,480
magnets in the power piston oscillate

592
00:24:47,510 --> 00:24:44,559
through the stator laminations to

593
00:24:49,990 --> 00:24:47,520
produce alternating current

594
00:24:52,870 --> 00:24:50,000
the pressure volume diagram shows the

595
00:24:55,029 --> 00:24:52,880
cyclic variation of pressure and volume

596
00:24:57,110 --> 00:24:55,039
in the working space between the power

597
00:24:59,590 --> 00:24:57,120
and displacer pistons

598
00:25:02,230 --> 00:24:59,600
the area enclosed by this diagram is

599
00:25:04,310 --> 00:25:02,240
indicative of the engine's thermodynamic

600
00:25:06,310 --> 00:25:04,320
power

601
00:25:09,269 --> 00:25:06,320
the following computer-generated

602
00:25:10,789 --> 00:25:09,279
animation shows relative motions of the

603
00:25:12,870 --> 00:25:10,799
three pistons

604
00:25:15,110 --> 00:25:12,880
for clarity their speeds have been

605
00:25:19,190 --> 00:25:15,120
greatly reduced from the normal 90

606
00:25:21,430 --> 00:25:19,200
cycles per second operating frequency

607
00:25:23,430 --> 00:25:21,440
we hope you've enjoyed our program i'm

608
00:25:25,830 --> 00:25:23,440
america forester hoping you'll walk with

609
00:25:27,990 --> 00:25:25,840
me again along the future path at the

610
00:25:59,669 --> 00:25:28,000
nasa lewis research center in cleveland

611
00:25:59,679 --> 00:27:47,430
so

612
00:27:47,440 --> 00:28:13,750
oh

613
00:28:13,760 --> 00:28:27,590

so

614
00:28:27,600 --> 00:28:32,149
too

615
00:28:38,230 --> 00:28:35,990
sink rate is now uh 70 feet per second

616
00:28:41,510 --> 00:28:38,240
here are down

617
00:28:47,830 --> 00:28:44,470
uh 86 feet

618
00:28:50,230 --> 00:28:47,840
gear down and locked and we have

619
00:28:51,430 --> 00:28:50,240
touchdown at mission elapsed time seven

620
00:28:53,190 --> 00:28:51,440
days

621
00:28:55,350 --> 00:28:53,200
one hour