



1
00:00:33,830 --> 00:00:14,870
basking in its warm rays nature seeks

2
00:00:39,350 --> 00:00:36,470
this nuclear reactor burns four million

3
00:00:44,150 --> 00:00:39,360
tons of hydrogen every second creating

4
00:00:48,549 --> 00:00:45,910
ancient observers worship the

5
00:00:50,790 --> 00:00:48,559
life-giving rays of this day star

6
00:00:53,029 --> 00:00:50,800
modern science has taught us to harness

7
00:00:55,510 --> 00:00:53,039
its power

8
00:00:58,229 --> 00:00:55,520
this superstar is essential to life on

9
00:00:59,670 --> 00:00:58,239
earth as well as to one of man's boldest

10
00:01:09,310 --> 00:00:59,680
ventures

11
00:01:14,310 --> 00:01:11,830
196 000

12
00:01:17,510 --> 00:01:14,320
cells will collect energy to power this

13
00:01:28,870 --> 00:01:17,520

laboratory and indeed become the solar

14

00:01:32,230 --> 00:01:30,950

the united states

15

00:01:33,429 --> 00:01:32,240

canada

16

00:01:36,149 --> 00:01:33,439

japan

17

00:01:41,670 --> 00:01:36,159

and the european space agency have come

18

00:01:47,190 --> 00:01:43,910

responsibility for the entire electric

19

00:01:49,830 --> 00:01:47,200

power system known as work package 4

20

00:01:54,870 --> 00:01:49,840

rests in cleveland ohio at the nasa

21

00:01:59,030 --> 00:01:56,950

the power collection system is being

22

00:02:02,469 --> 00:01:59,040

developed by the solar array branch of

23

00:02:06,310 --> 00:02:02,479

the photovoltaic power module division

24

00:02:08,389 --> 00:02:06,320

design of space station began in 1984.

25

00:02:10,949 --> 00:02:08,399

now its pencils down

26

00:02:12,710 --> 00:02:10,959

time to build and test the actual flight

27

00:02:15,990 --> 00:02:12,720

hardware

28

00:02:17,910 --> 00:02:16,000

in the summer of 1991 for the first time

29

00:02:19,750 --> 00:02:17,920

anywhere in the world

30

00:02:22,150 --> 00:02:19,760

an array of cells and structural

31

00:02:24,710 --> 00:02:22,160

components were tested together in the

32

00:02:27,110 --> 00:02:24,720

simulated low earth orbit environment of

33

00:02:36,470 --> 00:02:27,120

tank 5 in the electric propulsion

34

00:02:41,110 --> 00:02:38,710

funding from nasa's office of safety and

35

00:02:42,550 --> 00:02:41,120

mission quality and the work package 4

36

00:02:45,190 --> 00:02:42,560

project office

37

00:02:47,750 --> 00:02:45,200

allowed engineers to develop and design

38

00:02:51,430 --> 00:02:47,760

a high-fidelity plasma generation and

39

00:02:53,750 --> 00:02:51,440

diagnostic system the intent

40

00:02:56,150 --> 00:02:53,760

to test the electrodynamic reaction

41

00:03:03,270 --> 00:02:56,160

between the photovoltaic system the

42

00:03:07,830 --> 00:03:05,509

a nitrogen cold wall was attached to a

43

00:03:09,910 --> 00:03:07,840

test fixture to regulate temperature of

44

00:03:11,750 --> 00:03:09,920

the test article

45

00:03:13,910 --> 00:03:11,760

the cage design allowed for quick

46

00:03:16,630 --> 00:03:13,920

installation and removal of hardware

47

00:03:20,790 --> 00:03:16,640

from the vacuum tank

48

00:03:23,030 --> 00:03:20,800

a light bank of 252 ded lamps was built

49

00:03:26,630 --> 00:03:23,040

to provide illumination equal to

50

00:03:28,470 --> 00:03:26,640

one-third of the sun's intensity

51
00:03:30,710 --> 00:03:28,480
spherical probes measured the current

52
00:03:32,710 --> 00:03:30,720
voltage profile to determine plasma

53
00:03:35,509 --> 00:03:32,720
density

54
00:03:37,589 --> 00:03:35,519
in preparation for the test an engineer

55
00:03:41,190 --> 00:03:37,599
checks to ensure that illumination is

56
00:03:43,830 --> 00:03:41,200
falling evenly on each solar cell

57
00:03:46,789 --> 00:03:43,840
the cells eight millimeters thick and

58
00:03:49,990 --> 00:03:46,799
eight centimeters square are the largest

59
00:03:54,149 --> 00:03:51,910
the cells are welded to a flexible

60
00:03:56,869 --> 00:03:54,159
printed circuit which is insulated from

61
00:04:01,110 --> 00:03:56,879
the outside environment the cell edges

62
00:04:05,990 --> 00:04:03,589
sixteen thousand four hundred individual

63
00:04:08,390 --> 00:04:06,000

cells are grouped into blankets one

64

00:04:09,429 --> 00:04:08,400

hundred ten feet long by fifteen feet

65

00:04:11,270 --> 00:04:09,439

wide

66

00:04:14,390 --> 00:04:11,280

each blanket is protected by and

67

00:04:16,390 --> 00:04:14,400

deployed from a blanket box

68

00:04:19,430 --> 00:04:16,400

underwater testing was conducted by

69

00:04:21,189 --> 00:04:19,440

lockheed corporation aiding engineers in

70

00:04:24,629 --> 00:04:21,199

improving deployment techniques of the

71

00:04:28,469 --> 00:04:27,110

from the beginning of life on earth and

72

00:04:31,749 --> 00:04:28,479

now in space

73

00:04:34,469 --> 00:04:31,759

nature has relied on the sun

74

00:04:37,749 --> 00:04:34,479

these sunflower seedlings track the sun

75

00:04:43,350 --> 00:04:41,270

technology imitates nature

76
00:04:46,230 --> 00:04:43,360
once freedom's wings are attached to the

77
00:04:48,870 --> 00:04:46,240
truss alpha and beta gimbals will enable

78
00:04:51,350 --> 00:04:48,880
them to track the sun during orbit

79
00:04:53,510 --> 00:04:51,360
60 minutes in sunlight and 30 minutes in

80
00:04:55,909 --> 00:04:53,520
eclipse

81
00:04:58,310 --> 00:04:55,919
while in sunlight the six wings will

82
00:05:00,230 --> 00:04:58,320
collect light and convert it directly to

83
00:05:03,590 --> 00:05:00,240
electric current

84
00:05:06,070 --> 00:05:03,600
at the same time 304 nickel hydrogen

85
00:05:10,230 --> 00:05:06,080
battery cells will be charged to provide

86
00:05:12,870 --> 00:05:10,240
power while freedom is in earth shade

87
00:05:15,510 --> 00:05:12,880
up and energized the solar arrays will

88
00:05:18,150 --> 00:05:15,520

supply more than 56 kilowatts of

89

00:05:22,150 --> 00:05:18,160

condition power to the user

90

00:05:24,469 --> 00:05:22,160

the most power ever used in space

91

00:05:26,629 --> 00:05:24,479

solar energy will supply power for

92

00:05:29,029 --> 00:05:26,639

experiments

93

00:05:31,270 --> 00:05:29,039

research projects

94

00:05:34,150 --> 00:05:31,280

housekeeping functions

95

00:05:36,469 --> 00:05:34,160

and life support systems

96

00:05:40,310 --> 00:05:36,479

however these can come crashing to a

97

00:05:42,390 --> 00:05:40,320

halt in the harsh environment of space

98

00:05:43,749 --> 00:05:42,400

micrometeors can damage freedom

99

00:05:46,710 --> 00:05:43,759

structure

100

00:05:49,990 --> 00:05:46,720

contamination can degrade its power

101
00:05:50,830 --> 00:05:50,000
and an invisible gas known as plasma can

102
00:05:54,469 --> 00:05:50,840
cause

103
00:05:56,629 --> 00:05:54,479
arcing why is that a threat

104
00:05:58,950 --> 00:05:56,639
the potential effects of such arcing was

105
00:06:01,189 --> 00:05:58,960
studied by the photovoltaic power module

106
00:06:04,629 --> 00:06:01,199
division

107
00:06:06,790 --> 00:06:04,639
project manager marion felder

108
00:06:09,189 --> 00:06:06,800
the threat that plasma poses to the

109
00:06:11,909 --> 00:06:09,199
space station freedom was examined here

110
00:06:14,550 --> 00:06:11,919
in tank 5 during the plasma interactions

111
00:06:17,110 --> 00:06:14,560
test the objectives of this test were to

112
00:06:19,029 --> 00:06:17,120
investigate on a systems level the

113
00:06:22,070 --> 00:06:19,039

possibly detrimental effects of the

114

00:06:23,909 --> 00:06:22,080

space plasma on the photovoltaic system

115

00:06:25,830 --> 00:06:23,919

as well as on the structures that make

116

00:06:28,390 --> 00:06:25,840

up space station freedom

117

00:06:30,710 --> 00:06:28,400

we also wanted to investigate the

118

00:06:33,830 --> 00:06:30,720

effectiveness of a possible mitigation

119

00:06:36,710 --> 00:06:33,840

strategy that is a plasma contactor for

120

00:06:39,270 --> 00:06:36,720

hardware we used two fully populated

121

00:06:41,909 --> 00:06:39,280

photovoltaic panels in combination with

122

00:06:43,830 --> 00:06:41,919

a variety of anodized aluminum

123

00:06:45,909 --> 00:06:43,840

structures which were there to simulate

124

00:06:47,029 --> 00:06:45,919

various structures on the space station

125

00:06:49,029 --> 00:06:47,039

freedom

126

00:06:51,590 --> 00:06:49,039

the solar ray circuit that we had was

127

00:06:53,990 --> 00:06:51,600

capable of generating 160 volts at

128

00:06:56,950 --> 00:06:54,000

almost one amp under test illumination

129

00:07:00,070 --> 00:06:56,960

conditions we used the voltage that was

130

00:07:03,029 --> 00:07:00,080

generated on the solar array to drive

131

00:07:05,029 --> 00:07:03,039

the potential of the aluminum piece to a

132

00:07:08,070 --> 00:07:05,039

voltage that would be quite close to

133

00:07:10,309 --> 00:07:08,080

what it would be seeing when on orbit

134

00:07:13,430 --> 00:07:10,319

the combination of the largest aluminum

135

00:07:15,749 --> 00:07:13,440

panels and the photovoltaic circuit was

136

00:07:18,469 --> 00:07:15,759

approximately one four hundred ninety

137

00:07:20,790 --> 00:07:18,479

the scale of the space station freedom

138

00:07:23,350 --> 00:07:20,800

and therefore allowed us to get the very

139

00:07:25,670 --> 00:07:23,360

first large-scale test of plasma

140

00:07:28,950 --> 00:07:25,680

environment interactions with space

141

00:07:31,749 --> 00:07:28,960

station type hardware

142

00:07:34,070 --> 00:07:31,759

our data capture system was designed to

143

00:07:36,950 --> 00:07:34,080

return information in three specific

144

00:07:39,830 --> 00:07:36,960

areas current collection floating

145

00:07:41,350 --> 00:07:39,840

potential and arc transients as well as

146

00:07:42,950 --> 00:07:41,360

to give us information on key

147

00:07:45,749 --> 00:07:42,960

environmental parameters like

148

00:07:47,909 --> 00:07:45,759

temperatures and the plasma potential

149

00:07:50,390 --> 00:07:47,919

concern for the possible detrimental

150

00:07:52,550 --> 00:07:50,400

effects of arcing on the space station

151
00:07:54,950 --> 00:07:52,560
freedom led us to plan and conduct this

152
00:07:57,350 --> 00:07:54,960
plasma interactions test

153
00:07:59,430 --> 00:07:57,360
so that the program office could assess

154
00:08:00,869 --> 00:07:59,440
the risks and develop engineering

155
00:08:03,110 --> 00:08:00,879
solutions

156
00:08:05,270 --> 00:08:03,120
we look to the space environment's

157
00:08:07,430 --> 00:08:05,280
effects branch here at lewis for a more

158
00:08:09,589 --> 00:08:07,440
detailed description of the low-earth

159
00:08:13,510 --> 00:08:09,599
orbit plasma environment and its

160
00:08:18,869 --> 00:08:16,070
contrary to popular belief space station

161
00:08:21,110 --> 00:08:18,879
freedom will be orbiting not in empty

162
00:08:23,749 --> 00:08:21,120
space but in the upper reaches of the

163
00:08:26,550 --> 00:08:23,759

earth's atmosphere the upper reaches of

164

00:08:29,029 --> 00:08:26,560

the atmosphere are mainly atomic oxygen

165

00:08:31,749 --> 00:08:29,039

and this atomic oxygen gets ionized by

166

00:08:36,310 --> 00:08:31,759

the ultraviolet radiation from the sun

167

00:08:39,750 --> 00:08:36,320

ultraviolet radiation splits the atomic

168

00:08:42,230 --> 00:08:39,760

oxygen atoms up into an ion and electron

169

00:08:43,750 --> 00:08:42,240

and in the altitudes the space station

170

00:08:46,389 --> 00:08:43,760

will be flying there will be something

171

00:08:48,389 --> 00:08:46,399

like a million electrons and ions per

172

00:08:50,150 --> 00:08:48,399

cubic centimeter

173

00:08:53,670 --> 00:08:50,160

that is flying through

174

00:08:55,110 --> 00:08:53,680

this space plasma as we call it is is

175

00:08:57,269 --> 00:08:55,120

going to be important in terms of

176
00:08:59,269 --> 00:08:57,279
interactions between the space station

177
00:09:01,430 --> 00:08:59,279
and its surroundings

178
00:09:04,310 --> 00:09:01,440
first of all what what will happen if

179
00:09:07,590 --> 00:09:04,320
the arcing does occur

180
00:09:10,470 --> 00:09:07,600
one of the things is it can

181
00:09:12,870 --> 00:09:10,480
cause tiny holes in the anodized surface

182
00:09:14,550 --> 00:09:12,880
and change its properties in particular

183
00:09:17,269 --> 00:09:14,560
could change the thermal properties of

184
00:09:19,990 --> 00:09:17,279
the surface so that it wouldn't maintain

185
00:09:21,910 --> 00:09:20,000
the right temperature

186
00:09:23,670 --> 00:09:21,920
in addition the material that comes off

187
00:09:25,990 --> 00:09:23,680
during these arcs

188
00:09:28,230 --> 00:09:26,000

will deposit somewhere else on the space

189

00:09:30,949 --> 00:09:28,240

station the solution to the possible

190

00:09:34,870 --> 00:09:30,959

arcing problem on space station we think

191

00:09:36,949 --> 00:09:34,880

is a device called the plasma contactor

192

00:09:39,590 --> 00:09:36,959

mike patterson of the space propulsion

193

00:09:42,310 --> 00:09:39,600

technology division explains his group's

194

00:09:45,509 --> 00:09:42,320

involvement with the test here at nasa

195

00:09:47,829 --> 00:09:45,519

lewis at the epl facility tank 5 our

196

00:09:49,750 --> 00:09:47,839

organization provided support for the

197

00:09:51,990 --> 00:09:49,760

plasma interactions test for the space

198

00:09:54,150 --> 00:09:52,000

station freedom solar array one of the

199

00:09:56,389 --> 00:09:54,160

critical aspects of conducting that

200

00:09:58,470 --> 00:09:56,399

experiment was to provide a simulation

201
00:10:01,190 --> 00:09:58,480
of the low earth orbit space plasma

202
00:10:04,389 --> 00:10:01,200
environment and to do that we provided

203
00:10:06,710 --> 00:10:04,399
holic acid plasma sources to generate a

204
00:10:09,110 --> 00:10:06,720
quiescent low density low electron

205
00:10:11,030 --> 00:10:09,120
temperature space plasma environment we

206
00:10:12,870 --> 00:10:11,040
used a number of hollow cathode plasma

207
00:10:15,350 --> 00:10:12,880
source devices

208
00:10:17,590 --> 00:10:15,360
optimized for operation to provide a low

209
00:10:20,230 --> 00:10:17,600
electron temperature and a very uniform

210
00:10:23,430 --> 00:10:20,240
plasma to engulf the solar array to

211
00:10:25,350 --> 00:10:23,440
simulate the low earth orbit environment

212
00:10:28,150 --> 00:10:25,360
the plasma contactors have been

213
00:10:29,910 --> 00:10:28,160

developed previously for specific

214

00:10:32,230 --> 00:10:29,920

mission applications on specific

215

00:10:34,150 --> 00:10:32,240

spacecraft primarily for science this is

216

00:10:35,910 --> 00:10:34,160

really the first time that the plasma

217

00:10:39,670 --> 00:10:35,920

contactor is going to be used as a

218

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

utility as a technology to ensure that

219

00:10:43,829 --> 00:10:42,000

the spacecraft can perform its function

220

00:10:45,190 --> 00:10:43,839

as it turns out it's a vital component

221

00:10:46,949 --> 00:10:45,200

it will be a vital component of the

222

00:10:48,710 --> 00:10:46,959

power system aboard space station and

223

00:10:49,910 --> 00:10:48,720

it's critical for space station

224

00:10:52,389 --> 00:10:49,920

operations

225

00:10:53,910 --> 00:10:52,399

so in that in that context it's the

226

00:10:55,590 --> 00:10:53,920

first time that the technology has

227

00:10:57,590 --> 00:10:55,600

really been utilized and it's not a

228

00:11:00,150 --> 00:10:57,600

demonstration of the technology it's

229

00:11:02,150 --> 00:11:00,160

there to perform a specific function the

230

00:11:03,990 --> 00:11:02,160

demanding requirements for the plasma

231

00:11:07,430 --> 00:11:04,000

contactor system for space station

232

00:11:08,949 --> 00:11:07,440

freedom uh require us to uh

233

00:11:10,870 --> 00:11:08,959

do everything we can to push the

234

00:11:11,750 --> 00:11:10,880

holocaustic technology that we presently

235

00:11:15,030 --> 00:11:11,760

have

236

00:11:17,910 --> 00:11:15,040

and uh that's a a real challenge for us

237

00:11:19,590 --> 00:11:17,920

but we'll be able to deliver on that

238

00:11:22,470 --> 00:11:19,600

one of the important space flight

239

00:11:24,470 --> 00:11:22,480

experiments for space station is

240

00:11:25,590 --> 00:11:24,480

what we call sampy

241

00:11:28,550 --> 00:11:25,600

that's

242

00:11:29,990 --> 00:11:28,560

solar array module plasma interaction

243

00:11:33,030 --> 00:11:30,000

experiment

244

00:11:35,190 --> 00:11:33,040

here at lewis

245

00:11:37,590 --> 00:11:35,200

it's going to be flown on the space

246

00:11:40,310 --> 00:11:37,600

shuttle in the year 1994

247

00:11:42,470 --> 00:11:40,320

and it's being built right now hopefully

248

00:11:46,790 --> 00:11:42,480

when it flies we'll have confirmation

249

00:11:51,030 --> 00:11:49,190

in a room much like this lewis will

250

00:11:53,190 --> 00:11:51,040

monitor the performance of the space

251
00:11:54,550 --> 00:11:53,200
station's electric power system once on

252
00:11:56,389 --> 00:11:54,560
orbit

253
00:11:59,190 --> 00:11:56,399
personal computers such as these are

254
00:12:01,590 --> 00:11:59,200
used daily to design systems and conduct

255
00:12:03,670 --> 00:12:01,600
analyses to verify characteristics of

256
00:12:06,069 --> 00:12:03,680
space station freedom

257
00:12:08,550 --> 00:12:06,079
soon computers will be used to run the

258
00:12:10,230 --> 00:12:08,560
machines that fabricate the various

259
00:12:12,790 --> 00:12:10,240
components

260
00:12:14,790 --> 00:12:12,800
along with sampi work package 4 plans to

261
00:12:16,949 --> 00:12:14,800
conduct a qualification type plasma

262
00:12:19,190 --> 00:12:16,959
interactions test with a flight design

263
00:12:21,430 --> 00:12:19,200

solar array circuit to confirm the

264

00:12:23,190 --> 00:12:21,440

operational characteristics of the solar

265

00:12:25,509 --> 00:12:23,200

arrays in plasma

266

00:12:27,509 --> 00:12:25,519

work package 4 also plans to take

267

00:12:30,310 --> 00:12:27,519

advantage of other space flight

268

00:12:32,790 --> 00:12:30,320

experiments such as pass plus and spear

269

00:12:35,990 --> 00:12:32,800

3 to gain confidence in the array's

270

00:12:38,069 --> 00:12:36,000

operation before it flies

271

00:12:40,550 --> 00:12:38,079

beginning in the mid 90s with the first

272

00:12:42,150 --> 00:12:40,560

element launch of one photovoltaic power

273

00:12:43,670 --> 00:12:42,160

module

274

00:12:44,710 --> 00:12:43,680

and continuing with the remaining

275

00:12:46,069 --> 00:12:44,720

elements

276

00:12:48,310 --> 00:12:46,079

space station freedom will be

277

00:12:50,470 --> 00:12:48,320

constructed in stages to yield a

278

00:12:52,949 --> 00:12:50,480

permanently manned configuration by the

279

00:12:54,710 --> 00:12:52,959

end of the decade

280

00:12:56,710 --> 00:12:54,720

the knowledge that we gain from our

281

00:12:58,949 --> 00:12:56,720

research in tank 5 will enable