1
00:00:00,000 --> 00:00:59,500
I

2
00:01:04,250 --> 00:01:02,030
electrical storms are one of nature's

3
00:01:07,250 --> 00:01:04,260
most spectacular and unpredictable

4
00:01:09,680 --> 00:01:07,260
phenomenal despite our technology we

5
00:01:14,450 --> 00:01:09,690
remain poems to control this awesome

6
00:01:16,940 --> 00:01:14,460
force nevertheless the conditions that

7
00:01:18,980 --> 00:01:16,950
cause lightning are at the very heart of

8
00:01:22,940 --> 00:01:18,990
a groundbreaking experiment at NASA

9
00:01:25,280 --> 00:01:22,950
Lewis Research Center in Cleveland the

10
00:01:28,310 --> 00:01:25,290
solar array module plasma interaction

11
00:01:29,810 --> 00:01:28,320
experiment or Sam p is an essential step

12
00:01:32,030 --> 00:01:29,820
toward the development of future

13
00:01:35,749 --> 00:01:32,040

high-voltage power systems for space

14
00:01:37,730 --> 00:01:35,759
exploration dr. Dale Ferguson is

15
00:01:40,280 --> 00:01:37,740
principal investigator of the santee

16
00:01:41,960 --> 00:01:40,290
project he and his team are nearing the

17
00:01:46,490 --> 00:01:41,970
most critical phase of the experiment

18
00:01:48,650 --> 00:01:46,500
flight testing in low-earth orbit before

19
00:01:50,450 --> 00:01:48,660
earth-based technologies are used for

20
00:01:52,309 --> 00:01:50,460
space applications they must be

21
00:01:54,020 --> 00:01:52,319
thoroughly tested to ensure that they

22
00:01:57,050 --> 00:01:54,030
will perform as needed in the space

23
00:02:00,919 --> 00:01:57,060
environment flight testing is crucial to

24
00:02:03,590 --> 00:02:00,929
the engineering process historically

25
00:02:05,840 --> 00:02:03,600
electric power generation in space has

26
00:02:08,510 --> 00:02:05,850
relied on photovoltaic solar arrays

27
00:02:11,059 --> 00:02:08,520
Volta voltaic cells commonly made of

28
00:02:13,490 --> 00:02:11,069
silicon are semiconductors that convert

29
00:02:16,370 --> 00:02:13,500
visible light into direct electrical

30
00:02:18,710 --> 00:02:16,380
current the cells are covered with a

31
00:02:21,620 --> 00:02:18,720
transparent housing that allows light to

32
00:02:25,820 --> 00:02:21,630
easily penetrate them excess current is

33
00:02:28,220 --> 00:02:25,830
stored in batteries photovoltaic power

34
00:02:31,970 --> 00:02:28,230
is routinely used in such low voltage

35
00:02:34,430 --> 00:02:31,980
items as calculators the amount of

36
00:02:37,070 --> 00:02:34,440
current created by photovoltaic cells is

37
00:02:38,720 --> 00:02:37,080
a direct function of surface area the

38
00:02:41,660 --> 00:02:38,730

greater the surface the greater the

39
00:02:44,330 --> 00:02:41,670
power cells are connected in small units

40
00:02:46,850 --> 00:02:44,340
called coupons and coupons are strung

41
00:02:50,420 --> 00:02:46,860
together in larger sheets known as solar

42
00:02:52,160 --> 00:02:50,430
array modules photovoltaics has proven

43
00:02:54,930 --> 00:02:52,170
to be a reliable source of electricity

44
00:03:01,080 --> 00:02:54,940
for the 28 volt power systems in Paris

45
00:03:03,600 --> 00:03:01,090
from the aviation industry however

46
00:03:07,020 --> 00:03:03,610
future space exploration will require

47
00:03:09,720 --> 00:03:07,030
higher voltages as much as 160 volts DC

48
00:03:12,300 --> 00:03:09,730
on earth when you want to increase the

49
00:03:17,070 --> 00:03:12,310
power of a photovoltaic array you

50
00:03:18,540 --> 00:03:17,080
increase the number of cells and as the

51
00:03:22,550 --> 00:03:18,550
number of cells goes up so does the

52
00:03:24,840 --> 00:03:22,560
power in space adding more cells

53
00:03:27,750 --> 00:03:24,850
increases the voltage that the system

54
00:03:30,390 --> 00:03:27,760
will operate at and and a high voltage

55
00:03:34,590 --> 00:03:30,400
in space can be a problem for a

56
00:03:37,320 --> 00:03:34,600
spacecraft when we think of the space

57
00:03:40,470 --> 00:03:37,330
environment we immediately think of zero

58
00:03:42,240 --> 00:03:40,480
gravity however what poses the gravest

59
00:03:46,110 --> 00:03:42,250
problem to designers of a high voltage

60
00:03:48,750 --> 00:03:46,120
power system is space plasma plasma is

61
00:03:50,700 --> 00:03:48,760
created when a gas is subjected to high

62
00:03:53,190 --> 00:03:50,710
temperatures or bombardment by

63
00:03:54,930 --> 00:03:53,200

ultraviolet rays from the Sun the

64
00:03:56,580 --> 00:03:54,940
electrons are literally stripped away

65
00:03:59,580 --> 00:03:56,590
from their normal orbits around the

66
00:04:01,350 --> 00:03:59,590
nucleus when this happens the gas which

67
00:04:03,479 --> 00:04:01,360
is normally an excellent insulator

68
00:04:07,110 --> 00:04:03,489
becomes a fairly good conductor of

69
00:04:08,880 --> 00:04:07,120
electricity this chart depicts the

70
00:04:11,040 --> 00:04:08,890
density of the plasma relative to the

71
00:04:14,400 --> 00:04:11,050
altitude above the earth the density

72
00:04:16,920 --> 00:04:14,410
decreases as we increase in altitude for

73
00:04:19,110 --> 00:04:16,930
low voltages plasma does not present

74
00:04:21,210 --> 00:04:19,120
much of a problem but in high voltages

75
00:04:23,700 --> 00:04:21,220
in low-earth orbit it's a stumbling

76
00:04:26,100 --> 00:04:23,710
block when the electric potential

77
00:04:28,650 --> 00:04:26,110
between two points is great enough the

78
00:04:30,810 --> 00:04:28,660
gas between them ionizes creating a path

79
00:04:34,140 --> 00:04:30,820
of low resistance for electricity and

80
00:04:36,750 --> 00:04:34,150
when that happens arcing takes place an

81
00:04:39,960 --> 00:04:36,760
undesirable and destructive current is

82
00:04:42,750 --> 00:04:39,970
unleashed it's lightning with all of its

83
00:04:47,070 --> 00:04:42,760
hazards and unpredictability only on a

84
00:04:49,740 --> 00:04:47,080
smaller scale arcing can destroy or

85
00:04:51,810 --> 00:04:49,750
degrade most materials it contacts from

86
00:04:54,120 --> 00:04:51,820
the delicate solar arrays to such

87
00:04:56,280 --> 00:04:54,130
durable materials as anodized aluminum

88
00:04:58,170 --> 00:04:56,290

which is used as the primary structural

89
00:05:01,650 --> 00:04:58,180
material for satellites and other space

90
00:05:03,480 --> 00:05:01,660
payloads arcing can also cause current

91
00:05:06,260 --> 00:05:03,490
disruptions that could hamper in space

92
00:05:08,940 --> 00:05:06,270
operations of every time

93
00:05:12,240 --> 00:05:08,950
among the important questions the sappy

94
00:05:15,540 --> 00:05:12,250
flight test will help answer are at what

95
00:05:21,090 --> 00:05:15,550
voltage does arcing occur at what rate

96
00:05:23,850 --> 00:05:21,100
does arcing occur at what intensity and

97
00:05:26,190 --> 00:05:23,860
specifically what effect will arcing

98
00:05:29,340 --> 00:05:26,200
have on all the various materials and

99
00:05:31,410 --> 00:05:29,350
geometries currently designated not only

100
00:05:34,890 --> 00:05:31,420
for the solar arrays but for the whole

101
00:05:37,740 --> 00:05:34,900
space station all other materials need

102
00:05:40,440 --> 00:05:37,750
to be found how can we protect them and

103
00:05:45,360 --> 00:05:40,450
ultimately what steps can be taken to

104
00:05:47,370 --> 00:05:45,370
eliminate or minimize argue the sappy

105
00:05:49,950 --> 00:05:47,380
payload consists of an electronics

106
00:05:52,320 --> 00:05:49,960
enclosure with an experiment plate fixed

107
00:05:54,300 --> 00:05:52,330
to the top surface it will be mounted

108
00:05:57,630 --> 00:05:54,310
directly to the top of a hitchhiker M

109
00:05:59,490 --> 00:05:57,640
carrier the instruments and electronics

110
00:06:03,150 --> 00:05:59,500
that run the experiment and record data

111
00:06:05,400 --> 00:06:03,160
are located inside the enclosure the

112
00:06:07,740 --> 00:06:05,410
experiment plate will expose more than a

113
00:06:10,350 --> 00:06:07,750

dozen different materials geometries and

114
00:06:12,770 --> 00:06:10,360
technologies to conditions identical to

115
00:06:15,060 --> 00:06:12,780
those the space station will encounter

116
00:06:17,370 --> 00:06:15,070
extensive ground testing is always

117
00:06:20,219 --> 00:06:17,380
conducted first and is critical to

118
00:06:22,440 --> 00:06:20,229
research but certain conditions are

119
00:06:27,180 --> 00:06:22,450
simply impossible to simulate on the

120
00:06:31,350 --> 00:06:27,190
ground such as pressure plasma flow and

121
00:06:33,360 --> 00:06:31,360
electron temperature for example results

122
00:06:35,790 --> 00:06:33,370
from previous flight tests of silicon

123
00:06:38,790 --> 00:06:35,800
solar cells differ radically from the

124
00:06:40,500 --> 00:06:38,800
ground tests of those cells the sappy

125
00:06:42,630 --> 00:06:40,510
experiment plate will flight test

126
00:06:44,760 --> 00:06:42,640
leading-edge technologies but more

127
00:06:47,400 --> 00:06:44,770
familiar materials are also represented

128
00:06:50,100 --> 00:06:47,410
all u.s. spacecraft that have flown to

129
00:06:51,990 --> 00:06:50,110
date have used silicon solar cells they

130
00:06:54,300 --> 00:06:52,000
therefore will provide a baseline for us

131
00:06:56,060 --> 00:06:54,310
to allow us to compare our data with

132
00:06:58,740 --> 00:06:56,070
data that has been taken in the past

133
00:07:00,480 --> 00:06:58,750
even though other technologies are more

134
00:07:02,730 --> 00:07:00,490
efficient silicon is still the cheapest

135
00:07:04,170 --> 00:07:02,740
and is still the most commonly used we

136
00:07:07,710 --> 00:07:04,180
have to take a look at what happens to

137
00:07:10,020 --> 00:07:07,720
silicon them also to be tested is a

138
00:07:12,150 --> 00:07:10,030

coupon of advanced photovoltaic solar

139
00:07:14,970 --> 00:07:12,160
array or absa cells

140
00:07:16,530 --> 00:07:14,980
these cells hold great promise because

141
00:07:20,040 --> 00:07:16,540
they are much thinner and lighter than

142
00:07:21,750 --> 00:07:20,050
silicon Sampey will also test the impact

143
00:07:23,730 --> 00:07:21,760
of arcing on several state-of-the-art

144
00:07:27,180 --> 00:07:23,740
alloys being considered for use on the

145
00:07:29,400 --> 00:07:27,190
space station when the sappy experiment

146
00:07:31,500 --> 00:07:29,410
completes its set of flight tests the UH

147
00:07:33,840 --> 00:07:31,510
norbit data collected will be brought

148
00:07:35,850 --> 00:07:33,850
back and analyzed by scientists and

149
00:07:37,950 --> 00:07:35,860
engineers at the Lewis research center

150
00:07:40,650 --> 00:07:37,960
this flight data will provide the

151
00:07:42,600 --> 00:07:40,660
foundation for developing future high