
PLANET CAPTURE

1
00:01:06,500 --> 00:01:02,720
low thrust propulsion is essential for

2
00:01:08,630 --> 00:01:06,510
all space missions and NASA's Lewis

3
00:01:11,750 --> 00:01:08,640
Research Center is conducting programs

4
00:01:14,930 --> 00:01:11,760
to provide a broad range of low thrust

5
00:01:18,650 --> 00:01:14,940
propulsion concepts for both auxiliary

6
00:01:20,960 --> 00:01:18,660
and primary functions auxiliary

7
00:01:24,230 --> 00:01:20,970
propulsion is used for keeping space

8
00:01:28,580 --> 00:01:24,240
systems in desired locations or for

9
00:01:31,340 --> 00:01:28,590
orientation typical examples are the

10
00:01:35,359 --> 00:01:31,350
reaction control system for earth to

11
00:01:38,330 --> 00:01:35,369
orbit vehicles drag makeup and attitude

12
00:01:41,810 --> 00:01:38,340
control for low Earth orbit systems such

13
00:01:44,180 --> 00:01:41,820

as Space Station freedom station-keeping

14
00:01:47,859 --> 00:01:44,190
for higher orbit systems such as

15
00:01:51,410 --> 00:01:47,869
geosynchronous satellites and finally

16
00:01:55,340 --> 00:01:51,420
retropropulsion functions near planetary

17
00:01:57,680 --> 00:01:55,350
bodies primary propulsion functions

18
00:02:00,290 --> 00:01:57,690
include the moving of space vehicles

19
00:02:03,020 --> 00:02:00,300
from point to point in earth space as

20
00:02:07,640 --> 00:02:03,030
well as propulsion between Earth space

21
00:02:09,919 --> 00:02:07,650
and various planetary bodies to

22
00:02:13,070 --> 00:02:09,929
understand these various propulsion

23
00:02:16,220 --> 00:02:13,080
applications specific auxiliary and

24
00:02:18,860 --> 00:02:16,230
primary missions will be discussed on

25
00:02:21,920 --> 00:02:18,870
earth to orbit vehicles such as the

26
00:02:24,100 --> 00:02:21,930
shuttle orbiter Auxiliary low thrust

27
00:02:28,009 --> 00:02:24,110
propulsion systems are used to control

28
00:02:33,650 --> 00:02:28,019
vehicle orientation or to perform small

29
00:02:35,870 --> 00:02:33,660
orbit changes examples are orientation

30
00:02:39,080 --> 00:02:35,880
of the shuttle orbiter to face the Sun

31
00:02:41,030 --> 00:02:39,090
and rendezvous with low Earth orbit

32
00:02:46,370 --> 00:02:41,040
systems such as the long-duration

33
00:02:48,470 --> 00:02:46,380
exposure facility led F the low thrust

34
00:02:51,410 --> 00:02:48,480
devices for these applications are

35
00:02:53,690 --> 00:02:51,420
called reaction control systems which

36
00:02:58,400 --> 00:02:53,700
generally operate at thrust levels from

37
00:03:01,009 --> 00:02:58,410
25 to a few hundred pounds space station

38
00:03:04,330 --> 00:03:01,019

freedom requires low thrust propulsion

39
00:03:07,300 --> 00:03:04,340
for both orbit and attitude control

40
00:03:11,170 --> 00:03:07,310
orbit control includes atmosphere drag

41
00:03:13,630 --> 00:03:11,180
makeup and collision avoidance attitude

42
00:03:16,900 --> 00:03:13,640
control includes damping of disturbances

43
00:03:20,910 --> 00:03:16,910
such as shuttle docking and momentum

44
00:03:22,240 --> 00:03:20,920
management small electric rockets called

45
00:03:25,770 --> 00:03:22,250
resistojet

46
00:03:29,350 --> 00:03:25,780
with thrust levels less than a pound and

47
00:03:32,350 --> 00:03:29,360
25 to 100 pound chemical rockets are

48
00:03:36,750 --> 00:03:32,360
being considered for orbit and attitude

49
00:03:40,900 --> 00:03:39,250
communication satellites are usually

50
00:03:44,650 --> 00:03:40,910
first placed in a geosynchronous

51
00:03:48,550 --> 00:03:44,660
transfer orbit or GTO

52
00:03:51,460 --> 00:03:48,560
a 100 to 200 pound thrust apogee

53
00:03:54,759 --> 00:03:51,470
propulsion system is used to change the

54
00:03:58,470 --> 00:03:54,769
gto to a circular geosynchronous orbit

55
00:04:01,900 --> 00:03:58,480
at an altitude of about 20 2,300 miles

56
00:04:04,270 --> 00:04:01,910
in the geosynchronous orbit small

57
00:04:06,670 --> 00:04:04,280
station-keeping Rockets are used to

58
00:04:10,539 --> 00:04:06,680
overcome gravitational forces from the

59
00:04:14,580 --> 00:04:10,549
Sun Moon and Earth to maintain the

60
00:04:17,590 --> 00:04:14,590
satellite in the desired position a

61
00:04:20,920 --> 00:04:17,600
final example of auxiliary propulsion is

62
00:04:24,580 --> 00:04:20,930
the use of 100 to 500 pound retro

63
00:04:29,529 --> 00:04:24,590

rockets for orbit change or capture of

64
00:04:31,570 --> 00:04:29,539
satellites near planetary bodies low

65
00:04:34,659 --> 00:04:31,580
thrust systems are also useful for

66
00:04:38,460 --> 00:04:34,669
primary propulsion applications for

67
00:04:41,050 --> 00:04:38,470
Earth orbit and planetary missions

68
00:04:43,210 --> 00:04:41,060
examples in Earth space include the

69
00:04:46,180 --> 00:04:43,220
transport of communication satellites

70
00:04:48,790 --> 00:04:46,190
from low-earth orbit into geosynchronous

71
00:04:51,460 --> 00:04:48,800
orbit and the placement of weather

72
00:04:55,719 --> 00:04:51,470
satellites in polar orbits for earth

73
00:04:58,000 --> 00:04:55,729
observations planetary missions include

74
00:05:03,900 --> 00:04:58,010
transferring of systems beyond earth

75
00:05:09,390 --> 00:05:06,570
low thrust electric propulsion is

76
00:05:12,390 --> 00:05:09,400
particularly valuable for very energetic

77
00:05:16,130 --> 00:05:12,400
planetary applications such as cargo

78
00:05:18,870 --> 00:05:16,140
vehicles for major moon Mars missions

79
00:05:21,420 --> 00:05:18,880
the Lewis Research Center is developing

80
00:05:25,010 --> 00:05:21,430
low thrust chemical and electric

81
00:05:27,960 --> 00:05:25,020
propulsion systems chemical propulsion

82
00:05:32,010 --> 00:05:27,970
includes rockets which use hydrogen

83
00:05:34,110 --> 00:05:32,020
oxygen and storable propellants although

84
00:05:36,930 --> 00:05:34,120
chemical rockets use various propellants

85
00:05:39,540 --> 00:05:36,940
all involved heating the propellant and

86
00:05:44,490 --> 00:05:39,550
its subsequent expansion through a

87
00:05:47,280 --> 00:05:44,500
nozzle to produce thrust chemical

88
00:05:50,220 --> 00:05:47,290

rockets using gaseous hydrogen oxygen

89
00:05:53,820 --> 00:05:50,230
have been developed for possible use on

90
00:05:56,670 --> 00:05:53,830
the space station designs ranging from

91
00:06:00,570 --> 00:05:56,680
25 to 50 pounds thrust have been built

92
00:06:02,940 --> 00:06:00,580
and life tested studies indicate that

93
00:06:05,430 --> 00:06:02,950
future launch vehicles would benefit

94
00:06:08,670 --> 00:06:05,440
from liquid hydrogen oxygen reaction

95
00:06:12,630 --> 00:06:08,680
control systems and optimal approaches

96
00:06:15,120 --> 00:06:12,640
are being defined a breakthrough in

97
00:06:19,520 --> 00:06:15,130
storable chemical propulsion technology

98
00:06:22,680 --> 00:06:19,530
has been verified with a 5-pound rocket

99
00:06:24,870 --> 00:06:22,690
100 to 200 pounds storable rockets are

100
00:06:26,970 --> 00:06:24,880
now under development which will provide

101
00:06:30,600 --> 00:06:26,980
major increases in the life and

102
00:06:34,920 --> 00:06:30,610
performance of Apogee retro and orbit

103
00:06:36,720 --> 00:06:34,930
change propulsion systems specific

104
00:06:39,840 --> 00:06:36,730
electric rockets have very different

105
00:06:42,740 --> 00:06:39,850
operating principles but all electric

106
00:06:45,870 --> 00:06:42,750
propulsion systems share many features

107
00:06:48,960 --> 00:06:45,880
energy is derived from a solar or

108
00:06:51,870 --> 00:06:48,970
nuclear power source and is converted

109
00:06:54,600 --> 00:06:51,880
into electricity and then conditioned

110
00:06:56,930 --> 00:06:54,610
for use by the electric rockets which

111
00:06:59,550 --> 00:06:56,940
use the power in various ways to

112
00:07:04,380 --> 00:06:59,560
accelerate the propellant to produce

113
00:07:07,230 --> 00:07:04,390

thrust resistojet s' the simplest

114
00:07:10,380 --> 00:07:07,240
electric rockets add energy to a

115
00:07:13,530 --> 00:07:10,390
propellant via heat transfer from an

116
00:07:17,040 --> 00:07:13,540
electrically heated resistor

117
00:07:19,530 --> 00:07:17,050
a version which uses waste gas from the

118
00:07:22,560 --> 00:07:19,540
station modules as the propellant is

119
00:07:26,910 --> 00:07:22,570
being developed for drag makeup on Space

120
00:07:29,820 --> 00:07:26,920
Station freedom in our Jets

121
00:07:32,370 --> 00:07:29,830
the propellant is heated by an electric

122
00:07:37,080 --> 00:07:32,380
arc and is then expelled through a

123
00:07:39,660 --> 00:07:37,090
nozzle arc Jets which use about one

124
00:07:42,180 --> 00:07:39,670
kilowatt of power and hydrazine

125
00:07:44,580 --> 00:07:42,190
propellant are under intense development

126
00:07:49,050 --> 00:07:44,590
for station keeping on commercial

127
00:07:52,640 --> 00:07:49,060
geosynchronous satellites electrostatic

128
00:07:55,920 --> 00:07:52,650
or ion thrusters and magneto plasma

129
00:07:59,580 --> 00:07:55,930
dynamics or MPD Rockets are being

130
00:08:04,050 --> 00:07:59,590
developed for Earth orbit and planetary

131
00:08:07,110 --> 00:08:04,060
primary propulsion functions ion Rockets

132
00:08:09,750 --> 00:08:07,120
first emit electrons from a cathode to

133
00:08:12,200 --> 00:08:09,760
create positively charged ions in a

134
00:08:14,850 --> 00:08:12,210
discharge chamber and then

135
00:08:18,480 --> 00:08:14,860
electrostatically accelerate those ions

136
00:08:19,970 --> 00:08:18,490
through two perforated plates called ion

137
00:08:22,920 --> 00:08:19,980
optics

138
00:08:26,190 --> 00:08:22,930

this is a typical discharge chamber

139
00:08:31,850 --> 00:08:26,200
along with the ion optics which contain

140
00:08:38,570 --> 00:08:34,440
this scene shows an ion thruster

141
00:08:41,730 --> 00:08:38,580
operating at approximately 10 kilowatts

142
00:08:44,970 --> 00:08:41,740
MPD Rockets produce thrust by using an

143
00:08:49,470 --> 00:08:44,980
electromagnetic field to accelerate a

144
00:08:52,770 --> 00:08:49,480
plasma direct measurements of ion and

145
00:08:56,010 --> 00:08:52,780
MPD performance and exhaust plumes are

146
00:08:58,470 --> 00:08:56,020
necessary these measurements require

147
00:09:04,320 --> 00:08:58,480
large frost stands and state-of-the-art

148
00:09:07,320 --> 00:09:04,330
plume Diagnostics ion and MPD Rockets

149
00:09:10,290 --> 00:09:07,330
both require large space simulation

150
00:09:13,260 --> 00:09:10,300
facilities with high gas pumping speeds

151
00:09:16,550 --> 00:09:13,270
in order to obtain space like vacuums

152
00:09:21,829 --> 00:09:19,460
in summary advanced low thrust

153
00:09:23,350 --> 00:09:21,839
propulsion provides benefits for many

154
00:09:26,090 --> 00:09:23,360
applications

155
00:09:28,939 --> 00:09:26,100
these range from reaction control

156
00:09:31,970 --> 00:09:28,949
systems for Earth orbit vehicles such as

157
00:09:34,579 --> 00:09:31,980
the Space Shuttle and drag make up and

158
00:09:37,759 --> 00:09:34,589
attitude control devices for large

159
00:09:41,420 --> 00:09:37,769
platforms in low-earth orbit such as

160
00:09:43,730 --> 00:09:41,430
Space Station freedom it also includes

161
00:09:46,210 --> 00:09:43,740
significantly reducing the propellant

162
00:09:48,679 --> 00:09:46,220
for Apogee propulsion and

163
00:09:53,119 --> 00:09:48,689

station-keeping propulsion for

164
00:09:55,960 --> 00:09:53,129
geosynchronous satellites and then

165
00:09:58,730 --> 00:09:55,970
advanced electric propulsion systems

166
00:10:01,819 --> 00:09:58,740
enable an order of magnitude reduction

167
00:10:04,809 --> 00:10:01,829
in the propellant required for primary

168
00:10:09,889 --> 00:10:04,819
propulsion in both earth orbital and

169
00:10:11,720 --> 00:10:09,899
planetary missions the lowest Research

170
00:10:15,429 --> 00:10:11,730
Center is conducting a low thrust

171
00:10:19,790 --> 00:10:15,439
propulsion program utilizing an in-house

172
00:10:22,970 --> 00:10:19,800
university and industrial team this

173
00:10:25,309 --> 00:10:22,980
blend of skills assures that the program

174
00:10:28,819 --> 00:10:25,319
will develop practical devices for

175
00:10:31,549 --> 00:10:28,829
near-term applications and also produce

176
00:10:35,210 --> 00:10:31,559
more advanced concepts for the