



1  
00:00:00,506 --> 00:00:29,926  
[ Music ]

2  
00:00:30,426 --> 00:00:35,346  
>> We have developed planes  
that fly at supersonic speed.

3  
00:00:36,876 --> 00:00:37,866  
We've walked on the moon,

4  
00:00:38,916 --> 00:00:43,106  
created a reusable space  
shuttle, an orbiting lab.

5  
00:00:43,826 --> 00:00:46,036  
And now we're developing  
a spacecraft

6  
00:00:46,036 --> 00:00:47,226  
to take us to Mars or beyond.

7  
00:00:48,896 --> 00:00:51,346  
NASA has had so many  
great accomplishments,

8  
00:00:52,226 --> 00:00:53,786  
but none of that would  
have been possible,

9  
00:00:54,196 --> 00:00:55,886  
nor would we reach  
our future goals

10  
00:00:56,256 --> 00:00:59,606  
without stringent ground tests.

11  
00:00:59,656 --> 00:01:02,746  
NASA Glenn Research Center has  
built many world-class ground

12

00:01:02,806 --> 00:01:05,926

test facilities at both Lewis  
Field and Plum Brook Station.

13

00:01:06,716 --> 00:01:09,406

And as the chief of the test  
facility management branch,

14

00:01:09,936 --> 00:01:13,066

my team and I are charged with  
ensuring that the facilities

15

00:01:13,266 --> 00:01:15,646

at Lewis Field are  
ready to test.

16

00:01:16,316 --> 00:01:18,896

And we advocate for ways  
to improve them to keep

17

00:01:18,986 --> 00:01:20,426

up with the demands  
of the future.

18

00:01:21,556 --> 00:01:22,906

I'll share with you  
a few examples.

19

00:01:25,786 --> 00:01:27,986

At GRC, we have three facilities

20

00:01:28,766 --> 00:01:31,056

where we test aircraft  
components,

21

00:01:32,336 --> 00:01:37,556

scaled aircraft models, as well  
as scaled space launch vehicles

22

00:01:38,176 --> 00:01:41,336

to better understand how air moves through and around them.

23

00:01:41,746 --> 00:01:44,436

They are the ten-by-ten foot super sonic wind tunnel,

24

00:01:45,716 --> 00:01:47,966

the eight-by-six foot transsonic wind tunnel,

25

00:01:48,936 --> 00:01:50,826

and the nine-by-fifteen foot low-speed wind tunnel.

26

00:01:53,086 --> 00:01:55,576

In the eight-by-six foot transsonic wind tunnel,

27

00:01:56,066 --> 00:01:59,576

we can achieve air speeds up to 1,300 miles per hour.

28

00:02:00,526 --> 00:02:04,426

And in the ten-by-ten, 2,700 miles per hour.

29

00:02:06,036 --> 00:02:10,626

In both tunnels we use large hydraulic jacks to push and pull

30

00:02:10,626 --> 00:02:14,696

on each of the tunnel walls to create the contour that's needed

31

00:02:14,696 --> 00:02:15,906

to achieve those air speeds.

32

00:02:17,326 --> 00:02:21,226

You'll see in a time

lapse video as nearly inch

33

00:02:21,226 --> 00:02:25,346

and a half thick stainless

steel walls are forced to flex

34

00:02:25,346 --> 00:02:27,156

about three feet to

meet those conditions.

35

00:02:28,966 --> 00:02:31,616

In the nine-by-fifteen foot

tunnel we achieve air speeds

36

00:02:31,686 --> 00:02:36,246

up to 175 miles per hour and

we simulate takeoff, approach,

37

00:02:36,406 --> 00:02:37,286

and landing conditions.

38

00:02:38,366 --> 00:02:41,456

And this tunnel remains

in high demand for tests

39

00:02:41,456 --> 00:02:42,436

in reducing aircraft noise.

40

00:02:43,606 --> 00:02:46,086

But as airplanes get

quieter, it's important

41

00:02:46,086 --> 00:02:47,656

that our tunnel get

quieter, too.

42

00:02:48,726 --> 00:02:51,776

So in our acoustic improvement

project scheduled for completion

43

00:02:51,776 --> 00:02:55,806

in late 2018, we are  
refurbishing multiple sections

44

00:02:55,806 --> 00:02:56,796

of the wind tunnel circuit,

45

00:02:57,566 --> 00:02:59,726

including making  
smoother walls and turns.

46

00:03:00,516 --> 00:03:15,516

[ Inaudible ]

47

00:03:16,016 --> 00:03:18,396

Above our atmosphere  
the challenges continue.

48

00:03:19,576 --> 00:03:22,046

The condition of weightlessness  
that one would experience

49

00:03:22,126 --> 00:03:26,256

in space can only be achieved  
here on Earth by being

50

00:03:26,256 --> 00:03:27,576

in a state of free fall.

51

00:03:28,386 --> 00:03:30,506

So to mimic this condition

52

00:03:30,506 --> 00:03:35,156

in the 1960's GRC built the  
world's tallest low-gravity drop

53

00:03:35,276 --> 00:03:37,916

tower, called the  
Zero-Gravity Research Facility

54

00:03:38,396 --> 00:03:39,596  
or Zero-G for short.

55

00:03:40,736 --> 00:03:44,356  
Now, Zero-G is a 28-foot  
diameter hole in the ground

56

00:03:44,806 --> 00:03:46,476  
that extends about  
500 feet deep.

57

00:03:48,016 --> 00:03:50,956  
There we load experiments  
into a drop vehicle,

58

00:03:51,946 --> 00:03:55,356  
place a cap over the  
chamber, and remove the air.

59

00:03:56,456 --> 00:03:58,016  
When the drop vehicle  
free falls,

60

00:03:58,596 --> 00:04:01,306  
the experiment inside will  
experience weightlessness

61

00:04:02,426 --> 00:04:09,916  
for one, two, three, four,  
five seconds before landing

62

00:04:09,916 --> 00:04:11,496  
in a bed of styrofoam pellets.

63

00:04:12,996 --> 00:04:16,146  
We can conduct two drops  
per day, and we average

64

00:04:16,146 --> 00:04:17,566  
about 100 drops per year.

65

00:04:18,976 --> 00:04:22,766  
But in those precious  
five seconds per drop,

66

00:04:23,816 --> 00:04:25,656  
we have conducted  
fundamental studies

67

00:04:25,656 --> 00:04:30,286  
in many areas including  
material science, fluid physics,

68

00:04:30,996 --> 00:04:33,376  
and combustion just  
to name a few.

69

00:04:36,386 --> 00:04:40,386  
Recently at GRC we  
began investigating ways

70

00:04:40,946 --> 00:04:42,516  
to extend the duration  
of weightlessness

71

00:04:43,156 --> 00:04:45,386  
within the same footprint  
of zero-G.

72

00:04:46,366 --> 00:04:49,836  
We call one concept an  
electromagnetic drop tower.

73

00:04:51,276 --> 00:04:55,086  
In this concept experiments  
are loaded into a vehicle

74

00:04:55,086 --> 00:04:58,716

at ground level, then slowly  
lowered along the rails

75

00:04:59,296 --> 00:05:03,316

of a vertical maglev train  
to the bottom of the chamber.

76

00:05:03,316 --> 00:05:07,406

And then like an amusement park  
ride, accelerated up to the top

77

00:05:07,786 --> 00:05:12,056

and back down again, effectively  
providing ten seconds

78

00:05:12,316 --> 00:05:13,606

of weightlessness.

79

00:05:14,436 --> 00:05:18,256

The additional five seconds of  
weightlessness can open the door

80

00:05:18,256 --> 00:05:22,116

to additional fields of  
study, such as plant growth,

81

00:05:23,416 --> 00:05:27,266

fire safety, and even the  
human cellular response

82

00:05:27,576 --> 00:05:28,786

to weightlessness.

83

00:05:30,896 --> 00:05:35,386

In addition to weightlessness,  
the extremely cold temperatures

84

00:05:36,046 --> 00:05:39,146

in the absence of air molecules  
are the other differences

85

00:05:39,206 --> 00:05:40,416  
between Earth and space

86

00:05:40,826 --> 00:05:43,446  
that make realistic  
ground testing essential

87

00:05:43,726 --> 00:05:46,006  
for our success.

88

00:05:46,006 --> 00:05:48,426  
At GRC we have about  
two dozen chambers

89

00:05:48,676 --> 00:05:52,946  
in which we simulate this vacuum  
of space to test everything

90

00:05:53,056 --> 00:05:56,106  
from small components to  
large spacecraft facilities.

91

00:05:57,556 --> 00:06:00,476  
When fully evacuated,  
the environment inside

92

00:06:00,476 --> 00:06:03,326  
of these metal containers  
is very similar

93

00:06:03,326 --> 00:06:04,926  
to that of low-earth orbit.

94

00:06:06,706 --> 00:06:09,866  
The primary use for most of  
our chambers at Lewis Field is

95

00:06:09,936 --> 00:06:12,016

to test electric  
propulsion devices.

96

00:06:12,316 --> 00:06:16,126

Now, these devices are  
also own as ion engines

97

00:06:16,126 --> 00:06:19,096

or thrusters are  
highly efficient engines

98

00:06:19,866 --> 00:06:21,176

that can use gas  
as a propellant,

99

00:06:22,156 --> 00:06:23,796

but they only operate in space.

100

00:06:26,246 --> 00:06:28,826

At GRC we actually developed  
the first ion engine.

101

00:06:29,466 --> 00:06:31,806

It was actually Dr.  
Harold Kaufman

102

00:06:32,616 --> 00:06:35,906

who developed this engine  
here in our largest facilities

103

00:06:36,016 --> 00:06:40,186

at Lewis Field back in  
Facility Five and Six were made

104

00:06:40,186 --> 00:06:42,946

in the 1960's to  
support the development

105

00:06:43,146 --> 00:06:44,486  
of ion engine technology.

106

00:06:46,516 --> 00:06:48,656  
Now, Vacuum Facility Five or VF5

107

00:06:48,656 --> 00:06:53,236  
as we call it is a workhorse  
facility for electric propulsion

108

00:06:53,686 --> 00:06:55,216  
because of its unique ability

109

00:06:55,636 --> 00:06:58,866  
to maintain a highly  
pure vacuum even when gas

110

00:06:58,966 --> 00:07:01,176  
from a thruster is being  
added to the chamber.

111

00:07:01,176 --> 00:07:05,796  
The rate at which we  
evacuate air or gas

112

00:07:05,896 --> 00:07:08,206  
from a chamber is what we  
call the pumping speed.

113

00:07:09,316 --> 00:07:13,046  
And VF5 has the highest  
theoretical pumping speed

114

00:07:13,046 --> 00:07:18,396  
in the world at 3.5  
million liters per second.

115

00:07:18,576 --> 00:07:22,966  
At 3.5 million liters per  
second, you could evacuate all

116

00:07:22,966 --> 00:07:25,216  
of the air out of  
Cleveland's Terminal Tower

117

00:07:25,566 --> 00:07:28,186  
in less than one minute.

118

00:07:29,476 --> 00:07:32,576  
Vacuum Facility Six is our  
largest chamber at Lewis Field

119

00:07:32,576 --> 00:07:35,646  
and it's equipped with an  
interior shroud that can get

120

00:07:35,646 --> 00:07:38,406  
down to negative 330  
degrees Fahrenheit

121

00:07:38,986 --> 00:07:40,886  
to simulate the cold  
environment in space.

122

00:07:41,916 --> 00:07:44,326  
Now, with the installation  
of the interior shroud,

123

00:07:44,326 --> 00:07:47,036  
VF6 has been the go-to facility

124

00:07:47,366 --> 00:07:49,396  
for clean-power testing  
for many years.

125

00:07:50,666 --> 00:07:54,976  
But in 2016, as we  
began to use VF6 again

126

00:07:54,976 --> 00:08:00,246  
for electric propulsion testing,  
we covered the interior shroud

127  
00:08:00,246 --> 00:08:03,076  
with thin carbon sheeting  
in order to protect it

128  
00:08:03,076 --> 00:08:04,316  
from the thruster's exhaust.

129  
00:08:05,076 --> 00:08:08,966  
And since that time we have once  
again successfully conducted

130  
00:08:08,966 --> 00:08:10,226  
electric propulsion testing.

131  
00:08:11,836 --> 00:08:17,116  
Now we are investigating ways  
to improve the pumping capacity

132  
00:08:17,116 --> 00:08:20,976  
of VF6 to be equivalent to  
or even surpass that of VF5

133  
00:08:21,836 --> 00:08:23,896  
so that we may test  
higher power,

134  
00:08:23,996 --> 00:08:25,456  
higher thrust engines there.

135  
00:08:25,876 --> 00:08:29,066  
Because these are the types  
of engines that we'll need

136  
00:08:29,626 --> 00:08:32,976  
to power our spacecraft for our  
missions to Mars and beyond.

137

00:08:35,446 --> 00:08:38,346

Improvements and  
sustained investments

138

00:08:38,516 --> 00:08:40,226

in our facilities  
have allowed GRC

139

00:08:40,746 --> 00:08:43,796

to offer unique testing  
environments to NASA,

140

00:08:43,946 --> 00:08:47,376

other government  
agencies, academia,

141

00:08:47,886 --> 00:08:49,416

as well as our industry  
partners.

142

00:08:51,116 --> 00:08:54,916

As NASA continues to push the  
boundaries of space exploration

143

00:08:55,546 --> 00:08:58,166

and the envelope of  
aeronautic advancements,

144

00:08:59,416 --> 00:09:03,336

GRC will be on the forefront  
of specialized testing

145

00:09:03,336 --> 00:09:07,336

and technology development by  
conducting amazing research

146

00:09:07,716 --> 00:09:11,106

in amazing facilities  
for the benefit of all.

