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1  
00:00:00,867 --> 00:00:06,038  
[ Music ]

2  
00:00:06,038 --> 00:00:09,776  
>> The single word I would use

3  
00:00:09,776 --> 00:00:11,310  
to characterize FOSS  
is revolutionary.

4  
00:00:11,310 --> 00:00:14,481  
If it can be used and utilized  
and implemented effectively,

5  
00:00:14,481 --> 00:00:17,750  
I believe it can really  
revolutionize the way we do our

6  
00:00:17,750 --> 00:00:20,486  
business in aerospace.

7  
00:00:20,486 --> 00:00:22,755  
>>Gamechanger. Fiber optics is  
a gamechanger

8  
00:00:22,755 --> 00:00:26,725  
because we can lay a line of  
fiber in any orientation

9  
00:00:26,725 --> 00:00:29,028  
on that structure and we  
can get a continuous measurement

10  
00:00:29,028 --> 00:00:30,729  
of strain.

11  
00:00:30,729 --> 00:00:34,133  
>> It's a gamechanger because  
it gives designers real time

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00:00:34,133 --> 00:00:36,102

information which they never had before.

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00:00:36,102 --> 00:00:39,004

[clacking]

14

00:00:39,004 --> 00:00:42,541

>> These are all individual fiber optic sensors on the wing,

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00:00:42,541 --> 00:00:45,811

and then these are the individual strain values.

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00:00:45,811 --> 00:00:48,414

>> We have deeper insight into how a structure performs,

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00:00:48,414 --> 00:00:51,851

not only in operation but all the way through its life cycle

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00:00:51,851 --> 00:00:53,886

from the development of the structure;

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00:00:53,886 --> 00:00:55,955

as you get it ground tested, as you transition

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00:00:55,955 --> 00:00:58,424

into a flight environment, as you get to the end

21

00:00:58,424 --> 00:00:59,926

of a life cycle when you're trying

22

00:00:59,926 --> 00:01:02,028

to determine how much  
life is really remaining

23

00:01:02,028 --> 00:01:03,529

in the structure?

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00:01:03,529 --> 00:01:05,698

FOSS can save time on your  
schedule for installing sensors,

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00:01:05,698 --> 00:01:08,701

it can give you greater insight  
and much more spacial fidelity

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00:01:08,701 --> 00:01:11,471

in your measurement  
system than ever before.

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00:01:11,471 --> 00:01:14,573

>> We have given the designers  
a new tool within their toolbox

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00:01:14,573 --> 00:01:16,910

to use to validate their models.

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00:01:17,910 --> 00:01:19,145

>> The state of the  
art technology

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00:01:19,145 --> 00:01:22,348

in fiber optic sensing is  
something we've been advancing

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00:01:22,348 --> 00:01:24,884

in order to be able to  
allow a wing in flight

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00:01:24,884 --> 00:01:27,687

to maintain the optimal configuration

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00:01:27,687 --> 00:01:30,590

and the first step towards wing shape control is knowing what

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00:01:30,590 --> 00:01:33,893

the position or the displacement or deformations of that wing is

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00:01:33,893 --> 00:01:36,729

as they traverse through the air and they're subjected

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00:01:36,729 --> 00:01:40,833

to wind gusts and atmospheric turbulence and things like that.

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00:01:40,833 --> 00:01:43,535

The genesis of FOSS came about as a result of working

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00:01:43,535 --> 00:01:45,538

with conventional technology.

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00:01:45,538 --> 00:01:47,240

What I mean by that is strain gauge technology

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00:01:47,240 --> 00:01:49,108

in particular, and thermal couples.

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00:01:49,108 --> 00:01:50,876

Strain gauges measure strain

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00:01:50,876 --> 00:01:52,378

and thermal couples measure temperature.

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00:01:52,378 --> 00:01:54,113

>> This is the conventional way

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00:01:54,113 --> 00:01:57,616

of doing health monitoring  
for structures.

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00:01:57,616 --> 00:02:01,020

Each one of these connectors  
is the termination for each one

46

00:02:01,020 --> 00:02:05,257

of these gold packages that you  
see mounted on this panel.

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00:02:05,257 --> 00:02:10,063

And each of these gold packages,

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00:02:10,063 --> 00:02:11,464

these conventional  
strain gauges,

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00:02:11,464 --> 00:02:14,200

have with them the  
associated wires that have

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00:02:14,200 --> 00:02:17,202

to be soldered on,  
has to be prepared,

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00:02:17,202 --> 00:02:20,439

they have to be terminated using  
various types of connectors.

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00:02:20,439 --> 00:02:22,441

There's a lot of work involved

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00:02:22,441 --> 00:02:26,112

in installing these  
conventional strain gauges

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00:02:26,112 --> 00:02:27,713  
and with the strain gauges,

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00:02:27,713 --> 00:02:29,982  
they are only making  
point measurements.

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00:02:29,982 --> 00:02:32,885  
So wherever you see a gold  
package, we are making

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00:02:32,885 --> 00:02:35,388  
that strain measurement  
at that one location.

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00:02:35,388 --> 00:02:39,124  
>> Imagine having your  
arm have one measurement

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00:02:39,124 --> 00:02:40,292  
and you wouldn't be able to  
feel anything else around it,

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00:02:40,292 --> 00:02:42,161  
it's kind of limiting.

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00:02:42,161 --> 00:02:44,597  
Same thing structurally, you  
don't have a lot of insight

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00:02:44,597 --> 00:02:46,499  
into what's going  
on in the structure

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00:02:46,499 --> 00:02:48,500  
if you have a sensor  
every several feet.

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00:02:48,500 --> 00:02:50,169

The FOSS technology allows you

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00:02:50,169 --> 00:02:52,805

to have a sensor every quarter  
inch along the single optical

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00:02:52,805 --> 00:02:55,708

fiber; that allows you  
to look more and more

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00:02:55,708 --> 00:02:57,142

like a biological system.

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00:02:57,142 --> 00:03:01,146

>>Very light weight, much easier  
to install, less complexity,

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00:03:01,146 --> 00:03:05,752

21 strain measurements, 1400,

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00:03:05,752 --> 00:03:11,657

one thousand four hundred strain  
measurements on a single fiber.

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00:03:11,657 --> 00:03:15,862

For practical purposes, you  
can put as many of these fibers

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00:03:15,862 --> 00:03:18,964

on your vehicle as you want to  
or on your structure as you want

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00:03:18,964 --> 00:03:21,367

without sacrificing the  
weight requirements.

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00:03:21,367 --> 00:03:25,805

>> Instead of using current  
and voltage and resistance

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00:03:25,805 --> 00:03:28,575  
of that electrical  
resistant strain gauge,

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00:03:28,575 --> 00:03:30,643  
now we're shining a light  
down this optical fiber.

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00:03:30,643 --> 00:03:33,479  
>> And as that light  
propagates down the fiber,

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00:03:33,479 --> 00:03:39,418  
it comes in contact with  
what we call Bragg gratings.

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00:03:39,418 --> 00:03:44,691  
And these Bragg gratings are  
like translucent mirrors that

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00:03:44,691 --> 00:03:46,726  
reflect at very unique  
wavelengths.

81

00:03:46,726 --> 00:03:48,027  
These unique wavelengths

82

00:03:48,027 --> 00:03:52,731  
that are reflected are  
actually sampled and measured.

83

00:03:52,731 --> 00:03:56,669  
>> Those changes in wavelength  
are what we calibrate

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00:03:56,669 --> 00:03:59,105  
to engineering parameters.

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00:03:59,105 --> 00:04:00,305

>> One of the powerful aspects of FOSS is

86

00:04:00,305 --> 00:04:03,109

that it's not only the number of measurands

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00:04:03,109 --> 00:04:06,913

that you can monitor, a measurand being strain or

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00:04:06,913 --> 00:04:08,848

temperature, basic engineering parameters

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00:04:08,848 --> 00:04:11,584

that we use quantify a structure's performance.

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00:04:11,584 --> 00:04:14,553

It could also measure liquid level, magnetic field,

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00:04:14,553 --> 00:04:16,088

three dimensional shape.

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00:04:16,088 --> 00:04:17,756

>> As I apply pressure on this test article,

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00:04:17,756 --> 00:04:19,658

we can see how the shape is changing,

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00:04:19,658 --> 00:04:20,792

as well as the intensity

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00:04:20,792 --> 00:04:22,695  
of the strain being felt  
by the test article.

96  
00:04:22,695 --> 00:04:24,430  
What we have here  
is the demonstration

97  
00:04:24,430 --> 00:04:26,432  
of the liquid level  
sensing technology.

98  
00:04:26,432 --> 00:04:28,834  
What we're able to do is  
use the fiber optic sensors

99  
00:04:28,834 --> 00:04:33,206  
to monitor the different  
absorption rates of the liquid

100  
00:04:33,206 --> 00:04:35,674  
and the air to determine  
where is the boundary

101  
00:04:35,674 --> 00:04:37,376  
between liquid and air.

102  
00:04:37,376 --> 00:04:39,211  
Here we have a demonstration

103  
00:04:39,211 --> 00:04:41,581  
of our hybrid fiber  
optic system.

104  
00:04:41,581 --> 00:04:45,584  
With this, we're able to get our  
quarter inch spatial resolution,

105  
00:04:45,584 --> 00:04:49,388  
at up to 100 samples a

second and at strategic places,

106

00:04:49,388 --> 00:04:52,258

we can place a strong  
grating that we call it,

107

00:04:52,258 --> 00:04:55,327

allows us to acquire  
strain measurements

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00:04:55,327 --> 00:04:58,063

at up to 5 kilohertz.

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00:04:58,063 --> 00:05:00,365

>> I think commercial  
applications are really endless

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00:05:00,365 --> 00:05:06,739

and the more that we explore  
interest in different realms,

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00:05:06,739 --> 00:05:10,542

we understand that there's  
really a role for FOSS in ways

112

00:05:10,542 --> 00:05:14,013

that we never imagined  
to begin with.

113

00:05:14,013 --> 00:05:15,914

>> In 20 years, the hope  
is that we would see this

114

00:05:15,914 --> 00:05:18,250

on commercial aircraft;  
we would see it

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00:05:18,250 --> 00:05:19,952

on expendable launch vehicles,

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00:05:19,952 --> 00:05:22,655  
as health management systems  
for ELVs.

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00:05:22,655 --> 00:05:26,459  
Another big area is oil and gas;  
monitoring the drill head on a

118

00:05:26,459 --> 00:05:30,263  
down-hole rig, being  
able to look

119

00:05:30,263 --> 00:05:33,466  
at what the status is  
on the holding tanks.

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00:05:33,466 --> 00:05:36,435  
>> Liquid level inside of  
tank, in cryogenic propellants

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00:05:36,435 --> 00:05:38,203  
or in any kind of  
fluid through pipes.

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00:05:38,203 --> 00:05:40,539  
>> The list just goes on and on.

123

00:05:40,539 --> 00:05:46,312  
[ Music ]

124

00:06:07,033 --> 00:06:08,700  
>> I think what excites me most

125

00:06:08,700 --> 00:06:12,204  
about FOSS is seeing the  
light go on in people's eyes,

126

00:06:12,204 --> 00:06:15,074  
the lightbulb actually shows up

above people's heads

127

00:06:15,074 --> 00:06:17,477

when you start to  
describe, for the first time,

128

00:06:17,477 --> 00:06:19,979

the capability of  
the technology.

129

00:06:19,979 --> 00:06:22,347

This could really change  
the way they do business.

130

00:06:22,347 --> 00:06:24,216

This could save a lot of time

131

00:06:24,216 --> 00:06:25,851

on their schedule because now  
they only have one system

132

00:06:25,851 --> 00:06:27,553

that can perform all  
these measurements.

133

00:06:27,553 --> 00:06:33,125

So for me, seeing that epiphany,  
seeing that actually develop

134

00:06:33,125 --> 00:06:34,961

and seeing the application  
potential, I think,

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00:06:34,961 --> 00:06:36,962

has really been rewarding.

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00:06:36,962 --> 00:06:38,965

You know, it does go almost  
anywhere into various places

137

00:06:38,965 --> 00:06:40,699

where you're monitoring  
structure,

138

00:06:40,699 --> 00:06:42,435

structural response so to see