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Teleprompter Script for Dr. Owen Brown, Program Manager, Virtual Space Office

<u>Access Infrastructure</u>

» **OWEN BROWN:**
A simple beep...

The surprise came from just a simple beep.

America's singular enemy had beaten us to space with what seems today to be an innocuous 84 kg sphere of aluminum,
but, more ominously -
the Soviets had shown the R-7 missile that orbited the first man-made satellite could also lob a nuclear weapon onto an American city.

Sputnik was the catalyst that motivated the first American generation of steely eyed missile men
to respond in kind.

They answered back quickly, with a secret surprise of their own.

It was an
ARPA sponsored reconnaissance satellite program called Corona – an eye in the sky that kept track of the Soviet's arsenal of nuclear tipped missiles.

So here we are,
50 years later, in a world that is very different from the days of

Eisenhower and Khrushchev.

At the time of Sputnik and the many decades
which followed,
the enemy was just on
the other side of a wall.

Today, we can not predict with certainty just who the enemy will be, or where he will be globally scattered on or above the earth when he shows up to fight.

The early years of the space age coexisted with the age of industry,
a time when the rate of technology’s linear progress could be estimated in time periods of 2, and even 5 years.

Now, in a post information age, technical progress is non-linear and is subject to forces of disruption.

We can not forecast what the next generation MP3 player may look like come the holiday season, let alone what revolutionary new technology may be universally available two to five years from now.

Five decades after our first entry into the heavens, our space systems have changed a great deal.

The spacecraft and the rockets that launch them are much larger;
the satellites carry more capability, and last longer – in some cases,
10 to 20 years.

This design philosophy has led to many unintended consequences, among them complexity.

Complexity has led to space system design and production cycles that now take 5 to 10 years.

This adds yet more cost to an already costly system.

Complexity has bred fragility.

And by fragility –
I mean the appearance of unanticipated modes of failure.

With multiple payloads,
it takes a problem with just one of them during the build phase to delay and add cost to an already lengthy program.

Once built, the failure of a $100 part, or a bad line of software code –
whether that problem occurs on the rocket or
in the spacecraft --
can sink a mission costing potentially billions of dollars.

Our response to failure had been to build in
a lot of margin and redundancy, and test our satellites with extreme rigor on the ground.

Yet, all of that margin,
all of that testing, still has not prevented what a materials scientist would call "brittle fracture",
as a fragile system breaks rapidly and catastrophically before yielding under pressure.

So –
50 years after Sputnik, here are the challenges.

First, Uncertain threats.

The implication:
our spacecraft may not be at the right place at the right time to see one, or they may be in the wrong place at the wrong time to avoid one.

Second, Uncertain technological change.

Really,
the change is certain – it is the products of change that are unpredictable.

The result:
Our spacecraft, which take 5 to 10 years to build, and then last up to 20 in a static hardware condition, will be configured to solve tomorrow's problems using yesterday's technologies.

Third, uncertain success.

Because of the complexity of our space systems, failures will continue to occur...
on the ground –
during launch –
and in space.

The failures are brittle ones.

The cost -- both in time lost and money spent --
is extreme.

The underlying theme of these problems is quite simply this:

We face an uncertain future.

Oddly enough though,

it is uncertainty which makes it perfectly clear where we must go and what we must do to be ready.

We must create a new space architecture –
a spacecraft architecture radically different from the one that has evolved since the late 1950’s.

It is a space architecture based on preparedness, not reaction.

It must be an architecture that uses as its design tenet a quality that acts as the best prescription for an uncertain future.

That quality is flexibility.

Flexibility and the technology that enables it is the cornerstone of DARPA’s vision for a new space architecture.

Let me define Flexibility.

Flexibility is the result of being able to change or modify a system –
not just software –
but hardware too -- at any time in the life cycle.

So when a new threat emerges, we must have the flexibility to maneuver or adapt our space systems to address it.

When new technology becomes available,
we must have the flexibility to insert it, test it, and use it in a year or two,
not at the end of the next decade long design cycle.

When a $100 part fails, we must have the flexibility to rapidly replace the part – or at least a small portion of the system containing the part,
not the entire spacecraft.

This is all great talk –
so, what’s DARPA’s plan?

Well, with the incredibly successful Orbital Express program,
we have just proven that if it’s best for a spacecraft to maneuver with a limited supply of propellant,
go ahead and do so:

We have the flexibility to refuel it later.

If we need to replace a broken part,
or add a better one,
we can do that too.

Yes, flexibility provided by robotic servicing is indeed technically possible.

But, DARPA is just gettin’ warmed up: in fact,
one of our newest ideas could change the game.

It is called F6.

With F6 we intend to demonstrate that we can decompose a large monolithic spacecraft into a group of wirelessly linked elements, or nodes.

Each node executes a specific spacecraft function.

One node for example might be a computing node.

Another, a payload node – like say a transponder,
or an intelligence sensor.

These nodes -
operating together - create a single "virtual" spacecraft.

F6 offers great flexibility.

Let’s say for example,
you wish to upgrade a spacecraft with a new, faster computer.

The solution is to fly a new module that performs "just" that computing function into the cluster.

The virtual spacecraft will then seamlessly integrate this new capability into the network.

By decoupling –
or, fractionating -- various parts of the spacecraft,
we can reduce fragility, and implement new flexible design and acquisition paradigms.

For instance, we can physically isolate payloads from the rest of the system.

This addresses two major issues plaguing our current generation of large multi-payload space systems.

If a payload is late in arriving, we have the flexibility to launch it when it is ready on its own module.

Fractionation also alleviates the systems engineering nightmare that results from having multiple,
structurally coupled, sensing payloads.

Fractionation now means that you can have a large space system built from small satellites.

I am not saying we can get rid of large systems.

What I am proposing is that fractionation allows us to use a collection of small satellites to make large virtual spacecraft – maybe even spacecraft that are bigger than the monoliths of today.

Using this approach, satellites in the small, micro, nano, pico, and even femto scales can be taken out of the boutique, and become part of the mainstream.

As the foundation of a new architecture,
small satellites could eventually play a primary role across the full spectrum of planning – tactical to strategic, theaters – local to global – orbits - LEO to GEO,
and mission timescales – hours and days to undefined ends.

This move,
from the large and costly, back to the small,
and more affordable,
in many ways,
returns us to the past.

Recall Corona.

On February 28, 1959,
the first Corona satellite test launch was made.

Thereafter, attempts to successfully collect images with one of these small spacecraft continued,
but so did the failures.

Launch 13 succeeded
as a test.

Finally, on the 14th try, launched on August 18th, 1960, only 18 months after the first attempt, photos were finally retrieved.

Nearly a dozen successive failures.

14 launches in 18 months.

How did we do it:
how was it that we did not break under stress?

It has been proposed that the lack of email and Power Point had something to do with it.

Certainly, the national security imperative was really "why" we did it – but "how" that is the question:

I say "how" we were able to keep going and rebound quickly during the storm of failure – under the cloud of uncertainty –had a lot to do with the relatively small size of the spacecraft and the associated low cost of failure.

There is a saying in the space community.

It goes “one strike and you’re out”.

I don’t accept that slogan as our predestined fate.

This is not to say we stop doing the right things that ensure quality.

It is not saying we need to stop building large systems and accept reduced capability.

It is saying we need to move the operating point on the risk curve back to where it was decades ago so that we can stop the hand wringing.

F6 can return us to the old risk paradigm,
in which the failure of one launch or of one component does not result in brittle fracture.

And, oh by the way,
this resistance to brittle fracture holds true whether the induced stress comes from a bad part breaking or an adversary attacking.

This concept of operations implies we won't use a large launch vehicle full of F6 modules to orbit a system.

It means we can rely on smaller launch vehicles to place into orbit small satellites that will create large systems.

Smaller launch vehicles provide decision makers with options.

Their absolute cost – which DARPA is working to drive down in its FALCON program –
can potentially ease the decision cycle when it comes time to use them in the rapid and flexible manner they are envisioned.

Now I know,
the conventional wisdom is that small vehicles are not as cost effective as larger ones –
that is, the cost per lb curve begins to climb steeply as you go down in rocket size.

But, I think cost per lb
is a flawed metric as we get into the small launch vehicle domain.

The real metric of importance is cost – period.

Let me give you an example:

If you mail a single letter overnight via the postal service, you don't fret that you are paying around $1,600 per pound for that speedy delivery.

You're only concerned about the absolute cost of about $16.00.

That's almost 40 times regular postage by the way, but consumers attribute value to timeliness.

So it should be with a launch.

Reducing launch costs in absolute dollar amounts will change our operational mindset regarding flexible space systems.

Imagine how our test and development strategy for space would change if,
for example,
we could launch a 20 kg satellite for less than one million dollars.

Changing the nation's space architecture sounds hard.

But, after several years at DARPA, to quote
Werner Von Braun,
"I have learned to use the word impossible
with the greatest caution".

The F6 demonstration will, I believe, not only become a reality in space, but act as a new beginning for our next 50 years in orbit.

Instantaneous world-wide sensing, a global payload support infrastructure in orbit – these could be some of the next ideas generated by fractionation.

New digital technologies, combined with fractionation, could lead to F6 clusters that act like transformers in space – that is, spacecraft systems that can adapt into anything at anytime - a navigation satellite,
a communications satellite for any band, or a remote sensing spacecraft.

Now that is flexibility.

It was a simple beep
fifty years ago.

The next surprise, whether it comes from land, sea, the cyber-world, or space will not be as simple.

If from above, it could be a Space Pearl Harbor, executed by a conventional military force.

Just as likely though,
is a Space 9-11, where the enemy appears from the shadows,
using advanced and commercially available technologies in an evil yet innovative manner.

But; regardless,
we should spend less time predicting, and more time preparing.

We don’t want to be surprised by a beep from above, or even more simply a broken part from within.

Creating flexibility with technology is the key.

It is a flexible space architecture that will mitigate the risk of the unknown, as well provide us with the opportunity to seize the initiative and
use surprise in our favor.

Now, to address how we reduce the uncertainty of knowing what is orbiting above us, is my shipmate and fellow Program Manager, Roger Hall.

Thank you.