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Teleprompter Script for Dr. Douglas Kirkpatrick, Program Manager, Strategic Technology Office – The Warfighter Presentations

Energy as a Tactical Asset

»**Douglas Kirkpatrick:**
Throughout history, energy has been the limiting factor in all military operations, whether it was Roman armies foraging for supplies…

…or General George S. Patton running out of fuel as he dashed across France…

…or the long military buildup in Desert Storm.

The situation today is little different.

Most of the convoys on the road in Iraq are delivering fuel and batteries.

These are arguably our most exposed targets, and the toll in lives and material is huge.

We're tied down in an endless web of logistics.

70% of our strategic logistics lift requirement is in bulk fluids, primarily fuel.

Ammunition, by contrast, is only 20%.

Batteries take up 15-20% of a soldier's load.

Special Forces troops, whose effectiveness depends on agility,
speed and stealth,
are weighted down by
re-supply needs –
much of it energy.

A typical SOF team member deploys with 27 pounds of batteries in his gear, and re-supply often drives the fundamental limit of mission duration.

Re-supply can be the single greatest signature alerting the enemy to their presence.

Given present technology, these conditions are only going to get worse.

Power demands are increasing dramatically, with ubiquitous communication and sensor systems reaching down to the individual soldier.

At DARPA, we see a situation like this and we ask ourselves:
What if we could liberate the war fighter from the endless energy logistics train?

You've heard MTO focus on making Microsystems that use less power.

But we're not just talking about doing more with less, or about simply extending battery life or fuel efficiency, though all that may be part of it.

We're talking complete self-sufficiency.

The ability to satisfy our energy needs *in situ*.

That's our end-state vision.

That's where we want to go.

For decades, science fiction has simply assumed this vision.

Have you ever noticed that the Starship Enterprise never stopped to refuel?

The Enterprise traveled to warp speed on di-lithium crystals, which enabled it to fly several parsecs per picogram.

That was science fiction, of course.

But what about Michael J. Fox's time-traveling DeLorean in
"Back to the Future"?

That took energy right from the surrounding environment –
first lightening striking the clock tower, and then banana peels and other organic garbage.

That's not just science fiction any more.

We need to achieve "tactical energy independence" for <u>all</u> our deployed military forces at <u>every</u> level –
from unattended sensors to small units to large military facilities.

Clearly, the energy needs at each level will be very different, and each will need a different mix of technologies to satisfy those needs.

So what are our goals?

<u>We need infinite sustainability</u>,
the ability to draw all our energy needs from the environment around us.

We need zero logistics demands –
or short of that,
a significant reduction in logistics re-supply exposure.

And we need to do it all with a vastly
reduced signature and reduced footprint.

We know this end-state vision is doable because of the progress we're already making at DARPA in solar cells and bio-fuel.

As you know,
the efficiency of current commercial solar cells is around 16%.

As of two months ago, the world record was 40.7%

Recently,
DARPA announced a breakthrough world record performance of 42.8%.

Our goal is to bring that well over 50% in the next two years.

And that includes technology that can manufacture solar cells at the same rate as newspapers are printed – a square meter per second, ten times the current world production rate.

In bio-fuels, we plan to demonstrate the ability to produce affordable JP-8 jet fuel from vegetable oils some 15 months from now – "affordable" meaning less than $3 per gallon.

We're looking at as much as 90% efficiency converting the raw energy in the oil to JP8 and other co-products.

Beyond that we're shooting at an even bigger target –

affordable fuel from algal or cellulosic feedstock.

These options offer tremendous flexibility – but the challenge of
30-50% conversion from cellulosic material,
for example,
IS NOT TRIVIAL.

DARPA's thrust in fuel cells has provided
"proof-of-concept" for portable generators that have as much as ten times greater specific energy than current batteries.

Right now these generators are converting hydrocarbon fuels to electric power,
but each fuel cell requires a specific type of fuel.

Our goal is fuel cells that are feed-stock flexible -- so that our soldiers can generate the power they need with whatever they have on hand at that moment.

As I say, this is all doable.

But there are very real barriers to achieving our vision.

Those barriers aren't
all in the chemistry,
the materials,
or the physics.

Many are in our own minds.

We need new people with new ideas and the intellectual fertility that comes with cross disciplinary approaches.

We need a whole new shift in paradigms, because
<u>incremental</u> advances aren't going to get us where we need to go.
So let me suggest a few ideas that I believe will help us achieve energy independence.

Basically, we're talking one of several different sources.

The first is wind.

You need a minimum speed of three - five miles
per hour and –
for mobile forces --
scaling is critical.

For special ops,
the overall package will need to be reduced to the size of a breadbox.

We may also want to consider micro- hydropower from mountain streams.

Another source is
geo-thermal energy, exploiting the temperature gradient between the surface of the ground and sub-surface.

This will probably only supply small amounts of energy – though it might be enough for small unattended sensors that could store up energy for a brief radio burst communication.

Clearly the most promising are solar cells and organic matter, including algae and
plant matter.

We're looking for ways to apply these regenerative technologies at five

distinct levels of military activity:

* Zero Presence Unattended Sensors.

* Small unit operations, such as Special Forces teams.

* Medium, or battalion-sized, formations.

* Small facilities,
such as a camp.

* And large facilities,
such as airbases.

Let’s take each in turn.

For unattended sensors, solar cells and geothermal energy would seem to be the most relevant technologies.

Batteries will probably be necessary,
to store energy when no power source is available, but they won’t be sufficient.

Supplying batteries generates a signature, creates a logistics train and puts soldiers at risk.

So what batteries there are should be rechargeable, automatically,
by drawing on available energy resources *in situ*.

For small team and special ops, the number one concern is getting re-supplied.

We want to get to the point where the time a SOF team can stay

deployed is not driven by energy requirements.

Solar panels, too, need to be portable, deployable, and constructed in such a way as to minimize signature.

Fuel cells and bio-fuel converters should be small and portable, possibly the size of a small filing cabinet.

Feed stock flexibility is critical, because our forces are going to be deploying at short notice to different geographies in different seasons.

If bananas aren't in season, they should be able to use other cellulosic material.

The ultimate test is:
does this technology free our Small Units teams from the re-supply chain, enhance their freedom of movement and mitigate risk?

For small and large facilities we can include algae as well.

An algae bio-reactor,
with CO2 and sunlight, can be self-sustaining, and an open pond can produce six to eight harvests for every one
in the field.

It's even possible that an algae farm could be made portable and therefore applicable to Special Forces as well.

For medium-scale, "battalion" applications, the metric of affordability is the current cost of about $10 per gallon for truck-delivered fuel.

For smaller,
more remote applications, what's "affordable" should be compared to

the current cost of $400 to $600 for re-supply by air.

In all these cases,
we need to think in terms of “systems of systems” that are flexible and adaptable to circumstances, combinations that compensate for each other’s strengths and weakness.

Sometimes the sun won’t shine.

Sometimes there’s a drought and crops don’t grow.

We need equipment that will work anywhere,
any time.

If we do go in with batteries, maybe we take two solar rechargeable batteries and one fuel cell – whatever works.

We don’t want to predetermine the outcome.

DARPA was founded in order to provide a strategic response to the challenge posed by the Soviet launch of Sputnik in the 1950s.

Strategic implications are our business.

Our focus today is on “tactical energy independence,”
but the strategic implications of these technologies are hard to miss.

Writ large, these new technologies would transform the geopolitical environment into one in which energy was completely removed as a source of conflict.

When we announced that our solar cell efficiency goal was 50%, many said we were wasting prime research talent on an impossible task.

Well, no one thinks so any longer.

We’re here today, because we refuse to set the bar too low –
with the consensus version of what can and can’t be done.

With your help,
we want to completely redefine what is possible -- by achieving what
everyone says is the impossible.

Thank you.

To wrap up STO's Warfighter Support presentation,
I'd like to welcome to the stage... Dr. Larry Stotts.