Introduction to the Tactical Technology Office

Remarks Made to the 2004 DARPATech Conference

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I'd like you to imagine the battlefield of the future.

Unmanned combat aircraft dominate the skies above the theater. A swarm of unmanned ground vehicles prowls the forests and fields of our enemies. These vehicles have sensors that can see, hear, and maybe even smell.

High above the theater, peering down from space, are spacecraft that are being refueled on-orbit. Their on-board electronics and software are also being upgraded and replaced as easily as sliding a PCMCIA card in-and-out of a laptop.

A helicopter glides over the battlefield and drops a box of missiles. This box is identical to dozens of missile boxes that are already in place on the battlefield, many sitting in the rear compartments of Humvees. These boxes of missiles are very different, though. They aren't attended by human operators, and they already know where they are – each has GPS and a COMM link. They sit, poised, waiting for command signals.

A corporal out in the field sees the enemy coming over the hill. He radios, "I need fire support NOW!" The box just dropped by the helo knows where the corporal is and it knows where the bad guys are. It launches its first flight of missiles. Some are loitering missiles that fly a little slower. They are launched first. They go up and post a high-watch over the battlefield. Next, faster, precision attack missiles are launched and detonate on their targets, and we have lots of smoking holes…but we missed one or two. One of the missiles loitering overhead surveys the scene, detects a surviving moving target, and says, "You missed one; I can take him." On command, he dives in and takes out his target. The battle is over.

The enemy never even knew the corporal was there! But now you have a lot of smoking holes where the bad guys used to be.

Good morning. I'm Gary Graham, Deputy Director of DARPA's Tactical Technology Office, TTO. I'm standing in for TTO's Director, Dr. Art Morrish, who is unable to be here today. He sends his regards to you all.

You know, being an Office Director is the *second* best job at DARPA. The *best* job is being a DARPA program manager, and I just showed you some of the cool battlefield technologies that the program managers in TTO are developing *right now*. And, of course, we couldn't have tackled these problems without the help of our innovative industrial colleagues.

I'm not going to say much more about what you just saw in the video, because you can see and hear about them at our booth. You see, what I just showed you are examples of things we think we have a pretty good handle on!

This morning I want to describe some really hard problems that are showing up on TTO's radar screen today. These are the challenges that are just now coming down the pike…areas where our program managers need your help.

In TTO, we are interested in a very broad range of topics. We try to "bin" our ideas and activities roughly into four areas:

Space Systems: We're looking at technologies to implement low-cost, rapid access to space. We want turnarounds measured in days, not months. And we're developing on-orbit servicing of our satellites: to refuel and replace items such as electronics while the bird is on orbit. We want our spacecraft to keep up with Moore's Law through continual upgrades.

We are also active in Space Situational Awareness, Space Mission Protection, and Force Application.

I'm not going to spend much time talking about TTO's space activities right now. I will be back up here this afternoon to kick off the Virtual Space Office presentations, where you will hear all about DARPA's space activities.

Unmanned Systems: In Unmanned Systems, TTO does air systems, ground systems – and we're even looking at unmanned things that get wet: small boats, that sort of thing.

You all know that DARPA's Grand Challenge is coming up at the end of the week. Twenty teams will showcase their innovations in unmanned ground systems, These innovations are of great interest to DARPA. I encourage you all to come out on Friday and see the Grand Challenge displays!

Tactical Multipliers: These are weapon systems or subsystems that will give combat advantages to our warfighters -- ideas that are more tactical in nature, rather than strategic.

So what Tactical Multipliers are we looking at?

Systems like high energy lasers. Photons are fairly fluffy, and it's hard to use them to burn holes in things. We're looking at new ways to make lasers more effective as weapons in the future.

We're looking at new high energy density materials: new materials that will make better explosives, better propulsion; new ideas for developing high performance engines for airplanes and ground vehicles.

Urban Operations: We realize that future military operations are not going to be confined to open terrain. So in TTO, we are just starting a new thrust area in Urban Operations.

Those are a few of the areas TTO is interested in, and we need your help in all of them.

Now let's take a few minutes and reflect on some of the factors that drive TTO's investment strategy.

From a geopolitical perspective, we know that the U.S. will have hyperpower status for at least the next decade, given our overwhelming technology and training superiority in conventional operations. That means that our adversaries are probably *not* going to take us on in a conventional stand-up fight. We are seeing growing military participation in nation-building, peacekeeping, and homeland security. We have no reason to believe that this trend will change any time soon, and these additional roles strongly influence the broader and broader scope of technology investments we have to consider to benefit our warfighters!

Therefore, in the next 10 years or so, I see several challenges to the way the U.S. has traditionally conducted military operations. These challenges include more potent and widespread threats to our aircraft, ships, and land-vehicles. We are developing low-cost precision-guided munitions; using small boats – manned or unmanned – to attack big ships; and addressing the increased threats of suicide bomber attacks and improvised explosive devices or IEDs.

We see a decline in the relevance of heavy platforms on land and at sea, and, to some extent, in the air against asymmetric threats. Heavy tanks were exactly what we needed in the Fulda Gap scenarios of the Cold War. But they *are* heavy, and it takes a long time to get them positioned where you need them. So the Army is moving toward lighter, more rapidly deployable forces like the Future Combat Systems – which, by the way, was initiated and led by DARPA.

If we're going to be relevant, we need to get to the fight before things get out of hand. That means we have to get there *quickly* and *with overwhelming force*.

All of these developments have profound implications for future weapons systems.

Let's talk about some of them.

Unmanned ground- and air-vehicles have recently proven themselves. We have Predators flying in Iraq and Afghanistan; we are conducting operations with Global Hawks. Unmanned systems work! But Predator and Global Hawk are relatively simple systems compared to what we're going to need in the future. We will increasingly put unmanned systems in harm's way -- letting them do the dull, dirty,

and dangerous jobs. People will still be in-the-loop. Autonomy just allows us to *not* risk our highly trained of pilots and soldiers in the first days of the war.

Predator and Global Hawk were both DARPA projects, and although they were visionary, it is time to move ahead.

Let's talk about collaboration. I envision a future where unmanned vehicles fly in formations, collaborating not only among themselves but also with manned air vehicles operating in the same airspace, *and* with manned and unmanned ground vehicles.

And oh-by-the-way, these aren't going to be relatively slow-moving, fixed-wing vehicles like today. They are going to be highly autonomous, armed rotorcraft, such as TTO's Unmanned Combat Armed Rotorcraft or UCAR program. They are going to be hypersonic, fixed wing, unmanned vehicles. Or they might be swarms of very small vehicles, going out and doing a mission that would be very, very dangerous for manned aircraft. But they are doing it *with* their human counterparts, as opposed to going out and doing it in isolation.

The unmanned air vehicles of the future will be working as part of a *man-machine team*.

One of the things we need to do – one of the challenges we need to look at – is to move to higher levels of supervision. Right now it takes several people to fly one of the vehicles I just talked about – the Global Hawks and the Predators.

I'd like to see *one* lieutenant managing *ten to fifteen* of these unmanned aircraft! The lieutenant only needs to give them general directions and let them go out and do their mission. This means they autonomously do things like route planning and adjusting the formation of vehicles to account for losses and new targets. The things a capable subordinate should be able to do. They should only come back to him when they have a problem that they need a higher authority to solve.

In a few minutes, Dr Larry Jackle will be up here discussing these sorts of challenges with you.

Let's talk a little about performance.

Today's unmanned air vehicles are medium-sized and subsonic. We're challenging designers to move to supersonic platforms with a much larger payload.

On the other end of the spectrum, we're also interested in developing very small UAVs that can perform a broad variety of missions. I'd like a UAV that can fly in through a window; I'd like a UAV that can hover like a hummingbird or perch on a telephone wire; I'd like a UAV that can fly among the trees.

This is the future. The future is here, and it's going to get a lot more exciting.

The next part of this adventure is the Joint Unmanned Combat Air System, J-UCAS. Very briefly, the J-UCAS will provide the Air Force and the Navy with highly autonomous, unmanned combat air vehicle systems. J-UCAS has recently moved out of TTO to become an office in its own right, and Dr. Mike Francis will be telling you all about it Thursday night.

Now let's move to another TTO thrust area -- Tactical Multipliers. We are looking at things like lasers, and high energy density materials, and advanced propulsion systems.

A major problem that we face is the escalating cost of military platforms. It would provide a huge benefit to the nation if we could find a way for our platforms to be "multi-mission." We currently do this, to some extent, with fighter aircraft: we expect fighter aircraft to be fighters, pursuit aircraft, attack aircraft, light bombers, *and* to provide close air support. During the Second World War, we had a separate class of airplanes for each of these missions! Now we do them all with a single platform!

One of the things we've been thinking about, is whether we could use that same paradigm for large aircraft. Could you have an airplane that, today, is a tanker; tomorrow is an arsenal airplane; and the day after *that* is a bomber? The warfighter can operate with fewer airplanes, and enjoy a huge tactical advantage because he can field the right mix of aircraft configurations *exactly when he needs them*.

The ability to be modular has a lot of real advantages. For example:

On a really small UAV, it's clear that taking the pilot out can benefit the vehicle from payload, mission, and maneuverability points of view. On larger aircraft, it's not necessarily so clear, since there are some missions that will always require a pilot's ability to react in real time.

So why can't the pilot be optional, modular equipment on the airplane, just like everything else is?

We would like to be able to slide a cockpit module in-and-out of the airplane so that we can save our pilots for those really high priority missions that have to be done right, that depend on the human's ability to think and react on-the-spot, without asking higher authority for permission. On the other hand, if we're acting as an arsenal or delivering fuel, why do we need a pilot? This presents a very different set of challenges and departures from today's generation of UAVs, and we're looking for your help and ideas.

Another active area of interest is high performance propulsion systems.

We want, for example, to be able to deliver large payloads over long distances very quickly. To do that, we are going to need hypersonic propulsion systems. One of the

speakers that you will hear from in just a few minutes is Dr. Steve Walker, and Steve will share his vision of future hypersonic systems.

In TTO, we have an interest in advanced propulsion systems of all types -- to reduce the weight of heavy-fuel internal-combustion engines and to improve the specific fuel consumption of turbine engines.

We have good propulsion systems, generally, for today's military missions. But *persistence* is the name-of-the-game, and right now a lot of our manned systems are limited by the persistence of the pilot. If I take the pilot out, I probably want to have a different class of engine so I can operate for 40 or 50 hours at a time…maybe longer! That's *not* how we typically operate manned aircraft today.

We want to come up with *better* engines, and I solicit your good ideas on how we can make this happen. Please come see us on this!

The last topic I want to address is our new initiative in Urban Operations.

As Tony said, recent actions in Iraq have forcefully brought home the message that, operating in-and-around cities and urban areas is very different from standard open-terrain military operations. This is equally true for ground vehicles, air vehicles, and the dismounted soldier. If the future has any relationship to the recent past, we can expect more and more operations in urban areas -- for combat, peacekeeping, and nation-building missions. In general, it's imperative that the U.S. military own the urban battlespace in the same way that we own the air.

"Owning the urban battlespace" sounds great, but what does it mean *specifically*? To me it means the ability to move in an unrestricted fashion into and around cities.

Typically when we're fighting in the open, the Air Force makes sure we own the air and the Army makes sure we own the ground. (You know, when the M1A1 shows up, *everybody else* leaves!)

But we can't map those tactics, techniques, procedures, and technologies directly into the urban environment. Airplanes have a hard time maneuvering around cities, and taking armored vehicles into cities can be a sporty proposition, at best.

We need to "own the cities." That means being able to find and eliminate improvised explosive devices along the routes of convoys. That means being able to counter the MANPAD threat that our helicopters face when they're trying to operate in-and-around cities.

Our urban warfighters also tell us about the problem of random assaults on troops and convoys. We need to be able to give our troops adequate warning, and the bad guy needs to know there will be a penalty associated with these assaults.

So IEDs and random assaults are both places where we're really looking for your help!

Can we develop a way to repel *up* the side of a building, just like we repel down? That gets back to owning the rooftops: I want to be able to go quickly up the side of the building just like Spiderman does. If any of you has "sticky webs" in your back pocket, I'd like to hear about it!

Can you give us a way to seal off stairwells and sewers without blowing them up and booby trapping them? Many times, we only want to seal them off for a short time, and we don't want to have to go back and clean up after ourselves.

We want you to help us think out-of-the-box about how to fight in an urban setting – both near-term and far-term – because it's *not* just a matter of rolling in and firing weapons.

Dr. Brad Tousley will be speaking more about the challenges of urban ops toward the end of TTO's presentation.

Well, that's a snapshot of the future-world that we in TTO live and work in, everyday. So while you're all coming up with great ideas for TTO , I'd like to show you a short movie about some of the things that DARPA has done.

This video is about DARPA's role in aviation history. It is a good example of how DARPA works to revolutionize the technology that our military uses -- to dominate our enemies and defend our country.

Right after the movie, Van Olinger is going to speak with you about the future of aviation.

I want to thank you again for your attention; I'll be back at the end of TTO's presentations to wrap things up.

In the meantime, please remember: We're looking for your help. Come visit us at our booth! We have a *lot* of cool stuff to show you!