DARPATech '04 Presentation

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Welcome to IXO - the Information Exploitation Office.

IXO's emphasis is on detecting, identifying, tracking, targeting and engaging enemy ground targets - the target engagement chain - across a wide range of battlefield environments and on verifying that our actions have achieved the desired results. We invest in innovative new sensors, processing algorithms for target recognition and tracking, and in advanced decision aids and command and control techniques. We're laying the technology foundation for future joint operations involving multiple, heterogeneous platforms, sensors and weapons, many of which will be unmanned.

Our programs are aimed at lifting the fog of war for our own troops and our allies, while at the same time creating a more lethal battlefield environment for our adversaries.

Let's define what we mean by the fog of war …why it exists and how to lift it, and also what it will take to make future battlefields more lethal for our enemies.

Real fog is only water droplets. But the fog of war is a lot more complicated. It's caused by incomplete knowledge about a dynamically changing battlefield situation. Both fogs prevent you from seeing clearly and understanding what's happening around you and both can be dangerous. But the fog of war can cause you to lose a battle – or a war – and it can cost lives. The fog of war will plague us as long as the information provided to any level of command is incomplete, inconsistent, delayed in time, difficult to manipulate or hard to visualize. To lift that fog we must provide each of our warfighters with total, accurate and up-to-the-minute battlefield situational information - information that's tailored to individual users so they're not overloaded with data that's irrelevant to their missions. As the technologies we develop in our information exploitation programs find their way into operational use, the fog of war will begin to lift.

To make the battlefield more lethal for our adversaries we need to improve our ability to quickly isolate and immobilize selected enemy assets. And we must be able to more rapidly and precisely place a weapon on a designated target. This means we need near-zero latency in the command decision process – and that in turn requires that the right information be available to the decision maker at the right time, in a concise and instantly understandable format.

Effective information exploitation is essential for lifting the fog of war for our side and for creating a more lethal battlefield environment for our adversaries. This is the IXO mission. We invest in the application of newly emergent information technologies to critical military problem areas, based on the principle that information superiority is - and must continue to be - a major differentiator between our own capabilities and those of our enemies.

Here are some of the realities that guide our choice of new IXO programs. We'll first look at sources of fog and then we'll address issues of battlefield lethality.

FIRST: Our enemies know how to hide – and since our sensing capabilities are limited, we can't always see them. We need to see clearly through foliage and camouflage, and we need to see the enemy whenever and wherever he moves, stops or hides - for instance in complex terrain that obscures our vision - and in cities, where we'd like to see around corners and through walls and quickly determine the interior layouts of buildings that are occupied by enemy forces. Our investments in new types of sensors and new sensor modalities are directed at reducing the likelihood that our adversaries will be able to evade us.

SECOND: We don't always know if we're seeing our own forces or those of the enemy. We need to know if someone is a good guy, a bad guy, or a non-combatant. And we have to know that regardless of whether he's driving an armored vehicle across flat, open and unobstructed terrain, or if he's dismounted and moving through a group of civilians in a crowded urban marketplace - or anywhere else. We're interested in advanced technologies for interrogating and identifying friendly troops and assets in ways that don't betray their positions - or even their very existence - to the enemy. And we're looking for new ways to differentiate non-cooperative enemy targets from neutral or non-threatening individuals and objects.

THIRD: We're not always sure our weapons have achieved their objectives. This too often results in the expenditure of multiple, often costly, weapons on previously disabled targets, leaving fewer weapons available for self protection or for use against additional threats.

So major contributors to the fog of war are that our enemies can hide from us, we don't always know if we're seeing friends or foes, and we're not always sure our weapons have achieved their objectives. These problems motivate our interest in new sensors, new sensor exploitation methods, new techniques for achieving positive combat ID, and in ways of achieving timely and accurate assessment of weapons effectiveness.

Let's now address the second major element of IXO's mission: creating a more lethal battlefield environment for our adversaries. We're responding to two serious problems in this area:

FIRST: Commanders and decision makers are faced with ever-growing amounts of data which they must interpret quickly and accurately in deciding whether and how to engage a target or group of targets. Data volumes will expand considerably in the future as additional sensors and new sensor types come on line, and as more communications capacity becomes available through advanced networking technologies.

Reviewing and digesting large volumes of data in order to make critical life and death decisions takes time. This delay gives the adversary a chance to evade our sensors and

weapons. So if we want the enemy to experience a more lethal battlefield we must reduce to near-zero the time it takes commanders to review the data and reach militarily correct decisions. If we're not careful, the data torrent presented by our proliferating sensor and wideband communications systems could actually backfire on us, causing thickening, rather than lifting, of the fog of war.

SECOND: As demonstrated in recent conflicts, we have the capability to emplace a precision weapon at virtually the exact spot we specify. But to use this capability to its best advantage we've got to know the target location with a precision commensurate with that of the weapon - and for moving targets, we've got to predict their exact locations at the instant of impact.

Data overload and precision targeting are the major issues associated with our goal of creating a more lethal battlefield environment for our enemies. We must eliminate, or at least minimize, things that add delay and uncertainty to the target engagement process. This goal motivates our programs in precision tracking, situational visualization, mission planning, battle management and command decision aids.

The target engagement chain requires networked systems of manned and unmanned platforms that are interconnected through a common communications infrastructure. That's because area surveillance, sensor exploitation, target recognition, precision location and tracking, command, control, weapons and weapon effectiveness assessment functions never all reside in a single airborne or ground-based vehicle. These components must perform in a coordinated and cooperative fashion under the supervision of one or more command and control centers. But current methods of managing and coordinating teams of disparate platforms, sensors and weapons fall far short of providing the needed capability.

IXO's programs in adaptive planning and dynamic control of robotic assets are aimed squarely at this problem area.

A challenge in deploying multi-asset systems is to anticipate, coordinate and manage the non-trivial logistics that are needed to maintain the various warfighting components in states of high mission-readiness. Adequate quantities of spare parts, fuel, weapons, and other expendables must be available when and where they will be needed, along with appropriate operations and maintenance personnel. This requires that we sense, track and predict the states of our own assets in addition to those of the enemy, using many of the same technologies for both. Advanced logistics management is a DARPA-hard information exploitation problem that constitutes an important component of IXO's diverse portfolio of research programs.

Here's how we go about evaluating and selecting new IXO program initiatives:

Our choice of programs is motivated by two equally important considerations: A new program must satisfy an acknowledged critical, unmet military need - and in addition, it ought to accelerate the development of one or more newly emergent technologies that

will be important enablers of future warfighting systems. These considerations embrace two substantially different time frames. We seek to transition important new near-term capabilities to military users within a few years. Concurrently, our longer-term goal is to bring to maturity revolutionary or transformational technologies that will lead to more effective warfighting solutions ten or more years hence. Here's how we try to bridge the gap and accomplish both of these objectives:

We satisfy our near-term requirement by coordinating with potential military users during the program planning process. This provides a sanity check on the military utility of what we're proposing and it also paves paths for eventual transition of the technology to operational military users.

We assess the long-term value of a candidate program in the context of a model, or vision, of a future warfighting environment. We ask whether the technology to be developed will enable one or more aspects of our future vision. If the answer to this question is "yes" then we consider the program to have good long term implications.

Our vision of the future is outlined below, as it pertains to IXO's mission of lifting the fog of war for ourselves and our allies and making battlefields more lethal for the enemy. Our model is very broad, and it lacks a lot of detail. However, it is fairly straightforward to identify gaps in our current technology portfolio that, if filled, would help to bring this vision of the future closer to reality. This vision represents a context within which we can assess the long-term potential of proposed new technology developments.

We anticipate that future battles will be fought using greater numbers and many more types of surveillance, reconnaissance and weaponry resources than we've seen in recent conflicts. In other words future U.S. military operations will be conducted using a far richer inventory of engagement assets, both in variety and in number, than have been used thus far.

We believe the dominant operating approach of the future will be heavily oriented toward unmanned systems that operate autonomously and in small, ad-hoc teams. Human participation will be focused on high-level commands that define mission objectives, while detailed planning and real-time execution of the specified missions will be accomplished by the unmanned systems themselves. For lack of a better description we refer to this concept as a networked federation of target engagement assets. It will include people at the command level in addition to a wide range of manned and unmanned ground, air and space vehicles, all interconnected by a robust and reliable communications infrastructure.

Serious efforts aimed at creating and fielding early, skeletal, versions of such systems are underway in the Army's Future Combat Systems initiative. And the Navy and Air Force will conduct future intelligence, surveillance, reconnaissance and strike missions using coordinated teams of unmanned air vehicles that are currently under development in the Joint UCAS program. But the IXO vision is considerably more far-reaching. It embraces virtually all elements of the target engagement chain - on the ground, in the air

and in space - and for battlefield environments that range from wide open spaces to densely populated urban centers.

Future systems of unmanned platforms carrying a wide variety of sensors and weapons will self-organize into autonomous ad-hoc teams in response to high level command inputs that define tasks and mission objectives. Individual components and teams of components will maintain cognitive awareness of their objectives and their environment, and they will adapt to unplanned and unforeseen circumstances in much the same way that teams of humans do. These teams will communicate with human commanders relatively infrequently, perhaps only in response to new tasking directives or to verify successful completion of mission assignments. Mission planning efforts will focus on selecting the right statistical mix and density of assets to deploy over given ground areas in order to maximize the likelihood of having the right assets available when and where they may be needed.

Entirely different sensor management and exploitation methods may be appropriate in the future compared to those that evolved in our present resource-limited environment. We're interested in innovative new sensing and information exploitation ideas specifically oriented toward distributed, resource-rich target engagement architectures.

Distributing weapons of various types throughout the battlespace will substantially reduce the engagement chain latency, and that means the battlefield will be a more lethal place for our adversaries. Just like the surveillance assets, weapons will be deployed statistically so as to maximize the probability of their immediate availability when needed.

Our vision for the future doesn't assume unlimited communications bandwidth, either within the federation or for reach-back to remote command centers. So it follows that data-intensive exploitation processing and target tracking functions will be conducted locally within individual sensor platforms or distributed among several platforms in a local region.

We anticipate that generically similar networks of mostly unmanned assets will be effective across a broad range of battlefield situations, including urban environments as well as historically traditional warfighting situations. There will be significant differences in the number and types of assets deployed for different mission scenarios, but the idea of high-level tasking of the system as a whole and ad-hoc teaming of intelligent networked ISR and strike assets ought to work well in a variety of situations.

To summarize our vision of the future, we imagine networked federations of mostly autonomous target engagement assets whose mix, density and deployment patterns are tailored to specific mission objectives. We expect that high-level commands will be issued to the overall system instead of to individual components, and that distributed, agent-based software will organize ad-hoc teams of platforms and sensors to perform ISR functions. Sensor exploitation and target nomination and recognition tasks will be performed in a distributed computing environment comprised of processors located on

the various sensor platforms. Reduced strike latency will be achieved by distributing weapons throughout the battlespace, and these will be coordinated with ISR, battle damage assessment and command resources by way of a common network infrastructure.

Our program thrusts in sensors, exploitation, precision tracking, battlespace management and command and control can all be related to this long term vision. Each contributes one or more new technology results that will enable different aspects of a future system-of-systems based on this model.

We believe it will be possible, given appropriate technologies, to cause federations of separately developed assets to perform like truly integrated systems-of-systems. We think this can happen despite the fact that many or all of the individual components may be so-called stove-pipe designs. An analogy worth mentioning is that of the internet, where large numbers of inherently incompatible computing platforms are able to solve problems collaboratively, even though they were never originally designed to talk to each other. We think a similar result should be achievable for networked communities of C2ISR and strike assets and we invite your ideas on how to accomplish it.

Our plan for the future calls for us to continue to invest in R&D programs in all of our current focus areas. In addition, we'll be placing greater emphasis on developing new techniques for combat ID, both cooperative and otherwise, and we plan to initiate new efforts in weapons effectiveness assessment as well. Our experiences in Afghanistan and Iraq have shown that we need to strengthen our capability in both of these areas - and they represent DARPA-hard problems that we're eager to take on. We will also seek to expand our investments in urban warfighting technologies, since a greater percentage of future conflicts is likely to occur in cities and villages than in rural environments.