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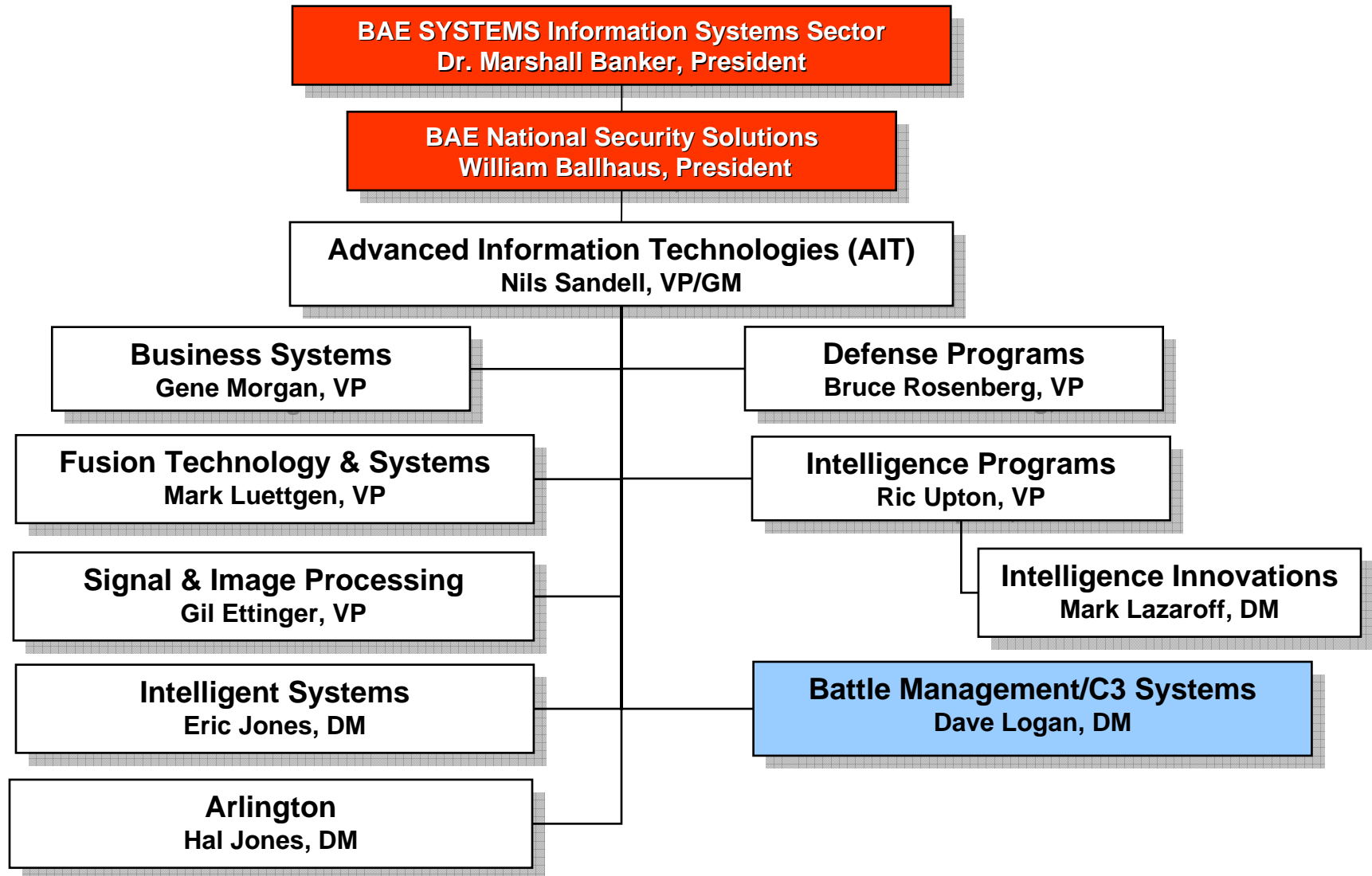
Multi-vehicle Mission Control System (M2CS) Overview

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ALPHATECH ⇒ BAE Advanced Information Technology

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Multi-Vehicle Mission Controller (M2CS) Product Overview

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- **Multi-vehicle Mission Control System (M2CS) Capabilities**
 - Cooperative Control of Heterogeneous Teams of Unmanned Vehicles
 - Autonomous, Rapid Mission Replanning
 - Synchronization of Manned and Unmanned Teams
 - Designed to support broad range of CONOPs
 - On-Board or Ground Station Processing
- **Customers**
 - DARPA, USAF, USN, Primes



Why is this a Hard Problem?

- **Multi-Vehicle Coordination of variable size, heterogeneous teams**
 - Vehicle performance, endurance, weapon/sensor inventory and mix
 - Dynamic role selection, ad hoc teaming
- **Uncertain environment and dynamics**
 - Unknown targets, threats, enemy tactics
 - Uncertain effectiveness (P_{detect} , $P_{identify}$, P_{kill} , etc.)
- **Dual Control: Information acquisition and enemy neutralization**
 - Many mission tasks increase risk to platforms
 - Active risk reduction through cooperation to enhance survivability
 - Tight coupling of available capabilities to achieve desired effects
- **Example: Representative team formation and tasking subproblem**
 - 10^{33} states $\Rightarrow 10^{19}$ years for optimal solution on 2GHz CPU

M2CS Technology Breakthrough

- **Fusion of Multi-Disciplinary Technologies**

- Receding Horizon, Model Predictive Control provides Scalable Framework
- Closed-Loop Feedback Stochastic Optimization Provides Anticipatory, Real-Time Situational Dependent Tactics
- Deterministic, Large-Scale Vehicle Routing and Scheduling Technologies provides Multi-Commodity, Depot, and Person Travel Salesman with Time and Activity Synchronization
- Robust Feedback Control Theory Provides Responsiveness while Eliminating Unnecessary Plan Variations

- **Single-Pass, Multi-Resolution, Hierarchical Decomposition**

- Situational Dependent Tactics are Refined into Multi-vehicle, Synchronized Flyable Routes and Mission Activities
- Aggregate/Consistent Models Used at All Levels of the Hierarchy

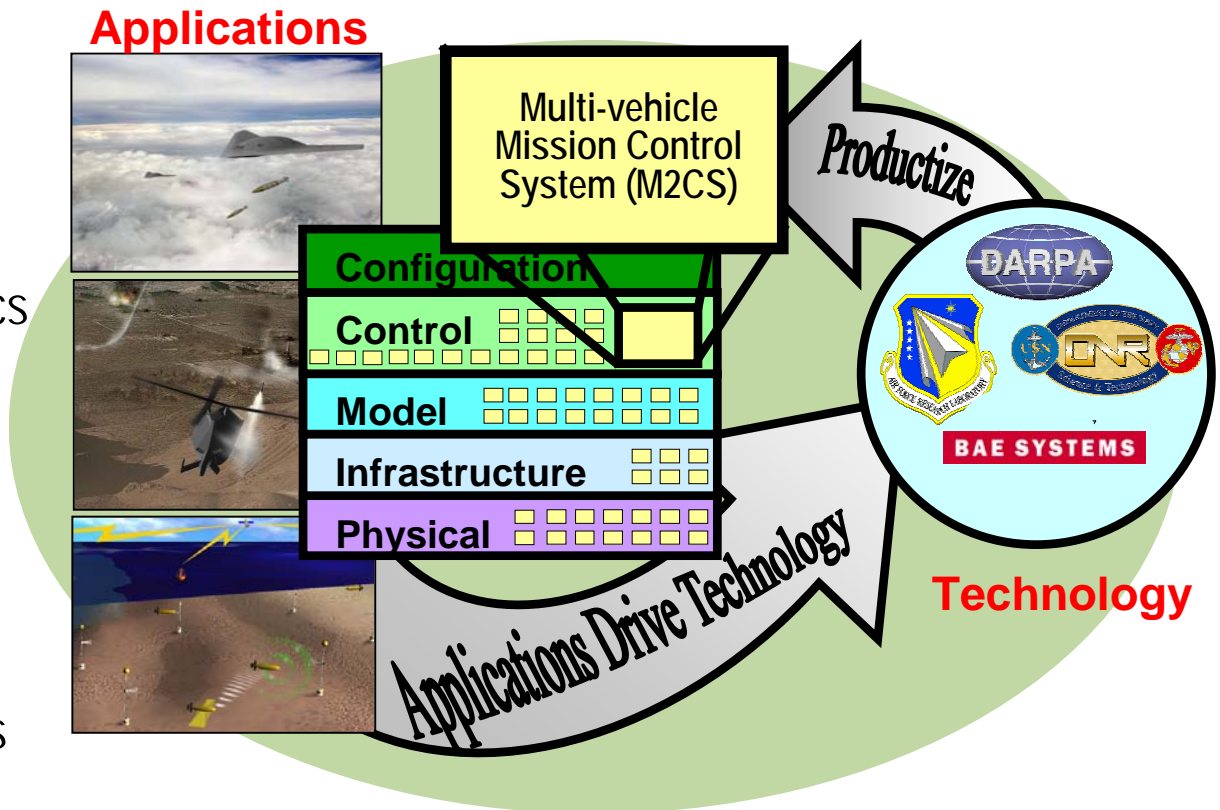
- **Model-Based Optimization**

- Optimization Determines Tactics and Execution Plan that Maximizes Effectiveness for Current/Predict Battlespace
- Platforms, Weapons, Sensor Abstracted from the Algorithms

M2CS Product Strategy

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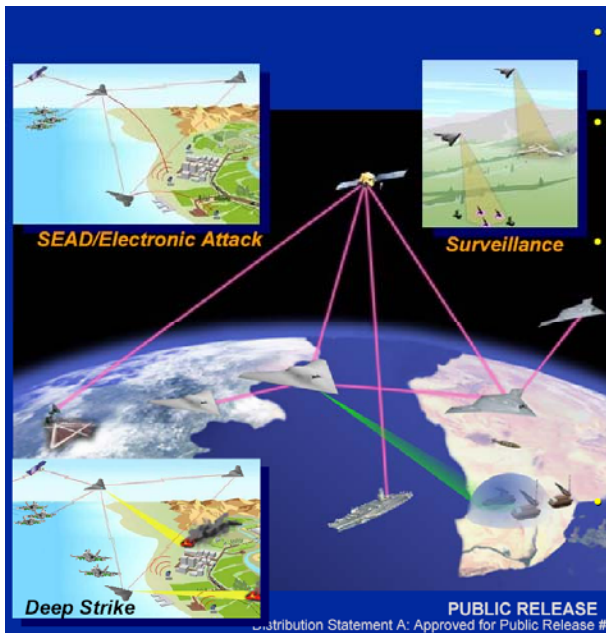
- Close contact with application customers
 - Establish understanding of target environments
 - Technology challenges
 - Influence CONOPS and Tactics
- Synchronized technology development
 - Leverage CRAD and IRAD to develop product
 - Integrated master schedule
 - Common standards/processes
 - Service-based architecture



Joint Combat Air System (J-UCAS) Program

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- M2CS Product Instantiation for J-UCAS: AuTonomous Task Allocation Controller (ATTAC)
 - Real-time, Onboard Control of Large Teams of Unmanned Combat Air Vehicles in Highly Lethal and Uncertain Environments
 - Multiple J-UCAS Missions
 - Mission Effectiveness Analysis
 - Common Operating System (COS) Build 0



SEAD/Electronic Attack

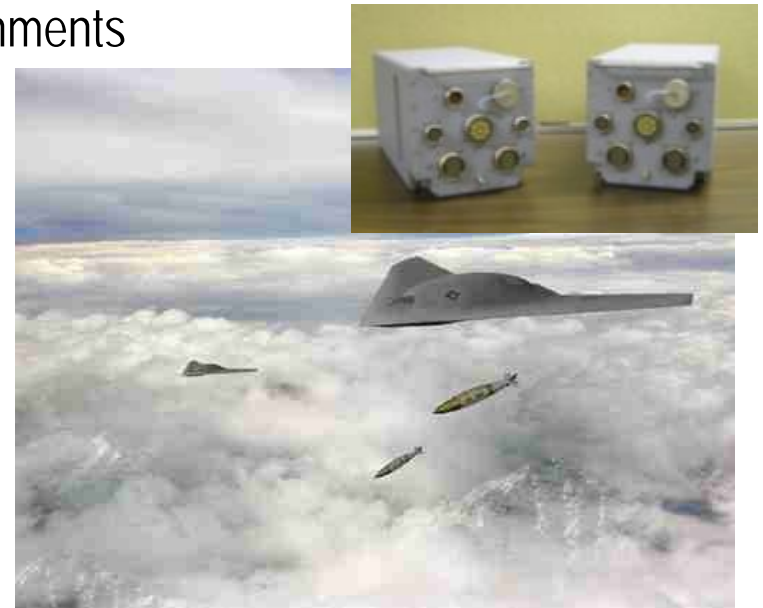
Surveillance

Deep Strike

PUBLIC RELEASE

Distribution Statement A: Approved for Public Release #2139 – Distribution Unlimited.

- **Versatile Combat Capability**
 - Multi-Mission Adaptability
 - Global Operations
- **Manned Force Augmenter**
 - Unique, Difficult Missions
 - Operational Synergy
 - Force Amplification
- **Network-Centric Operations**
 - Network-based Architecture
 - Multi-Vehicle Collaboration
 - High Levels of Autonomy
 - Flexible Human Intervention
 - Enhanced Situation Awareness
 - Dynamically Adaptive System
 - Predictable Battlefield Effects
 - ... Unpredictable Tactics
- **Affordable System-of-Systems**
 - Common Operating System
 - Air Vehicle Compatibility
 - Reduced Support Costs



Unmanned Combat Armed Rotorcraft (UCAR) Program

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- M2CS Product Instantiation for UCAR: AuTonomous Mission Manager (ATM2) for Manned/Unmanned Teaming
 - Real-time, Onboard Control of Large Teams of Unmanned Combat Armed Rotorcraft in Highly Lethal and Uncertain Environments
 - Supports Armed Reconnaissance Mission
 - Manned/Unmanned team virtual demonstration with TRADOC pilots



M2CS Summary

- **Applicable to Manned/Unmanned Hunter-Killer Missions (SEAD ⇔ Armed Recon)**
 - Situational dependent, ad-hoc teaming provides high-tempo operations in highly uncertain and dynamic battlespaces
 - Dynamic discovery of targets and threats
- **Stochastic Optimization**
 - Uncertainty management produces operationally consistent hedging behaviors
 - Scalability achieved via multi-resolution, hierarchical decomposition
- **Rapid Replanning**
 - Missions plans in ~5.0 seconds for large scenarios
 - Robust performance theory enables agility while dampening plan variations
- **Model-Based Representation of Environment**
 - Heterogeneous models (aircraft, weapons, sensors, targets, threats, CONOPS) permit rapid and customized adaptation to new environments and missions
 - Example: same software runs on J-UCAS and UCAR