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Abstract:

This paper presents a list of operational deficiencies facing military planners in the era of dynamic targeting and provides a discussion of potential solutions identifying technical issues needing to be resolved in order to meet operational needs within the information age. The paper outlines and discusses a notional solution enabling real-time re-tasking and reallocation of airborne assets through utilization of "information integration" within an enterprise solution. The enterprise framework is designed to support a collaborative Distributed Command & Control construct that utilizes: efficient spectrum management; policy-driven approaches; generation of rule-based solutions within the context of a users request and constraints; adaptive protocol management; and knowledge-based processing to provide war fighters a real-time re-targeting capability. Technical issues such as: communications and network architectures; seamless, secure, reliable data-linking and networking; limited throughput capacity; efficient management of links & networks; and quality of service (QoS) responses in constraint- driven environments are highlighted and discussed. Experimental data is presented that demonstrates how operationally a secure real-time retargeting capability can be achieved through the enterprise framework, web-enabled technologies, collaborative software applications, spectrum management techniques, quality of service (QoS) enforcement algorithms, and prioritization & optimization of network scheduling and data linked information that re-assigns aircraft to prosecute time sensitive high-value targets of opportunity.

Text

I. Operational Problem/Issues:

In today's complex battle-space environment, decision-makers are assailed with a barrage of constantly changing data and information. Further, the scope of requirements being levied on Naval and Fleet Marine assets to support asymmetric dynamic targeting has placed an even greater burden on communications networks and decision-making capability. Severe deficiencies in our knowledge layer, communication's architecture and the business enterprise infrastructure reduce our critical information-sharing ability and support for real-time decision-making.

An Operational Requirement exists for real-time (< 10 minutes) re-tasking and reallocations of airborne Strike assets in dynamic re-targeting environments. Driven by critical shortfalls in our operational capability, this threat is tactically more complex and varied than one-on-one cold war stand-off scenarios between the major super-powers. Today our military is faced with combating on-the-move terrorist who employ hit and run tactics against civilian and military targets. Aiding and abetting the growth of this threat are anti-democratic radical groups who provide money, material and readily available commercial technologies (i.e. cell phones, mobile computing, and internet access) to suicidal-prone terrorist cells that form the core of a loosely-knitted, highly mobile distributed fighting force. This type of threat has created major shifts in military thinking and planning while exacerbating the gap between the deliberative target-planning-process and prosecution of unplanned targets that appear unannounced at random locations to

plan or carry out missions against the U.S and its allies. To combat this 21st Century threat the U.S. Military, which has been evolving its technical prowess over the last decade, must create a Joint collaborative fighting force among Service Components and their organizational units which enables rapid redeployment of widely disbursed war fighters and assets against, time-sensitive high value targets of opportunity.

Today many technical issues exist in our dynamic targeting processes, communication structures, and command and control architectures that must be reconciled in order to satisfy operational requirements identified above. Some of these deficiencies are discussed below:

- ***Collaborative Dynamic Targeting Processes***: A fully networked distributed command and control construct designed to achieve real time re-tasking and reallocations of assets. Streamlined functionality for mission, structure, and processes are required in a Dynamic Targeting Cell (virtual or otherwise). A list of such needs are categorized below:

  o Streamlined target authorization process, including ROE decisions.

  o Flexible and responsive management of assets across Warfare Commander and Component Commanders areas of responsibility.

  o Ability to dynamically manage large numbers of Joint and coalition assets.

  o Scaleable TTP's (and doctrine) across all sizes of operations from single ship to coalition campaign.

  o Mechanisms and protocols by which digital targeting information is exchanged seamlessly across Joint organizations.

- ***Networking and Communications***: A seamless infra-structure among various command echelons and war fighters is essential if newly nominated high priority, perishable targets are to be prosecuted successfully. To ensure "on-demand" operational connectivity is available when needed under any condition one must: a) continue to eliminate stove-piped communications and data-linking systems; b) identify acceptable levels of throughput for supporting the growing demands placed on resources by mission re-planning and re-targeting operations; c) implement spectrum management techniques and methods to manage existing bandwidth more efficiently; d) ensure data transfer and network assurance under uncertainty of battlefield conditions; e) utilize knowledge-based processing coupled with adaptive protocol management within the battlefield communications architecture; f) provide Quality of Service (QoS) software that enforces policy-driven approaches to support short timeline high priority tasking; g) generate solutions based on rules, requests, and constraints derived from continuous monitoring of network asset and states; h) efficiently and effectively manage existing network resources to improve network service-quality by utilizing unused network resources and i) provide autonomous network management to accommodate higher priority data transmission.

- **_Command and Control Architecture:_** Tantamount to achieving success in a highly charged, fast paced dynamic battle field environment is the ability to perform real-time, reliable, accurate retargeting. As new computing processes and smart software find there way into Fleet operations utilization of the Net-Centric Enterprise Service (NCES) framework, Information Integration and a Navy tailored strike Enterprise Framework is critical to providing seamless connectivity between and among the Air Operations Center (AOC), Carrier Strike Groups (CSG), Expeditionary Strike Groups (ESG), Strike Planners, Airborne Controllers, and Strike aircraft.

II. Concept of Operations (CONOPS):

Successful implementation of a naval transformation philosophy for on-the-move re-tasking and re-rolling of assets in dynamic targeting environments will require utilization of the Net Centric Enterprises Services (NCES) framework for supporting distributed Command, Control & Communications functionality and knowledge-based processing. This framework will allow access to data and information integration applications that can provide a truer representation of the battle space's tactical picture. This constantly updated tactical picture with dynamic-targeting indicators will immediately alert Watch Standers to the presence of high priority targets-of-opportunity within their area of responsibility (AOR). Given such alerts, subsequent unfolding events has a Strike team initiating target-folder development using: an enterprise solution, web-enabled technologies, collaborative decision-making tools, smart software, horizontal and vertical communications (up and down the chain of Command); and enhanced state-of-the-art computing power to provide decision makers greater speed in the re-planning and execution phases of targeting process.

With newly developed technologies accompanied by streamlined functionality and processes, and a seamless network connectivity one can envision a USN Carrier Strike Group (CSG) operating within a Joint Task Force (JTF) / Joint Forces Air Component Commander (JFACC) environment without immediate oversight (alone and unafraid). In this scenario imagine that intelligence information is being passed that identifies time-sensitive high-value-targets-of-opportunity within the Carrier's AOR. An ATO is disseminated to each of the Task Unit Commanders who then select Strike leads to commence immediate collaborative re-planning efforts. The planning involves receiving real time updated threat information and assessing asset availability, and risk factors that will result in the initiation or modification to the target folder. Within this operational vignette, multiple functions and processes will be performed in parallel, Tactical Networks will incorporate information management routines, distributed computing concepts must be adopted, and enterprise solutions will be required to assure timely and accurate dissemination of information. This framework will result in effective and efficient mission management with imposed temporal constraints along with streamlined processes for maintaining command and control across Command echelons — achieving successful prosecution of dynamic targets. Listed below are functions within an

Enterprise Framework that must be automated and seamlessly aligned with other stacks in the systems architecture.

1. ***Knowledge-Layer Functions:***

   ♦ Validate initial Detection / Awareness of a Potential Targets.
   ♦ Initialize evaluation process to verify detected targets are potential Targets Of Interest (TOIs).
   ♦ Initiate Target Folder Development and Notification.
   ♦ Nominate 'Flagged' Target as Responsive or Dynamic Target.
   ♦ Review the potential weapons options.
   ♦ Verify with Airborne Command and Control aircraft status and availabilities.
   ♦ Verify Weapons JMEM effectiveness for selected targets
   ♦ Procure Weather data (if required)
   ♦ Generate potential Courses of Action (CoA).
   ♦ Request Weaponeers conduct target localization and target-mensuration
   ♦ Conducts collateral damage assessment (CDA).
   ♦ Review ROE and Commanders Intentions Messages.
   ♦ Assess Environment (Risk).
   ♦ Initiate 4D-deconfliction planning.
   ♦ Decide to engage target.
   ♦ Assign assets
   ♦ Utilize Knowledge Layer within Communications Network Layer to determine best path for routing information to assets.

2. ***Communication-Layer Functions:***

   ♦ Determines optimum communications paths for transmitting data to, from and between the Aircraft Carrier, the Airborne Controller and Strike Aircraft within a specified quality of service (QoS).
     i. Manage all RF communication paths continuously to assure efficient usage and assurance of data receipt
   ♦ Transmits mission and weapon data packages to Strike aircraft.
   ♦ Transmits strike aircraft acceptance/rejection of re-targeting assignment.
   ♦ Transmit weapon targeting data for weapons release.

3. ***Enterprise Functions:***

   ♦ Provides real time collaboration environment.
   ♦ Provides information integration tools for situational awareness, information sharing and decision making
   ♦ Provides web-enabled services interface
   ♦ Provides network scalability
   ♦ Manages user-request for enterprise services.

♦ Provides load balancing across the network.

These functions, layers and processes should be automated, interoperable and synchronized. Once designed as a system of functions and processes it will allow the Knowledge Layer's smart software, enabled by its Enterprise backbone, the ability to provide seamless networking and data linking connectivity that is able to support behind the scenes parallel processes such as collaborative: re-planning; target validation and prioritization; weapon-to-target-pairing; and optimization of courses of action (COA).

This construct will enable an Airborne Controller to re-vector F/A-18 pilots, launched from the Carrier deck en-route to pre-planned ATO targets, to prosecute newly detected higher priority targets. The concept is for each launched aircraft to register with an airborne enterprise server via on-board Spectrum Managers (SM) thus allowing services on board the aircraft to be available to anyone in the airborne domain or to other domains via the domain controller. Spectrum management techniques and priority RF connectivity will exist between all networked parties who are pursuing time-sensitive high-value targets. This connectivity will invoke newly developed protocols, quality of service software, and in conjunction with its Enterprise Framework, result in a reduced gap between the deliberate planning processes and ad-hoc dynamic targeting.
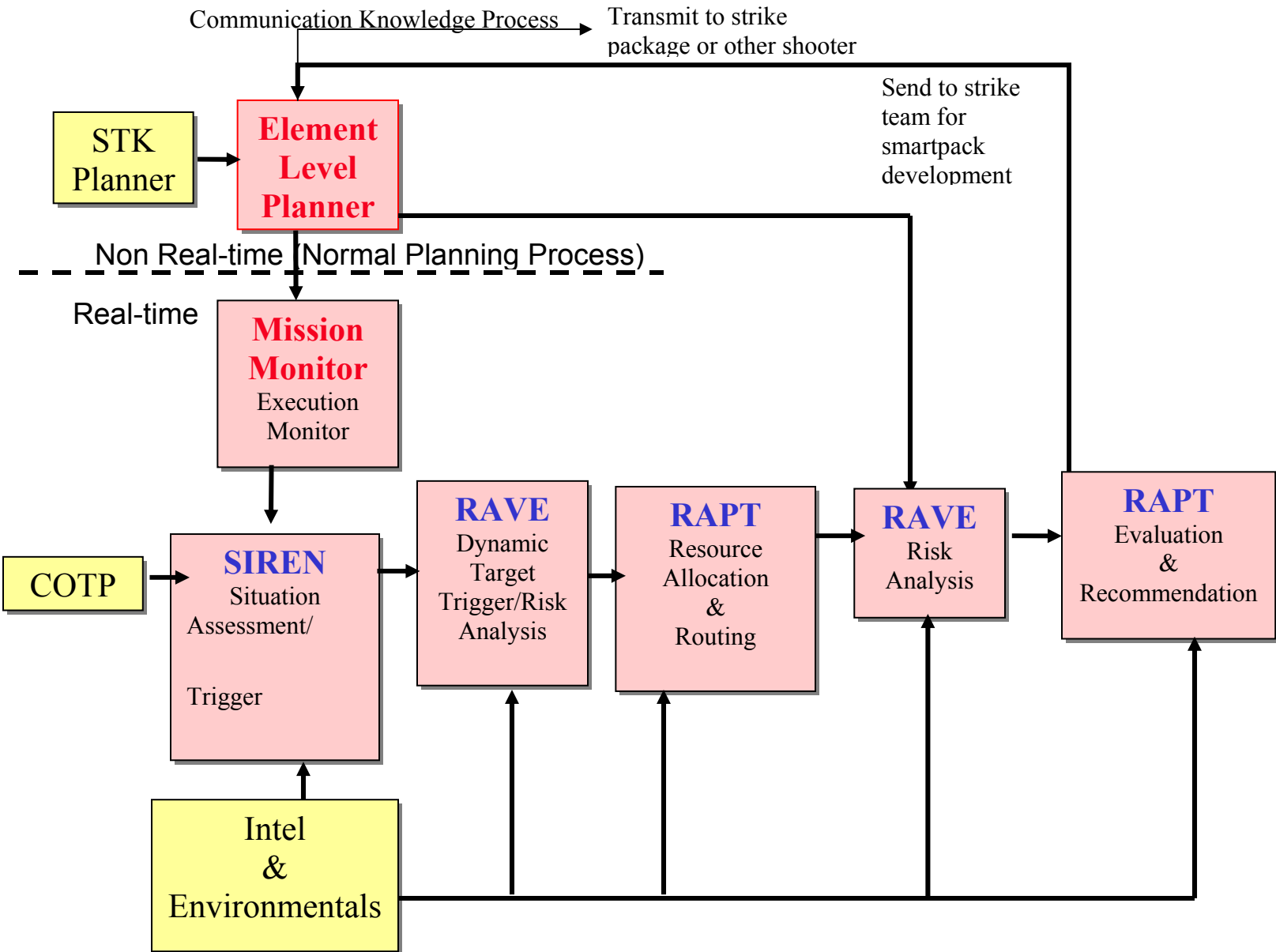
III. Technical Approach:

In response to the requirements identified in Section I dynamic targeting requires the following capabilities: a) C2 Information Management and Decision Support System; b) functionality that takes advantage of the parallel nature of current mission planning and targeting cycles; c) distributed network-centric software tools; d) an enterprise solution to provide backend processes to maintain event-driven updates and provides web-services interfaces for real time collaboration/information-sharing/decision making; e) a medium to interact with heterogeneous data sources; f) scalability and load balancing while managing user-requests for enterprise services; and g) a horizontal and vertical linkage processes (communication up and down the chain of command with watch-station-to-watch station communication across war fighting boundaries) for seamless command and control.

The immediate aim of this approach is to create a workable dynamic targeting process to the point where emergent threats are handled with routine standard procedures not on a crisis with ad-hoc basis. The technical approach is to achieve interoperable functionality and information integration through the constructs depicted in the block diagrams depicted below in Sections **A, B, & C.**

A. *Knowledge-Layer:* There are two key areas that define the Knowledge Layer. They differ in their functionality but are required to assure consistent and reliable information management. The functional areas lie within the decision process and the communication process. Figure 1 depicts a Decision Process Knowledge Layer block diagram showing capabilities and triggering events that are

essential to strike re-planning and target execution. Overall mission re-planning cycle time in high tempo operations and can be reduced through this distributed, collaborative planning processes shown below. The improved speed and quality of information the decision support software seeks to achieve results in a reduced mission planning time by a factor of 4-5X; ergo facilitating rapid retargeting utilizing available strike force assets within minutes of a risk assessment trigger or insertion of a dynamic target into the scene.

FIG. 1 STRIKE PLANNING & RETARGETING INFORMATION FLOW

Communication Knowledge Process → Transmit to strike package or other shooter

Send to strike team for smartpack development

STK Planner	→	**Element Level Planner**

Non Real-time (Normal Planning Process)

Real-time

Mission Monitor
Execution Monitor

COTP	→	**SIREN** Situation Assessment/ Trigger	→	**RAVE** Dynamic Target Trigger/Risk Analysis	→	**RAPT** Resource Allocation & Routing	→	**RAVE** Risk Analysis	→	**RAPT** Evaluation & Recommendation

Intel & Environmentals

Each of the functions, software applications and module outputs depicted in Figure 1 are discussed below:

- ***Element Level Planner (ELP):*** ELP is designed to respond in real time to dynamically changing retargeting situations by providing war fighters the capability to do rapid mission re-planning and mission execution. The ELP is a strike planning software application predicated on the Naval Strike Air Warfare Center (NSAWC) Strike Planner's Checklist and Naval Warfare Publications (NWPs). It offers an automated, knowledge-based implementation of the Strike Planner's Checklist. The software provides real-time dissemination of strike data for collaborative planning and allocation of available strike assets based on the changing battle space and occurrence of high-priority targets.

- ***Mission Monitor (MM):*** Is a real time execution monitoring application to display tasking, planning, and status information pertaining to strike operations. It allows decision makers a method to collaborate, develop schedules, and task the aircrew. MM can view and parse the ATO, Air-plan, Load-Plan and target lists as well as develop inputs for the following days Air-plan. The software can monitor the ATO mission numbers, target assignments, and the collaboration & de-confliction of assignments.

- ***Sensor, Intelligence, ROE, Environment Net (SIREN):*** SIREN is a real-time situational monitoring and analysis software application predicated on receipt of correlated track data from existing track management systems. It is designed to receive intelligence information from airborne and ground sensors. It offers an automated, knowledge-based analysis capability through processes that evaluate track status, compare target priorities, assesses weather; ROE; Collateral Damage Tier assignments; incorporates risk assessment; and develops emitter trends. SIREN provides a continuous impetus to alert watch-standers to changes in the environment and a profiling capability that allows the user to define their view of the COP. Profiles are shared within the enterprise so all SIREN clients can view them and collaborate.

- ***Risk Assessment and Validation Engine (RAVE):*** RAVE provides real time risk assessment and analysis. It Determines risk to Blue entities in the COP through validation of threat capability based on situational and a-priori information provided by RCS templates. It provides a quantified numerical value based on de-confliction, platform state, predicted state, and threat state as part of Kill Chain Analysis. RAVE provides the risk-based trigger function to RAPT

- ***Rapid Assessment Pairing Tool (RAPT):*** RAPT is a real time asset pairing tool. that dynamically reallocates assets based on: changing environment; current status and geographical distance from target; probability of mission success/effectiveness; risk time; LAR; collateral damage; weather and fuel information; and a minimized disruption to the Air-plan or ATO. It generates

multiple weapon-target pairing options against the new targets and for SEAD support.

Once the modules have completed there tasking the output from the **_RAPT_** module is fed back to the Element Level Planner **_(ELP)_** with evaluations and recommendations. This information constitutes the airborne reassignments and a re-planned strike package. The package, once approved, will be transmitted over the network where the Communication Processes take over to assess "Best Path" routing via data links to the Airborne Controller and the Strike Package for mission execution.

B. *Communications-Layer:* Figure 2 (To Be Added Prior to April Modification

Date) will manage communication systems within each asset. The Spectrum Manager is a knowledge-based system that incorporates a General Best First (GBF) Heuristic using AND/OR Graphs along with adaptive protocol logic. A discussion of the Knowledge Layer follows below in the next paragraph. Once the re-planned strike package has been put together data transmission and networking become critical links to successful execution for the re-planned strike. This requires an effective and efficient use of the communications spectrum and tactical networks with policy-driven approaches that utilizes and wraps existing physical (native) networks into a single logical structure supported by expert sub-systems. Figure 3 below depicts a notional implementation of such an expert sub-systems. It consists of three distributed, robust communication protocol layers that abstract the underlying physical (native) network to provide needed functionality for network connections and transport services to applications. Together these protocol layers (transport, network and data or link layer) form the "logical network" that: 1) provide connections and transport services to applications (i.e. TCP/IP via any digital link); 2) support the discovery and routing needs of the transport layer; and 3) abstracts nodes and links from the underlying physical networks. The three protocol layers are required throughout varying stages of real-time operations to ensure successful prosecution of time-critical targets. To achieve this goal the concept of a Spectrum Manager(SM) is introduced to encompass the three protocol layers (transport, network and link layer) within various modules of the Spectrum Manager. These design modules are called: the Transport Protocol Layer; the Communications Manager (ComMan); and the Common Service Plane (CSP).

GBF Application (To be added as a modification prior to April Deadline)

The SM implements a Transport Protocol Layer to abstract and augment the transport services of a set of existing (native) networks. It provides a single logical network interface to applications, hiding the details of how or which underlying physical network is used to transport data. SM is dedicated to exploiting unused or underused network resources so as to present an increased capacity and functionality to applications. The interface services that are provided (such as connect, send, and receive) can be controlled by expressive policies that permit applications to specify QoS needs, such as bandwidth, delay, security, and other service policies. This design feature will improve the application interface to even a single non-multiple-access network, for example, by providing the following capabilities:

- Sharing the network interface (multiplexing).
- Sharing the network resources (routing and scheduling).
- Adding functionality such as error control and policy (including security).
- Hiding details of how or which underlying physical network is used to transport data in a single logical network interface.

In addition to the Transport Protocol Layer, the Spectrum Manager (SM) design contains a Communications Management component discussed below.

Through its Communications Manager (ComMan) the SM implements its logical protocol layers. It manages logical link data through the individual physical networks (logical link layer), the flow of application data through the logical network (logical network layer), and the application connections across the logical network (logical transport layer). It is controlled by the rules and policies in the SM and is dedicated to exploiting unused or underused network resources so as to present an increased capacity and functionality to applications. ComMan improves its throughput with better scheduling based on data attributes (metadata), such as data source, type, and priority. Additionally, when SM services are abstracted from *multiple* networks, it has more latitude to route, schedule and to share resources. It can aggregate resources of multiple networks to provide services not otherwise available, such as increased bandwidth and reduced delay by using multi-path, and routing with multiple constraints. Multi-constrained routing becomes easier because there are more choices for resources. SM dynamically responds to changing resource availability, and since availability is generally distributed in time across the networks, ComMan provides a more uniform service than normally possible with a single network. Note that the underlying networks are normally shared with other systems, which impacts resource availability in a nondeterministic manner. Listed below are some functions that are provided by ComMan for both the logical and physical network. These functions are controlled by rules and policy in the overall SM system. ComMan functionally:

- Maintains network state
- Schedules data
- Manages errors
- Preprocesses data (e.g., compresses)
- Manages security
- Manages connections
- Tunnels connections
- Translates protocol (not needed in logical network)
- Forwards messages (routes in logical network)
- Segments and routes data

In addition to performing these functions ComMan functions as a distributed node operating in a logical network which enables it to advertise and receive services from other SMs. In order to advertise its services SM utilizes a Common Service Plane (CSP) which is described below.

The Common Service Plane (CSP) advertises its services and its capacities and applications to other SMs. Each SM within its domain is designed to communicate information about services it can provide such as configuration control. Additionally, CSP information is available to other components in a larger (host) system that uses the services of SM. For example a service requester is able to check the service plane information to see if an SM node has a service need and its capacity. The SM node is able to respond to the requester that the service requested could only be filled to a partial degree, whence the requester can accept that or make other plans. An SM node can also use the CSP to check the service capacities of other SM nodes to determine routes and can be abstracted to communicate all of the service components and their attributes available in a general system. CSP is designed to: provide run-time information necessary to efficiently and expertly use the available services; facilitate the composition of a general system from subsystems; and coordinate applications and feedback among stages of information giving an implicit nesting of rules that provide system stability. This feedback is provided by rules with inputs from previously interpreted information, such as a rule that is a function of an information base value and a knowledge base value, will produce a new knowledge base value. The design concept for the Spectrum Manager's Composite Service Layer is shown below in Figure 2.

FIG. 3: COMPOSITE SERVICE LAYER WITH POLICY-CONTROL
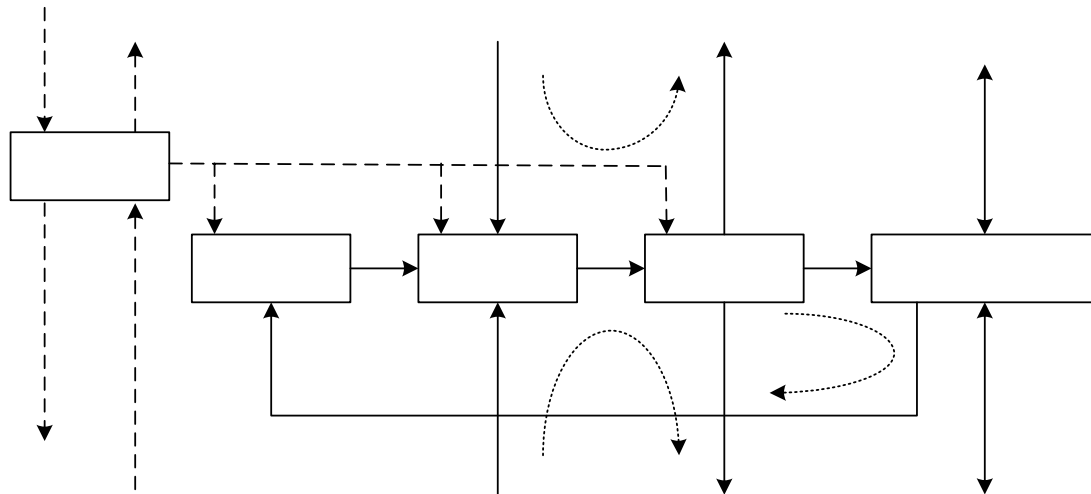
C. *Enterprise Architecture:* The key to success in dynamic targeting will be a real time, robust, layered enterprise architecture that is composed of standard components that support real-time planning and retargeting of airborne strike assets. The enterprise solutions must consist of an infrastructure that supports: collaborative environments; searching, analyzing and pulling of data from heterogeneous sources; decision support

tools; primary planning algorithms (like those found in the Knowledge-Layer); standard protocols for tool management and extensions; interfaces to web-enabled technologies; and selection and optimization of network data links for transmitting 9-line messages to selected airborne assets.

Figure 6 below provides a notional enterprise architecture showing access to software applications, intelligent agents, data bases, interoperability between ground and air domains, multiple clients/servers and is designed to achieve desired levels of *quality of service (QoS)* for re-targeting strike assets against targets of opportunity. This N-tier architectural approach allows the data and logic layers to be separated from information and application services and is connected via user interfaces and protocols to perform various strike mission kill-chain functions associated with dynamic targeting.

The design principles used in this enterprise domain is an open architecture that is independent of underlying object models, programming languages and applications platforms. It allows decentralized operations and management that can accommodate continual asynchronous change, support of COTS standards and services, is scaleable proportionally for its mission and provides an integrated layered security with access to multiple IP networks. Interoperability and integration of various domains within the enterprise is structured to perform as a service-producer or a service-consumer and to deliver services such as rapid and precise discovery and pulling of information and/or the ability to dynamically form collaborative groups for problems solving.
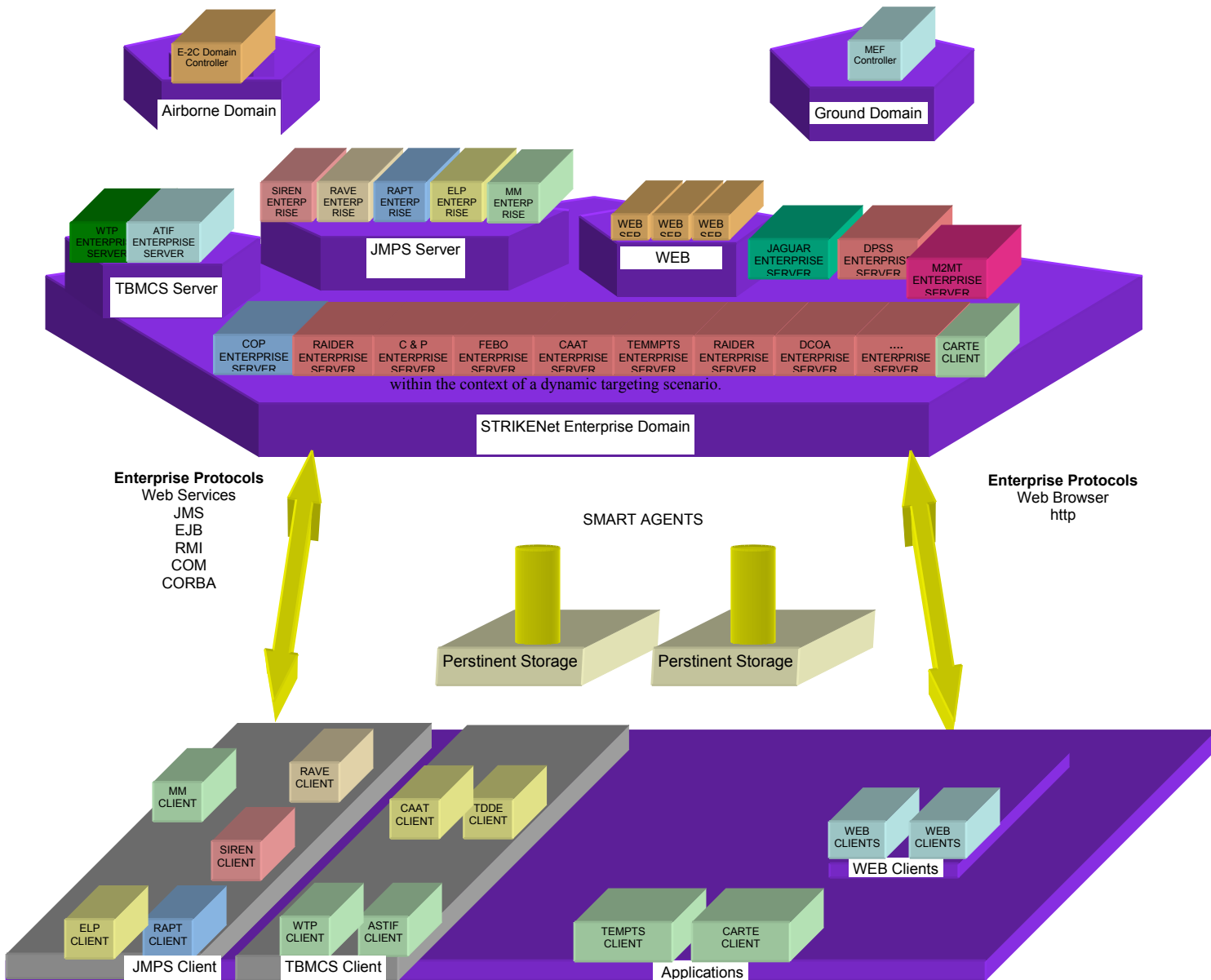
N-TIER ARCHITECTURE
StrikeNet Framework

Figure 6: StrikeNet N-Tier Architecture

The N-tiered enterprise addresses horizontal and vertical linkages, communications up and down the chain of command as well as watch-station-to-watch-station communications across war fighting boundaries thus enabling seamless command and control to the point where emergent threats are handled with routing standard procedures and not as a crisis with ad hoc responses.

Networks that incorporate information management functions, distributed computing concepts, and enterprise solutions will assure timely and accurate dissemination of information for managing mission execution which is essential to command and control across all echelons. This integration of decision making, tactical data and information within an enterprise framework provides decision makers with greater speed in the re-planning and execution phases of dynamic targeting.

IV. Technical Experiment & Results:

A. Value to the Warfighter/Assessment.

Knowledge Layer:

1   Capability: Information Management and Decision support applications that facilitate optimal weapon-target pairing of available, in-theatre assets with de-conflicted routes. This re-planning decision aid expedites the re-planning process to dynamically allocate available strike assets based on the changing battle space dynamic targets.

2   Value: One-of-a-kind situational assessment capability that reduces operator fatigue and provides multiple decision-makers with continuous, easily assimilated information to support operational requirements.

3   Measure: The measure of capability is the reduction in the time required to execute the targeting cycle. By expediting the decision process, we can quantify the value added by the system. We can also measure the reduction in human interaction in managing the process. Through distributed processes, the collaboration between watch officers will be more efficient and reduce the ambiguity in coordinating effects based targeting.

4   Trigger Event/Requirements to Demonstrate: Real time decision support is required as a mission management system to provide initial alerts, conduct the analysis, and integrate with the enterprise architecture. Software will automatically retrieve and fuse operational and tactical battle space information through distributed real time and near real time sources.

Communication Layer:

1. Capability:

The ComMan has shown in lab testing over Link-16 a throughput capability of 80Kbps within the constraint of a J series message structure. This is a vast improvement over current methods since moving TCP/IP messages within this medium has not been accomplished operationally to date with any significant success.

2.   Value:
The significance of this capability is to allow web services to be available for transferring data.

Decision Layer:

1. Capability:

The ability to plan, replan and provide viable options to the decision maker.

2.   Value:

Ability to plan within less than two hours, replan within minutes, and provide options with minutes. Current lab and field testing has shown these capabilities to be realizable within the current framework of applications and networks.