HORIZONTAL SYSTEM-OF-SYSTEMS INTEGRATION VIA COMMONALITY

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Problem – The U.S. Army's Future Force Unit of Action (UA) is the initial solution to the challenges of modern warfighting. The Army is satisfied that information technology has matured to the point that implementation of 21^{st} Century technologies can address these challenges. FCS will exist as an implementation of advanced information technology, which creates a lightly armored, highly mobile, self sustaining force that trades tons of armor for gigabytes of information. The UA achieves superiority (across the full spectrum of conflict) through a distributed, tightly coupled system of systems (SoS) that includes current force capabilities, new offensive systems, and complementary systems. These systems are coupled via information assets with a backbone of distributed, secure, mobile, ubiquitous, *ad hoc*, communications network. This new mix of advanced weapons and information technology enables a revolutionary paradigm of: "see first, understand first, act first, and finish decisively." The underlying information technologies are: (1) accurate and timely data gathering; (2) high-speed networks to acquire and distribute the information (as noted above); (3) high-performance computers to process the information; and (4) advanced weapons systems that are used by highly trained soldiers to engage the enemy on our terms. Item (1) involves Intelligence, Surveillance and Reconnaissance (ISR) to gather the pertinent data via appropriate sensors. Item (3) consists of computers on the battlefield and elsewhere. Item (4) includes unmanned and manned, air and ground vehicles, sensors, weapon systems and their respective munitions (lethal and non lethal), and soldiers. The UA basis for action and decision-making is the integrated combination of C4ISR: Command and Control (C2), Communications, Computers, Intelligence, Surveillance and Reconnaissance. Horizontal integration across all SoS components is essential for UA success, but current force systems lack such integration because the means and methods for such integration have only recently become available or envisioned.

Solution – Kent Brookins [Director of the Army's Simulation and Modeling for Acquisition, Requirements and Training (SMART) office] is funding our Future Force Integrated Support Team (FIST) to identify examples of and develop the methods for understanding commonality. A product of this effort is a methodology to assist the Large Scale Integrator (LSI) in the integration of the complex UA SoS. Our work addresses the UA requirements (future goal), the LSI's architecture (present), and M&S models (past). This effort includes the following FY04 tasks: (1) explicit enumeration of the necessary functions (functional decomposition) that comprise one UA Integrated Process (IP), as a sequence of well-defined steps to perform a specific mission for C2, communications, and sensors (including ISR); (2) correspondence of the functional decomposition from (1) with the ORD requirements and determination of any gaps; (3) characterization of three representative Army models and their correspondence to the functional decomposition from (1); and (4) determination of functions that are common (functional commonality, which is defined in detail below) across (1) - (3).

Three benefits arise from functional commonality, namely: (a) overlaps, where simulations, models and systems can be integrated; (b) opportunities for re-use of software; and (c) assurance of necessary and sufficient horizontal SoS integration via commonality, in terms of data parameterization of data and algorithms. The FY04 work focuses on a small portion (a narrow slice) of the available results of functional decomposition (FD). (Indeed, a number of different FDs exist, from which we have chosen one as representative from the LSI.) We seek a tractable and defensible approach that is also scalable and testable for the remainder of the UA domain. Functional decomposition is one tool to identify examples of commonality. The initial slice is the Networked Fires IP (IP03), which establishes the necessary ISR, invokes the necessary communications load and network infrastructure, and requires an appropriate level of C2 to represent a potentially rich arena for this fiscal year's analysis.

Results – The significant accomplishments to date on this project are as follows:

- First, the FIST team has achieved a functional decomposition of the UA activities for planning, execution, assessment, and supporting use cases for the networked-fires Integrated Process (IP) on the basis of the LSI's hierarchical list of system functions.
- Second, we have developed a series of definitions for function, commonality at the parameterized level of input/output, commonality at the functional level, systems integration, and others. These terms and concepts provide a working lexicon for our continuing methodology development, whose description will be available at the end of FY04 or early FY05. We expect to continue refinement of these term and concepts.
- Third, the functional decomposition has allowed identification of commonalities within the networked-fires Integrated Process, among C2, ISR, and Communications. The presence of commonality just within the networked fires IP is very significant for software re-use, coding efficiency, and assurance of UA SoS horizontal integration.
- Fourth, we have begun characterization of the Army's current M&S models as sources (resources) toward identification of any useful commonality in those existing packages.

We find that the C2 functional decomposition is adequate for the above purposes. Moreover, we find that the steps for the Air Defense IP are identical to the NF IP. The Conduct Cooperative Engagement IP also has the same steps as NF, without consultation of higher echelons for revenge and line-of-sight kills. Thus, the NF IP is representative of <u>three</u> IPs, not just one. Thus, our findings for functional decomposition and commonality apply to three IPs (not one).

We also find that the functional decomposition for ISR and communications is not adequate. For example, a typical entry for sensor data collection is shown below for one sensor functional step:

Collect Sensor Data … collectData(SensorData) … process(SensorData)

Other (non-generic) entries for sensor data collection include the same two subsidiary functions as above for the following data types: elevation data, feature information data, obstacle detection, CBRN, SIGINT data, target data, identify target, track target, meteorological survey, and collect imagery. These functions have important differences: (i) physical phenomena (e.g., barometric pressure, versus optical image); (ii) observation times (e.g., slow weather updates, versus rapid tracking updates); and (iii) observation areas and resolutions (e.g., weather monitoring at low spatial resolution over a large area, versus tracking at high spatial resolution over a smaller area).

Our team is working to elucidate appropriate details for an adequate functionality description and example decomposition. This work should be available by the end of FY04 and perhaps as early as the end of July performance period.

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