Improving the Decision Space in C4ISR Systems:

An adaptation of a Human Systems Integration (HSI) analytic approach in System-of-Systems (SoS)

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Agenda

- SoS: The HSI Challenge
- HSI SoSE Approach & C4ISR Use Case
- Lessons Learned
- Way Forward

SoS: The HSI Challenge

SoS: The HSI Challenge

- A System of Systems (SoS) leverages a framework or architecture to integrate independent systems and to deliver additional, emergent capability
- Newer SoS approaches and innovations in technology provide the ability to quickly move large amounts of *data* among systems
- However, an SoS approach does not necessarily integrate *information* in a way that provides optimal utility, usability, and decision support to the user

C4ISR

- Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems are critical warfare areas
- These warfare areas are responsible for the integration of real-time and near real-time information
  - Command & Control (C2): Operational and tactical logistics capabilities
  - Intelligence, Surveillance, and Reconnaissance (ISR): Battlespace awareness
  - Meteorology and Oceanography (METOC): Environmental conditions
- To successfully maintain awareness and control over the battlespace, systems and users must share information between warfare areas and across Navy and USMC to inform operations

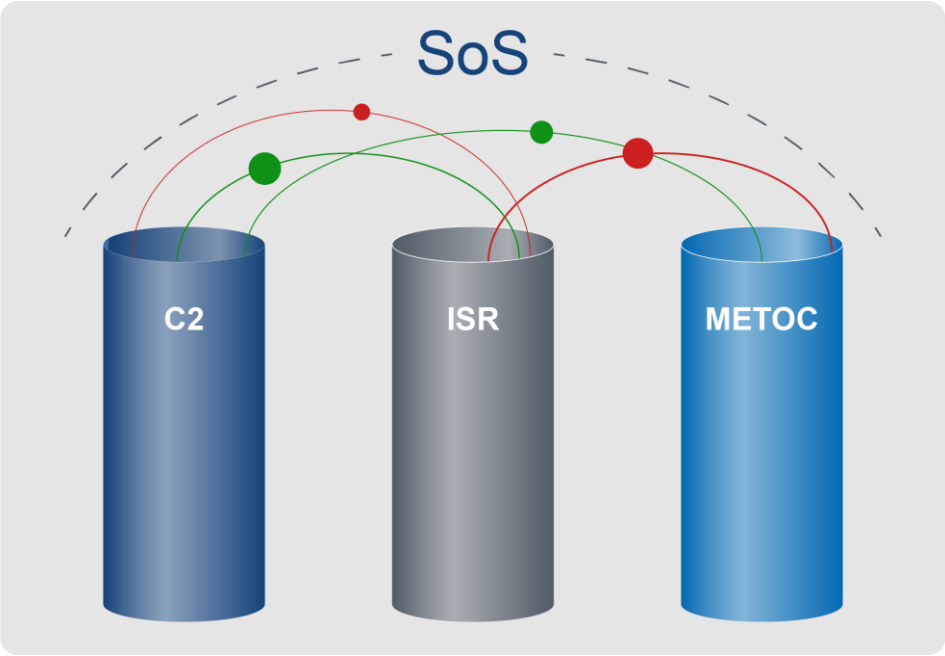
Source: http://www.public.navy.mil/spawar/PEOC4I/Pages/default.aspx

SoS in C4ISR

- C4ISR systems have traditionally been stove-piped
- Stove-piped systems preclude sharing of timely information and products among systems
- This also limits the information needed to integrate and inform decisions by the users

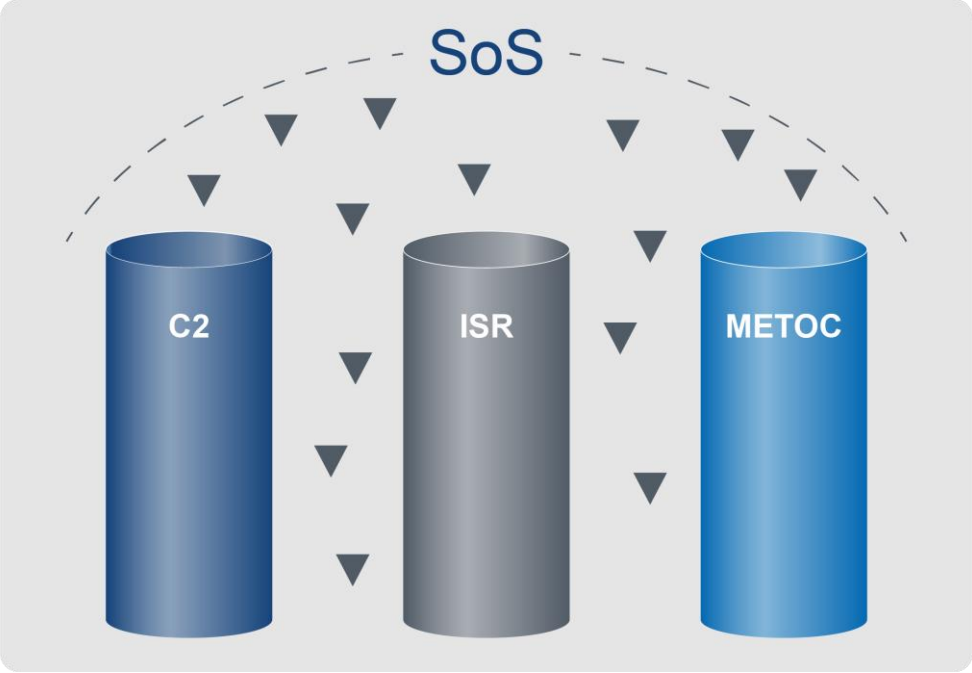
SoS HSI Considerations: Emergent Properties

- While additional capabilities emerge from an SoS, additional properties may also emerge that negatively affect the utility and usability of the system for the user
- Users are required to adapt to accommodate the system



SoS HSI Considerations: Unplanned Capability

- Additionally, capabilities from independent systems may not be accounted for in an SoS
  - If implemented, these unplanned capabilities may become beneficial, emergent SoS properties
- Ownership of critical capability may become unclear



Addressing SoS HSI Challenges

- A recent Navy C4ISR demonstration provided an opportunity to develop and execute a new HSI approach to System of Systems Engineering (SoSE)
- This top-down, analytic HSI approach is intended to inform architecture and systems engineering decisions by mitigating risks related to emergent SoS properties and unplanned capabilities

HSI Goals for C4ISR SoSE

- Mitigate suitability and user acceptance risks
- Ensure independent system capabilities are accounted for in an SoS
- Identify personnel Knowledge, Skills, and Ability (KSA) gaps
- Ensure *data* is integrated in a way that provides optimal utility, usability, and decision support to the user

HSI SoSE Approach & C4ISR Use Case

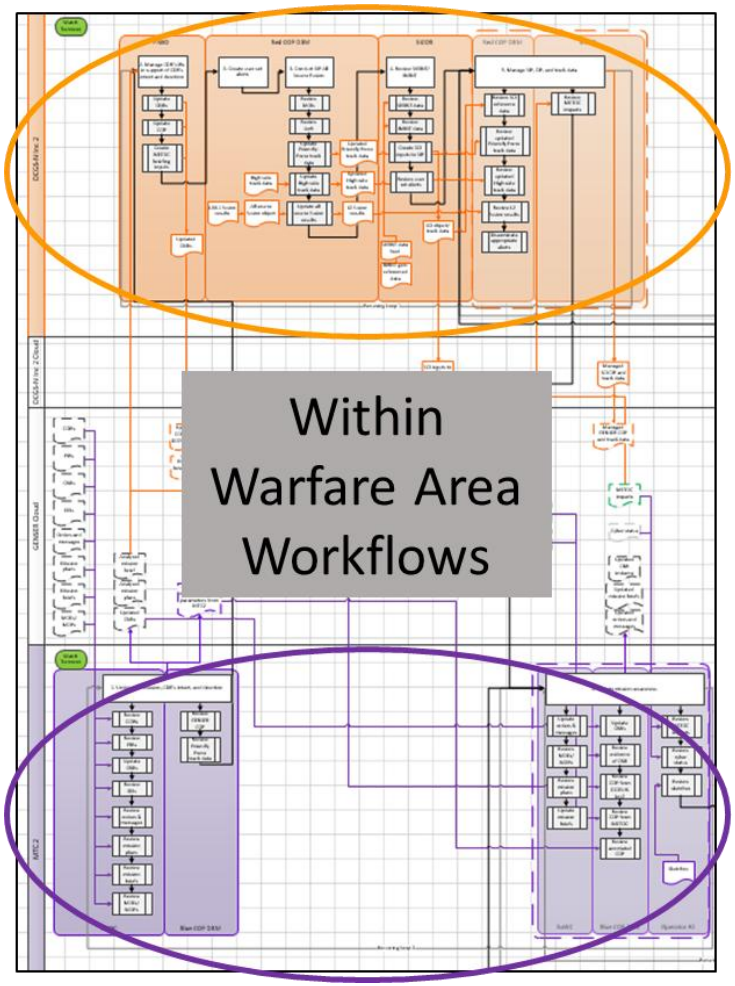
HSI in C4ISR: SoSE Use Case

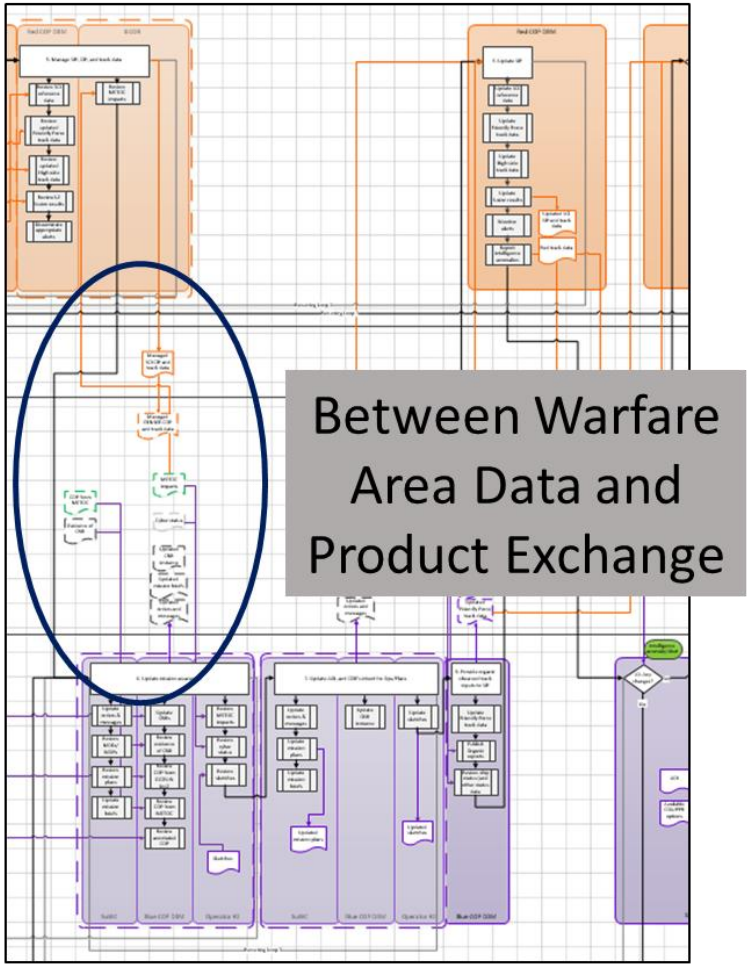
- Navy C4ISR SoS operational demonstration emphasized the cross-warfare area user workflow and information needs (C2, ISR, and METOC)
- The primary interest was an assessment of how system capabilities may be designed to support both the workflow and needs of the users and information consumers
- As a result, the HSI effort identified SoS knowledge gaps, cross-domain products, and system requirements to improve SoS utility, timeliness, and accuracy of products across warfare areas

HSI SoSE Approach

1. Conduct top-down workflow analysis
   a. Document user workflows within and between warfare areas
   b. Identify user and total system performance metrics (e.g., task completion times, success, etc.)
   c. Identify KSA gaps to inform system requirements, design, personnel allocation, and training
2. Implement HSI standards, best practices, and policy
3. Identify cross-warfare area products
4. Include human performance metrics in mission-level modeling of system performance

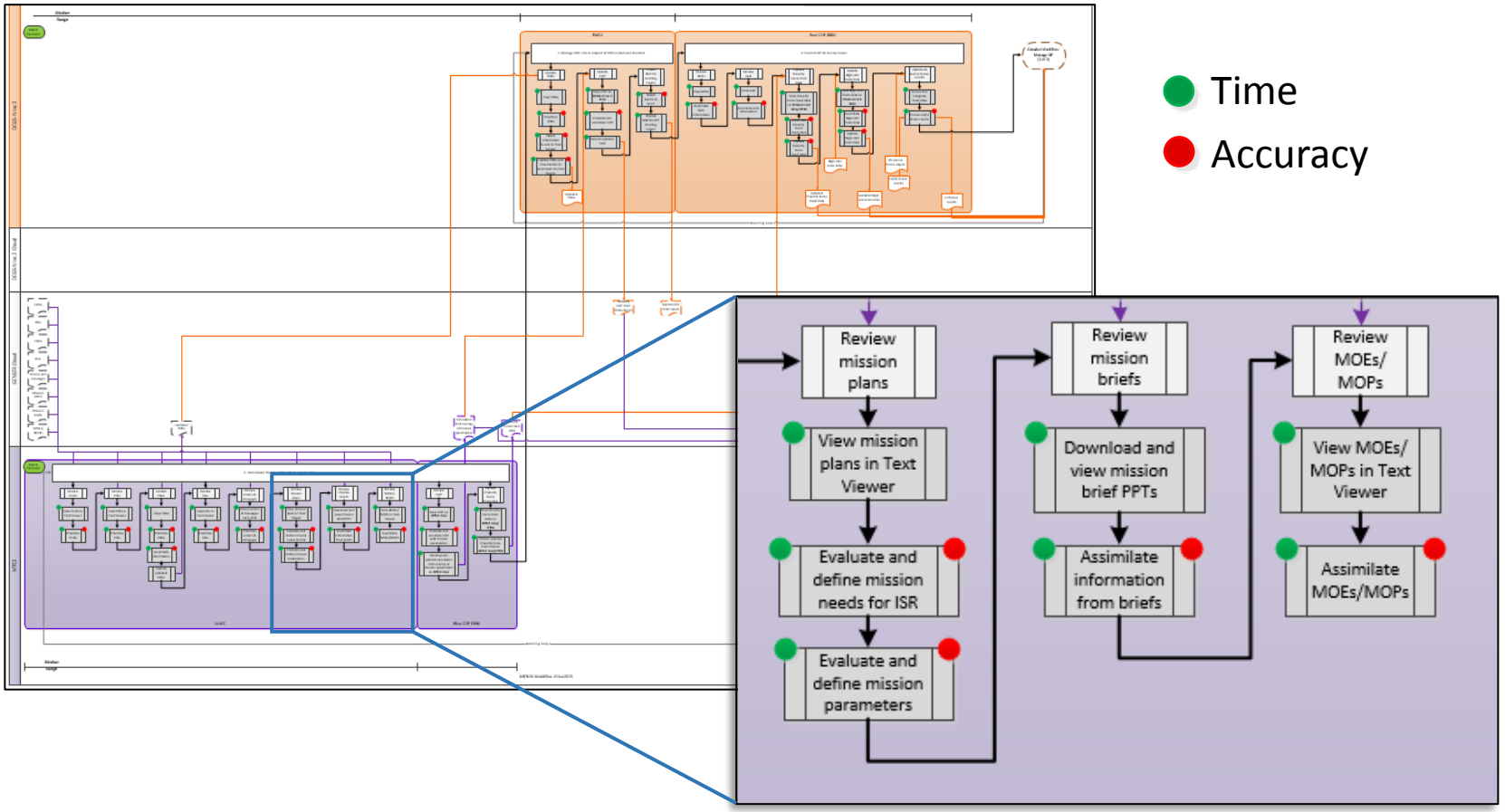
Top-Down Workflow Analysis: User Workflow





Identification of tasks, products, decisions, technologies, and communication methods

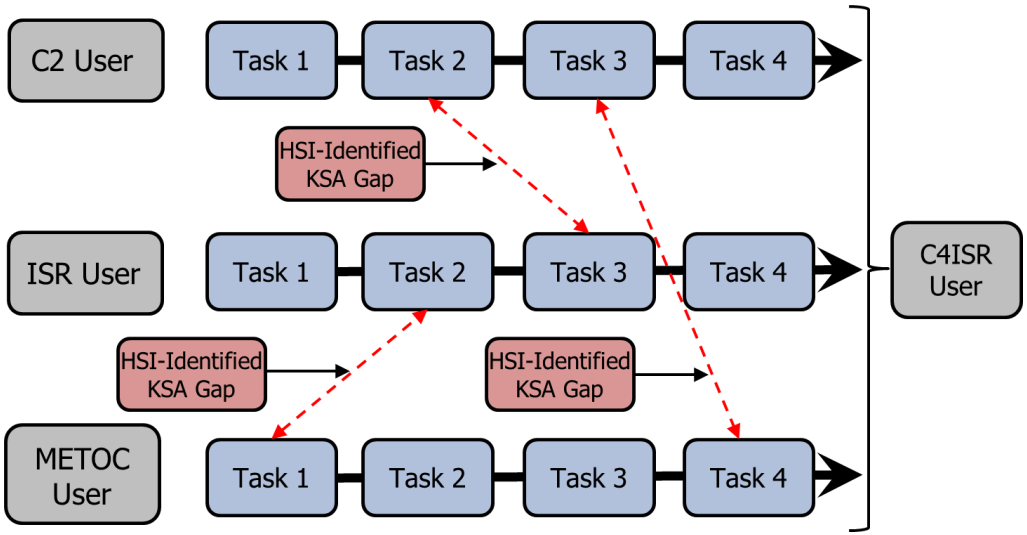
Top-Down Workflow Analysis: Human Performance Metrics



Identification of operational user impact metrics

Top-Down Workflow Analysis: KSAs

- Once information is shared by a warfare area (e.g., METOC), the receiving warfare area (e.g., Intel) may not possess the KSAs needed to properly interpret and apply that new information
- KSA gaps can be identified through top-down workflow analysis and mitigated through Manpower, Personnel, or Training (MPT)



HSI Guidance & Best Practices

- Implementing HSI guidance, best practices, and policy is critical within individual systems and more so within an SoS to proactively mitigate usability, suitability, and training risks
- Implementation of consistent user interactions within the system:
  - Supports system interoperability
  - Optimizes design and development
  - Enhances user performance with system
  - Reduces training time for SoS
  - Improves usability within and between systems

Cross-Warfare Area Products

- Identify information needs across warfare areas
  - Content, frequency, mission-based needs, workflow, timing, etc.
- Establish mission-specific needs to ensure only information that provides utility is provided across warfare areas
- Provide system design and UI support to automate product generation and dissemination

Available Products

C2	ISR	METOC
• AOI • Timeframe • Blue, White, Red tracks • Intent • Org structure • CCIRs • Scheme of Maneuver	• Case Studies • Imagery • Indications and Warnings • Pattern of Life	• Atmospheric Forecast • Oceanographic Forecast • Observations • Model Data • Acoustics • EM/EO Conditions • Bathymetry • Winds and Seas • Mission Impacts • Sunrise/Sunset

Mission 1 Product Needs

C2	ISR	METOC
• AOI • Timeframe • Blue, White, Red Tracks • CCIRs	• Indications and Warnings • Pattern of Life	• Atmospheric Forecast • Oceanographic Forecast • Bathymetry • Winds and Seas • Mission Impacts • Sunrise/Sunset

Mission 2 Product Needs

C2	ISR	METOC
• AOI • Timeframe • Blue, White, Red Tracks • Intent • Org structure	• Case Studies • Imagery • Indications and Warnings • Pattern of Life	• Atmospheric Forecast • Acoustics • EM/EO conditions • Winds and Seas • Mission Impacts

HSI Modeling and Simulation

- HSI modeling and simulation tools offer an effective means for conducting rapid operational, system performance analyses in support of mission-level analyses
  - User performance rarely considered in total system performance during modeling
- Developed a modeling framework to bridge the gap between component-level human models, human interface devices, and a DoDAF-compatible architecture model
  - Provides mission-level impacts of human performance to make trade space decisions among materiel and non-materiel solutions
- Using data from top-down workflow analyses (e.g., task times, error rates, etc.), user performance may be modeled, improving the accuracy and robustness of mission analyses
  - Provides cost effective decision-making support and measurement of ROI

HSI Benefits to SoSE

- Improved HSI analyses and design approaches in SoSE will:
  - Ensure a more comprehensive approach where the right *information* is accessible to the right user, at the right time, to improve cross-domain SoS decision support and total system performance
  - Afford the opportunity to provide new information to the end-user
  - Support strategic management and engineering decisions

Lessons Learned

SoSE HSI Lessons Learned: Top-Down Workflow Analysis

- Map HSI data to other SoSE processes and products
  - Provides traceability back to architecture and engineering and test documents
- Identify and share HSI-related requirements concerning touch-points between systems
  - Coordinates efficient exchange of data and products between systems
  - Ensures unplanned capability is not overlooked
- Document cross system human-to-machine and human-to-human interactions
  - Provides list of assumptions
  - Ensures emphasis of human's role in system success

SoSE HSI Lessons Learned: HSI Guidance & Best Practices

- Ensure consistent user interactions across systems (e.g., style and functionality guidance and policy)
  - Mitigates usability issues in SoS integration
  - Helps optimize training
- Collaborate across systems to design UIs for capabilities utilized by multiple user groups
  - Ensures better operational support for majority of users
- Account for maintainers in system design and implementation
  - Improves system resilience

SoSE HSI Lessons Learned: Cross-Warfare Area Products

- Provide centralized access to shared user resources (e.g., conversion services, product repository, maps)
  - Reduces duplicative work and ensures consistency within and across systems
- Ensure users understand system dependencies (e.g., data feeds required)
  - Especially critical for maintainers
- Make underlying metadata, especially in the context of automated tools, accessible to users
  - Provides additional utility to users and encourages user acceptance

SoSE HSI Lessons Learned: Modeling & Simulation

- Implement weighting of human performance metrics
  - Allows model sensitivity to be adjusted based on the weighting of individual human performance metrics
- Leverage automation to capture human performance metrics
  - Provides additional fidelity to model predictions
- Include other HSI domains such as Manpower, Personnel, and Training to evaluate non-materiel solutions as an alternative mitigation strategy

Summary

- Integration of individual systems into an SoS poses unique HSI challenges
- HSI approach developed to mitigate SoS challenges through HSI SoSE approach
  - Top-down workflow analysis
  - Implementation of HSI guidance and best practices
  - Identification of cross-warfare area products
  - Human performance parameters to model total system performance in a mission context
- Validated and refined HSI approach for SoSE during Navy C4ISR operational demonstration

Way Forward

- Develop mission-based architectures that incorporate HSI in C4ISR SoSE
- Further analyze potentially unplanned capabilities to enhance SoS emergent capabilities
- Assess the way in which system capabilities can be designed to support workflow and capability needs of disparate user groups
- Quantify human performance impacts to total system performance at the mission level

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