Azimuth Check: How Intelligence Modeling & Simulation Executes Gap Analysis

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ABSTRACT

The world has changed in the past ten years to affect Intelligence Modeling and Simulation (M&S) more than almost any other defense area. Developing new Intelligence capabilities is challenging due to the criticality of Intelligence in current operations as well as increasing scrutiny and related policy aspects. These considerations exist against the backdrop of a flood of new information. The US Army has a major challenge in identifying and prioritizing Intelligence research needs. The research decisions made now for Intelligence training, analysis and acquisition will impact operations as much, or more, than any other M&S decisions made over the next decade.

This paper describes a rigorous Gap Analysis conducted for the U.S. Army Modeling and Simulation Office (AMSO) as part of a larger Capability Portfolio Review (CPR) of Army M&S. The identified gaps span Intelligence as well as Sensor M&S research. This analysis was conducted over a period of approximately one year, starting with an identification of 10 crucial gap areas by a team of Subject Matter Experts (SMEs). The team further refined the initial gaps which resulted in over 40 detailed gaps, including prioritization of the gaps and recommended Courses of Action (COA) to resolve each gap.

We focus on the methodology for identifying the gap areas. While engineers tend to identify Materiel software and hardware needs – many of the gaps involve processes, i.e. DOTL as part of the DOTMLPF - Doctrine, Organization, Training, Materiel, Leadership & Education, Personnel, and Facilities framework. The identified gaps address how best to meet new requirements for the Operational Environment (OE) and needs for representation of an ever-evolving threat environment. High-level results of the gap analysis, as well as potential M&S trends, will also be presented. This case study is intended to be useful for similar efforts in other Services and nations.

ABOUT THE AUTHORS

Mr. Kirby Thomas serves as the Chief, Army Intelligence Modeling and Simulation (M&S) on the Headquarters, Department of the Army (HQDA) G-2 Staff. Mr. Thomas has been actively involved in Army Intelligence for more than three decades. Since 1996, he has worked exclusively with Intelligence M&S to include design and development of multiple training, experimentation and acquisition models and simulations. As a member of the HQDA staff, Mr. Thomas has 10 years' experience working Intelligence M&S policy and proponency issues and is the primary Army representative to multiple Army, Defense and Intelligence Community (IC) forums and councils. In addition to Intelligence and M&S courses, Mr. Thomas is a graduate of the Russian Basic, Intermediate (LeFox), and Advanced On-Site Inspection Agency (OSIA) courses at the Defense Language Institute Foreign Language Center. For over a quarter of a century, he has coached community and youth soccer teams around the world and currently volunteers with the SeaPerch underwater robotics training and education program in support of multiple high schools in Northern Virginia.

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INTRODUCTION

One of the difficulties of advancing the state-of-the-art in Modeling and Simulation (M&S) is identifying the greatest challenges to focus on. The Intelligence M&S domain is unique due to the continued and rapid development of new technologies and the growing training and analysis requirements. New advances in data analysis and sensors have perhaps had more impact on M&S in Intelligence than any other community. In this paper, we present the results of a recent initiative to formally document the U.S. Army's M&S Intelligence Community capability gaps. This effort was part of a U.S. Army Modeling & Simulation Office (AMSO) Special Topic Capability Portfolio Review (CPR) to identify and prioritize key M&S gaps across the Army M&S enterprise. The M&S CPR identified seven technical gap areas and formed corresponding Working Groups (WGs): Cyber / Electronic Warfare (EW); Network Modeling; Fires; Chemical, Biological, Radiological, and Nuclear (CBRN); Intelligence Environment; Terrain and Sensors.

Early on in the process, the Intelligence Environment gap WG was combined with the Sensors gap WG to form the Intelligence and Sensors M&S WG. This decision was made for both technical and practical reasons and resulted in greater synergy; enabling superior analysis. One of the key drivers of this gap analysis effort was the need to identify enterprise gaps, defined as areas benefiting more than one domain (e.g., training, analysis, testing and evaluation). This effort also revealed those areas where the Intelligence M&S community needed to work together with other Army, Joint, Department of Defense (DoD) and Industry communities to address common issues.

In addition to sharing the Intelligence and Sensors M&S WG gap results with the community, this process can be viewed as a case study useful to other Service, Industry, and National enterprises. This new process can be used by others seeking to analyze current capabilities, identify gaps, and take actions to prioritize and address gaps with limited resources available. It can be scoped to meet particular aims and goals, with the identification and publication of key research needs in a rigorous manner providing enduring benefits.

> The processes and results documented in this paper will provide readers with:
> - A method to assess Army Intelligence and Sensor M&S capabilities across multiple organizations, commands, and communities.
> - Research gaps identified by the Army Intel and Sensors M&S WG applicable to Joint Services, Department of Defense, and Industry.
> - The Army enterprise approach to M&S capability gaps and how to get involved.

BACKGROUND – ARMY INTELLIGENCE M&S

Army Doctrine Reference Publication 2-0 (ADRP 2-0) (2012) defines Intelligence as "the product resulting from the collection, processing, integration, evaluation, analysis, and interpretation of available information concerning foreign nations, hostile or potentially hostile forces or elements, or areas of actual or potential operations." Intelligence is vital in battlefield operations as it informs the commander and influences what actions will be taken. The ability of a force to gather, interpret, process, and disseminate pertinent and timely information is a key success factor in the operational environment. Because of the criticality and complexity of intelligence gathering and use, it is important for the M&S community to model the entire intelligence process; however, this has been a difficult task for models, simulations, and stimulators.

Army Intelligence M&S

The Army Intelligence Process is comprised of four functions: 1) plan and direct; 2) collect; 3) produce; and 4) disseminate. These functions are encompassed within the iterative processes of analyze and assess (ADRP 2-0, 2012). During the M&S CPR, the Intelligence Process was considered and analyzed to determine where insufficient or no M&S capabilities existed. Figure 1 shows the Intelligence Process and some examples of how it applies to M&S of Intelligence.
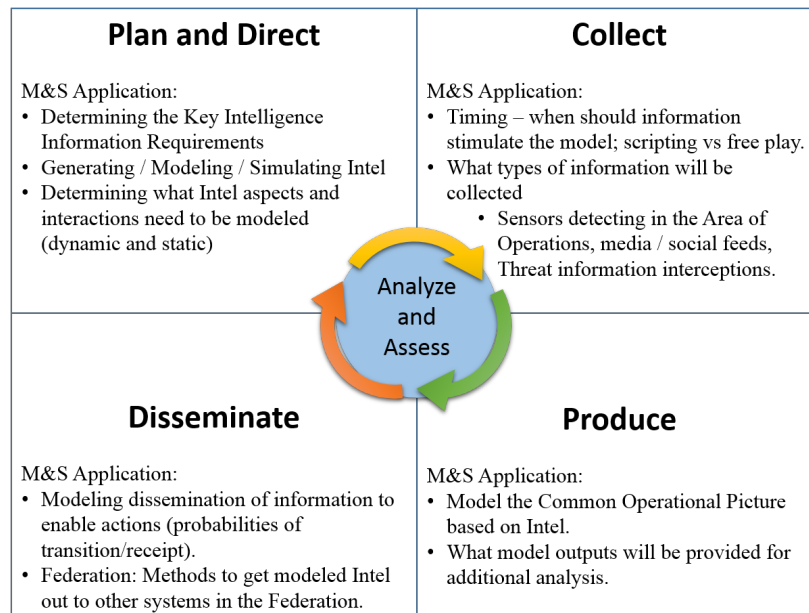

Plan and Direct

M&S Application:
- Determining the Key Intelligence Information Requirements
- Generating / Modeling / Simulating Intel
- Determining what Intel aspects and interactions need to be modeled (dynamic and static)

Collect

M&S Application:
- Timing – when should information stimulate the model; scripting vs free play.
- What types of information will be collected
  - Sensors detecting in the Area of Operations, media / social feeds, Threat information interceptions.

Analyze and Assess

Disseminate

M&S Application:
- Modeling dissemination of information to enable actions (probabilities of transition/receipt).
- Federation: Methods to get modeled Intel out to other systems in the Federation.

Produce

M&S Application:
- Model the Common Operational Picture based on Intel.
- What model outputs will be provided for additional analysis.

Figure 1. Intelligence Process and M&S Application

The steps of the Intelligence Process are not always modeled independently or in minutia because of the processing power required for high fidelity modeling. Therefore, the focus of modeling the Intelligence Process is on the concepts and the impacts to a modeled participant's actions. Even using a high-level perspective, as Captain Carl R. Pawling, U.S. Air Force, points out in his paper "M&S of the Military Intelligence Process" (2004), this method can still require extensive input data requirements and scenario development. The data and scenario in a model, simulation, stimulation, or federation needs to be of sufficient volume, complexity, and fidelity in order to 1) represent the operational environment as well as to 2) simulate relevant functions of the Intelligence Process. Further, depending on the purpose and desired outcome from a simulation execution, steps in the Intelligence process may be simulated, stimulated, or both.

While the Army M&S communities share the same Intelligence Process and the need to accurately model intelligence, the methods used and fidelity applied vary greatly across Army organizations. This difference has resulted in 'silos of excellence' where each community is able to achieve their mission using customized processes and tools, but often at the cost of greater effort, time, and redundancies. Customization will always be required to

meet the differing needs of each community; however, there are opportunities for sharing which could benefit all Intelligence M&S stakeholders and enable the Army and Intelligence community to invest in future developments meeting needs not currently addressed.

GAP ANALYSIS PROCESS

The Army annually conducts a systematic Capabilities Portfolio Review (CPR) of major functional areas. While M&S was not identified as a formal Army portfolio, it was designated as a Special Topic CPR for 2015. A detailed review of the first ever M&S Special Topic CPR is described in the paper titled "Modeling and Simulation Capability Portfolio Review and Gap Analysis" (Traylor et. al., 2016). The method was to apply, with modifications, the established Army Requirements Oversight Council (AROC) CPR framework to Army M&S tools, conducting an assessment of M&S portfolio requirements, capabilities, priorities, and strategy. The desired end-state was to examine the requirements that drive M&S capability development, acquisition and sustainment. The goal achieved by the M&S CPR was to provide visibility of Army modeling and simulation capabilities and gaps. The M&S CPR initial gap identification was executed in 2015 with support and participation from all Army M&S enabled Communities (Acquisition, Analysis, Experimentation, Intelligence, Test and Evaluation, and Training).
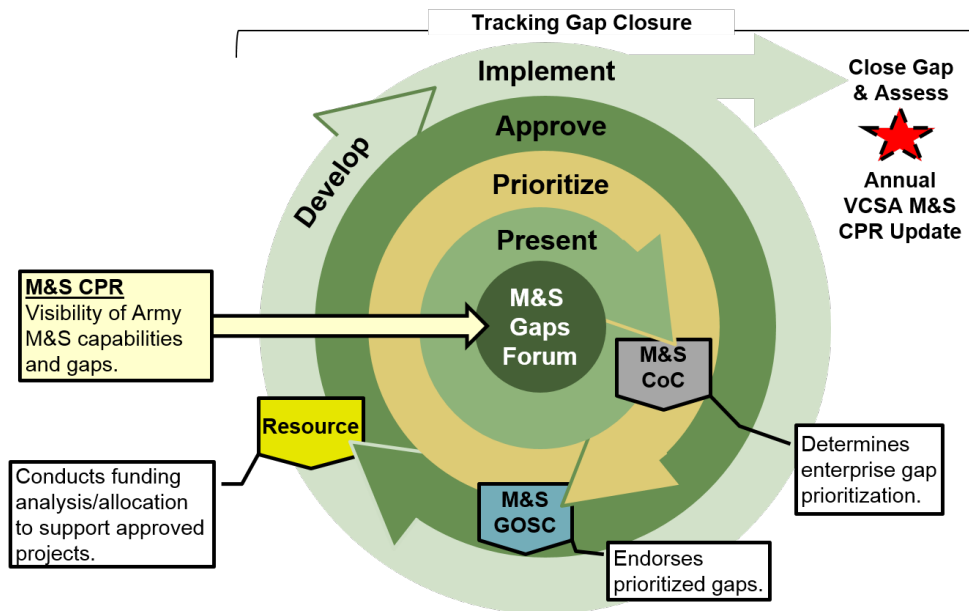

Figure 2. Army M&S Enterprise Approach to M&S Gaps

Working groups were established for each identified major gap area to further analyze M&S gaps. Those working groups were brought together in February 2016 for the first annual Army M&S CPR Gaps Forum (Nolan, 2016). This forum enabled the M&S community to join together to analyze the gaps and identify any additional gaps not captured in the original CPR efforts. The M&S CPR and associated products will be an enduring process allowing Army communities to track gap closures and capture new M&S gaps as missions and needs change.

Intelligence & Sensors WG

Two of the working groups established to address the gaps identified during the M&S CPR, Intelligence Environment and Sensors, completed a stakeholder and gap analysis and determined there would be great benefit to joining efforts. These working groups consisted of common members and the gaps often relied on each other for full functionality. As a result, the groups combined to be the Intelligence & Sensors M&S WG, collaboratively analyzing each identified enterprise M&S gap in the scope of the Intelligence Environment and Sensors. The working group was given guidance to fully define each gap, identify potential courses of action, and prioritize the gaps. The following is how each area was defined in the M&S CPR:

- Sensors - Need to update and develop M&S capabilities to show how new technologies and different environments impact the ability to detect, identify, and track various targets / systems.
- Intelligence Environment - Need to update and develop M&S capabilities to represent intelligence fusion, processing and distribution to provide accessible and authoritative data to the other communities in the area of terrain, social, environmental, cultural geography, and opposing force capabilities / capacities.

Both gap areas each had seven initial gaps identified, which were further analyzed by M&S SMEs and decomposed into discrete, well defined M&S gaps. Using the Intelligence Process concept and coordinating with all Army M&S Communities, the Intelligence & Sensors WG considered all aspects of intelligence utilized in Army M&S. The working group also reached out to DoD, Joint, and Industry M&S partners to gain additional insights into Intelligence gaps and potential solutions. Gaps were considered from across the intelligence disciplines: Counterintelligence (CI), Geospatial Intelligence (GEOINT), Human Intelligence (HUMINT), Measurement and Signature Intelligence (MASINT), Open-source intelligence (OSINT), Signals Intelligence (SIGINT), and Technical intelligence (TECHINT).

ARMY INTELLIGENCE M&S CHALLENGES

Early analysis of the findings developing through the M&S CPR process identified three areas where deficiencies were seen across communities: Operational Environment (OE), Sensors and Signatures, and the Intelligence Process. The need to model a dynamic OE was identified as the top gap area for Intelligence and Sensors. This is the result of the complexity of modeling the OE and associated Intelligence and sensor aspects during a continuously changing scenario. Figure 3 captures the Intelligence Cycle as it is represented in M&S. The scenario and OE will feed the players in the model, resulting in analysis of the information and appropriate reactions to the information received. Depending on the desired outcome of the simulation, the M&S capabilities can simulate and / or stimulate Intelligence processes and sensors to drive decision making and further impact the functions of the 'driver', which can then send information to the model or a federation of models. The cycle will continually loop during a simulation-supported run and the fidelity will vary depending on the need and scope of the M&S effort.

The Operational Environment can be viewed as a combination of the Political, Military, Economic, Social, Infrastructure, Information, Physical Environment and Time (PMESII-PT) factors (identified as operational variables), and their interdependencies, that affect military operations [US Army, 2008]. Each of these factors itself is complex and possibly nonlinear. It is important to note that the OE for a given simulation event can vary greatly from an OE utilized in other simulations.
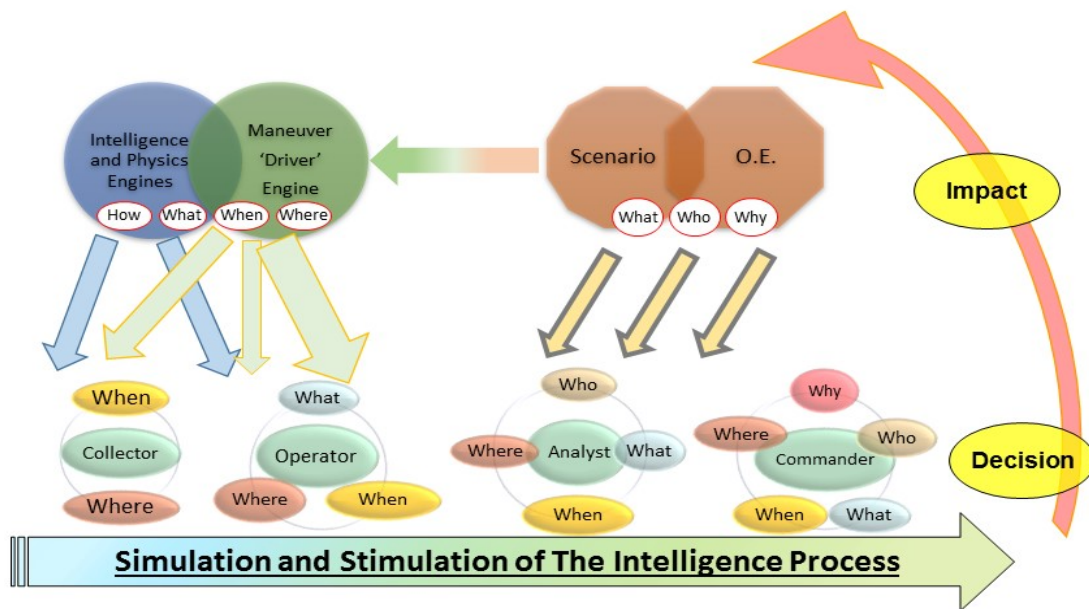

Figure 3. Intelligence Cycle in M&S

RESULTS OF THE INTELLIGENCE M&S GAP ANALYSIS

Prior to and during the CPR M&S Gaps Forum, the Intelligence & Sensors WG analyzed and defined the gaps based on the Intelligence Process, their community needs, and subject matter expertise. This resulted in the further identification of some gaps, additional decomposition, and, in some cases, the combining of gaps where similar needs were submitted by different communities. The following provides the results from the Gaps Forum.

A. Operational Environment Gaps

The first gap area stated an overarching need to sufficiently model the OE to enable Army Training, Analysis, Testing, Experimentation, Intelligence, and Acquisition efforts. This gap closure would be accomplished by modeling the physical environment and information environment including cyberspace, threat, political, military, social, economic, and time factors. Figures 4 and 5 show the priority of the gaps under A1 to A9 where yellow designates high priority and grey designates gaps that were combined with other gaps. The working group defined the gaps as:

A1. Army M&S requires a dynamic operational environment (i.e., signals, threat, terrain, weather and other effects on the physical environment) to properly represent the complex OE across the Army M&S Communities. The following aspects were found to be insufficient in capability:

   A1.1. Munition effects on terrain and infrastructure

   A1.2. Munition effects on personnel within infrastructure

   A1.3. Effects of combined munitions

   A1.4. Megacities

   A1.5. Subterranean features

   A1.6. Ecological factors (i.e. temperature, weather, time of day)

   A1.7. Complex rules of engagement

   A1.8. Influence of terrain and foliage

      A1.8.1. Terrain effects on tasking of platform / sensor packages

      A1.8.2. Dynamic tasking and re-tasking of platform / sensor packages

   A1.9. IED related communications and detections (e.g. disturbed earth)

   A1.11. Image Signature data

      A1.11.1. Image signature data to explicitly model bridges, roads and mountains

      A1.11.2. Decision criteria based on image signature data

   A1.12. Intel indicators of entity movement based on physical environment changes
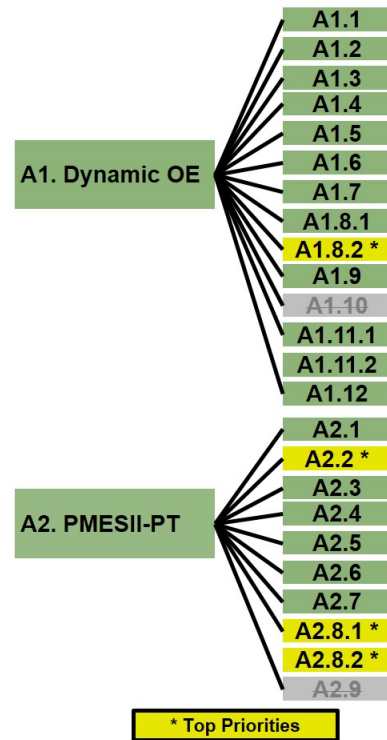

Figure 4. Dynamic OE and PMESII-PT M&S Gaps

A2. To enable decision support and properly portray the complexities of the OE across all M&S Communities, Army M&S requires representation of the PMESII-PT factors that define the OE. The following aspects were found to be insufficient in capability:

   A2.1. Changes in noncombatants due to operations such that they can become combative / uncooperative

   A2.2. Representation and effects of the political, economic and social conditions

   A2.3. Effects of Civil Military Operations (CMO), Military Information Support Operations (MISO), and media

A2.4. Effects of influence, coercion, corruption, criminal activity, or non-state and Non-governmental organization actors on combatants and noncombatants

A2.5. Protracted operations, back-story data, and movement to contact data

A2.6. Grey zone events

A2.7. Crowd Dynamics

A2.8. Patterns of Life

    A2.8.1. Authoritative simulation-ready exercise data which includes ongoing activity: traffic patterns, work, shopping, pedestrian flow, etc., and the effects of altering that activity

    A2.8.2. Signals / communications modeling and associated signatures, signature effects and data associated with patterns of life behavior, terrain effects, OE and interactions among other federates.

A3. Threat and operational environment representation: require accuracy and consistency. The following aspects were found to be insufficient in capability:

A3.1. Signal emission and propagation effects with terrain, OE and interactions amongst other federates

A3.5. Signals, effects of signals, and resulting product outputs – to achieve a fully inactive electromagnetic spectrum OE modeling to include selectable levels of interference

A3.6. Future signal OE problem space modeling

A3.7. Live, Virtual, Constructive federate consistent level of fidelity (dynamic synchronization)

A3.8. OE context library – reusable set of actions, conversations, events, indicators, etc.

A4. Low Resolution Acquisition Methodology - target acquisition at an appropriate level of resolution based on the needs of the study.

A5. Insufficient understanding of the synergistic benefits of fusing multiple bands of sensor data.

A6. No methodology (algorithm) for predicting Light Detection and Ranging (LIDAR) National Imagery Interpretability Rating Scale (NIIRS) and no model to translate to probabilities of acquisition.

A7. Lack of data to quantify the difficulty of aircraft detection, acquisition, and identification using thermal devices to Verify, Validate and Accredit (VV&A) current methods using ground to ground acquisition algorithms.

A8. Insufficient live data to inform the modeling of hyperspectral imagers (tasks and performance).

A9. Insufficient exposure and acceptance of the asset tasking data, for mission and collection activities that are mostly internal to models and simulations.
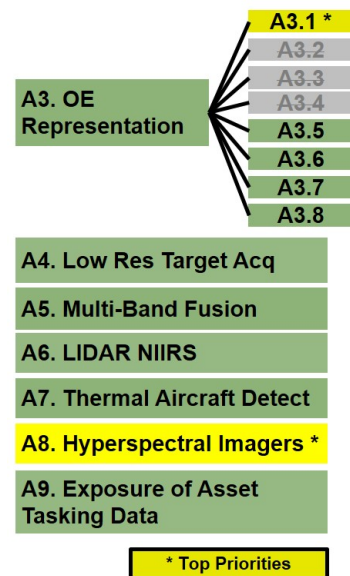

Figure 5. OE Representation M&S Gaps

Figure 6 shows the priority of the gaps under B1 to B4 and C1 to C2, where yellow designates high priority and grey designates gaps that were combined with other gaps.

B. Sensors and Signatures

The second gap area focused on the need to model sensors and signatures, the information gathered, the effects, and the ability to fuse information from multiple sources. This included modeling changes which occurred during the execution of a model run, and data made available prior to executing M&S to reduce set-up time. This gap area had four identified gaps:

B1. Insufficient capability to represent the fusion of observational data into more detailed and refined information, knowledge and understanding of threat intent and appropriate friendly response to that intent.

B2. Insufficient modeling of OSINT.

B3. Lack of auto-generated credible HUMINT to support / control training and operational testing (OT) events vs. scripting which incurs large white cell investments (time and money).

B4. Lack of auto-generated credible Sensor Emulation products, defined as voice cuts, video/imagery of live players integrated with synthetic, to support / control training and operational testing events vs. scripting which incurs large white cell investments (time and money). These products must also be integrated with receivers, networks, etc.

C. Intelligence Processes

The third gap area covers the modeling of the Intelligence Process discussed previously. The gap has two main topics of needing data to support modeling the Intelligence Process within complex OEs and modeling Processing, Exploitation and Dissemination (PED) processes. These topics were decomposed as follows:

C1. Army lacks appropriate type, volume and depth of data needed to support the M&S Communities in their representation of the complexities of the Operational Environment.   The following aspects were found to be insufficient in capability:

C1.1. An authoritative, simulation-ready, "other-than-blue" order of battle (OOB) database.

C1.3. OE data sets that enable joint training and can be shared with Joint, Interagency, Intergovernmental, and Multinational (JIIM) partners.

C1.4. Ability to rapidly update current system parametric data to insure systems and system-of-systems are properly represented in M&S across all communities.

C1.5. An authoritative database of Intelligence, Surveillance, and Reconnaissance (ISR) aerial and terrestrial layer platform and sensor characteristic and performance data.

C2. PED process modeling and effects. The following aspects were found to be insufficient in capability:

C2.1. Implementation of a pull system of common operating picture dissemination.

C2.2. Data and methodology to analyze the performance impact of PED on the Intelligence Process including the impacts of the network, force structure, application / tools and human-based activities.
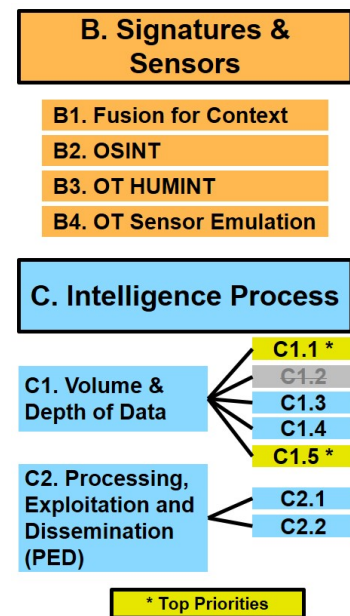
Figure 6. M&S Signatures, Sensors, and Intelligence Process Gaps

CONCLUSIONS

Top 5 Priority Gaps

One of the key activities executed by the Intelligence & Sensors WG during the M&S CPR Gaps Forum was the voting by each participant as to the level of difficulty to resolve the gap, which communities the gap impacts, and the priority of the gap. This voting process included participants from all Army communities, Joint Staff, Air Force, Academia, and Industry. Further analysis was completed after the forum resulting in the following gaps being submitted to AMSO as the top priority enterprise Intelligence & Sensors M&S gaps:

1. **Gaps A2.8.1, A2.8.2, A3.1** Insufficient modeling of the representation of "patterns of life" to demonstrate ongoing activity levels and the ability to interrupt these patterns as a function of IO or physical events leading to different activity patterns. Includes signals / communications modeling and associated signatures, signature effects and data associated with patterns of life behavior, terrain effects, OE and interactions among other federates.
   - Communities Impacted: Analysis, Experimentation, Intelligence, Test and Evaluation, Training
   - Objective: Representation of the PMESII-PT factors that define the OE to enable decision support and properly portray the complexities of the OE across all M&S Communities.

2. **A1.8.2** Insufficient modeling of dynamic tasking and re-tasking of platform/sensor packages.
   - Communities Impacted: Analysis, Intelligence, Test and Evaluation, Training
   - Objective: Ability to explicitly task platform/sensor packages. Collection Management functions modeled (C2 type tools) in order to interact with various Simulations.

3. **A2.2** Insufficient modeling of the representation of the political, economic and social conditions within the Area of Interest (AI), and their effects on combatants and noncombatants.
   - Communities Impacted: Analysis, Experimentation, Intelligence, Training
   - Objective: Address AR 5-11 doctrinal training requirements with regard to 'operational variables' (i.e., PMESII-PT) across the communities.

4. **C1.5** The Army lacks an authoritative database of blue ISR aerial and terrestrial layer platform and sensors characteristic and performance data.
   - Communities Impacted: Acquisition, Analysis, Experimentation, Intelligence, Test and Evaluation, Training
   - Objective: An authoritative blue ISR database satisfying the needs of the Army community.

5. **C1.1** The Army lacks an authoritative, simulation-ready, "other-than-blue" order of battle (OOB) database.
   - Communities Impacted: Acquisition, Analysis, Experimentation, Intelligence, Test and Evaluation, Training
   - Objective: Ensure consistent delivery of the OE across the force, eliminating locally produced OE solutions not grounded in today's intelligence.

Proposed Studies

The Intelligence & Sensors WG also developed potential courses of action for each gap which enabled the identification of six gaps with the phase one solution of research. These gaps have been flagged as potential study topics and will be submitted to community study programs for research.

- Combined study for **A8 and A5**: Insufficient live data to inform the modeling of hyperspectral imagers (tasks and performance) and insufficient understanding of the synergistic benefits of fusing multiple bands of sensor data.

- **A1.11.1** Lack of image signature data to explicitly represent physical features such as bridges, roads, and mountains. Requires data and knowledge about areas where feature detection will impact decision-making.

- **A1.11.1** Lack of decision criteria based on image signature data (bridges, roads, and mountains).

- **A7** Lack of data to quantify the difficulty of aircraft detection and identification using thermal devices to VV&A current methods using ground to ground acquisition algorithms. Lack of algorithms to accurately represent aircraft acquisition using thermal devices.

- **C2.2** Lack of data and methodology to analyze the performance impact of PED on the Operations and Intelligence Processes including the impacts of the network, force structure, applications/tools and human-based activities.

LESSONS LEARNED

The following lessons learned were captured and documented by the Intelligence & Sensors M&S CPR WG. The first lesson captured was that the "standard" Army CPR process does not align with how the Army manages, develops and applies M&S. One of the difficulties was that Army M&S is so distributed across the Army it is difficult to obtain input from all relevant contributors and perform a comprehensive analysis of all capabilities and gaps. Addressing this dispersed challenge brought together the M&S SMEs, enabling the building of communication networks and carrying the results of the M&S CPR back out to the Army Communities.

The M&S CPR Gaps Forum facilitated discussions of how M&S is used within the Army by each Community and also how it is used outside the Army. Initial gaps identified by the M&S CPR process were refined and sometimes expanded to show how the same gap may be applied to several Army M&S Communities, but differing in details such as fidelity. One example of this is the requirement for modeling patterns of life. The Analytical, Experimentation, and Intelligence Communities often have a need for high fidelity modeling of patterns of life with second and third order effects. The Test & Evaluation Community has varying fidelity needs depending on the requirements of the system under test, and the Training Community typically requires low fidelity to meet training needs and prevent negative impacts to processing speeds.

The Forum provided the catalyst to begin documentation of Army Intelligence & Sensors Enterprise M&S gaps that will be translated into requirements for future capability development. This capability is important for Army M&S since it is not a traditional portfolio. By capturing Army Intelligence & Sensors M&S Enterprise gaps affecting multiple Army M&S Communities, the Army has been able to verify, validate, and prioritize cross-community M&S gaps in need of future funding and capability development. The Intelligence & Sensors WG also noted the value of combining the initial CPR gap areas of Intelligence Environment and Sensors into one working group. This combined working group was able to discuss M&S gaps which crossed between gap areas, creating greater synergy and better defined M&S gaps. The Intelligence & Sensors WG also reached out to the Fires and Terrain CPR gap working groups to further collaboration efforts on gaps affecting multiple areas such as munition effects on terrain and their impact to sensing capabilities and intelligence gathering.

Finally, the Intelligence and Sensors working group's use of voting sheets during the M&S CPR Gaps Forum was highlighted as a best practice by AMSO and other M&S CPR gap working groups. The individuals in the working group were able to vote on how difficult the gap would be to solve, determine which Army M&S Communities would benefit from a solution and rank the perceived priority of each gap in relation to the other Intelligence & Sensors gaps.

PATH FORWARD

The Intelligence & Sensors gaps were submitted to AMSO to follow the Enterprise Approach to M&S Gap's process shown in Figure 2. These gaps will also be sustained within the Intelligence & Sensors WG and in M&S aspects of the Intelligence M&S Strategic Plan. Gaps will be reviewed and revised annually, and contribute to spend plan considerations as M&S are funded for updates. The Intelligence & Sensors WG will participate in the annual February M&S CPR Gaps Forum and continue the best practices of using the AMSO SharePoint, pre-forum working groups, and forum voting forms.

BENEFITS AND REUSE

The Intelligence & Sensors M&S experts and stakeholders found the M&S CPR and working group processes and deliverables to be very valuable in identifying gaps and prioritizing needs. The working group meetings and the M&S CPR Gaps Forum enabled communication between communities facilitating a greater understanding of how Intelligence & Sensors are modeled, used, at what fidelity, and where problems may exist. During the forum, there were several occasions where representatives from one community would request additional information from another community representative regarding capabilities which could potentially be expanded or leveraged to address additional needs. This communication and M&S community-wide effort to analyze Intelligence & Sensors M&S gaps will result in reduced redundancy; greater leveraging of processes, data, and methodologies; and better integration of Intelligence & Sensor M&S into model federations.

The concepts, processes, and procedures used by the Intelligence & Sensors WG can be used by others to analyze capabilities which do not easily fit within one community. The Intelligence Environment and sensors are involved in and impact most warfighting functions, making it a challenging area to analyze and assess. Using the Special Topic CPR process and by developing analytical and voting procedures for the working group, this process was able to document 'what right looks like' and where there were deficiencies. Providing the results to the M&S Governance Forums and to the M&S community (Army, Joint, DoD, and Industry), allowed greater communication of existing solutions, tools and methodologies under development, and plans for future improvements which can meet the identified needs. The Intelligence & Sensors decision makers are also provided powerful information as to what the communities have prioritized as top needs and who are impacted by those gaps. This will provide funding decisions with solid analysis regarding who will use the solution and how critical it is to meet mission needs.

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REFERENCES

Headquarters, Department of the Army. (August 2012). *Intelligence*. Army Doctrine Reference Publication 2-0. Washington, DC: U.S. Department of the Army.

Nolan, J. (2016). Army Modeling and Simulation Forum. *Military Training International.* Retrieved April 13, 2016, http://www.mti-dhp.com/interesting-post/army-modeling-and-simulation-forum/

Pawling, C,R. (2004). *Modeling and Simulation of the Military Intelligence Process*. Air Force Institute of Technology, Graduate School of Engineering and Management. Master of Science Thesis, Wright Patterson Air Force Base, OH. http://www.dtic.mil/dtic/tr/fulltext/u2/a422885.pdf

Traylor, R., Johnson, C., Gavlinski, J. and Pilar, J. (2016). Modeling and Simulation Capability Portfolio Review and Gap Analysis, *The Interservice/Industry Training, Simulation & Education Conference*, Orlando FL, November 2016 (to appear).

US Army (2008) Field Manual 3-0. *Operations*, February.

Pirolli, P, Card, S.K. (2005). The Sensemaking Process and Leverage Points for Analyst Technology as Identified through Cognitive Task Analysis, *Proceedings of the International Conference on Intelligence Analysis*.

Tolone, W.J., Wang, X., and Ribarsky, W. (2014). Making Sense of the Operational Environment through Interactive, Exploratory Visual Analysis, *NATO/OTAN Symposium on Visual Analytics IST-116/RSY-028*.