Low-level Automation as a Pathway to appropriate Trust in an Intelligent PED Enterprise: Design of a Collaborative Work Environment

Michael P. Jenkins, Arthur Wollocko, Martin Voshell, & Mike Farry
Charles River Analytics, Inc.
Cambridge, MA USA
Email: mjenkins@cra.com

Abstract—**In Military Intelligence, Processing, Exploitation, and Dissemination (PED) functions are critical to success. These functions provide an array of capabilities that support the entire lifecycles of intelligence requests. Advanced PED capabilities are becoming increasingly available to smaller, more-centralized teams supporting multiple battlespace operators. As the PED domain evolves and more distributed information requests are made relying on an increasing volume of Multiple-Intelligence (MultiINT) information, automation support has become critical to success. However, automated support and cognitive incongruence between existing automated solutions and the support required by analysts, resulting in a lack of trust in these "black box" capabilities. To overcome this and other current and future PED challenges, we present a Collaborative Work Environment, serving as a central software platform providing communication channels and tailored workflow support tools for PED operations. Integrated within these capabilities is automation support in the form of decision-centered analytics, that carry out low-level tasks in a transparent manner, reducing workloads and establishing the intelligent human-machine dialogues required to form appropriate attitudes of trust towards the system (e.g., avoiding overreliance). This approach has shown promise in supporting trust in the overall joint human-automation system, enabling the PED enterprise to roll out higher-level, planned automation capabilities to further offload PED tasks.**

Keywords- PED; miliatry intelligence; intelligence analysis; automation; intelligent HCI; trust in automation .

I. INTRODUCTION

Maintaining military superiority in the 21st century is of utmost importance to the United States armed forces, but this preservation does not come without cost and significant changes to doctrine, ideology, and process. In order to dominate the 21st century battlefield, the Army has the need to transform from the premier land force of the past, and enhance itself for the evolving conflicts ahead. Warfare and battlefield operations are evolving at a previously unseen rate, causing an increased emphasis on decision dominance and speed. This emphasis is appropriate, because it drives and informs the decision making process at every echelon. Decision management is enabled by information superiority, which can be defined as the speedy generation, collection, and effective use of information to inform Commander's battlefield intent. The battle rhythm is shaped by this intent, which is passed through various echelons and different units through "information requirements" (IRs) about the environment [1].

For system developers looking to provide technology-based support in the form of automated capabilities, it is still unclear how this information collection is conducted, how it is converted into useful and manageable intelligence, and how it is distributed throughout the tiers of military command. Processing, Exploitation, and Dissemination (PED) is collectively defined as the conversion of collected information into forms suitable for the production of intelligence [1]. Overall, it is the process where analysts receive Commander's intent from IRs, and set about collecting and analyzing raw intelligence, converting it into usable and command-actionable forms.

PED has been conducted for decades in continually evolving formats, but its key functional components are getting increasingly difficult to define as new technologies and missions continue to outpace force structure changes and blur the lines between individual roles, responsibilities, and authorities [2]. System designers looking to provide relief for PED operations with shrinking manpower and rapidly expanding volumes of MultiINT data need guidance to ensure developed capabilities will succeed. This guidance must be grounded in a robust and deep understanding of the PED force structure, capability gaps, existing tactics, techniques and procedures, and where PED is evolving to ensure novel systems and capabilities succeed within the challenge PED landscape.

Section II of this paper presents a brief overview of the current state of PED and where the domain is trending, based on a series of knowledge elicitation interactions that our team has had with the PED community. Section III then covers the need for providing automated support capabilities to meet the challenges of current and future PED. Section IV provides a set of guidelines for establishing and maintaining trust in automation as a critical requirement for successful system design and deployment within the PED domain. Finally, Section V presents a brief overview of our ongoing efforts to design, evaluate, and deploy a collaborative work environment to meet a number of challenges facing current and future PED, referred to as PEDX.

II. PROCESSING, EXPLOITATION, & DISSEMINATION

PED (see Figure 1) is one of the most essential pillars of intelligence collection today, with the Army's focus currently being aimed towards developing ISR capabilities in support of PED. As MultiINT and multi-payload platforms have become increasingly utilized in current operations, they have not automatically reduced sensor operator workload or reduced manpower requirements. Instead these technologies

 ISBN: 978-1-61208-437-4

have led to both a growth of personnel requirements for their operation and, because they require operators to work at new intensities and new tempos of activity, they have created new complexities across military intelligence (MI) systems. While the Army is investing in novel sensors and automation capabilities in an attempt to reduce the burden placed on operators, acceptance of novel capabilities has been slow, delaying any significant enhancements to efficiency or performance at the forefront of the PED process. This results in analysts wedged between increased demands and reliance on antiquated technologies to perform their tasks.

The challenge for designers looking to provide new automated capabilities is that automation typically extracts humans from core processes that help them to better understand the context of a situation or analysis. In the case of multiple distributed operators (which is becoming commonplace as the Army transitions forward-deployed PED nodes connected to a centralized reachback PED center of excellence), if automation contributes to some small piece of a single contributor or cell of contributors workflow – the resulting impact on shared situational awareness can rapidly propagate to other collaborators as well. If this has significant impacts on collaborators productivity, the automated capabilities are likely to fail. This is evident by the many systems developed to aid PED analysts, which have fallen by the wayside in favor of antiquated, but proven technologies that are heavily relied upon throughout the PED community. While there is no doubt that automation has a significant role in both current and future PED workflows, introducing automation to those workflows in a way that will be adopted and enhance mission efficiencies is a challenging task that requires a strategic approach to planning, design, development, and deployment of system capabilities.

III. PED Automation Benefits

Ever increasing amounts of data are being generated by newly developed MultiINT sensor platforms, and demands for analysis of this data are increasing, all while the PED personnel footprint has remained stagnant and even reduced in many situations. In order for PED to continue to be successful in generating valuable and timely intelligence information with any sort of analytical rigor, automation is necessary to assist overburdened and overtasked analysts. For example, the vast majority of collaboration across PED stakeholders takes place via online chat. As a result, part of dissemination activities often involves generation of a communication log. This requires analysts to manual compile chat logs that typically involve 20+ individual and group conversations that take place over the course of an analysis. It is not hard to envision an automated capability to log and compile these chat dialogues. In fact, many procedural and analytical tasks throughout the PED cycle lend themselves towards automation, if capabilities are employed and integrated into existing workflows correctly.

While there is a clear need for automation in the PED process, even in cases where automated capabilities exist there is failure to adopt and rely on them by analysts. Often it is the case where more seasoned analysts who have a reliable workflow simply do not trust automated processes enough to learn or rely on them. This is in part because the majority of existing capabilities fail to integrate with existing workflows, requiring time-stressed and overloaded analysts to blindly abandon their proven methods and rely on a new workflow. PED analysts suffer from the same problems of introducing new automation that common across domains, including lack of understanding of the automated techniques that have already been developed, the availability and usability of automated software to help with simple or repeated tasks, and their lack of faith in these capabilities leading to a mistrust and lack of familiarity with the tools with potential to increase operating efficiencies and thereby increase the robustness of PED analyses and artifacts.

IV. Trust in Automation

For any automated capability to succeed in the PED environment, it must encourage analysts to trust the capability to improve their performance and to consistently meet their expectations with respect to what it can provide. While many system attributes (e.g., reliability, performance, predictability, availability, explication of intentions) are known to influence trust in automation, it is important to note that it is not the actual state of these attributes that influences attitudes of trust, but rather the perceived state of these attributes (which may not align with the true automation capabilities). However, a prerequisite for any change in analyst trust to occur is the decision of the analyst

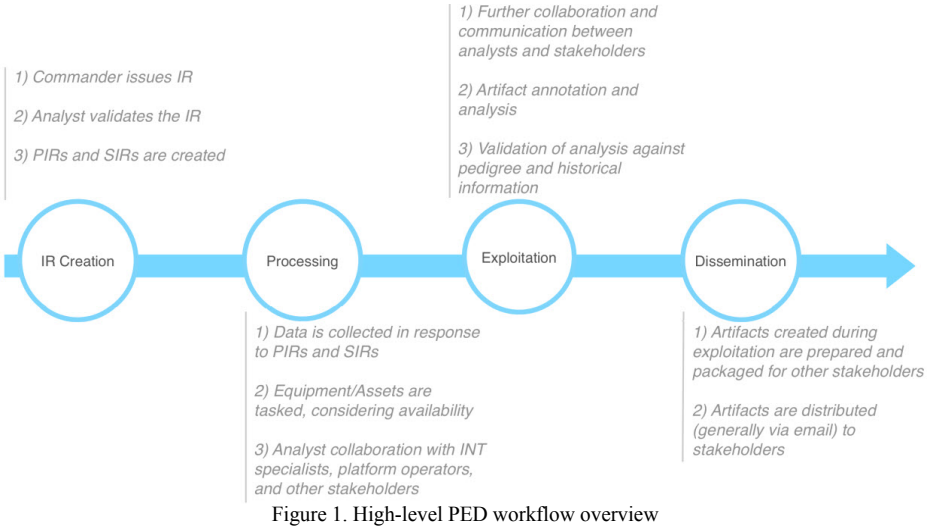

Figure 1. High-level PED workflow overview

to rely on the automated capability.

The decision to rely on any automated capability will result from situations where the analyst's reliance threshold (i.e., the point at which they decide to rely on an automated capability based on their system perception, workload, perceived risks, etc.) for the automated system is exceeded by the combination of changes in their trust in the system, self-confidence, and trust in alternative options. Consequently, any circumstances that result in decreases in the analyst's self-confidence or their trust in alternative options will create the potential for this prerequisite to be met and in turn for trust in the system of interest to evolve. As previously discussed, the real-world dynamics of the PED domain can create these circumstances based on changes to the overall task uncertainty, resulting from changes to data sets, problem structure and/or organizational uncertainty, or changes in the availability of the alternative options. Another set of circumstances that can result in the shifting of analyst trust based on differences in perceived capabilities would be situations where the analyst relies on the automated system and it meets/exceeds expected capabilities or fails to meet its expected capabilities (which would require a system feedback mechanism) causing the analyst to update the perceived state of the various automated capability attributes. While there is a vast collection of existing literature on trust in automation (see [3-5]), the implication for system designers is the need to design automated capabilities that facilitate initially establishing trust, while also providing system feedback elements that can help maintain it over time through an appropriate man-machine dialogue.

A. Designing for Successful Automation

One of the most critical characteristic of an automated system that will facilitate appropriate attitudes of trust is the ability of that system to effectively communicate its ability to perform as designed and expected [3,5]. While this may seem a simple requirement to system designers, effectively building out a system that can proactively recognize system shifts and effectively communicate self-health in a timely manner so as to calibrate operator expectations is a significant challenge. For the PED domain, this issue is compounded by the reluctance of PED operators to deviate from existing proven workflows and technologies given minimal resources to dedicate to learning nuances of new systems and adapting their procedures on mission critical operations. For this reason, we have established a series of

TABLE 1. GUIDELINES FOR SUCCESSFUL PED AUTOMATION SUPPORT DEVELOPMENT

Guideline	Justification
Integrate with existing workflows and workflow support systems	The engrained reliance on existing tools and systems is unlikely to be severed given fast tempos and constrained resources for PED analysts. Without buffers to enable analysts to experiment with new tools and augmented workflows to justify changing practices, it is unlikely new technologies will succeed over existing, proven systems and practices. By integrating with existing systems and workflows, analysts will have the ability to rely on novel automation capabilities to start calibrating their expectations of how those capabilities can enhance their productivity leading to the establishment of an initial attitude of trust.
Focus initial system capabilities on low-level automation	The performance variability of an automated capability is most often dependent on the variability of the inputs it must act upon. If available inputs are consistently changing or are of questionable pedigree, there is an increased potential for system performance to suffer. For new systems being deployed to the PED domain, if performance is highly variable, then it will be more challenging for analysts to appropriate calibrate expectations for a given system interaction. This creates the potential for inappropriate attitudes of trust that can lead to further mismatches in system performance and expectations, or simply analysts deciding to not rely on the capabilities at all. Instead, novel systems should deploy a set of low-level automated capabilities that do not require inputs with varying degrees of reliability. These types of capabilities often target highly redundant tasks. The benefit of this approach is that it facilitates appropriate calibration of performance expectations (given that performance is unlikely to significantly change) and fosters initial establishment and ongoing maintenance of positive attitudes of trust in the system. This initial calibrated attitude of trust then serves as a foundation for deploying more volatile automation capabilities such that system designers will be able to leverage the existing trust to encourage reliance on new system features to in turn foster appropriately calibrated expectations – without resulting in a significant enough decrement of trust in cases where expectations are not met to lead to abandonment of system reliance altogether.
Maintain transparency in automation	This is a standard piece of guidance for any automated system, and it applies to PED automation as well. For analysts trying to maintain context of multiple parallel analyses, processing data or allocating workflow tasks to automated capabilities will create a degree of separation for analysts and degrade their frame of reference unless automated processes are made transparent.
Utilize an ongoing dialogue to calibrate expectations	Similar to the third recommendation, automated capabilities should maintain an ongoing man-machine dialogue to foster appropriately calibrated expectations of system performance – this will ensure that attitudes of trust do not degrade when analysts make the decision to rely on automated capabilities.
Do not force reliance	Related to the first recommendation, integrating any new capability into the PED workflow and forcing reliance is likely to result in an extreme prejudice towards the system if it fails in any way to meet analyst expectations. Forcing analysts to rely on automation, and abandon their already proven and trusted systems will create potential for analysts to enter into system reliance with a negative view of the system and a significant desire to validate the system as faulty or not meeting requirements as justification for reverting to their trusted systems. Instead, novel capabilities should be provided that the analyst can optionally rely upon, enabling them to depend on capabilities when they see the benefit so they enter into the interaction with positive expectations for capabilities that will benefit their own effectiveness. This will remove the bias from situations of reliance and improve (with properly calibrated expectations) the likelihood of the analyst's attitude of trust towards the system improving based on the interaction.

guidelines (see Table 1) for system developers seeking to design successful automated capabilities to assist analysts in the PED or other similarly characterized domains.

The underlying assumption with these guidelines is that successfully deployment of novel technology-driven capabilities relies on the establishment and maintenance of an appropriately calibrated attitude of trust and pre-existing faith towards the introduced system's true capabilities. In order to establish and maintain this attitude of trust, it requires operators to make the decision to rely on the capabilities so they can benefit from the various feedback elements afforded by supporting the guidelines provided in Table 1. Therefore, these guidelines are intended to be applied in a stepwise manner, initially motivating decisions to rely on the automated capabilities to establish an initial attitude of trust and then incorporating the feedback dialogue layers to foster appropriate calibration and maintenance of this trust to motivate continued reliance on system capabilities when appropriate. This approach is beneficial as it encourages rapid deployment of relatively simplistic automated capabilities prior to their creation of more complex capabilities that may have a greater degree of performance variance (based on factors such as the quality of inputs made available to the system).

V. PEDX COLLABORATIVE WORK ENVIRONMENT

Through our numerous Knowledge Elicitation sessions with both reachback analysts and PED training experts, we have identified the central pillar of the PED cycle to be based around the efficient communications needed to support distributed (temporally and geographically) collaboration, with a particular focus on chat based collaboration. To this end we have begun prototyping an asynchronous chat client (PEDX; see Figure 2), modeled after a standard email client to increase familiarity and communication robustness by allowing for multiple concurrent conversational threads and in-line responses among other features. Chat is the main medium by which IRs are communicated, requirements for collection and exploitation are updated, and different stakeholders are informed of analysis. However, there is a severe lack of automation or utilization of new technologies employed today, with PED personnel continuing to rely on antiquated chat clients that become overwhelming as the number of conversations occurring at once increases.

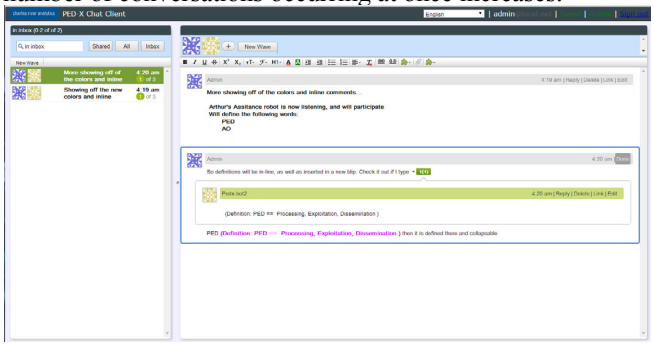

Figure 2. PEDX asynchronous thin-client chat

Following the guidelines presented in the previous section, we are developing and integrating automated capabilities (e.g., alerting and attention direction systems) that maintain transparency and do not force reliance, we hope to raise awareness, acceptance, and reliance of these tools as a pathway to support higher level automated features. Currently, the list of low-level automated capabilities that PEDX supports includes the following, and while they may seem simplistic, they offer significant enhancements to the PED process by offloading mental workload and providing added support for shared awareness between geographically and temporally distributed collaborators:

- Message date and time stamping
- Multi-thread chat log compiling / output generation
- New or revised information and content alerting
- Information prioritization and organization
- Acronym definition
- Platform asset capabilities and availability indexing
- Automated chat agents (e.g., weather request bots)
- Integrated file sharing
- Asynchronous multiple user geospatial layout editing
- Automated database queries
- Thread / chat log search

VI. CONCLUSIONS

This paper provided an overview of our attempts to integrate novel automated capabilities into existing and evolving PED workflows. We present guidelines for successfully deploying new technology to PED (and similarly characterized domains) centered on the idea of facilitating initial establishment and ongoing maintenance of trust to motivate appropriate decisions to rely on new capabilities. Our strategy focuses on building initial trust through low-level automation that integrates with existing workflows and systems, and without a dependence on highly variable system inputs to ensure consistent performance. This reduces the need for analysts to frequently calibrate system performance expectations, helping the system to meet expectations. Once initial trust is established, it can be leveraged to support deployment of more complex automation with a higher degree of performance variability. The initial attitude of trust serves as a buffer that will encourage decisions to rely on the automated capabilities so expectations can be properly calibrated and appropriate decisions to rely can be made.

REFERENCES

[1] M. Voshell et al., "Application of emerging technologies to support Army Processing Exploitation and Dissemination (TAPED)," Charles River Analytics, Cambridge, MA, USA, Tech. Rep. R0901542, 2013.

[2] J. Kraiman, B. Kingston, and J. Muccio. "Modeling and simulation of the ISR tasking, processing, exploitation, and dissemination (TPED) process." *AeroSense 2000*. Int. Soc. for Optics and Photonics, 2000.

[3] J. D. Lee, and K. A. See, "Trust in automation: Designing for appropriate reliance." *Human Factors: The Journal of the Human Factors and Ergonomics Society*, vol. 46.1, pp 50-80, 2004.

[4] R.R. Hoffman, M. Johnson, J.M. Bradshaw, and A. Underbrink, "Trust in automation," *Intelligent Systems, IEEE*, vol. *28*(1), pp 84-88, 2013.

[5] R. Parasuraman, Raja, and V. Riley. "Humans and automation: Use, misuse, disuse, abuse." *Human Factors,* 39.2 (1997): 230-253.

 ISBN: 978-1-61208-437-4