# Human Factors Guidelines for Developing Collaborative Intelligence Analysis Technologies

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# Human Factors Guidelines for Developing Collaborative Intelligence Analysis Technologies

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Intelligence analysis is changing in its the breadth and scope, bringing forth many new problems and challenges. Problems are increasing in volume, scope, and context. In response to changes, new technologies and the utilization of teams to conduct analysis have become imperative. Yet, though both are individually perceived as important, less consideration is given to *collaborative technologies* in intelligence analysis. More specifically, there is limited understanding of how to develop and design them in a meaningful and impactful way for the analysts. In this paper, through a review of the literature, our own work, and anecdotal reports from subject matter experts, we outline multiple human factors guidelines that are beneficial in studying and designing collaborative intelligence analysis technologies and tools. We conclude by highlighting multiple challenges specific to developing collaborative technologies in intelligence analysis.

## THE IMPORTANCE OF HUMAN FACTORS WITHIN COLLABORATIVE INTELLIGENCE ANALYSIS

The breadth and scope of intelligence analysis is changing. The problems that intelligence analysts now focus on are larger and more complicated than ever. Problems are increasing in volume, scope, and context. The amount of intelligence that analysts receive is significantly growing due to the implementation of soft/hard sensors, big data, and social media continually providing intelligence. The scope and context of intelligence problems is also constantly growing. Many of the problems are *relatively* new, focusing on global issues, such as climate change, healthcare, and cyber warfare. These are issues that are not going to be solved anytime soon, and are creating many new challenges for the domain of intelligence analysis. Due to the influx and change in volume, scope, and context, intelligence analysis is more difficult than ever. In response to the many changes within the intelligence analysis domain, many new methods, technologies, and challenges have presented themselves.

Over the years, internal (Department of Defense) and external (academic and industry) mechanisms of inquiry and evaluation have provided insights about the successes (capturing Bin Laden) and failures (9/11) of intelligence analysis. Two main areas of research directly linked to the successes and failures of intelligence analysis that have been articulated as being extremely impactful are: 1) Development of Technology & Tools (Elm et al., 2004), and, 2) Teamwork and Collaboration (Trent, Patterson, & Woods 2007).

Recently, intelligence analysis has become technology and/or tool driven. The constant barrage of information coming to an intelligence analyst has made it difficult to organize, synthesize, and articulate the information. One meaningful way to aid in this is the implementation of tools to provide assistance. Yet, for these tools to be successful, they must be motivated by the intelligence analysts' work. Intelligence analysis is a highly cognitively demanding workspace, so specific attention must be paid to both analysts' interaction and cognition, and the interplay between both.

Often, in the intelligence analysis domain, there is the mistake of creating an intelligence technological product (aid or tool) just to create it, without fully understanding how the technology should be designed to aid the intelligence analysts' current work or problems. In addition, once these tools are created, they are often not introduced in a meaningful way to extend their usage. In order for analysts to use a new tool, they must understand *when* and *how* to use it. This is one need that the human factors community can address to make a significant impact. Through the utilization of cognitive task analysis (CTA), some researchers have articulated the work and challenges of intelligence analysis while also recommending design concepts and ideas (Hutchins, Priolli, & Card, 2007; Connors et al., 2004). Although this work is valuable, there has not been enough of it, and more specifically there has not been enough *recent* work to keep up with the changing world of intelligence analysis.

Another area that is being recognized as beneficial for intelligence analysis is the utilization of teamwork and collaboration. One of the main failures of 9/11 was the lack of collaboration within and throughout the intelligence community (Kean & Hamilton, 2004). In response to that failure, we know that the intelligence community now encourages and uses teams more than in the past. Yet, there is a paucity of literature focused on teams within the intelligence analysis domain. But, just recently, researchers identified that teams of people are better than individuals at conducting intelligence analysis (Mellers et al., 2015). This aligns with research that identifies significant performance advantages to collaborating and working within teams (Salas, Cooke, & Rosen, 2008). The ability to collaborate within the context of intelligence analysis has the potential for more information being shared, multiple perspectives being integrated during information synthesis, and corroboration of information analysis.

This paper aims to outline multiple human factors guidelines that can be utilized to develop collaborative technologies to aid intelligence analysis. The paper is outlined as follows. First, we review multiple specific human factors guidelines for designing collaborative intelligence analysis technologies. Next, we discuss the challenges to implementing many of the aforementioned guidelines in intelligence analysis

practice and how to approach these challenges. Finally, we conclude the paper with the suggestion that these guidelines be further considered in future research studies and the development of collaborative technologies.

## HUMAN FACTORS GUIDELINES FOR DEVELOPING COLLABORATIVE INTELLIGENCE ANALYSIS TECHNOLOGIES

Due to the importance and closely linked relationship of technology and collaboration within the intelligence analysis domain, it is extremely valuable to understand how collaborative technologies are developed in this space. As previously noted, we take the perspective of using human factors as a theoretical perspective for developing and implementing collaborative intelligence analysis technologies. Below, we present human factors design guidelines that should be considered during the development of collaborative intelligence analysis technologies and tools. These guidelines were developed from a review of the literature, our own work, and anecdotal reports from experts in the field of intelligence analysis. We are not making any claims that these guidelines are new, or necessarily innovative beyond their application to intelligence analysis. In reviewing the literature, we have learned that the domain of intelligence analysis has not considered human factors to the degree that it should. Finally, this is not a comprehensive list, but rather guidelines that we feel are most important for this unique context.

### Understand Analysts' Work

This is the single most important guideline. An accurate understanding of the analysts' work must motivate the development of a collaborative intelligence analysis tool. Understanding analysts' work should be broken down into two similar yet different perspectives: 1) Understanding and Supporting Individual Work, and 2) Understanding and Supporting Collaborative Work.

*1) Understand and Support Analysts' Individual Work*

The work and job functions of an intelligence analyst historically take place at an individual level (Swenson, 2003). From a high level, an analyst is required to look at information, understand the information, connect information together, and synthesize connecting information, all with the goal of producing an intelligence report. This is normally done by one individual. The emphasis and manner in which intelligence analysis is conducted is most likely always going to be dominated by individual work, strictly due to the nature of the work itself. This means that designs for collaborative technologies in this space must understand, account for, and support the individual functions mentioned above.

*2) Understand and Support Analysts' Collaborative Work*

Although individual work is highly prevalent within the analysts' scope of work, collaborative work is apparent and its utilization is continually growing. Therefore, it is incredibly important to consider collaboration during intelligence analysis. Specifically, *when* and *how* analysts currently collaborate must be identified. Simply understanding when an analyst chooses to collaborate with other analysts is incredibly beneficial in understanding how to design a collaborative tool. Knowing when collaboration happens can help inform the design to support this moment in time (assuming it occurs routinely). Similarly, knowing how collaboration happens within the context of the analysts' work is also fundamental to informing the design. The work of an intelligence analyst is so specialized that significant efforts must go into understanding the many intricacies of both individual and collaborative work. We recommend that researchers first conduct a CTA to understand the (individual and collaborative) work of intelligence analysis. This approach has been taken by other researchers and has helped to inform technology development within the context of intelligence analysis (Hutchins, Priolli, & Card, 2007; Trent, Patterson, & Woods, 2007).

### Design to Compliment Analysts' Existing Workflow

This guideline directly ties into the previous guideline, aimed at understanding the analysts' work. As a researcher, the goal should not only be to understand the functions and responsibilities of the analysts' job, but also understand when and how they perform these aspects of their job. Understanding when and how allows for a greater understanding of the analysts' current workflow. For the most part, whereas the problems and content that intelligence analysts are working with is constantly changing, their workflows are highly structured and often persist on a daily basis. This makes it easier to design collaborative technologies due to the increased ability to assume when and how analysts will collaborate based on an understanding of their previous workflows. Furthermore, workflows are often cemented in place before the researcher shows up to analyze the setting (especially true in the intelligence analysis setting). Although, while it is certainly possible to change workflows, it is challenging and requires a great deal of up front analysis, and even more importantly, time and patience. In response to this challenge, the development of new collaborative technologies can be implemented to compliment the existing workflow. Yet, this should really only be done if the existing workflow is successful.

### Integration, Transition, & Interoperability of Individual & Collaborative Work

Not only is it critical to support both individual and collaborative work, it is imperative that the design of collaborative technologies account for the transition between individual to collaborative work and collaborative to individual work. Work by Scott et al. (2003) previously identified the significant impact of transitioning between the two settings, suggesting that one way to aid the transition is to provide both individually oriented (personal display) and team oriented technologies (large tabletop display). Although we agree that this is a useful recommendation, we feel that it goes beyond just having individual and team oriented technology. In order for these technologies to support the transition between and among them, they must also be integrated with each other and complement one another. For example, the work that an analyst is conducting on an individually oriented tool should be able to seamlessly be displayed or transitioned onto the team tool. Furthermore, it is extremely useful if the individually oriented tools are designed using similar principles as the collaborative

tool. This goes beyond having the user interface look the same, but rather that there are features built within each that complement one another at different levels of work. Ultimately, when designing for collaborative intelligence analysis tools, it is important to have tools that both support individual and team based work. Yet, it is equally important that those tools efficiently interact with each other to create a collaborative ecosystem.

**Consideration of Current & Previous Intelligence Analysis Technology to Inform New Design**

As noted earlier, intelligence analysis is technology and tool driven. Intelligence analysts already have a multitude of tools available at their disposal. Yet, even though they have many tools, we know that these tools often do not support their tasks (Pirolli, Lee, & Card, 2004). Therefore, understanding specifically how previous and current tools succeed or fail in supporting the analysts' work is meaningful to informing new technologies. Because so many tools have already been developed for intelligence analysts it is critical that these tools are reviewed, specific to how they either supported or did not support the analysts' work. Considering previous and current technology's successes and failures generates new knowledge that can then be applied directly to the development of a new technology. This new technology should be 1) motivated by the analysts work, *but* also 2) consider aspects of previous and current designs that have succeeded and failed. If we know that a previous technology failed due to aspects of visually oriented information overload within the context of imagery analysis, then the aim should be to prevent that from happening again within a new technology. The point here is not to base new technology on old poor existing technology. Rather, to look at where old poor technologies failed within intelligence analysis and learn from that. Understanding both current and previous analyst technologies should feed right into the development of new technology. It is incredibly important not to reinvent the wheel, if it is not necessary.

**Accounting for Dynamics of Collaboration: Communication and Coordination**

Often, when people consider collaboration they think about working together or sharing information. This is certainly part of collaboration, but there are also many detailed dynamics associated with it. Communication and coordination are at the foundation of what is considered collaboration. Communication occurring during teamwork is vital to understanding team content and knowledge. Coordination explains when communication takes places, thus greatly impacting how communication is cognitively processed. Both communication and coordination develop and result in interaction. That interaction (at a team level) is team cognition (Cooke et al., 2013). The implications of accounting for and understanding analysts' communication and coordination in a collaborative design ensures that interaction is able to occur in a meaningful way, while helping to also develop team cognition.

**Consider Analysts' Physical Work Space**

As noted in the previous guideline, collaboration is dependent on team dynamics (communication & coordination), team interaction, and team cognition. Yet, an aspect that is often overlooked when considering all of the aforementioned is physical space. Physical space has a direct impact on how we interact and cognitively process our environment. Space has the ability to encourage or limit collaboration depending on the physical layout. In the context of intelligence analysis, space is traditionally defined by individual workstations, limiting aspects of collaboration. When developing a collaborative tool, the physical space must be assessed in order to understand how the tool can accurately support (and in some cases encourage) collaboration. If the collaborative tool does not match the physical constraints of the workspace, it will become burdensome for the analysts to use and they will not adopt it.

**Consider Information or Intelligence Being Displayed or Presented Within Technology**

Clearly, information is extremely critical to intelligence analysis. The amount of information that analysts must parse through and synthesize is overwhelming in some cases. Analysts need tools that help them understand information, not present unneeded or unnecessary information to them. For this reason, any tool associated with information needs to be highly motivated by the importance of the information. In addition, that information must be presented in a way that is meaningful to the analysts. Often, too much information is presented, resulting in information overload and stretching one's cognitive capacity (Chen, Pederson, & Murphy, 2012). In a collaborative environment, there is even more information presented due to multiple team members bringing their information to the table. This means that a collaborative tool must identify what information is important and display it in way that is valuable for the entire team. Understanding what information is valuable and how to most effectively present it can be ascertained through the aforementioned CTA methodology.

**Development of Awareness and Team Cognition**

The impact of awareness and the development of team cognition are well documented in the literature and should be accounted for when designing collaborative intelligence analysis technologies. Awareness is home to multiple research communities, but most often mentioned in the light of situational awareness. Increased situational awareness has proven numerous times to have the ability to positively affect team performance (Bolstad, Endsley, & Cuevas, 2013). In addition, situational awareness develops during team cognition (Cooke et al., 2004). The development of team cognition during teamwork or collaboration is also directly related to increased team performance (Salas, Cooke, & Rosen, 2008). Therefore, knowing the impact that situational awareness and team cognition have on collaborative performance, collaborative technologies must be designed to aid in the development of both.

In the context of intelligence analysis, researchers have noted the importance of team cognition (Trent, Voshell, & Patterson, 2007). In intelligence analysis teams, analysts are often working on the same or similar problems. Because of this, much of the information among the analysts is the same or has

some overlap. Developing awareness of what other teammates are working on and the information that the team is utilizing is beneficial to developing team cognition.

### Train Analysts for When & How to Use Technology or Tool

It's not enough to design the perfect collaborative tool, if the users are not properly trained in when and how to use the tool. Training is extremely valuable in all aspects of collaboration (Salas et al., 2012), including technology adoption. If users fail to understand how to use the tool and do not see significant benefit in using the tool, they will not adopt it. In the context of intelligence analysis, analysts are severely time pressured and will not continue to attempt to use a tool if they fail to see the value in it or if it just does not work. Simply, intelligence analysts know how to complete their work. So, if something new is introduced and they do not understand how to use it or feel that it will not help them complete their work, they will stop using it and revert back to how they previously conducted their analysis. An argument can be made that training is even more important for a collaborative tool. Not only do users need to be trained on how to use and interact with the tool itself, but they should also be trained on how to interact with their collaborators while using the tool.

## CHALLENGES TO IMPLEMENTING HUMAN FACTORS GUIDELINES WITHIN COLLABORATIVE INTELLIGENCE ANALYSIS TECHNOLOGIES

Although taking a human factors approach to designing and implementing collaborative intelligence analysis technologies is valuable, it is still very difficult due to the unique context of intelligence analysis. Intelligence analysis is a highly contextualized context that is unlike any other. Much of the domain is restricted from the public, making it incredibly hard to analyze and understand. Through our experiences in conducting intelligence analysis research and reviewing the associated literature, we have identified three main challenges that limit the ability to implement some of the aforementioned human factors guidelines. Issues with access, culture, and variance among analysts are all challenges found within intelligence analysis. Our point here is not to say that the guidelines can't be utilized within intelligence analysis, rather that the context's uniqueness makes it difficult in some instances. Below we describe each of the challenges in detail.

### Access Restrictions

Acquiring access to intelligence analysts is challenging. The context is extremely private due to the need to protect national security interests. The process of actually being able to collect data from intelligence analysts is tedious, with the researcher having to go through many protocols. In addition, if the researcher wants to actually talk with an intelligence analyst or observe the analyst doing work, they almost have to have a national security clearance. Furthermore, even after one has acquired access, it is hard to actually collect data due to analysts being very busy. An intelligence analyst's time is extremely limited due to the pressure to produce reports based on the information that each is analyzing. Therefore, having an analyst fill out a survey or submit to an interview is difficult due to the analysts' limited time. Analysts are not going to jeopardize their own work, which they are evaluated on, in order to take part in research. The agency must back the researcher and allow for analysts to take off time to participate in research, or it will not happen.

The implications of limited access greatly impact the ability to consider many of the aforementioned guidelines. If researchers are not given the opportunity to understand analysts' work, environment, technology, and challenges, then designing or recommending any type of new collaborative technology is limited. In fact, if researchers fail to learn about these aspects of intelligence analysis, there is little need to even attempt to design new technologies. The design will not be informed by any real world motivation, with the consequence being that the design will not be meaningful or useful to the analysts' work. The need to understand *humans* and their *work* is paramount in implementing a human factors approach to design.

The traditional response to this problem is to have researchers internal to each agency conduct evaluations on analysts' work, environment, and technology. Although this is a worthy effort, there are flaws associated with it. First, conducting a CTA is a highly involved process that requires specific training (Crandall & Hoffman, 2013; Cooke et al., 2000). A CTA is *not simply* asking users what they think and observing them, there is much more to it than that. And, in order to conduct a proper CTA, the researcher must understand the context and which methods are most effective within the context. It is likely that many agencies do not have a CTA expert on staff. If there is no one who is fully trained in conducting CTAs, then the evaluation and recommendations derived from the analysis will not be as rich or insightful as someone who is formally trained on CTA. Second, having internal employees perform evaluations or analyses such as a CTA is detrimental to the analysis because internal employees inherently have a cognitive bias. This bias is oriented to their organization and their peers and is built on the knowledge that they have acquired through their numerous experiences within the organization. These experiences then manifest themselves as assumptions or expectations. Assumptions and expectations are harmful when completing an analysis like a CTA. It is only normal for a human to develop these assumptions and expectations, and it is nearly impossible to harness them and not let them affect judgments. This is why a CTA truly needs to be conducted by an outsider. Yet, in this context, it is quite challenging to gain access to conduct a proper CTA. That being said, it has been done, as noted by the previous articles we have cited.

### Culture

The culture of intelligence analysis is quite unique, mainly due to the nature of the work. Traditionally, intelligence analysis is a very isolated activity, dependent mainly on the individual and not teamwork. Anecdotal reports from people working within intelligence analysis suggest that the job attracts more introverts than extroverts. This directly impacts the culture in relation to teamwork and collaboration. Introverts certainly collaborate and enjoy working in teams when they perceive it as beneficial, but they are generally not going to initiate collaboration as

much as an extrovert would. In addition, previous work has indeed found that extraversion is a variable positively impacting contextualized team performance (Morgeson et al., 2005). The introverted nature of many analysts poses challenges for designing collaborative technologies. First, and simply, there is a possibility that introverted analysts will not adopt the collaborative technologies as fast as extroverts. Therefore, it is even more integral that designers consider the introverted nature of the analysts and also provide extensive training to show the technologies benefits.

In addition to the introverted culture of intelligence analysis, there is also an aspect of the culture that is secretive. This stems back to pre-9/11 when agencies failed to share information with one another, resulting in significant and tragic failures. Since then, agencies and analysts within the agencies share information with each more effectively, but there is still an underlying sense of secrecy. In many cases, analysts are not given the source of the information they are analyzing, which negatively impacts the ability to judge or validate it (Treverton & Gabbard, 2008). In addition, many analysts are on a need to know basis (Treverton & Gabbard, 2008). Finally, there are concerns with security clearances and who can view what information.

Aspects, such as these, make it difficult for analysts to feel open about sharing and discussing their intelligence. These difficulties impact how analysts then view and use collaborative technologies. If analysts are constantly worrying about what information they can share with one another, then they will also worry about how collaborative technologies will impact these issues.

### Intelligence Analyst Variance

The role of an intelligence analyst varies greatly due to many different considerations. Ultimately, at the highest level, an intelligence analyst is making sense of a great deal of information. Yet, there are *many* different types of analysts, dependent on job specific functions, sources of data, and the area of the world that their intelligence is focused on. Due to this, it is extremely hard to produce a generalized description of an intelligence analyst. Consequently, due to this large variance, designing collaborative technologies for intelligence analysts is very difficult. This is one of the many reasons that we recommend that upfront analysis must be conducted on the analysts' work and environment. Different analysts will collaborate in very different ways, making it extremely hard to develop a technology for one analytical context and implement it in another.

## CONCLUSION

In this paper, we have presented some high level human factors design guidelines that are beneficial to the development of collaborative intelligence analysis technologies. We feel that these guidelines are imperative to the intelligence analysis context and will help inform further studies and the development of future collaborative technologies. In addition, we have outlined potential challenges that are specific to this context and the development of collaborative technologies. We hope that our experiences will inform and help future researchers in this field.

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