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COGNITIVE RESEARCH FOR PLANNING AND DIRECTION, COLLECTION, PROCESSING AND EXPLOITATION, ANALYSIS AND PRODUCTION, AND DISSEMINATION (PCPAD-X) AND ANALYST TESTBED (ATB) USER ANALYSIS IN ANTI-ACCESS/AREA-DENIAL (A2/AD)

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Final Report

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14. ABSTRACT
This effort was to support the study of analysis tasks and candidate supports in contested Planning and Direction, Collection, Processing and Exploitation, Analysis and Production, and Dissemination (PCPAD) environments. The work encompassed a broad series of objectives, ranging from cognitive data collection and analysis, to process and tool redesign to exercise support, to continuous provision of both cognitive and intelligence analysis expertise across many efforts. These endeavors identified, established, and maintained critical connections across the Air Force Intelligence, Surveillance and Reconnaissance Agency (AFISR) enterprise to enhance analyst performance in A2/AD environments.

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1.0 OVERVIEW

This primary objective of this effort was to support the Air Force Research Laboratory (AFRL) 711TH Human Performance Wing (HPW), Airman Systems Directorate, Warfighter Interactions and Readiness Division, Mission Analytics Branch (7llth HPW/RHWA) in the study of analysis tasks and candidate supports in contested Planning and Direction, Collection, Processing and Exploitation, Analysis and Production, and Dissemination (PCPAD) environments. In doing so, the 361 Interactive Research and Development (R&D) research team provided support that took a range of forms, and encompassed a broad range of objectives, including cognitive data collection and analysis, process and tool redesign, exercise support, and the continuous provision of both cognitive and intelligence analysis expertise across multiple efforts. In addition, the team helped to further identify, establish, and maintain critical connections across the Air Force Intelligence, Surveillance and Reconnaissance Agency (AFISR) enterprise, thus enabling 711th HPW/RHW to continue current awareness of the state of this critical component of the Intelligence Community (IC). The ultimate objective of this support was to enhance analyst performance when conducting analyses in existing and emerging environments.

1.1. Broad PCPAD Analysis Expertise/Support.

The team provided PCPAD cognitive and intelligence analysis expertise and support across a wide range of groups and needs across for AFRL and AFISR partners, including, but not limited to:

- AFRL Sensing & Effects Analysis Branch (AFRL/RYAA): – Patterns of Life R&D group
- R&D briefings to Global Hawk community
- R&D briefings to PCPAD-X committee
- Multisource Analytics Development and Evaluation (MAD-E)/ Investigative Search for Graph-Trajectories (INSIGHT) Hackathon support
- Jukebox18 (JB18) Exercise Working Groups
- Patterns of Life working groups (Overhead Persistent Infra-Red [OPIR]/Automatic Target Recognition [ATR] technology briefings and expertise)
- 711th HPW/RHWA – National Air and Space Intelligence Center (NASIC) OPIR Search information exchanges
- National Geospatial-Intelligence Agency (NGA) Innovision team
- AF/A2 Data to Decisions (D2D)-sponsored MAD-E Systems for High-Performance and Accelerated Global Intelligence (SHAGI) MAD-E Systems for High-Performance (MASH) program
- Multiple Air Operations Center (AOC) & Distributed Common Ground Station (DCGS) locations, identifying communications paths and structural differences, candidate workstation reconfigurations, and an overall cross-matrix
- Demonstrations for multiple R&D tools in development, including the Speech-to-Text for Enhanced PED (STEP) system and others.
- Air Combat Command - providing Geospatial Intelligence (GEOINT) Mission Thread document inputs

Specific technical achievements resulting from this effort are listed below and summarized at an unclassified level in the sections that follow. Note that while these activities all supported the common thrust of studying and promoting the analysis processes and potential supports for PCPAD in contested environments, their individual contexts varied as they were driven by AFRL mission and research demands. Additional detail on these activities beyond that presented in this summary report is available upon request.

2.0 COGNITIVE ELICITATION AND ANALYSIS

2.1. Elicitation Guide Development.

The research team developed a range of cognitive task analysis knowledge elicitation guides. These guides were tailored to the needs of individual project objectives, and they aimed to focus the data collection teams on common objectives and elicitation methods to achieve those objectives. The guides provided clear direction, with visual supports, on how to conduct various elicitation techniques aimed at different elements of the decision making process. Methods focused on team communications/dynamics, cognitive components of individual decision-making, barriers to effective operations, and tools/processes currently used. Figure 1 illustrates a partial sample of an elicitation guide (See Appendix A for a complete sample guide).

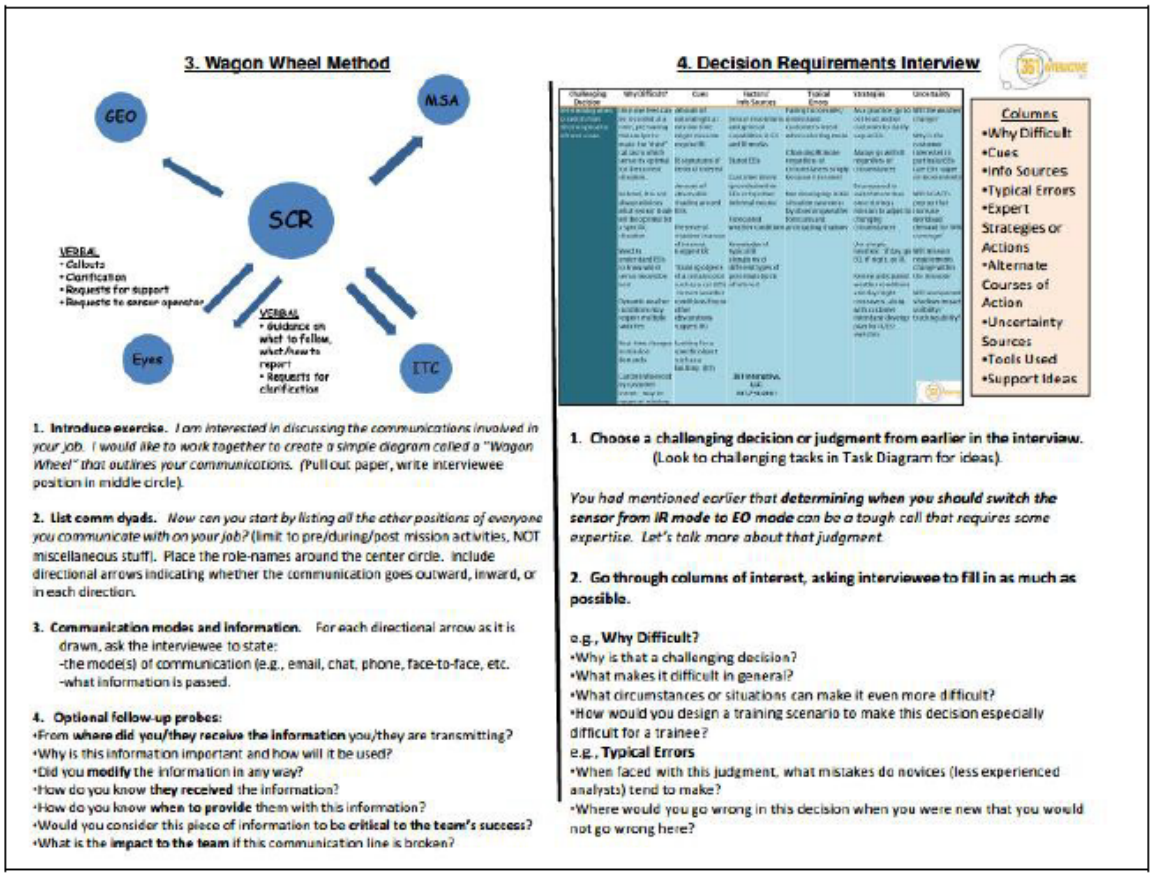

Figure 1. Partial Sample of the Cognitive Elicitation Guide.

2.2. Pre-Collection Training.

Related to the Cognitive Elicitation Guides, the research team also trained interview team members on data collection requirements for upcoming trips. These were informal, often one-on-one sessions, focused on aligning interviewers, and ensuring they had the resources and abilities to consistently collect needed data in a semi-structured format.

2.3. Cognitive Task Analysis (CTA) Workshops.

Also related to the Guides, the team developed and presented multiple workshops to AFRL personnel, training them on a higher level and across efforts on the theory and practice of CTA

interviews, representation, and analysis. Although these workshops directly benefited efforts under this thrust, they also included personnel associated with other projects. The overall broader workshop materials, while already provided to multiple AFRL personnel, are available upon request.

2.4. Data Collections/Knowledge Elicitations.

Team members led and participated in a wide range of cognitive data collections and exercise observations in support of varied AFRL/RHCM efforts. They conducted many interviews, primarily with intelligence analysts, but also with intelligence unit leadership, decision analytic developers, and exercise developers. Target audiences for our knowledge elicitations included, but were not limited to:

- AOC, Distributed Ground Station (DGS), 501st, and USAF Korea
- 178th Intelligence Wing (several occasions)
- 181st Intelligence Wing (several occasions)
- Strategic Analysis Enterprises (SAE)-Virginia
- JB18 Exercise Planning Working Groups and Exercise
- Visiting analysts from USAF Korea
- NASIC Intelligence Analysts (several occasions serving multiple purposes)
- Trident Spectre Exercise
- AFISR Open Source Intelligence (OSINT) analysts (several occasions)
- Collected data for Synthetic Aperture Radar (SAR) Study, running multiple participants with differing intelligence roles
- Defense Advanced Research Projects Agency (DARPA) Causal Exploration Program Planning Exercise participation and observation
- DARPA Causal Exploration Program operational exercise observation

Following these data collections, research team members commonly led the data analysis, knowledge representation and subsequent outputs and products.

3.0 MAD-E/INSIGHT R&D

Multiple members of the team were heavily involved in the MAD-E program. The intent was to provide both cognitive support and intelligence analysis expertise/perspective to the INSIGHT tool and user interface development. To get up to speed, the team reviewed extensive documentation on the INSIGHT tool, and attended meetings at BAE Systems, the main subcontractor developing INSIGHT to elicit knowledge regarding evidence matrix collection. We also attended "Hackathons," providing ISR subject matter and Joint Planning (Course of Action [COA] Development) expertise to the MAD-E developers. We provided inputs on how to approach COA predication models to make them operationally relevant, also conducting a literature review on adversary COA prediction modeling.

3.1. Cognitive Input/Review of Products

Throughout the course of the effort, our team developed novel design concepts for supports, and also reviewed multiple analytic products in development by AFRL and by others across the period of performance (PoP). These products were all intended to promote PCPAD analysis.

4.0 DARPA CAUSAL EXPLORATION SUPPORT

The team performed cognitive analysis of DARPA Causal Exploration tool across multiple meetings and collaborations in addition to the above. Team members traveled to both a pre-exercise planning session, where we played the roles of users and provided usability feedback, and to the official United States Indo-Pacific Command (USAINDOPACOM) exercise, where the tool was implemented with a group of strategic planners, establishing Critical Connections in the IC. Throughout the effort, the research team leveraged their knowledge of, and connections within, the AFISR community to identify, contact, and secure access to a wide range of both intelligence analyst experts, and AFISR leadership. These connections were leveraged repeatedly to support a wide range of AFRL efforts, ensuring that data collected was representative of real-world operational environments, that decision supports were informed by in-context, expert decision making, and that RHWA efforts had advocates in the operational community.

5.0 DATA REPOSITORY

The team worked on developing a user analysis data repository. We conducted significant research on assessing alternate strategies for incorporating the resultant database into classified environments and to revise key categories and basic structure to better support entering/managing inputted information (better distinguishing data from analysis products) The team investigated Joint Worldwide Intelligence Communications System (JWICS) Intelipedia to investigate candidate database housing solutions, studies Amazon Web Services, and researched and submitted a ticket for MediaWiki on JWICS. We met repeatedly with the sponsor to discuss options regarding Confluence, pros and negatives, usability, and the differences between Confluence and MediaWiki. Ultimately, we identified Jira/Confluence as a most likely, feasible, and optimal database housing solution. We transferred collected data into Confluence working through various issues, making confluence more streamlined and user friendly. We registered, and were approved for, a Defense Intelligence Information Enterprise (DI2E) account so that research team can collaborate on unclassified network.

6.0 HUMAN-CENTERED SUPPORT TO ANTICIPATORY ANALYSIS TOOL DEVELOPMENT

The research team provided support to an AFRL/RHWA effort to analyze and improve an anticipatory analysis tool under development by SAE. In addition to working with the sponsor to align the effort with RHWA objectives and thrusts, the team performed several knowledge elicitations with SAE. The emphases of these elicitations and meetings was to gather information to enable tool interface redesigns, and to support the SAE team in developing an understanding of the perspective of users who could eventually be interacting with the tool, ensuring that user needs guide interfaces and functionalities. The team developed interface concepts and prototypes, tutorials, and visualizations, and also elicited and framed issues and goals for limited-capability tool deployment, creating a taxonomy of uses/tasks. The team met repeatedly with SAE modelers and software engineers to discuss specific requirements, and established direct lines of communication with SAE to provide timely tool analysis support. The team also interacted with Drs. Lyons and Panganiban (Fallon) regarding strategies to enhance human-machine trust calibration and user acceptance of the SAE products. In order to gain a better understanding of the intended users and further guide interface concept design, the team elicited sponsor specifications about intended users.

The team developed tutorial concepts, explored commercially available visualization tools (e.g., Plotly, RAWGraphs) that could be leveraged to design interfaces to support OSINT analysts monitor key 'first-person' indicators (e.g., sentiment, social identity, cognitive complexity) in open sources. The goal was to provide analysts with a tool that can provide an additional lens to complement the data and analyses they currently use. The team conducted research to better understand OSINT analysis to determine the best approach to support the design of visualizations and interfaces for OSINT analysts. They also conducted multiple reviews of the literature, gathering resources to guide the re-design of the SAE interface, including research on ecological interface design for military command and control and on interactive visualization for health care.

The research team developed a taxonomy of uses/tasks in order to organize the types of uses/tasks that interfaces must support. For example, for monitoring use, they emphasized change detection and developing interface features to highlight changes that might warrant the user's attention. When used to compare alternative courses of action, the goal is different. Interface features should allow users to easily see how the forecasted outcome changes with different factors and selected courses of action.

This taxonomy was intended to facilitate discussion about interface design concepts by clearly distinguishing different uses/tasks that may require different interface features to be most useable.

The team developed a mock version of an interface to display the impact of alternative COAs on indicators and outcomes. Based on meetings with the sponsor, the team then continued to explore approaches to research COAs involving actors other than the US engaging with the target. The team refined and expanded the initial mock version of an interface to display the impact of alternative COAs on indicators and outcomes based on the data available on the Anticipatory Analysis slide deck. They then integrated a subset of the variable levels to simulate envisioned functionality and illustrated the interface concept to the sponsor. The team also began development of a notional and interactive interface to support SAE's anticipatory analysis tool,

showing levels of potential outcomes in terms of mediating variables and launches, given changes in U.S. actions taken. The team then developed an initial concept design focused on supporting the decision maker (first) and providing the ability to dig into the underlying data and model (second).

7.0 LIST OF ABBREVIATIONS, ACRONYMS AND SYMBOLS

AFRL/RYAA	AFRL Sensing & Effects Analysis Branch
ACC	Air Combat Command
AFISR	Air Force Intelligence, Surveillance and Reconnaissance Agency
AFRL	Air Force Research Laboratory
AOC	Air Operations Center
ATR	Automatic Target Recognition
COA	Course of Action
D12E	Defense Intelligence Information Enterprise
D2D	Data to Decisions
DARPA	Defense Advanced Research Projects Agency
DCGS	Distributed Common Ground Station
DGS	Distributed Ground Station
GEOINT	Provided Geospatial Intelligence
IC	Intelligence Community
INSIGHT	Investigative Search for Graph-Trajectories
JB18	Juke Box 18
JWICS	Joint Worldwide Intelligence Communications System
MAD-E	Multisource Analytics Development and Evaluation
MASH	MAD-E Systems for High Performance Program
NASIC	National Air and Space Intelligence Center
NGA	National Geospatial-Intelligence Agency
OPIR	Overhead Persistent Infra-Red
OSINT	Open Source Intelligence
PCPAD	Planning and Direction, Collection, Processing and Exploitation, Analysis and Production, and Dissemination
PoP	Period of Performance
R&D	Research and Development
SAE	Strategic Analysis Enterprises
SAR	Synthetic Aperture Radar
SHAGI	Systems for High-performance and Accelerated Global Intelligence
STEP	Speech-to-Text for Enhanced PED
USINDOPACOM	United States Indo-Pacific Command

APPENDIX A - Sample Interview Guide

Overall Objectives

This data collection is intended to explore the following questions:

1. How do analysts who are experienced in target research and/or selection:
    a. Determine when an existing target no longer merits observation?
    b. Conduct research on specific upcoming targets prior to mission, or enroute?
    c. Conduct research (using what intelligence (INT) sources) to identify candidate new targets?
    d. Evaluate/Prioritize alternate candidate targets?
2. How would these same analysts specifically use Interrogation Control Element (ICE) in conjunction with Human Intelligence (HUMINT) sources to do the above?

Additional ICE interviews will be conducted if needed to assess overall ICE usage and issues, both current and projected. Candidate ICE configurations may be presented and reviewed as well.

Interview Protocol

Part 1: Concurrent Thinkalouds During Simulated New Target Search Overview:

Interviewees will identify a recent or candidate target and conduct research while interviewees probe with thinkaloud questioning. They will first conduct "preparatory" research on that target, and then research other candidate targets. They will first use their standard research methods, and will then be asked to research using a combination of ICE and HUMINT reporting.

DURATION:

45-90 minutes depending on depth of research

ASSUMPTIONS:

This protocol assumes that interviewers will be sitting with analysts at their workstations and that there is mission downtime.

It also assumes that analysts can pull up Google Earth and any research tools that they normally use to conduct target research.

ENVISIONED INTERVIEWEES:

Mission Commanders

- Multi-Source Analysts
- Screeners (if they conduct target research)
- Other analyst positions that conduct target research at Distributed Ground System Arkansas (DGS-AR)

INTERVIEW STEPS:

Step 1: ***Select initial target. (10 min)*** Have analyst pull up GoogleEarth or another viewer that they are most familiar with during the course of their missions. Ask them to locate a static target

they recently (within last month) covered in a relatively populated area that has other potential targets within a 30 km radius. Potential target types they can focus on might include:

- Compounds
- Factories
- Mosques
- Beddown house/block
- Checkpoints

Elicit a quick description of the tasking they had and an overview of what they focused on at a general level.

Step 2: ***Elicit how analysts do preparatory research around the target area.*** (20-30 min) Tell analysts they have up to a half hour to conduct research on this target in preparation for the mission. As they conduct research, note and concurrently ask about:

- How long they would normally take to do this task;
- What they do and in what order (and rationales);
- Which sources they use and what search filters they set (and why);
- How they assess intel validity;
- How they combine different pieces and sources of intel;
- What draws them to explore and in what order (e.g., clusters of intel, particular pieces of intel, intel notations on top of particular target types;
- Which targets they consider, disregard, and ultimately choose and in what order.

Step 3: ***Elicit reasons to begin new search. (5 min)*** Tell analysts they have sensor tasking authority and ask them what activities (or lack thereof) related to the mission they had would drive them to begin searching for alternate targets.

Step 4: ***Research walkthrough. (20-30 min)*** Ask analysts to use whatever sources they normally leverage (or would leverage) to conduct target research. If the sources would be different for an STA situation, have them distinguish the two cases. Observe them as they research alternate targets. We may need to limit their time and tell them they need to identify at least one candidate alternate target within 30 minutes. As they conduct research, note and concurrently ask about:

- Which sources they use and search filters they set (and why);
- How they assess intel validity;
- How they combine different pieces and sources of intel;
- What draws them to explore and in what order (e.g., clusters of intel, particular pieces of intel, intel notations on top of particular target types;
- Which targets they consider, disregard, and ultimately choose and in what order.

Step 5: ICE and HUMINT Research. (30 min) Have the analyst select a different target and location with which they are familiar, and introduce them to ICE and CFG (if they are not already familiar with them). If not familiar, we will have to help them configure, but ask them to

describe what filters, etc. they want to set as you configure them.

As they conduct research, note and concurrently ask

about:

- Which filters they set (and why);
- How they assess intel validity;
- How they combine different pieces and sources of intel;
- What draws them to explore and in what order (e.g., clusters of intel, particular pieces of intel, intel notations on top of particular target types;
- Which targets they consider, disregard, and ultimately choose and in what order.

Also note any confusions, frustrations or misinterpretations analysts have

PART 2: DECISION REQUIREMENTS INTERVIEW OVERVIEW:

Interviewers elicit context surrounding challenging decisions associated with researching upcoming targets and identifying alternate ones. These are referred to as "decision requirements". After Part 1 of the interview, challenging decisions/judgments will likely emerge and will probably be centered around the Objective questions above. This should provide context to now conduct a decision requirements interview. If Part 1 is skipped, the interview can focus on either the Objective questions or decisions viewed as challenging or requiring expertise involved in conducting target research.

See Step 1 for examples.

Once the decision is identified, the interviewers and interviewee work together to construct a Decision Requirements Table.

DURATION:

30 minutes per decision requirement table

ASSUMPTIONS:

This protocol can be conducted anywhere, but might be easier at a table. The main benefit of conducting the interview at the analyst's workstation is that they can pull up tools they describe, or information sources they access.

ENVISIONED INTERVIEWEES:

- Mission Commanders
- Multi-Source Analysts
- Screeners (if they conduct target research)
- Other analyst positions that conduct target research at DGS-AR

INTERVIEW STEPS:

Step 1: **Identify challenging decision/judgment.**

Some options for doing this are:

- Extend from interviews Part 1: *As you were conducting research and trying to*

identify alternate targets, what were the most challenging decisions or judgments that you had to make? In other words, what required the most experience or expertise, where a novice would be likely to screw up?

- Ask about prior experience: When you conduct target research in the context of your missions (either in progress or upcoming) can you tell me what decisions or judgments require the most expertise? In other words, what mental tasks really make you feel challenged, not because of the time required, but because they require experience and expertise to do well?
- Construct a Task Diagram (see below for guide)
- Show them the sample Decision Requirements Table (see below)

Step 2*:* **Elicit Decision Requirements** (repeat for each decision of interest as time allows)

Inform the interviewee that we want to break down this decision into greater detail, discussing both actual experiences and hypothetical "what-ifs".

Show the participant a blank decision requirements table and explain each column. Then use probes such as the ones below to fill out the table:

- ***Challenging Decision*** (the decision identified in Step 1)

1. ***Why Difficult*** – factors that make this decision especially challenging and requiring expertise
    - **a.** Why is that a challenging decision?
    - **b.** Why was it difficult in the previous task?
    - **c.** What makes it difficult in general?
    - **d.** What circumstances or situations can make it even more difficult?
    - **e.** How would you design a training scenario to make this decision especially difficult for a trainee?
2. **Cues** – perceptual or environmental elements that the analyst sees, hears, etc. that impact this decision
    - **a.** What were you noticing – seeing, hearing, or generally picking up in the environment that impacted this decision
    - **b.** Going a step higher, what are other environmental cues that can impact this decision in one way or another?
3. **Information Sources** –prior, or existing knowledge and/or resources that can impact this decision
    - **a.** Unlike cues, which you are experiencing in the moment, what sources of information inside your head, such as internal knowledge of enemy tactics, can impact this decision?
    - **b.** Also unlike cues, what reference materials, or knowledge thereof,can impact this decision?
4. **Typical Errors** – Mistakes that novices, or even experienced analysts tend to make

when dealing with this decision

   a. When faced with this judgment, what mistakes do novices (less experienced analysts) tend to make?

   b. Where would you go wrong in this decision when you were new that you would not go wrong here?

5. **Strategies –** Different approaches or mindsets that individual analysts may use (or are dictated to use) when making this decision
   a. What are some different strategies that a seasoned analyst may take when faced with this decision?
   b. What strategies or sub-strategies are dictated and must be followed?
   c. What strategies are good on paper, but do not work in reality? Why?
   d. What strategies would less-experienced analysts tend to use?
   e. For each, how effective are they and what are the consequences, both good and bad?
6. **Uncertainty Sources –** Anything that can cause, or be an additive factor of uncertainty that impacts the decision
   a. What are different sources of uncertainty that make this decision harder to make? They can be organizational, related to uncertainty in the data, tool related, related to the nature of the task, or anything else that generates confusion and ambiguity related to the task.
7. **Tools Used –** In this case, software and/or online tools that can be used to support this decision or judgment
   a. What are the different tools that you use, or could use, when dealingwith this decision?
      i. Name
      ii. Version
      iii. Purpose – what information does the tool provide or what purpose does it serve?
      iv. Location
   b. Can you provide examples of how you tend to use these tools together?

SUPPORT IDEAS

   c. What do you not have but wish you could have to support this decision? It can be an envisioned tool or functionality, access to certain information, organizational/expertise support, etc.

Part 3: **Task Diagram (TD) Construction**

For this interview, analysts are asked to develop a TD. The purpose of a TD is to elicit the major components of the analyst's job. In this case, we can probably just focus on aspects of their job that pertain to involve research. Specifically, we are interested in how the analyst characterizes the job as it was actually done, not in how the doctrine or other guidance prescribes the job is to

be done. We further want to understand what parts of the job are most cognitively demanding, or in this case, which parts of the job required the analyst to make the most assessments and decisions based on their tasks.

Create Circles: With a piece of paper in front of them, the analyst will be asked something akin to the following: "Can you tell me what major mission tasks you have that involve target research? I (or they) will draw 3-6 circles and each one will represent a major component of task performance within this area. We will label each component.

Fill in Circles: Next, we will generate bullets within each circle to more deeply describe the subtasks that constitute that task. If the major components are dependent on each other or occur in chronological order, we will indicate that with arrows."

Identify Cognitively Demanding Subtasks: After this portion of the TD is finished, we ask the analyst to tell us which of the major components was the most challenging (and second most challenging) in terms of analyses, decisions and assessments. We also have them identify the tasks that are not demanding, or are only demanding in terms of time or frustration versus cognitively challenging. This exercise helps us understand which areas are most challenging and potentially fruitful to probe for incidents and sometimes identifies tasks that are not already recognized in existing doctrine.