<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Presenter/Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>Check-in</td>
<td>All</td>
</tr>
<tr>
<td>1030</td>
<td>Welcome</td>
<td>Mr. Steve Jameson, I2O, Program Manager</td>
</tr>
<tr>
<td>1035</td>
<td>Security</td>
<td>Ms. Marissa Sylvester, SID, Program Security Rep</td>
</tr>
<tr>
<td>1040</td>
<td>Contracts</td>
<td>Mr. Mark Jones, CMO, Contracting Officer</td>
</tr>
<tr>
<td>1100</td>
<td>Causal Exploration Program</td>
<td>Mr. Steve Jameson, I2O, Program Manager</td>
</tr>
<tr>
<td>1200</td>
<td>Lunch/Informal Teaming</td>
<td>All</td>
</tr>
<tr>
<td>1230</td>
<td>Discussions/Turn in Questions</td>
<td>All</td>
</tr>
<tr>
<td>1230</td>
<td>Government Response to</td>
<td>All</td>
</tr>
<tr>
<td>1300</td>
<td>Sidebar Discussions with</td>
<td>As scheduled</td>
</tr>
<tr>
<td></td>
<td>Program Manager</td>
<td></td>
</tr>
</tbody>
</table>

Distribution Statement A – Approved for Public Release, Distribution Unlimited
Causal Exploration

"To find out what happens when you change something, it is necessary to change it."

- George Box
What are we building?
A modeling platform to aid military planners (e.g., member of a planning staff supporting a Joint Task Force (JTF) Commander) in understanding and addressing underlying causal factors that drive regional hybrid conflicts.

What capabilities will it enable?
• Rapid creation and maintenance of a causal model tailored to the operational environment (OE)
• Exploration of causal dynamics impacting the OE
• In-depth and holistic understanding of the OE

For what purpose?
Support and inform planning efforts to address conflicts with a complex human dimension, dominated by factors such as political, ethnic, or religious tension; low intensity conflict; economic aggression; or cyber intimidation.
Inadequate Causal Understanding Can Lead to…

- Unanticipated negative outcomes (2\textsuperscript{nd} and 3\textsuperscript{rd} order effects)
- Failing to address the underlying factors
- “Solving the problem right” instead of “solving the right problem”
### Operational Vision

<table>
<thead>
<tr>
<th>Operational Environment</th>
<th>Problem</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>“Who are the key actors impacting and impacted by the conflict?”</strong></td>
<td><strong>“What are the underlying causal factors driving the conflict?”</strong></td>
<td><strong>“What mix of kinetic and non-kinetic actions will achieve objectives?”</strong></td>
</tr>
</tbody>
</table>

| Today (without *Causal Exploration*) | | |
| Manual assembly of knowledge | Human-generated problem hypotheses subjectively evaluated | One to three options discussed at whiteboard |

| With *Causal Exploration* | | |
| Automatic extraction and organization of knowledge | Exploration of causal factors through semi-automatically built causal model | Hundreds of quantified options automatically generated |

The envisioned *Causal Exploration* system will help the user:

- Gain a deep and holistic understanding of the OE, the vectors and drivers of adversary actions, the dynamics and perspectives of other relevant actors, and the various potential issues at stake
- Explore causal factors underlying current conditions as well as desired and undesired futures
- Develop an understanding of the range of possible outcomes of various intervention approaches
- Continuously assess the OE/problem/situation
Notional System User and Tasks

The notional user is a member of a planning staff supporting a JTF Commander.

To more effectively and efficiently accomplish his/her tasks, the user needs the system automation to help them:

- Develop an initial model to support some level of causal analysis in the early planning stages of an operation.
- Incorporate newly obtained information through the course of the operation to augment and refine the model.
- Identify potentially high-impact knowledge gaps to drive additional information collection.
- Identify and resolve discrepancies between the causal structure of the ICM and the current OE.

*Don’t make assumptions about user experience level or familiarity with models/tools*
Crisis erupts in the Niger Delta, with militants seizing oil fields and coastal territory, and teaming up with organized crime groups to attack shipping in the Gulf.
Causal Exploration Concept

Crisis erupts in the Niger Delta, with militants seizing oil fields and coastal territory, and teaming up with organized crime groups to attack shipping in the Gulf

Data Sources

Military and Intelligence
Operational assessments, military messaging, intelligence reports

Government and NGO
Demographic/economic reports and databases

Open Source
(Publicly Available Information)
Text-based news media, web-based content, social media

Web-based content
Causal Exploration Concept

Crisis erupts in the Niger Delta, with militants seizing oil fields and coastal territory, and teaming up with organized crime groups to attack shipping in the Gulf.

**Automatic Knowledge Extraction**

**Entities**
- Nigerian Government
- Nigerian Security Forces
- Niger Delta Population groups
- Oil Companies
- Criminal groups
- Militants
- Boko Haram

**Conditions, Events, and Trends**
- Security Force Abuses
- Population Support for Militants

**Causal Relationships**
- “Security Force Abuses increases Population Support for Militants”

**Domain Tailored Ontology**
- Terrorist
- Non-State Military Actor
- Militant
- Militia
- Boko Haram
- Militants
Crisis erupts in the Niger Delta, with militants seizing oil fields and coastal territory, and teaming up with organized crime groups to attack shipping in the Gulf.

Semi-automatic Causal Model Assembly

- **Security Force Abuses**
- **Government Corruption**
- **Organized Crime Activity**
- **Oil Industry Employment**
- **Population Support for Militants**
- **Militant Attacks**

Entities:
- Nigerian Government
- Nigerian Security Forces
- Niger Delta Population Groups
- Oil Companies

Conditions, Events, and Trends:
- Security Force Abuses
- Population Support for Militants
- Oil Industry Employment

Causal Relationships:
- "Security Force Abuses increases Population Support for Militants"
Crisis erupts in the Niger Delta, with militants seizing oil fields and coastal territory, and teaming up with organized crime groups to attack shipping in the Gulf.

“Abuses, from extortion, to arbitrary arrest following attacks, to outright physical cruelty, are rampant within the Nigerian Security Forces (NSF). These abuses have driven population mistrust and fear of the NSF, and increased sympathy for Boko Haram.”
The centerpiece of the *Causal Exploration* system is the ICM that combines qualitative and quantitative analysis capabilities.

**Integrated Causal Model (ICM)**

Reason backward from observed or hypothesized conditions to underlying causal factors:

"Why did 'X' happen?"

Project forward from proposed actions to provide estimates of ranges of outcomes:

"What will happen if we do 'Y'?"

Once initially constructed, the ICM is dynamically updated as the OE changes.

Example not intended to be prescriptive of proposed technical approaches!
System Concept

Knowledge Organization

- Knowledge Needs/Gaps, Request/Response
- Entities, Causal Relationships, Domain-tailored Ontology

Integrated Causal Model

- Model Assembly/Population/Configuration/Adaptation
- User Input and Feedback to Model Assembly

Human Model Interaction

- ICM Exploration
- Intuitive Interaction

User

Shared Services

- Shared Repository
- Common Standards and Interfaces
- Scalable Processing

Operational, Government-provided, and Open Source Documents and Databases
**Program Structure**

**TA1**  
**KO**  
**Knowledge Organization**  
Automatically extract and organize OE knowledge from heterogeneous and semantically-diverse information sources which will be used to assemble the ICM

**TA2**  
**CMA**  
**Causal Model Assembly**  
Semi-automatically assemble a tailored computational ICM from extracted knowledge

**TA3**  
**HMI**  
**Human Model Interaction**  
Enhance human understanding through hands-on exploration and manipulation of the ICM

**TA4**  
**Model Assessment**  
Assess suitability of models to support user activities

**TA5**  
**SI**  
**System Integration**  
Integrate system and support experimentation and evaluation

TA4 not solicited under the BAA
Functions

- Extracts knowledge about entities (actors, conditions, events, etc.) and relationships
- Operates on a wide variety of heterogeneous and semantically diverse text and numeric information sources
  - Military and intelligence documents (e.g. intelligence reports, operational assessments, military messaging)
  - Open source text (e.g., news media, web-based content)
  - Government or NGO data (e.g., reports and databases such as demographic and economic analyses)
- Resolves across information sources to minimize duplicate elements
- Maps entities and relationships into a common ontology
Challenges

- Widely varying source material
- Bias or unreliability of source information
- Causal relationships that do not conform to clear syntactic patterns
- Consistent estimation of causal relationship characteristics (e.g., confidence, strength, latency)
- Alternative modes of processing (e.g., targeted inspection of information sources for entities or relationships, based on requests from TA2 or TA3, or due to logic internal to TA1)

Metrics should include

- Correctness and completeness of
  - Entity extraction and resolution
  - Causal relationship extraction
  - Ontology assignment
- Characterization of confidence and credibility of extracted knowledge
Functions

- Assembles an ICM (capable of supporting a set of computational operations) from TA1/KO output products/datasets (and possibly other sources such as encoded expert knowledge)
- Identifies ICM deficiencies and discrepancies and 1) requests human input to assist in resolving uncertainties and filling model gaps, and 2) communicates knowledge needs/gaps to TA1/KO for resolution
- Incorporates human inputs to modify or augment the ICM
- Incorporates new knowledge to update or refine the ICM
Challenges

• Differing degrees of specificity, i.e., some relationships refer to specific entities whereas others refer to broader classes
• Differing precision for attributes such as strength or confidence
• Logically inconsistent causal relationships
• Incomplete information, inconsistent information, deceptive information
• Uncertainty in model outputs
• Continuous stream of new/updated information from the OE

Metrics should include

• Level of human intervention required for model assembly
• Portion of model content derived from \textit{a priori} knowledge vs. KO output
• Computational performance of model assembly
• Consistency and correctness of model outputs for a given KO dataset
• Consistency of outputs across varying datasets
• Uncertainty quantification
Use existing causal templates to form initial graph

Link existing quantitative models into the graph structure by mapping model inputs and outputs to nodes in the graph.

Not intended to be prescriptive of proposed technical approaches!
Functions

- Enables users with varied levels of experience and expertise to interact with the ICM to build understanding.
- Provides techniques for capturing the results of the ICM, along with user context, into flexible and dynamic products.
- Provides intuitive exploration capabilities to help users surface underlying causal factors and assess potential approaches.
- Enables users to manipulate the ICM structure, execute computations, and visualize and brief results.
Challenges

• Flexible workflows (agnostic to user experience/expertise levels)
• Rapid prototyping of user interfaces to support productive experimentation
• Capture of tailorable and dynamic products
• Intuitive interaction semantics
• System and user interaction concepts (e.g., exploring, visualizing, and manipulating the ICM)

• TA3 provides basic HMI capabilities for experienced users to exercise the ICM (Phase 1)
• TA3 provides end user HMI capability, to support experimentation and evaluation with a wide range of users of different experience levels (Phase 2)
• TA3 provides user training material
Exploration of Underlying Factors

- Exploration of the underlying causal factors driving the visible symptoms of a conflict in order to scope the problem to address
- Exploration of causal factors impacting desired or undesired futures
- “What if?” analyses to explore hypotheses about causal factors which are not well understood
- Synthesis of explanations for causal pathways
Model View of Key Causal Drivers

- Exploration of the underlying causal factors driving the visible symptoms of a conflict in order to scope the problem to address
- Exploration of causal factors impacting desired or undesired futures
- “What if?” analyses to explore hypotheses about causal factors which are not well understood
- Synthesis of explanations for causal pathways

“Poor government and security force professionalism create a sense of impunity that further enables corrupt and criminal activity. Corruption and criminal involvement constrain government and security force effectiveness and fail to deter population involvement with criminal and terrorist organizations.”
Exploration of Underlying Factors

- Exploration of the underlying causal factors driving the visible symptoms of a conflict in order to scope the problem to address
- Exploration of causal factors impacting desired or undesired futures
- “What if?” analyses to explore hypotheses about causal factors which are not well understood
- Synthesis of explanations for causal pathways

Feedback Loop View

Loop 1: Endemic Corruption Creates a Sense of Impunity
- Gov't Professionalism
- Gov't Operating Capacity and Effectiveness
- Gov't Judicial Capacity and Fairness
- Fear of Punishment for Illegal Activities

Loop 2: Impunity Invites Security Force Abuses
- Fear of Punishment for Illegal Activities
- NSF Professionalism
- NSF Operational Capacity and Effectiveness

Loop 3: NSF Corruption Reinforces Impunity
- NSF Professionalism
- NSF Institutional Capacity
- NSF Operational Capacity and Effectiveness
- Fear of Punishment for Illegal Activities
TA3 HMI – Example User Interaction

Exploration of Projected Outcomes

- “Design of Experiment” style comparative analyses of a space of options to assess the relative strengths and weaknesses of different approaches/combinations of actions
- Sensitivity analyses to assess the relative impacts of different elements of an approach or the robustness of an approach to a range of conditions or assumptions
Exploration of Projected Outcomes

- “Design of Experiment” style comparative analyses of a space of options to assess the relative strengths and weaknesses of different approaches/combinations of actions
- Sensitivity analyses to assess the relative impacts of different elements of an approach or the robustness of an approach to a range of conditions or assumptions

![In-depth Exploration of Outcomes Table]

<table>
<thead>
<tr>
<th>VEOs (Boko Haram)</th>
<th>6 mo ago</th>
<th>Current</th>
<th>6 month</th>
<th>1 year</th>
<th>2 year</th>
<th>5 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boko Haram Casualties</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boko Haram Local Attacks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boko Haram Manpower Size and Skill</td>
<td></td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>Training Support from IVEOs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**TA3 HMI – Example User Interaction**

**Exploration of Projected Outcomes**
- “Design of Experiment” style comparative analyses of a space of options to assess the relative strengths and weaknesses of different approaches/combinations of actions.
- Sensitivity analyses to assess the relative impacts of different elements of an approach or the robustness of an approach to a range of conditions or assumptions.

<table>
<thead>
<tr>
<th>In-depth Exploration of Outcomes</th>
<th>Projected Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEOs (Boko Haram)</td>
<td>6 mo ago</td>
</tr>
<tr>
<td>□ Boko Haram Casualties</td>
<td></td>
</tr>
<tr>
<td>□ Boko Haram Local Attacks</td>
<td></td>
</tr>
<tr>
<td>□ Boko Haram Manpower Size and Skill</td>
<td></td>
</tr>
<tr>
<td>□ Training Support from IVEOs</td>
<td></td>
</tr>
</tbody>
</table>

**Boko Haram Casualties**

![Boko Haram Casualties graph](image)
TA3 HMI – Example User Interaction

Exploration of Projected Outcomes

• “Design of Experiment” style comparative analyses of a space of options to assess the relative strengths and weaknesses of different approaches/combinations of actions
• Sensitivity analyses to assess the relative impacts of different elements of an approach or the robustness of an approach to a range of conditions or assumptions

Rapid Comparison of Multiple Approaches

- Governance Reform and Partnered HVT Ops
- Military Training and Equipment
- Counter VEO Messaging and Financial Policing
- Economic Development

COA Impact Over Time

Boko Haram Focus on International Targets

Boko Haram Potential to Strike International Targets
Dynamic Products

• “System as Briefing” (move away PowerPoint) for explanation with supporting evidence
• ICM outputs are captured, along with user context, and used as products to inform decision makers

Source Pedigree

Supporting Evidence

Explanation

Poor government and security force professionalism hamper both willingness and ability to punish illegal acts, creating a sense of impunity that further enables corrupt and criminal activity. This further constrains government and security force effectiveness and fails to deter population involvement with criminal and terrorist organizations.
### TA4 Model Assessment (MA)

Federally Funded Research and Development Center (FFRDC) or University Affiliated Research Center (UARC)

<table>
<thead>
<tr>
<th>Role</th>
<th>Purpose</th>
<th>Assessment</th>
</tr>
</thead>
</table>
| **Assess KO Technologies** | Provide an independent performance/output product assessment of KO technologies | • Traditional metrics (e.g., precision and recall)  
• Other factors  
  • Appropriateness of domain-tailored ontology  
  • Cross-document resolution of entity and causal relationship references  
  • Correct placement of entities into the domain-tailored ontology |
| **Assess CMA Technologies** | Provide an independent performance/output product assessment of the range of models and the set of technologies used to create the models | • Correctness and completeness of causal structure  
• Ability to predict and explain  
• Quality and precision of outputs |
| **Develop Assessment Methodologies** | • For a “fitness for purposes” assessment  
• For techniques to evaluate human-system models | • Level of human involvement required for the CMA process  
• Suitability of resulting models to support a range of users and user tasks  
  • Situation understanding, problem identification  
  • Projection of outcomes/approach development  
  • Design, planning, and decision making |
• Provide the information management and processing framework that unites the TA1/TA2/TA3 capabilities into an integrated platform
  • Scalable storage and retrieval, scalable distributed processing, other shared services
• Provide repository/ingest mechanism for source data retrieval
• Integrate system prototypes for use in experimentation and evaluation
• Plan and execute a series of collaborative experiments
• Support operational evaluations
Challenges

- Multiple components from multiple performers
- Consistent development
- Technology development drivers
- Concepts of operation

Collaborative Experiments

- Bring operational users and technology developers together to explore and refine concepts for end-user employment
- Provide a feedback loop from users to developers to ensure capabilities developed are relevant and provide value/meet user needs
- Prepare for operational evaluations

TEAM WORK

- TA5 provides system architecture (common services (repository, ingest/retrieval mechanisms), standards, SDKs)
- TA5 provides processing facility
- TA5 facilitates independent development and test (Phase 1)
- TA5 integrates system prototypes for use in experimentation and evaluation (Phase 2)
- TA5 executes collaborative experiments (Phase 2)
Unclassified and Classified Processing

Unclassified development, integration, and testing:

- TA1
- TA2
- TA3
- TA4

Secured Internet-based access to TA5 facility

All Phases

Classified testing (Secret level):

- TA1 (not required)
- TA2
- TA3 (not required)
- TA4

Access at TA5 facility

Phase 2 and Phase 3

Secured Internet-based access to TA5 facility

Distribution Statement A – Approved for Public Release, Distribution Unlimited
## Schedule and Milestones

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 Months</td>
<td>18 Months</td>
<td>12 Months</td>
</tr>
</tbody>
</table>

### Exploratory Technology Development

- **TA1 - Knowledge Organization**
  - Causal interaction extraction, ontology tailoring
  - Uncertainty and bias in information sources, dynamic updates
  - Technology hardening

- **TA2 - Causal Model Assembly**
  - Semi-automated model assembly
  - Uncertainty propagation, dynamic updates
  - Technology hardening

### Rapid Prototyping

- **TA3 - Human Model Interaction**
  - Basic model interaction
  - Model exploration and visualization, analytic workflows
  - Model manipulation

### Assessment, Experimentation and Evaluation

- **TA4 - Model Assessment**
  - Methodology development, static model evaluation
  - Methodology refinement, dynamic model evaluation
  - Final evaluation

- **TA5 - System Integration**
  - Architecture development
  - Integrated system development and experimentation
  - System maturation

### Technology Assessments

1. 3
2. 2
3. 3
4. 4
5. 6

### Collaborative Experiments

1. 1
2. 2
3. 3
4. 4
5. 5
6. 6

### Operational Evaluations

1. 1
2. 2

### Kickoff and PI Meetings

1. 1
2. 1
3. 3
4. 3
5. 5
6. 6
7. 2