Advancing Campaign Analytics
18 – 21 November 2019
Chair: Mr. Jim Bexfield
Chair: Ms. Robbin Beall

Unannotated version – expect to replace with annotated version by Jan 1, 2020
Objectives

To update the community on advances in campaign analytics and to foster collaboration on enhancing the tools, techniques, and procedures used by the national security community to inform joint strategic and operational decisions. This includes

• Exploring opportunities to make campaign analysis more agile, relevant, and responsive
• Credibly incorporating non-kinetic effects, such as cyber-attacks and information warfare, across the physical domains
• Addressing challenges to workforce development and continual education
• Integrating advances in high performance computing and computational methods
• Leveraging capabilities used by practitioners in other analytic disciplines.
- Working Group Out-briefs
  **Working Group 1:** Chair: Mr. Tim Stacy, AF/A9  
  Co-Chairs: Mr. Bill Woodson, USMC-CD&I & Mr. Tim Smetek, IDA  
  **Working Group 2:** Chair: Mr. Rich Perry, SAIC  
  Co-Chairs: Dr. Craig Ewing, AFRL & Dr. John Young, AF/A9  
  **Working Group 3:** Chair: Mr. Shane Brucker, AF/A9  
  Co-Chairs: Mr. Andy Turner, Northrup Grumman, Mr. Jeff Martin, Group W & Mr. Michael Warme, CAA  
  **Working Group 4:** Chair: Mr. Al Sweetser, IDA  
  Co-Chairs: Dr. Bob Richbourg, IDA; Mr. Tim Walton, CSBA & MAJ Joe McCarthy, CAA  

- Break
  **Working Group 5:** Chair: Dr. Mabel Ramirez, MIT LL  
  Co-Chairs: Mr. Jaime Bestard, AFRL; Mr. Alex Tempe, JS J7 & Ms. Sarah Stewart, CAA  
  **Working Group 6:** Chair: Mike Lepson, Navy – NWDC  
  Co-Chairs: Mr. Phil Pournelle, LTSG & Mr. Chuck Burdick, IDI  
  **Synthesis:** Chair: Mr. Trip Barber, SPA  

- Road ahead/what next
- Recognition
Working Group 01

Campaign Analysis in DoD and Industry

Chair: Mr. Tim Stacy, AF/A9
Co-Chair: Mr. Bill Woodson, HQMC, CD&I
Co-Chair: Dr. Tim Smetek, IDA

21 November 2019
Working group members:
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Lt Col Katie Batterton, AF/A9
LTC Jeremy Riehl, CENTCOM
Mr. Joe Nowack, AFRICOM
Dr. David Knudson, CAA
Working Group Charter

• Workshop Objectives:
  • Explore opportunities to make campaign analysis more agile, relevant, and responsive
  • Credibly incorporate non-kinetic effects, such as cyber-attacks and information warfare, across the physical domains
  • Address challenges in workforce development and continual education
  • Integrate advances in high performance computing and computational methods
  • Leverage capabilities used by practitioners in other analytic disciplines

• Scope – Foundational to other Working Groups

• Questions to be answered by Working Group
  • Defining Campaign Analysis
  • Tools and Techniques to Enhances Campaign Analysis
  • Campaign Analyst Development Recruitment and Development
Background

- Challenges to meeting timely, credible, and relevant campaign analysis
- Lack of community agreed upon definition of campaign analysis

Approach

- 1.5 days of presentations
  - Campaign Analysis Process: CENTCOM, USMC, AFRICOM, USN, Army
  - SMART Campaign Assessments
  - MATE, BEAM, BrainSTORM Overview
  - Recruiting, Managing, and Developing the campaign analyst workforce
  - NPS Campaign Analysis Course
  - Campaign Analyst Development
- 0.5 days consolidation of findings
- Underlying Theme: Evaluate in context to meet “Timely, Credible, Relevant” analysis
General Insights

Foundational data / Breaking down barriers

What are the common threads in the community

Interest the qualified vs qualify the interested
Defining Campaign Analysis

Disciplined study of operational-level military campaigns to investigate and provide quantitative and qualitative insights leading to a frame of reference within which the value of specific capabilities, force structure, new technologies, and concepts can be evaluated in an operational context.

Additionally, campaign analysis applies various methods, tools, and research including assessments, wargaming, modeling and simulation as appropriate depending on the questions, uncertainty of problem definition, and desired insights needed.
Defining Campaign Analysis Continued

What it is…
• Comparative
• Investigative framework
• A set of tools and methodologies
• A combination of Art & Science

What it is not..
• Predictive
• A point solution
• A specific model or tool
• A highly precise representation of physics and/or engineering
Existing Tools and Techniques to Enhance Campaign Analysis

• Pre/Post Analysis Tools
  • Freeware: Excel/VBA, R, Python, MariaDB
  • COTS: JMP, Tableau, SAS, Power BI

• Campaign-Specific Tools
  • Vary from lower- to higher-resolution based on questions asked, time available, data available
  • Lower-Res, Decision-space Exploration: AFRICOM SMART process, MATE Methodology
  • Higher-Res: STORM, JICM
Tools and Techniques: Challenges

- Security restrictions becoming extremely prohibitive to tool access
  - Mitigation: Create an approved Joint Toolset on NIPR/SIPR/JWICS
- Analyst Collaboration is lacking
  - Mitigation: Re-energize JDS collaboration tools; make better use of MORS Working Group 10 (Campaign Analysis)
- Analyst skillset may be out-dated
  - Mitigation: Emphasize entry-level skills with Python, R, Tableau, SQL; provide opportunities for skills development
- Poor tool ease-of-use prohibitive to insightful analysis
  - Mitigation: Invest in modern interfaces for existing tools that allow the analyst to “drive the model”
- Mission/engagement-level data generation needs to be timely, relevant—regardless of campaign tool resolution
  - Mitigation: Develop processes to quickly generate “feeder” data
Tools and Techniques: Going into the Future

• On-going development of quick-turn techniques (e.g., BEAM, MATE) that rapidly explore decision-space—foundational feeder data still must be addressed

• Exploration of AI (BrainSTORM) providing useful, realistic insights
  • Campaign analysis IS NOT chess—significantly higher complexity, decision space
  • AI-enabled, human-in-the-loop methods may be best
  • Significant computational challenges need to be overcome for implementation of full, Joint operation scenarios

• High-Performance Computing is greatly improving exploration of decision-space—wider access by analytic community is needed
Campaign Analyst Recruitment, Development & Evaluation

Recruitment

• Traits – critical thinking, intellectual curiosity, interest in military/military history
• Teaming approach, Mix of skills
• Two major pools of potential campaign analyst
  • Prior military, operations, analysis, planning
  • Straight out of school, typically Master’s or PhD level
    • STEM Intern Program, Palace Acquire

Challenges

• OPM hiring timelines
• Security
• High demand work force; Competition with Google, Amazon, etc..
Campaign Analyst Recruitment, Development & Evaluation

Development

- Formal Professional Military Education – resident/non-resident Squadron Officer School, Staff College, War College
- Individual Courses – Joint Planning & Operations Course, ORSA MAC, Online courses (e.g., Coursera)
- Internal agency libraries- Analyst handbooks, Brain books, Continuity Books
- External Development – MORS, INFORMS, Advance Degree Programs

Challenges

- Funding Constraints
- Time Commitment
Campaign Analyst Recruitment, Development & Evaluation

Evaluation

- Career Progression – Novice, Intermediate, Analyst, Senior Analyst, Senior Leader
- Holistic – whole analyst, not model, technique specific
- Feedback – formal/informal, internal (team, supervisor) and external (peer-review, customer)
- Evaluation Criteria – critical to identify linkage back to the mission
  - Strategy to task

Challenges

- No single standard, individually developed
Conclusion

- Foundational data / Breaking down barriers
  - Mission/engagement/assessment-level data generation needs to be timely, relevant—regardless of campaign tool resolution
  - Create an approved Joint Toolset on NIPR/SIPR/JWICS
- What are the common threads in the community
  - Mix of skills, breadth and depth of analytic experience
- Interest the qualified vs qualify the interested
  - Key Traits – critical thinking, intellectual curiosity, interest in military operations

- Future MORS activities
  - Tutorials on tools/techniques (e.g., R, Python, etc…)
  - Analysts development tutorials (e.g., best practices, techniques, etc.)
Working Group Two

Improving Inputs to Campaign Analysis

Rich Perry, SAIC
Dr. John Young, AF/A9
Dr. Craig Ewing, AFRL

21 November 2019
• Objectives
  – Identify best practices across the community, and the impediments to obtaining/developing/sharing/inputting information across the community
    – Key words/attributes: Speed, Traceable, Shareable

• Scope
  – Highlight tools and techniques currently used to identify, collect, and create input for campaign analysis
  – Focus on what tools and techniques work well now and identify major challenges and gaps
  – Identify potential new tools and techniques to populate current campaign modeling tools
General Insights

- Paths exist to obtain authoritative input into the analysis
  - Systems performance data
  - Tactical employment
  - Concepts of operations

- Observations:
  - Common data repository is a good thing (Joint Data System)
    Can we expand that service?
    - Capability for broad access and discovery
    - USAF Strategic Development Planning Experimentation (SDPE) is building a data pillar / data exchange mechanism, with improved discoverability
    - US Army Data & Analysis Center (DAC) single source ground data
  - A central repository of all campaign inputs would be helpful
  - Processes to QA / validate inputs needed
  - Automate where possible but maintain analyst oversight
• Red and Blue CONEMP / CONOP development best practices
  – Wargaming
  – Table Top Exercise
  – Live virtual constructive CONEMP development

• Red CONOPS present additional challenges
  • Significant uncertainty
  • Analyst proposed COA is usually best start

• Significant level of effort required
  – SME availability and accessibility
  – Iterative process
  – Documentation
• Opportunities exist to leverage other work
  – Not always used - community awareness key
  – Central repository of studies would be extremely helpful

• Communications in the course of analysis critical
  – Study lead to study sponsor
    ▪ Inform decision maker of progress
    ▪ Leader feedback to analysis team
  – Study team to stakeholders
• How do we build confidence in model data?
  – Perceived issues with data resident in existing model data bases – especially externally provided model data base
  – Mitigated by analyst notes and documentation
  – Mitigated by documentation for any subsequent changes

• Quality Assurance
  – Currently relies on analyst identification of outliers and follow-on investigation
    ▪ Formalized process in some teams (e.g. CAA, J-8 WAD)
    ▪ Ideally becomes part of the analysis process
  – Additional resources required to investigate completed work
Conclusion

• Data is the foundation for our campaign analysis its management should be a deliberate effort
• Frequent communications in the course of the analysis is key to its success
• Incentivize analyst documentation of inputs to campaign analysis to improve traceability and opportunity for reuse
Working Group 3
Responsiveness vs Resolution

Shane Brucker
Michael Warme
Jeff Martin
Andy Turner

11/21/2019
Working Group Charter

• Objectives
  • Develop a framework for assessing appropriate levels of resolution and responsiveness given the study problem
  • Develop list of resources and methods for addressing resolution and responsiveness issues

• Scope
  • Focus on analysis methods and processes

• Questions to be answered
  • What are the challenges to achieving responsiveness?
  • What are potential solutions to overcoming these challenges?
Background

Key Definitions
- Responsiveness – ability to deliver credible, relevant, timely insights to meet decision maker’s expectations
- Resolution – level of aggregation and abstraction
- Risk (analysis) – acceptable level of analytic uncertainty

Status quo: Campaign analysis process is seen as too slow and inflexible.

Assumptions
- Wide variety of campaign analysis techniques to consider
- No single technique is appropriate for all questions
- Thinking analyst synthesis/judgement always required
Approach

• General Discussion – identify and explore problem and key themes
  • Timeliness
  • Breadth vs depth
  • Setting expectations

• Specific Talks – focus on specific topics
  • Conceptual modeling and deep uncertainties
  • Design of experiments
  • Quick turn modeling
  • Campaign impacts to enterprise analysis
  • Data lakes

• Synthesize
General Insights

Observations

• Multiple areas to address timeliness – not just model run time

• Balance of depth and breadth required according to the question

• Decisionmaker expectations must be accounted for
Responsiveness Decision Space

Decision maker needs and problems

- Timely
- Responsive
- Risk
- Relevant
- Resolution
- Credible

?
**Timeliness**

**Challenges**
- Model run-time is not the limiting factor
- Coordination is a major challenge
- Input data foundational work
- Joint CONOPS development and maturation
- Workforce flexibility and agility
- There is no fast enough – always faster, better, with less

**Potential Solutions**
- Provide lower resolution analysis at higher analytical risk
- Design of experiments for efficient runs
- Workforce development – balance of generalist, specialist, and SME
Breadth and Depth

Challenges

• Increasing complexity of representations and operations

• Deep uncertainties in questions, threats, and data

• Ability to model emerging technologies, CONOPS, and domains limited by underlying mission/engineering level data

• Increasing amounts of data

Potential Solutions

• Structured, flexible design and analysis of experiments rather than a point solution

• Integration of techniques at multiple resolutions

• Representation of dynamic behaviours

• Flexible data structures and analysis techniques
Decision maker Expectation

Challenges

• Increasing complexity of decisions

• There is no fast enough – always faster, better, with less

• Translation/communication of analysis into meaningful insights

• Historical baggage

Potential Solutions

• Include caveats/assumptions in conjunction with results

• Sensitivity analysis and examining assumptions provide context
Conclusion

• Low resolution campaign approaches still emerging

• The process drives responsiveness, not the model – communication and collaboration are time intensive

• Foundational activities are key – need warm base of methods, models, tools, data, and scenarios
Working Group 4

Representing New Technologies and Capabilities in Campaign Analysis

Dr. Al Sweetser, IDA
MAJ Joe McCarthy, CAA
Dr. Bob Richbourg, IDA
Tim Walton, CSBA

November 21, 2019
### Working Group 4 Members

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<tr>
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<th>Organization/Agency</th>
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<tr>
<td>Brian Abbett</td>
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<td>Mr. Jeffrey Alton Dubois</td>
<td>InfoSciTex</td>
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<td>Mr. Huu Manh Hoang</td>
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<td>JIATF West</td>
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<td>MAJ Joseph E. McCarthy</td>
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<tr>
<td>Kyle Wilkinson</td>
<td>USCYBERCOM J5</td>
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<tr>
<td>Alexander Young, PhD</td>
<td>Institute for Defense Analyses</td>
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Topics

- Cyber
- Artificial Intelligence/Autonomous Systems
- Battle Command and Control

Key Questions:

- What are the phenomena and effects we are trying to integrate and analyze?
- How these effects be adjudicated? (system or mission-level simulation? Wargame?)
- How can we integrate the adjudicated effects into a Campaign-level model?
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<tr>
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<td>Cyber</td>
<td>Analytic Support to Cyber Operations (discussions S/NF)</td>
<td>LTC John Agnello, CYBERCOM</td>
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<td></td>
<td>(S//NF) Cyber Wargaming</td>
<td>Jeremy Sepinsky, CNA</td>
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<td>Incorporating Cyber Effects in Campaign Analyses</td>
<td>MAJ Joe McCarthy, CAA</td>
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<td>AI</td>
<td>AI: Past, Present, Capabilities &amp; Limitations</td>
<td>Dr. Bob Richbourg, IDA</td>
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<td>Legal, Moral, Ethical Issues</td>
<td>Brian Williams, IDA</td>
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<td>Convergence of Trends in Autonomy and Simulation</td>
<td>Richard Bowers, Leidos</td>
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<td>Organizing Autonomy</td>
<td>Jerry Franke, Lockheed Martin</td>
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<td>Battle C2</td>
<td>Space Analysis with IMPACT</td>
<td>Dr. Gregg Burgess, Perduco Group</td>
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<td>Novel C2 Systems</td>
<td>LtCol “Rev” Jones, DARPA</td>
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<td>Mosaic Warfare Execution (MWX) Portfolio</td>
<td>David Ott, DARPA</td>
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<td></td>
<td>Modeling C2 in the Naval Simulation System Mission Level Model and</td>
<td>Michael Atamian, METRON</td>
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<td>Other Models</td>
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<tr>
<td>STORM Modeling/Synthesis</td>
<td>(S//NF) Analysis Techniques for Low-Cost Attritable Aircraft</td>
<td>Tim Smetek, IDA</td>
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<td>(S) Campaign Modeling of Advanced Technologies</td>
<td>Stew Sharp, N81</td>
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<td>Review/Discussion</td>
<td>WG</td>
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### Working Group 4: Cyber

**What are the phenomena/effects to integrate and analyze?**

<table>
<thead>
<tr>
<th>Traditional – Kinetic</th>
<th>Weapon</th>
<th>Cyber – Non-Kinetic</th>
</tr>
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<tbody>
<tr>
<td>Months - Years</td>
<td>Time to Develop</td>
<td>Months - Years</td>
</tr>
<tr>
<td>General Purpose – General End Effect</td>
<td>Purpose</td>
<td>Specific Purpose – Specific End Effect</td>
</tr>
<tr>
<td>High</td>
<td>Target</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Interchangeability</td>
<td>Functionality</td>
</tr>
<tr>
<td>Physics</td>
<td>Damage</td>
<td>May be reversible</td>
</tr>
<tr>
<td>Irreversible</td>
<td>Higher Order Effects</td>
<td></td>
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<tr>
<td>Somewhat perceptible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>Re-usability</td>
<td>Maybe</td>
</tr>
<tr>
<td>High</td>
<td>Confidence / Dependability</td>
<td></td>
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</table>
• **Wargame Techniques**
  - Person in network
  - Restaurant menu
  - Open-Ended / Person on Loop ~ (e.g., Merlin)

• **Mission Level Models** ~ (e.g., Cyber Assassin)

• Magazine Depth … *A function of capacity constraints (e.g., manning availability)*

• Worst Case Scenario … *Assume it happens (severity assessment)*

• Dialogue between Cyber SMEs and Operators … *Informs Wargames*
  - OCO – Cyber/ J2
  - DCO / MA – Cyber / J3

• Analytic Framework for Operators and SMEs
  - Cyber Taxonomy – [Target], [Access], [Effect], [Outcome]
  - [Probability], [Impact], [Duration]
  - Examples of previous Cyber Campaign Modeling … “If you can describe the campaign effect, we can build it”
Working Group 4: Cyber
How can we integrate the adjudicated effects into a Campaign-level model?

Growing Toolkit
- Cyber JMEMs
- Wargames
- Mission Level Models
- Sponsor / SME Assessment

Campaign Inputs
- Effects on individual systems (e.g., SA – 21)
- Commander Priorities, Magazine Depth, Implications
- Model Parameters (e.g., Sortie Generation Rate)

1st Order Effect (Impact, Probability, Duration)
- Parametric Analysis
- Find the Break Point
- Sensitivity

Campaign Model Outcome
Take that leap Cyber and Operations SMEs
What are the phenomena and effects we are trying to integrate and analyze?

- Man-in-the-loop systems
- Human-supervised systems
- Autonomous systems
- Swarming behavior
- AI-assisted C2 and cyber warfare (hack back)
- ML data processing - kill chain effects
- Autonomous nodes to address operations in “denied/degraded” comms environments

Challenge of Representing Adaptive Behavior
How these effects be adjudicated?

- In some cases, create AI-analogs to non-AI systems
- Highlight dependencies on comms and manned systems (e.g., robotic wingman) where appropriate
- Must account for trust and Lethal, Moral, and Ethical – adversaries may not be subject to the same constraints. Examine cases when AI goes awry.
- May be able to leverage investment in development of digital twins and T&E models.
- Consider system vulnerabilities to hacks and deception.
How can we integrate the adjudicated effects into a Campaign-level model?

• Creation of AI analogs to existing systems: USV, UUV, UGV, UAV (ISR and Lethal)
• STORM networked munitions capability for swarms
• Be prepared for challenges in “moving the needle” on campaign metrics.
• Plan to adjust force mix, basing, and CONOPS with assistance of operators/planners.

• Key Challenges:
  • Learning behavior
  • Dynamic changes in system performance
• Variable ROE
What are the phenomena and effects we are trying to integrate and analyze?(1)

1) Shift to cognition-based warfare

2) Adversary kinetic and non-kinetic action
What are the phenomena and effects we are trying to integrate and analyze?(2)

3) Geographic distribution of forces
4) Joint all domain operations
5) Behavior of autonomous units
6) Functional disaggregation of capabilities and novel effects chains
What are the phenomena and effects we are trying to integrate and analyze?(3)

7) Dynamic C2 structures, enabled by new planning/C2 tools

a) Human command; machine-assisted control

b) Context-centric C2
How these effects be adjudicated? (system or mission-level simulation? Wargame?)

1) Modeling cognitive warfare (including adversary kinetic and non-kinetic action to affect decision advantage) in a credible manner requires modeling of information flows, which are better-suited for mission-level models.

2) Campaign models well suited to model geographic distribution; impact of communications better-suited for mission-level models.

3) All domain operations stress specialization of campaign models.
How these effects be adjudicated? (system or mission-level simulation? Wargame?)(2)

4) Functional disaggregation of capabilities can be adjudicated with additional scripting of object characteristics; novel effects chains with creation of more extensive “playbooks” for potential interactions.

5) Adjudicating dynamic C2 structures will be challenging for many current tools. Rules-based approach in mission-level modeling a potential approach but tied to “playbooks.”
How can we integrate the adjudicated effects into a Campaign-level model?

1) Effects data and rules-based decision making tables from mission-level models can be applied within campaign-level models.
   a) Dialogue frequently necessary

2) Automatically linking mission and campaign models at different levels possible, but requires labor to troubleshoot, Monte Carlo analysis challenging, and run times increase.

3) All domain representation and future recomposable, disaggregated effects chains and dynamic C2 structure representation lacking.
Parallel Approach: Investigate Utility of Decision Aids

1) Leverage growth in planning tools/decision aids.
   a) Rapid, scalable, automatic planning
   b) Convergence between multi-domain DoD simulation and gaming environments

2) Programs offer potential opportunities to identify new advantage for force employment and design.

Adapting Cross-domain Kill-webs (ACK)
Decision aids supporting cross-domain formation and adaptation of effects chains

Air Combat Evolution (ACE)
Scalable autonomy for air combat

Gamebreaker
Methodologies and algorithms to assess & create imbalance in complex games/models
• **MORS and Services**: Develop and prioritize essential cross-service updates to STORM for Cyber/AI/battle C2. Seek opportunities for collaborative funding.

• **MORS and Senior Leaders**: Establish an analyst education program that incorporates operator and planner perspectives in emerging warfight areas (Cyber, AI, autonomous systems, battle C2).

• **Cyber and Campaign Analysis Community**: Develop agreed upon taxonomy (e.g., Access, Targets, Execution, Personnel - Critical Resource) and aggregated, genus cyber effects (e.g., Probability, Impact, and Duration) for incorporation into campaign analysis. CNA’s Merlin is a great start.

• **Services**: Begin the data collection process for AI/autonomous system performance with humans in the loop. Leverage AI/autonomous system test and evaluation models / digital twins.
Working Group 5
Advances in Computation for Campaign Analysis

Dr. Mabel D. Ramirez, Ms. Sarah Stewart, Mr. Jaime Bestard

18-21 November 2019
Working Group Members

- LCDR Matt Arndt
- Mr. David Bella
- Mr. Jaime J. Bestard
- Mr. George Blaha
- Major Matthew Bohman
- LCDR Charles Clark
- Mr. John R DeYonke
- COL Thomas Dillingham
- Dr. Angela Giddings
- Mr. Mark Goolsbay
- Maj Joshua Gordon
- Mr. Reed Jensen
- Mr. Conner Loughlin
- Mr. Michael Morefield
- Ms. Denise Padilla
- Dr. Mabel Ramirez
- Ms. Sarah E Stewart
- Dr. Randall L Walker

Thank you!
• Objectives
  • Develop a framework identifying areas where advanced technologies can be used to enhance current approaches and processes in campaign analysis
  • Discuss topics in advanced technology (e.g., machine learning, high performance computing, analytics, capabilities-based models, serious games/virtual environments) that can be leveraged to revolutionize current approaches to campaign analysis

• Scope
  • Exploration of advanced computational and technology advances to improve campaign-level agility
  • Leveraging discussions from WGs, comparison of current approaches in campaign analysis – what needs to change? How to do it differently?

• Questions to be answered
  • How can advanced technology help improve and/or augment current thinking in campaign analysis?
  • What key technologies are needed? Who needs to drive this change? Where are the first areas to insert new technology in campaign analysis that will demonstrate impact and promote agile change?
Campaign Analysis “Kill-Chain”
(Markov Chain/Dynamical System Approach)

- Question
- Model
- Analytic Engine
- Output
- Data
- Human Assessments
- Computational Assessment
- Performance Metrics
- Analyst-Algorithm Interpretation

Assessments
Challenges and Needs for Technology Integration to Enable Flexible Campaign Analysis
Challenges and Needs for Technology Integration to Enable Flexible Campaign Analysis

Data

- Access
- Generation
- Aggregation (classification)
- Common database
- Relevant Data
- Infrastructure & Processing power
- Metadata / Data labeling
- Structured & Unstructured

Agile Campaign Analysis

- Domain expertise
- Diversity of team’s knowledge
- CONOPs & Tactics
- COA Interpretation
- Policy and Rules of Engagements
- Acceptance of uncertainty
- Credibility/Trust in “machine” and in data sharing
- Integration of S&T into OR community

Advanced Technology

- Human-Behavior Learning Algorithms
- Human-centric domain & data collection
- Human interpretable results
- Explainability of AI decisions
- Open systems / Data fusion engines
- Visualization of results (and display of uncertainty levels)
- Automatic data labeling
- Human-in and on-the-loop decision aids (i.e., enhance human cognition)
- Cloud computing / scalability

Human & Culture

- Diversity of team’s knowledge
- CONOPs & Tactics
- COA Interpretation
- Policy and Rules of Engagements
- Acceptance of uncertainty
- Credibility/Trust in “machine” and in data sharing
- Integration of S&T into OR community
Interactive virtual (e.g., serious games) environments enable rapid data collection from human users to generate relevant and labeled data for analysis.

**Technology Enabler Example for Human Data Collection, Generation, and Digitization**

- **Data Quality**
  - Engaging: Users are invested in outcome
  - Automated Data Collection: Automatically record user actions and environment state
  - Experimental Design: Allows for control of experimental variables
  - Model-Based: Real-world physics & capability-based effects models

- **Data Quantity**
  - Short and Iterative: Executed in minutes
  - Accessible: Cloud-enabled app runs on desktop or laptop
  - Flexible: Quickly design, modify, and execute scenarios
  - Rewind & Replay: Ability to save and replay from known states

---

**Data Collection and Analytics Engine**

- Front End
- Simulation
- Database
- Models
Technology Enabler Examples for Agile and High Dimensional Data Analysis

**BrainSTORM: Novel and Enhanced Development of Courses of Action for Military Insight**

### A CAMPAIGN PROBLEM GOALS AND SCENARIO

<table>
<thead>
<tr>
<th>INTELLECTUAL FUNCTION</th>
<th>APTITUDE</th>
<th>COMPLEXITY</th>
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<tr>
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<td>Art</td>
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<td>Science</td>
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<td>Lowest</td>
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#### APPRECIATION
A strategy or set of high-level insights

#### OPERATIONAL DESIGN
A framework of insights that differentiate sets of COAs

#### COURSE OF ACTION
Sequences of moves that achieve an operational design

#### MOVE
A set of orders for a turn or phase

#### ORDER
An action for a unit

### TOOLS AND APPLICATION

- **BrainSTORM Tool Suite**
- **ARTIFACTS**
  - Commander’s Intent
  - Mission Analysis
  - COA Development
  - COA Analysis Wargaming
  - COA Comparison
  - COA Approval
  - Order Development

### EVALUATION
Are we on-plan or off-plan?
- Why?
- What do we do about it?

**AI C2 agents to achieve novel COA development and understanding**

**Parallel Algorithm for Approximating Nash Equilibrium in Multiplayer Stochastic Games with Application to Naval Strategic Planning**

Sam Ganzfried1, Connor Laughlin2, Charles Morefield3

Gansefried Research - Arteris, Inc.

**Abstract**

Many real-world domains contain multiple agents behaving strategically with probabilistic transitions and uncertain (potentially infinite) horizon. Such settings can be modeled as stochastic games. While algorithms have been developed for solving 4×4, computing a game-theoretic solution concept such as Nash equilibrium is prohibitive for two-player zero-sum stochastic games with a large number of states with only a finite number of players, which cannot model games of unknown duration, which can potentially contain infinite cycles between states. Such games must be modeled as Markovian games.

**Definition 1.** A stochastic game (as a Markov game) is a tuple $<Q, V, A, C, r_0>$, where:
- $Q$ is a finite set of states
- $V$ is a finite set of players
- $A$ is a finite set of actions
- $C$ is a finite set of terminal sets
- $r_0$ is a finite set of rewards

**Game-theoretical approaches to cover high dimensional and stochastic problems**

**Human-initialized optimization techniques that learns from human knowledge to warm start algorithms**

**Optimal**

**Goal-Based Search**
• Campaign analysis is a complex and high dimensional problem requiring:
  • integration of agile processes
  • infrastructure to input and process massive amounts of data
  • analytical engines to explore high dimensional data spaces
  • culture shift to accept and trust technology
  • insertion of technologies across all elements of campaign analysis “kill chain”

• Improved integration of technology R&D and operations research communities (e.g. WG forums)
Working Group 6

Relationship of Campaign Analysis to related fields
Wargaming, Training Exercises, and Experimentation

Chair: Mike Lepson (Navy – NWDC)
Co-Chairs: Phil Pournelle (LTSG)
Chuck Burdick (IDI)
Advancing Campaign Analytics  
18 – 21 November 2019  
Alexandria, VA

Working Group 6 - Participants

- Chair: Mike Lepson, NWDC  
- Co-Chair: Chuck Burdick, IDI  
- Co-Chair: Phil Pournelle, LTSG

<table>
<thead>
<tr>
<th>Full Name</th>
<th>Organization Name</th>
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<tbody>
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<td>Col Tim Barrick</td>
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<td>Ms. Robbin Beall</td>
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## Working Group 6 - Participants

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<td>Mark Stankiewicz</td>
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<td>Derrick Vincent</td>
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• **Objective:** to update the community on advances in campaign analytics and to foster collaboration on enhancing the tools, techniques, and procedures used by the national security community to inform joint strategic and operational decisions. This includes
  - Exploring opportunities to make campaign analysis more agile, relevant, and responsive
  - Credibly incorporating non-kinetic effects, such as cyber-attacks and information warfare, across the physical domains
  - Addressing challenges to workforce development and continual education
  - Integrating advances in high performance computing and computational methods
  - Leveraging capabilities used by practitioners in other analytic disciplines.
Themes and Objectives

• Identify how wargaming, training exercises, and experiments can inform, and be informed by campaign analysis
• Present a common framework that leverages the “cycle of research to support accelerated learning” or another paradigm to address short-falls in campaign analysis and related fields to support strategic decisions.

Approach

• Leveling Briefs - State of the art and current challenges/barriers
• What are the barriers to implementing a “cycle of research\learning”?
• What are the solutions to overcoming those barriers?
• What is a common framework that can be leveraged to implement a “cycle of research\learning”?
• What are the key insights?
  • Key insights of interest to DOD leaders
  • Describe how we bring about overall improvement in analysis by strengthening linkage between methods
The Cycle of Research

From *The Art of Wargaming* by Peter Perla
Barriers (what we can or cannot fix)

• Campaign-level analysis does not only equal campaign modeling
• Time and objective of effort create challenges (Geographic Combatant Commands/Service Components vs. Service HQ)
  • GCC are executing limited cycle of learning (aligned to wargaming, M&S, training exercises and experiments)—fight tonight, today’s force, OPLAN
  • Future force efforts are often ad hoc, and face the challenge of problem set
  • Gap exists between two perspectives
• We don’t have an joint campaign to analyze through a cycle (the hub)
  • Concept or scenarios need identified capabilities, tasks and assumptions to baseline analysis across different organizations and methods
  • Need starting point to support divergent to convergent thinking (vice an anchor)
  • Joint Force Operating Scenario (JFOS) is a start
• Communication
  • Of findings and reports
  • Across analytic community
  • To next “link” in the cycle
  • Tribalism, lack of Forums, Time, Synchronizing Authority are barriers
Barriers (what we can or cannot fix – Pournelle brief)

- Tribalism
  - We stick with what we know—Lack of multi-disciplinary analysts (e.g. OR community tend to specialize, many not trained in wargaming, other disciplines)
  - We are stuck doing “seminar” wargames, we are not advancing the level of understanding or providing the degree of detail needed to advance cycle
  - We are stuck doing “demos” in experiments
  - We think of war games as separate from analysis

- Efforts need to generate data that can move between methods (analyst needs to make translation)

- Organizational alignment and resourcing
  - Work is based on available method and aligned to support mission not advance learning across enterprise (works best in organization with multiple methods available to them, and ability/flexibility to align methods to problem)

- Need to apply foundational methods of ORSA (research, etc.)
Solutions

- Campaign analysis will benefit from a cycle of learning
  - Key is analysis not just result of method
- Need to involve decision-maker (experiential)
  - Relay insights via a credible story with analytical rigor.
  - Involved early and through cycle
- Services can learn from focus and approach of GCCs/Components in identifying forcing functions for analytic integration.
  - GCC/Components have better understanding of today’s problem, decision-makers aligned and oriented (most think about today’s problem), cone of uncertainty is less, and they own cycle of learning.
  - They have “forcing function” to provide starting point, and generate multi-disciplinary approach
  - Need to bridge the gap between near term and long term efforts.
Solutions

• Analytic agendas need to plan for the integration of wargaming, experiments, exercises and M&S
  • Problem definition and scoping must occur (what are the questions)
  • Basic standards need to be applied (e.g., collaboration, literature search, stakeholder analysis)
  • Analysts need to be involved in wargaming and experimenting planning (multi-disciplinary)
  • We are still building the “analytic preparation of the battlespace” for Great Power Competition and conflict
  • Hub must be identified to drive cycle (e.g., General Board)

• Alliances are critical (Services, SMEs, different disciplines, natural self-interest)

• If we leverage all methods, then we will have greater confidence that we are not “anchored”.
  • Some assumptions are better addressed through wargaming (vice just running a lot of excursions)
  • Allows for feedback from and into experiments and exercises
  • Mechanism needed to advance knowledge learned or gaps discovered to other entities or methods (experimentation sponsor, exercise, etc.)

• Enhancing communication of appropriate use of analytic methods
  • Best practices in communicating and integrating (fusing) results.
  • Reduce analytic fratricide, enhance synthesis
• Great Power Competition should be recognized and applied as a forcing function
  • Analytic preparation of the battlespace necessary
• A framework that leverages the “cycle of research to support accelerated learning” is required
• Analytic agendas need to plan for the integration of wargaming, experiments, exercises and M&S
• Analytic alliances are critical
• Best practices in multi-disciplinary integration need to be established and shared
Synthesis Group

21 November 2019
Synthesis Group Membership

- Trip Barber, FS, SPA – Chair
- George Akst
- Tom Allen, FS, IDA
- Jackie Henningsen, FS
- Myles Miyamasu, CAA
- Lisa Oakley-Bogdewic, MITRE
- Doug Otte, NPS
- Mike Ottenberg, Group W
Synthesis Group Charter

• Summarize advice on what ought to be done to make campaign analysis more agile, relevant, and responsive in order to improve its capability to support senior DoD leader decisions in two important but different areas:

  • Long-term investment decisions on force structure and capability
  • Near-term operational planning decisions
Keynote Address by Hon Robert O. Work

- DoD became complacent about and lost focus on analysis of great power/peer warfare and refocused on “shaping” -- and both China and Russia exploited the erosion of our analytic overmatch

- Great power warfare will be joint and global, not service-specific or regional, and it must be planned for and analyzed accordingly

- Need to increase the size, and greatly expand the rigor and scale, of the academic preparation of the analysis workforce

- Need strong research and rigorous quality control programs for analytic capabilities and connect them better to wargaming

- Manage analytic processes and capabilities so that they deliver answers at the speed of senior decision processes
General Insights on Key Problem Areas

• Perceptions of key leaders
  - Not agile and responsive enough
  - Insufficient transparency of assumptions
  - Does not adequately represent non-kinetic effects

• Perceptions of practitioners
  - Lack DoD-level process management for an activity that is inherently joint
  - Lack adequate common accessible source for authoritative joint and allied data
Make campaign analysis more relevant and responsive

• Model run-time is not generally the limiting factor; building authoritative inputs is what takes the most time

• Partnership with operational experts in building CONOPS and measurable campaign objectives is key to relevance

• Centralized availability of authoritative data on US, Allied, and adversary system performance, inventories, and structure is key to joint coherence of analytic effort

• Building and maintaining a “warm production base” of campaign models for key authoritative joint scenarios is key to responsiveness
Incorporate non-kinetic effects across the physical domains

- Translating a non-kinetic effect into a specific measurable operational impact is hard but necessary
  - Leverage wargaming, experimentation, and high-resolution engineering models

- Do parametric exploration of impact of decision speed/accuracy on campaign outcomes in order to screen non-kinetic effects for potential impact
  - Accept that there are things that campaign models will not be able to reflect explicitly
Address challenges to workforce development

- Size of government workforce doing campaign analysis does not match the scale of work desired
  - Substantial reliance on contractors for long-term expertise

- Minimal formal instruction available for campaign analysis practitioners, beyond model operator training
  - Only academic course is one quarter at NPS
  - No continuing education or community of practice
Integrate advances in computational capability

• Simply running campaign model baselines quicker is not the objective

• Using advances to explore sensitivity of campaign model outcomes to their many assumptions and uncertainties should be a primary focus
  - Find discriminating variables
  - Find best CONOPS/COA for detailed modeling

• Also use advances to automate the integration and collaboration of mission and campaign modeling
Leverage capabilities from other analytic disciplines

• Best practice is to systematically coordinate wargaming, exercises, lessons-learned, and experimentation processes with campaign analysis

• Integrate emulation of peer adversary approach to warfare decision-making into campaign analysis
Potential Future Government Activities

• Establish and sustain a framework to develop and maintain joint scenarios at sufficient detail to support DoD campaign analysis

• Establish a common DoD source and process for making authoritative and current data on US, Allied, and adversary system performance, inventories, and structure available for analysis

• Establish and educate a government workforce that matches the increasing demands of skills and capacity for this form of analysis
Potential Future MORS Activities

• Establish a Community of Practice for campaign analysis
  - Preferably with a means of sharing classified material

• Consider establishing a certificate program for campaign analysts

• Increase coverage on campaign analysis in Phalanx, leveraging presentations from this event

• Expand the Educational and Professional Development event to critically evaluate the depth and breadth of current analyst education programs
How well did we meet the objectives?

To update the community on advances in campaign analytics and to foster collaboration on enhancing the tools, techniques, and procedures used by the national security community to inform joint strategic and operational decisions. This includes:

- Exploring opportunities to make campaign analysis more agile, relevant, and responsive
- Credibly incorporating non-kinetic effects, such as cyber-attacks and information warfare, across the physical domains
- Addressing challenges to workforce development and continual education
- Integrating advances in high performance computing and computational methods
- Leveraging capabilities used by practitioners in other analytic disciplines.
Discussion: Next Steps?