DEFENSE ANALYSIS
CHALLENGES FOR
MODELING AND
SIMULATION

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Defense Analysis challenges for Modeling and Simulation

CHALLENGES: WHAT IS THE VALUE OF ANALYSIS OF "OPEN SYSTEM" ISSUES PERFORMED WITH CLASSIC "CLOSED SYSTEM" METHODOLOGY? HOW DO WE RECOGNIZE, DESCRIBE & ANALYZE "OPEN SYSTEM" ISSUES? WHAT IS IMPORTANT TO KNOW ABOUT "OPEN" MILITARY SYSTEMS BEHAVIOR? WHAT CAN WE REASONABLY TELL DECISION MAKERS ABOUT "OPEN" PROCESSES AND THEIR CONSEQUENCES? WHAT CAN WE LEARN FROM COMMERCIAL USES OF COMPLEXITY SCIENCE & OPEN SYSTEM ANALYSIS? WHAT IS THE "RIGHT WAY" TO USE THE COMPUTER? AGENT BASED SIMULATION "BREEDING & TESTING STRUCTURES vs DEFINING "THE SYSTEM"?
LISTEN TO THE EVOLVING LANGUAGE OF THE DEFENSE DEBATE

- "ASYMMETRIC" THREATS.
- ADAPTIVE THREATS.
- UNCERTAINTY" AND "CHANGE".
- INFORMATION BASED WARFARE.
- EFFECTS BASED WARFARE.
- EMERGENT BEHAVIOR.
- PRECISION ENGAGEMENT.
  - "UNINTENDED CONSEQUENCES".
- SYNCHRONIZING ALL INSTRUMENTS OF NATIONAL POWER TO ACHIEVE A DESIRED END STATE.
  - VARIETIES OF MOTIVATIONS & CAPABILITIES.

THE LANGUAGE OF "OPEN SYSTEMS".

THE LANGUAGE OF COMPLEXITY SCIENCE.

BEHAVIORS, SYSTEMS, STRUCTURES EMERGE FROM INTERACTIONS AMONG INGREDIENTS; THEY ARE "CONSEQUENCE" MORE THAN "CAUSE".
OPEN SYSTEMS

• THERMODYNAMICALLY, ENERGY CROSSES THE SYSTEM BOUNDARY.
  • “ENERGY” INCLUDES MENTAL ENERGY:
    • INFORMATION, CREATIVITY, PERCEPTION, MOTIVATION.

• STRUCTURE & BEHAVIOR “EMERGES” - ATTRACTORS
  • WHAT WE SEE AS “SYSTEMS” APPEAR AND ENDURE AND CAN CHANGE THEMSELVES TO SATISFY MOTIVATIONS ABILITIES AND OF THEIR INGREDIENTS.

• CHARACTERIZED BY STATE CHANGES: LIKE WATER
  • FIXED (SOLID) - “LOCKED” STRUCTURE.
  • TRADITIONAL, NEWTONIAN, ANALYSIS METHODS APPLY.

• BOUNDARY (LIQUID) - EMERGENT BEHAVIOR “WHIRLPOOLS”
  • COMPLEXITY SCIENCE & OPEN SYSTEMS ANALYSIS METHODS.
  • ADAPTATION, EVOLUTION, CHANGE.
  • STRUCTURES EXHIBIT, HOMEOSTASIS, RESILIENCE.

• CHAOS (GAS) - “EXTREME SENSITIVITY” TO INITIAL CONDITIONS.
  • FLAPPING BUTTERFLY WINGS → TORNADOES
WARFARE

A COMBINATION OF “OPEN & CLOSED” PARADIGMS

• COMMAND AND CONTROL & COMMUNICATIONS.

• “FOCUSED LOGISTICS” & TPFDD AND DEPOT BASED LOGISTICS.

• FORCE PLANNING FOR “ADAPTIVE” THREATS.
  • “THREAT” vs “CAPABILITY” BASED FORCE DESIGN.
  • “SCENARIOS” vs CO-EVOLVING FITNESS LANDSCAPES.

• BUDGET PLANNING.
  • “KNAPSACK” PROBLEM vs SURVIVAL & ADAPTATION ON AN EVOLVING FITNESS LANDSCAPE.
STATE OF DEFENSE
ANALYSIS METHODOLOGY

• DOMINATED BY LEGACY OF THE “CLOSED SYSTEM” PARADIGM.
  • “NEWTONIANISM” DETERMINISTIC CAUSE & EFFECT.
  • “REDUCTIONISM” DISASSEMBLE THE WHOLE, UNDERSTAND THE PIECES, REASSEMBLE TO UNDERSTAND THE “WHOLE”.

• USE OF “REALISM PAINT” TO MAKE A “CLOSED” MODEL LOOK MORE “REALISTIC”.
  • STOCHASTICS TO FUZZ THE BEHAVIOR
  • MORE DETAIL; THE ENDLESS QUEST.

• INCREASED USE OF GAMING AND FACILITATED SEMINARING IN COMBINATION WITH CLOSED PARADIGM M&S.
  • CAPTURE EMERGENT BEHAVIORS & UNINTENDED CONSEQUENCES
  • M&S USED HERE FOR “ACCOUNTING” AND “KINEMATICS”.

• BEGINNINGS OF A MILITARY COMPLEXITY SCIENCE.
  • AGENT BASED SIMULATION - PROJECT ALBERT, USMC.
EXAMPLE
CLOSED vs OPEN SYSTEM ANALYSIS

WWII SUBMARINE SEARCH:
THE “SYSTEM” = GERMAN ATLANTIC SUBMARINE OPERATIONS.

REAL WORLD SUBMARINE PRESENCE PERCEIVED WITH:
- RADIO REPORTS ATTRIBUTABLE TO SPECIFIC SUBMARINES.
- UNATTRIBUTABLE RADIO TRAFFIC FROM SUBS.
- TORPEDO HITS ON CONVOYS.
- RECCE & INTEL FROM SUB BASES.
- PHYSICS OF SUBMARINE PERFORMANCE.
- INTEL AND EXPERTISE ON SUBMARINE ORGANIZATION, OPS, ROE.
- GOOD KNOWLEDGE OF MY OWN SENSING CAPABILITIES.

LOTS OF ENERGY FLOWING FROM THE SYSTEM: OPEN
SYSTEM HAS GOALS & MOTIVATIONS; STRUCTURE, IT BEHAVES & EVOLVES.
CLOSED SYSTEM ANALYSIS APPROACH

QUESTION: HOW MANY SUBS ARE DEPLOYED?
APPROACH: DEFINE A CLOSED SYSTEM AND PREDICT ITS CHARACTERISTICS.

-CLOSED SYSTEM:
- USE ONLY THE RADIO REPORTS ATTRIBUTABLE TO SPECIFIC BOATS.
- IGNORE THE REST OF THE ENERGY PASSING THROUGH THE SYSTEM, (THE SIGNATURES OF THE REAL SUBMARINE OPERATING STRUCTURE)
- ASSUME A POISSON DISTRIBUTION. (UNIFORMITY ASSUMED)

5 SUBS REPORTED 1 TIMES.
3 SUBS REPORTED 2 TIMES
2 SUBS REPORTED 3 TIME.

PREDICTIONS: THERE ARE 2 SUBS NEVER HEARD/ 12 SUBS TOTAL.

NEXT QUESTION: HOW DO WE BEST FIGHT THESE SUBS??
- HEART & SOUL OF EFFECTS BASED WARFARE ANALYSIS.
OPEN SYSTEM
ANALYSIS APPROACH
AGENT BASED SIMULATION.
- TREAT CONVOY SHIPS AS “AGENTS (SCRIPTED)
- DEFINE SUB “AGENTS”. (TUNE DETAIL FOR REALIST BEHAVIOR)
- USE GENETIC ALGORITHMS TO “BREED”SUBMARINE
  FORCES AND OPS CONCEPTS
  - SUB CHARACTERISTICS (PRETTY GOOD BOUNDARIES)
  - C2 STRUCTURE (REPORTING RULES)
  - MOTIVATIONS (SINK SHIPS & DON'T GET SUNK)
  - OPS CONCEPTS (CRUISE DURATION, REPLACEMENT SCHEMES, OPS AREAS)
- AS SUB OPERATING STRUCTURES EMERGE FROM SUB AGENT
  INTERACTIONS WITH CONVOYS, SEARCH EFFORTS, PHYSICS, ETC)
- TEST THOSE EMERGENT SUBMARINE “STRUCTURES”.
  - COMPARE ITS PERCEIVABLE “SIGNATURES” (RADIO TRAFFIC,
    TORPEDO HITS, PORT INTEL REPORTS, ETC) TO REAL EXPERIENCE.
- OBSERVE “BEST FIT” OF AGENT MODEL TO REALITY
- NOW SPECULATE ON: HOW MANY, HOW TO FIGHT.
CLOSED vs OPEN SYSTEM COMPARISON

CLOSED SYSTEM APPROACH:
- Defined a structure; its shape & behavior—our “model”.
- Closed the boundaries of our investigation.
  - Worked with a fixed subset of the info available
  - Ignored data that did not fit the “model”.
- Learned very little of what there was to know about German submarine behavior.
- We fit the world to our design; not asking what might best explain what we were seeing; using all of what we were seeing; not considering how it might respond to something we might do.

OPEN SYSTEM APPROACH:
- Let a structure “emerge” from the possible interactions.
  --“Self organization”—it defines its “best” self.
- Use all the information available to test emergent structure.
- Have a tool for understanding the “whole” of the enemy ops and what might happen next—explore adaptive behavior.
- Have a methodology for effects based warfare analysis.
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