

**A SELF-RECONCILING EVIDENTIAL DATABASE
FOR INTELLIGENCE ANALYSTS***

INTELLIGENCE COMMUNITY AI SYMPOSIUM

By

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THE ANALYST'S DILEMMA

**DATA ARE OFTEN UNRELIABLE, INCOMPLETE,
INCONCLUSIVE, AND INCONSISTENT**

YET CONSUMERS COMPLAIN --

- **IF ESTIMATES REFLECT HIGHLY DIVERGENT
POSSIBLE CONCLUSIONS ("TOO MUCH
HEDGING")**
- **IF ESTIMATES REPORT NON-CONTROVER-
SIAL AREA OF AGREEMENT ("TOO BLAND")**
- **IF ESTIMATES TAKE A STRONG, PRECISE
POSITION -- AND TURN OUT TO BE WRONG.**

HOW TO PRODUCE ESTIMATES THAT

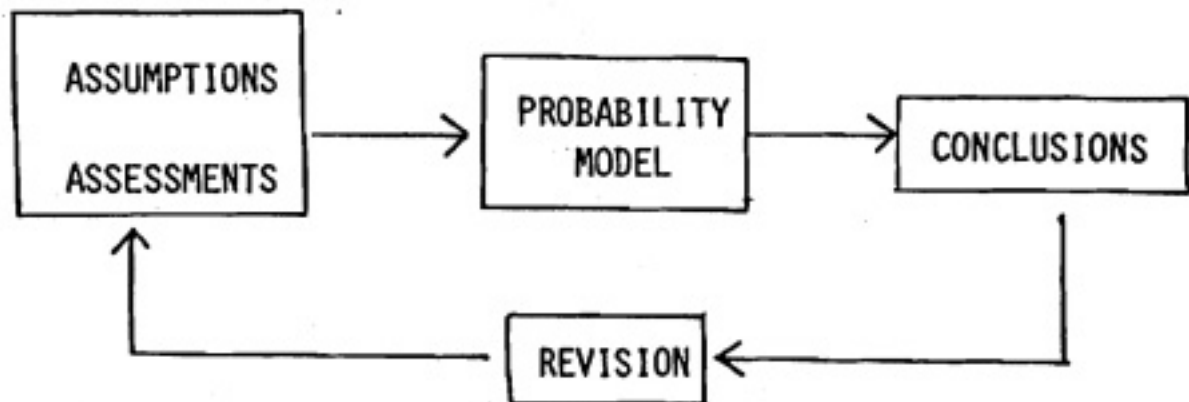
- **HAVE A CLEAR, DEFINITE CONCLUSION, BUT**
- **IN WHICH REASONS PRO AND CON, AND
LIMITATIONS OF THE ARGUMENT, ARE ALSO
CLEAR?**

OTHER PROBLEMS

AT THE SAME TIME, ANALYSTS NEED:

- **METHODS FOR INTEGRATING DIVERSE TYPES OF DATA (HUMINT, SIGINT, ELINT, ...)**
- **METHODS FOR INTEGRATING OUTPUTS OF DIVERSE TYPES OF MODELS**
- **METHODS FOR INTEGRATING CONCLUSIONS OF OTHER ANALYSTS**
- **METHODS FOR COORDINATING EFFORTS OF DIFFERENT ANALYSTS, AND ENSURING SMOOTH TRANSITIONS**

- (3) FOR HUMAN EXPERTS, PROBABILISTIC ANALYSIS IS
TYPICALLY ITERATIVE - PLAUSIBILITY OF RESULTS
CONFIRMS VALIDITY OF MODEL ASSUMPTIONS



BUT - IN CURRENT EXPERT SYSTEMS (CERTAINTY THEORY,
BAYES, SHAFER, ETC.)

PROBABILISTIC INFORMATION IS ENCAPSULATED
WITHIN MODULAR RULES

NO OPPORTUNITY TO ADAPT BASIC MODEL IN LIGHT
OF SUCCESSES OR FAILURES, ^{OR} TO DETERMINE NEED
FOR ADDITIONAL DATA _^

**CURRENT EXPERT SYSTEM AND DATA BASE APPROACHES TO
UNCERTAINTY:**

- (1) NO EXPLICIT REPRESENTATION OF COMPLETENESS OF
EVIDENCE OR RELIABILITY OF A PROBABILISTIC
ARGUMENT**

- E.G., $\text{PROB}(\text{COIN IS HEADS}) = .5$
 $\text{PROB}(\text{McENROE WILL}$
 $\text{WIN WIMBLEDON}) = .5$

**ONE DEPENDS ON MORE ASSUMPTIONS, AND IS MORE
SHIFTABLE WITH NEW EVIDENCE, THAN THE OTHER**

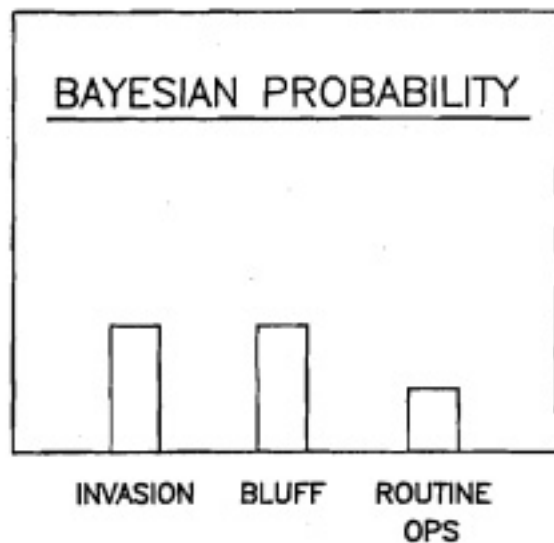
- (2) HIGHLY ARTIFICIAL NUMERICAL REPRESENTATIONS -
LITTLE ATTENTION TO STRUCTURE OF EVIDENTIAL
ARGUMENTS THAT UNDERLIE ASSESSMENTS**

PRESENT APPROACH

COMBINES ASPECTS OF

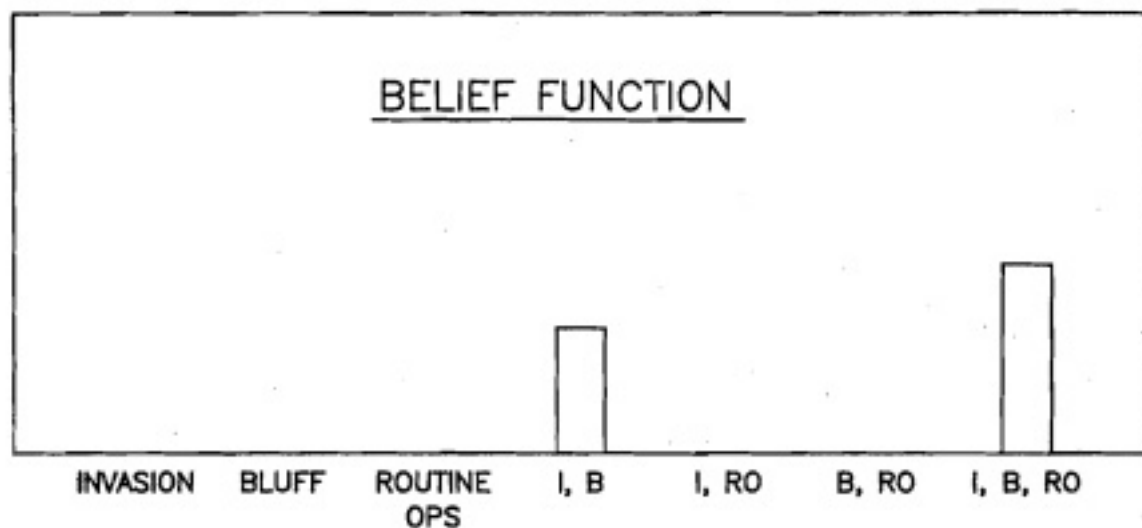
- QUALITATIVE (NON-NUMERICAL) APPROACHES
TO NATURAL ARGUMENT - TOULMIN, P. COHEN
- QUANTITATIVE REPRESENTATIONS OF
UNCERTAINTY - SHAFER, BAYES, ZADEH
- NON-MONOTONIC LOGIC - McDERMOTT, DOYLE

BELIEF FUNCTIONS (SHAFER/DEMPSTER)



ASSIGN BELIEF TO INDIVIDUAL HYPOTHESES

- ALLOCATION IS ARBITRARY IN CASES OF IGNORANCE
- NO REPRESENTATION OF QUALITY OF ARGUMENT



ASSIGN BELIEF TO SUBSETS OF HYPOTHESES

- NO NEED TO ALLOCATE BELIEF ARBITRARILY
- REPRESENTATION OF QUALITY OF ARGUMENT

NON-MONOTONIC LOGIC (DOYLE, McDERMOTT)

REASONING WITH INCOMPLETE INFORMATION:

- STATEMENTS MAY BE ACCEPTED AS LONG AS OTHER STATEMENTS ARE NOT ACCEPTED
- ASSUMPTIONS ARE REVISED WHEN THEY LEAD TO A CONTRADICTION

statement

sl < inlist, outlist >

"100 tanks in
xyz region"

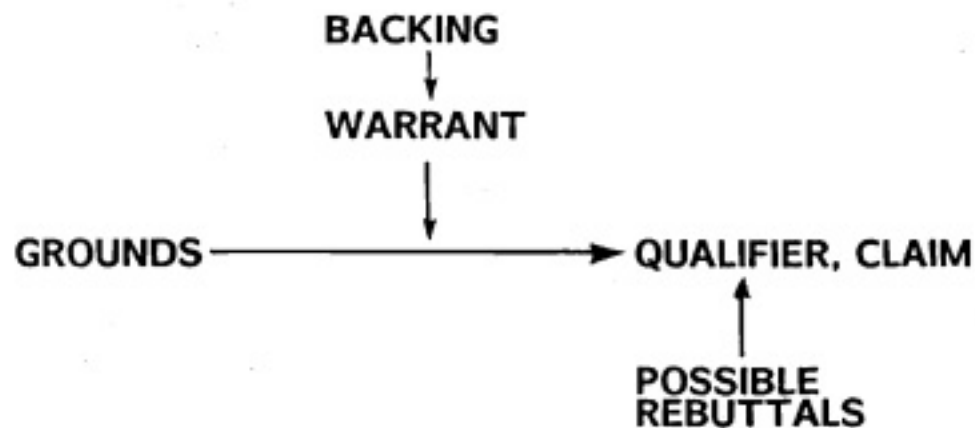
assume estimate valid if reported
by known observer, until reason to
doubt is discovered

PROBLEMS:

- APPLIES ONLY TO EXACT STATEMENTS
- NO NOTION OF GRADED SUPPORT
- SELECTION OF ASSUMPTIONS FOR REVISION IS ARBITRARY

TOULMIN'S THEORY OF ARGUMENT

- **SEEKING A NATURAL, CONSISTENT FRAMEWORK FOR ARGUMENTS IN MANY DOMAINS**



BACKING: BASIS FOR LINK BETWEEN EVIDENCE (GROUNDS) AND CONCLUSION (CLAIM)

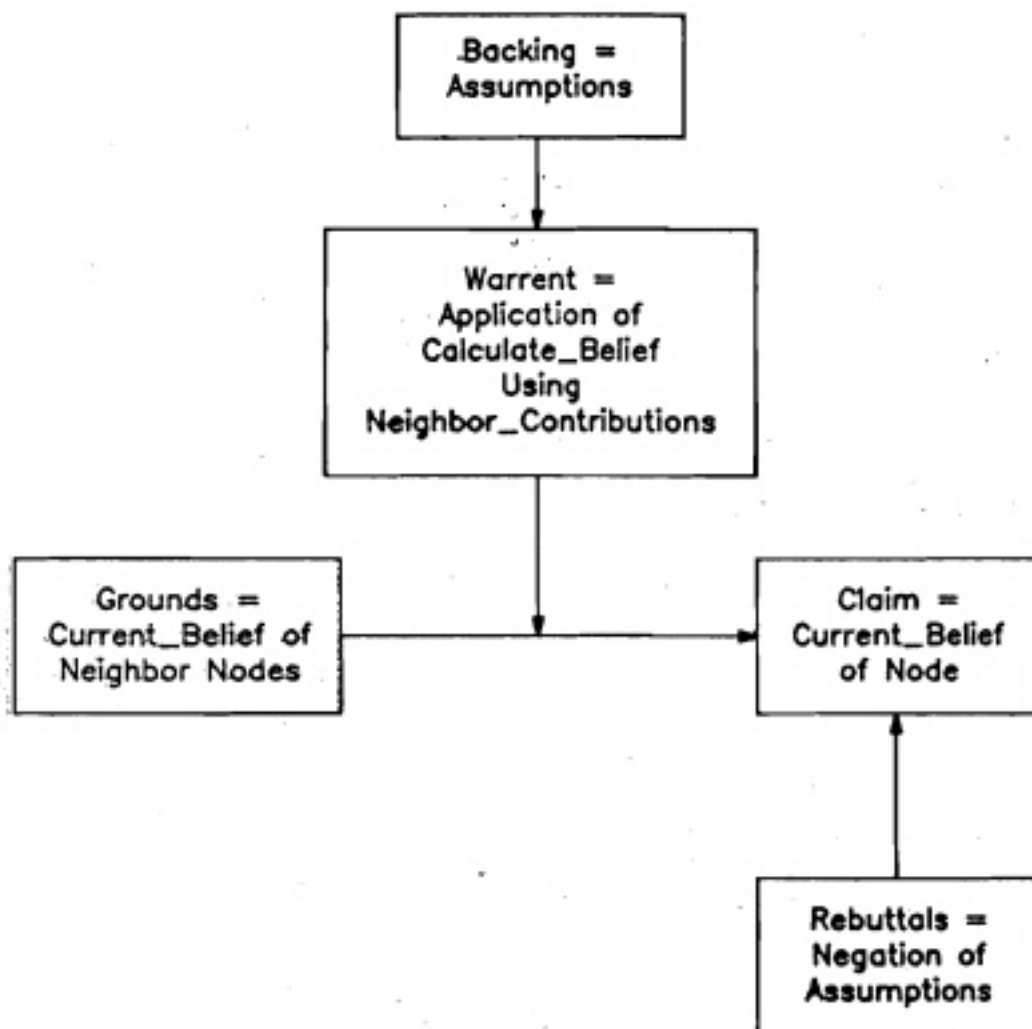
- **LIKE NON-MONOTONIC LOGIC: BELIEVE CLAIM UNLESS REBUTTALS FOUND TRUE.**
- **UNLIKE NON-MONOTONIC LOGIC: BELIEF MAY BE QUALIFIED; DIFFERENTIATED KNOWLEDGE STRUCTURE**

MORE TECHNICALLY:

- **USES SHAFER/DEMPSTER BELIEF FUNCTIONS
TO DEFINE CONCEPT OF "ASSUMPTION"**
 - **USES INFERENCE NETWORK TECHNOLOGY
(PEARL, ETC.) TO PROPAGATE BELIEF**
 - **EMBEDS QUANTITATIVE INFERENCING
WITHIN A HEURISTIC "METAREASONING"
CAPABILITY FOR ASSUMPTION MANAGEMENT
AND CONFLICT RESOLUTION**
- 57

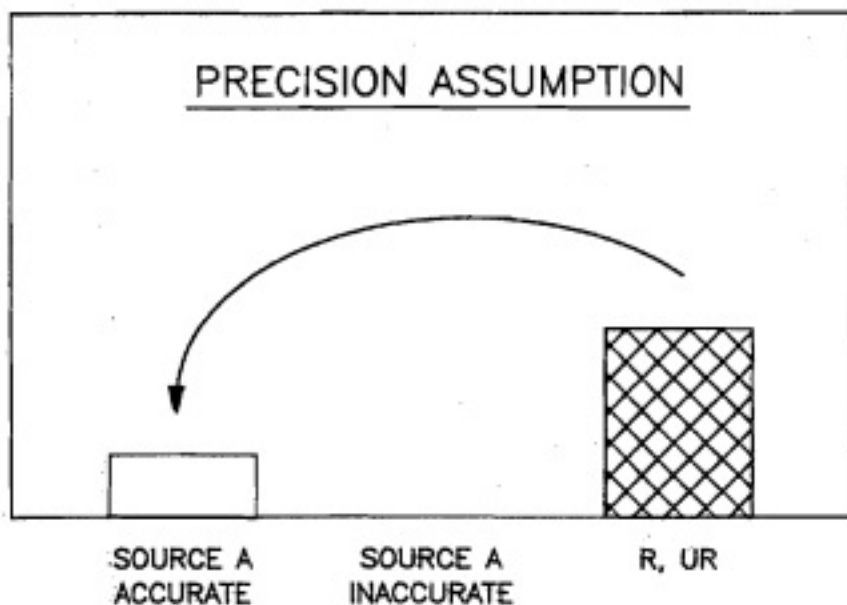
SELF-RECONCILING EVIDENTIAL DATA BASE

- **PROVIDES A NATURAL STRUCTURE FOR REPRESENTING EVIDENTIAL ARGUMENTS - IN A STANDARD RELATIONAL DATABASE**
- **HELPS ANALYST IDENTIFY FEATURES WHICH AFFECT RELIABILITY OF THE ARGUMENT**
- **PERMITS ANALYST TO EXPLORE DIFFERENT REPRESENTATIONS BY ADOPTING AND REVISING ASSUMPTIONS**
- **HELPS ANALYST RESOLVE CONFLICT BY TRACING THE ASSUMPTIONS INVOLVED IN THE CONFLICT AND RECOMMENDING REVISIONS**



Node Attributes and Toulmin's Argument Structure

ASSUMPTIONS INVOLVE ALLOCATION OF UNCOMMITTED SUPPORT



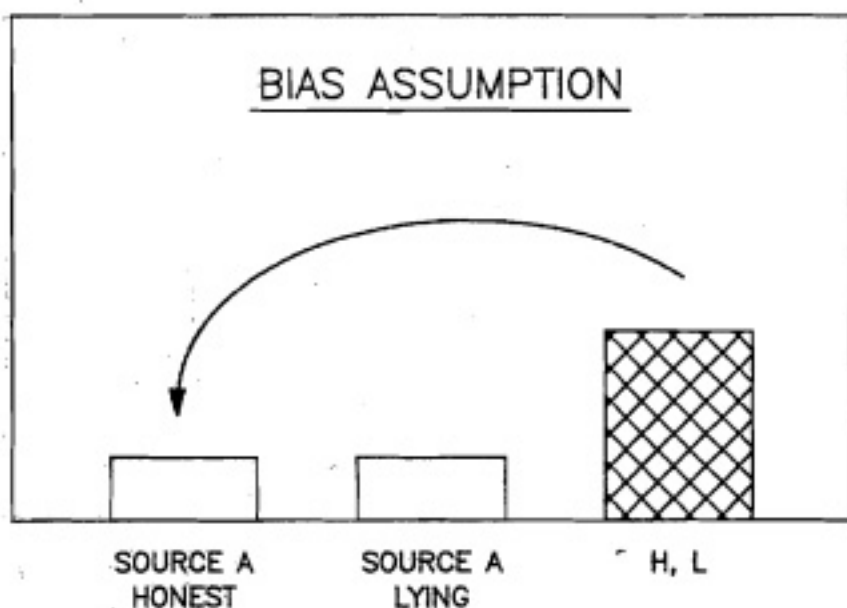
RESULT

MORE PRECISE
CONCLUSION:

"ENEMY IS NOT
ATTACKING"



"ENEMY IS
BLUFFING"



RESULT

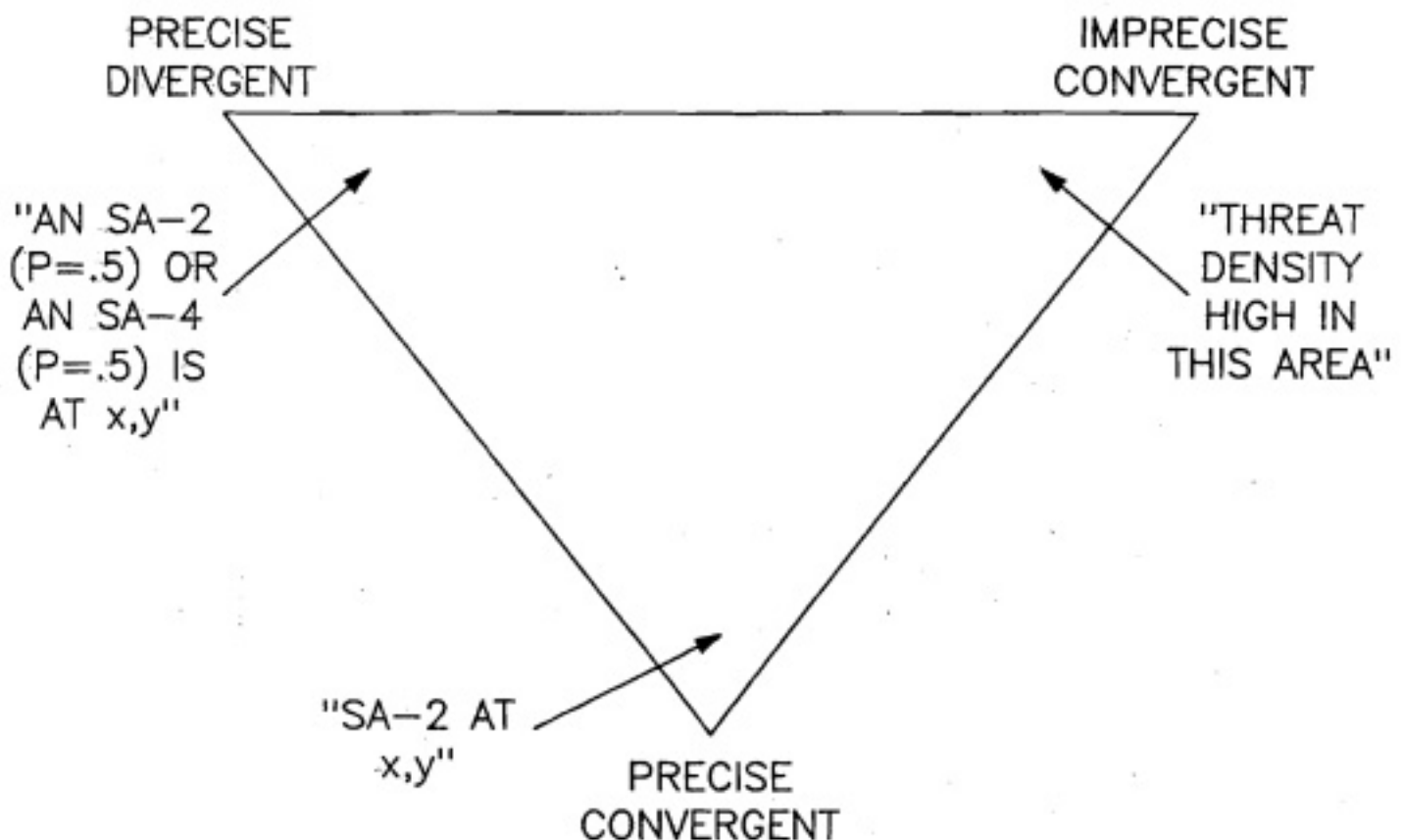
MORE CONVERGENT
CONCLUSION:

"ENEMY IS ATTACKING
OR ENGAGING IN
ROUTINE OPS"



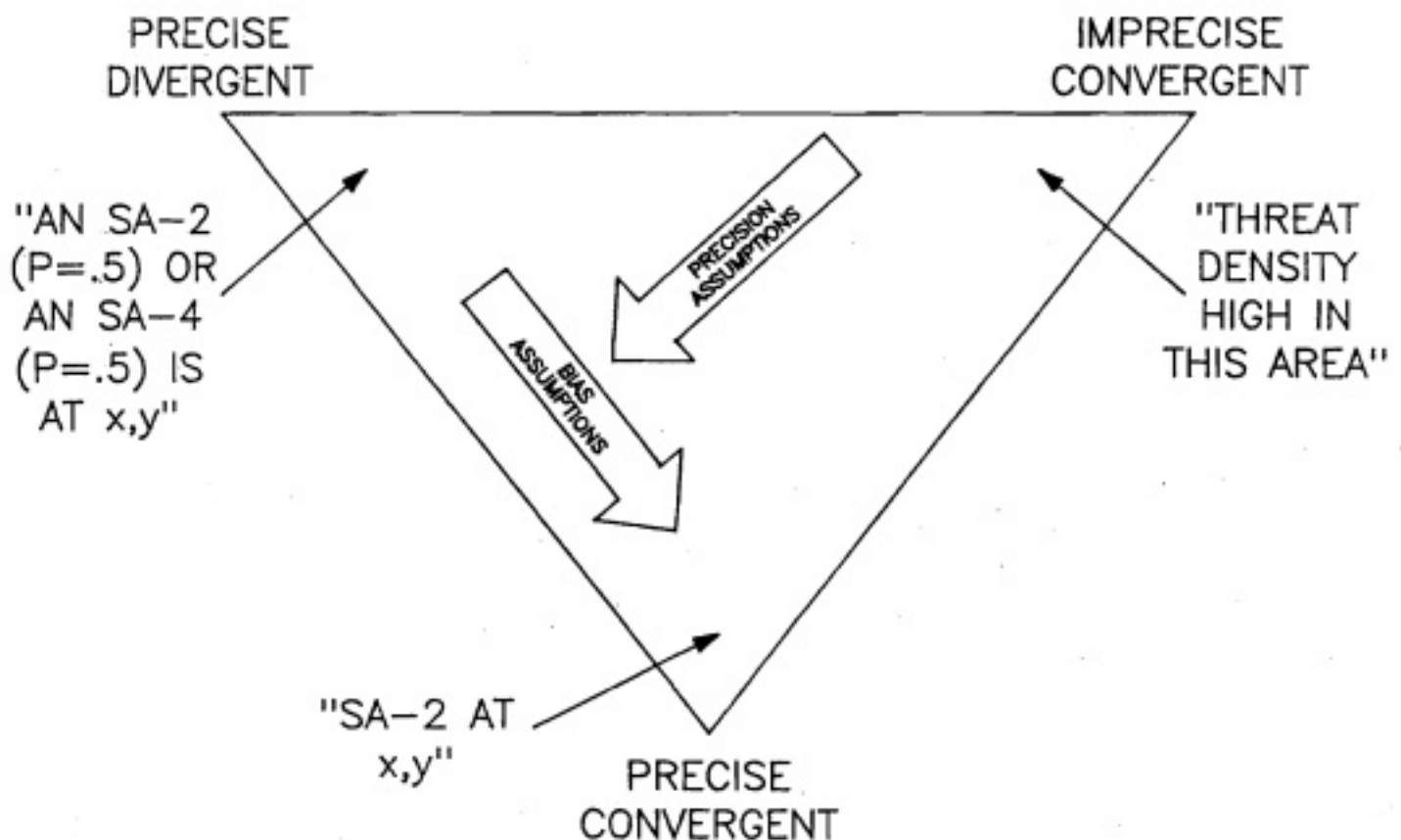
"ENEMY IS ENGAGING
IN ROUTINE OPS"

- THERE IS NO SINGLE UNIQUE REPRESENTATION OF THE UNCERTAINTY IN A PROBLEM AT THE LEVEL OF PROBABILITIES, BELIEFS, ETC.
- A MORE FUNDAMENTAL REPRESENTATION IS PROVIDED BY A SPACE IN WHICH THE PRECISION AND/OR CONVERGENCE OF A CONCLUSION CAN BE VARIED BY MAKING APPROPRIATE ASSUMPTIONS



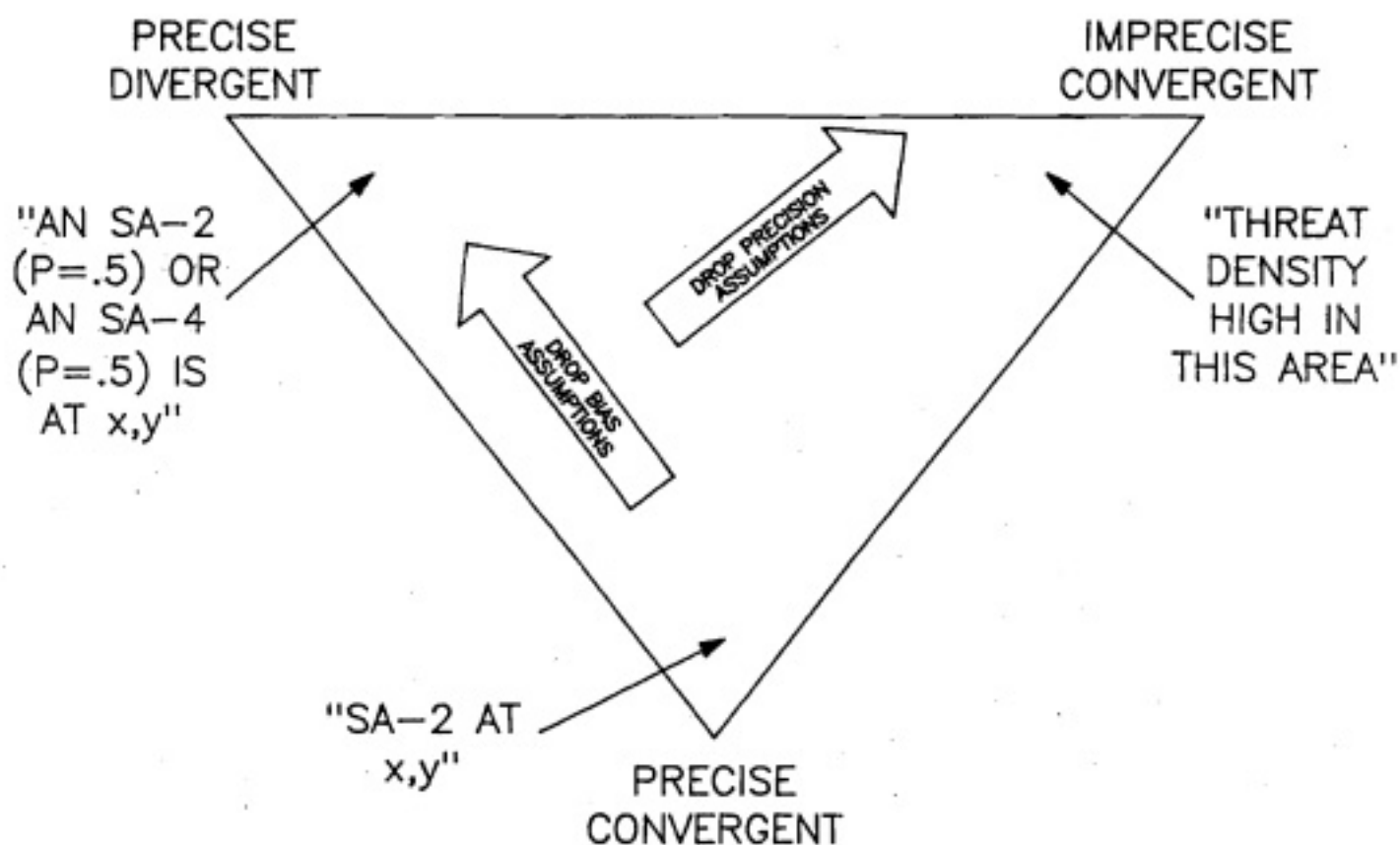
ANALYST MAY IMPOSE/REJECT ASSUMPTIONS IN ORDER TO:

- IMPROVE UNDERSTANDING OF PROBLEM
- TEST SENSITIVITY OF CONCLUSIONS
- SELECT LEVEL OF PRECISION AND CONVERGENCE APPROPRIATE FOR INTELLIGENCE CONSUMERS



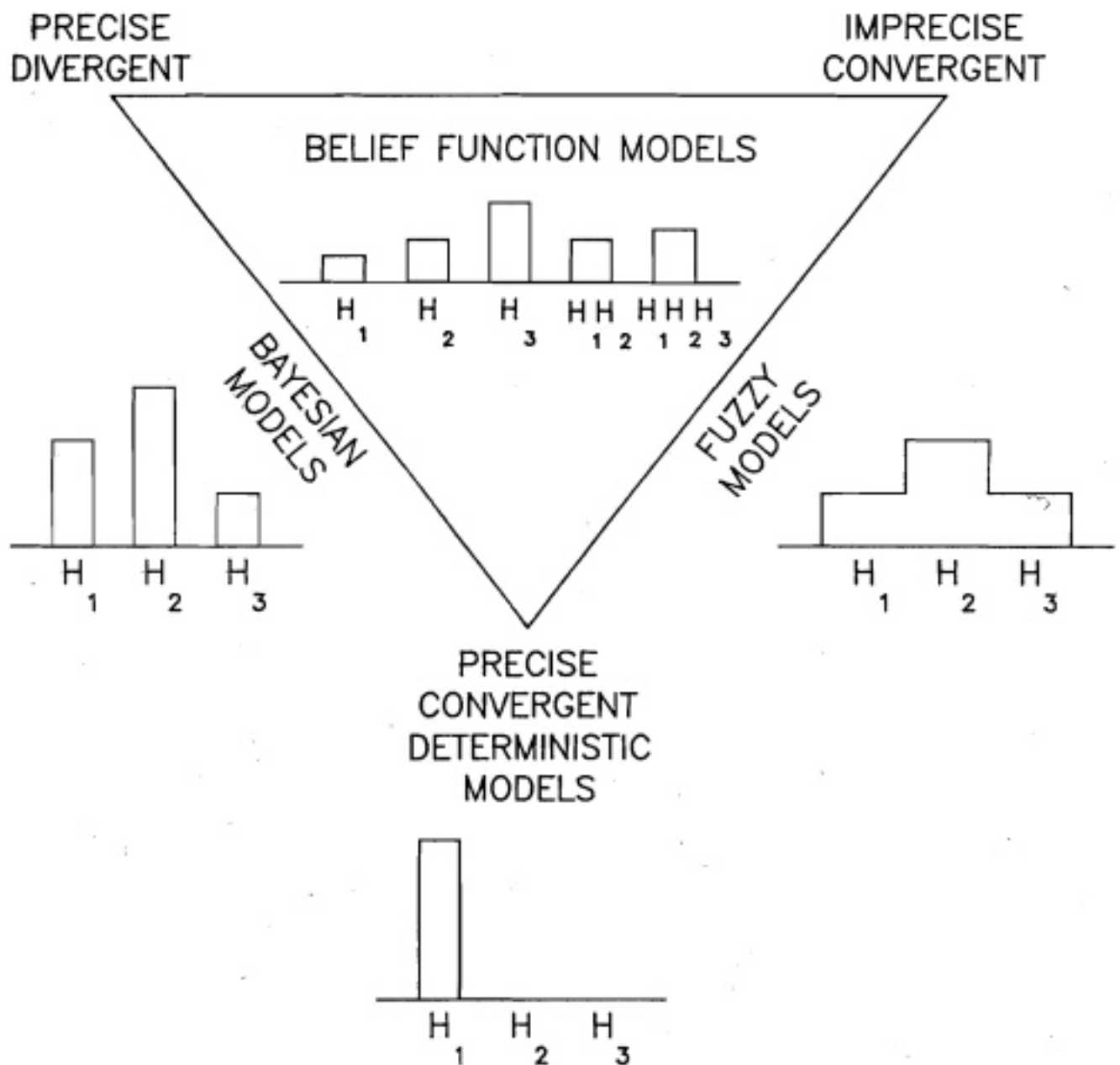
IN CONFLICT RESOLUTION, SYSTEM SUGGESTS:

- RETRACTION OF ASSUMPTIONS
- INFORMATION COLLECTION

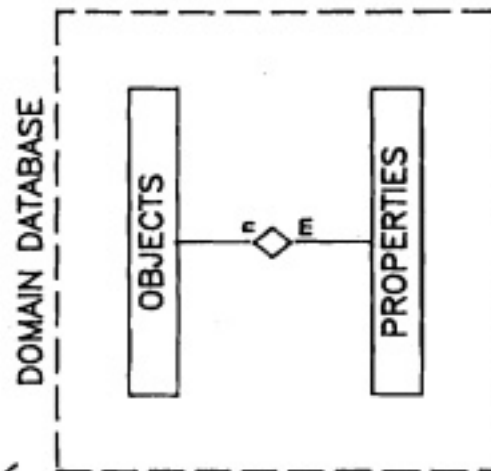
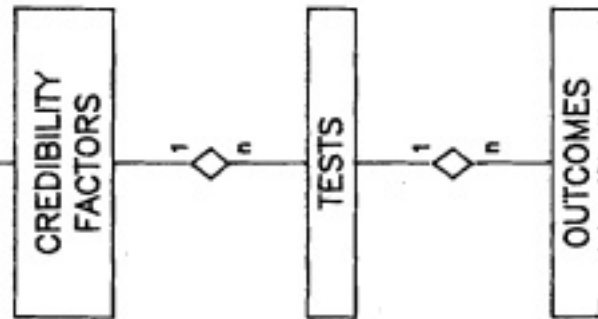
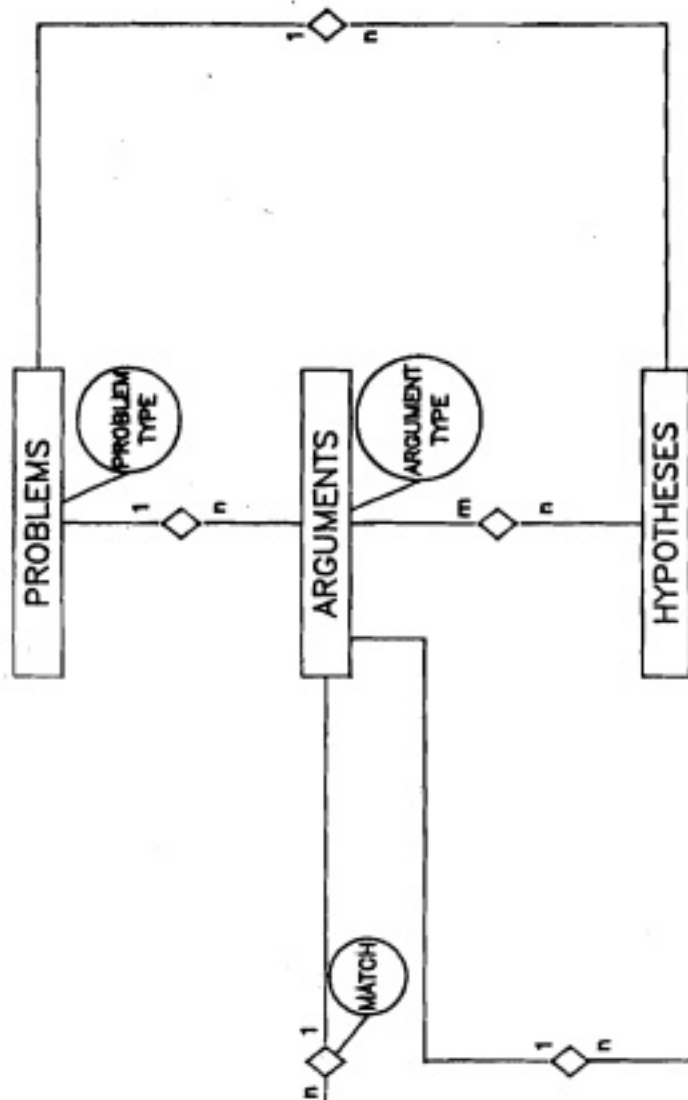
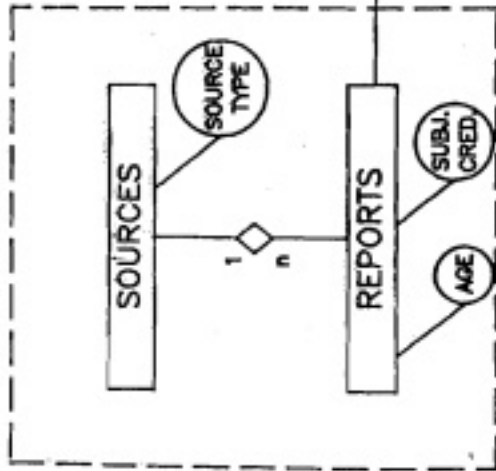


INTEGRATES DIVERSE APPROACHES TO
UNCERTAINTY

SUPPORTS HYPOTHETICAL REASONING
AND MODEL TESTING

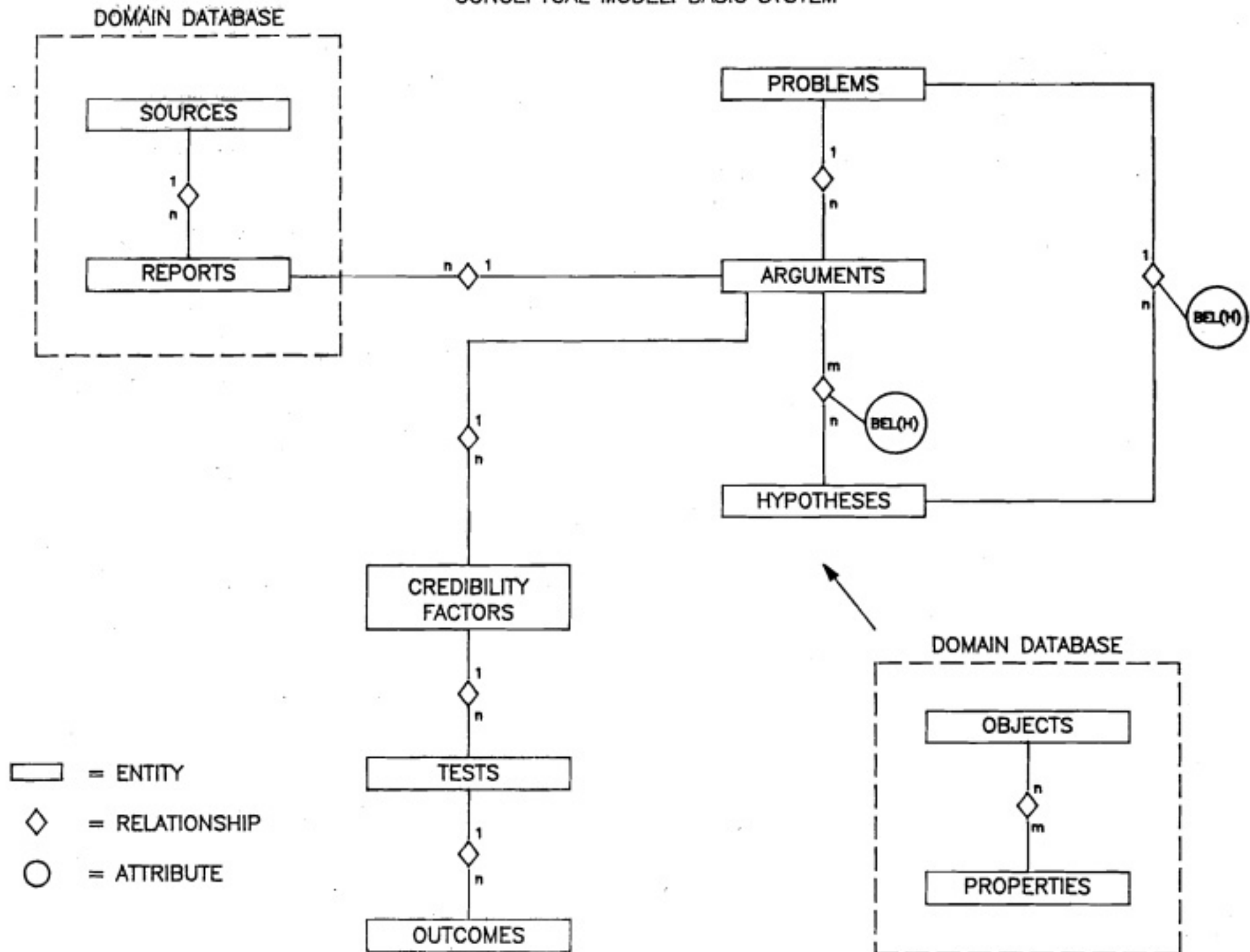


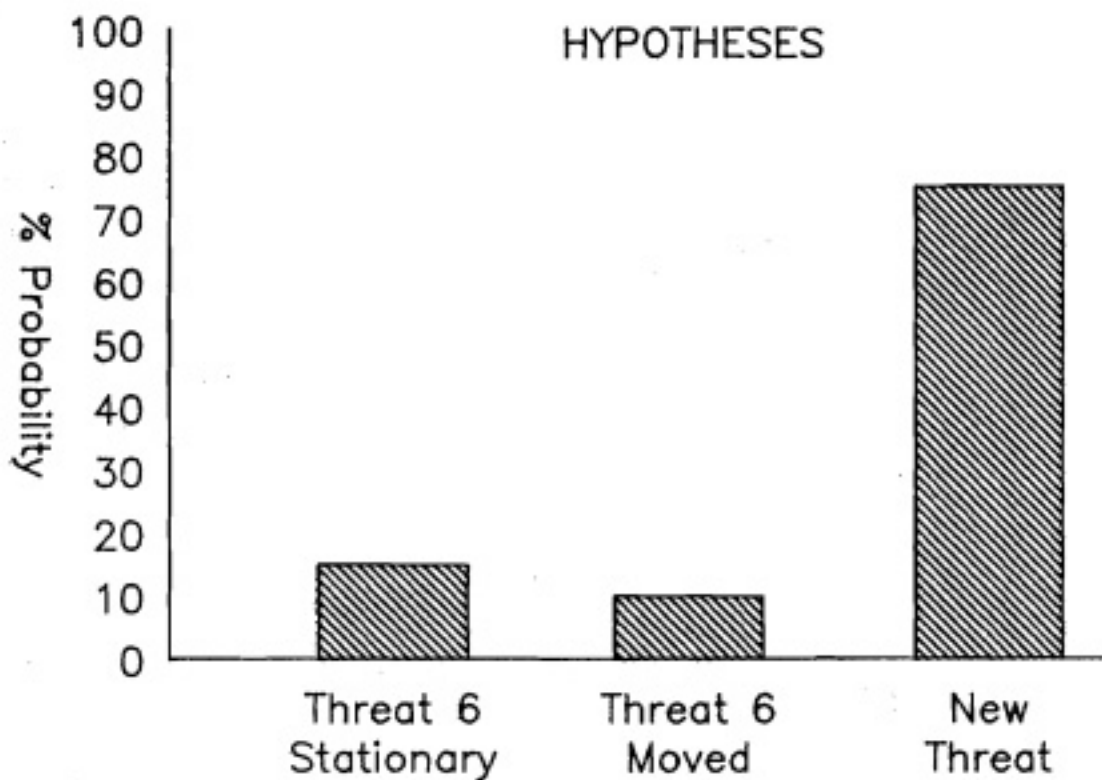
CONCEPTUAL MODEL: USER-SUPPLIED ATTRIBUTES WHICH AFFECT ARGUMENT RELIABILITY OR BIAS



- = ENTITY
- ◇ = RELATIONSHIP
- = ATTRIBUTE

CONCEPTUAL MODEL: BASIC SYSTEM





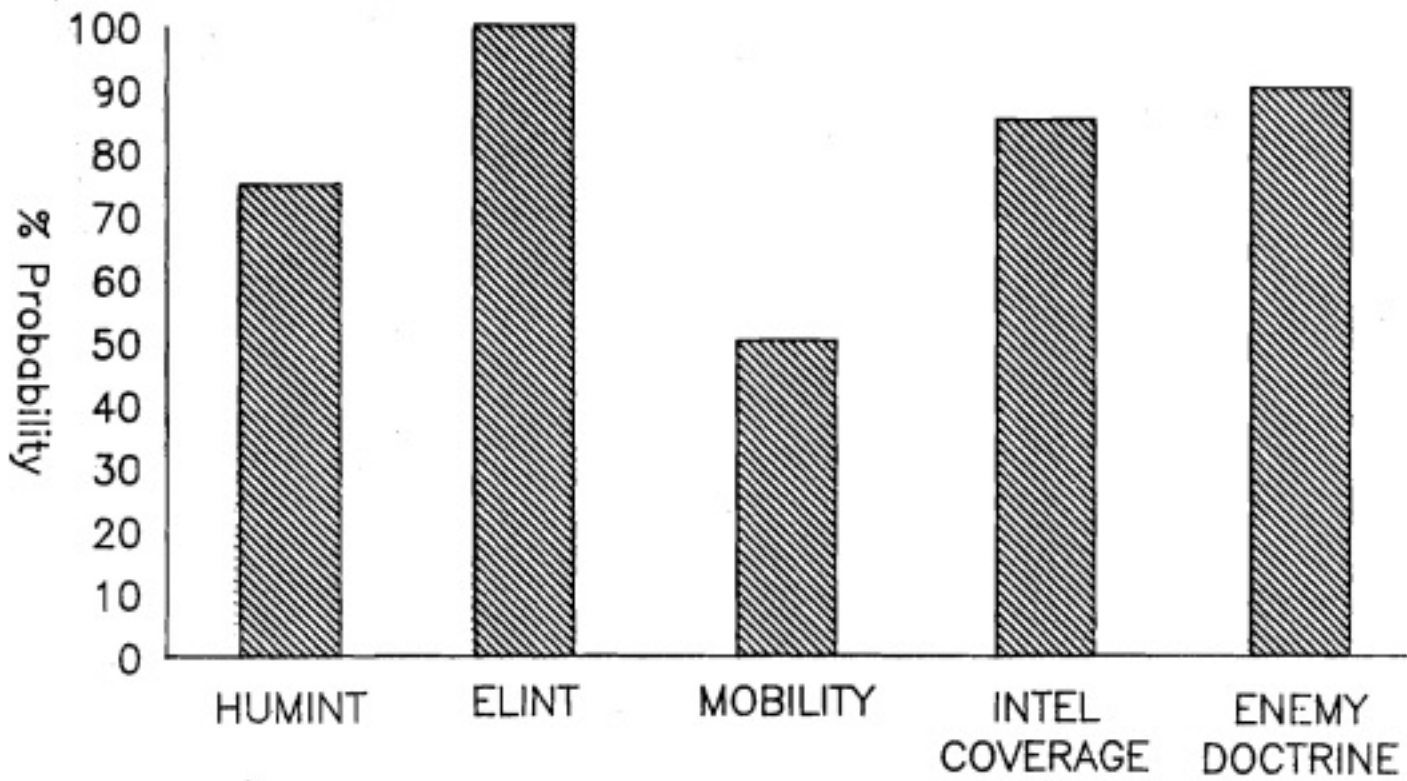
REASONS
(SOURCES)

- ELINT:
Signals
widely
separated

- MOBILITY:
Threat 6
not mobile

+ COVERAGE:
Poor area
intelligence

SOURCES



CREDIBILITY FACTORS

+ Accurate
+ Honest

+ ECM
Unlikely

- Terrain
not
Representative

+ Calibration
OK

+ Doctrine
Relevant

o Weather
Moderate

+ Ground
Reflective
Low

CONCLUSIONS

A RELATIVELY SIMPLE DATABASE SCHEMA AND META-REASONING CAPABILITY CAN:

- SUPPORT NATURAL PROCESSES OF STRUCTURING AND EVALUATING ARGUMENTS, EXPLORING AND TESTING ASSUMPTIONS**
- SUPPORT (AND INTEGRATE) A VARIETY OF DIFFERENT TYPES OF QUALITATIVE AND QUANTITATIVE ANALYSES**
- PROVIDE ALTERNATIVE (QUALITATIVE AND/OR QUANTITATIVE) REPRESENTATIONS OF CONCLUSIONS, REASONS, AND ASSUMPTIONS**