U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND SOLDIER CENTER

Measuring and Predicting Soldier Performance and Lethality Through Soldier-Systems Modeling

Robb Wilcox, Ph.D., P.E.

Human Systems Performance S&T Lead (A)

US Army DEVCOM Soldier Center

PROBLEM AND APPROACH

Limited means to objectively and holistically measure and predict Soldier, Squad and integrated systems performance and lethality

- Today we have the means to measure Soldier-Systems performance by ever increasing quantitative means

- Understanding the complexity of soldier systems requires a modelling process that integrates performance indicators, MOP, MOE and human-systems states that ultimately indicate task or function reliability

- A proposed methodology is proposed to include modelling through a combination of Event Tree and Success Tree analysis provides a framework to model and understand Soldier –System performance and lethality to support decisions improving lethality

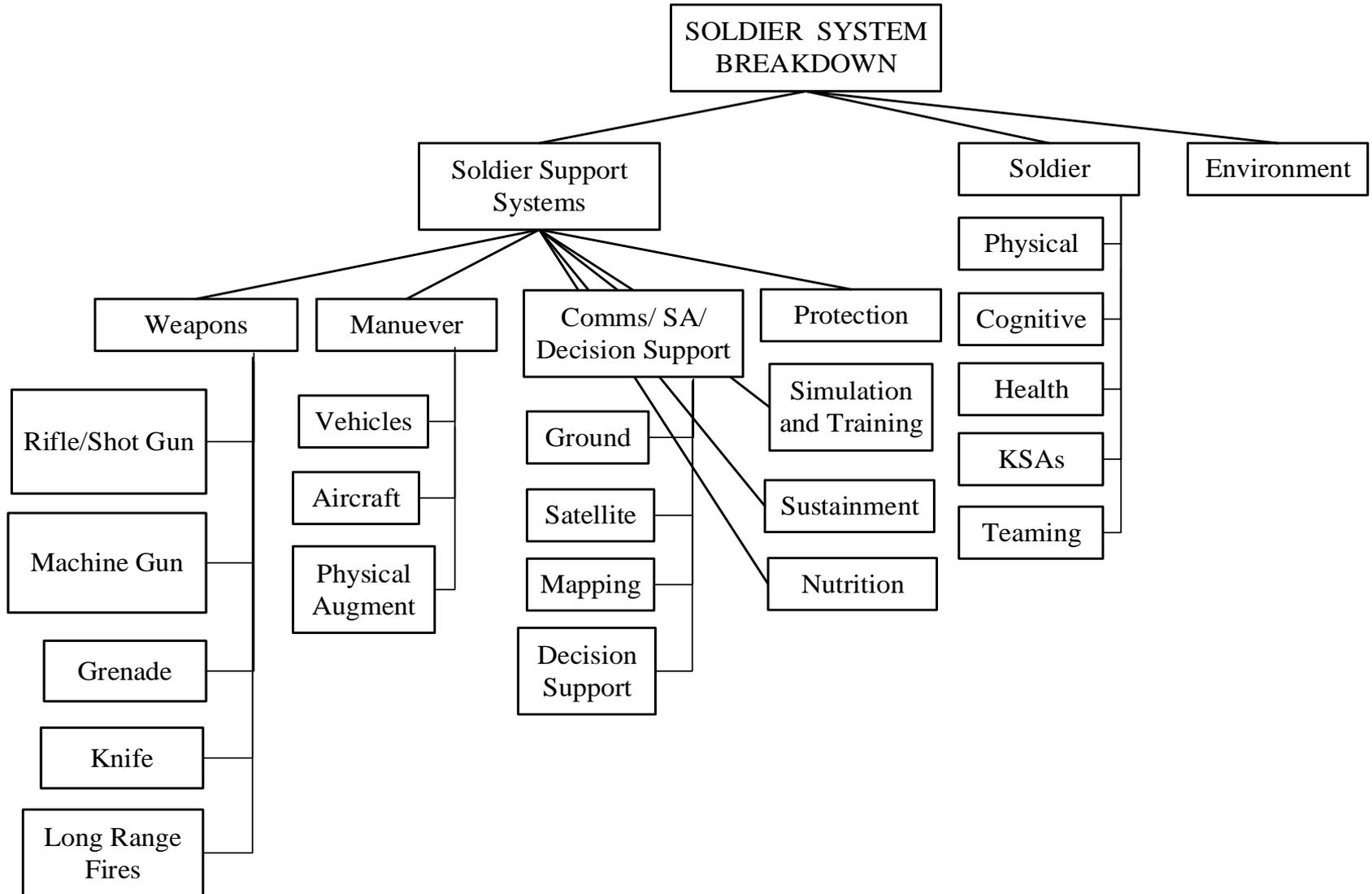# SOLDIER SYSTEMS PERFORMANCE ASSESSMENT AND DECISION SUPPORT METHODOLOGY
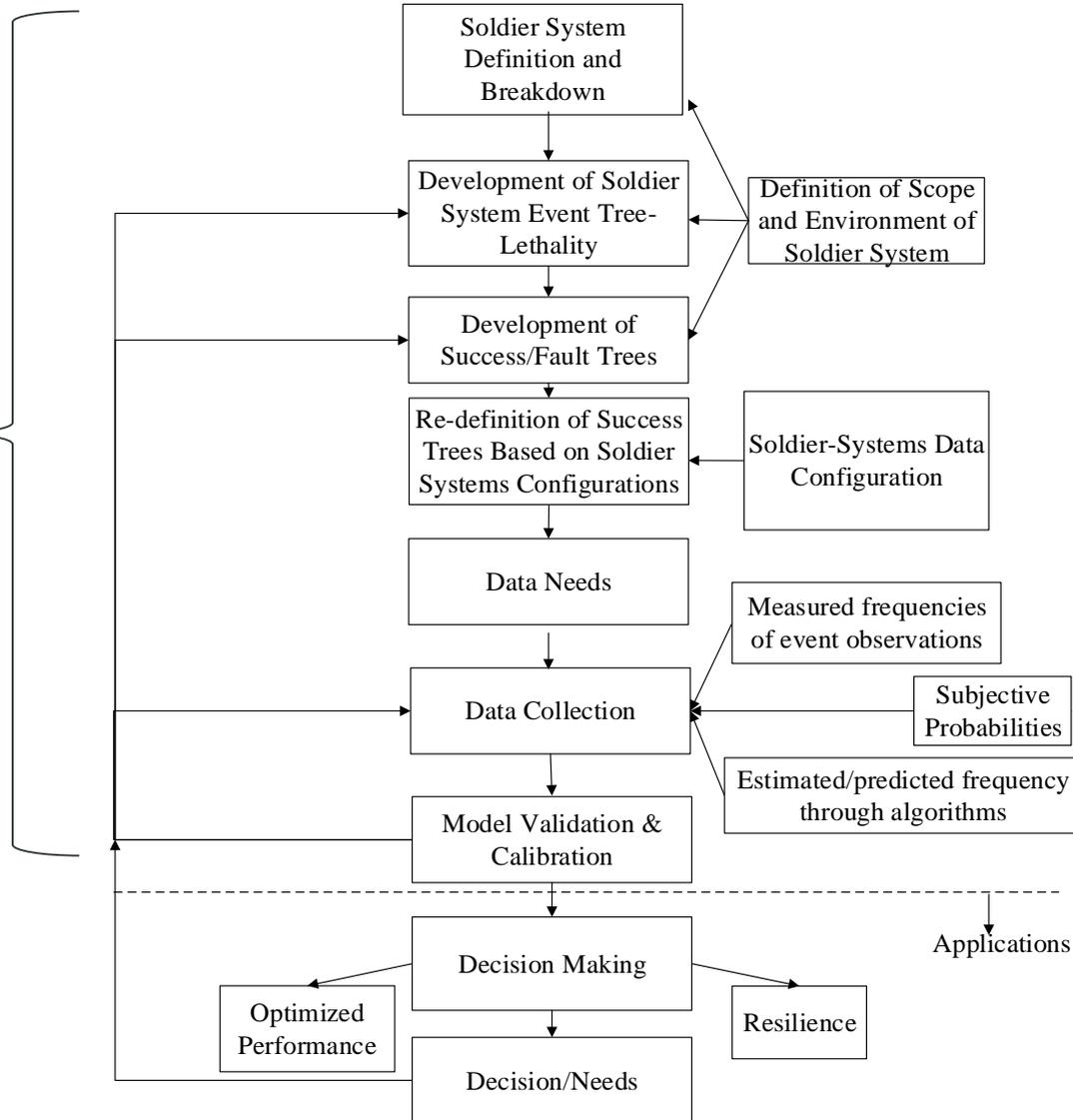
SOLDIER SYSTEM BREAKDOWN

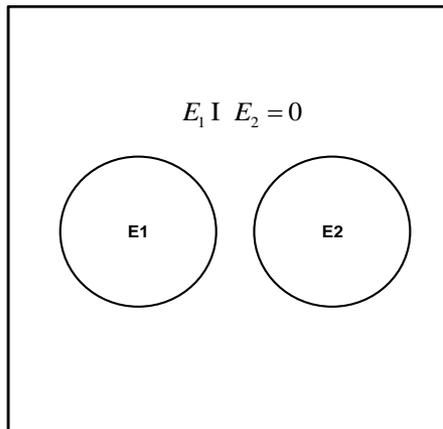# SYSTEM'S RELIABILITY MODELING

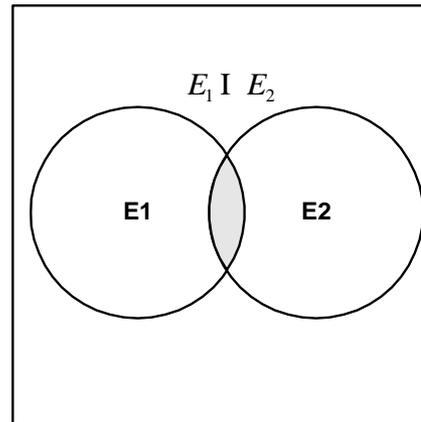## Probability Theory and Reliability Analysis Modeling

- – Set Theory

$$E_1 \text{ I } E_2 = 0$$

E1   E2

Mutually Exclusive Events

$$E_1 \text{ I } E_2$$

E1   E2

Intersection of Two Sets

$$E_1 \text{ U } E_2$$

E1   E2
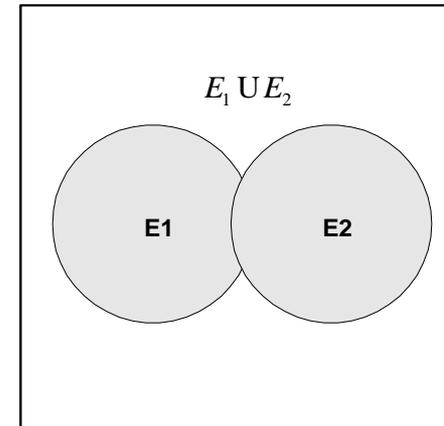
Union of Two Sets

- – Event Tree and Success Tree Analysis based on probability theory provides framework for Soldier-Systems performance modelling

EVENT TREE ANALYSIS
(SCENARIO DEVELOPMENT MODEL)

- **Description**
  - Inductive reasoning approach
  - Graphical model identifying scenarios (events- actions, tasks, functions) resulting in some consequence due to some initiating event
  - Appropriate when operation depends on a successive group of events

- **Strengths**
  - Accounts for timing and dependence of events
  - Used for quantitative or qualitative system performance evaluation
  - Shows success and failure scenarios of systems

- **Weaknesses**
  - Analysis quality depends on experience of experts
  - Limited to one initiating event per event tree
  - May need to collect many to get needed representation for model

EVENT TREE ANALYSIS
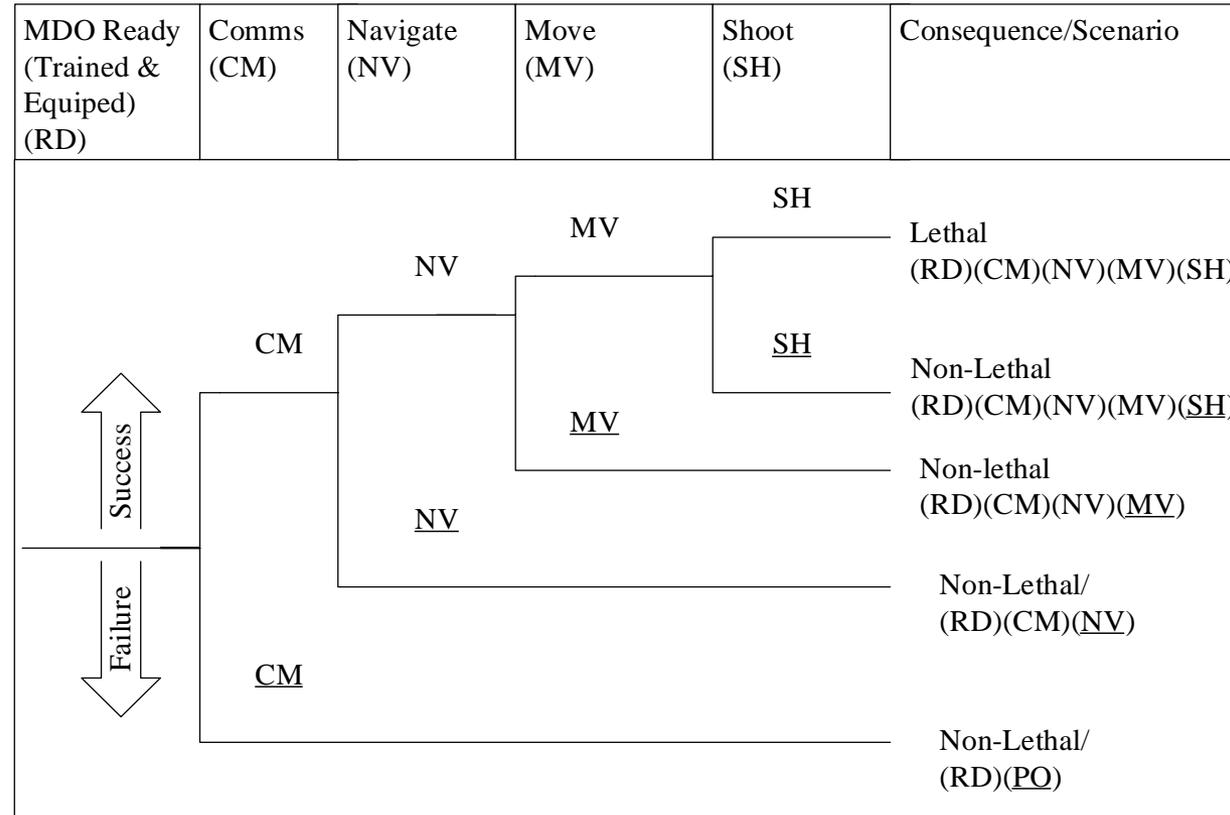## (SCENARIO DEVELOPMENT MODEL CONT.)

Process

- Define system/activity of interest

- Identify initiating event of interest

- Identify reactionary events (systems functions/task analysis)

- Define follow-on scenarios (both success and failures)

- Identify scenario sequence outcomes

- Summarize results- can quantify the results

- Use the results in decision-making- Decisions regarding systems performance and lethality

EVENT TREE ANALYSIS FOR SOLDIER LETHALITY
(Example)

- This modeling approach provides a framework to identify what is needed for a successful Lethality scenario
- Identifies and captures the probability of different states of Soldier-System activity. These states will depend on soldier environment, KSAs, ability to perform tasks in scenarios
- Tasks/Events can be further modeled to provide more comprehensive model. Task reliability or probability of performing the task can be used as a measure of performance.

MDO Ready (Trained & Equiped) (RD)	Comms (CM)	Navigate (NV)	Move (MV)	Shoot (SH)	Consequence/Scenario

Lethal
(RD)(CM)(NV)(MV)(SH)

Non-Lethal
(RD)(CM)(NV)(MV)(SH)

Non-lethal
(RD)(CM)(NV)(MV)

Non-Lethal/
(RD)(CM)(NV)

Non-Lethal/
(RD)(PO)

SUCCESS TREE ANALYSIS
(Boolean logic to describe events)

- **Description**
  - Deductive reasoning approach
  - Graphical model identifying event combinations resulting in some specific system success or "Top Event"
  - Applies Boolean logic relationship between events-equipment functions and/or human tasks successes leading to a successful event (MOE/MOP)
  - For human performance-physical and cognitive task analysis can support model development

- **Strengths**
  - Excellent for Identifying causes of specific human-system failures/successes
  - Used for quantitative or qualitative evaluation

- **Weaknesses**
  - Does not account for time dependency
  - Tree structure may vary based on analysts knowledge

SUCCESS TREE ANALYSIS

Process

- Define system/activity of interest
- Define the top event(s) for analysis
- Define the sub-events (Actions, tasks, functions, indicators that lead to the top event)
- Identify boolean logic for combining events (AND/OR)
- Solve the success tree for combinations of events leading to the top event success
- Perform quantitative/qualitative analysis
- Use the results in decision-making

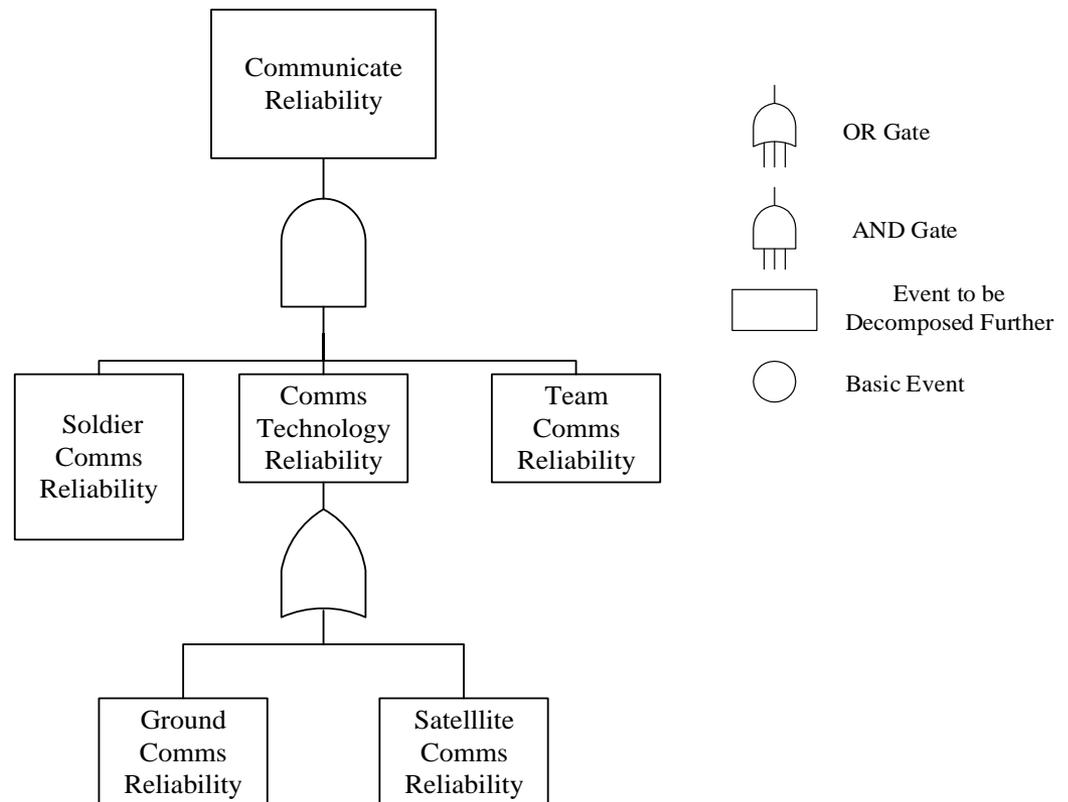# SUCCESS TREE EXAMPLE- Communicate Reliability

- Success trees provide the Boolean logic for combining events/tasks/functions of the model to an overall aggregated performance for the higher level entity
- This provides a hierarchy of understanding performance elements and combinations.
- When combined with the event tree structure, success trees provide an overall reliability/probability model for overall human-systems performance. In our example the probability of Soldier lethality.

Measure of Effectiveness (MoE) — A criterion used to assess changes in system behavior, capability or operational environment that is tied to measuring the attainment of an <u>endstate</u>, achievement of an objective or creation of an effect. (JP 3-0); Functional Effectiveness- ex. <u>Communicate Reliability</u> (measureable, collectable, relevant)

Measure of performance (MoP) – A criterion used to assess friendly actions that is tied to measuring <u>task accomplishment</u>. (JP 3-0); ex. <u>Soldier Comms Reliability</u>
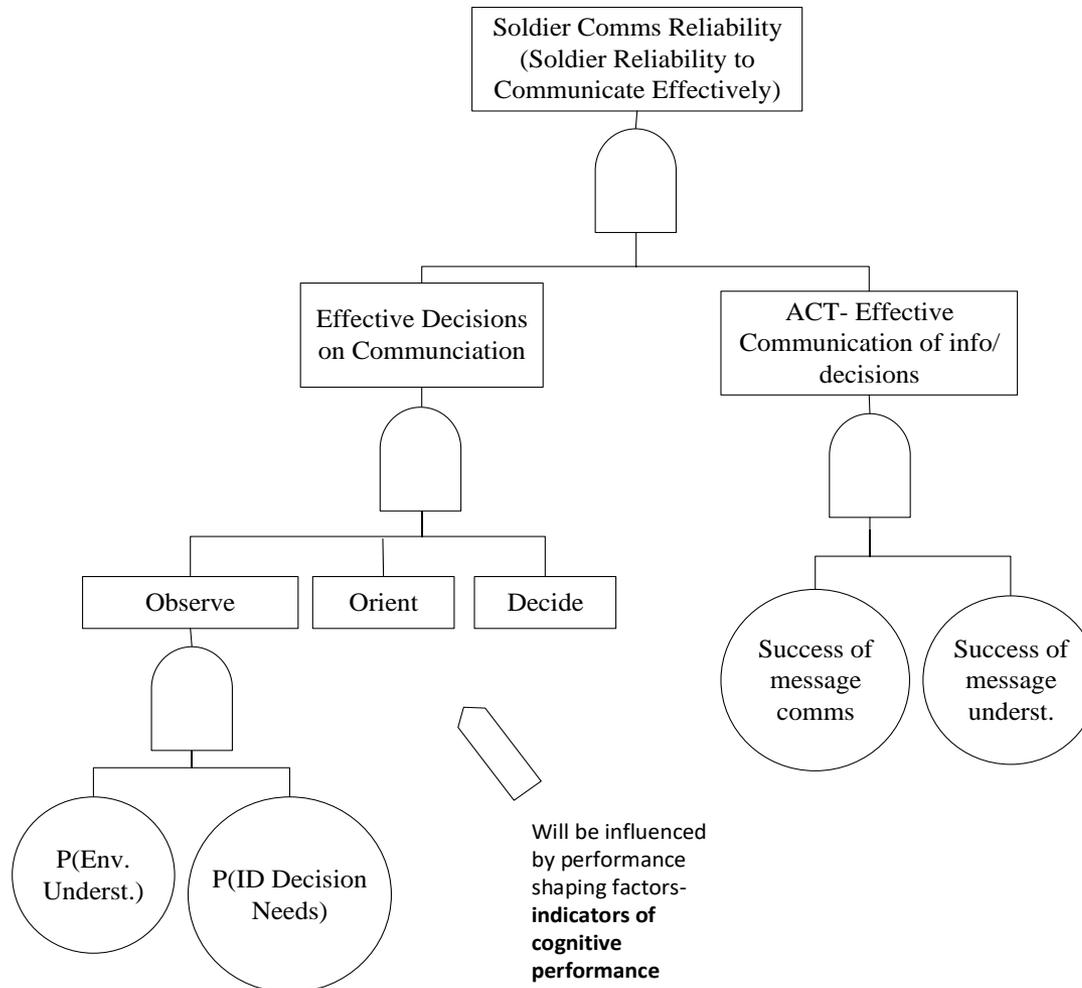
SUCCESS TREE EXAMPLE
COMMUNICATE RELIABILITY
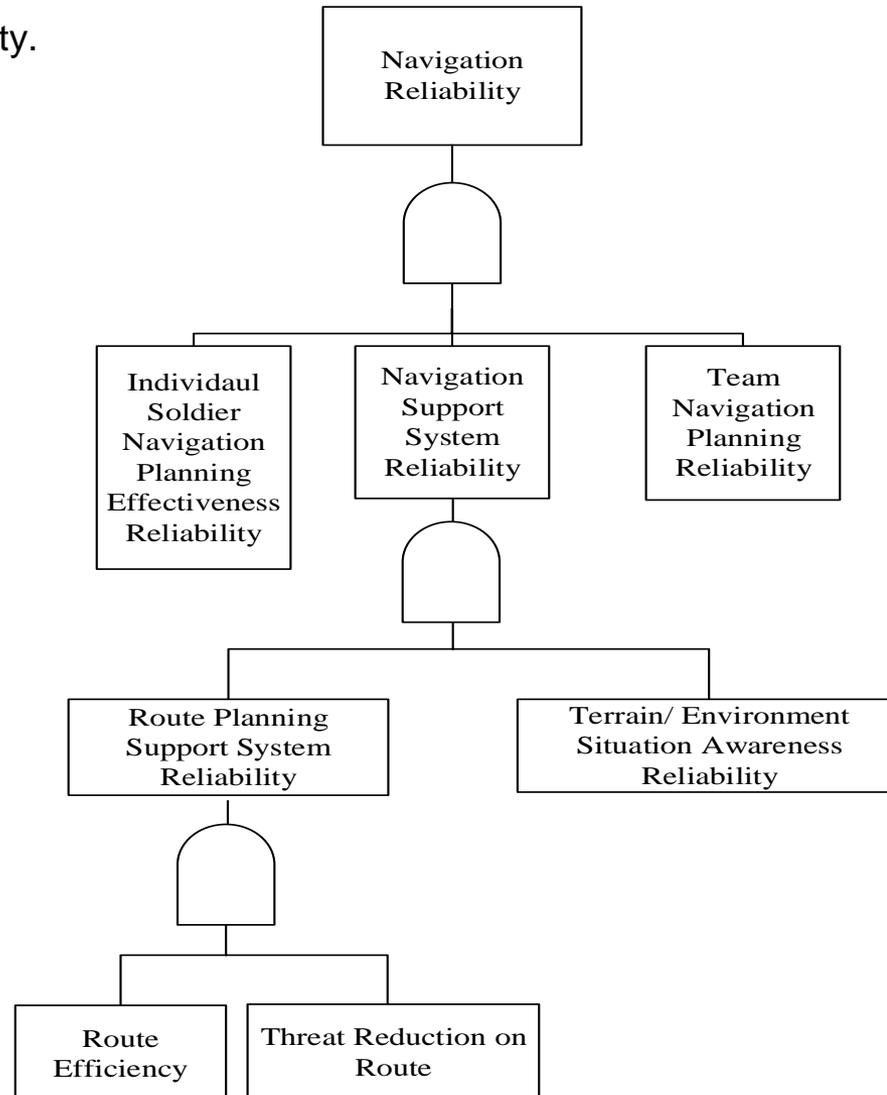
- More detailed model of Soldier Comms Reliability

SUCCESS TREE
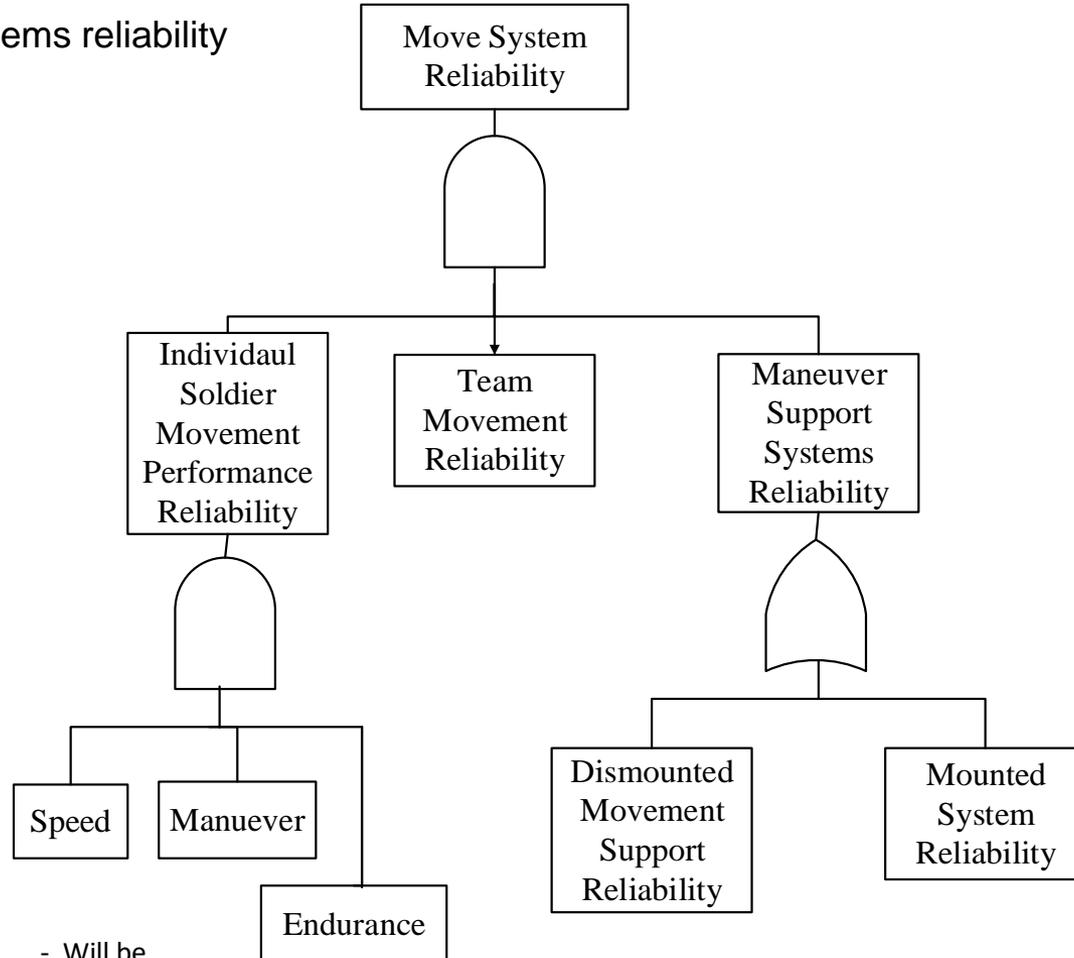# NAVIGATION RELIABILITY

- Success tree for navigation reliability.

Success Tree Move Reliability

- Success tree for move systems reliability

Move System Reliability

Individaul Soldier Movement Performance Reliability

Team Movement Reliability

Maneuver Support Systems Reliability

Speed

Manuever

Endurance

- Will be influenced by **physical performance** shaping factors

Dismounted Movement Support Reliability

Mounted System Reliability

SUCCESS TREE
SHOOTING RELIABILITY

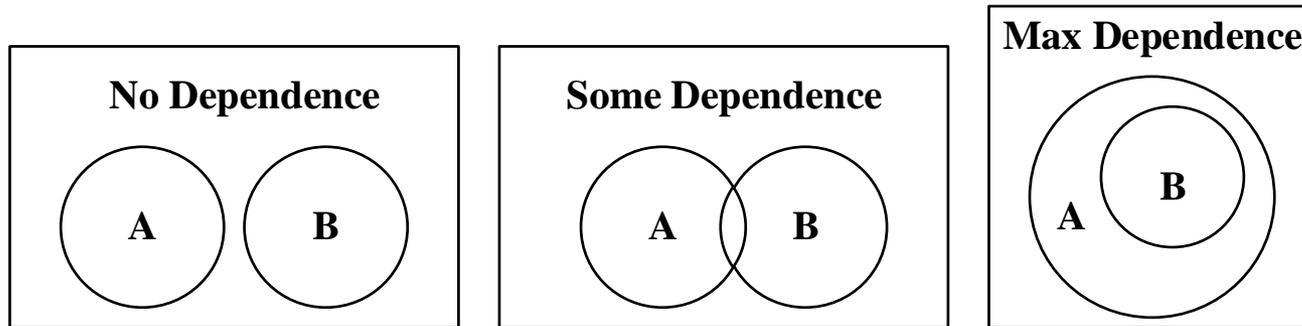- Success tree for shooting reliability
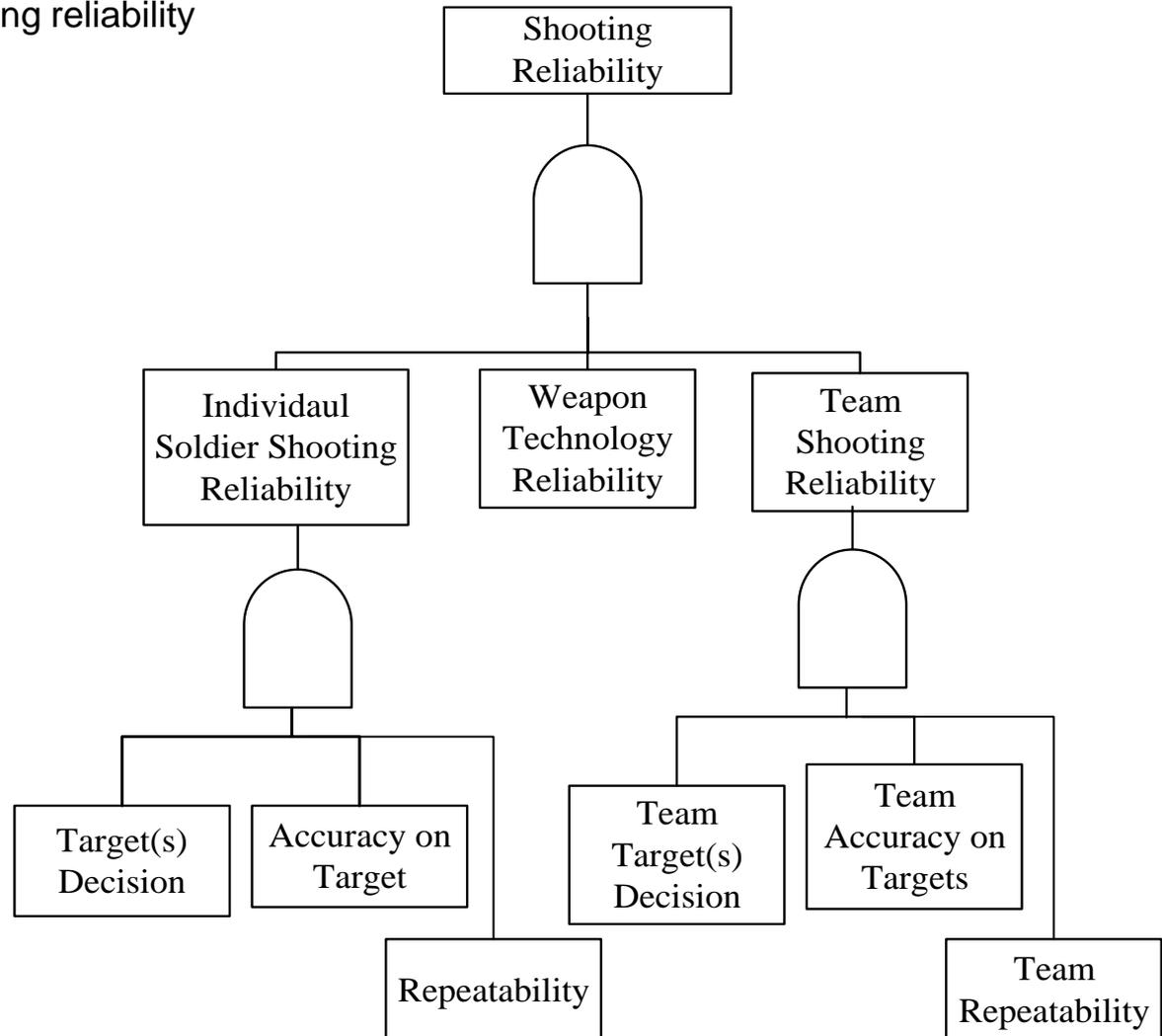
MODEL COMPLEXITY

- Model complexity and accuracy can be improved through better understand of event interactions such as dependency between events.

	No Dependence	Some Dependence	Max Dependence

	No Dependence	**Some Dependence**	**Max Dependence**
Union of Events $(A \cup B)$	$P(A) + P(B)$	$P(A)+P(B)-P(A)P(B)$ or $P(A)+P(B)-D(Min(P(A), P(B)))$	$Max(P(A), P(B))$
Intersection of Events $(A \cap B)$	0	$P(A)P(B)$ or $D(Min(P(A), P(B)))$	$Min(P(A), P(B))$

QUALITATIVE/QUANTITATIVE ANALYSIS

Qualitative

– Apply when data is lacking

– When cost to obtain data is too high

– When knowledgeable experts are available

– When relative performance measurement is necessary

Quantitative

– When data is available

– When quantitative detail is necessary for decisions

– When absolute performance is necessary

Apply Qualitative/ Quantitative Analysis

– Consider time/budget/ information

– Both can be used to rank human-systems performance and lethality

Performing Shaping Factors- Means to Monitor and Improve Soldier Systems Performance

- There are many PSFs- indicators impacting overall systems performance
- By increasing the model details and complexity… greater model accuracy is possible
- By maximizing performance conditions under PSF, you maximize performance and lethality
- The model can also identify what PSF are most important
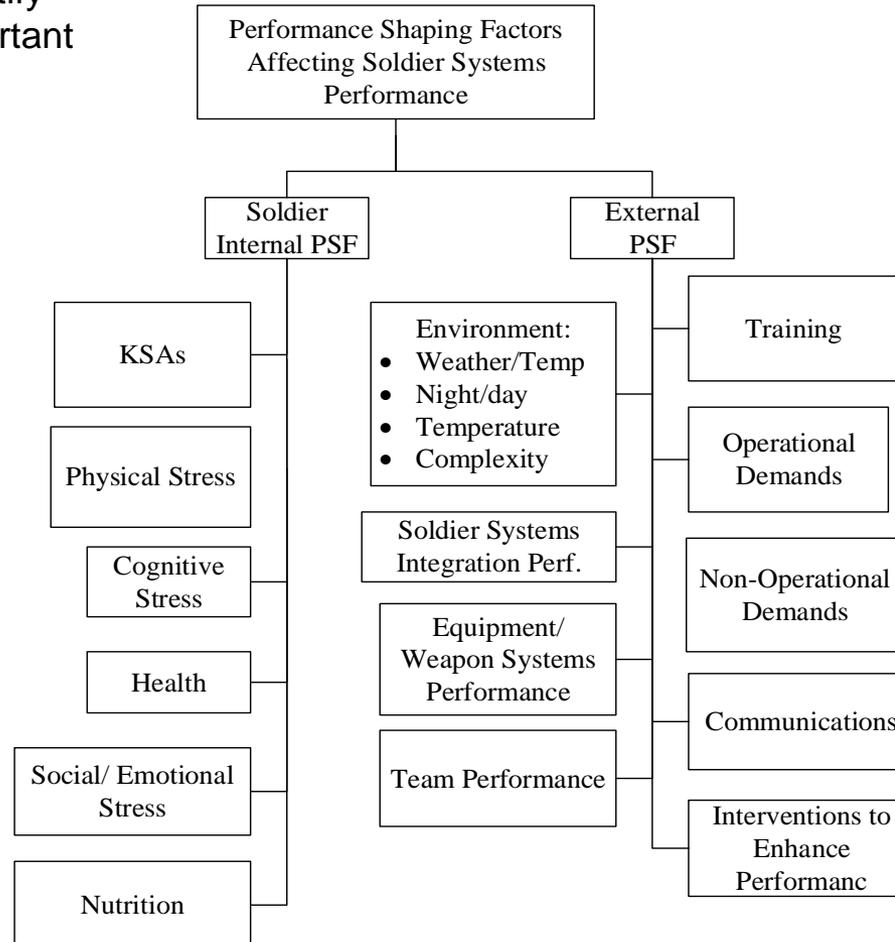
IMPROVING SOLDIER PERFORMANCE AND LETHALITY

- **Improve the Likelihood of Positive Performance-Lethality Probability**
  - Positive Performance Shaping Factors- MOP/ MOE

  - Improved Soldier Systems Integration

  - Improved Task Performance

  - Improved Functional Performance

  - Support Systems Performance- Enhancements

  - Add Redundancy in System

  - Reduce complexity- ex. effective decision support systems

SOLDIER SYSTEMS PERFORMANCE ASSESSMENT AND DECISION METHODOLOGY