



RDECOM



A Method to Assess
Survivability, Lethality and
Vulnerability in a System of
Systems

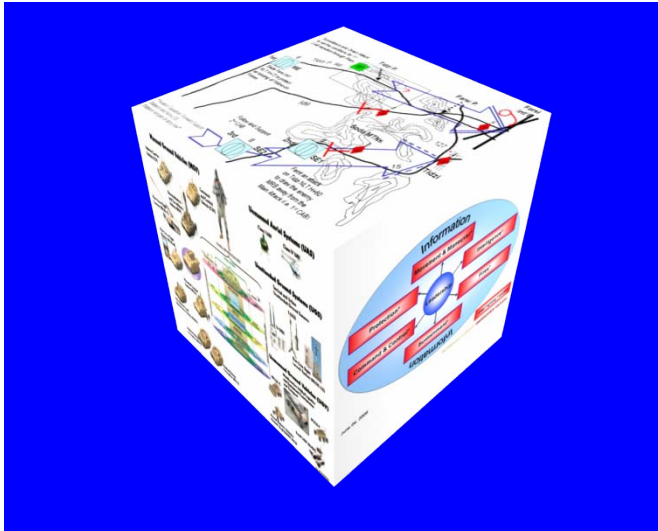


TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Jeffrey A. Smith, Ph.D.
U.S. Army Research Laboratory
WSMR NM, 88002-5513
(575) 678-1332
jeffrey.a.smith1@us.army.mil

- Purpose.
- Our concept of a SoS and SoS Analysis.
- MUVES 3 V/L Service Overview.
- An example analysis arc.
- Summary.
- Caveats and Path Forward.
- References.
- Acknowledgements.

- Follow up to a presentation given at last year's NDIA [1] and ITEA [2] conference.
 - Last year: High fidelity ballistics effects with a look up table into MUVES-S2 data.
 - This year: High fidelity ballistics effects with a dynamic client-server approach.
- Show an expanding capability to conduct System of Systems Analyses.



Working Definition: A design connecting multiple levels of decision makers and assets through which decision makers at every level can adapt the application of their assets to achieve their purpose [1-3].

The Physical Systems:

- e.g., BCT.

+ The Leaders

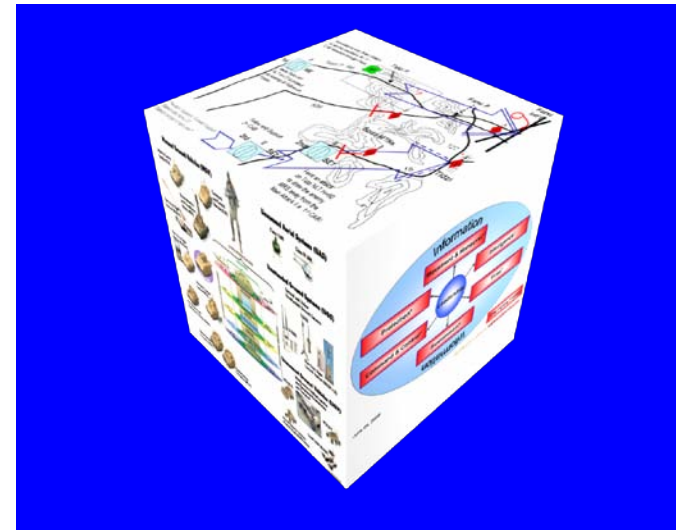
- Capabilities conceptualized as combat power, a term that encompasses all means available to a given unit at a given time.
- Leaders at the center, enabled by information, execute the six traditional warfighting functions.

+ The Context

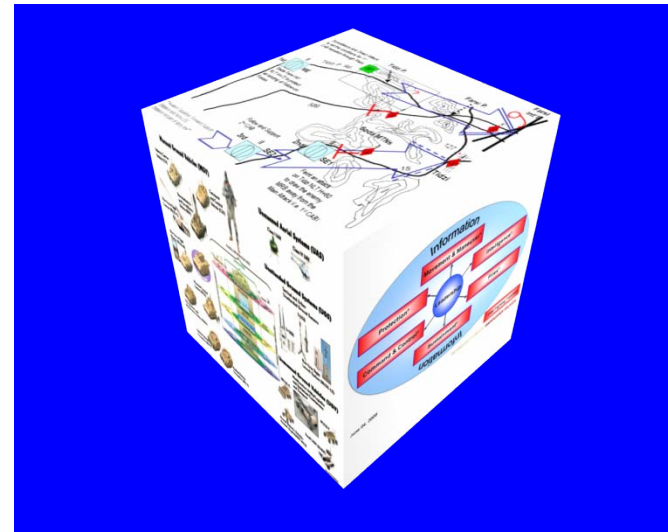
- Grounds the abstractions above.
- Allows us to quantify expressions for survivability, lethality and vulnerability, via metrics.
- Instantiates system concepts in the domain of the warfighter.

- What are the system weaknesses?
 - Component or system susceptibilities.
- What are the means available to an adversary to exploit these weaknesses?
- What is the system response should the adversary succeed in exploiting the weakness?
 - How do susceptibilities become vulnerabilities, or, in other words, “what is the impact to the warfighter” [4]?

- In a SoSA, one must first identify the particular issue to be studied (say, the impact of a susceptibility upon the SoS), and then trace the implications of that issue to a consequent impact on one or more warfighting functions.
- We determine the impact by mapping from left to right on the figure below, and interpreting the result in the analysis context given at the top of the figure. In this way, perturbations on the component level may become impact to the warfighter.
- A susceptibility in a component, or a relationship between component technologies, which when exploited by an adversary that realizes an observable and significant impact to one or more warfighting functions vulnerability.

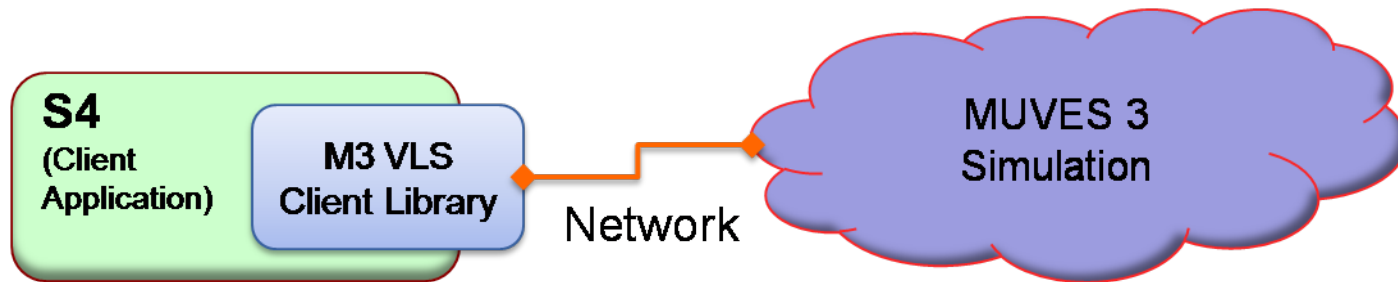


- Measurement of “Doing the correct thing well”.
 - Assesses an ability to reach the chosen position of attack, or to maintain arrangement of forces, etc.
 - Is more about the physical situation, and focuses more on the internals of a unit.
- Measurement of “Doing the correct thing”
 - Traces the flow of information (e.g., an enemy spot report) through the network to its consumer (a leader); thence, to an observable domain impact upon a war fighting function.
 - Is more about the information system, and looking outward from a unit.
- We do these assessments via the Objective Information Assessment (OISA) paradigm [5-7].



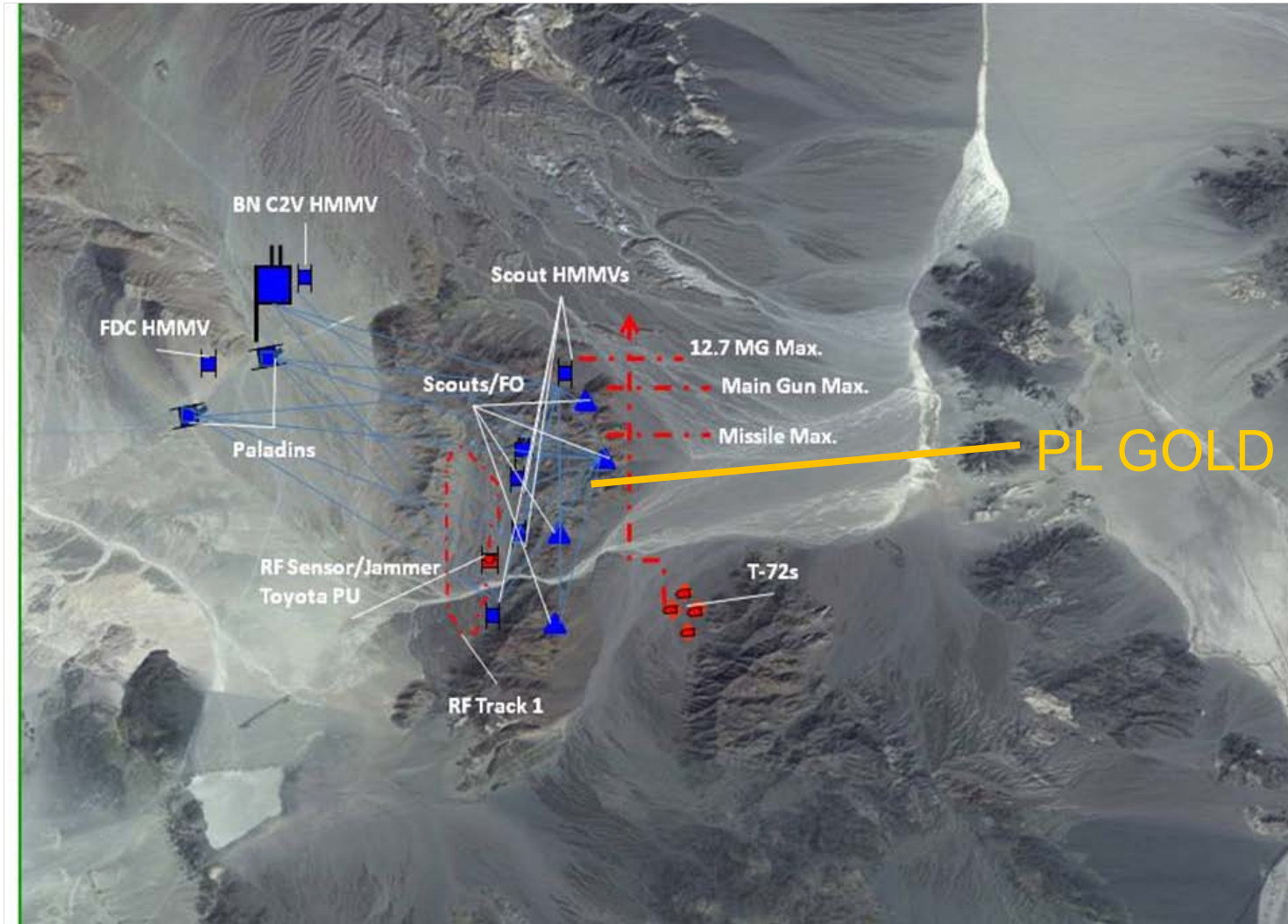
- An SoS assessment is a product of these measurements, taken jointly, and interpreted as an impact on the various warfighting functions.
- Through OISA, we normalize our data in a manner that allows us study the impact of information upon the functioning of the SoS.

Architecture



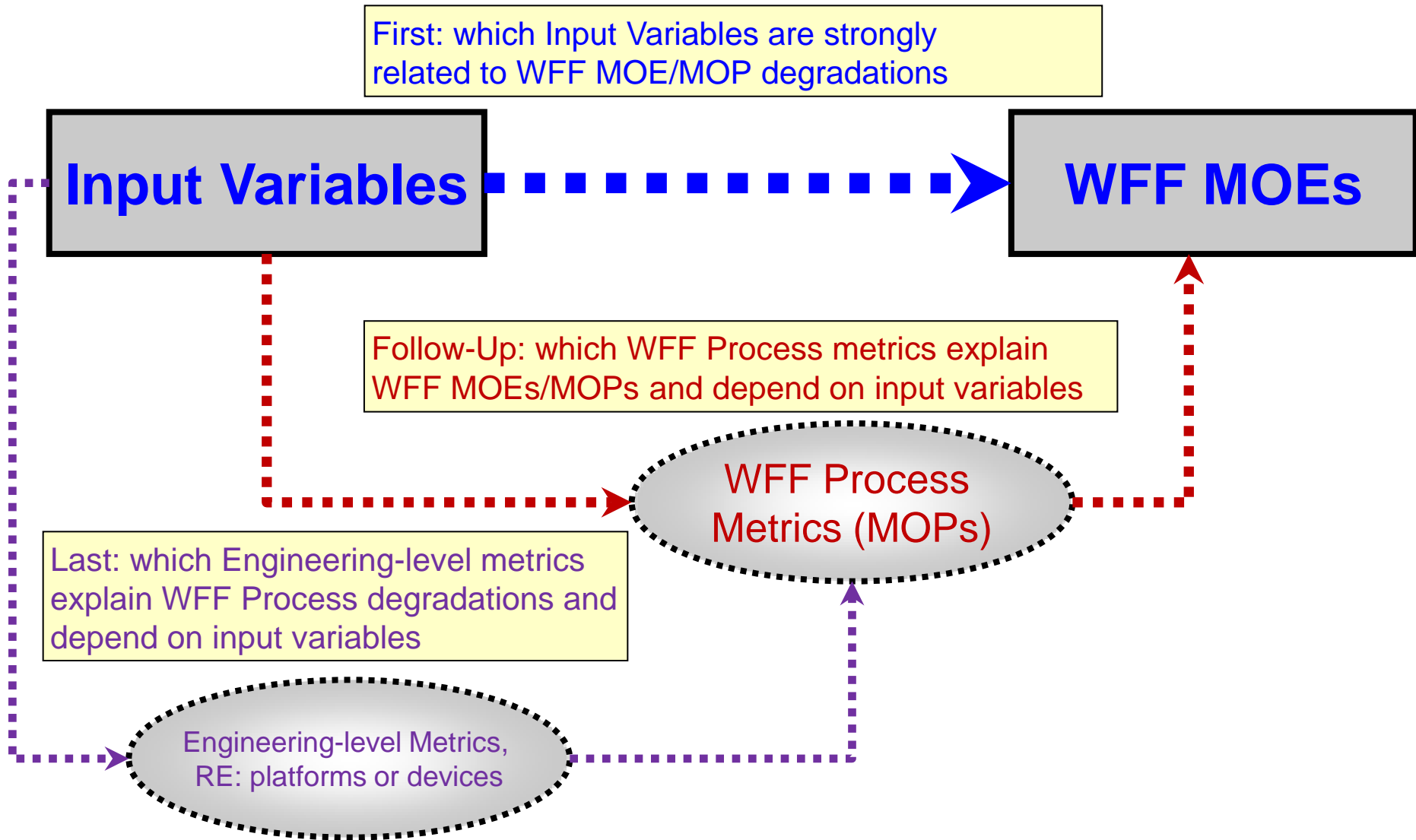
V/L Service Overview

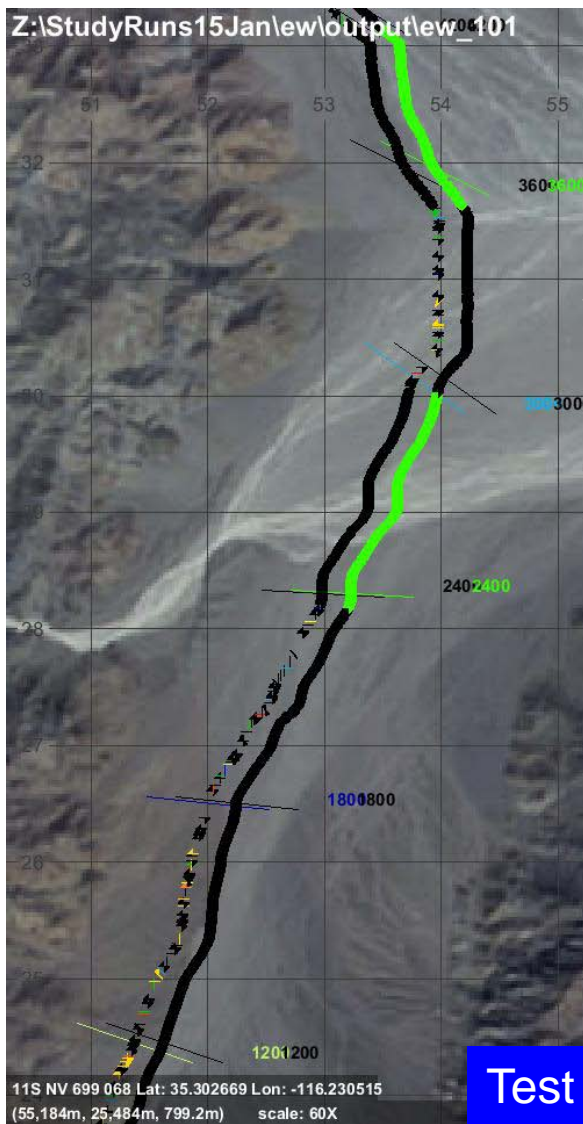
- Definition: The V/L Service is a feature of MUVES 3 that allows a client to interactively shoot one or more platforms and get the resulting platform states.
 - Damage accumulates.
 - States are calculated as a function of time.
 - Multiple platforms can be included in a scene and be damaged by a single shot.
- To enable V/L Service capability, two major enhancements were made:
 - A library that enables the client to connect to the MUVES 3 simulation and submit shot requests.
 - The VLS interface specification effort defined the API to the client library.
 - Custom simulation tasks that execute the client's request.



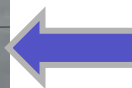
- The analysis questions are:
 - What are the impact(s) of EW on the Recon and Fires warfighting functions
 - Do EW and CNO have secondary impacts to the Maneuver warfighting function?
 - Does Reds EW capability impact Blue lethality?
- The threat attacks we consider are
 - a basic EW communications jamming scenario, and
 - a similar CNO scenario in which a ‘hacker’ uses denial of service to disrupt communications.
 - ballistic effects are those that occur normally in the scenario.

- EW has no effect on the ability of the recon elements to:
 - Spot, identify and report enemy movement, and
 - Call for fire to interdict enemy movement.
- EW has no effect on Blue lethality.
- CNO has no effect on the ability of the recon elements to:
 - Spot, identify and report enemy movement, and
 - Call for fire to interdict enemy movement.





Jammer is on when the right line is green.

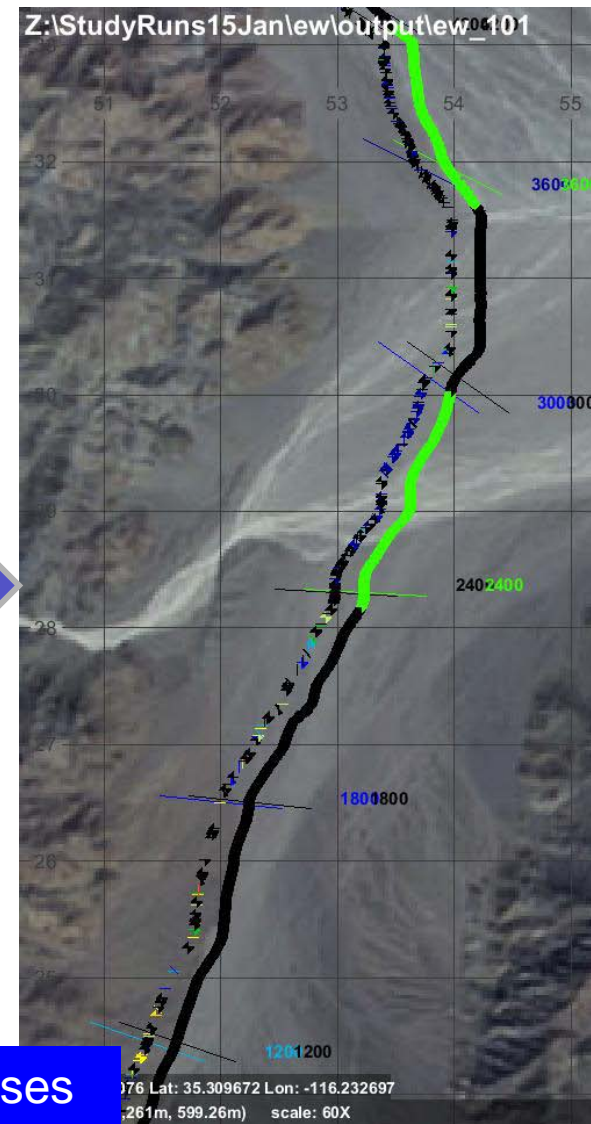


Bits Received by FO-121



Bits Received by FS-16

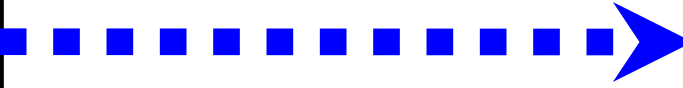
Black= No Utilization
Blue = Low Utilization
Red = High Utilization



Test Bed Data for Illustration Purposes

First: which Input Variables are strongly related to WFF MOE/MOP degradations

EW vs. Base



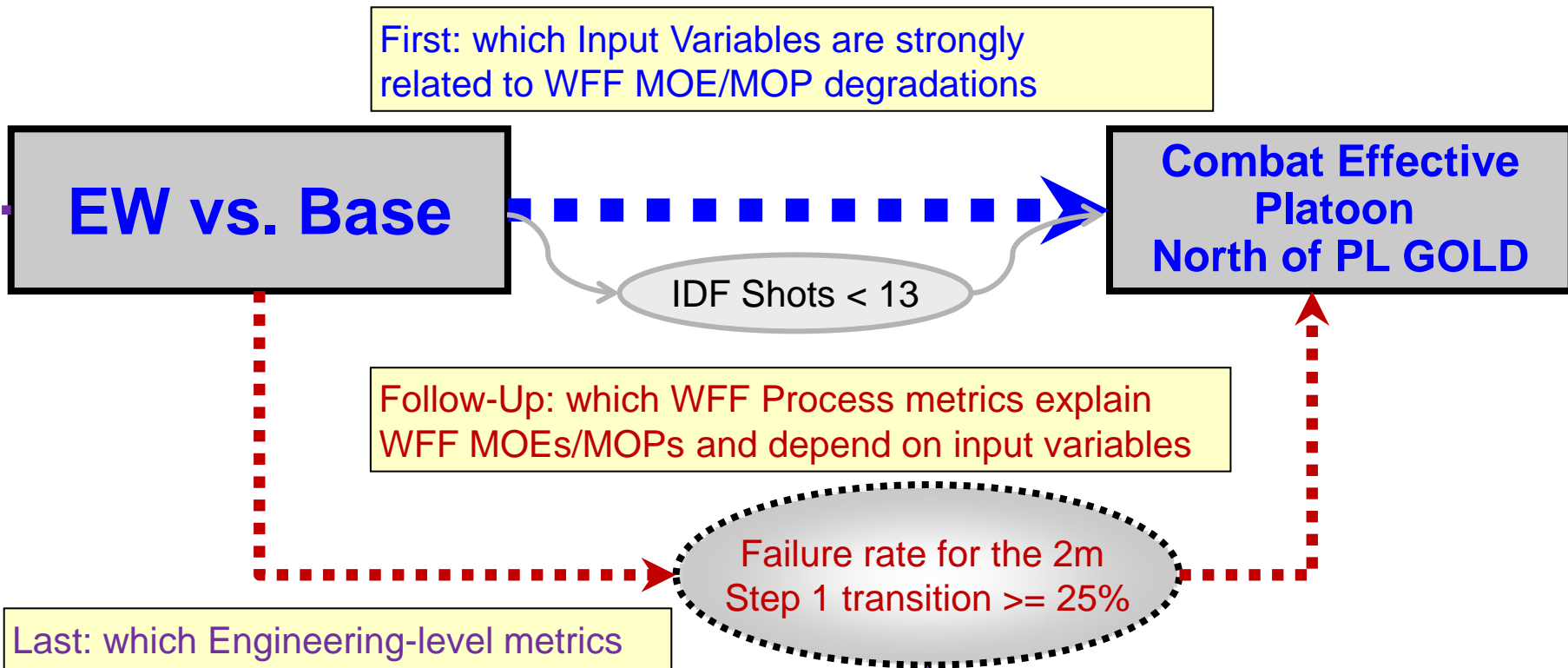
Combat Effective Platoon North of PL GOLD

The EW Threat drastically increases the probability (over Base runs) that the Fires WFF does not satisfy the MOE:

40% of EW runs fail to satisfy the MOE, that value is 3 times higher than in Base runs

Premise	Conclusion	Support	Confidence	Lift	Prevalence Ratio	OR 95-	Odds Ratio	OR 95+
EW	Fires MOE Failure	0.2	0.39	1.5	2.96	2.38	4.24	7.53

Test Bed Data for Illustration Purposes



Over the entire set of runs (Base and EW), this Failure Rate reaching at least 25% indicated that a Combat Effective Platoon of Tanks would reach PL Gold.

Test Bed Data for Illustration Purposes

- We can conduct analysis at the system of systems level.
- To do so, we trace an issue at the technology level to a consequent impact upon one or more warfighting functions:
 - Component effects to platform capabilities,
 - Platform capabilities to unit effects, and
 - Unit effects to impacts on warfighting functions.

- This requires that we consider in situ decision making in our models so that we can explore a possibly large decision outcome space.
- Thus, we must have models with some level of domain reasoning built in that allows the execution of a simulation without being exclusively driven by decision tables [8].
- Develop a rigorous method for relating components to platform capabilities. In the MMF lexicon [9], this is a level three metric. Note: The talk by Mr. Agan that follows is one approach we are considering.

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ARL\SLAD

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Acronym	Translation
BCT	Brigade Combat Team
BN	Battalion
CNO	Computer Network Operations
EW	Electronic Warfare
MMF	Mission and Means Framework
MOE	Measure of Effectiveness
MOP	Measure of Performance
NLOS	Non Line-Of-Sight
OISA	Objective Information Assessment Paradigm
SoS	System of Systems
SoSA	System of Systems Analysis
V/L	Vulnerability/Lethality
WFF	Warfighting Function.