Architecture-Based Concept Evaluation in Support of JCIDS

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Architecture Based Concept Evaluation

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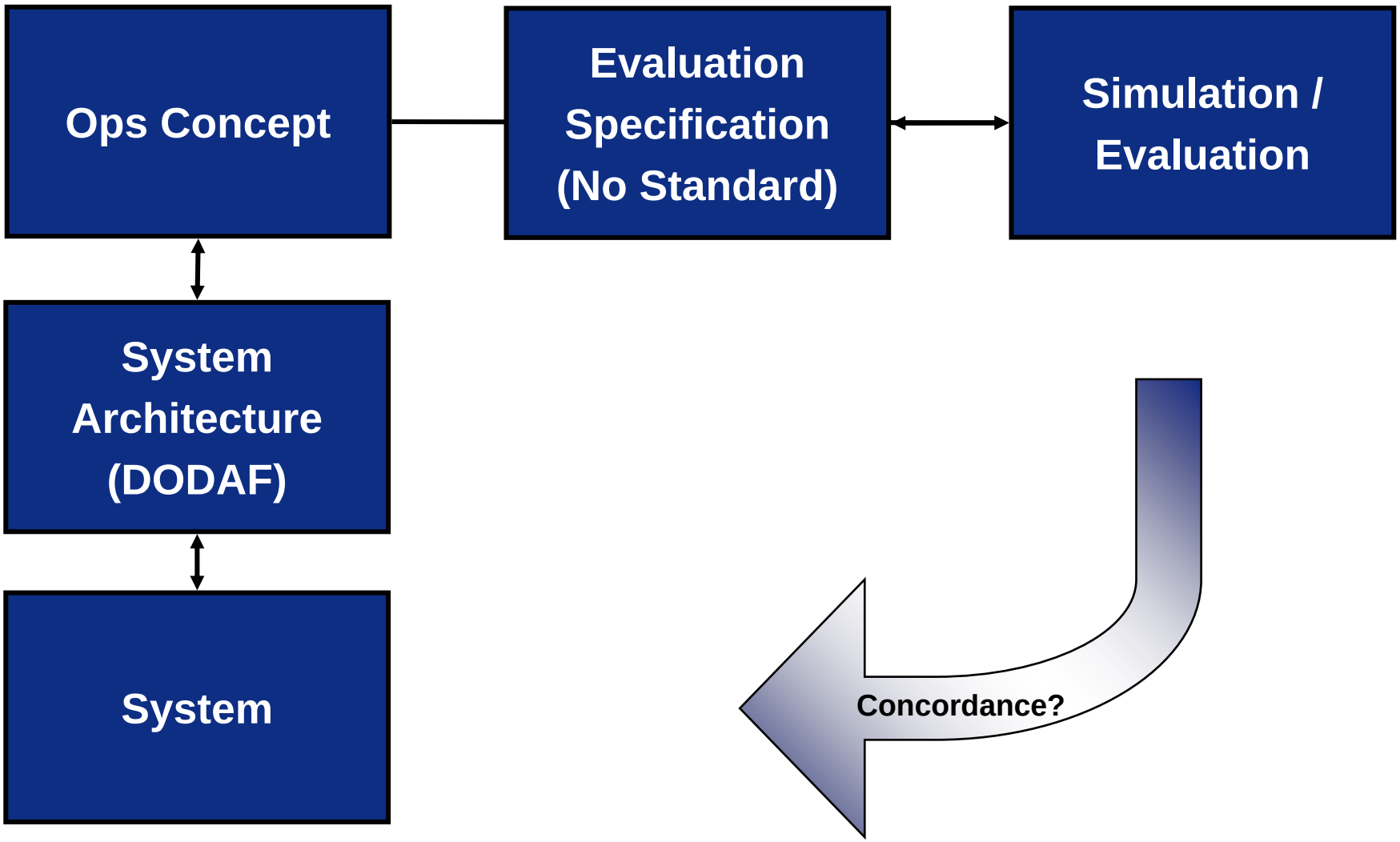
Architecture versus M&S?



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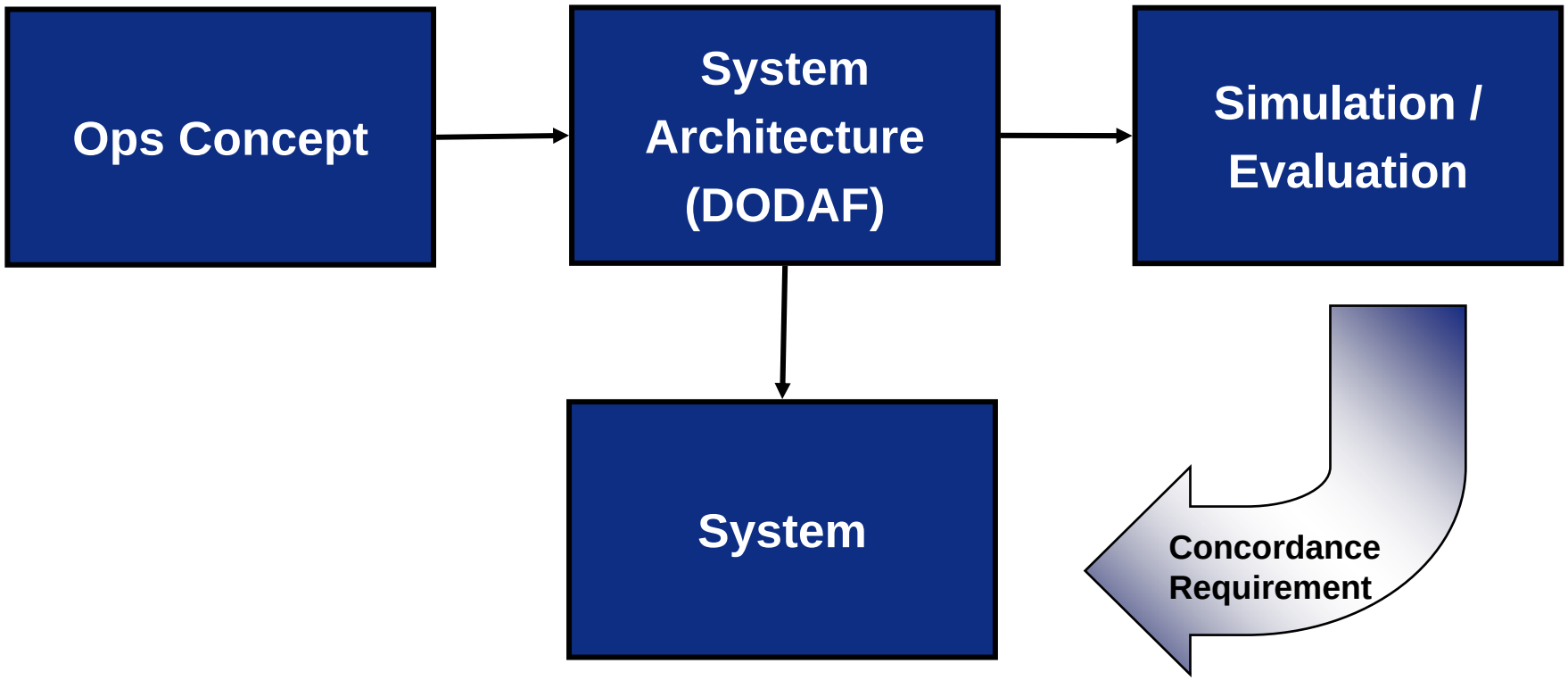
Bridge the Gap
Architecture and M&S



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Introduction

Research Objectives / Implications

Demonstrate an improved process of using architectures to evaluate/refine a proposed system concept

Application:

Weapon Borne Battle Damage Assessment (WBBDA)

System Concept (2015-2025 time frame)

- **Develop DODAF system architectures (both "as-is" and "to-be")**
  - **Key Products: OV-1, OV-2 (nodes), OV-5 (activities), OV-6a (rules), OV-6b (state transition diagram, or discrete event sim), OV-7 (data)**
- **Develop evaluation models directly from the system architectures**
- **Analyze results to identify key design parameters that can translate to system requirements and Key Performance Parameters in the JCIDS**

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Methodology

- Develop Architecture based on joint ops concept
  - DoDAF architecture views
  - Compare AS-IS and TO-BE architectures
- Develop and use simulations based on architecture
  - Analytical Model – Excel, with Decision Analysis add-in
  - Discrete Event Simulation– Rockwell Arena
- Evaluate the system concept based on the results

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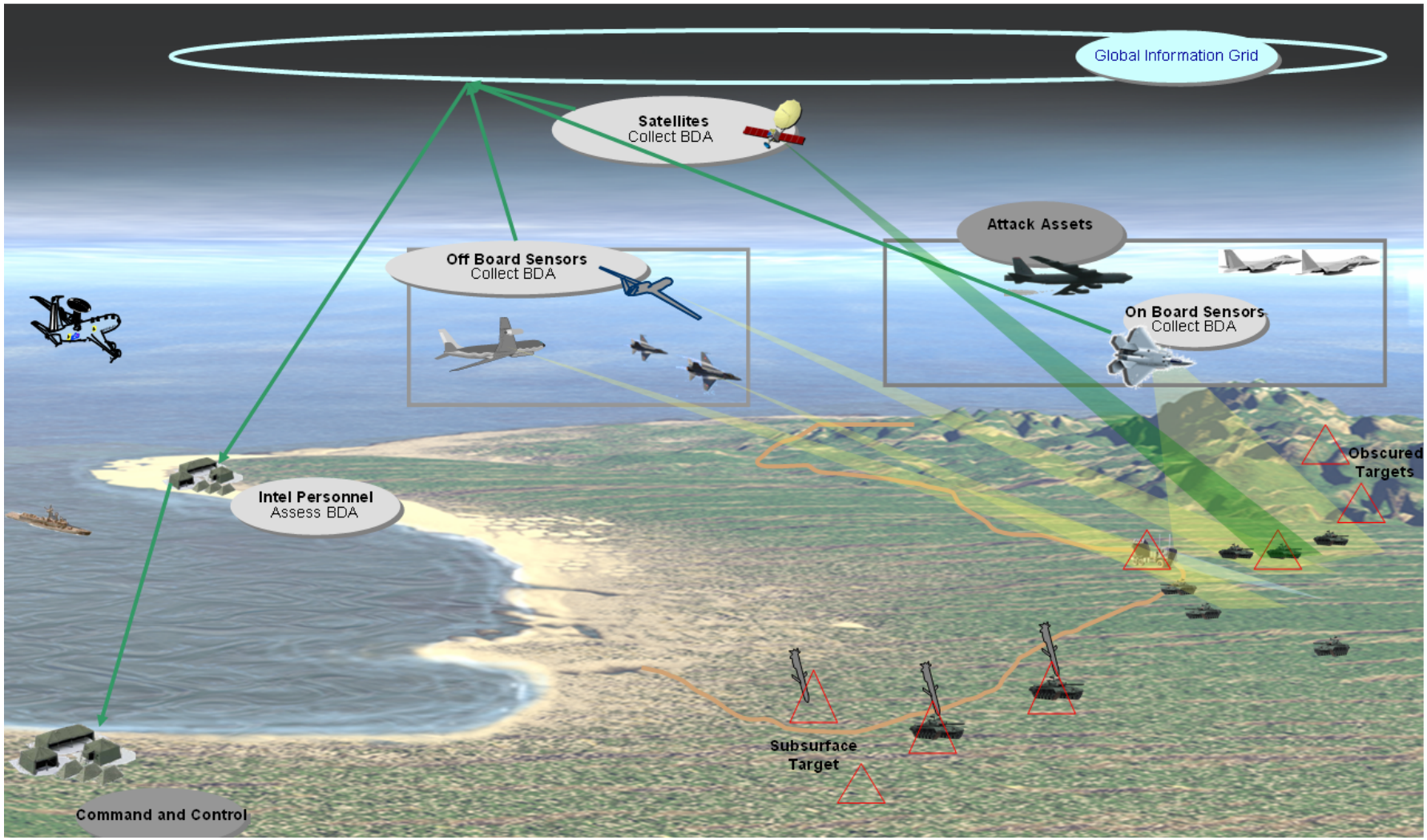
Current BDA Ops Concept

OV-1



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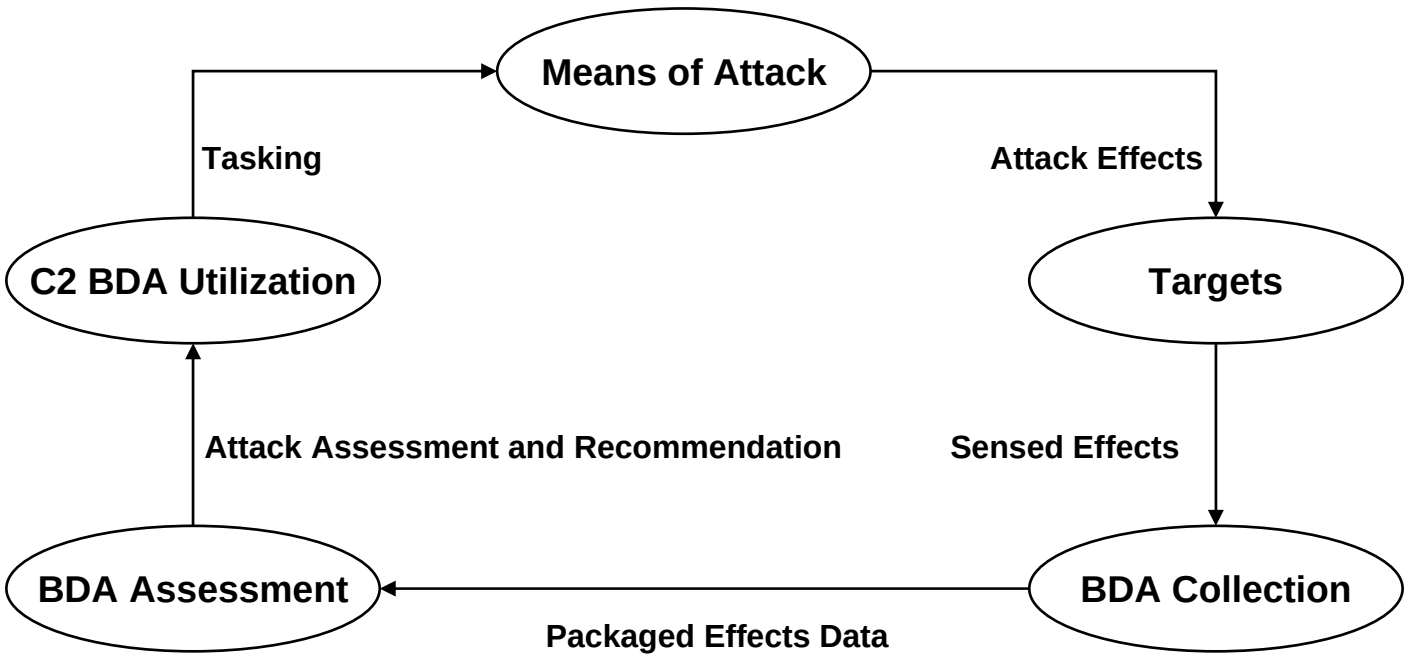
Architecture

AS-IS OV-2 Operational Node Connectivity

The BDA Cycle



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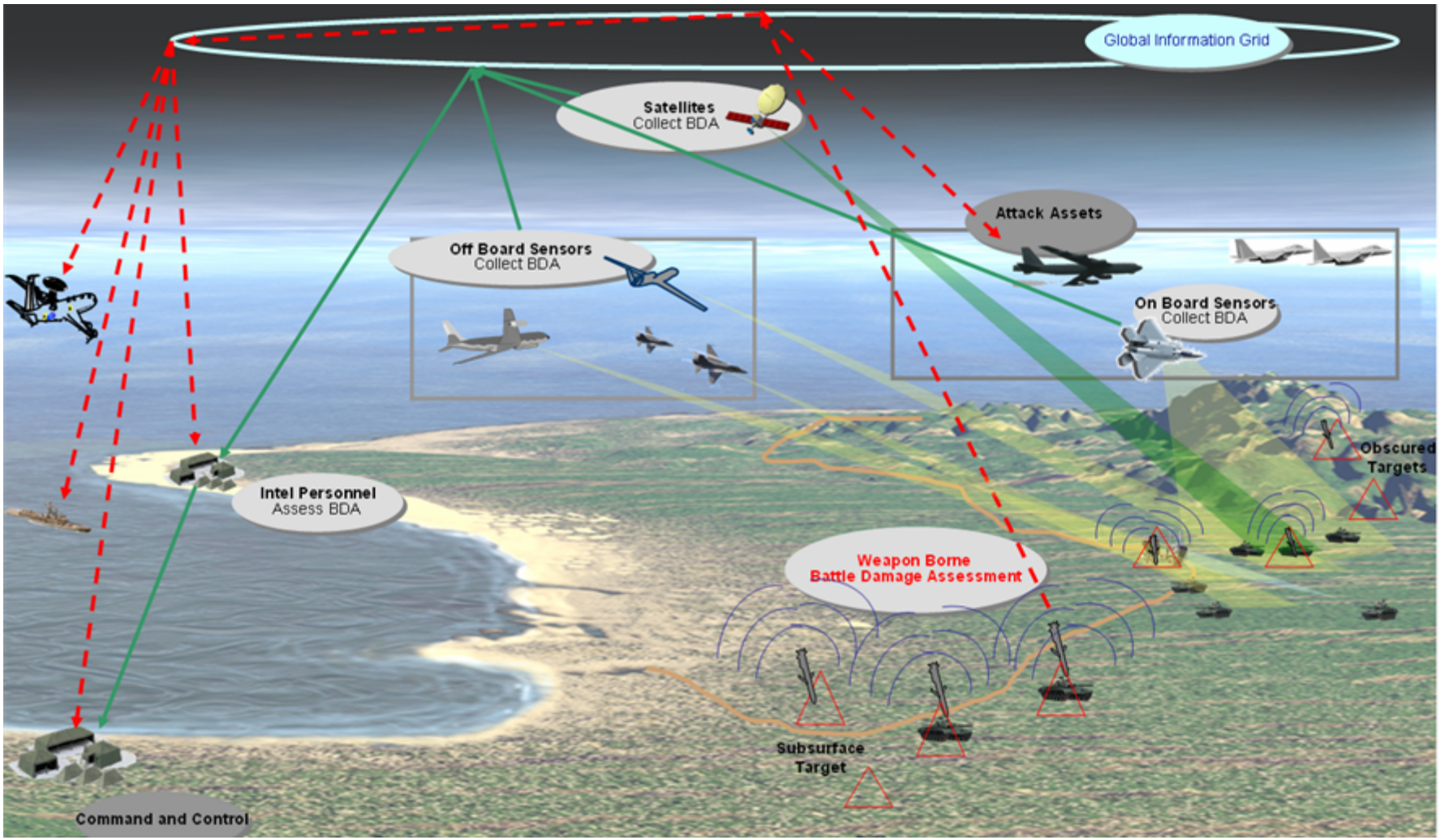
So what is WBBDA?

"To-Be" OV-1



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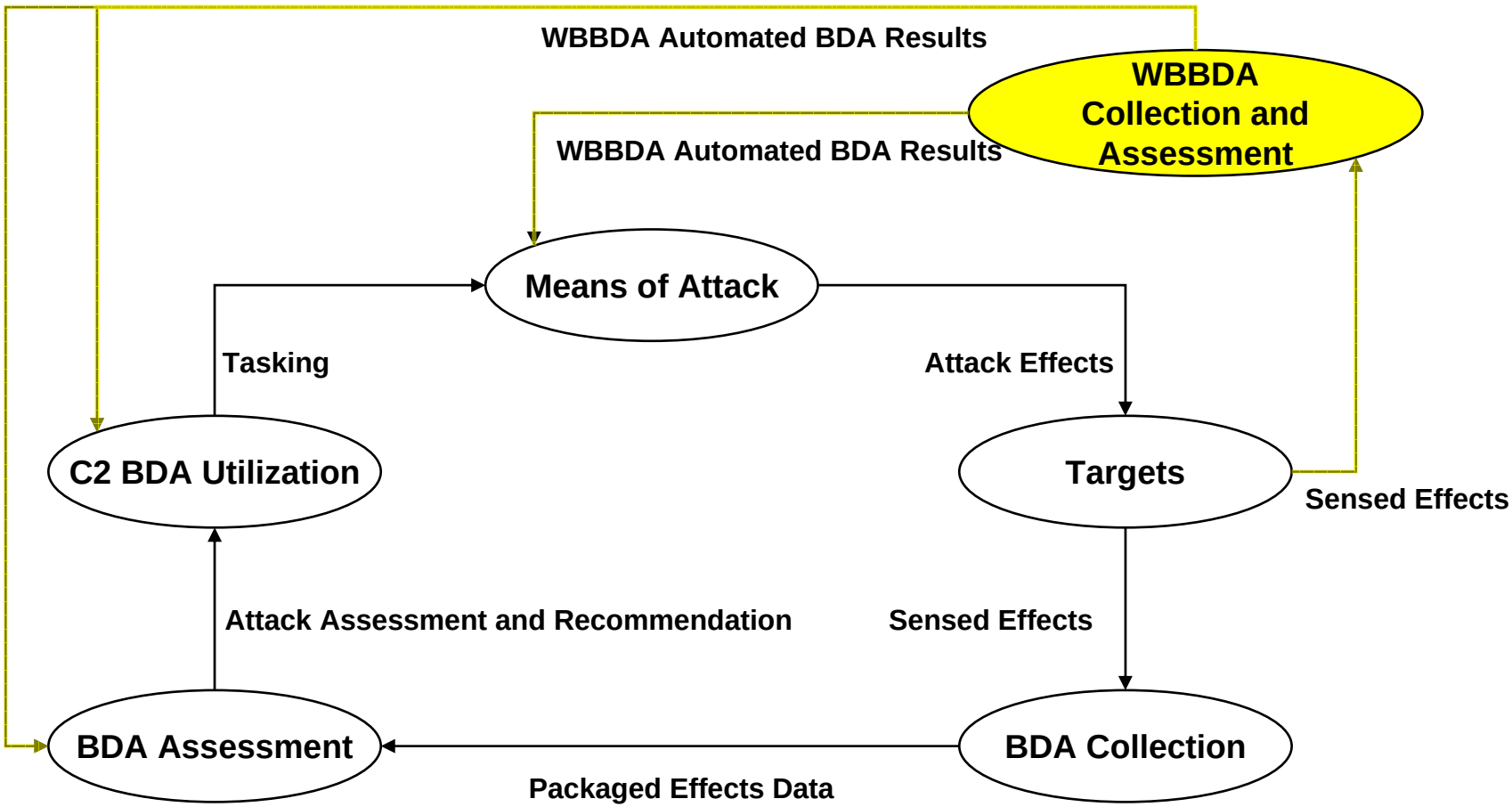
Architecture

TO-BE OV-2 Operational Nodes Diagram

The WBBDA enabled BDA Cycle



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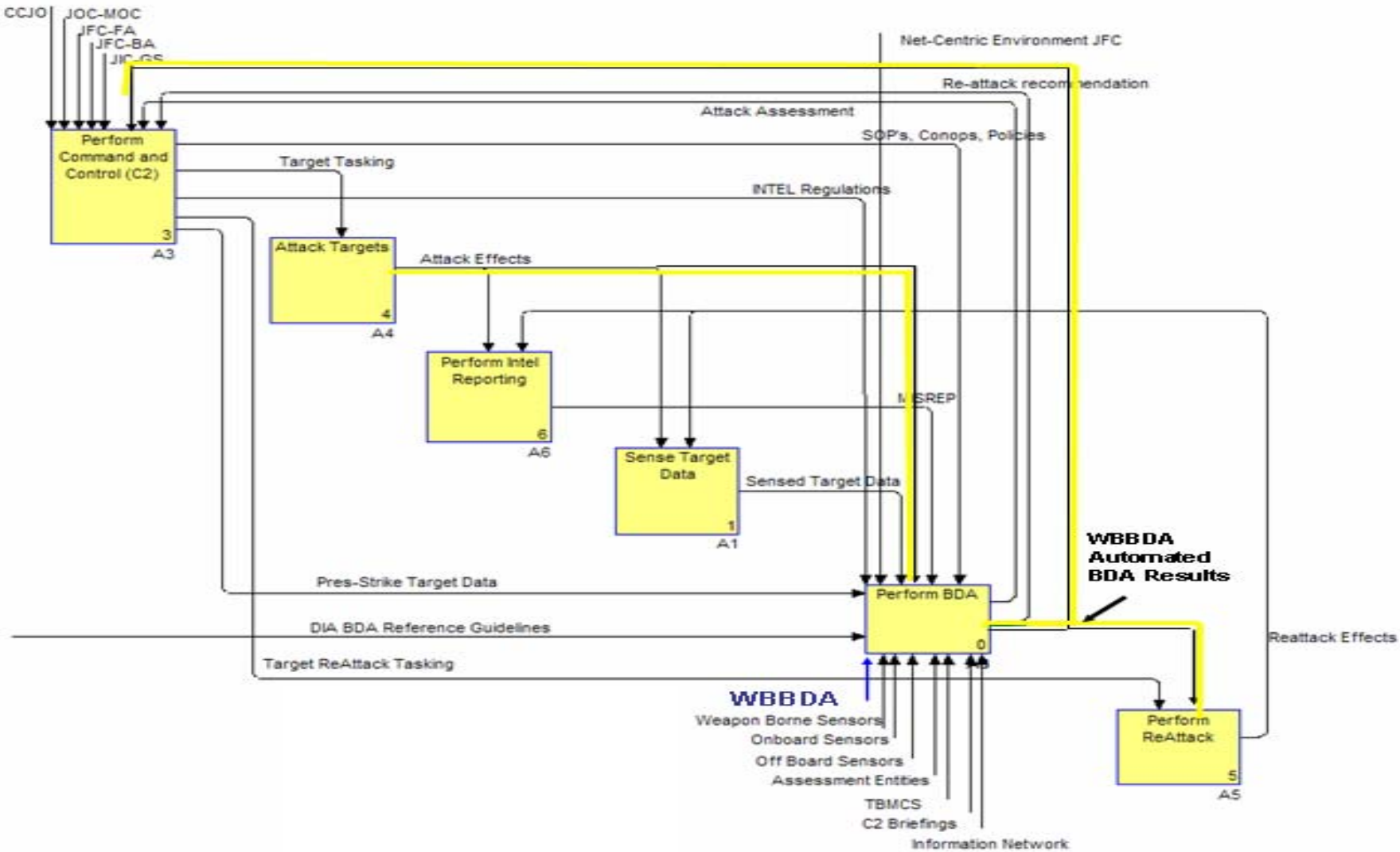
OV-5 Activity Diagram



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Architecture

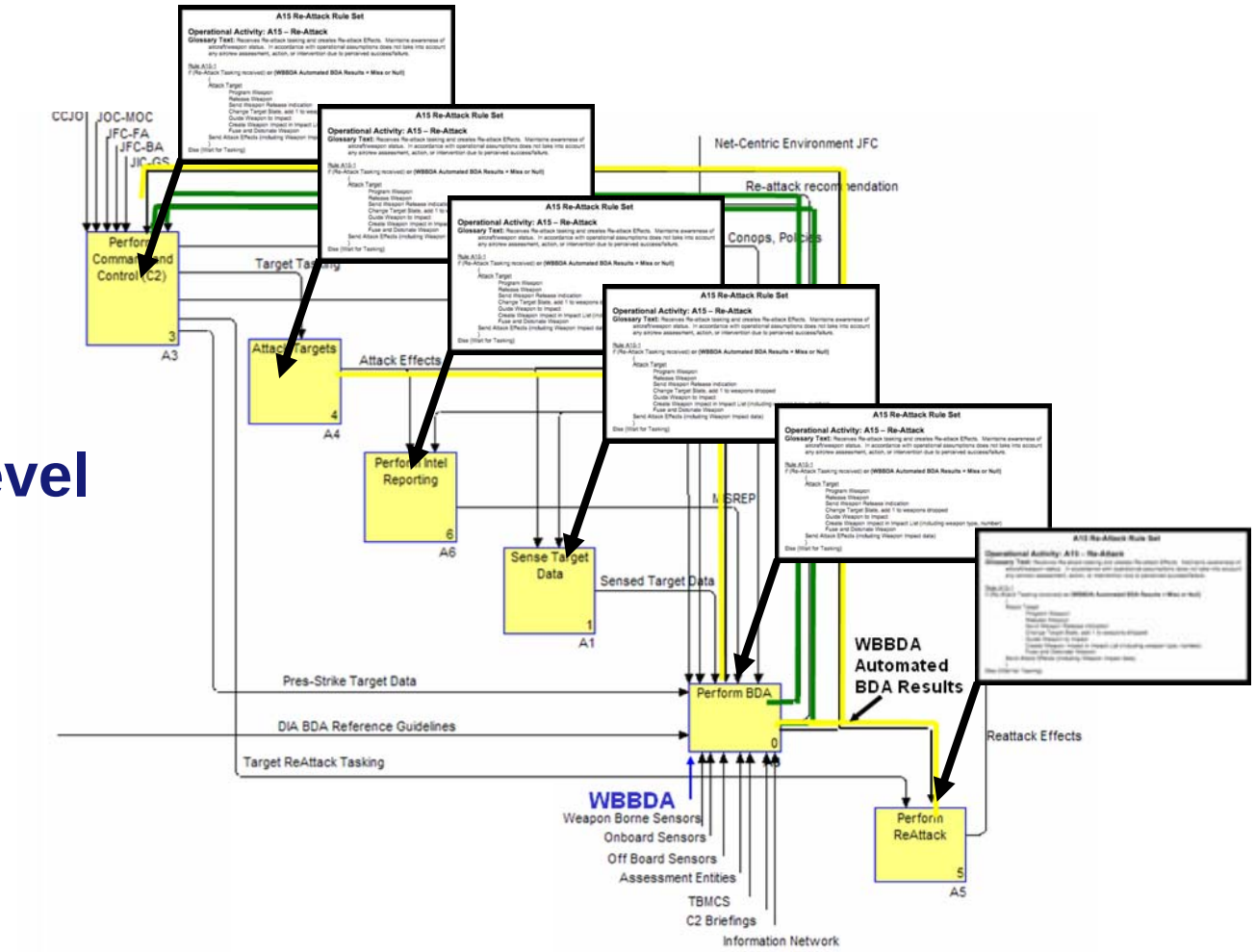
OV-6a Rules Model

At ESD Level…

Major Combat Operations

…and System Level

Perform BDA



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Architecture
Method for Metrics

- **MOEs Established in ICD**

Measure of Effectiveness	Numerator	Denominator
1. AOR Coverage (AORC) – % of targets that receive BDA results	# targets BDA is collected on	# of targets attacked per package
2. Total Time-Obscured Target (TT-OT)–Looks at total time from the completion of the attack strike (on obscured targets) to the point when all BDA assessment and dissemination is complete.	time	n/a
3. Total Time– Subsurface Targets (TT-ST) Looks at total time from the completion of the attack strike (on subsurface targets) to the point when all BDA assessment and dissemination is complete.	time	n/a
4. Package Effectiveness (PE)	# targets killed	# of packages
5. Package Planning Effectiveness (PPE)	# targets attacked	# of packages
6. Attack Effectiveness (AE)	# targets killed	# targets attacked
7. Weapons per Target Kill (WPTK)	total # of weapons dropped	# targets killed

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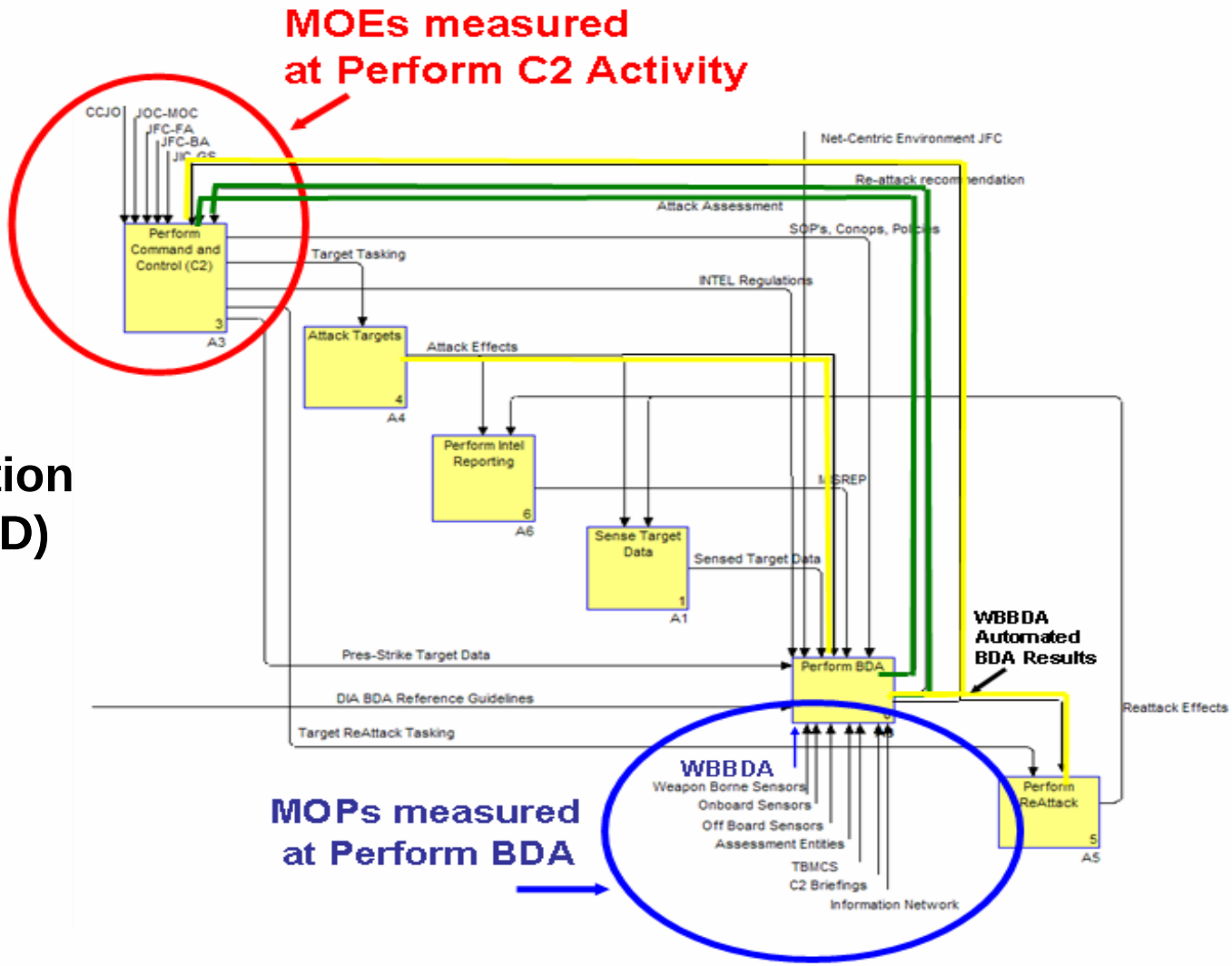
Architecture
Method for Metrics

- Initial system views did not capture MOE's
- Built additional views at higher level of abstraction for visibility (ESD)
- Established Traceability



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Single Package Model
Traceability to MOEs

- **Purpose: Construct analytical model based on architecture to evaluate the WBBDA system concept**

- **Model outputs values for the following MOEs:**
  - **Package Planning Effectiveness (PPE)**
    = # of targets attacked
  - **Package Effectiveness PE**
    = # of targets destroyed
  - **Attack Effectiveness AE**
    = # targets destroyed / # targets attacked
  - **WPTK = # weapons used per target destroyed**

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Single Package Model
Key Terms

- $\underline{P_k}$ – probability of kill (hit) based on all non-WBBDA factors (weapon performance, delivery system performance, etc.)
- Accuracy – probability WBBDA correctly determines a hit / miss
- Reliability – probability WBBDA correctly transmits and displays a hit / miss

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Single Package Model
Scenarios

- **AS-IS**
  - 2 bombs / target, simultaneous
  - A/C RTB w/ 0 bombs
- **TO-BE: WBBDA**
  - 1 bomb / target, repeat until WBBDA "hit"
  - A/C RTB w/ remaining bombs
  - Same # of targets, less bombs
- **TO-BE: WBBDA + Doctrine (W+D)**
  - DOT_LPF doctrine change (WBBDA + drop remaining bombs on additional/secondary tgts)
  - A/C RTB w/ no bombs
  - More targets, same # of bombs

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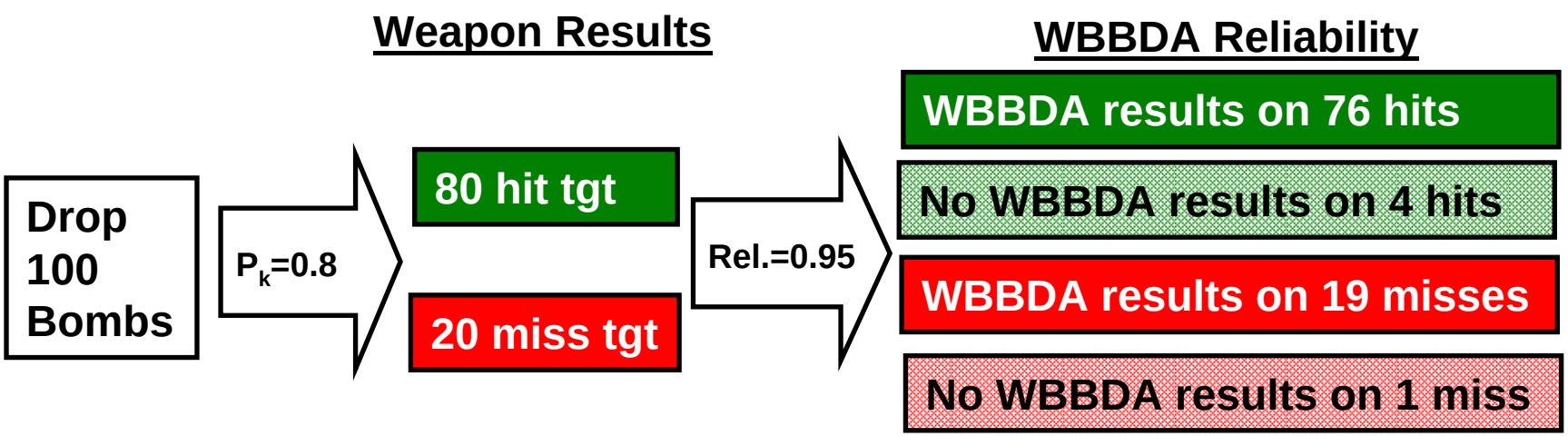
Single Package Model
Example

- Drop 100 bombs on 100 targets
- Assume: P_k = 0.80, Reliability = 0.95, Accuracy = 0.90



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Single Package Model
Example (cont'd)

WBBDA Reliability

WBBDA results on 76 hits

No WBBDA results on 4 hits

WBBDA results on 19 misses

No WBBDA results on 1 miss

Acc.=0.9

WBBDA Accuracy

Correctly assess 68 hits as hits

Incorrectly assess 8 hits as misses

Correctly assess 17 misses as misses

Incorrectly assess 2 misses as hits

Dropped 100 bombs

95 bombs →

← 5 bombs

Lack of WBBDA Results
(due to Reliability)

No WBBDA results = assumed miss on 5 tgts

WBBDA Results (Accuracy)

WBBDA	State of Nature: Hit Tgt	State of Nature: Miss Tgt
Assess Hit	68	2
Assess Miss	8	17

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Single Package Model
Example - Targeting Implications

- Results of 1st attack--implications to further targeting (P_k=.8, Rel.=.95, Acc.=.9)

Drop 100 bombs

- WBBDA results on 95
- No WBBDA on 5

WBBDA Results

WBBDA	State of Nature: Hit Tgt	State of Nature: Miss Tgt
Assess Hit	68	2
Assess Miss	8	17

Type I Errors
Retire targets
(targets survive)

Retire targets
(tgts destroyed)

Reattack targets
(all missed)

Type II Errors
Reattack targets
(all hit)

Lack of WBBDA Results

No WBBDA results = assumed miss on 5 tgts

Reattack targets
(80% already destroyed)

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Single Package Model

Example – Overall Results

- **Results after all reattacks (≤ 4 passes…100, 30, 5, 2)**
  - **Strike package departs with 100 WBBDA "hits"**
  - **Overall: 97 targets destroyed, 3 missed (Type I Errors)**

WBBDA	State of Nature: Hit Tgt	State of Nature: Miss Tgt
Assess Hit	97	3 Type I
Assess Miss	0 Type II	0

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Single Package Model

Actual Results w/ Inputs at Baseline

INPUTS: Components WBBDA Effectiveness (all baseline)	μ	σ	
Weapon Pk	0.80	0.051	normal distribution

OUTPUTS

	As-Is		WBBDA			WBBDA w/ doctrine change		
	μ	σ	μ	σ	% improve in μ	μ	σ	% improve in μ
PPE (planned)	100	0.0	100	0.0	0.0%	145	0.0	45%
PE (destroyed)	95	2.1	98	1.0	2.4%	139	4.7	45%
AE (PE / PPE)	0.952	0.021	0.975	0.010	2.4%	0.956	0.032	0.3%
WPTK	2.10	0.04	1.41	0.03	-33%	1.42	0.09	-33%

WBBDA

WBBDA + Doctrine

WBBDA capabilities improve on the AS-IS scenario

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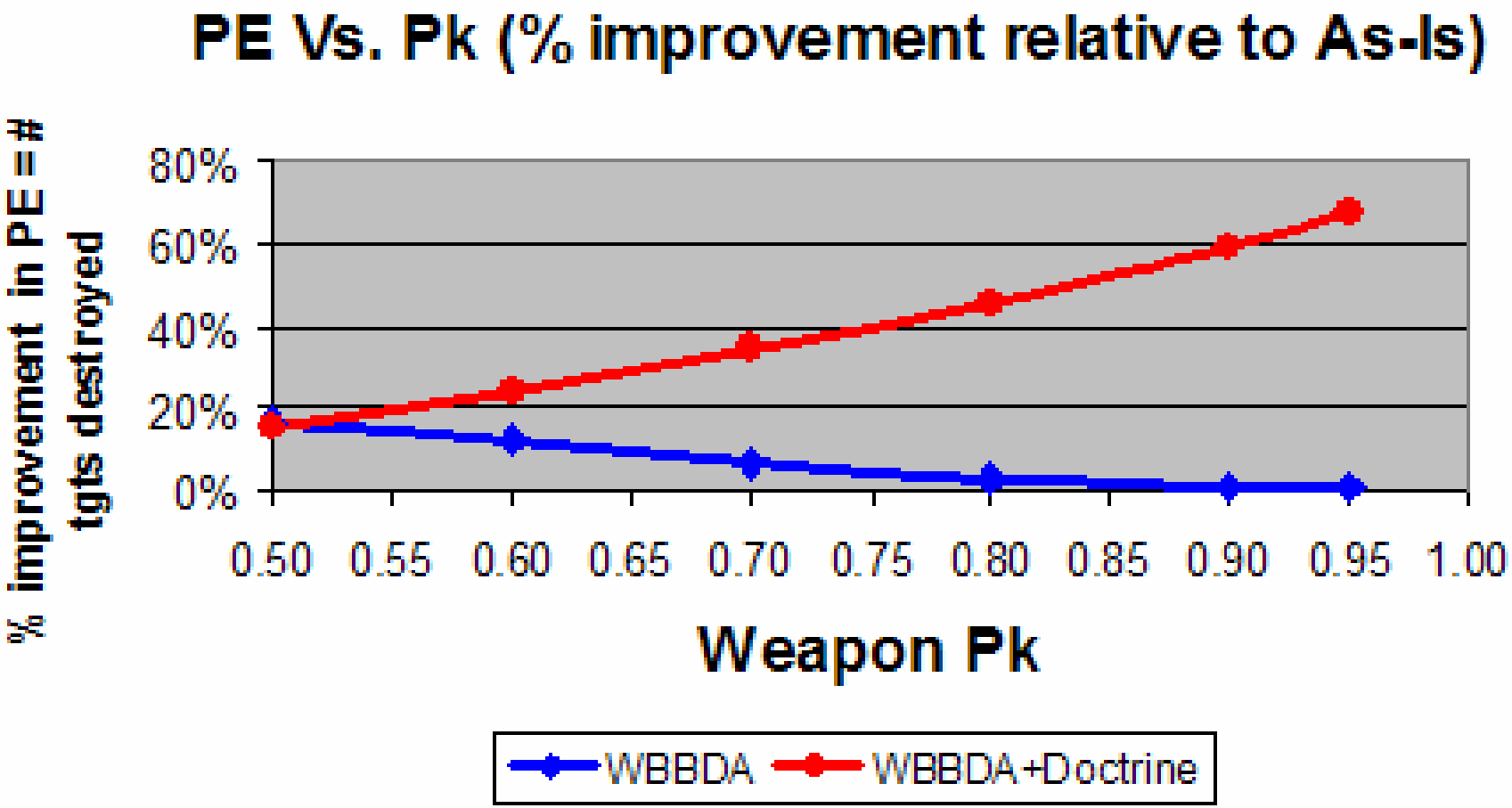
Single Package Model
Sensitivity to Weapon Pk



Strengthens argument to implement doctrine change

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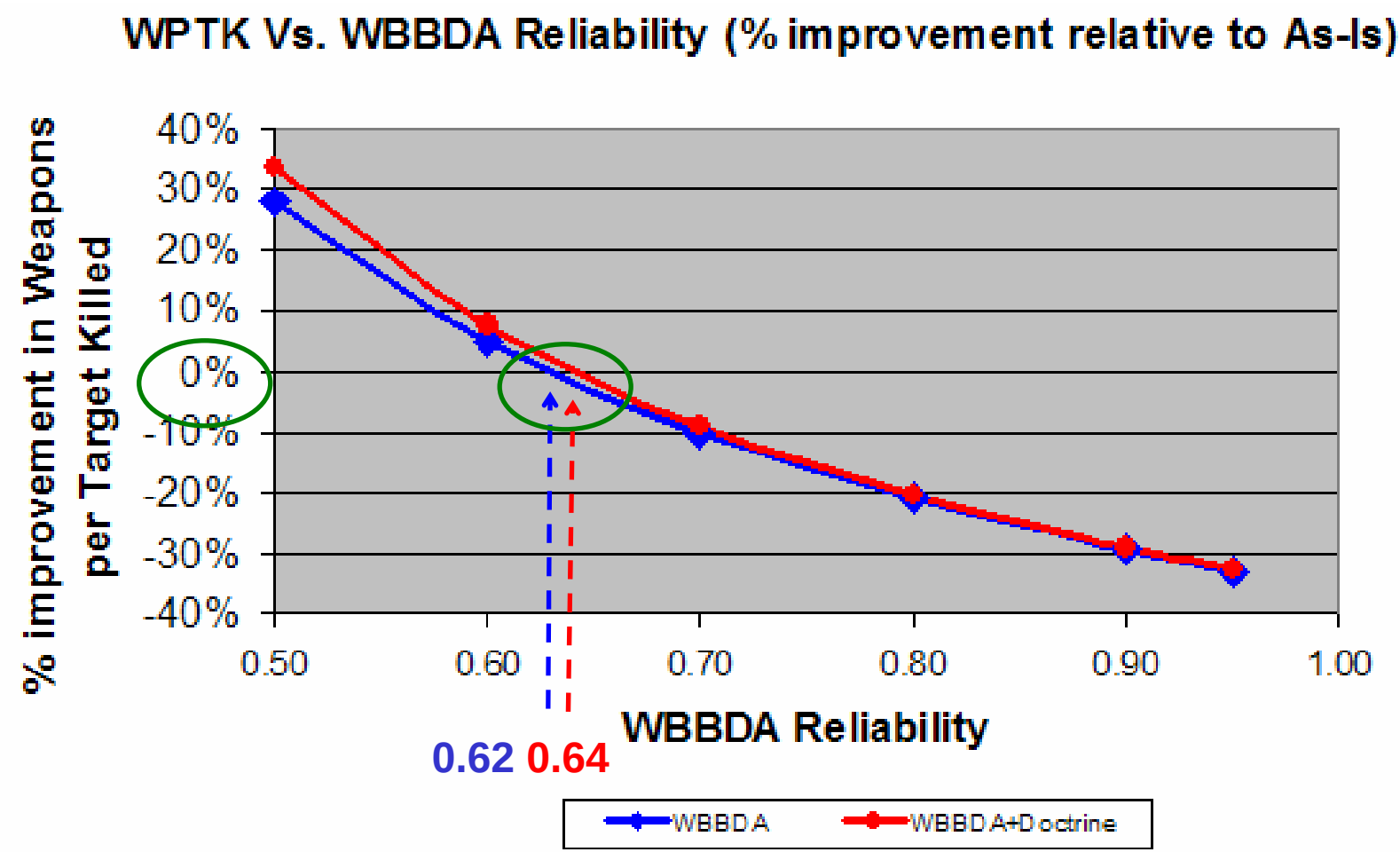
Single Package Model
Sensitivity to WBBDA Reliability



Supports establishment/study of a Reliability requirement

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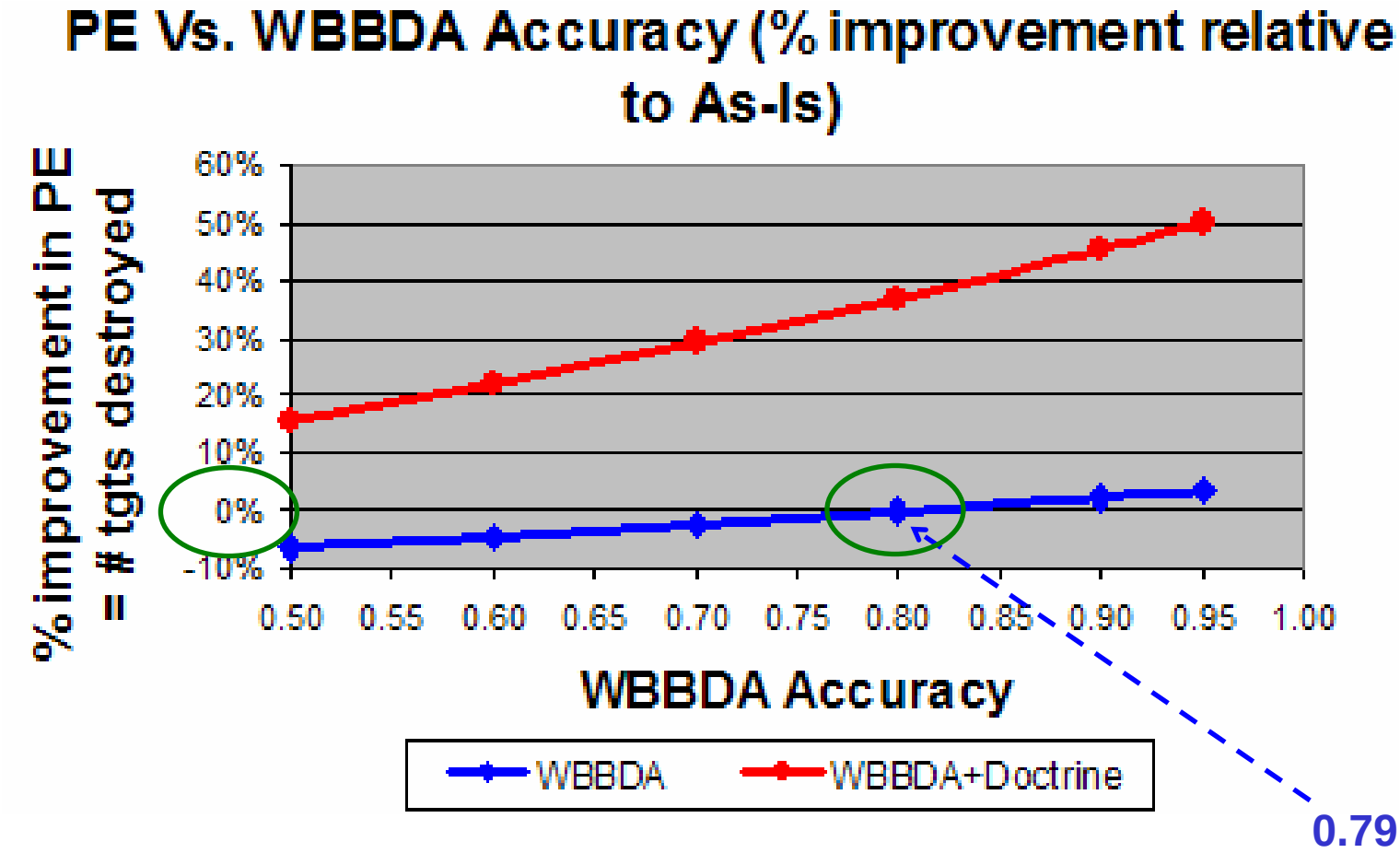
Single Package Model
Sensitivity to WBBDA Accuracy



Supports establishment/study of an <u>Accuracy requirement</u>

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Single Package Model
Aircraft Loadout Comparison

- **Does WBBDA capability favor either scenario?**
  - **More weapons per jet of lower P_k (SDB scenario)**
  - **Fewer weapons per jet of higher P_k (JDAM scenario)**

	2,000# JDAM			250# SDB			500# JDAM		
	As-Is	WBBDA	W + D	As-Is	WBBDA	W + D	As-Is	WBBDA	W + D
# Tgts Destroyed	78	1.3%	54%	70	8.6%	33%	78	1.3%	54%
# Bombs Dropped	160	-34%	0%	160	-19%	-1%	160	-34%	0%
#Sorties Flown	80	0.0%	0%	20	0.0%	0%	40	0.0%	0%
Optimum # of Sorties	80	-34%	0%	20	-15%	0%	40	-33%	0%
Tgts Dest. / Opt. Sortie	0.975	52.9%	54%	3.5	27.7%	33%	1.95	50.0%	54%

Analysis of model results forced reconsideration of MOEs, architecture, and model

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Architecture Based Evaluation Process (ABEP)

- **STEP 1: Design Ops Concept (OV-1) of System to be Evaluated**
- **STEP 2: Identify MOE's Relevant to the Decision/Evaluation**
- **STEP 3: Identify Required Level of Abstraction for Architecture to Show Traceability to MOE's**
- **STEP 4: Identify Architecture Views Necessary to Capture Structure/Relationships. NOT VIEWS, BUT DATA**
- **STEP 5: Develop Architecture Views NOT VIEWS, BUT DATA**
- **STEP 6: Modeling/ Simulation consistent with Architecture**
- **STEP 7: Evaluate Model Completeness**
- **STEP 8: Evaluate MOE**

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Conclusion

ABEP vs DODAF

ABEP Step 1.
OPS Concept

Step 2.
ID Mission
Level Metrics

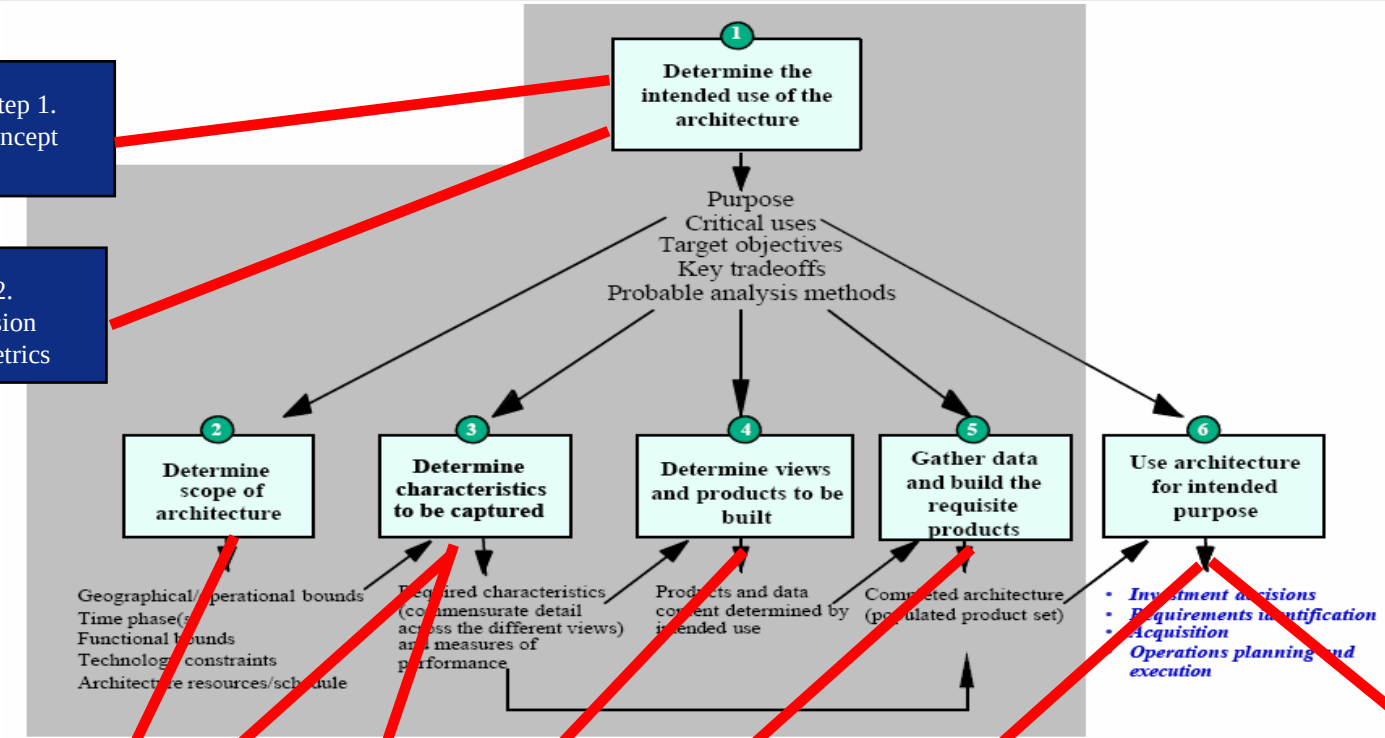

Figure 5-1. The Six-Step Process of Building an Architecture

Architecture Evaluation

Step 3.
ID Required
Level of Abstraction
for Traceability

Step 4.
Determine Views to
Capture Relationship

Step 5.
Develop Architecture
Views

Step 6.
Develop Modeling
Simulation

Step 7.
Evaluate
Model Completeness

Step 8.
Evaluate Model for
MOE Results

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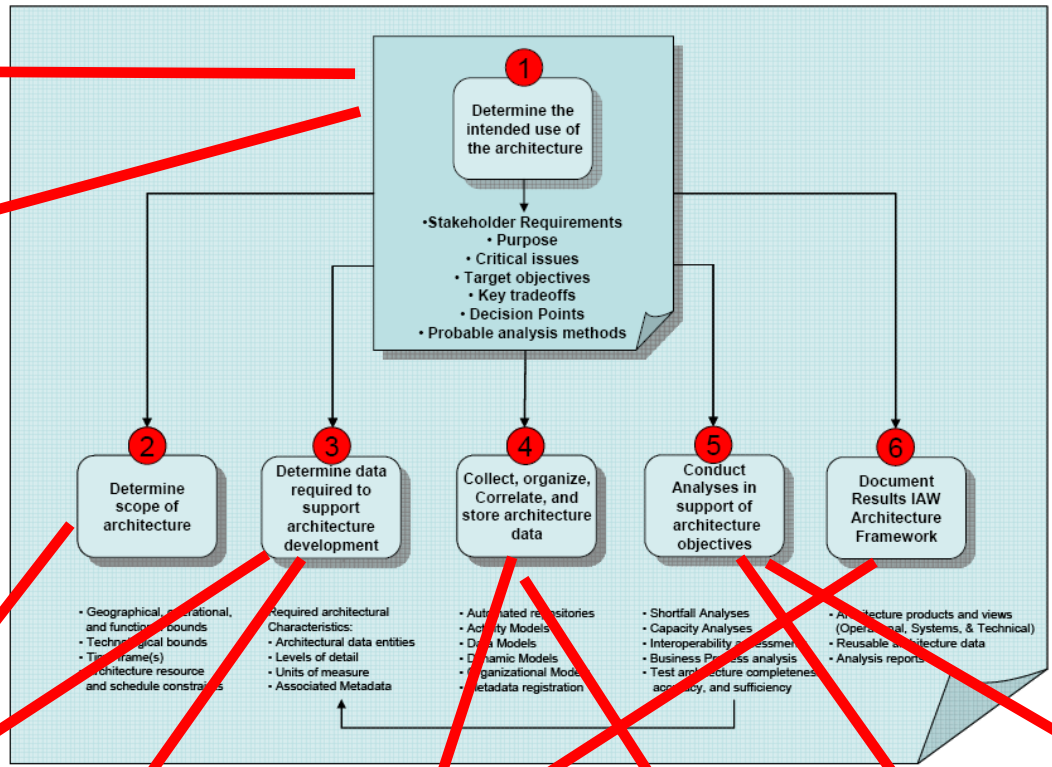
6 Step DoDAF v1.5

ABEP Step 1.
OPS Concept

Step 2.
ID Mission
Level Metrics



Step 3.
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Evaluate Model for
MOE Results

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Conclusion

- WBBDA Specific
  - WBBDA + Doctrine Shift significantly increases MOE's
  - WBBDA Performance is sensitive to Accuracy, Reliability, & Pk
- Non-WBBDA Conclusions
  - Architecture can be used to effectively evaluate a system concept
  - Evaluate Gaps (FNA) and Evaluate Alternatives (FSA and AoA)
  - Identify Critical Requirements, KPP's
  - Provide Feedback for Architectural Changes & Emerging MOE's
- Process
  - Evaluation w/o Architecture = Inaccurate Evaluation, redundant effort, non-Concordance
  - Architecture w/o Evaluation = Static Architecture

Architecture can be used effectively to perform concept definition and analysis in support of JCIDS