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The Missions and Means Framework Application

Presentation to 73rd MORSS
U.S. Military Academy

22 June 2005

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- Introduction

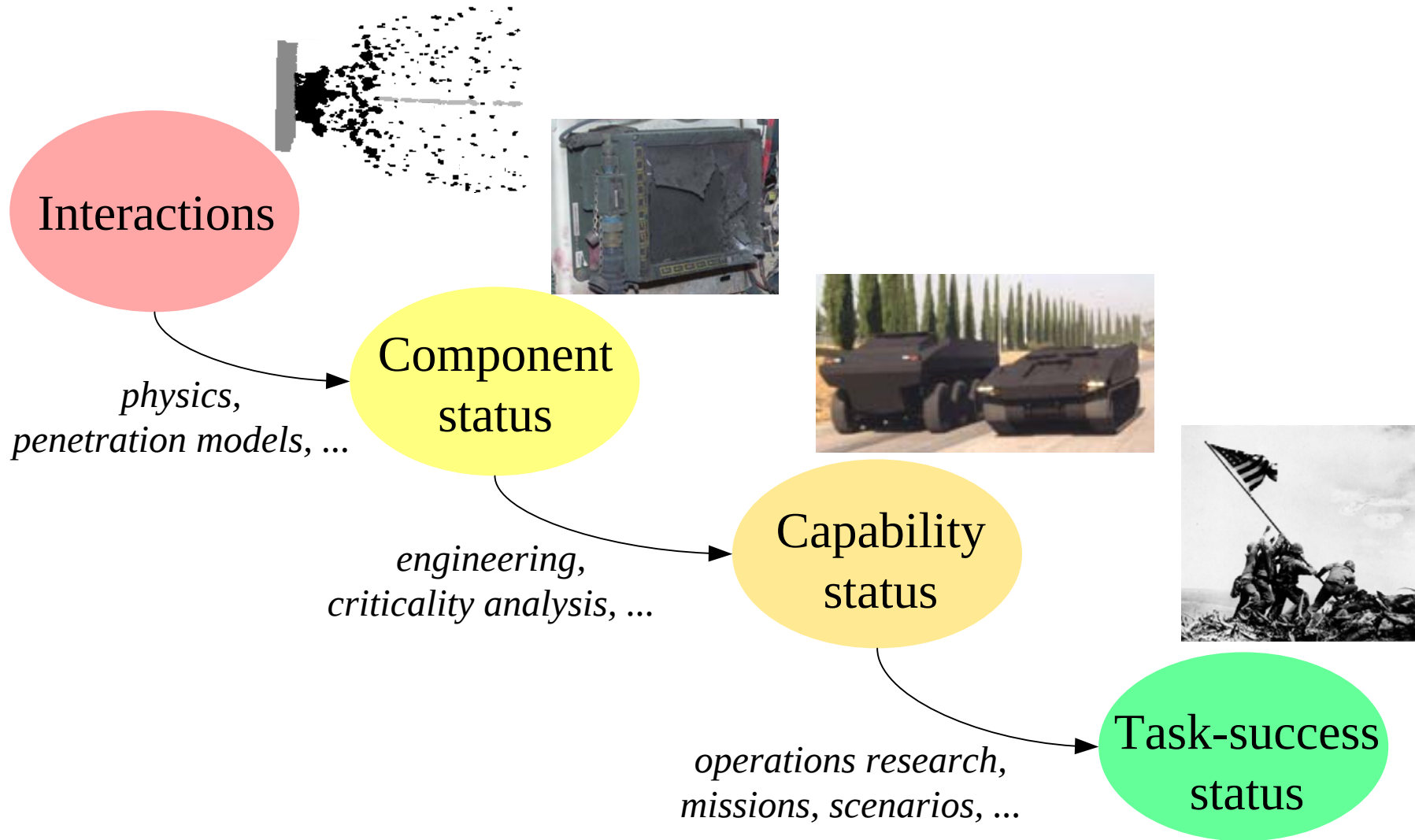
What is MMF? Where did it come from?

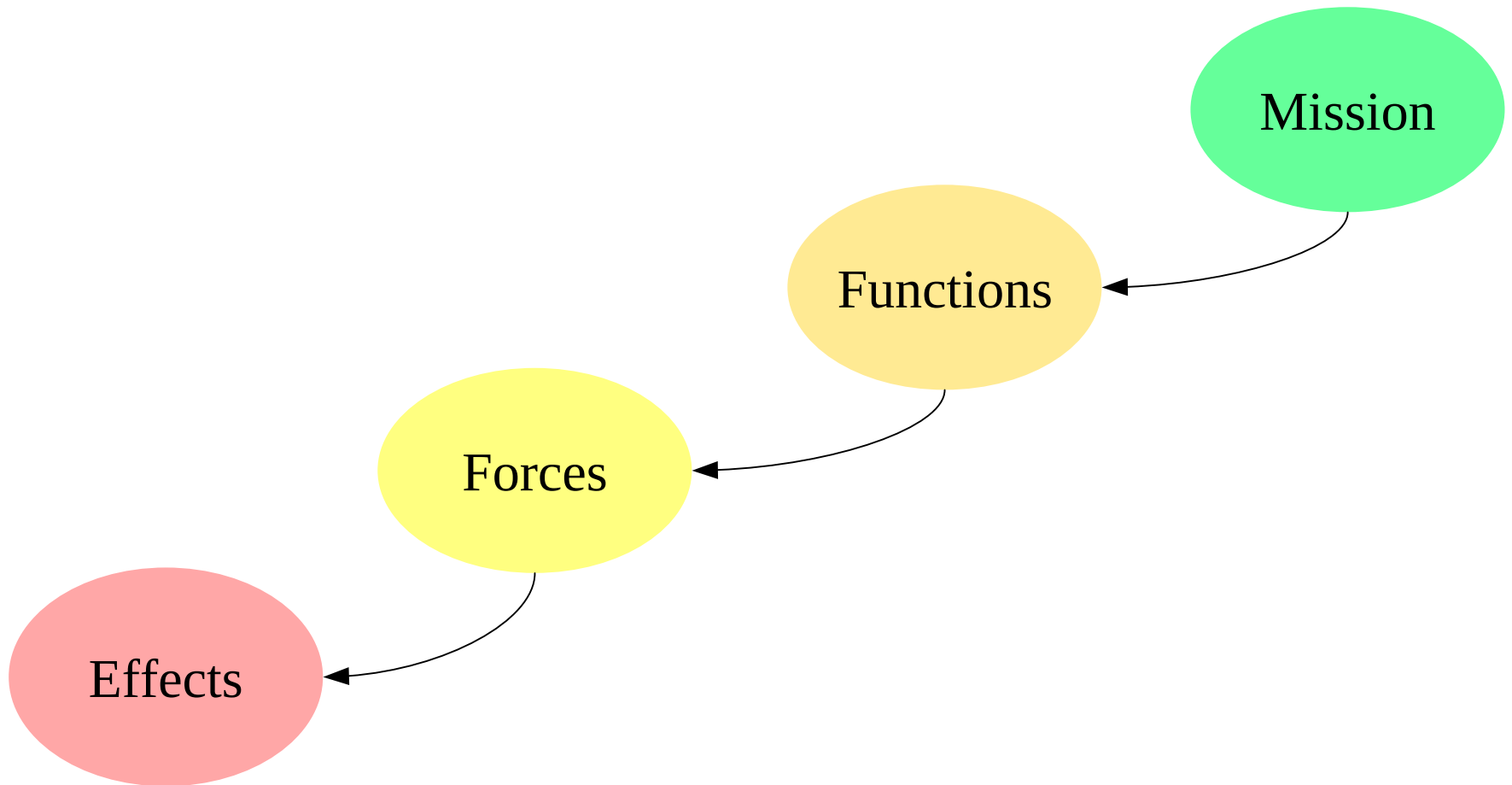
- How it might work
- Platform-level readiness
- The Storyboard Demo
- Other applications
- Summary and conclusions

- Army Research Laboratory
 - Rich Sandmeyer
 - Beth Ward
 - John Onofrey
 - Keon Burley
- Army Materiel Systems Analysis Activity
 - Paul Deitz
 - Alex Wong
- Defense Modeling and Simulation Office
 - Jack Sheehan

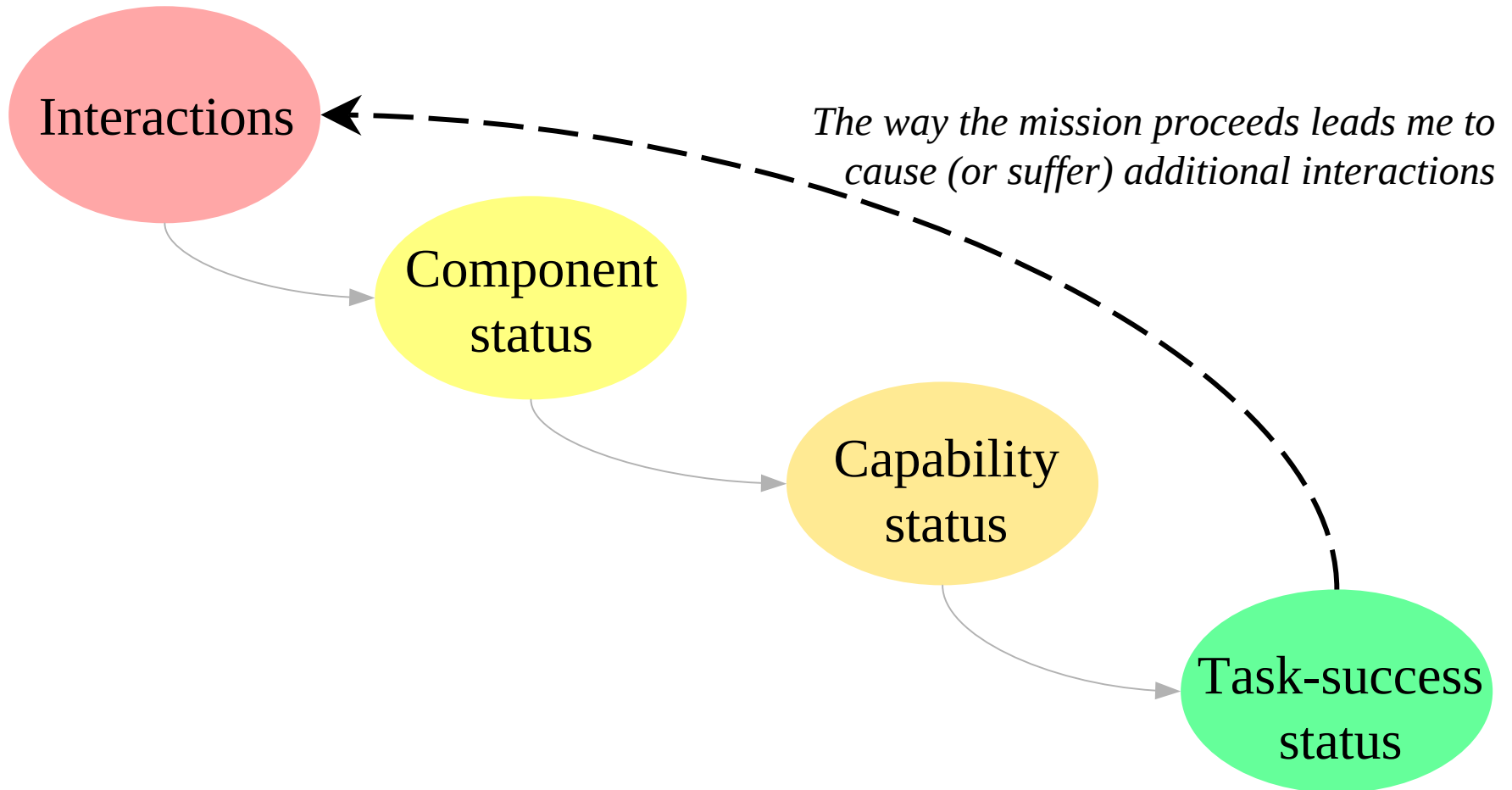
- Warfighter requirements are...
 - based on, but not explicitly traceable to mission;
 - not described in context of contribution to JFC mission;
 - originated in human-readable form and then translated into machine-readable form at great cost in time, money, and accuracy;
 - hard for the non-warfighter to follow because it leaves implicit much knowledge and procedure.
- Developing a complex system of systems requires tackling...
 - effectiveness, suitability, and survivability in terms of the contributions of individual parts to the whole; and
 - effectiveness of the whole in accomplishing assigned operational missions in the context of joint operating concepts.

The venerable vulnerability/lethality “taxonomy”

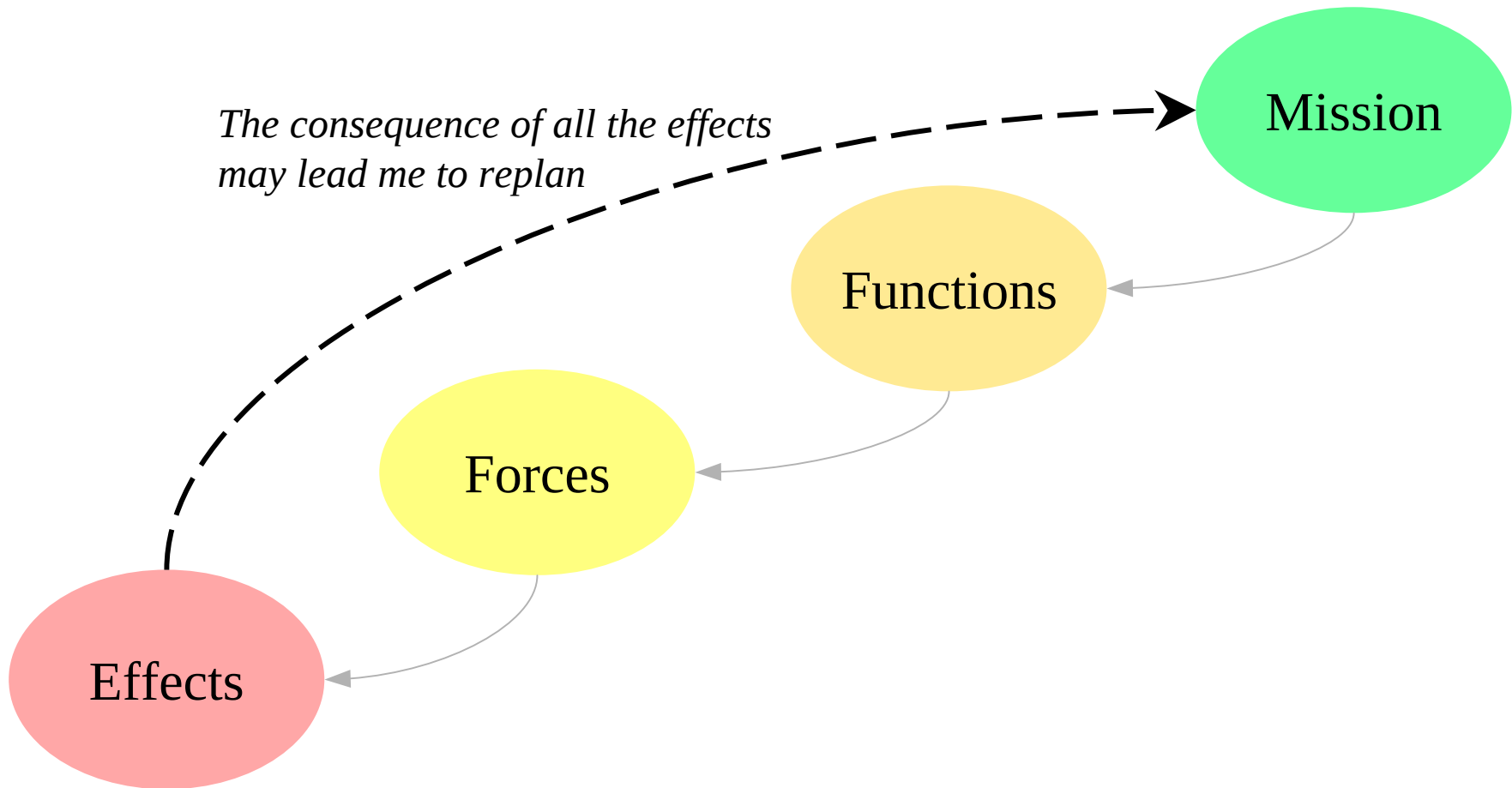


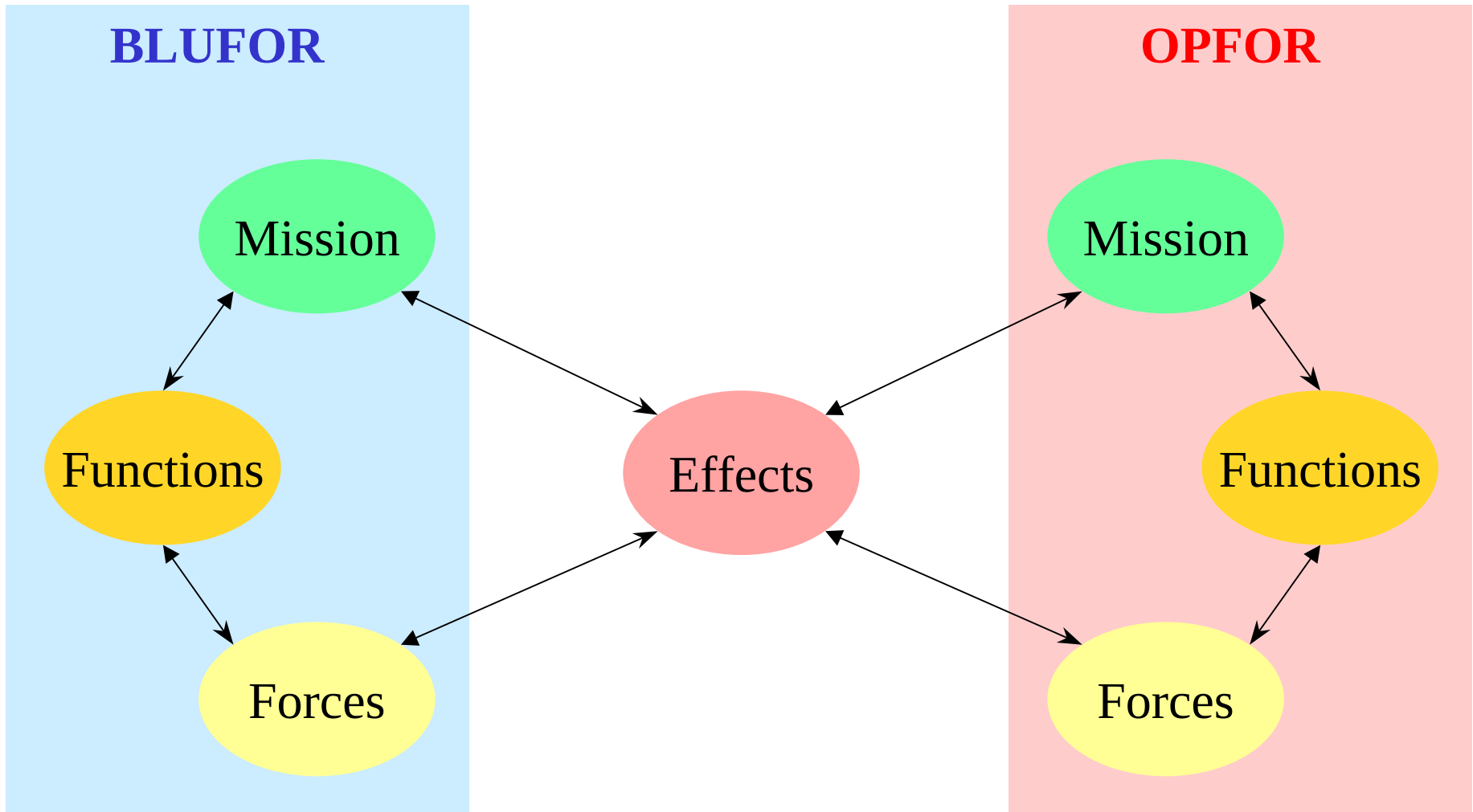


In execution, the taxonomy bites its own tail

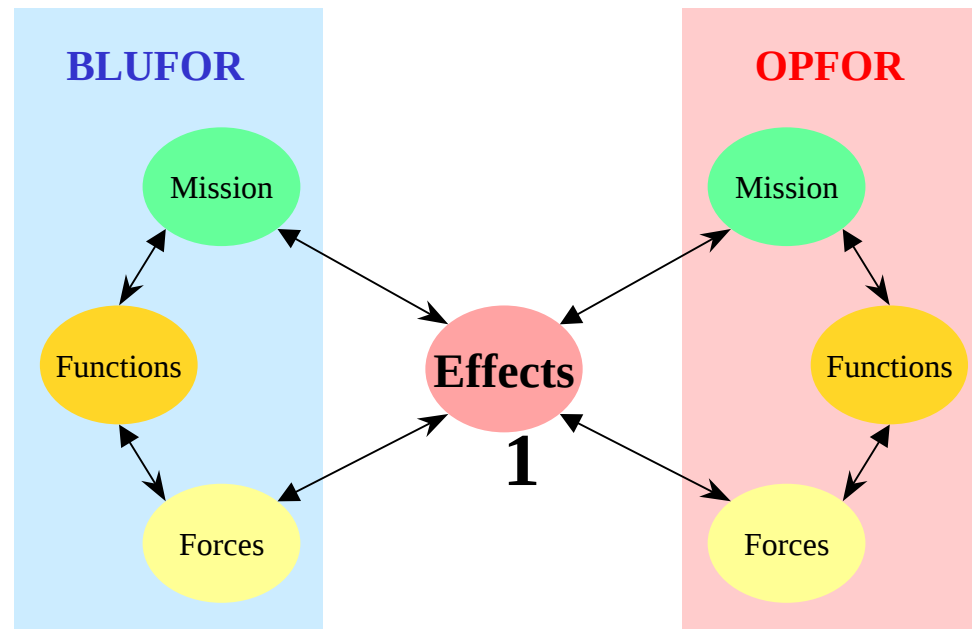


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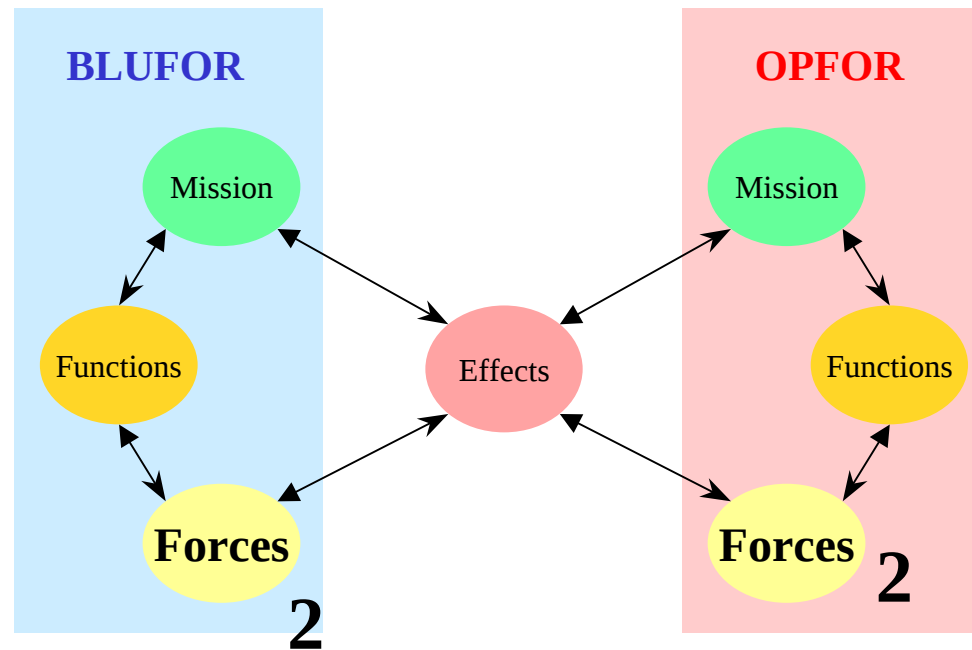




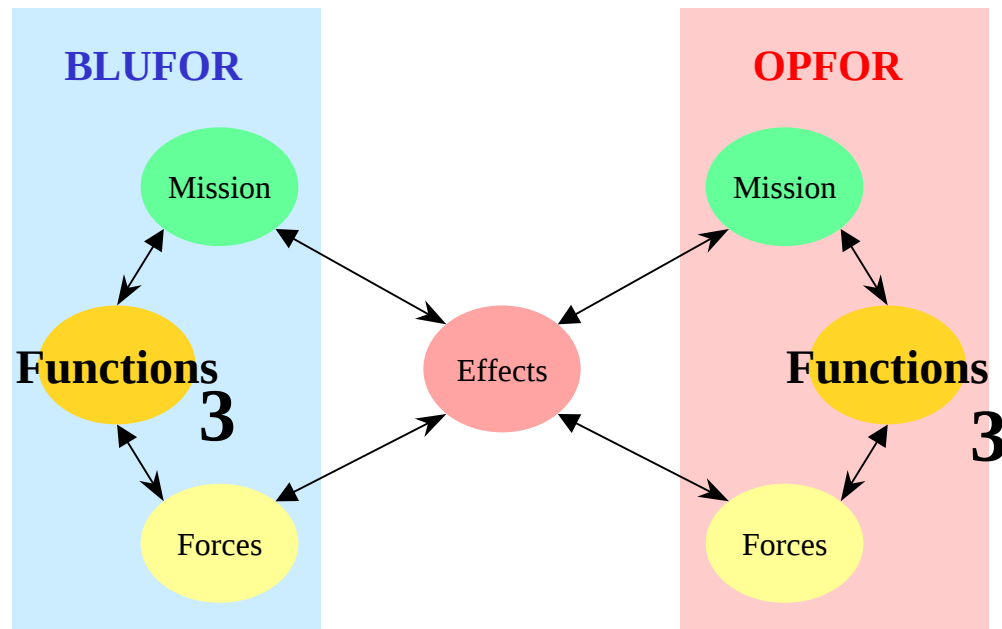
The Missions and Means Framework (MMF)



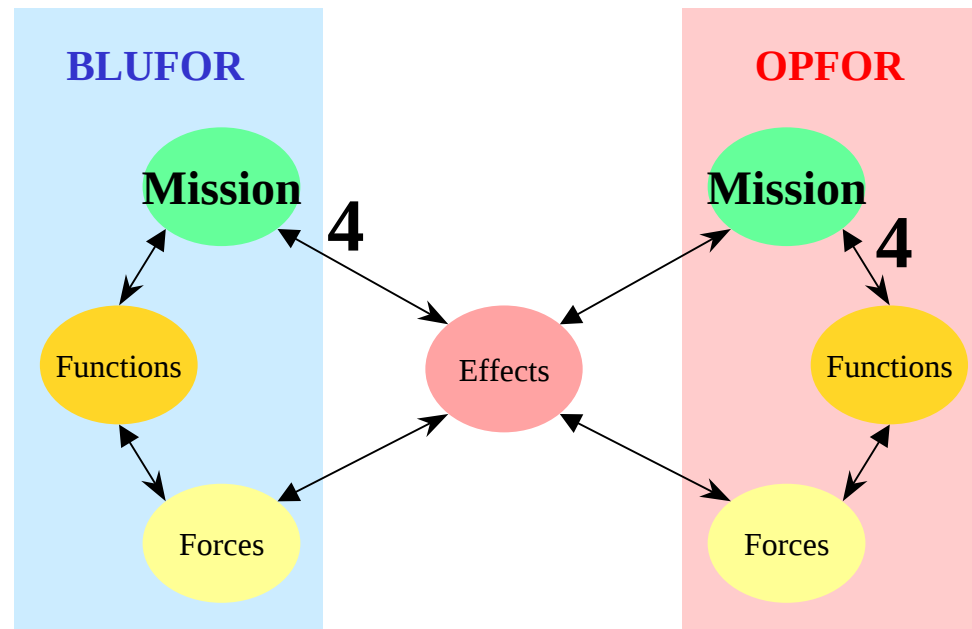
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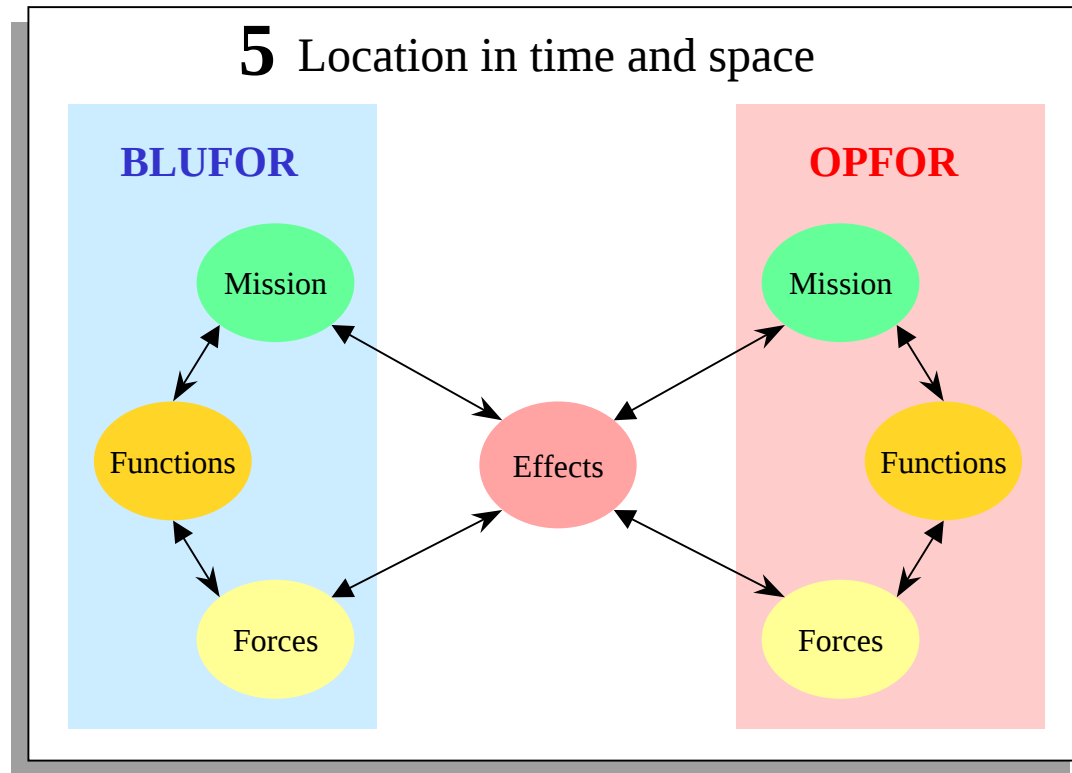


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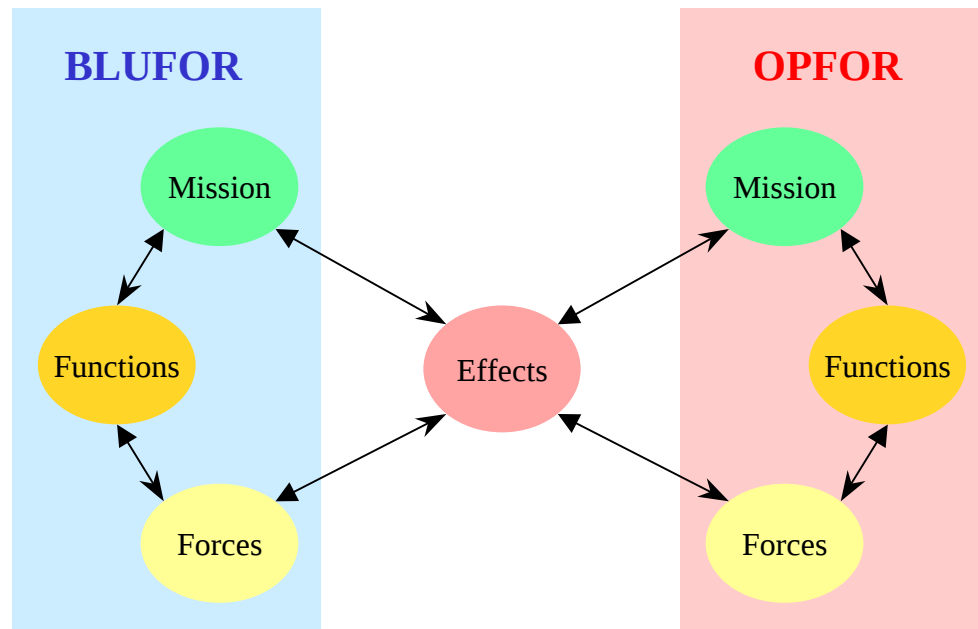
The Missions and Means Framework (MMF)





6 Context (military, political, physical, ...)

Location in time and space



The Missions and Means Framework (MMF)

7 OWNFOR's purpose

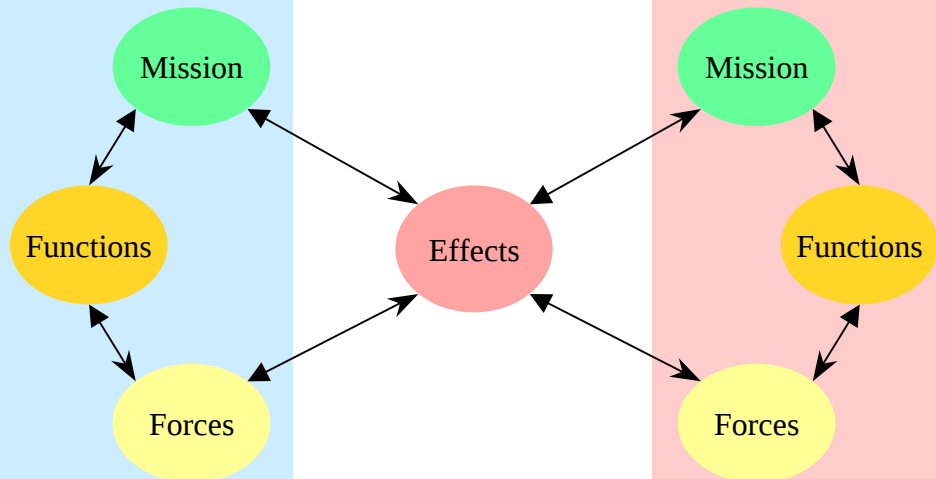
7 OPFOR's purpose

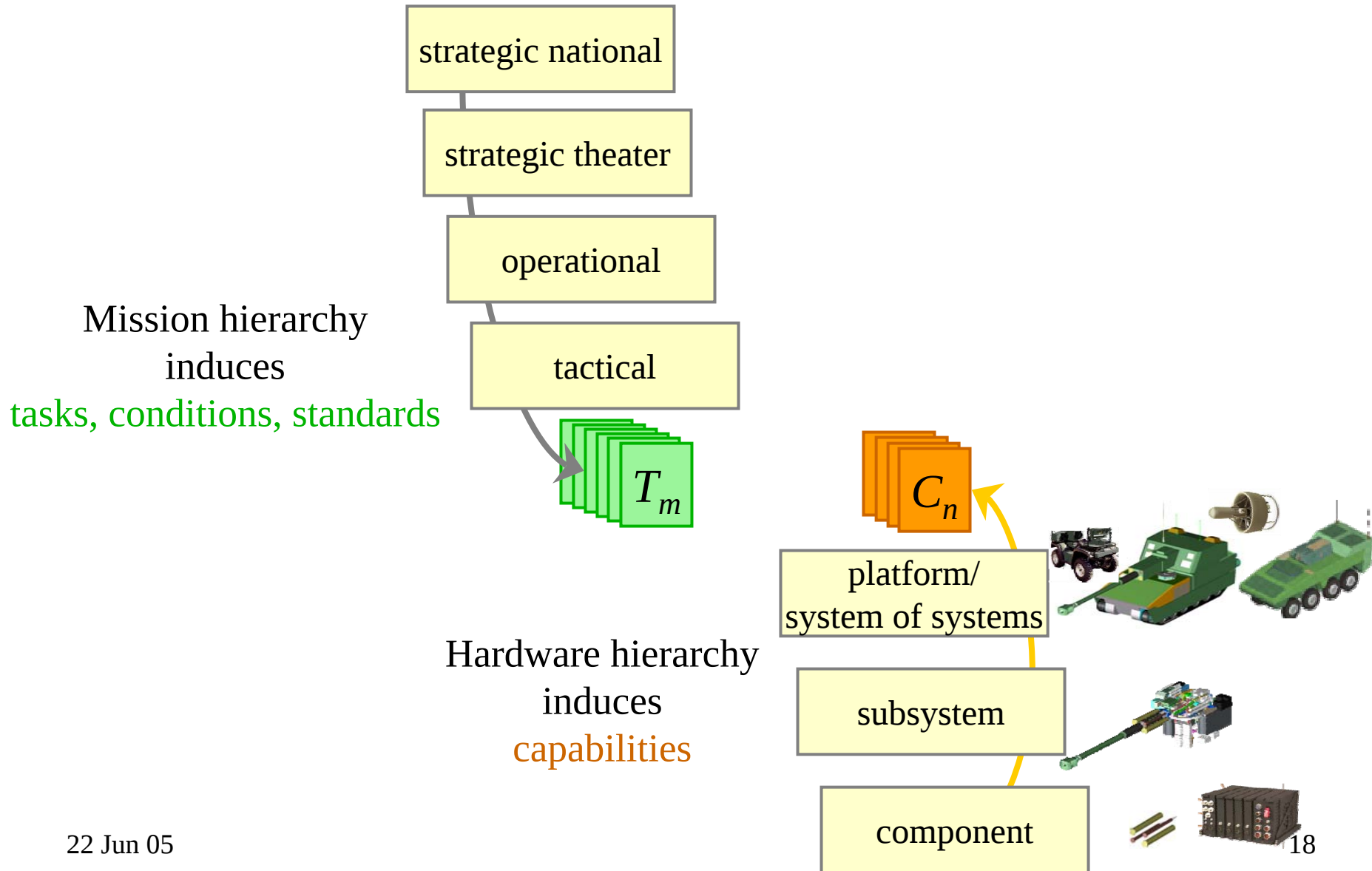
Context (military, political, physical, ...)

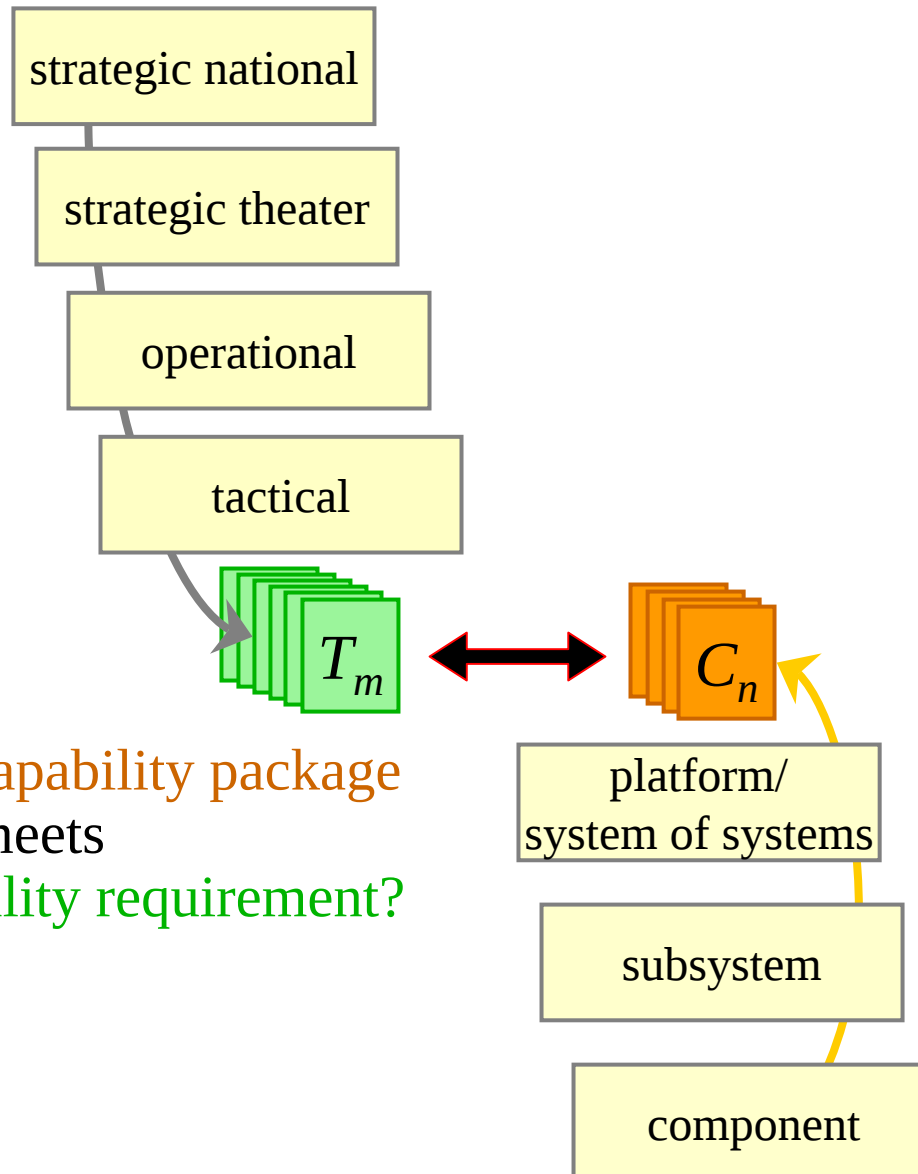
Location in time and space

BLUFOR

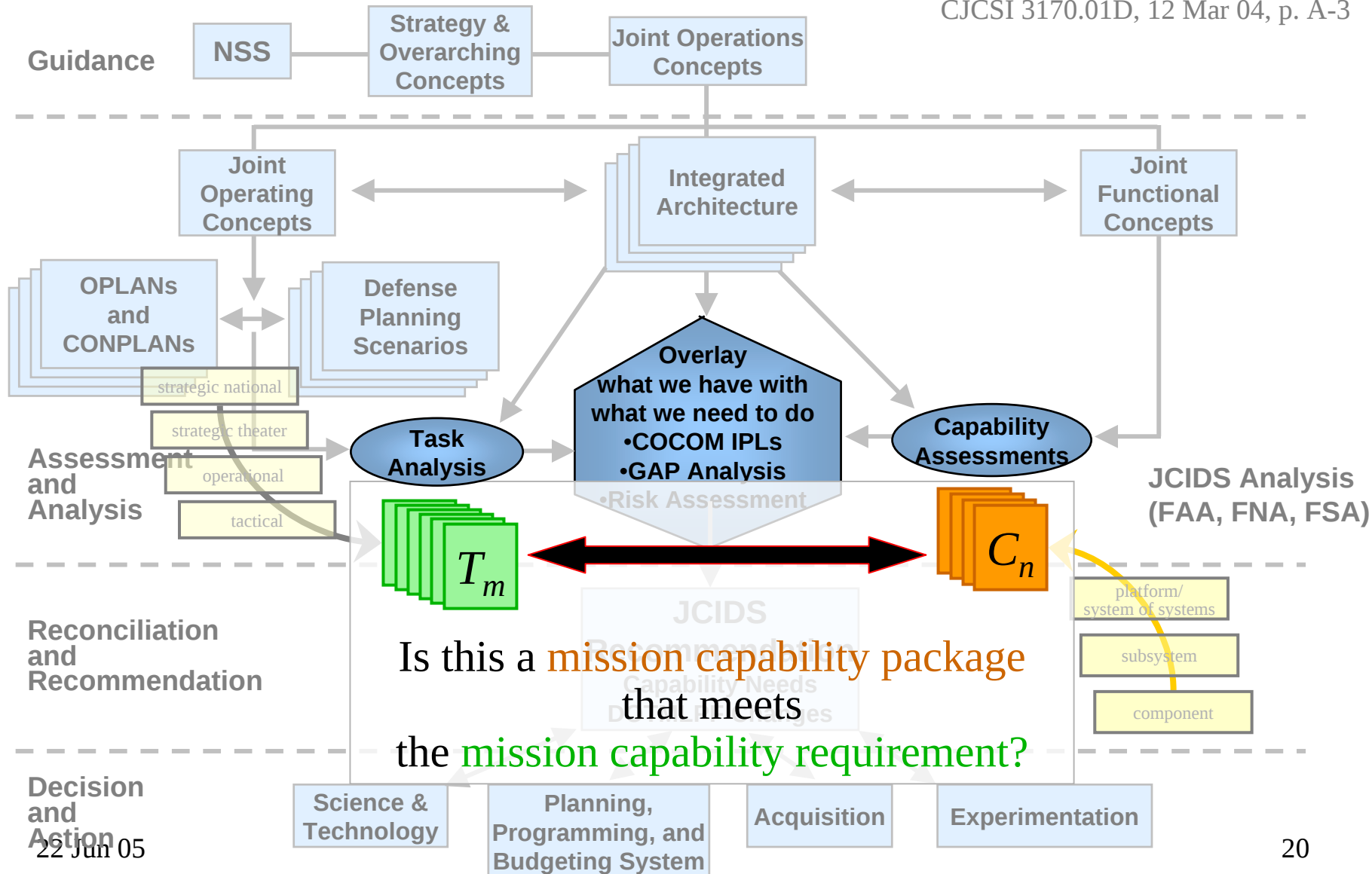
OPFOR







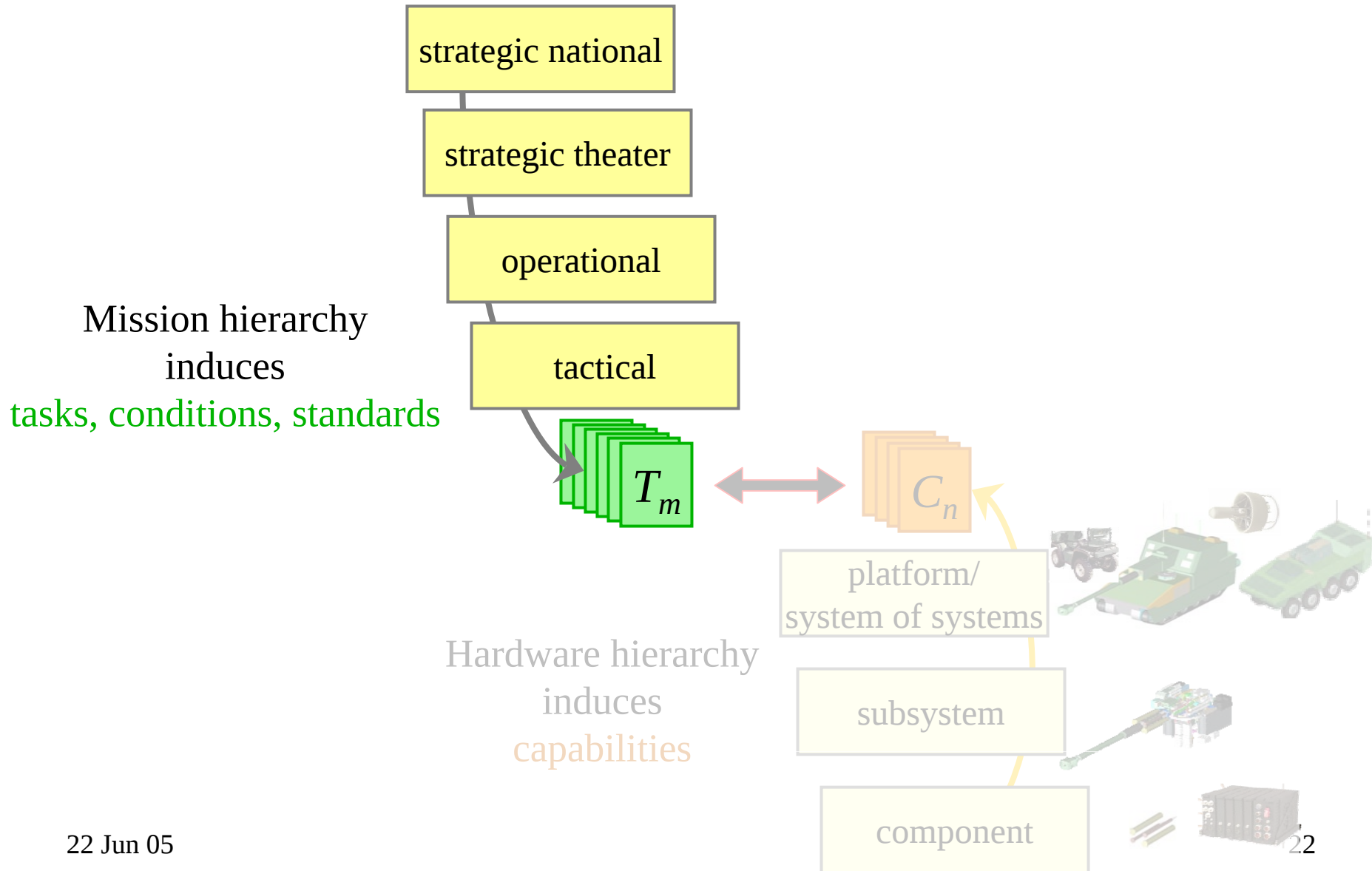
Is this a **mission capability package** that meets the **mission capability requirement**?



- Introduction

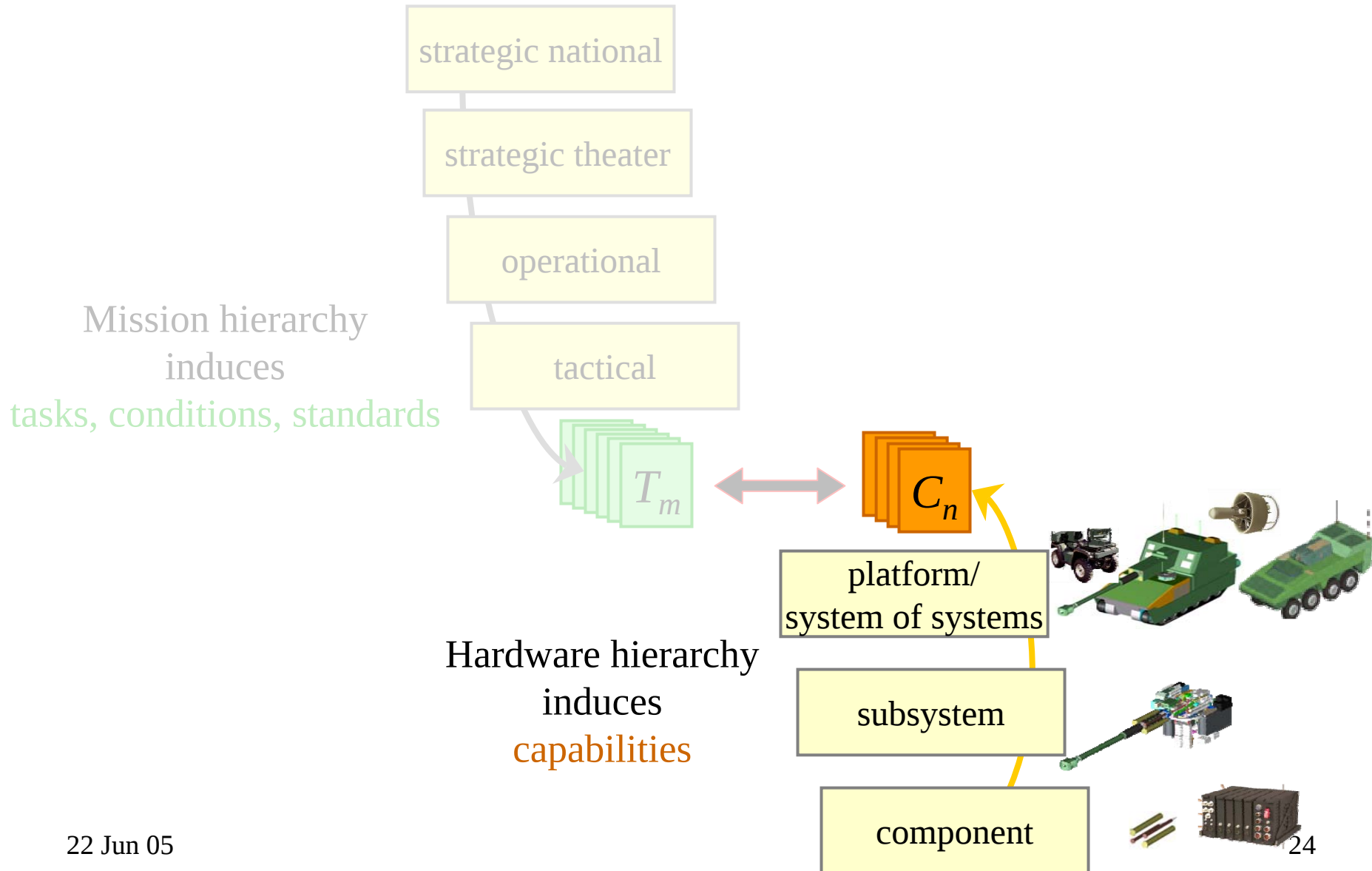
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- **How it might work**
- Platform-level readiness
- The Storyboard Demo
- Other applications
- Summary and conclusions



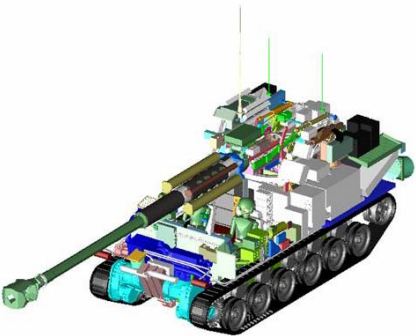
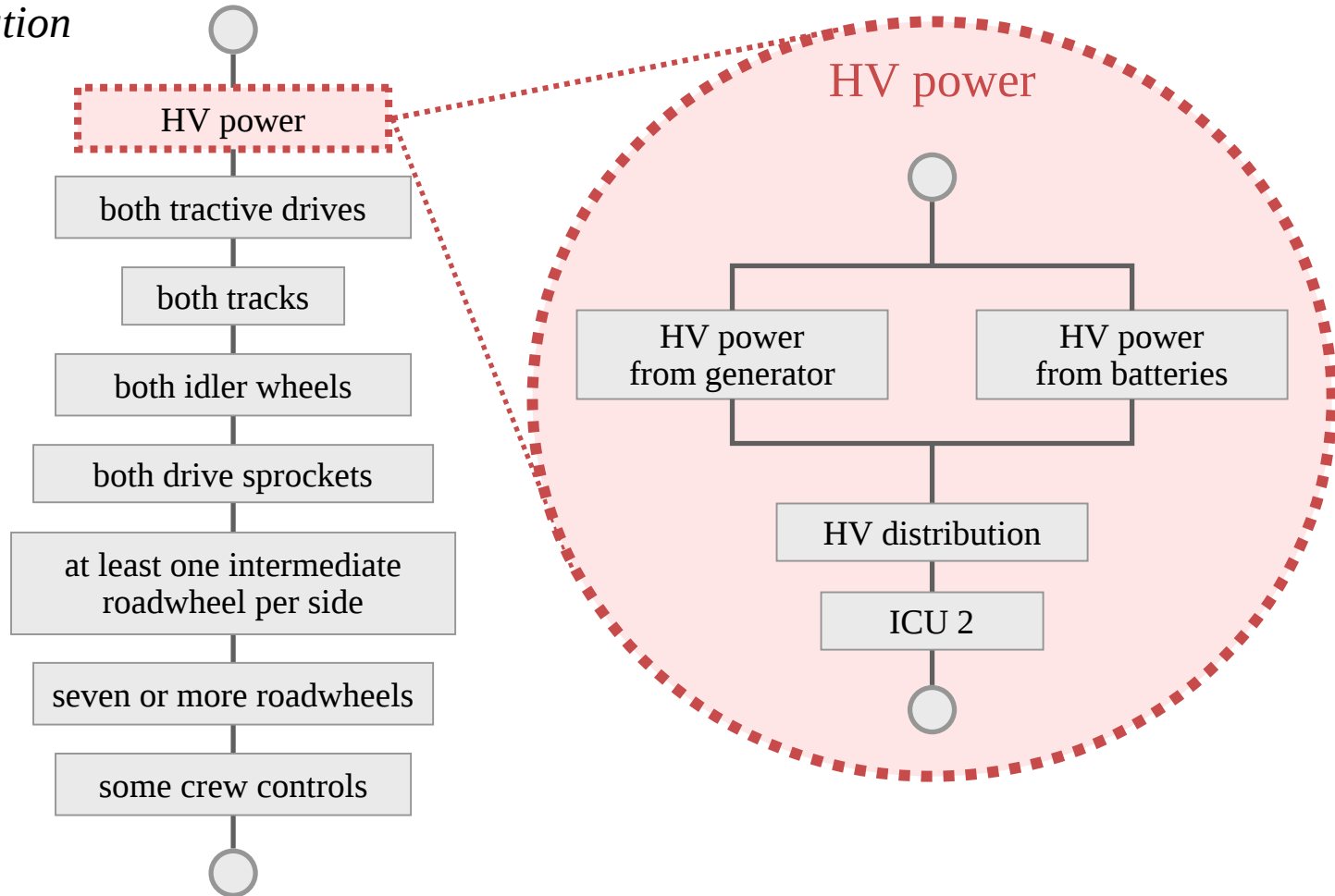
- Screen shot of results of Mission to Task decomposition using JTIMS automated KA tool.
- Used to document break down of MCS A mission into component tasks.
- Vignette mission thread is assembled from the component tasks.

Component-to-capability construction



System capabilities aggregate from subsystems and components

Cutting this fault tree results in a total immobilization



- Introduction
 - What is MMF? Where did it come from?
- How it might work
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Instantaneous comparison
of **available capability** to **required capability**

For each capability *category*...
(e.g., communication)

...there are various possible capability *states* for any platform
(e.g., lost external data and internal comms
but retain LAN and external voice)

Basic elements of platform degraded-capability state



C2V

Mobility

- m_1 Reduced maximum speed
- m_2 Reduced maneuverability
- m_3 Stop after t min (leaks)
- m_4 Total immobilization



**NLOS
(6)**

Firepower

- f_1 Lost ability to fire buttoned-up
- f_2 Degraded delivery accuracy: main
- f_3 Degraded initial rate of fire: main
- f_4 Degraded subsequent rate of fire: main
- f_5 Total loss of firepower: main



**ARV-RISTA
(3)**

Target Acquisition

- a_1 Lost daylight sights
- a_2 Lost night sights



**Class-II UAV
(3)**

Surveillance & Reconnaissance

- z_1 Lost primary sensor
- z_2 Lost secondary sensor
- z_3 Lost tertiary sensor
- z_4 Lost vision blocks

Communication

- x_1 Lost external data
- x_2 Lost external voice
- x_3 Lost internal comms
- x_4 Lost LAN
- x_5 Lost all comms

Survivability

- s_1 Lost NBC protection
- s_2 Lost ability to deploy obscurants
- s_3 Lost silent-watch capability
- s_4 Lost APS
- s_5 Lost secondary armament

Crew

- c_1 Commander incapacitated
- c_2 Squad leader incapacitated
- c_3 Driver incapacitated
- c_4 Operator 1 incapacitated
- c_5 Operator 2 incapacitated
- c_6 Gunner incapacitated
- c_7 Loader incapacitated

Other Mission Functions

- o_1 Lost situational awareness

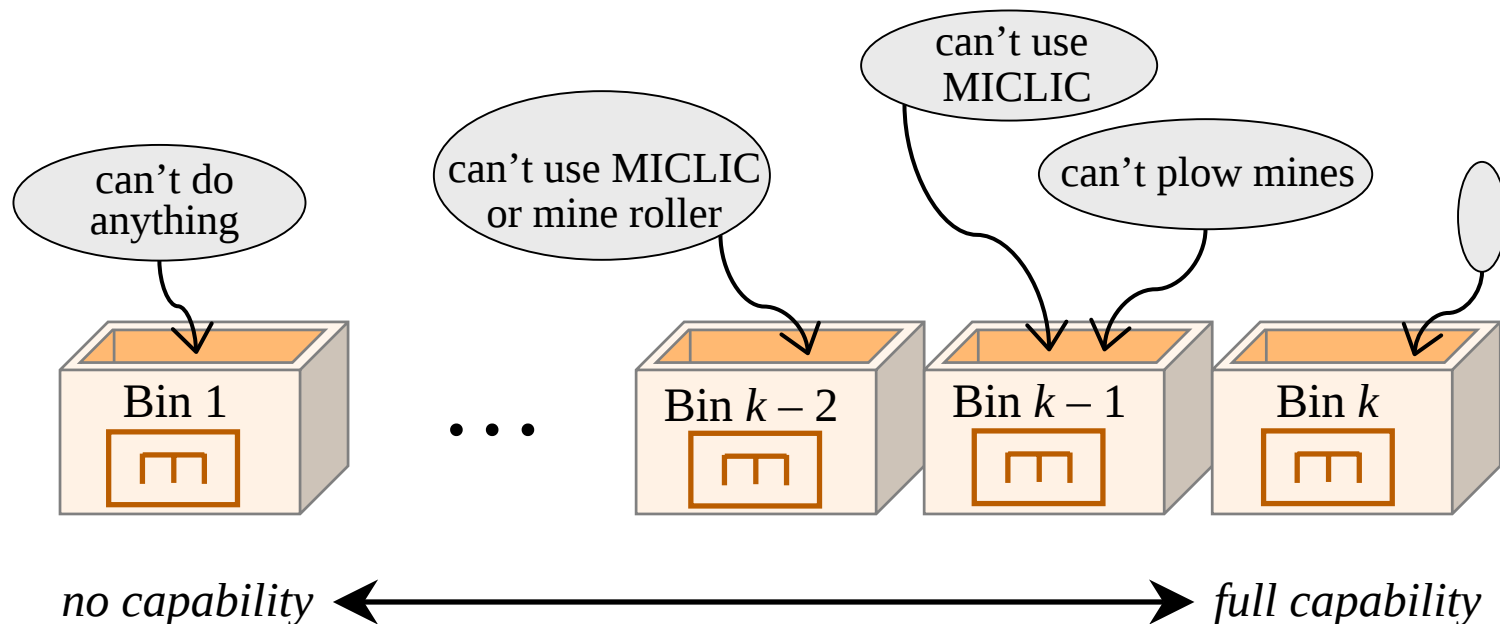
Catastrophic Loss

- k_1 Lost every capability (fuel fire, ammo detonation, ...)

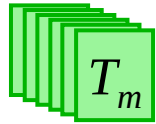
The context-independent part of the effects of platform capability

In the absence of particular tasks, conditions, etc.,
platform capability states
can only be binned by rough level of capability.

Example: Mine-clearing capabilities of an ESV



Visualizing how the current task would stress possible states of the platform



Current tasks determine which states are adequate.

Color each bin to indicate whether the contained states reflect sufficient capability to accomplish the current task to standards.

Example: Communication capability

No state here is adequate

States in these bins are adequate to the current task



Task T_j doesn't demand a whole lot from our comms system...

Some in this bin are, some aren't

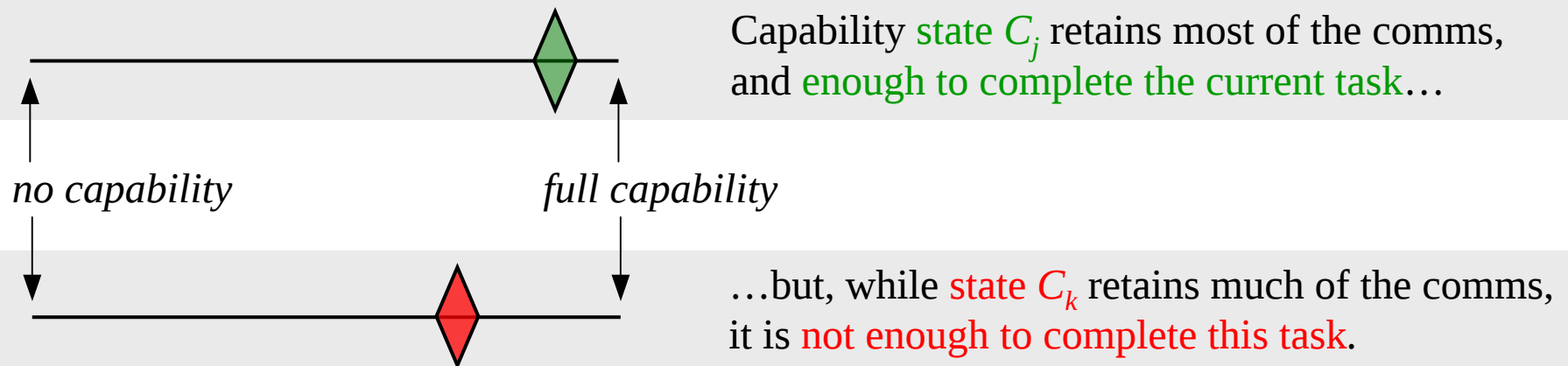


...but task T_k requires the platform's comms to be nearly at full capability.

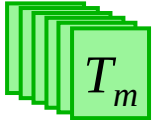
Visualizing how complete a capability is and whether it suffices for the current task

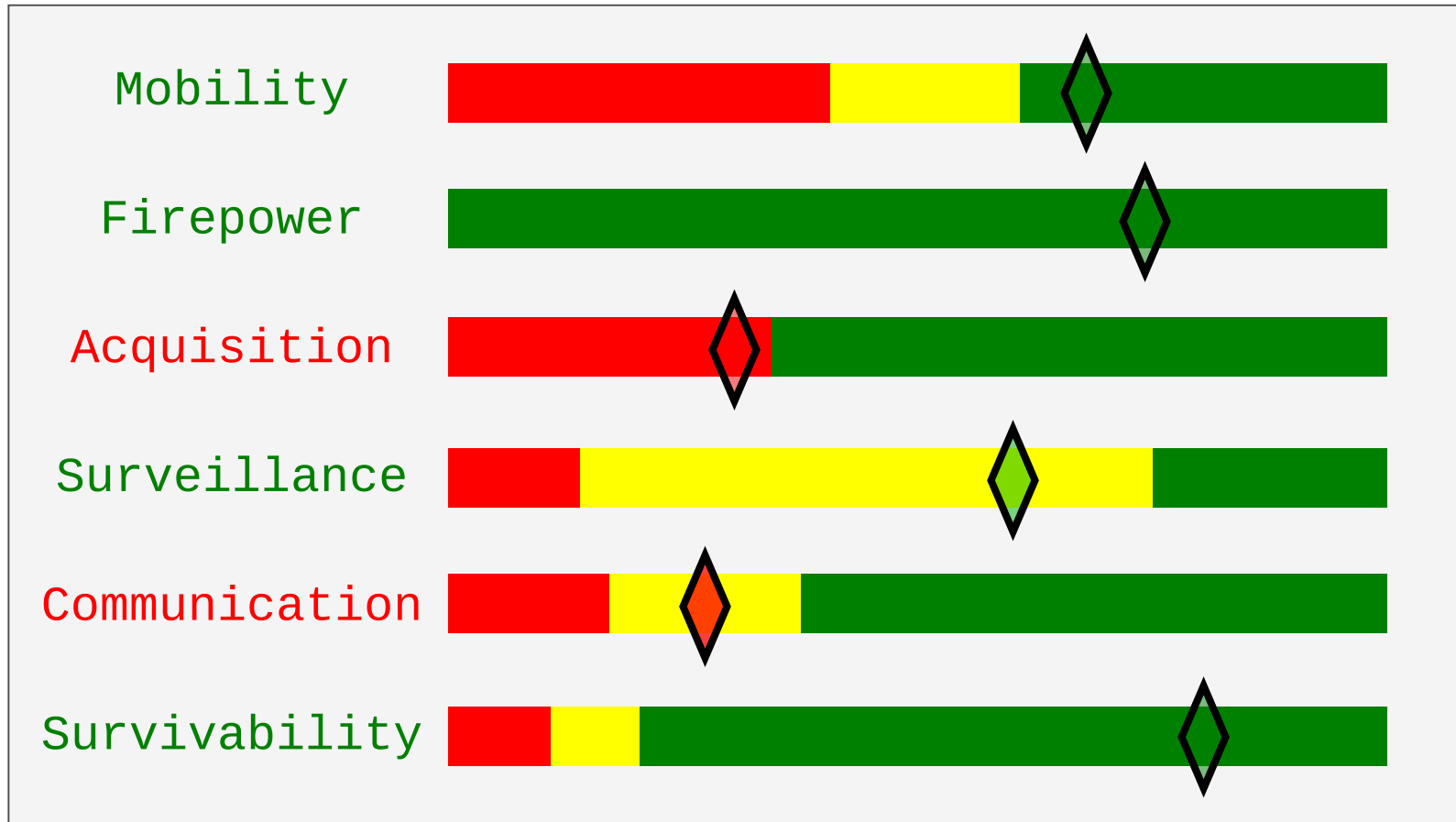
The platform's current condition results in specific **available capability**. 

With regard to this capability category (e.g., communication), which state—and hence bin—is the platform currently in? Is that state adequate to the current task?



Platform-level “health”

The **current capabilities**' adequacy 
in context of
 the **current tasks**' demands



An application of MMF— the Storyboard Demo

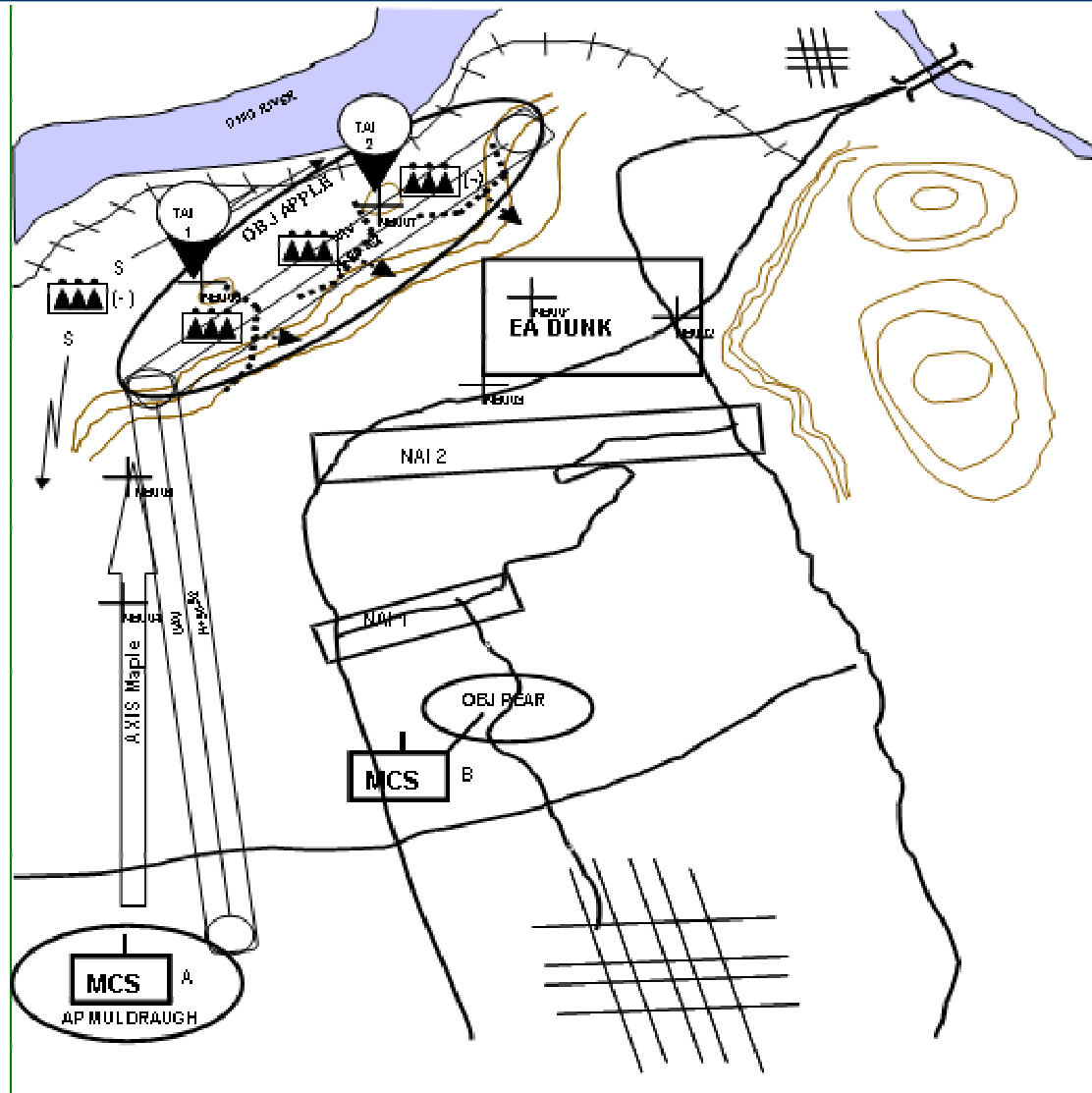
Client: Mr. Hollis, DUSA(OR)

Context: FCS Test & Evaluation Summit, Sep 04

Task: Develop a proof of principle to show how MMF could serve as the organizing approach for an evaluation of a system of systems

Vignette battle plan

MCS Co A phase 3 urban assault



MISSION:

Attack north on AXIS Maple and seize OBJ APPLE NLT 0600 hrs. Establish attack by fire positions on OBJ APPLE and engage enemy forces already in or entering EA DUNK IOT block enemy forces from moving north to support rebel leadership vic Westpoint or support enemy forces defending in and around Louisville.

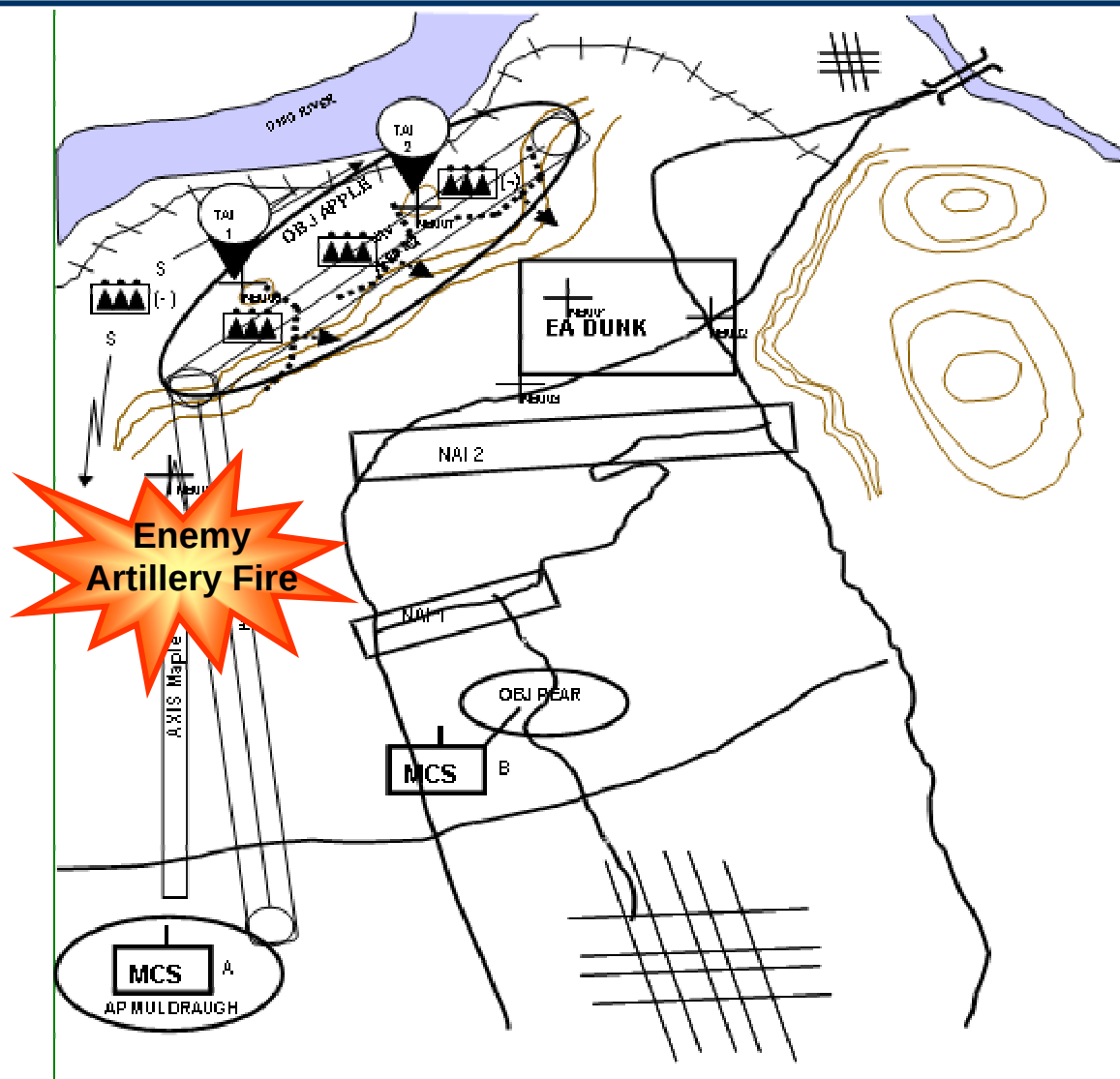
ENDSTATE:

Enemy forces vicinity of Knox remain south of EA DUNK until friendly operations vicinity of Westpoint are completed.

-  - Targeted Area of Interest
-  - Key Terrain
-  - MCS Engagement Area
-  - Named Area of Interest

Executing the battle

MCS Co A phase 3 urban assault



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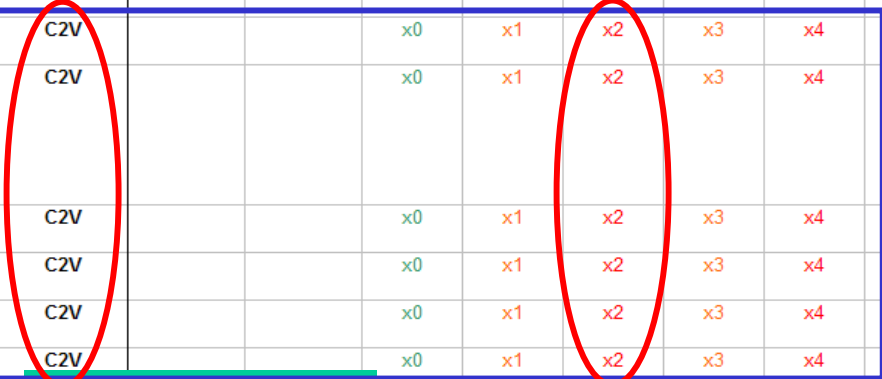
ENDSTATE:

Enemy forces vicinity of Knox remain south of EA DUNK until friendly operations vicinity of Westpoint are completed.

- Targeted Area of Interest
- Key Terrain
- MCS Engagement Area
- Named Area of Interest

The So what? of battle damage

1	Lines from the TOEL		TASKS	PLATFORM	Comms					
51	0200-1000	ART 7.2	*MTP 17-5-0011.17-KCRW Establish and Maintain Communications	ARV 2	x0	x2	x3	x4		
52	0412-0417	ART 7.2	*LSI A1.6.2.1.1.4.3 Report Enemy Information	ARV 2		x2	x3	x4		
53	0200-1000	ART 7.2	*MTP 17-5-0011.17-KCRW Establish and Maintain Communications	ARV 3		x2	x3	x4		
54	0757-0802	ART 7.2	*LSI A1.6.2.1.1.4.3 Report Enemy Information	ARV 3	x0	x2	x3	x4		
55	0200-1000	ART 7.2	*MTP 07-1-1COP.07-C332 Establish the Common Operational Picture	C2V	x0	x1	x2	x3	x4	x5
56	0200-0205, 0253-0258, 0308-0313, 0341-0346, 0437-0442, 0525-0530, 0633-0638, 0707-0712, 0800-0805, 0849-0854	ART 7.2	*ART 7.2.5 Disseminate Common Operational Picture and Execution Information	C2V	x0	x1	x2	x3	x4	x5
57	0200-1000	ART 7.2	LSI A2.3.1 Collect Relevant Information ART 7.2.1	C2V	x0	x1	x2	x3	x4	x5
58	0200-1000	ART 7.2	MTP 07-1-WT06.07-C332 Conduct Battle Tracking	C2V	x0	x1	x2	x3	x4	x5
59	0200-1000	ART 7.2	*MTP 17-5-0011.17-KCRW Establish and Maintain Communications	C2V	x0	x1	x2	x3	x4	x5
60	0255-0300, 0313-0318, 0339-0344, 0410-0415, 0523-0528, 0612-0617, 0706-0711, 0750-0755, 0844-0849	ART 7.2	*LSI A1.6.2.1.1.4.3 Report Enemy Information	C2V	x0	x1	x2	x3	x4	x5
61	0210-0542	ART 7.2	*MTP 17-5-0011.17-KCRW Establish and Maintain Communications	UAV 1						
62	0250-0255, 0305-0310, 030-0335	ART 7.2	*LSI A1.6.2.1.1.4.3 Report Enemy Information	UAV 1						
63	0340-0835	ART 7.2	*MTP 17-5-0011.17-KCRW Establish and Maintain Communications	UAV 2						
64	0431-0436, 0715-0720	ART 7.2	*LSI A1.6.2.1.1.4.3 Report Enemy Information	UAV 2	x0	x1				
65	0543-1000	ART 7.2	*MTP 17-5-0011.17-KCRW Establish and Maintain Communications	UAV 3	x0	x1				



No degradation

X1 External data

X2 External voice

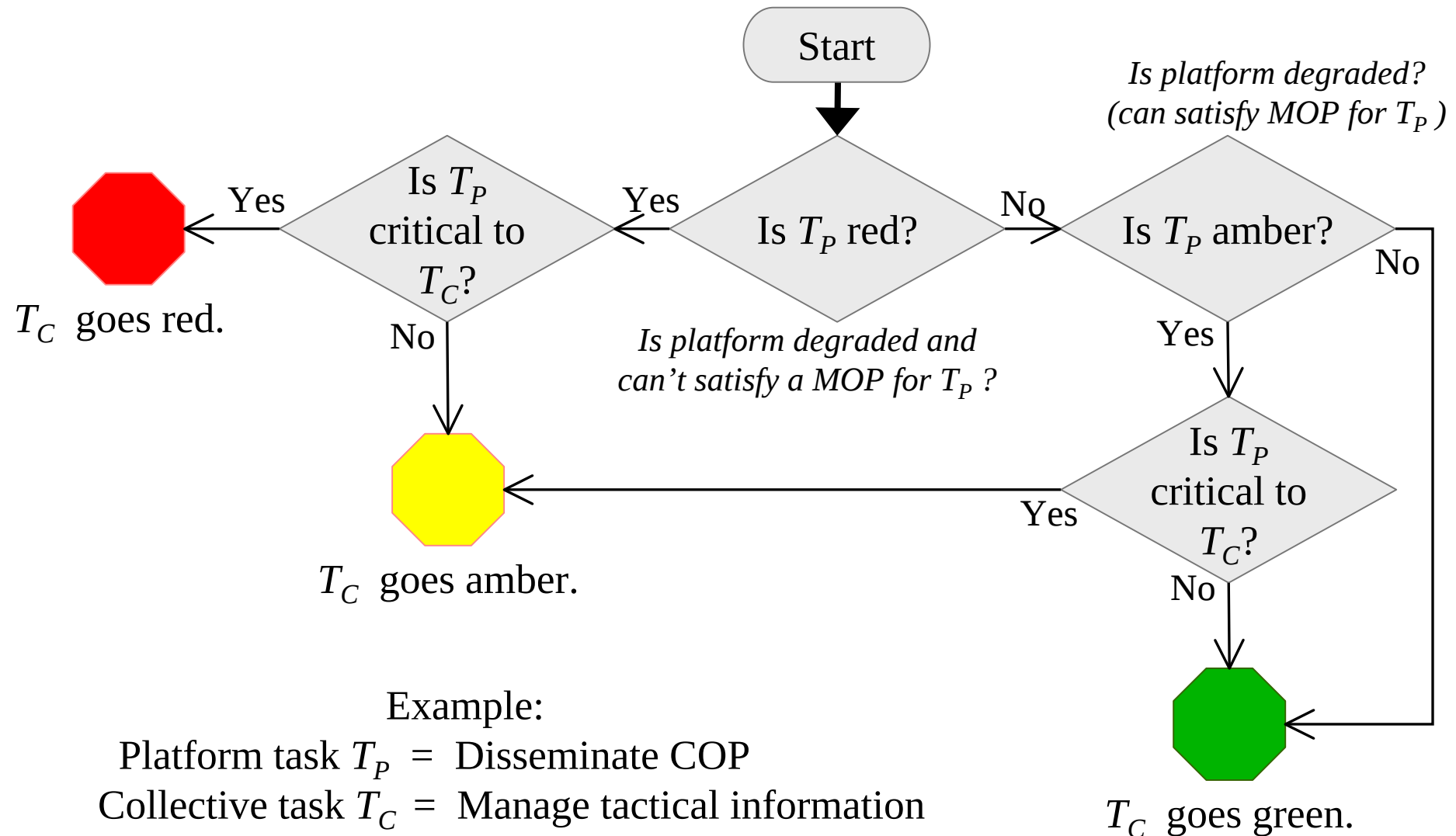
X3 Internal comms

X4 LAN

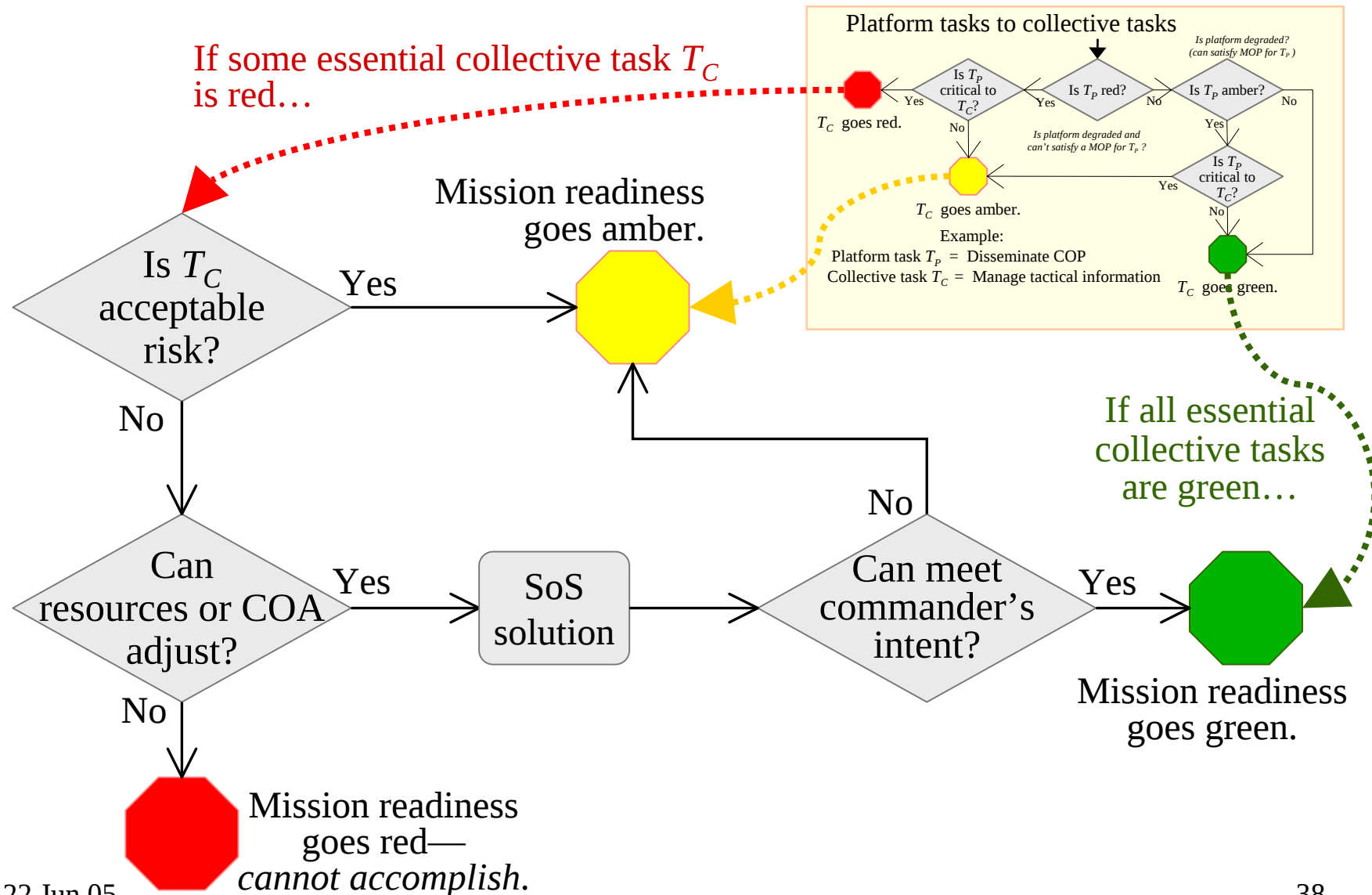
X5 All comms

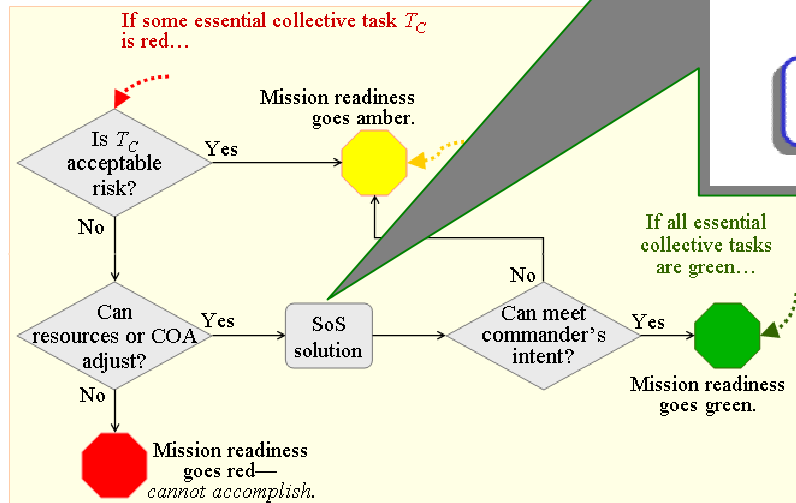
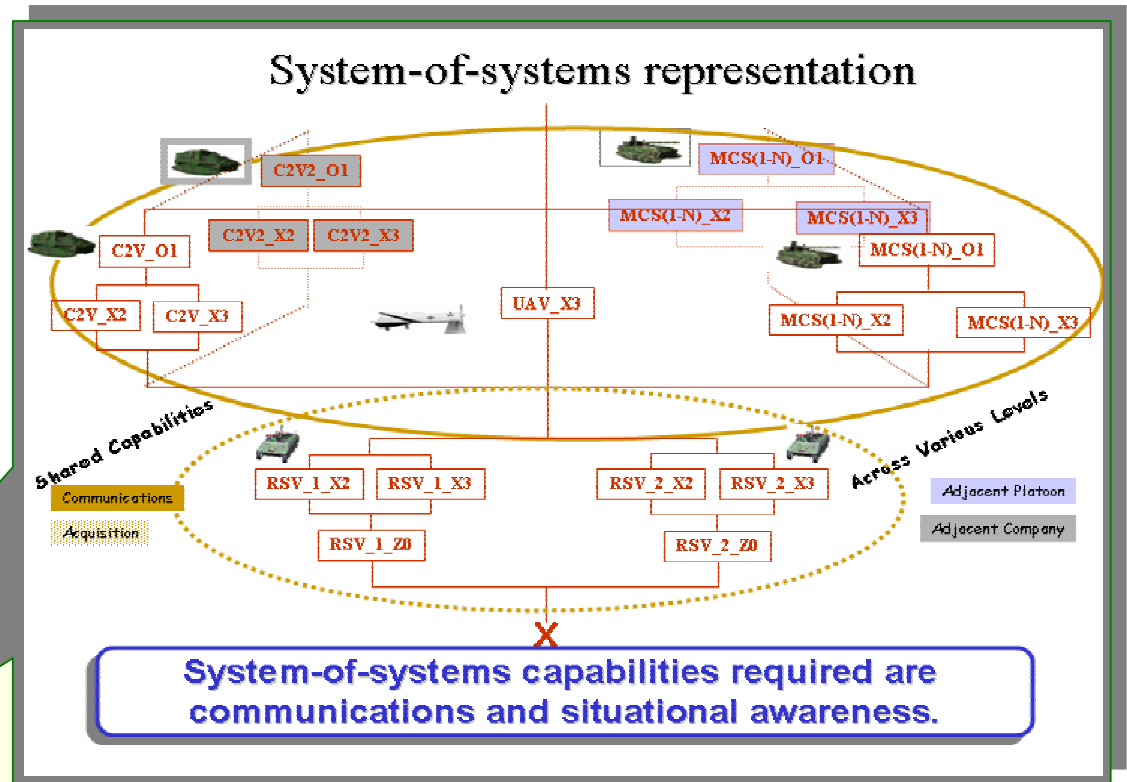
- No Degradation
- Acceptable Degradation
- Unacceptable Degradation

Effect of platform task T_P 's degradation on collective task T_C



Effect of essential collective tasks T_C on mission readiness





What options are available from the system of systems?

	Course of action	Outcome
COA 1	Transfer control of UAVs to 1st and 2nd platoons Orders C2V to transfer control of UAVs to 1st and 2nd platoons. Takes control of SA/fires. Orders company to continue advance to Objective Apple (5 km/h).	30-min delay to transfer operational control of UAVs and to assume SA/fires control.
COA 2	Transfer control of UAVs to FTTS Takes control of fires. FDNCO transfers to Cdr's vehicle to control fires. Situational awareness (SA) transferred to FTTS. XO transfers to FTTS. Orders C2V to transfer control of UAVs 1 and 2 to FTTS. Robotics NCO transfers to FTTS. Orders launch and recovery equipment transferred to 2nd Plt. 1SG transfers to 3rd platoon security force. Requests contact maintenance team from Bn trains meet the company on Objective Apple to repair C2V digital comms. Orders company to resume advance towards Objective Apple at increased speed (10 km/h).	15-min delay to transfer operational control of UAVs to FTTS and to assume SA/fires control. Delay offset by increased speed.
COA 3	Request support from CAB to pick up feed from UAVs 1 and 2 Requests CAB to pick up the feeds from UAVs 1 and 2 and to send updated feeds to the MCS CDR about enemy locations and activities as they are acquired. Takes control of SA/fires. Orders company to halt in place until receipt of new UAV feeds. Orders company to resume advance towards Objective Apple (5 km/h).	15-min delay while CAB assumes control of UAVs 1 and 2 and MCS CDR assumes SA/fires control.

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- Several applications within ARL to link materiel/human performance and residual capability to operational missions
- DTC to tie performance results in Multi-Service Distributed Experiment events to a single operational mission
- UAMBL micro-study to determine capability gaps for FCS UA performing S&RO
- TRADOC FC interested in using as analytic methodology to develop concept capability plan for LANDWARNET
- JFCOM JNTC conducting FAA, FNA, FSA, and ICD for supporting training and testing on Joint Tactical and Operational Tasks
- DMSO developing a formal specification encompassing military art and science, systems engineering, data integration, and computer science

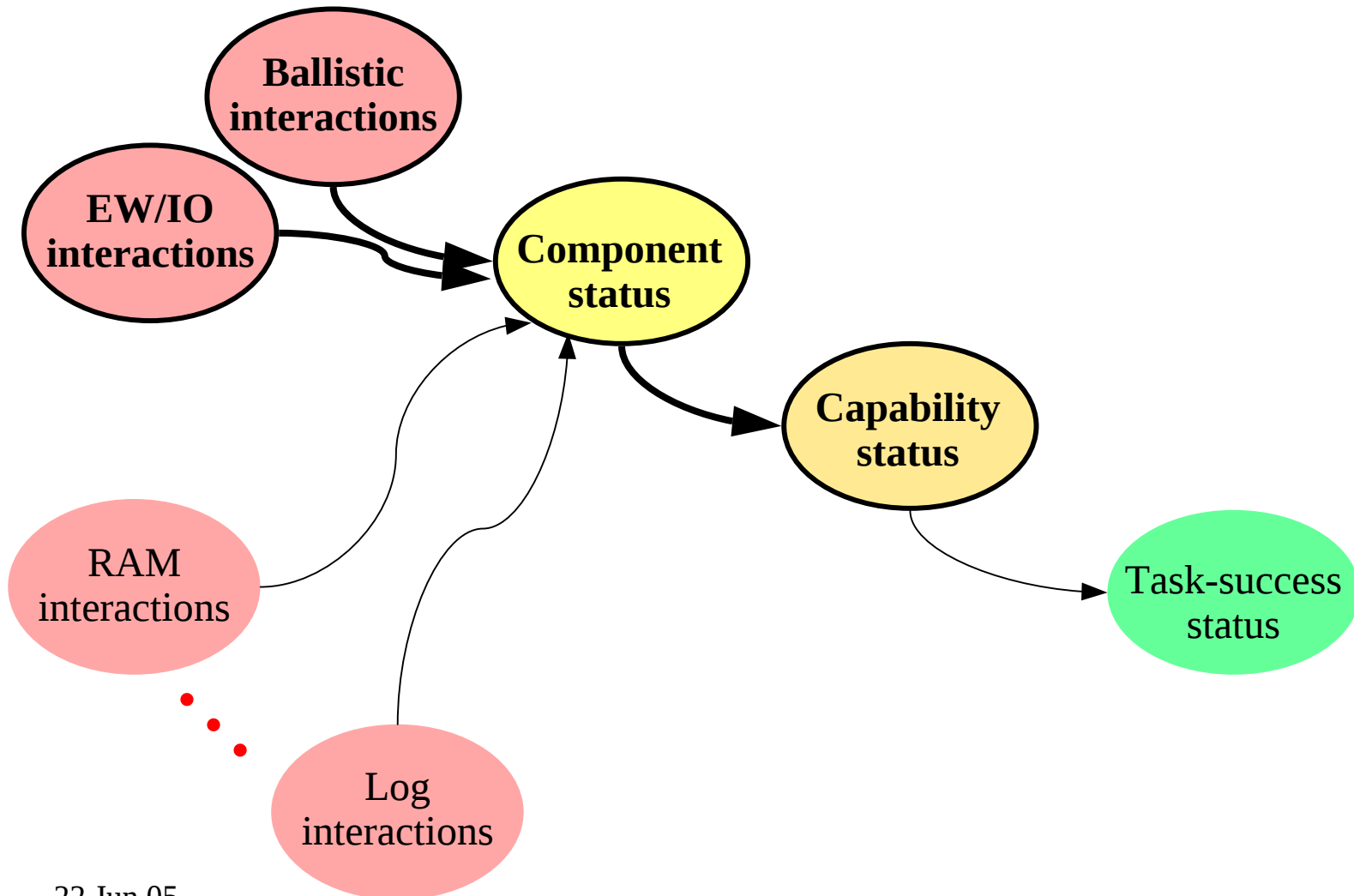
The Missions and Means Framework...

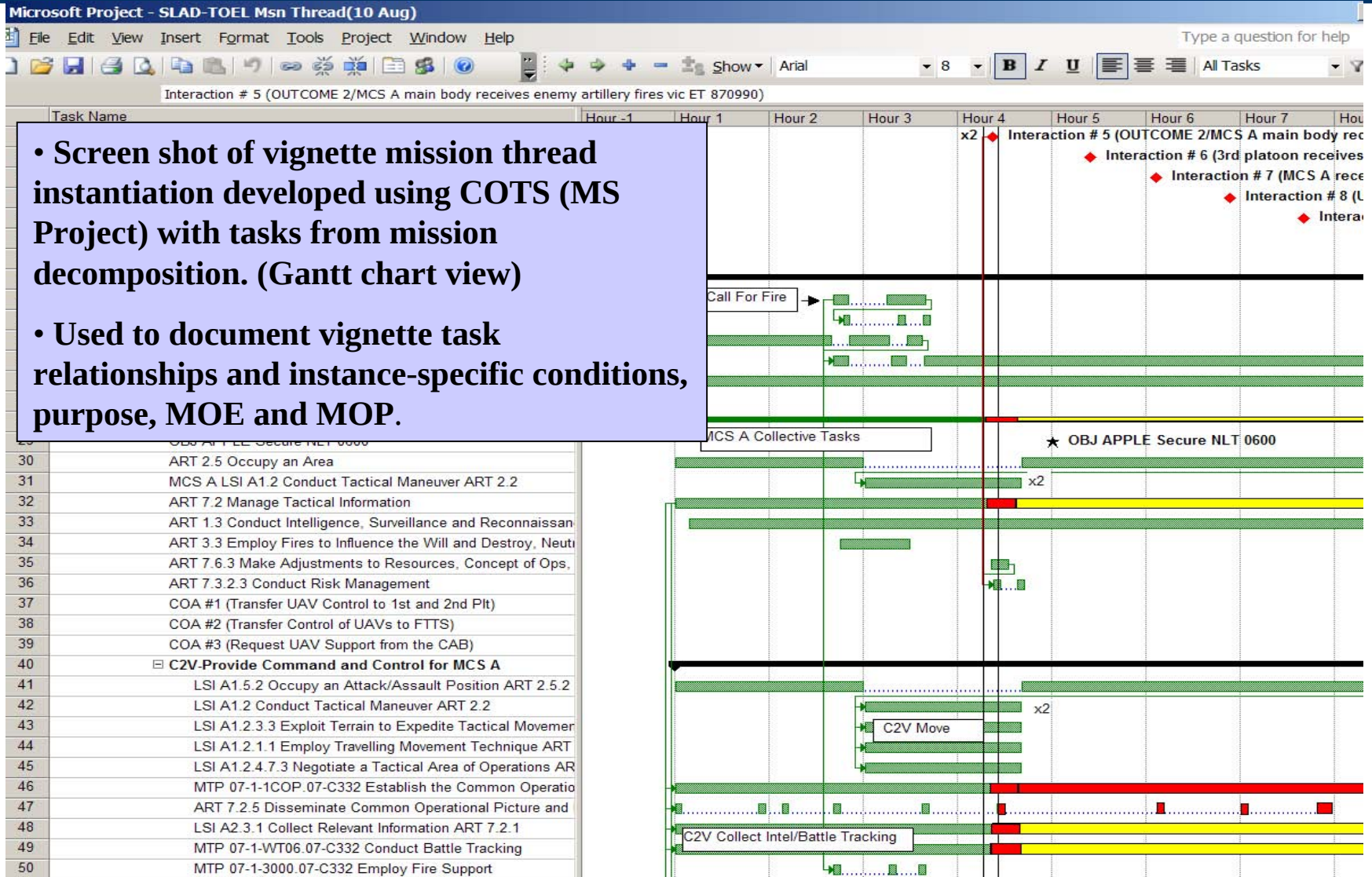
- makes explicit the linkage between requirements and solutions;
- provides a clear audit trail from the mission, through its derived tasks and the capabilities they demand, to a collection of means to prosecute that mission; and
- allows replacement of generic measures of success with more relevant measures expressed in terms of the particular problem at hand.

- MMF solves the mission-utility puzzle
(in the V/L taxonomy, for instance)
- It is clearly applicable to the generation of requirements
- It is applicable to technology development decisions
- It is applicable to evaluation, training, ...
- Applying this approach in a large-scale project requires further development

Back-up slides

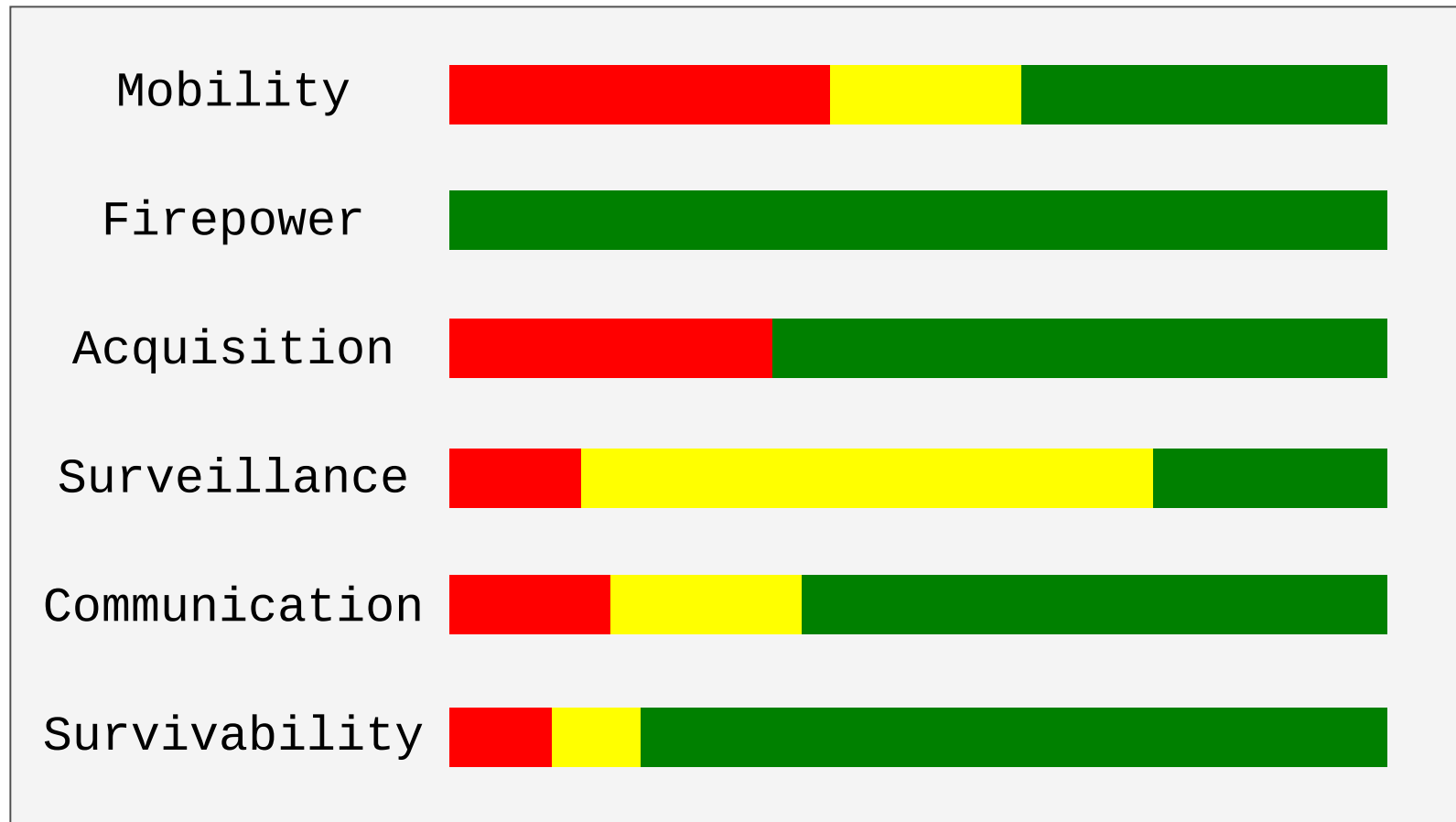
SLAD's core role in MMF: the state-change clearinghouse



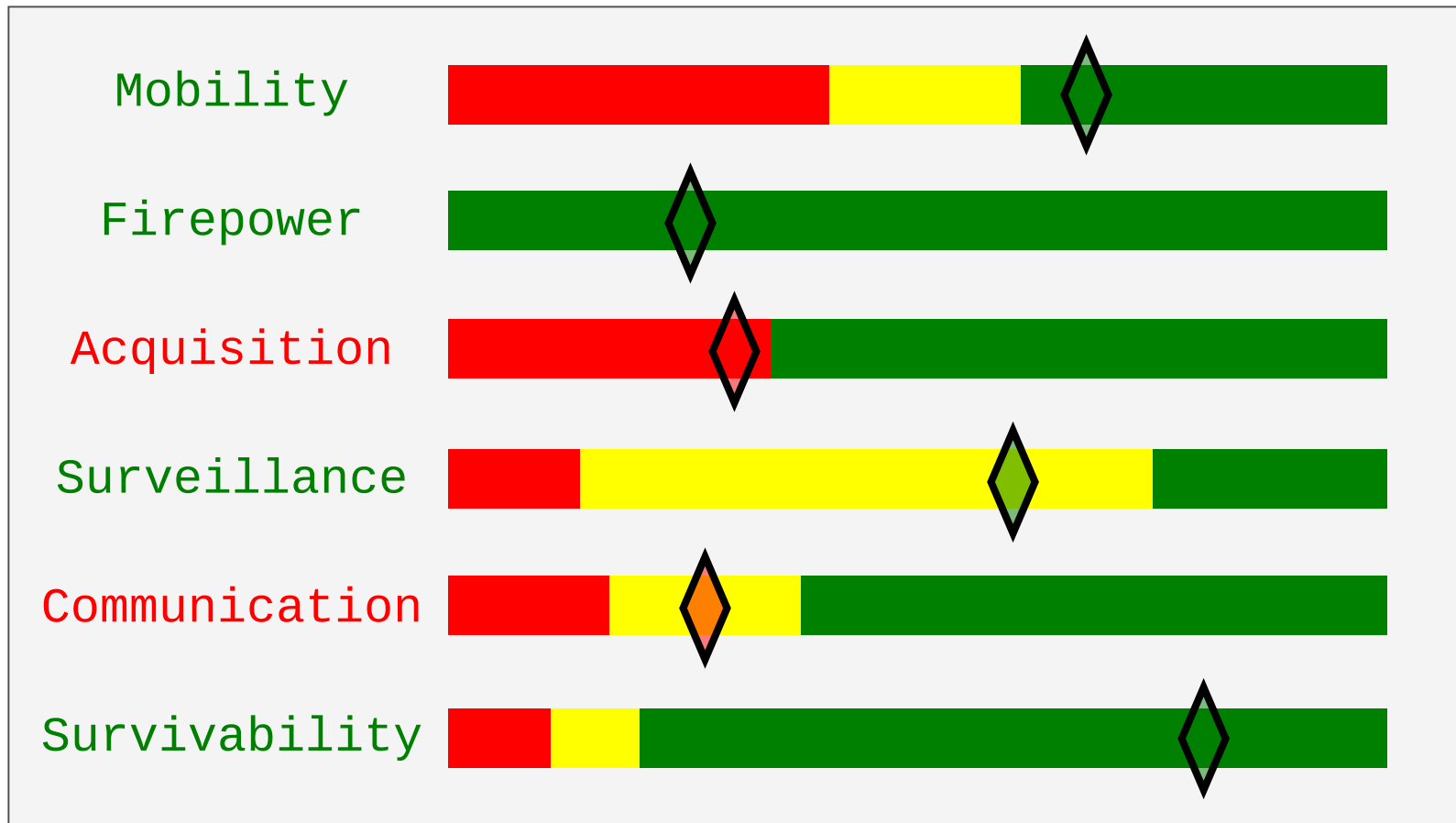


An instantaneous comparison
of *available* capability
to *required* capability

Platform-level capabilities required at any instant...



...and the capabilities available at that instant



Elements of platform capability for communication

x_1	no external voice
x_2	no external data
x_3	no internal
x_4	no communication
x_5	no LAN

Elements of platform capability for communication

x_1	no external voice
x_2	no external data
x_3	no internal
x_4	no communication
x_5	no LAN

semantic constraint: If x_4 , then x_1 and x_2 and x_3 .

system-design constraint: If x_5 , then x_2 .

Possible capability states for communication

Of the $2^5 = 32$ subsets of $\{x_1, x_2, x_3, x_4, x_5\}$,
the constraints preclude all but these 12:

$\{\}$

$\{x_1\}$

$\{x_2\}$

$\{x_3\}$

$\{x_1, x_2\}$

$\{x_1, x_3\}$

$\{x_2, x_3\}$

$\{x_2, x_5\}$

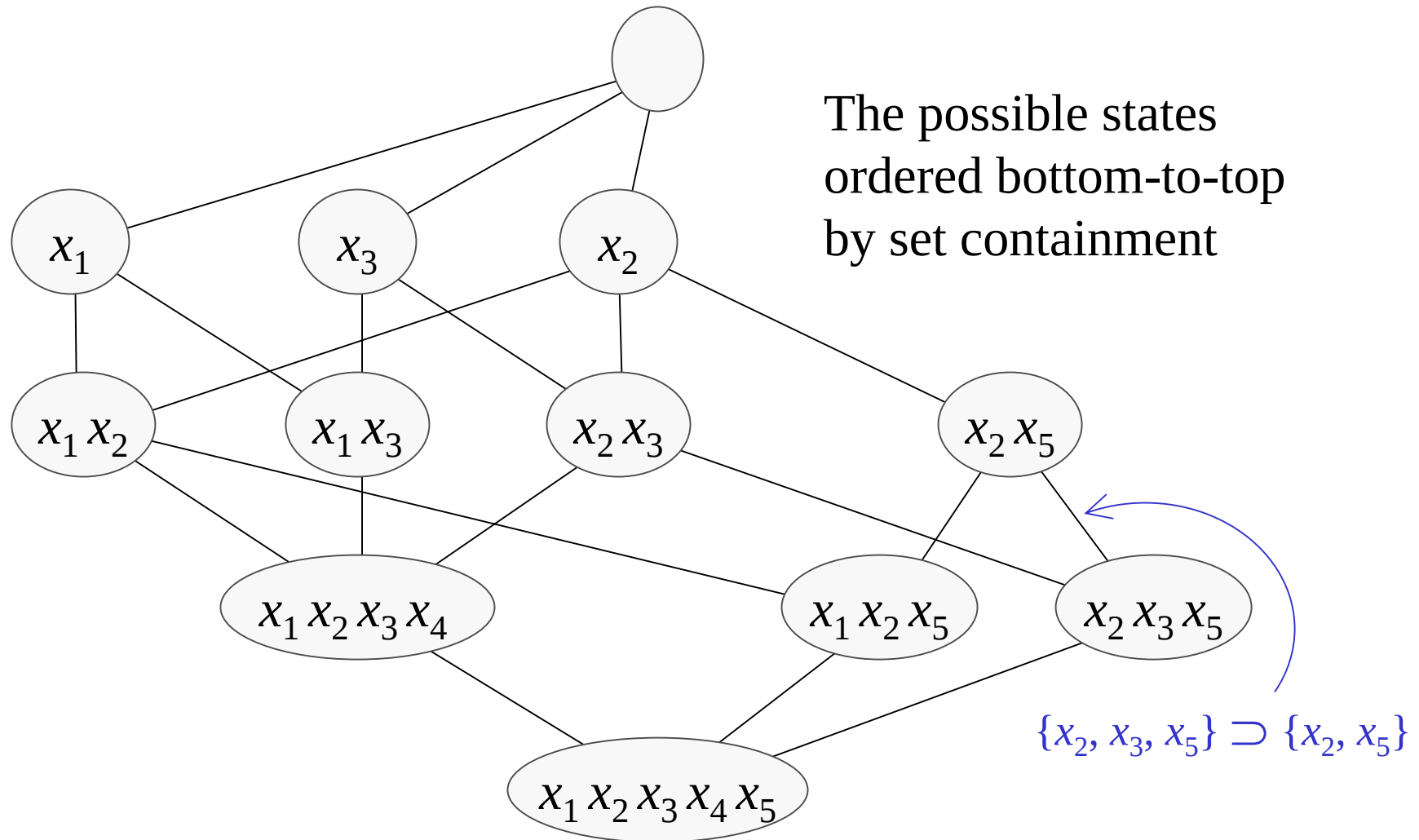
$\{x_1, x_2, x_5\}$

$\{x_2, x_3, x_5\}$

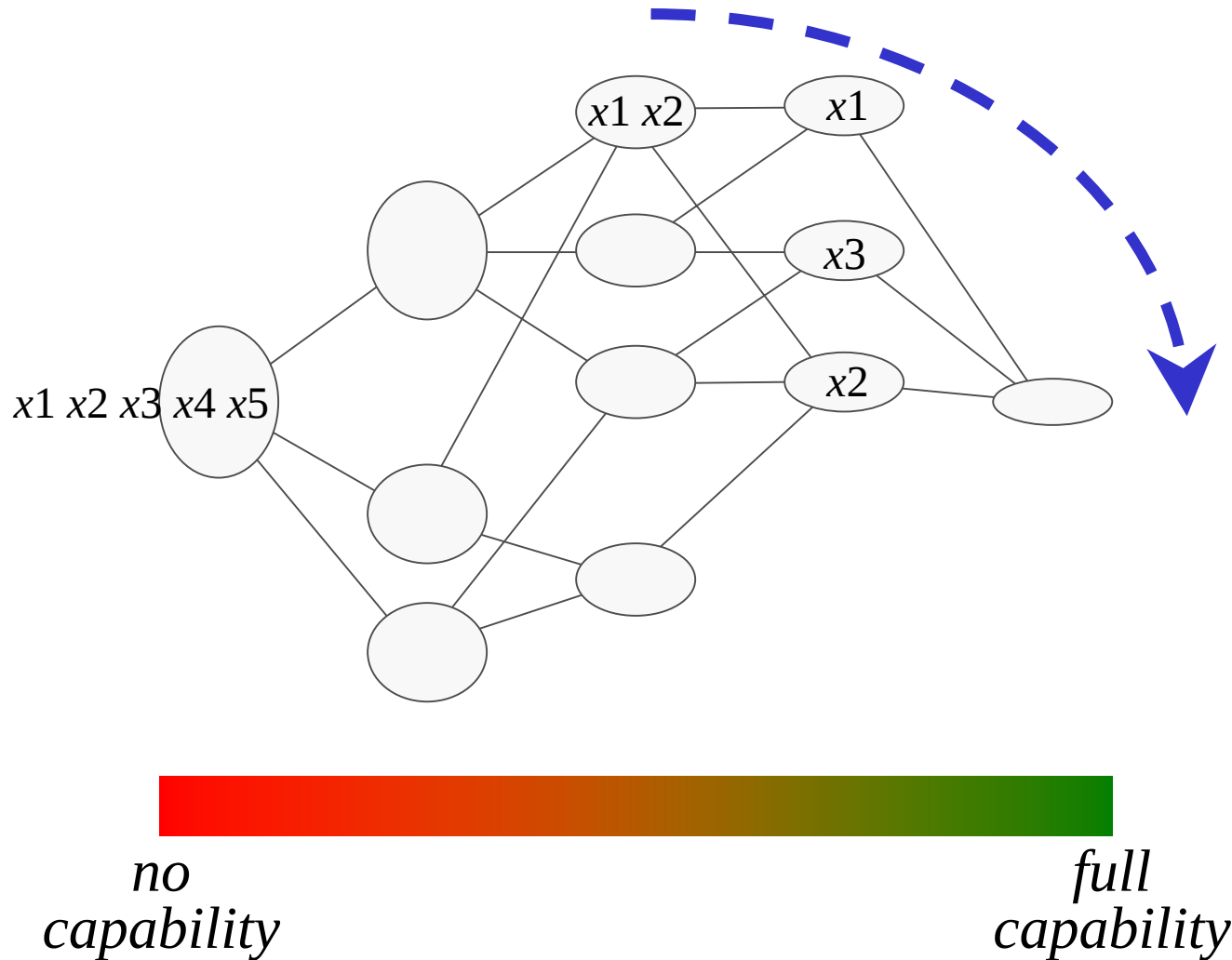
$\{x_1, x_2, x_3, x_4\}$

$\{x_1, x_2, x_3, x_4, x_5\}$

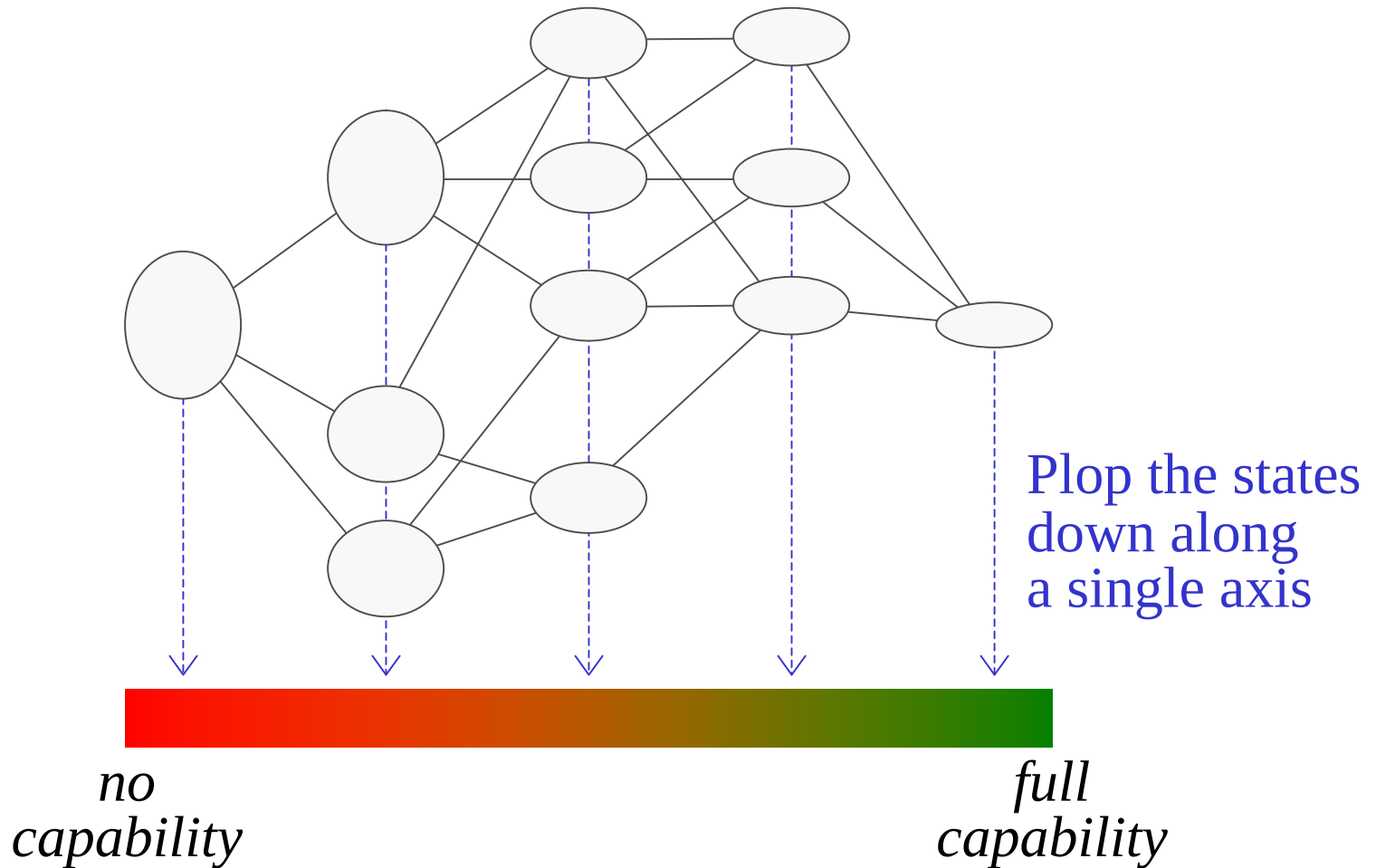
How the communication states compare for capability



Turned on its side
it gives a (passable) scoring of states



Turned on its side it gives a (passable) scoring of states



Mission-readiness “status” from essential collective tasks

● Mission: Attack to seize Objective Apple

- ART 2.5 Occupy an area
- ART 2.2 Conduct tactical maneuver
- ART 7.2 Manage tactical information
- ART 1.3 Conduct ISR
- ART 3.3 Employ Fires

● ART 7.6.3 Make adjustments to resources

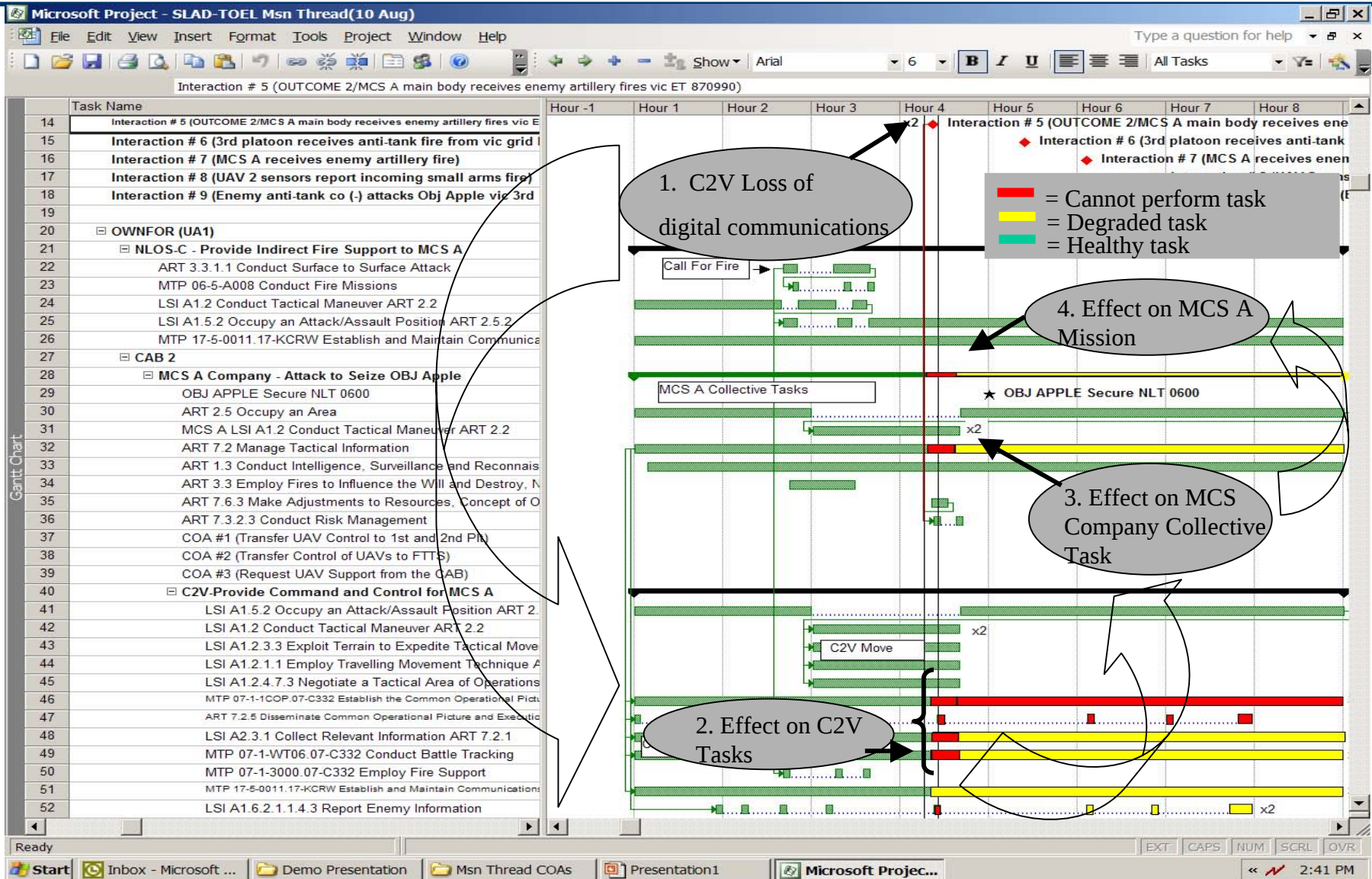
Mission:

- *Can accomplish and can meet commander’s intent*
- *Can accomplish but cannot meet commander’s intent*
- *Cannot accomplish*

Essential Collective Tasks:

- *No degradation*
- *Degradation, but can meet task standards*
- *Cannot meet critical standards*

Effects-based roll up (system/mission health)



Demonstration output— Tracing the causes of a mission failure

● Mission: Attack to seize Objective Apple

● ART 2.5 Occupy an area

● ART 2.2 Conduct tactical maneuver

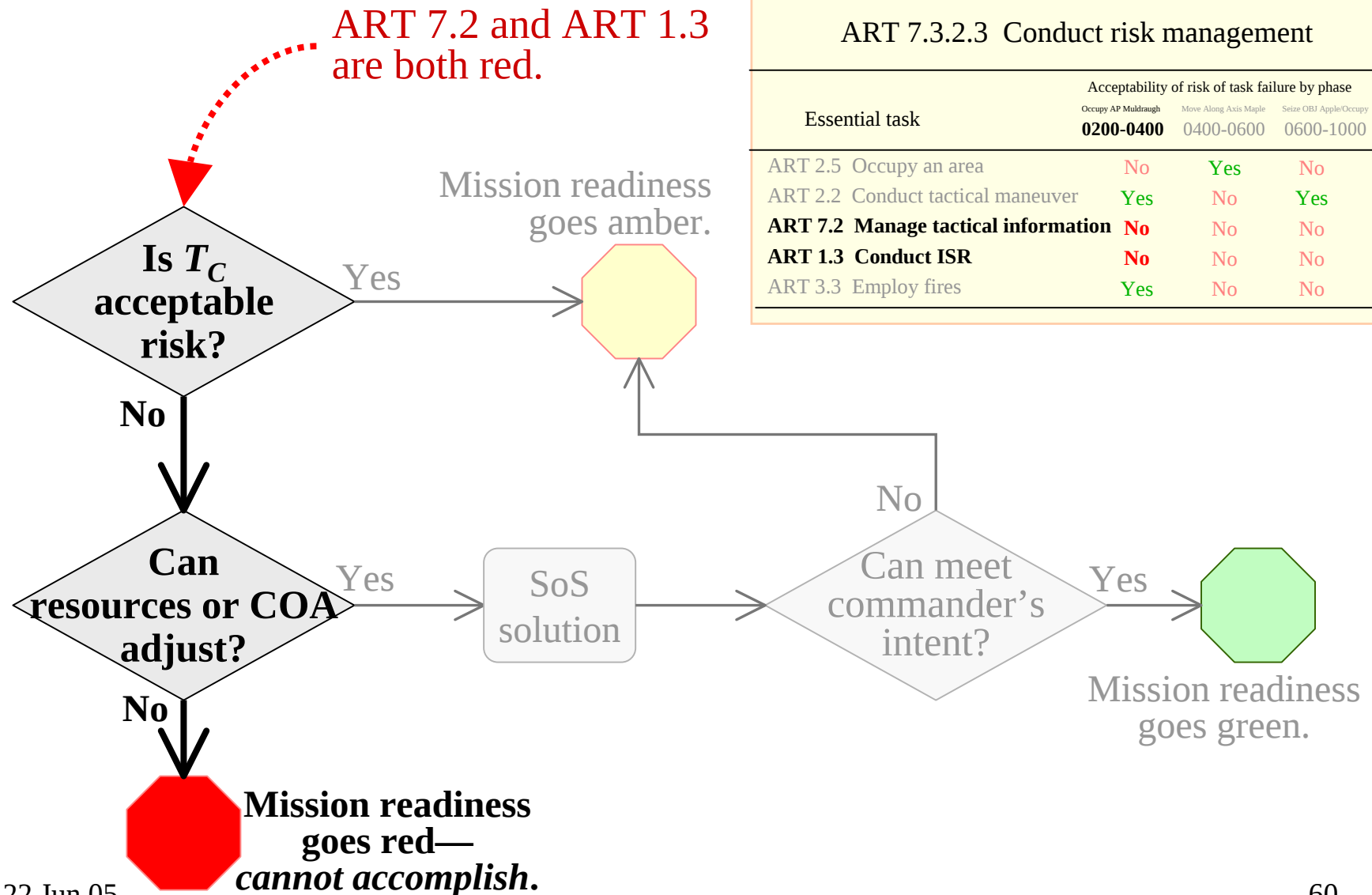
● ART 7.2 Manage tactical information

● ART 1.3 Conduct ISR

● ART 7.6.3 Make adjustments to resources

Time = 02:40:51.312

Demonstration output— What caused the mission failure?

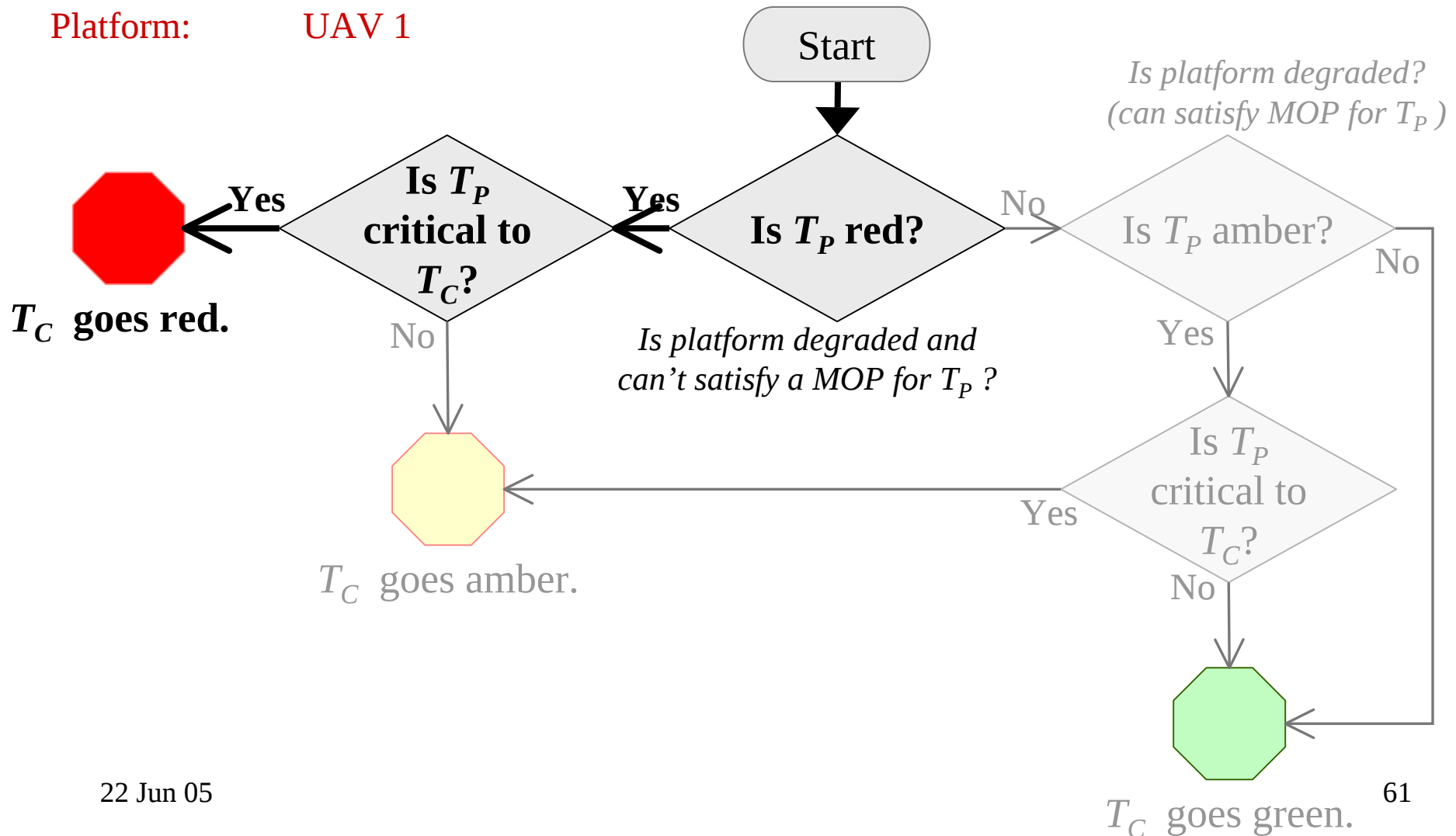


Demonstration output— Why did a collective task fail?

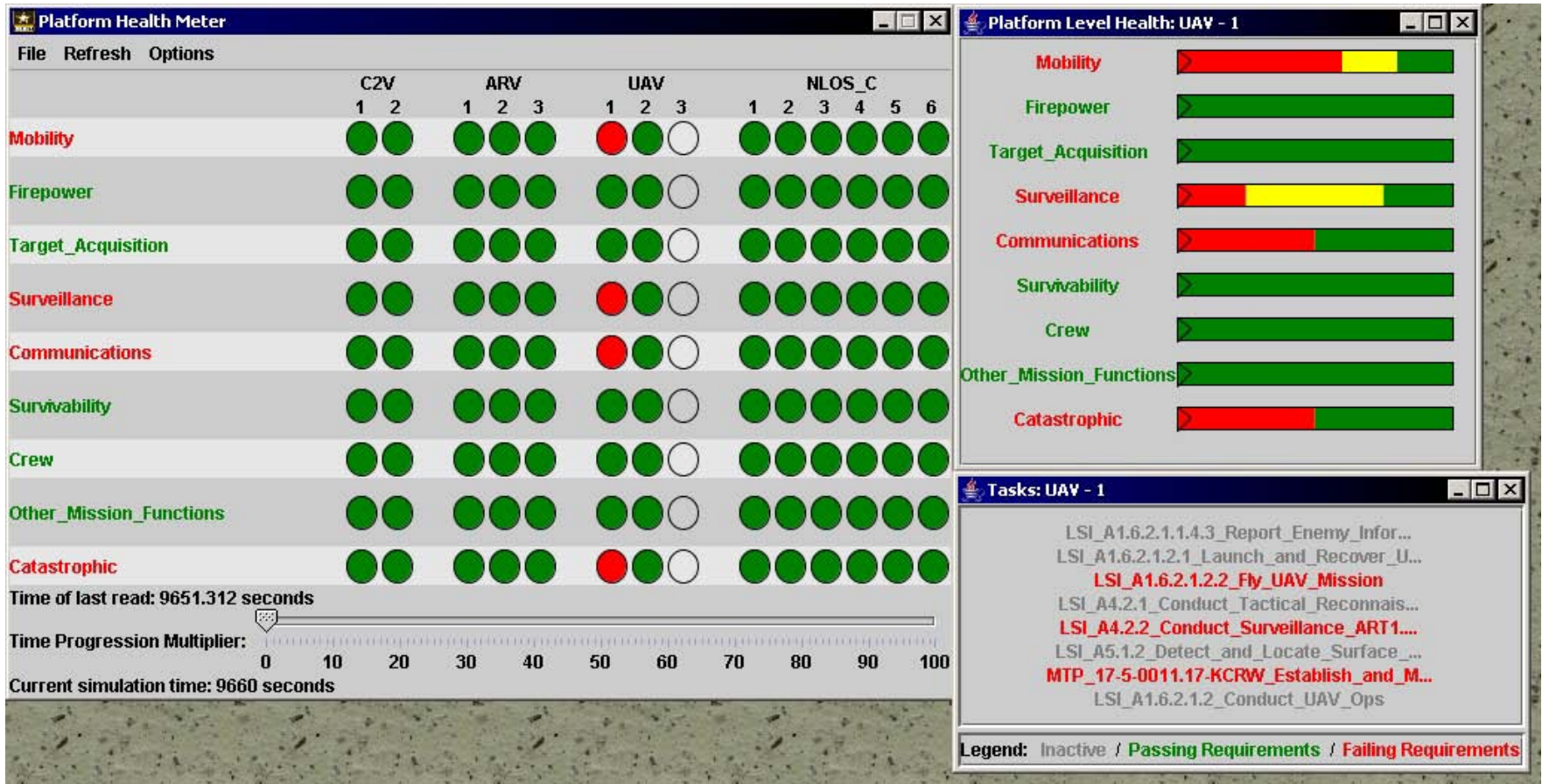
Collective task: ART 7.2 Manage tactical information.

Platform task: MTP 17-5-0011.17 KCRW establish and maintain communications

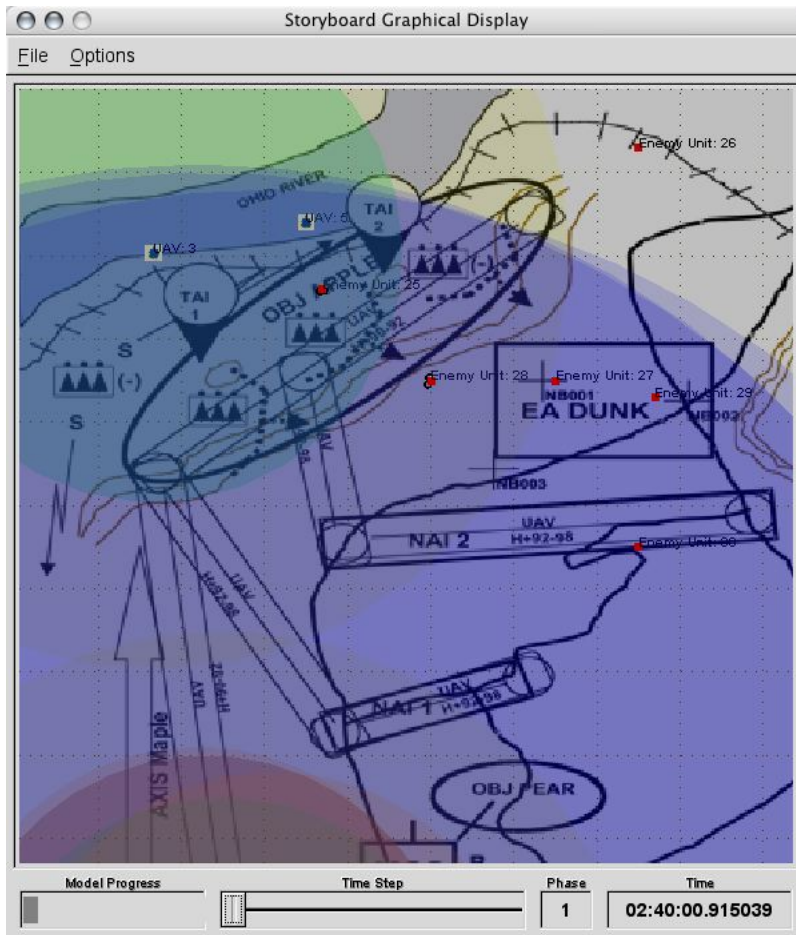
Platform: UAV 1



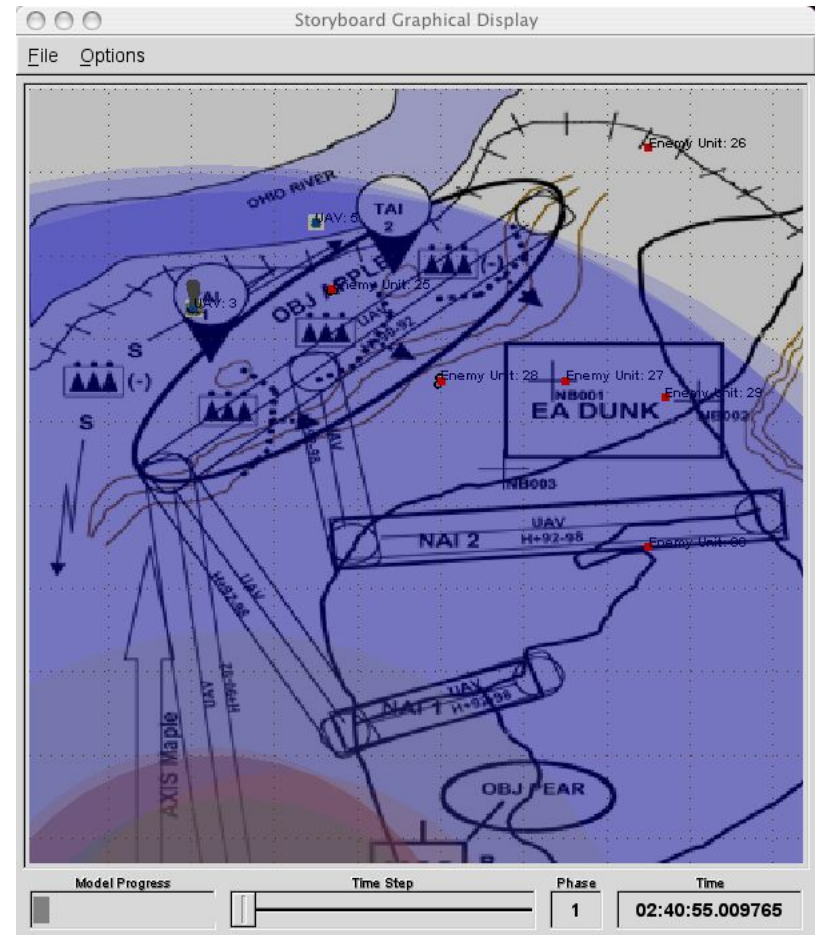
Demonstration output— Why did the platform task fail?



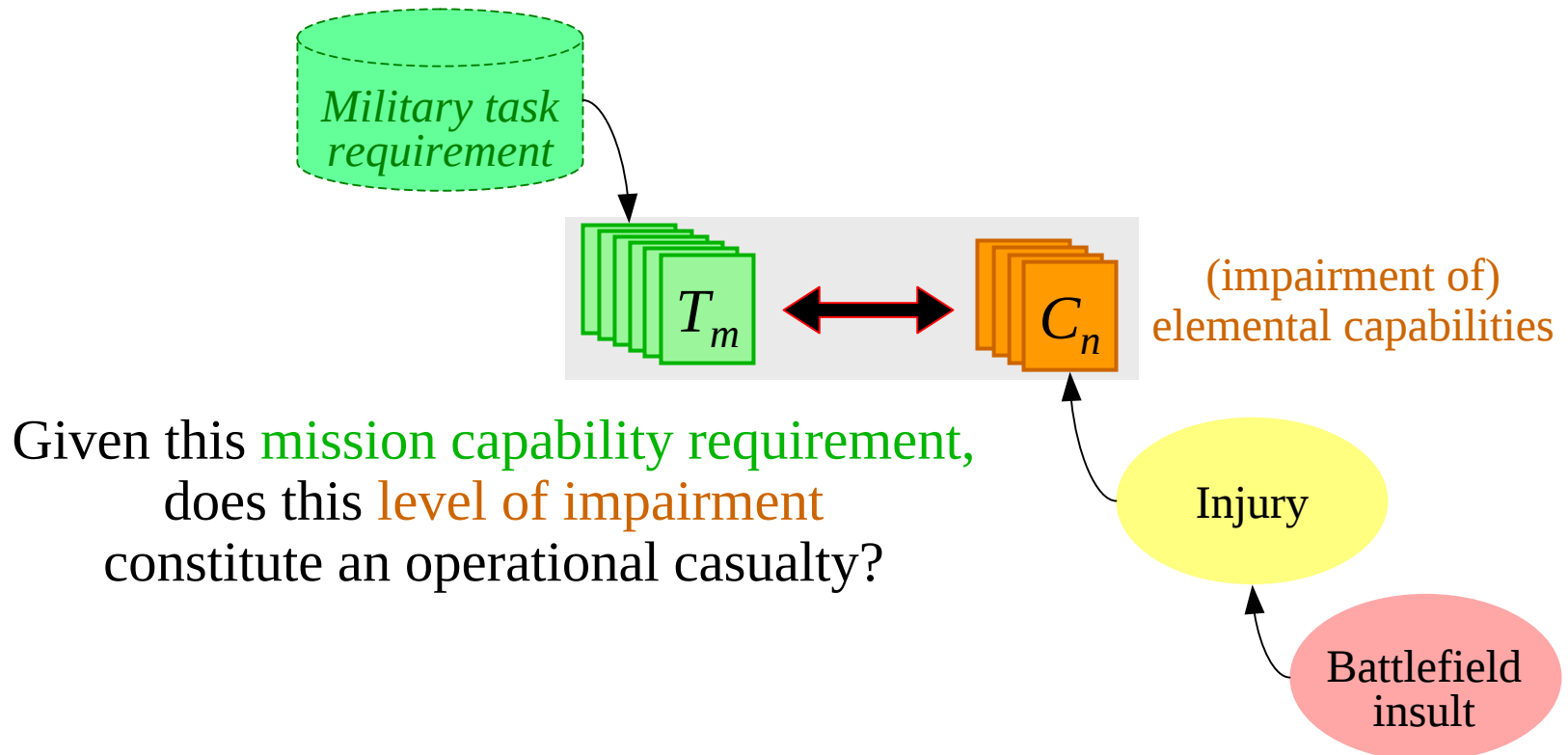
Before UAV 1 lost mobility



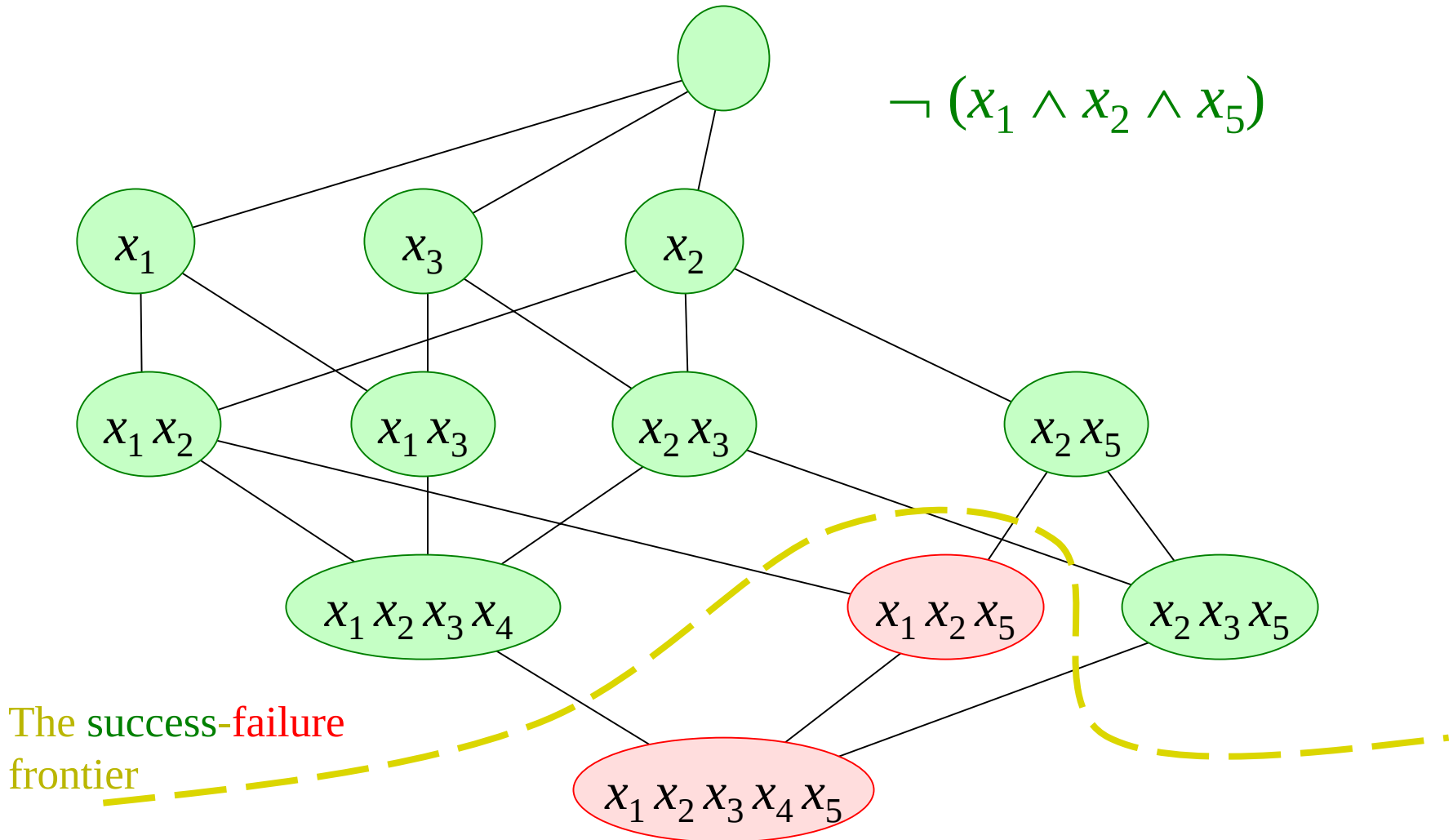
After



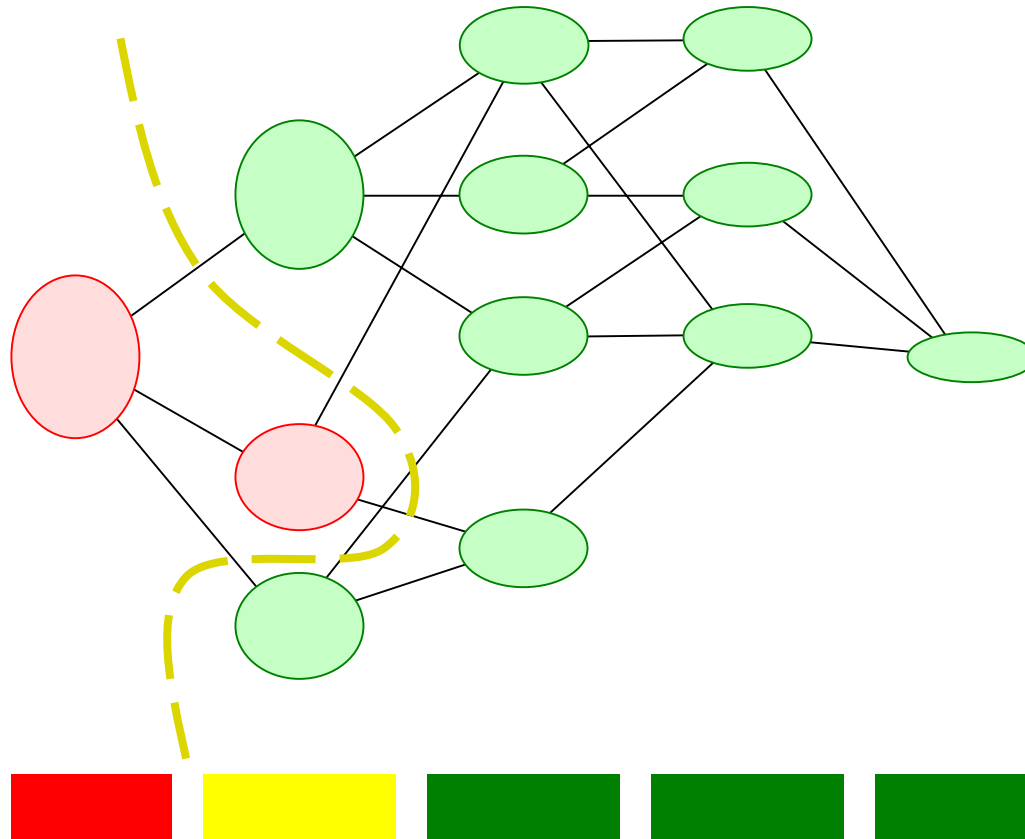
Personnel vulnerability paradigm has had it right for years—
MMF by any other name...



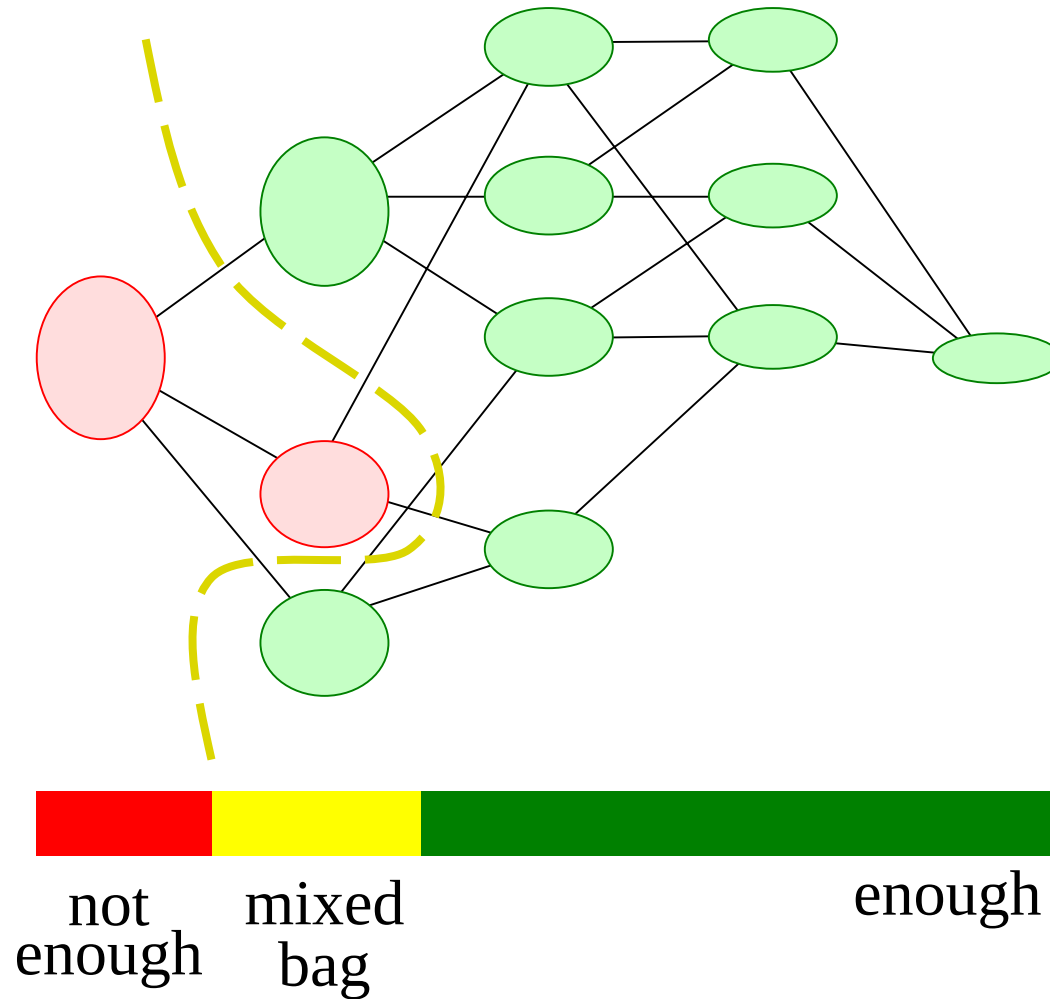
Suppose current task can be completed
so long as there's some external commo



Our passable state-scoring approach results in blurring on the frontier



Coloring the comms-capability bins by sufficiency to perform the current task



Demonstration output— platform capabilities

Mean percentage of vignette time during which platforms of each type endure each element of capability degradation

	Mobility				Firepower loss					Acquisition loss		Surv./recon. loss			
	m_1 Reduced max speed	m_2 Reduced manuev.	m_3 Stop after t min	m_4 Immobilized	f_1 Buttoned-up ability	f_2 Deliv. accuracy	f_3 Init. rate of fire	f_4 Subs. rate of fire	f_5 Total	a_1 Daylight sights	a_2 Night sights	z_1 Primary sensor	z_2 Secndry. sensor	z_3 Tertiary sensor	z_4 Vision blocks
C2V	13	12	2	12	0				0	0	0	0	0		0
NLOS-C	12	16	4	8		6	12	12	6						2
ARV	12	15	4	10					5	4	3	5	3	3	
UAV	25	27	25	25								26	25	25	

Demonstration output— platform capabilities, cont.

Mean percentage of vignette time during which platforms of each type endure each element of capability degradation

	Communication loss					Survivability loss					Personnel incapacitated									
	x_1 External data	x_2 External voice	x_3 Internal	x_4 LAN	x_5 All	s_1 NBC protec.	s_2 Obscurants	s_3 Silent watch	s_4 APS	s_5 Secondary wpn.	c_1 Commander	c_2 Squad leader	c_3 Driver	c_4 Operator 1	c_5 Operator 2	c_6 Gunner	c_7 Loader	o_1 Lost SA	k_1 Catastrophic loss	
C2V	0	1	1	0	0	2	0	2	0		2	3	2	1	3					
NLOS-C	2	2	2		2	3			3	3	2		2			2	2	2	2	
ARV	4				4			5												3
UAV	25																		25	

Demonstration output— success rate for (platform) critical tasks

Success rate*	Time succeeding (min)	Platform type	Task
	time required (min)		
1.000	1,280 / 1,280	C2V	Report enemy information
1.000	9,600 / 9,600	C2V	Establish and maintain comms
1.000	480 / 480	C2V	Employ fire support
0.999	9,588 / 9,600	C2V	Establish COP
0.999	9,588 / 9,600	C2V	Collect relevant information
0.999	9,588 / 9,600	C2V	Conduct battle tracking
0.990	1,584 / 1,600	C2V	Disseminate COP
0.969	7,501 / 7,740	NLOS-C	Conduct tactical maneuver
⋮	⋮	⋮	⋮
0.665	5,012 / 7,540	UAV	Fly UAV mission
0.648	2,312 / 3,570	UAV	Conduct tactical reconnaissance
0.595	773 / 1,300	UAV	Detect and locate surface targets

* Of the cumulative time the platform needed ability to perform the task, the portion during which it could actually do so.

ART 7.3.2.3 Conduct risk management

Essential task	Acceptability of risk of task failure by phase		
	Occupy AP Muldraugh 0200-0400	Move Along Axis Maple 0400-0600	Seize OBJ Apple/Occupy 0600-1000
ART 2.5 Occupy an area	No	Yes	No
ART 2.2 Conduct tactical maneuver	Yes	No	Yes
ART 7.2 Manage tactical information	No	No	No
ART 1.3 Conduct ISR	No	No	No
ART 3.3 Employ fires	Yes	No	No