NATO OTAN

Allied Command Transformation

Norfolk, Virginia | USA



LCI-X experimentation design

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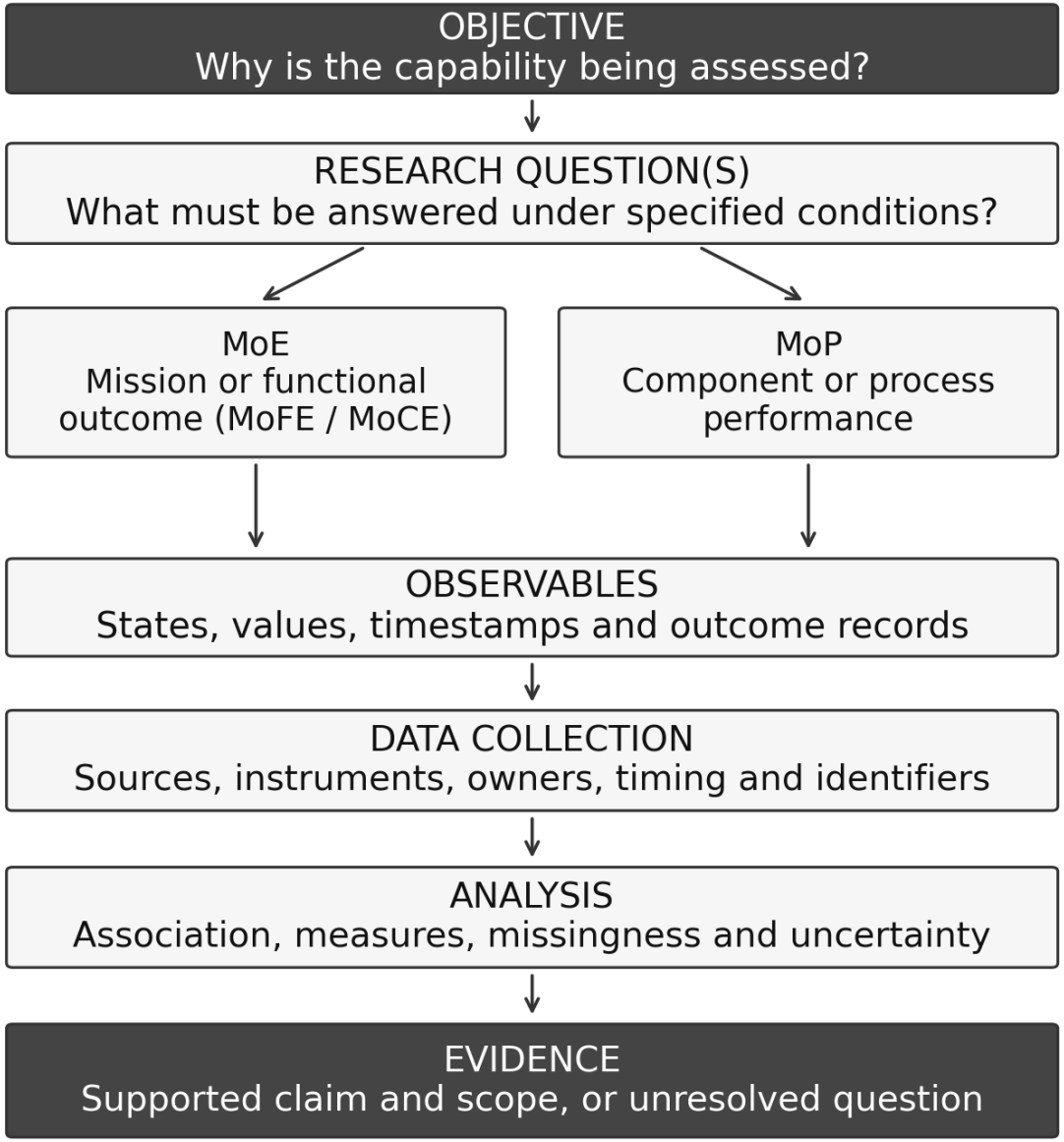
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Introduction to LCI-X

LCI-X strengthens NATO's defence against massed, low-cost aerial threats by identifying emerging C-UAS technologies and interoperability needs. Through experimentation, ACT will evaluate C-UAS effectiveness and collaborate with industry to reinforce operational capabilities along NATO's eastern flank.



Assessment hierarchy: complete paper figure



DCAP specifies and links every level before execution

Configuration, provenance and quality qualify the whole chain

Two complementary lines of effort



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Objective 1: Assess Cell-Level Kill Chain Performance

Assess effectiveness, responsiveness, and robustness of a C-UAS cell across the full kill chain under varying RED threat technology mixes and operational tactical contexts.

Objective 2: Assess Component-Level Performance and Contribution

Evaluate standalone performance of sensors, C2, and effectors, and their contribution to overall cell effectiveness.

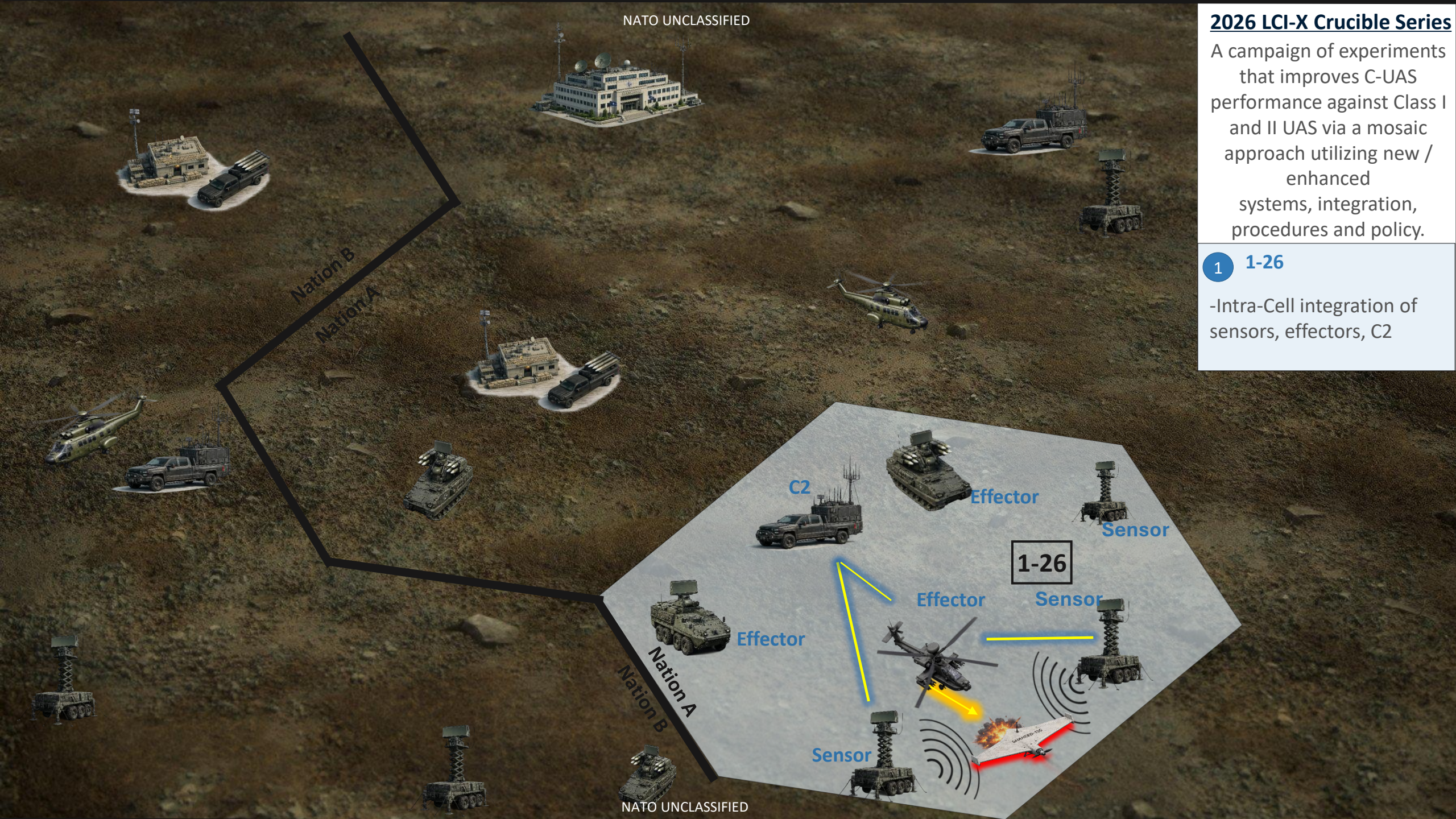
Blue workflow and Red experience provide complementary assessment perspectives.

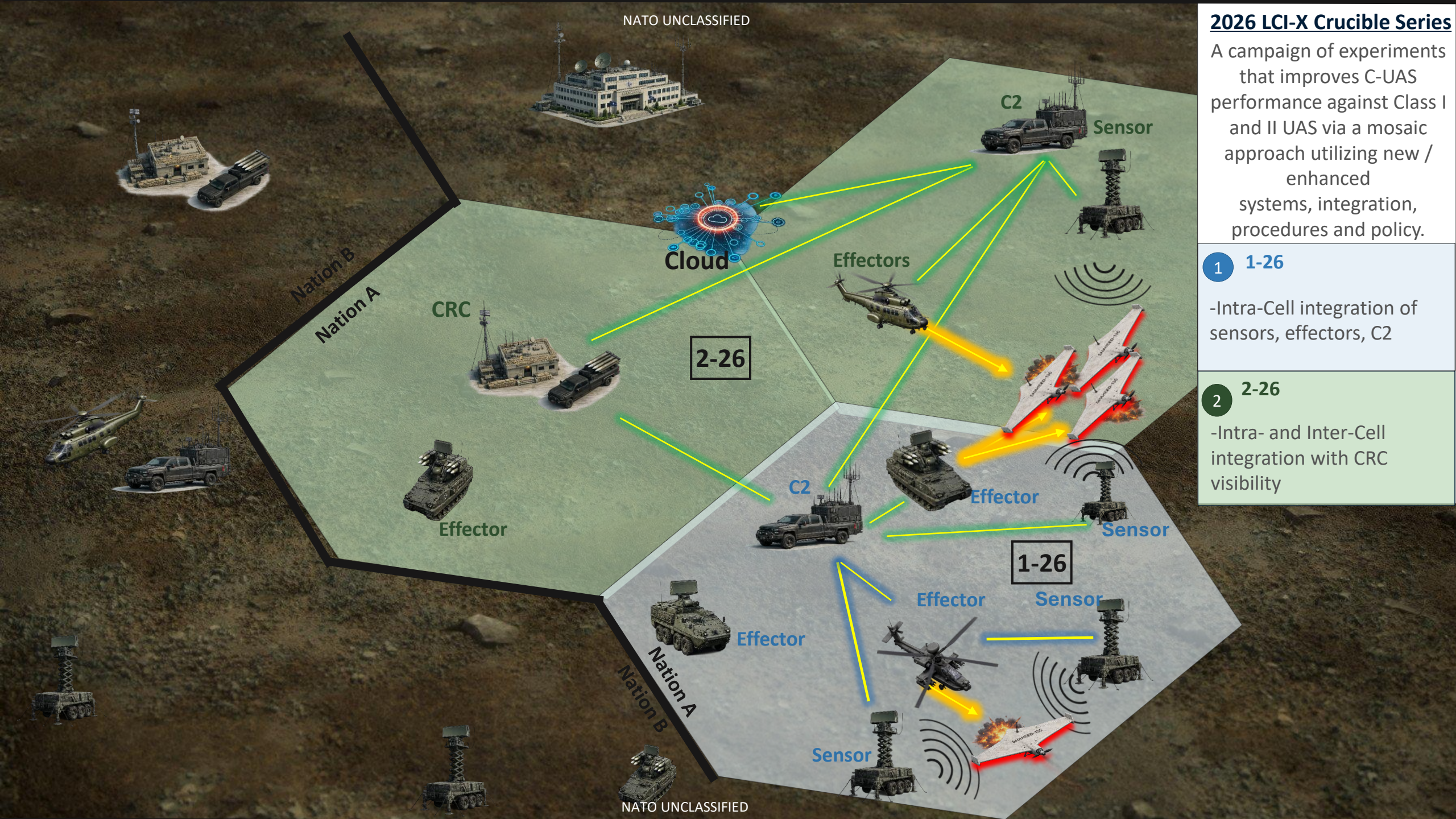
2026 LCI-X Crucible Series

A campaign of experiments that improves C-UAS performance against Class I and II UAS via a mosaic approach utilizing new / enhanced systems, integration, procedures and policy.

1 **1-26**

-Intra-Cell integration of sensors, effectors, C2





2026 LCI-X Crucible Series

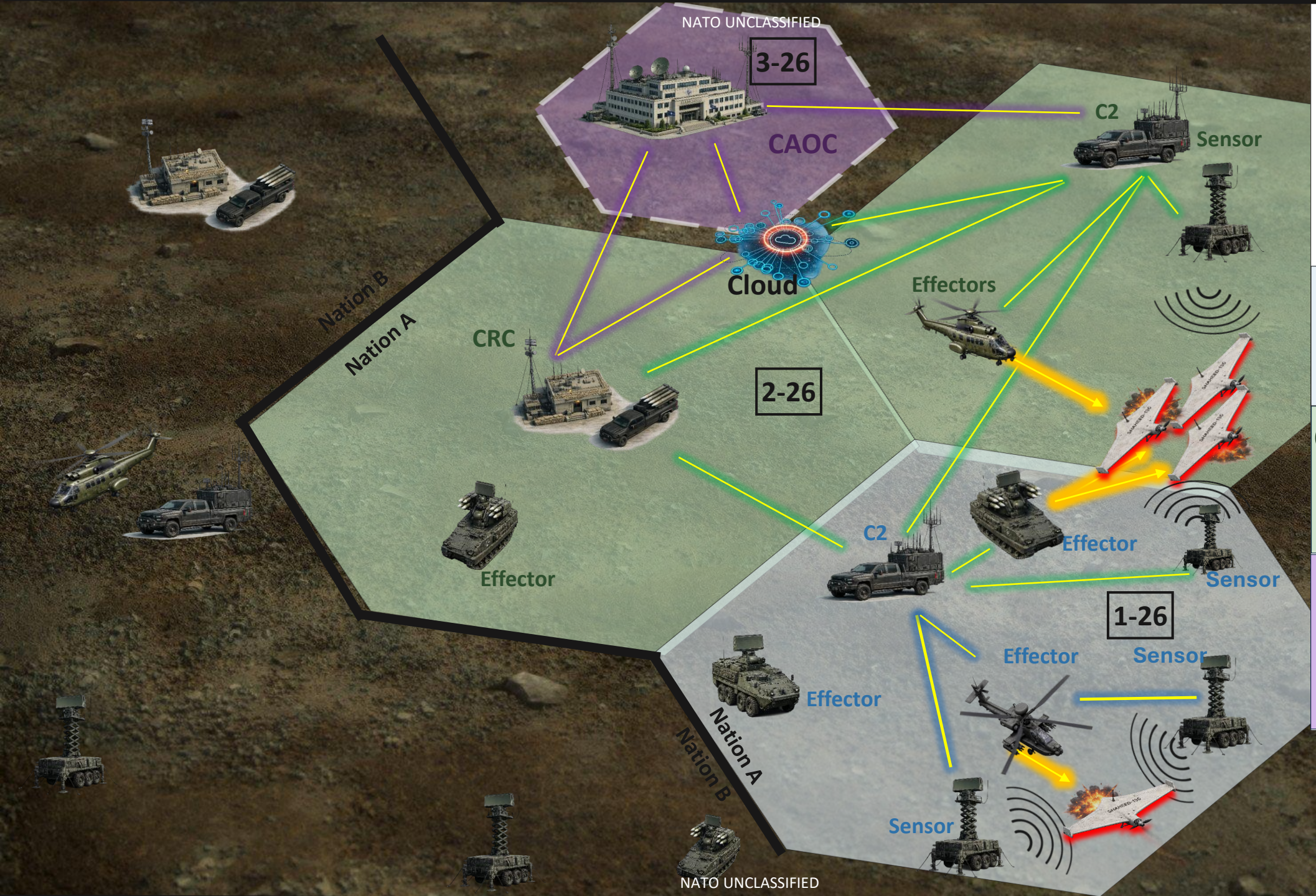
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1 1-26

-Intra-Cell integration of sensors, effectors, C2

2 2-26

-Intra- and Inter-Cell integration with CRC visibility



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-Multi-Cell integration and Connectivity to NATO AirC2 Ecosystem



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-Multi-Cell integration and Connectivity to NATO AirC2 Ecosystem

4 4-26

-Multi-Cell, cross border integration for detection, response, and NATO AirC2 enterprise visibility

MoFE catalogue

Identifier and measure	Description
MoFE-01: Neutralization Success Rate	Successful mission-preventing neutralizations relative to evaluated attempts.
MoFE-02: Probability of Detection	Accurate detections over eligible target-time intervals under stated conditions.
MoFE-03: Track Accuracy (GOSPA)	Localization error, missed targets and false targets in multi-object estimates.
MoFE-04: Initial Detection Latency	Elapsed time from defined ingress or launch to first valid detection.
MoFE-05: End-to-End Engagement Time	Elapsed time from first detection to confirmed neutralization.

Complete catalogue retained. Definitions, calculation requirements and caveats are in the measure catalogue in the paper.

MoP catalogue: detection and coverage

Identifier and measure	Description
MoP-01: Probability of False Alarm	False detections relative to all reported detections. The formula is a false-discovery proportion.
MoP-02a: Threat Identification Accuracy	Correct friendly, hostile or neutral identification against reference allegiance.
MoP-02b: Threat Classification Accuracy	Correct object classification against a predefined taxonomy and reference labels.
MoP-03a: Sensor Coverage Area	Nominal geometric sensor coverage derived from range and field of regard.
MoP-03b: Effector Coverage Area	Nominal geometric effector coverage derived from the stated operating envelope.

Complete catalogue retained. Definitions, calculation requirements and caveats are in the measure catalogue in the paper.

MoP catalogue: risk and sustainment

Identifier and measure	Description
MoP-04: Collateral Effects Risk Index	Potential collateral effects assessed with a defined qualitative risk rubric.
MoP-05: Cost per Neutralization	Included expenditure across attempts divided by confirmed neutralizations.
MoP-06: Operational Deployability and Sustainment Index	Demands of deployment, repositioning and sustainment. A composite index needs agreed weights.
MoP-07: Classification Performance (Confusion Matrix)	Classification errors and consistency across predefined classes using a confusion matrix.
MoP-08: Engagement Evaluation Accuracy	Agreement between engagement/BDA assessments and independently supported outcomes.

Complete catalogue retained. Definitions, calculation requirements and caveats are in the measure catalogue in the paper.

MoCE catalogue: technical integration

Identifier and measure	Description
MoCE-01: Inter-Cell Technical Interoperability	Usable information exchange across heterogeneous cell interfaces.
MoCE-02: System Integration Level	Integration of sensors, C2, effectors and operators within a single cell.
MoCE-03: Multi-Sensor Fusion Quality	Quality of sensor information integration supporting Find, Fix and Track.

Complete catalogue retained. Definitions, calculation requirements and caveats are in the measure catalogue in the paper.

MoCE catalogue: operational coordination

Identifier and measure	Description
MoCE-04: Operational Interoperability	Completion of coordinated activities across connected cells and their procedures.
MoCE-05: Decision-to-Engage Latency	Elapsed time from track confirmation to the engagement decision, including human interaction.
MoCE-06: Point of Decision Fusion Quality	Provisional assessment of fused information at tasking or engagement. Definition and scoring remain open.

Complete catalogue retained. Definitions, calculation requirements and caveats are in the measure catalogue in the paper.

DCAP: definitions, calculations and collection

Metric	Description	How the metric will be used in NATO	Sub-analyses	Calculation	Data Collection and Analysis	Notes to Industry
Measures of Force Effectiveness (MoFE)						
MoFE-01 — Neutralization Success Rate	Percentage of detected UAS that are successfully affected (kinetic or non-kinetic) by a counter-UAS cell, representing the overall effectiveness of a cell/effector in disrupting the threat.	In developing the CONOPS and the NDPP capability targets, studying this MoFE will help determine the quantity and the ratio of kinetic and non-kinetic effectors for NATO requirements.	-by each effector (or type) -by each sensor (or type) -for each scenario run* -by UAS platform, class* -across the entire exercise*	$\text{NSR} = \frac{N_{\text{Neutralized}}}{N_{\text{Detected}}} \times 100$	**Effector Data** and **Sensor Data**. For each effector attempt: effector ID, sensor ID, unique ID of detected UAS (if possible), effector type, result of effector attempt **Telemetry Data**. For each UAS: any BLUE ID (if possible), UAS ID, result of effector attempt, *total time affected* **Data Team.** Extract, load, transform (ELT), parse IAW TAB C; create static data tables that supports NSR: unique IDs, classification variables; validate BLUE data with RED data **Analyst Team.** Calculates and analyzes NSR across sub-analyses, curates information for NDPP dev.	Effector and sensor performance data will be released to respective industry partners. ***Per NATO policy, data for the annotated sub-analyses will not be shared outside of NATO.**
MoFE-02 — Detection Effectiveness Rate	Percentage of UAS entering the scenario area that are detected by at least one sensor in the counter-UAS cell. The measure represents the ability of the sensor layer to detect incoming threats under given conditions.	In developing the CONOPS and the NDPP capability targets, studying this MoFE will help determine the required quantity and the ratio of passive and active sensors.	-by each sensor (or type) -by UAS platform* -for each scenario run* -across the entire exercise*	$\text{DER} = \frac{N_{\text{Detected}}}{N_{\text{Ingressed}}} \times 100$	**Sensor Data**. For each acquisition (and attempt) at fixed time intervals: sensor ID, unique ID of detected UAS (if possible), timestamp, location of UAS, quality of acquisition (detection, classification, identification) **Telemetry Data**. For each UAS: any BLUE ID (if possible), UAS ID, timestamp, location. **Data Team.** ELT data tables IAW TAB C; create static data tables for DER: unique IDs, classification variables; validate BLUE data with RED data **Analyst Team.** Calculates and analyzes DER across sub-analyses, curates information for NDPP dev.	Sensor performance data will be released to respective industry partners. ***Per NATO policy, data for the annotated sub-analyses will not be shared outside of NATO.**
MoFE-03 — Track Continuity Rate	The length of time that counter-UAS cells maintain a usable track of a detected UAS until engagement or exit, as compared to the overall time the UAS spent in the detection area. This measure represents quality and persistence of tracking required to support targeting and engagement.	Studying this MoFE will help determine the proper force mix of passive and active sensors, which contributes to the development of CONOPS and the NDPP capability targets relating to CUAS operations.	-by each sensor -by each UAS* -by each sensor-UAS platform combination* -for each scenario run* -across the entire exercise*	*For each UAS i* $\text{TCR}_i = \frac{T_{\text{Tracked},i}}{T_{\text{Exposure},i}}$	**Sensor Data**. For each UAS tracked, at fixed time intervals: sensor ID, unique ID of tracked UAS (if possible), timestamp, location of UAS, quality of acquisition (detection, classification, identification) **Observer**: Record TRACK activities in C2 event log: C2 cell, time, activity, decision, specific UAS (if possible) **Telemetry Data**. For each UAS: any BLUE ID (if possible), UAS ID, timestamp, location. **Data Team.** ELT data tables IAW TAB C; create static data that supports TCR: unique IDs. **Analyst Team.** Calculates and analyzes TCR across sub-analyses, curates information for NDPP dev.	Sensor performance data will be released to respective industry partners. ***Per NATO policy, data for the annotated sub-analyses will not be shared outside of NATO.** NATO welcomes vendor feedback for how best to collect and parse the data to calculate this MoFE, including sample data extracts.

Triangulation and data quality

Evidence source	Contribution and limitation
Direct observation	Workflow and context, with limited field of view
Operators and Red pilots	Experienced effects and recovery, with recall and attribution limits
Surveys	Structured perceptions, dependent on timing and question design
Logs and reference data	Event timing and technical detail, dependent on coverage and synchronization

Common identifiers, clock alignment and missing-data rules connect the evidence sources.

LCIX 1-26, Vul 9 and10

Scenario:

Mass Saturation “Simultaneously” Sub-Packet

ISR UAS Threat

The adversary employs *2* ISR UAS, The ISR UAS operates at 200 - 500 feet AGL.

Bomber UAS Threat

The adversary launches *1* x bomber UAS

FPV Attack UAS Threat

The adversary launches 2 x *10* First-Person View (FPV) one-way attack UAS packets. High-speed, low-altitude (below 150 feet AGL) approaches.

Class 2 One-way Attack

The adversary launches **5** One-way attach UAS multi-azimuth and approach profiles

Resource Allocation:

Component 1.1 = 50

Component 1.3 = ***0

Component 2 = 5

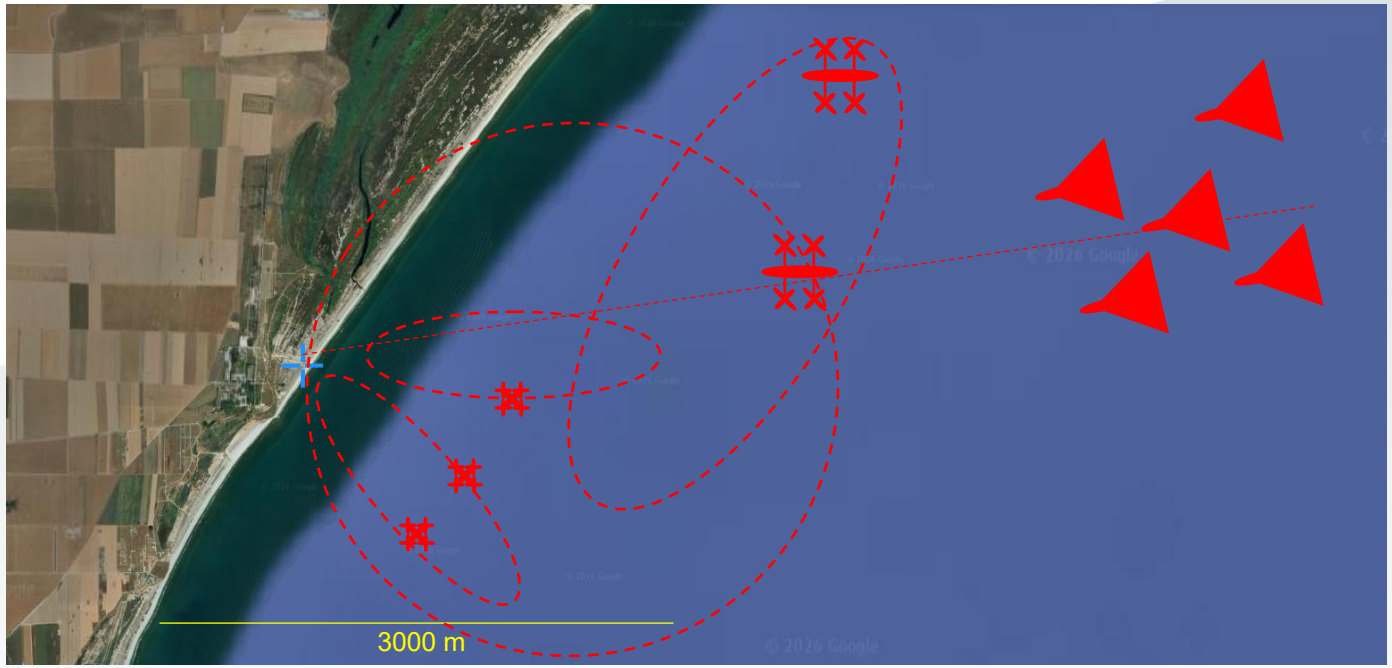
Component 4 = 10

- **Objective:**

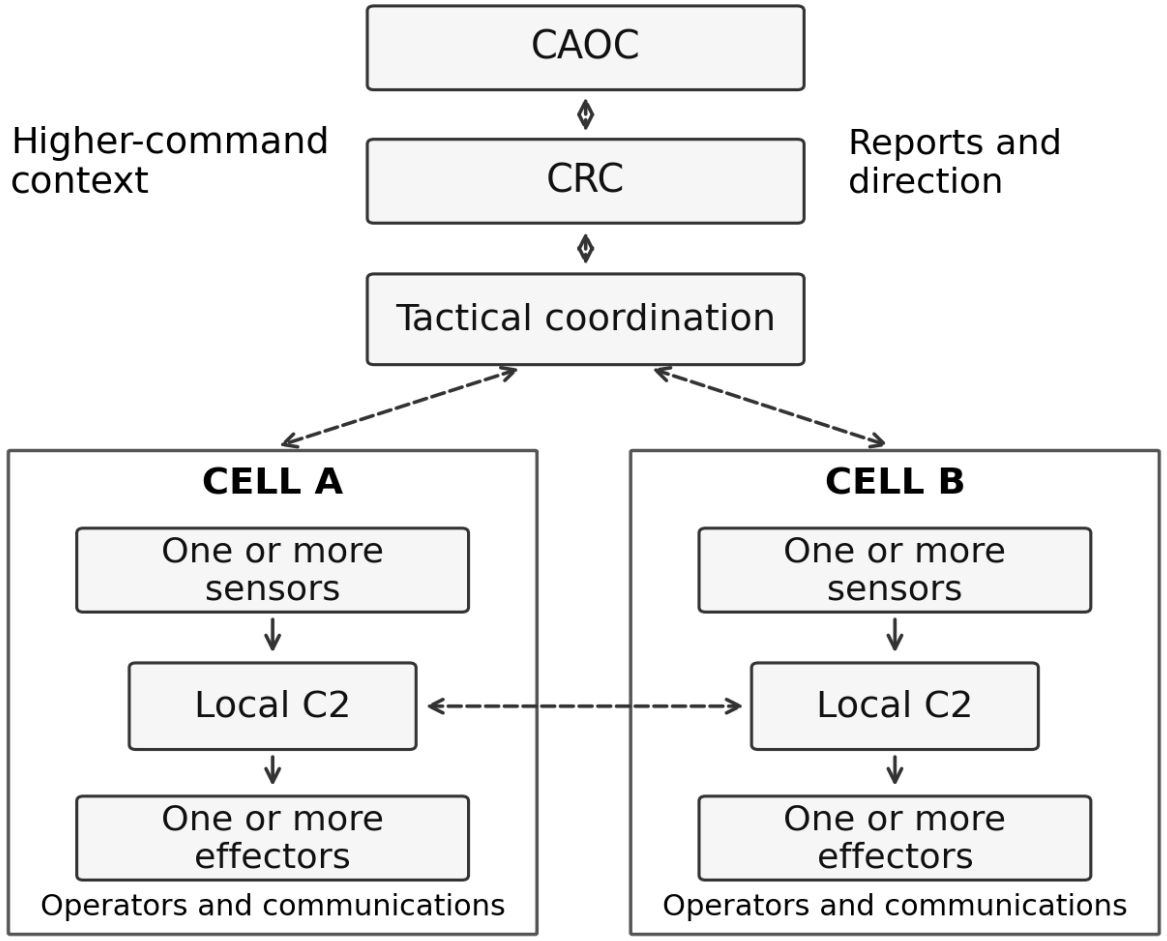
1. Evaluate latency in data fusion and threat handoff.
2. Confirm engagement chains and C2 process
3. Formulation of a multi-sensor recognised air picture

- **Innovation Objective:**

1. **Extrapolate max decision space to execute kill chain**
2. Mosaic Cell & Single Capability Detection of <1m2 at disance at altitude….
3. Counter MASS CL II tactics ….
4. …..



Mosaic architecture: complete paper figure

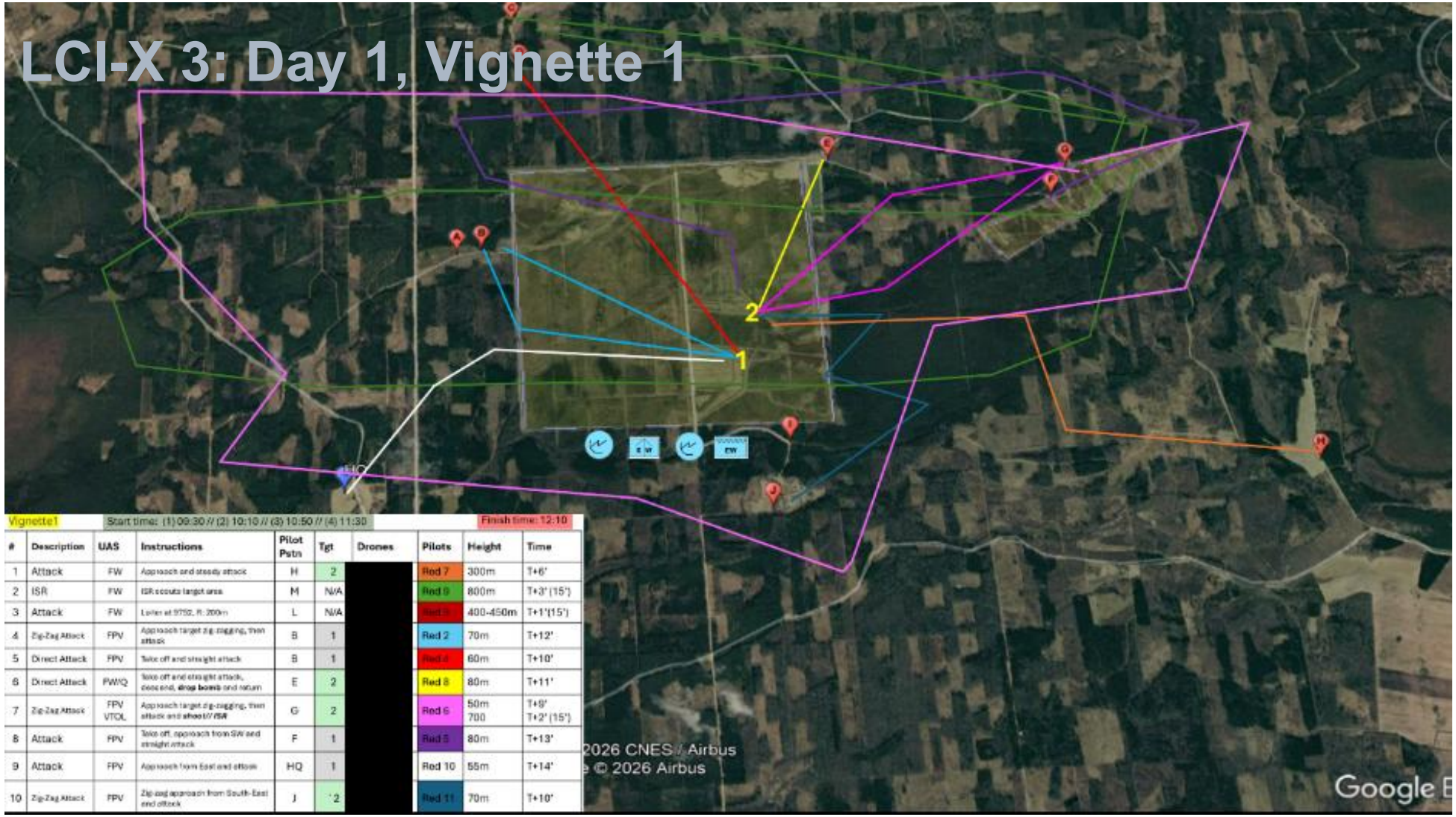


Solid links: local functional sequence

Dashed links: conceptual exchanges to be assessed

Conceptual arrangement — not demonstrated event connectivity

LCI-X 3: Day 1, Vignette 1

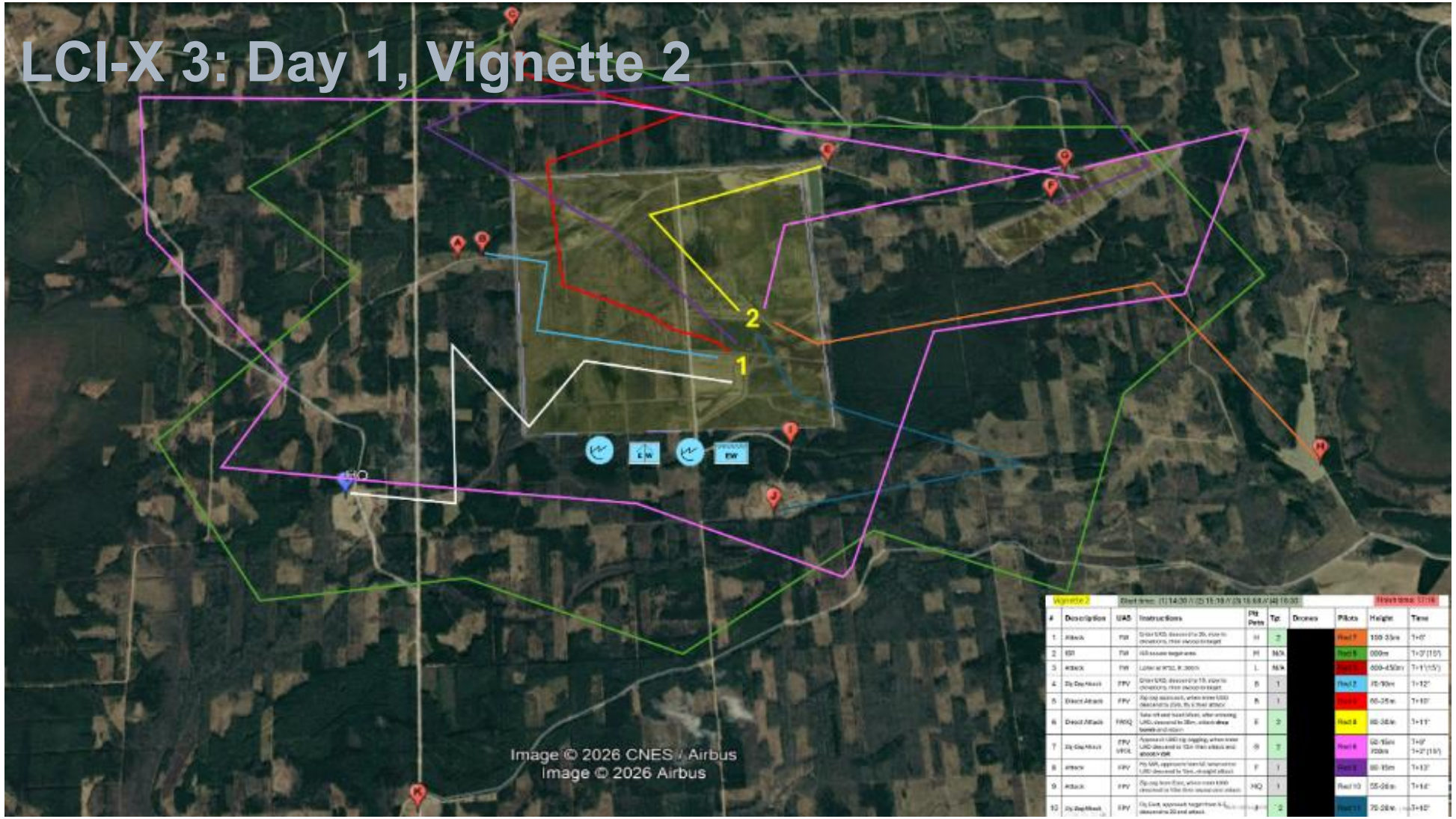


Vignette1 | Start time: (1) 09:30 // (2) 10:10 // (3) 10:50 // (4) 11:30 | Finish time: 12:10

#	Description	UAS	Instructions	Pilot Pstn	Tgt	Drones	Pilots	Height	Time
1	Attack	FW	Approach and steady attack	H	2		Red 7	300m	T+6'
2	ISR	FW	ISR scouts target area	M	N/A		Red 9	800m	T+3' (15')
3	Attack	FW	Loiter at 9750, R: 200m	L	N/A		Red 3	400-450m	T+1'(15')
4	Zig-Zag Attack	FPV	Approach target zig-zagging, then attack	B	1		Red 2	70m	T+12'
5	Direct Attack	FPV	Take off and straight attack	B	1		Red 4	60m	T+10'
6	Direct Attack	FPV/Q	Take off and straight attack, descend, drop bombs and return	E	2		Red 8	80m	T+11'
7	Zig-Zag Attack	FPV VTOL	Approach target zig-zagging, then attack and shoot UAV ISR	G	2		Red 6	50m 700	T+9' T+2' (15')
8	Attack	FPV	Take off, approach from SW and straight attack	F	1		Red 5	80m	T+13'
9	Attack	FPV	Approach from East and attack	HQ	1		Red 10	55m	T+14'
10	Zig-Zag Attack	FPV	Zig-zag approach from South-East and attack	J	2		Red 11	70m	T+10'

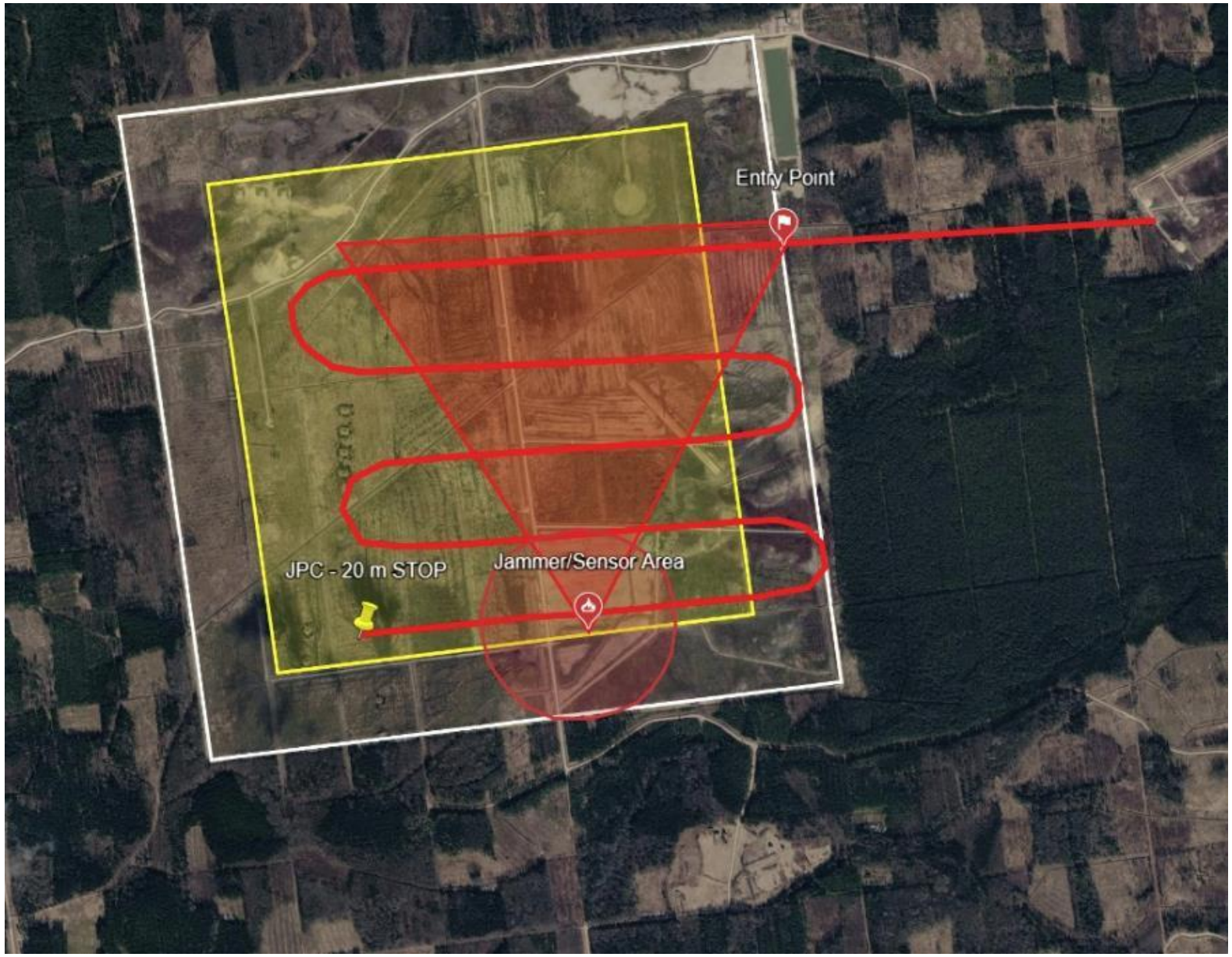
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LCI-X 3: Day 1, Vignette 2



#	Description	UAS	Instructions	Pilots	Height	Time
1	Attack	FW				
2	ISR	FW				
3	Attack	FW				
4	Zig Zag Attack	FPV				
5	Direct Attack	FPV				
6	Direct Attack	FPV/Q				
7	Zig Zag Attack	FPV (FOV)				
8	Attack	FPV				
9	Attack	FPV				
10	Zig Zag Attack	FPV				

LCI-X 3: Day 3 Jamming-test vignette



Transferable lessons

Observed assessment issue	Transferable methodological response
Connection without confirmed action	Observe receipt, interpretation and task completion separately
Disruption with possible recovery	Record initial effect, recovery and final mission outcome
Uneven timing or reference coverage	Reconcile clocks, identifiers and missingness before analysis
Evolving vignette and survey needs	Allow controlled changes with versioned, exportable records

M&S opportunities across the experiment

Experiment stage	Proposed M&S support
Design	Vignette exploration and identification of discriminating conditions
Controlled exploration	Repeatability, scale, sensitivity and uncertainty analysis
Review	Replay, after-action review and future live–synthetic environments
Model credibility	Calibration and validation using qualified experimental evidence

Future applications. The reviewed campaign provides no basis for claiming deployed simulation integration.