



LLM-Assisted Interoperability for Autonomous Systems Simulation: From Local SOMs to a Shared FOM

Marco Gotelli¹, Filippo Ghisi¹, Xhulia Sina¹ and Massimo Pedemonte²

¹ University of Genoa, Via Opera Pia 15, 16145 Genova, Italy

² Simulation Team, Via Magliotto 2, 17100 Savona, Italy



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Aerial



Ground



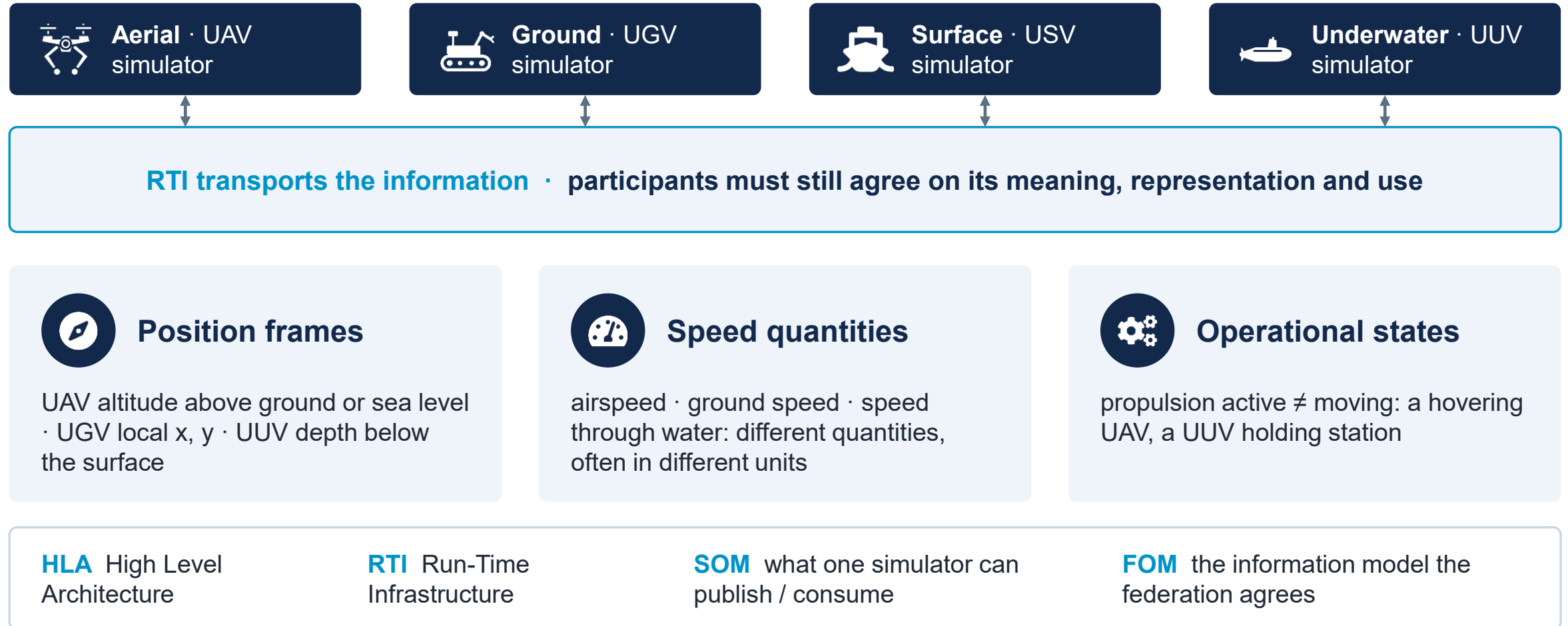
Surface



Underwater



Connectivity is only the first step

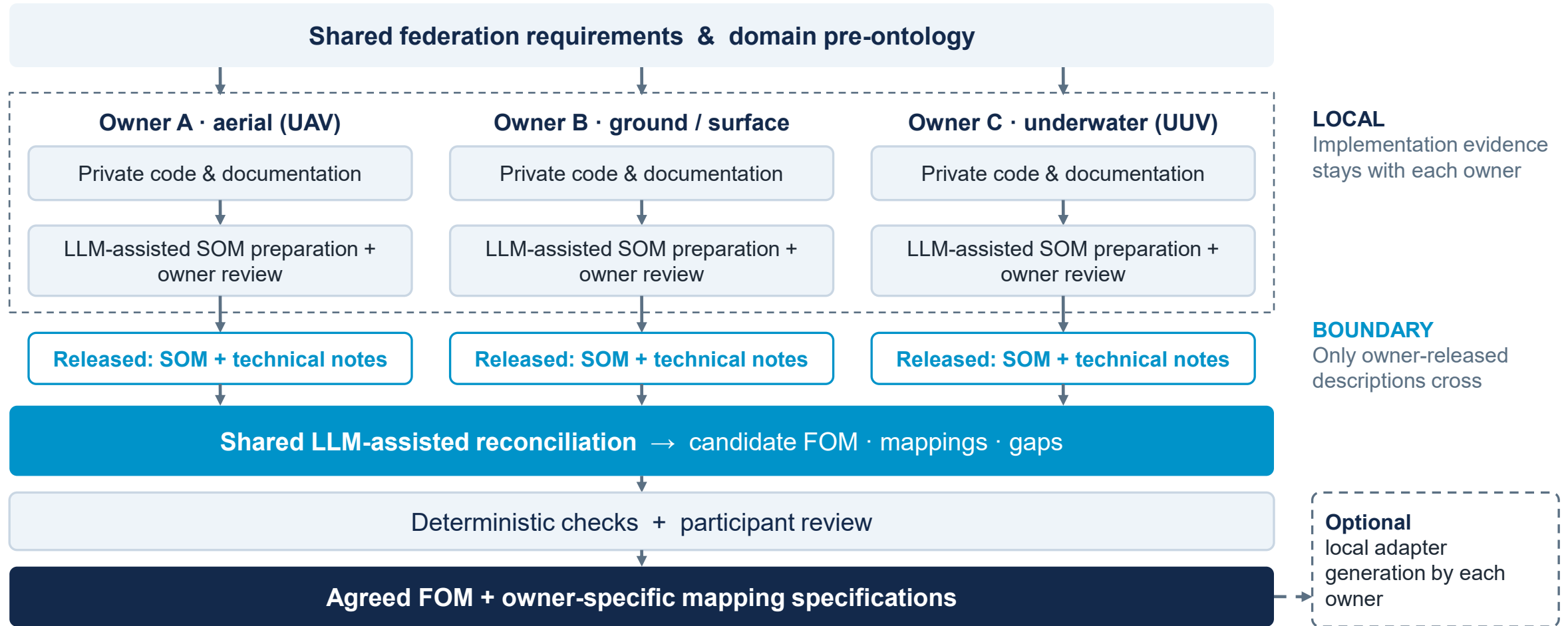


IEEE Std 1516.2-2010 (OMT) specifies object-model format, not domain content [1]. Domain examples illustrate the mismatch types in paper Sect. 4–5 and Table 1.



Local SOMs, one shared FOM

Proposed workflow



Redrawn from paper Fig. 1. Owner columns are conceptual multi-domain examples; the experiment covers a narrower subset (slide 6).



Matching names is not matching meanings

Illustrative example — not original simulator source

```
// C# — illustrative local representation
class PatrolBoat {
    double latitude, longitude;
    float speedKnots, headingDegrees;
    bool enginesActive;
}
```

```
// Java — independently defined representation
class Boat {
    double latitude, longitude;
    float speed, heading; // units require documentation
    boolean isMoving;
}
```



speedKnots ↔ speed

Confirm quantity and unit with the owner first; the Java unit is undocumented, so the mapping stays **CONDITIONAL**.



enginesActive ≠ isMoving

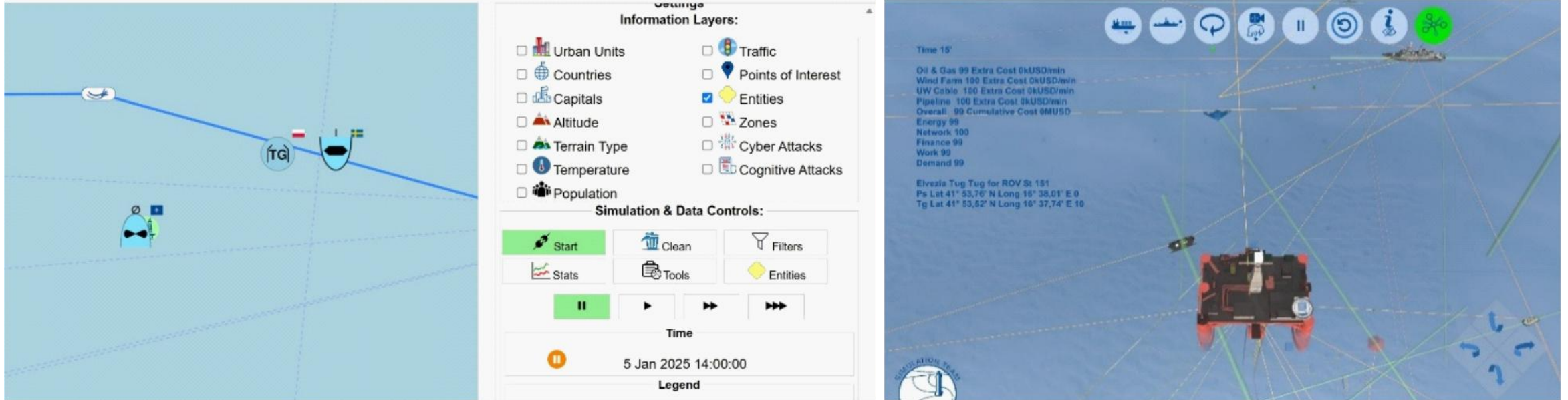
Engines can run while the vessel is stationary: keep two separate concepts instead of one merged state.

Code transcribed from the paper's illustrative C#/Java example (Sect. 5, Table 1); written for explanation, not extracted from DecisionTheater or CAPIAS.



Maritime case: two heterogeneous simulators

Illustrative maritime scenario



17

DecisionTheater

Java representation ·
candidate attributes in its
SOM

43

CAPIAS

Unity / C# representation ·
candidate attributes in its
SOM

Reconciliation inputs

Prepared SOMs + technical notes +
federation context

**Intended use: shared operational
picture**

Paper Fig. 2 (scenario illustration) and Sect. 6: two SOMs with 17 and 43 candidate attributes, prepared from simplified entity models.



Two tests: model generation and a runtime exchange

1 Model-generation test

Fixed inputs

2 prepared SOMs (17 + 43) + technical notes + federation context

5 SFS settings

0 · 25 · 50 · 75 · 100
one GPT-6 Extra High run each

5 candidate FOMs

with mappings, adapter requirements and open issues

Portico RTI

federation creation with each candidate FOM

2 Runtime exchange test

separate from model generation; one FOM only

SFS = 50 FOM

2 lightweight Java test federates

Initial target: HLA Evolved — IEEE 1516-2010

Paper Sect. 6.2 and Sect. 8. One execution per SFS setting; SOMs, notes and federation context unchanged across runs.



SFS sets how readily concepts merge

SFS is an instruction parameter defined for this study, ranging from 0 to 100 — not an HLA standard term and not a probability.



Toward 0

Broader abstractions and generalised attributes; more mappings left **CONDITIONAL** on further decisions

Toward 100

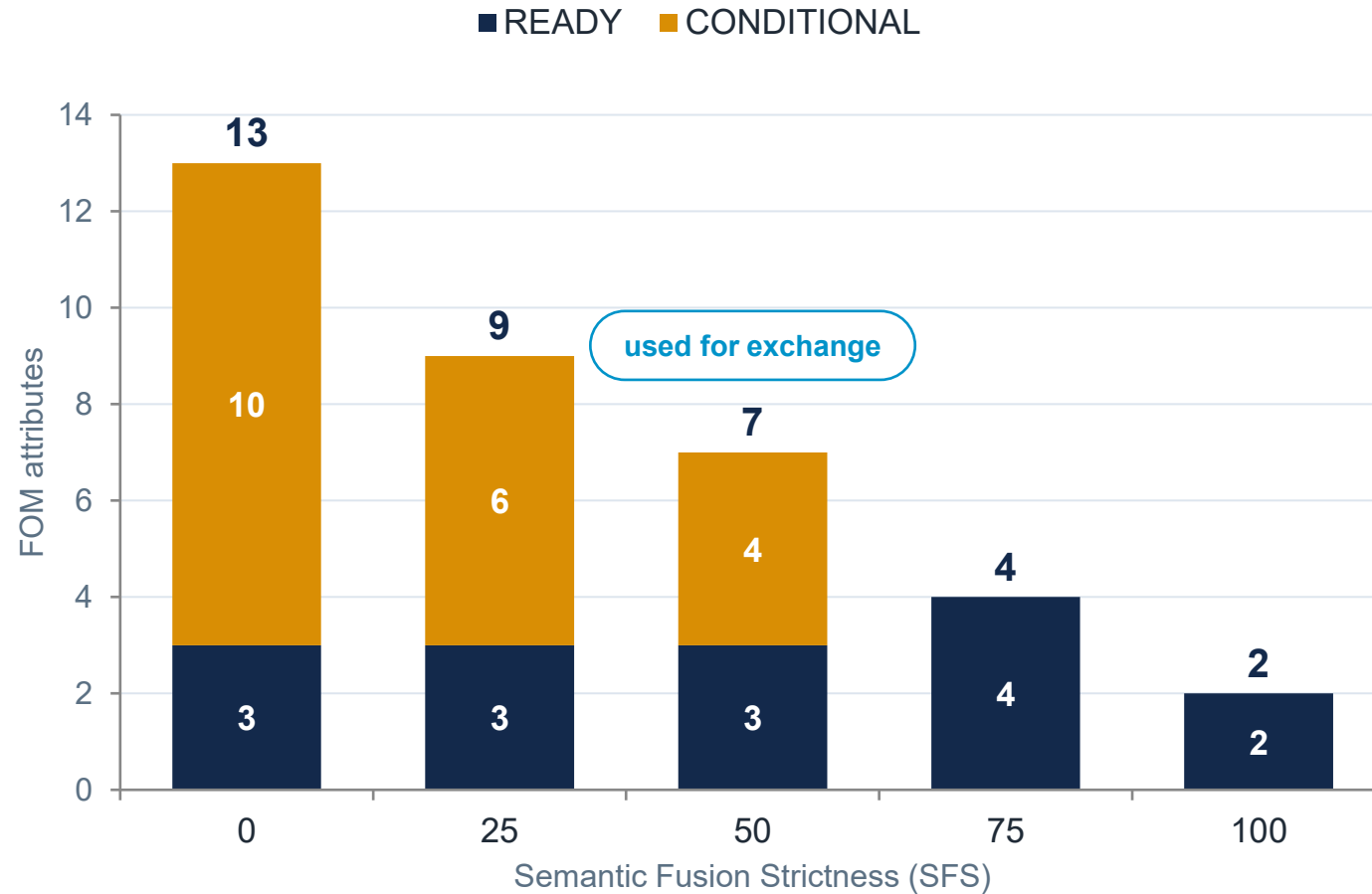
Stronger semantic equivalence and better-documented transformations required before merging

Trade-off: stricter fusion can exclude information the scenario actually needs.

Paper Sect. 7 (Semantic Fusion Strictness). Exact prompt wording and repeatability to be documented in follow-up work.



Stricter fusion produced smaller FOMs



13 → 2 attributes

as strictness rises from 0 to 100



Compactness ≠ success

a discarded mandatory exchange remains an unmet requirement



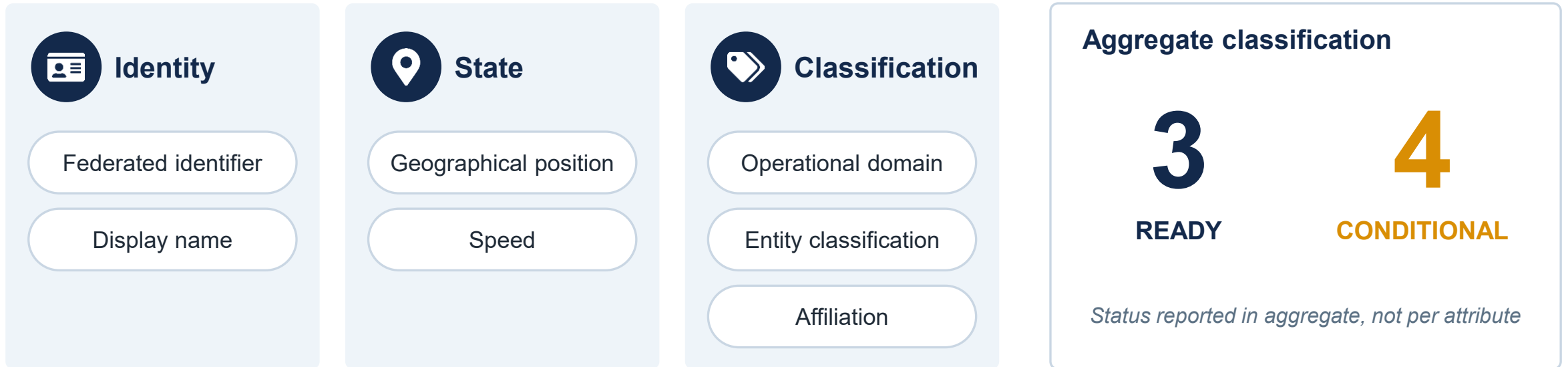
Five single runs

observations, not an averaged curve or statistical trend

Paper Table 3. READY = mapping specified enough for subsequent implementation and testing (not proven correct); CONDITIONAL = more decisions, information or verification needed.



The SFS = 50 candidate: seven attributes, with notes



Accompanying notes flag what each federate must adapt — examples:



Position

coordinate origin, axes, datum,
possible loss of vertical information



Speed

units to confirm between the two
representations



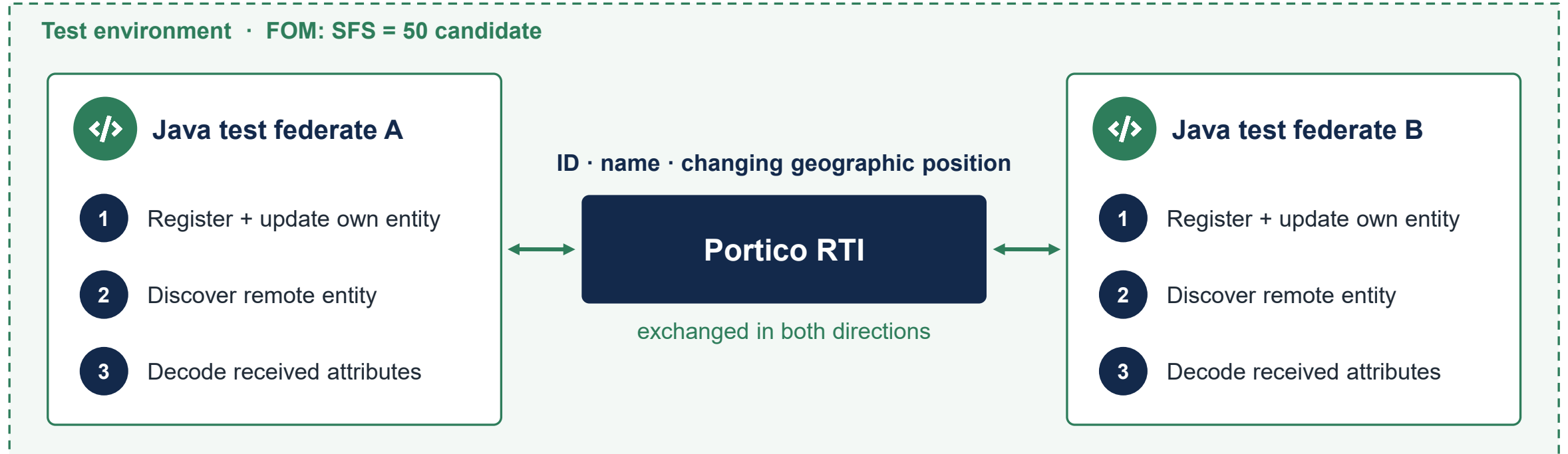
Affiliation

interpretation to agree between
owners



Basic runtime exchange through Portico

Schematic of the test set-up



All 5 candidate FOMs
accepted by Portico at federation creation



SFS = 50 FOM only
used for the reported bidirectional exchange

Paper Sect. 8. Lightweight test federates; the original DecisionTheater and CAPIAS applications were not connected in this test.



Same SFS, different model, different FOM

Exploratory · one run each · SFS = 50

GPT-6 Extra High

7

FOM attributes

4

CONDITIONAL

GLM-5.2

18

FOM attributes

15

CONDITIONAL

incl. parallel 2D and 3D position representations



Takeaway: outputs are sensitive to the model. Equal SFS values are not calibrated across models, so this calls for controlled, repeated trials — not a model ranking.

Paper Sect. 8: single exploratory GLM-5.2 run at SFS = 50 compared with the GPT-6 Extra High SFS = 50 run.



What the proof of concept shows, and what comes next



Demonstrated

- Candidate FOM synthesis from two prepared SOMs, five SFS settings
- Acceptance of all five FOMs by Portico
- Basic bidirectional exchange with the SFS = 50 FOM



Next to evaluate

- Local SOM extraction from owner code
- Semantic correctness vs. owner-validated reference mappings
- Full adapters for the original simulators
- Repeated, controlled runs
- Manual-effort baseline
- Pre-ontology contribution (ablation)

Next: 3 original simulators → 6 directed exchanges

Scope: air · ground · surface · underwater assets

HLA 4: version-specific checks (IEEE 1516-2025)

Paper Sect. 6.3 (proposed measures, Table 2), Sect. 8.1 and Sect. 9; IEEE Std 1516-2025 [15].



Take-home messages

1

Make interface meaning explicit

units, frames and concepts cannot be inferred from names

2

Generate more than a FOM

mapping conditions and gaps are part of the deliverable

3

Feasibility shown, validation next

this proof of concept motivates full, reference-based evaluation



From local capabilities to an agreed federation interface

Questions? · marco.gotelli@unige.it





Backup: full results and status definitions

SFS	FOM attributes	READY	CONDITIONAL
0	13	3	10
25	9	3	6
50	7	3	4
75	4	4	0
100	2	2	0

GPT-6 Extra High, one execution per setting; READY + CONDITIONAL = FOM attributes in every row.

READY

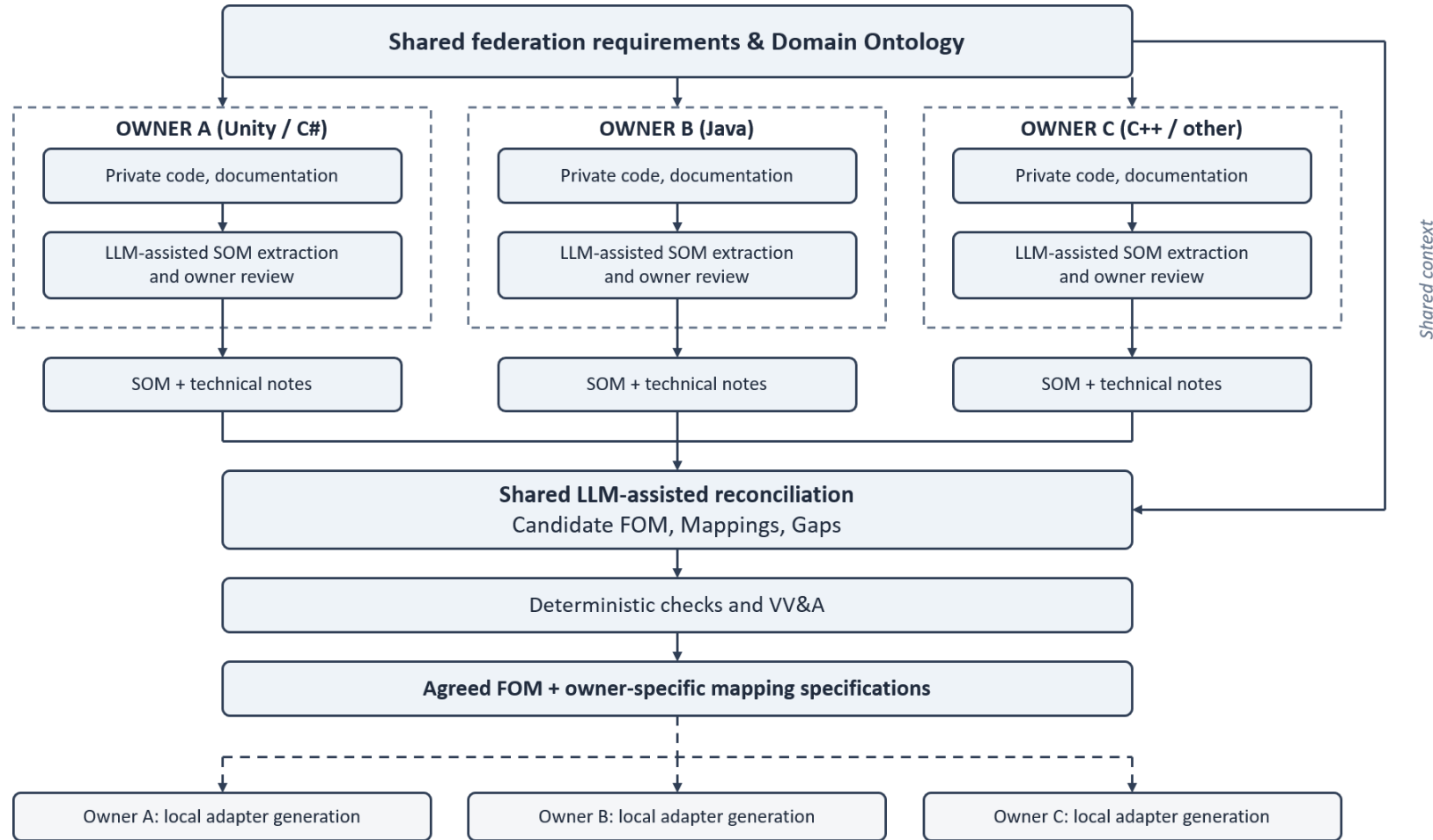
Semantic mapping specified sufficiently for subsequent implementation and testing. Not proven correct; not runtime-tested.

CONDITIONAL

Additional decisions, information or verification required before implementation.



Backup: original architecture figure (paper Fig. 1)



Reading notes

- Three owner columns illustrate scalability; they are conceptual.
- “Deterministic checks and VV&A” marks the intended validation stage; deterministic checks alone do not establish accreditation or semantic validity.
- The LLM need not take part in runtime exchanges.

Paper Fig. 1 (original image). Slide 3 shows the same structure redrawn for legibility.



Backup: selected references

- [1] IEEE (2010). IEEE Std 1516.2-2010: Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) — Object Model Template (OMT) Specification. <https://standards.ieee.org/ieee/1516.2/3746/>
- [10] Bocciarelli, P., D'Ambrogio, A., Giglio, A., Paglia, E. (2019). Automated Generation of FOM Modules for HLA-Based Distributed Simulations. 2019 Spring Simulation Conference (SpringSim), pp. 1–12. IEEE. <https://doi.org/10.23919/SpringSim.2019.8732865>
- [11] El Kassis, M., et al. (2024). An HLA-based automated approach for the interoperable simulation of collaborative business processes. Simulation Modelling Practice and Theory, 135, 102977. <https://doi.org/10.1016/j.simpat.2024.102977>
- [12] Hertling, S., Paulheim, H. (2023). OLaLa: Ontology Matching with Large Language Models. K-CAP '23, pp. 131–139. ACM. <https://doi.org/10.1145/3587259.3627571>
- [15] IEEE (2025). IEEE Std 1516-2025: Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) — Framework and Rules. <https://standards.ieee.org/ieee/1516/6687/>

Numbering follows the paper's reference list.