

Web3D 2026

From Signals to Geometry

Web-Rendered Digital Twins over the Asset Administration Shell

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Outline

01 **Context**
From a physical factory to a digital twin

02 **The problem**
The ubiquitous-sensing paradox

03 **Research questions**
Three challenges we want to solve

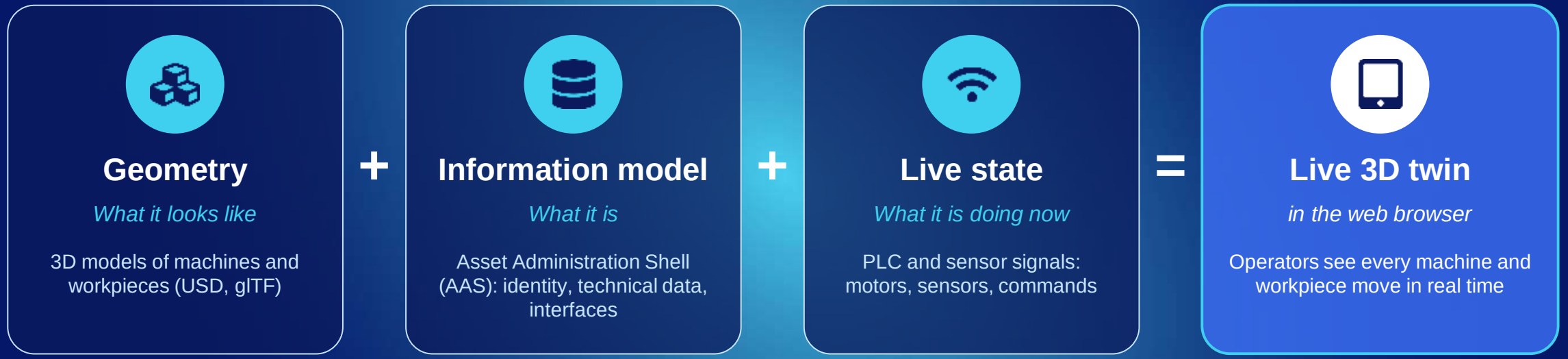
04 **Our solution**
System architecture and AAS extensions

05 **Validation**
Mini-factory testbed and live demo

06 **Wrap-up**
Limitations and conclusions

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From Physical Factory to Digital Twin



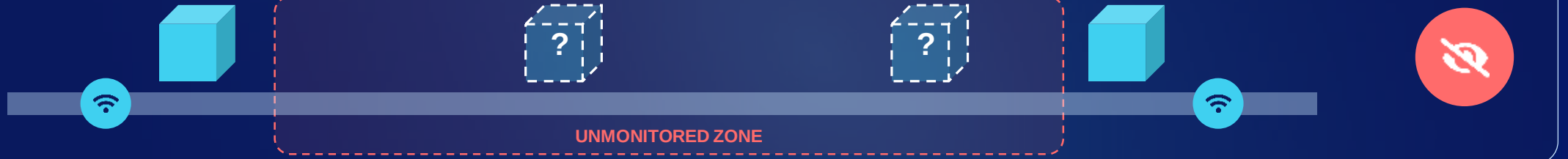
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The Ubiquitous-Sensing Paradox

WHAT 3D TWINS ASSUME — every workpiece tracked · sensors give the 3D pose directly



WHAT THE SHOP FLOOR HAS — sensors only at process boundaries → the piece disappears



OUR IDEA: SIMULATE IT — physics simulation predicts the missing positions



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Research Questions

RQ1

Signal-to-geometry recovery

PLCs only send raw signals (on/off, encoder counts), not 3D positions.

Can a physics engine connected through the AAS turn them into the correct position and orientation of every moving part — even in zones with no sensors?

RQ2

Reconciliation

When the piece reaches the next sensor, we compare the simulated pose with the real one.

Is the estimate good enough to correct the twin and to detect anomalies (stuck, lost or misplaced pieces)?

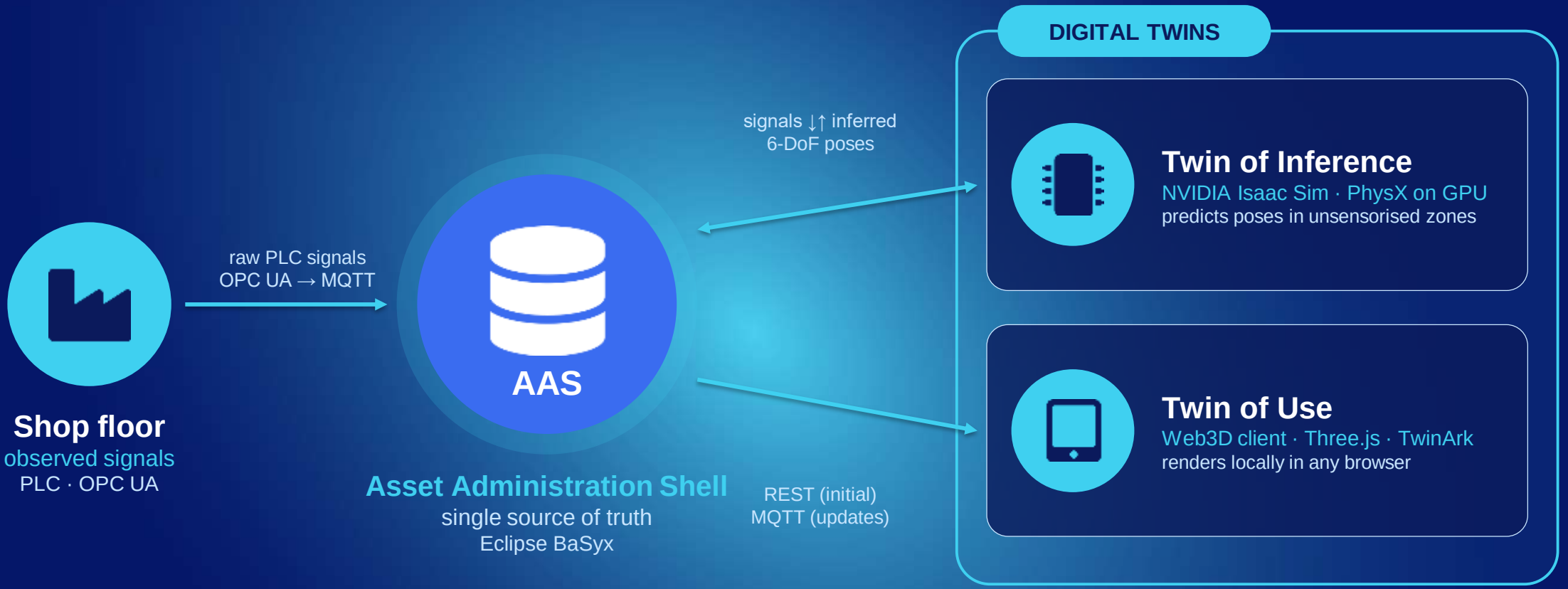
RQ3

Thin-client visualisation

All the heavy work runs on GPU engines such as NVIDIA Isaac Sim.

Can a normal web browser still show the live twin on low-power devices, using only AAS updates — no GPU and no special software?

System Architecture



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Extending the AAS for Live Web3D

1 Provenance qualifier

Identify where the data comes from: real data or simulated data

`source = observed`

real
sensor signal

`source = inferred`

simulated
physics estimate

Standard AAS Qualifier → any compliant client can read it

2 SceneMapping submodel

Map signals to geometric behaviour

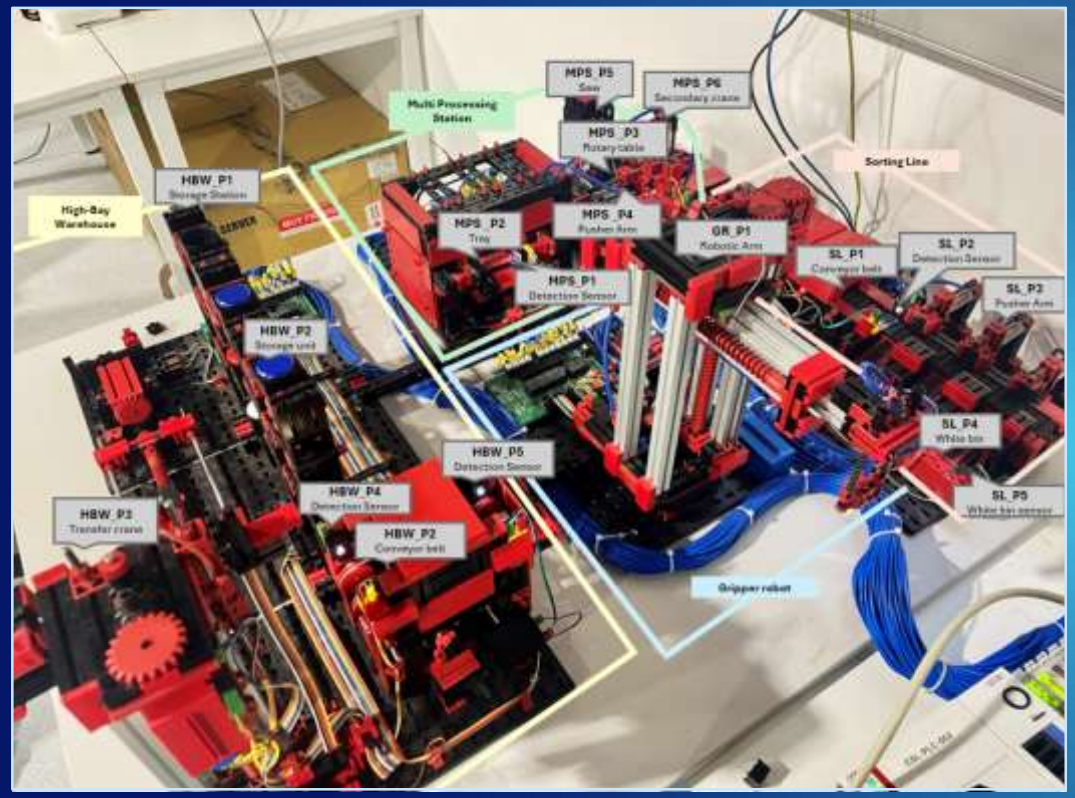
- **SceneMapping**
  - **MeshBinding** `Transfer_crane`
    - **GeometryBinding**
      - **Binding** `position · axis y`
        - **Source** `→ horizontalPosition`

BUILT ON 6 STANDARD IDTA SUBMODEL TEMPLATES + our two extensions above

02006	02003	02017	02027	02011	02026
Digital Nameplate identity	**Technical Data** specifications	**Interfaces Description** AID · how it talks	**Interfaces Mapping** AIMC · signal mapping	**Hierarchical Structures** BoM · how it decomposes	**Provision of 3D Models** where geometry lives

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Testbed: Fischertechnik Industry 4.0 Mini-Factory



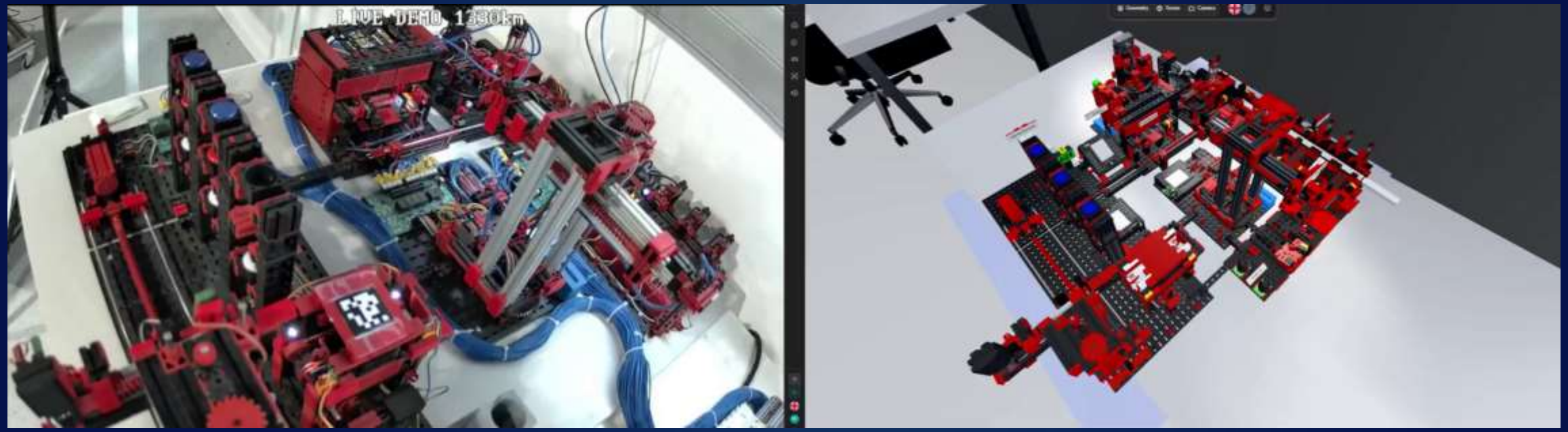
Four subsystems

- **High-Bay Warehouse**
  storage & retrieval
- **Gripper Robot**
  handling between stations
- **Multi-Processing Station**
  furnace oven, saw, rotary table
- **Sorting Line**
  colour detection & classification



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Testbed: Fischertechnik Industry 4.0 Mini-Factory



Limitations & Discussion

Single-object evaluation
Mini-factory moves one workpiece at a time — multi-object concurrency needs further benchmarking.

1

REST write-back overhead
≈16 POST requests per frame at 3 Hz from Isaac Sim to the AAS add avoidable latency.

2

Rigid-body assumption
PhysX suits solid parts; deformable materials or unmodelled friction need extra modelling.

3

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Conclusions & Key Takeaways



Modular, standard-based
Connects physical-AI tools like NVIDIA Isaac Sim into an AAS-driven ecosystem



No dense sensing required
Backend GPU physics fills the gaps between sparse sensors



Any device, flat bandwidth
Lightweight Web3D rendering driven by AAS state updates

Future work

1. Pure MQTT write-back pipeline
2. Fault-injection campaigns to benchmark residual-detection precision
3. Validation in full-scale, multi-line industrial facilities

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Thank You!

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