UNITEDXR EUROPE 2026 · SCIENTIFIC CONFERENCE · BRUSSELS

FROM NATIONAL DATA TO THE HEADSET

A **SPATIAL COMPUTING ARCHITECTURE** FOR DATA-TO-XR PIPELINES: BRIDGING NATIONAL GEOSPATIAL INFRASTRUCTURE AND IMMERSIVE DIGITAL TWINS

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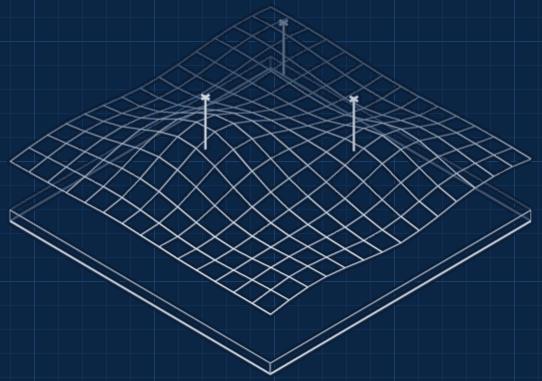
SPATIAL COMPUTING & CLOUD AI SOLUTIONS ARCHITECT

Founder at MetaParametric.com



NINE SUPERSITES · TERRAIN · SENSORS · OPEN EO DATA

Digital Waters · SAFIRE UNIVERSITY OF OULU · UNIVERSITY OF OULU

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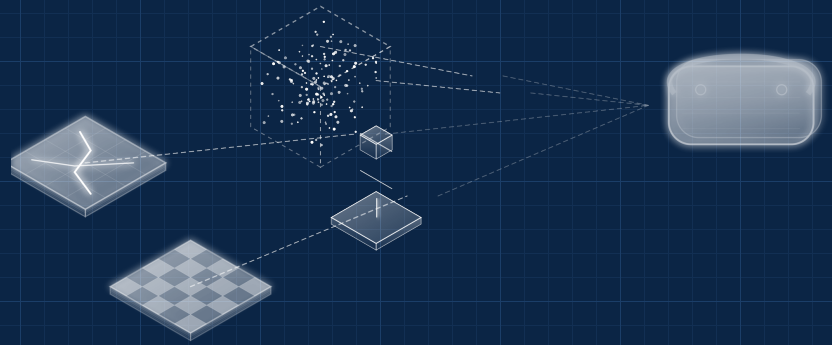
THE PROBLEM

THE DATA-TO-XR STEP IS THE WEAK LINK

01 **HETEROGENEOUS SOURCES**
Vector · raster · point cloud · live sensors

02 **BESPOKE PIPELINES**
Rebuilt for every project

03 **AN UNDERSPECIFIED LAYER**
Between harmonised data and the headset



Four source types: vector, raster, point cloud and sensor, each with a broken link to the headset

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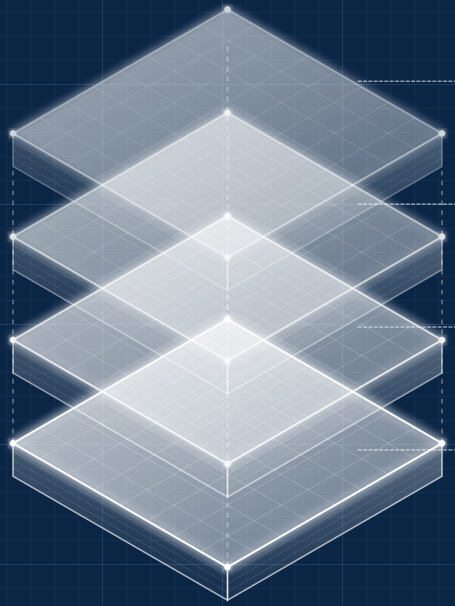
WHERE THIS WORK SITS



L4 **APPLICATION AND PRESENTATION**

L3 VIRTUALIZATION CORE

L2 DATA SPACE

L1 PHYSICAL ENTITY LAYER

Four stacked layers: the top slab is where the data-to-XR pipeline lives
DIWA: a Finnish national research infrastructure building a digital twin of the hydrosphere

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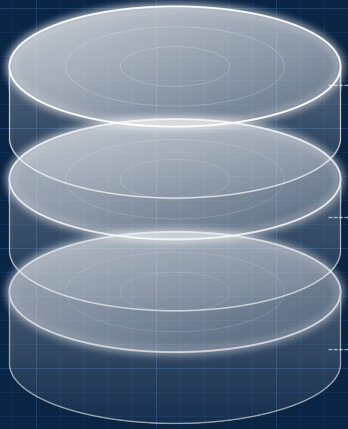
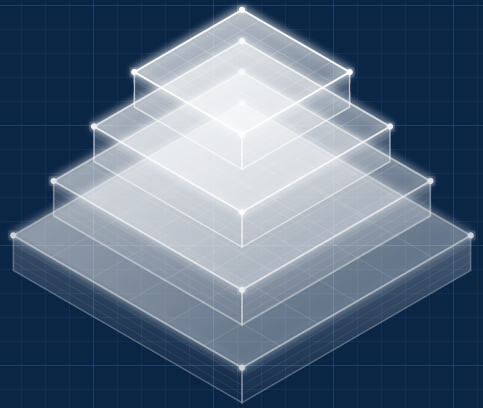
UPSTREAM SOURCES

TWO SOURCES, TIERED BY XR-READINESS



DIWA DATA SPACE

Three service discs feed one data space · SensorThings next



GEOPORTTI · NATIONAL

Stepped tiers: basemap at the base, international context on top.

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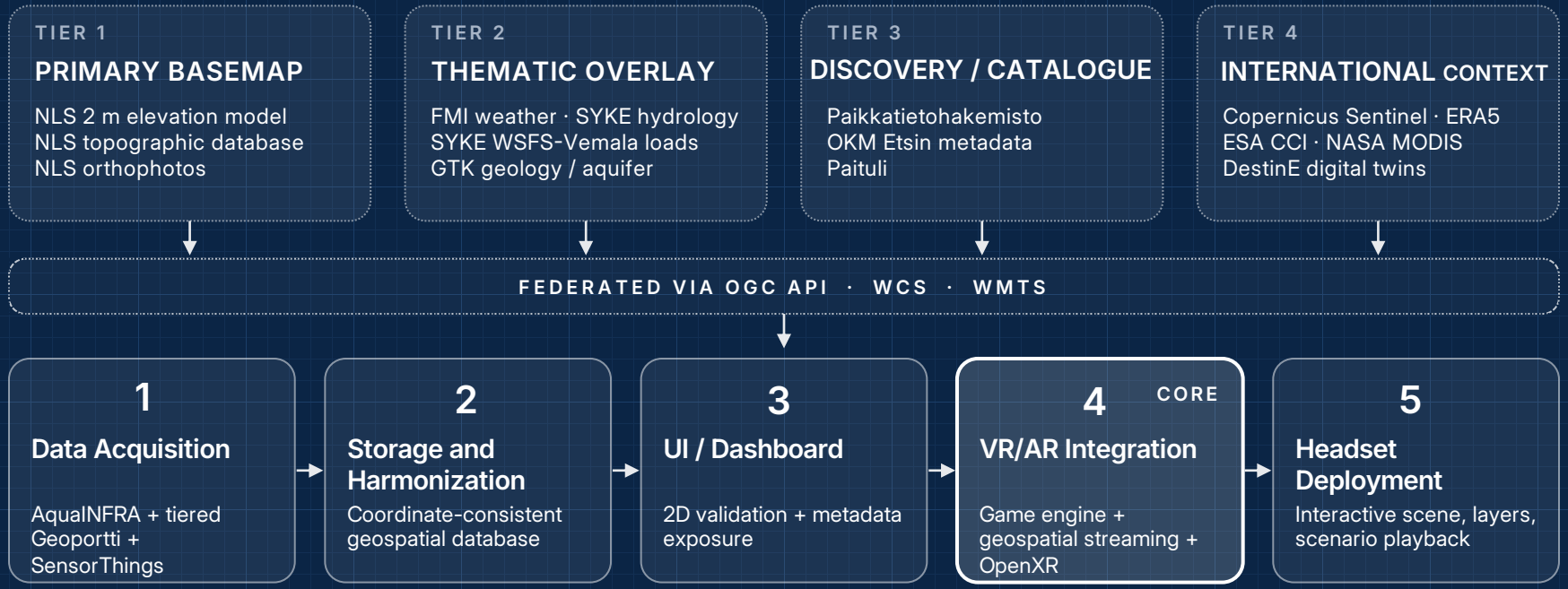
FIGURE 1 · SPATIAL DATA ARCHITECTURE

FOUR TIERS IN, FIVE STAGES THROUGH



Source tiering resolves which federated national datasets are basemap-ready before harmonization

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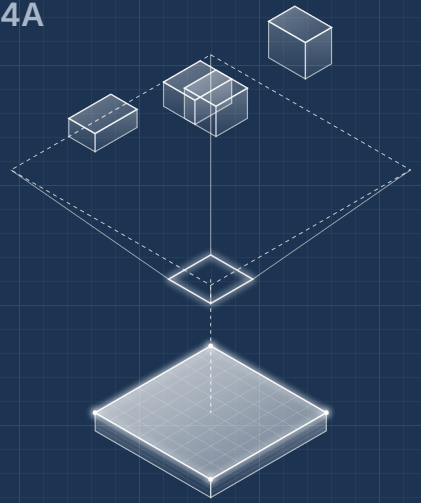
STAGE 4 · CORE CONTRIBUTION

HARMONISE, THEN STREAM

1 2 3 **4** 5
PIPELINE

4A

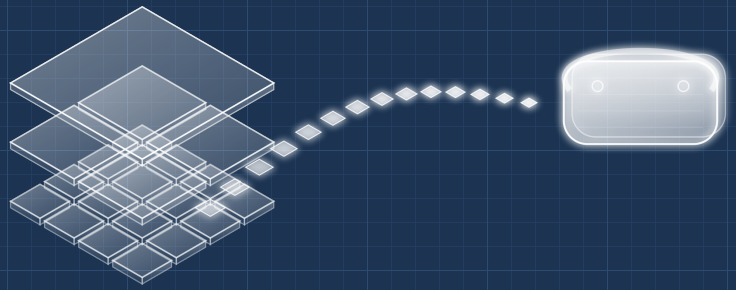


XR DATA HARMONISATION

- GeoJSON
- GeoTIFF · heightmaps
- LAS / LAZ
- glTF

Many formats in, one aligned XR-ready model out

4B



GEOSPATIAL STREAMING

3D streaming layer · OpenXR · any headset

Tiles flow to the headset at the level of detail it needs

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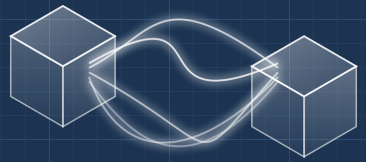
POSITIONING

COMPLEMENTARY, NOT COMPETING



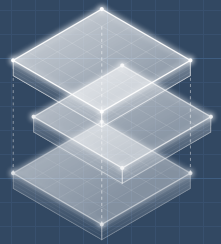
BESPOKE PIPELINE

- One project's data
- Coordinates fixed per project
- Little reuse



STREAMING PLATFORM ALONE

- Assets you upload
- Global frame only
- Reuse inside the platform



THIS ARCHITECTURE

- National + research infrastructures
- National CRS kept, one transform at export
- Pattern across sites and runtimes

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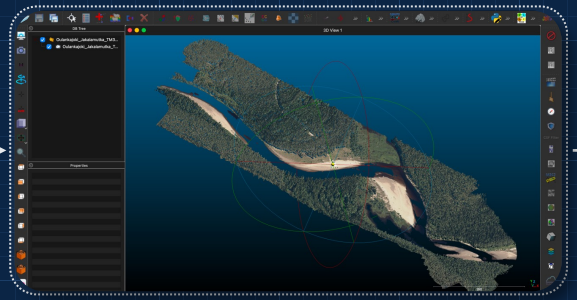
THE FIRST BUILD: UNITY ON QUEST 3

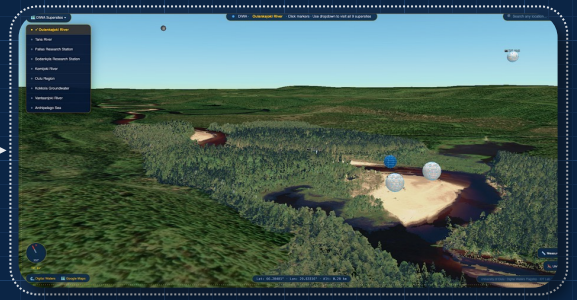
STAGE 1	STAGES 2–3	STAGE 4	STAGE 4	STAGE 5
REALITY CAPTURE	**CLOUDCOMPARE**	**CESIUM ION**	**UNITY + CESIUM**	**META QUEST 3**
Terrestrial LiDAR + drone orthomosaic	CRS harmonisation + point-cloud tiling	3D Tiles hosting + base map	OpenXR interaction, in-scene charts	Standalone VR runtime



SOURCE DATA



HARMONISED + TILED POINT CLOUD



IMMERSIVE TWIN ON THE HEADSET

Implemented: capture · processing · XR integration · visualisation. Next: live sensors via OGC SensorThings.

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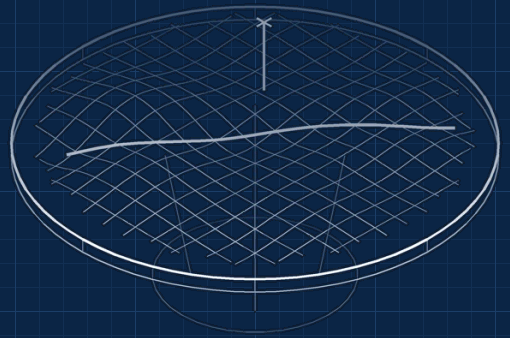
INSIDE THE OULANKAJOKI TWIN



VR · UNITY ON META QUEST 3



The same site in WebXR: a 3.7 km real-map table around the station

WEBXR · BROWSER, QUEST, AR

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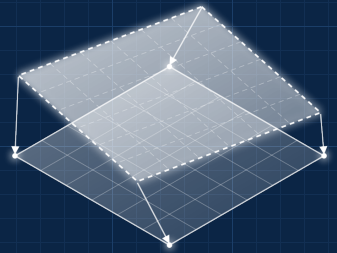
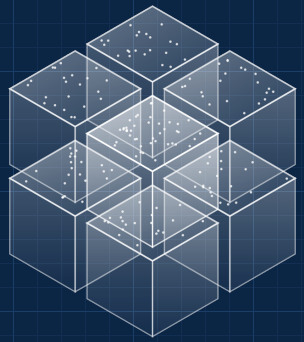
FOUR PATTERNS THAT GENERALISE



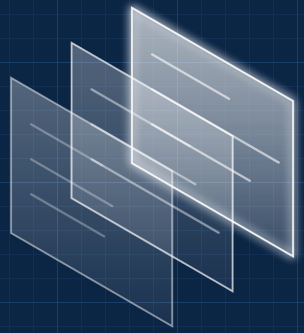
CRS HARMONISATION

ETRS-TM35FIN ↔ WGS84, one transform at export



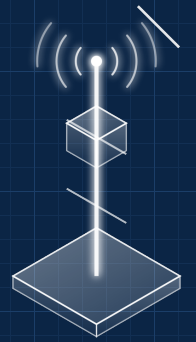
POINT-CLOUD TILING

Tile before streaming



LAYERED INFORMATION

No sensor overload in the headset



GRACEFUL DEGRADATION

Works with patchy field connectivity

Reusable spatial computing patterns, not site-specific fixes.

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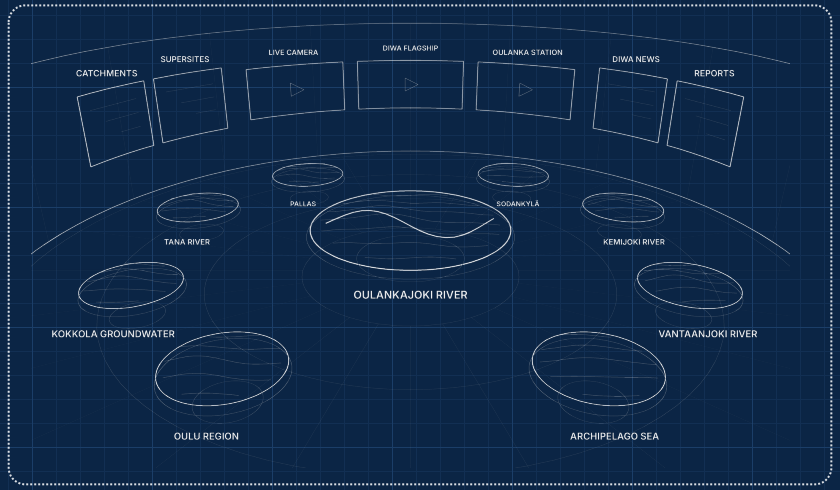
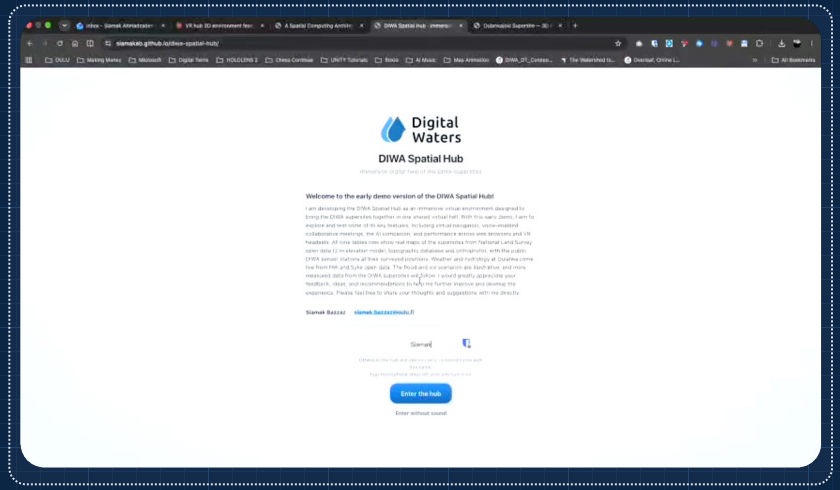
ONE HALL, EVERY SUPERSITE



A circular hall: the Oulankajoki Flagship Table in the centre and eight real-map supersite tables around it, each with sensors, weather, hydrology and water quality



WEBXR: Browser, Quest and AR · multi-user · no install

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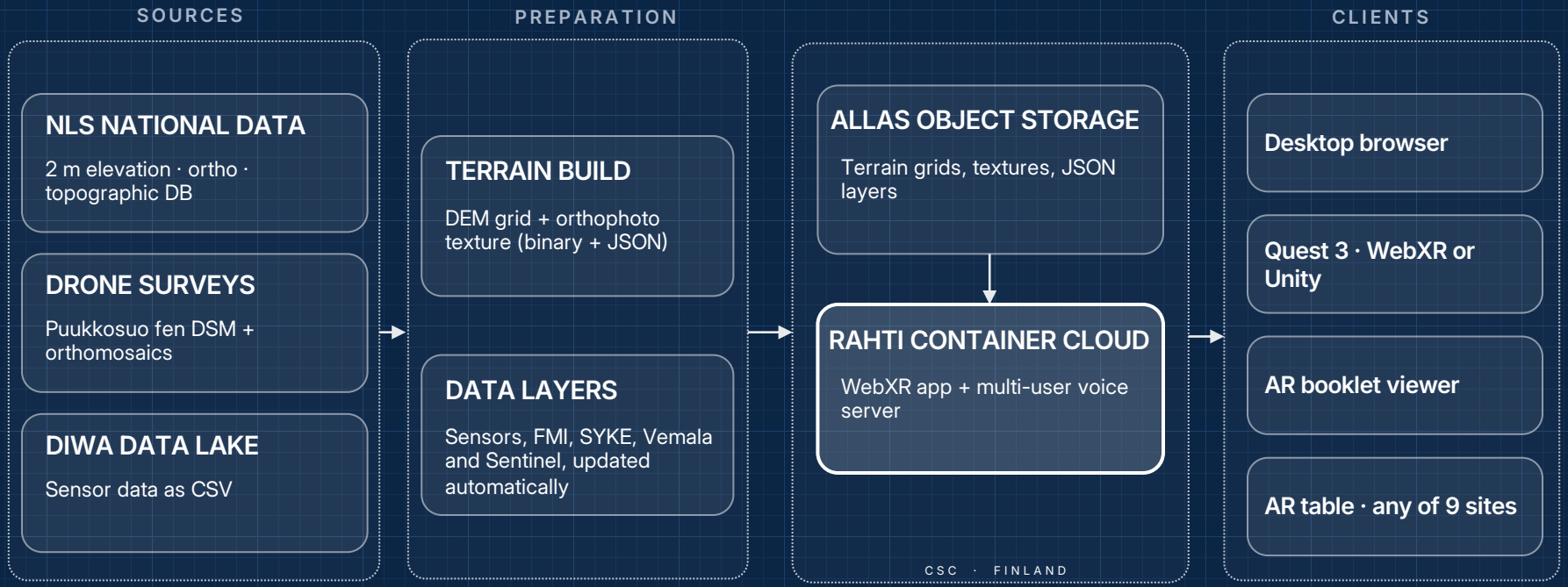
THE HUB, HOSTED ON CSC



Current: WebXR & multi-user validation | Deployment Architecture: Sovereign CSC Allas + Rahti Container Cloud (Finland)

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CASE B · OPEN DATA LAYERS

FROM SATELLITES, TO SUPERSITES

LIVE IN THE HUB

FINLAND

NLS terrain + ortho
FMI weather
SYKE rivers + Vemala

EU · RUN BY ESA

COPERNICUS

Sentinel-2 seasons
Sentinel-1 flood + ice
Snow · GloFAS · ERA5

CLIMATE RECORDS

ESA

CCI Snow since 1979
CCI Soil moisture
CCI Lakes · WorldCover

SINCE THE 1980s

NASA

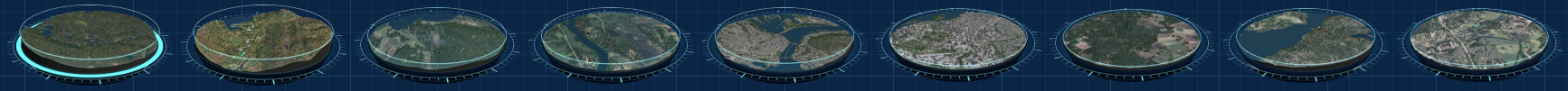
MODIS snow · SMAP
Landsat then and now
GRACE groundwater

ACCESS REQUESTED

DESTINE

Climate digital twin
Extremes digital twin
2050 table scenarios

NINE REAL-MAP TABLES · ONE COORDINATE SYSTEM · AUTOMATED OPEN-DATA UPDATES



Oulankajoki · Tana · Pallas · Sodankylä · Kemijoki · Oulu · Kokkola · Archipelago · Vantaanjoki

Every layer is free and open: real-map tables for all nine DIWA supersites, built from national and European open data

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CASE B · DEPLOYMENT FLEXIBILITY

ONE ARCHITECTURE, TWO CLOUD TRACKS

The same harmonised spatial pipeline deploys on sovereign research infrastructure or hyperscale commercial cloud.

SOVEREIGN & RESEARCH CLOUD · FINLAND / EU

CSC · IT Center for Science

- **Compute & simulation:** CSC LUMI (AMD GPU HPC) + cPouta
- **Storage & containers:** Allas Object Storage + Rahti Container Cloud
- **Best for:** National digital twins (DestinE, EDITO), public-sector and EU R&D compliance

COMMERCIAL & ENTERPRISE CLOUD · GLOBAL

AWS + OpenUSD ecosystem

- **Live telemetry & scene graph:** AWS IoT Core + OpenUSD / glTF pipelines
- **Spatial intelligence:** Amazon Bedrock + Model Context Protocol (MCP) agents
- **Delivery:** Cloud GPU streaming → zero-install WebXR, Quest 3 and AI smartglasses
- **Best for:** Energy grids, critical infrastructure and industrial operations

Decoupling data harmonisation from cloud runtime eliminates vendor lock-in across research and industry

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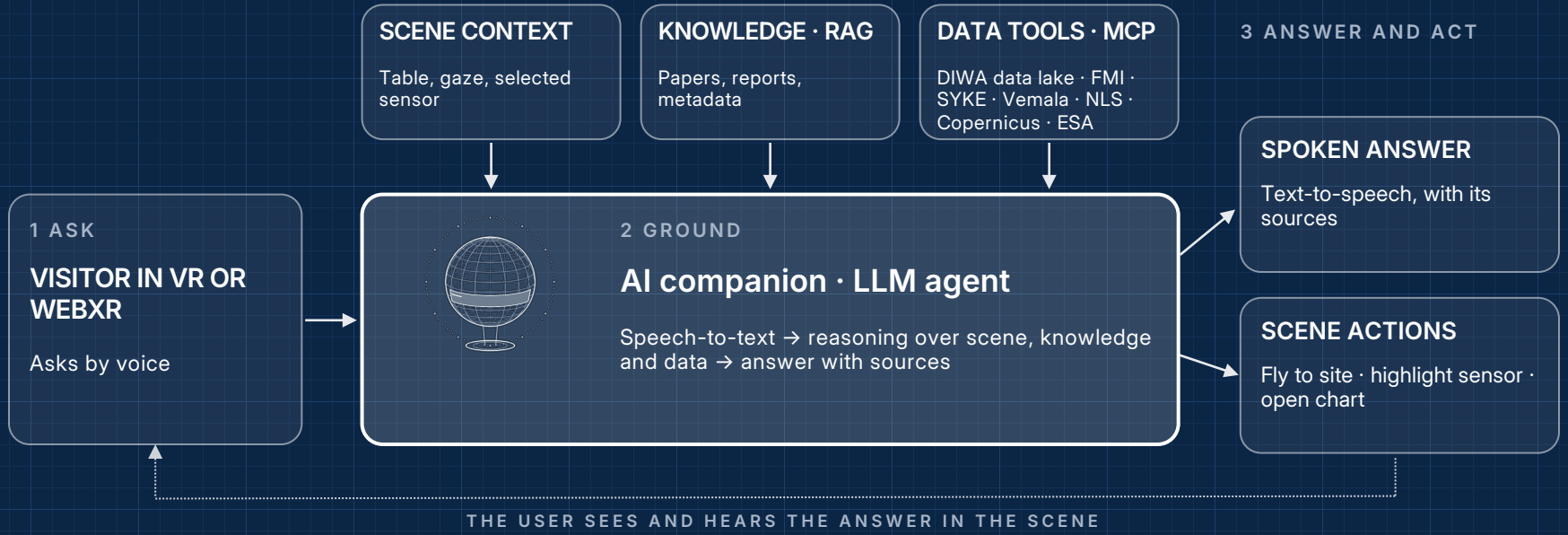
CASE B · AI AGENT IN THE HUB

ASK THE TWIN, GROUNDED IN DIWA DATA



Status: Active VR companion prototype; expanding to WebXR. Domain-agnostic MCP agent architecture transferable to energy and infrastructure twins

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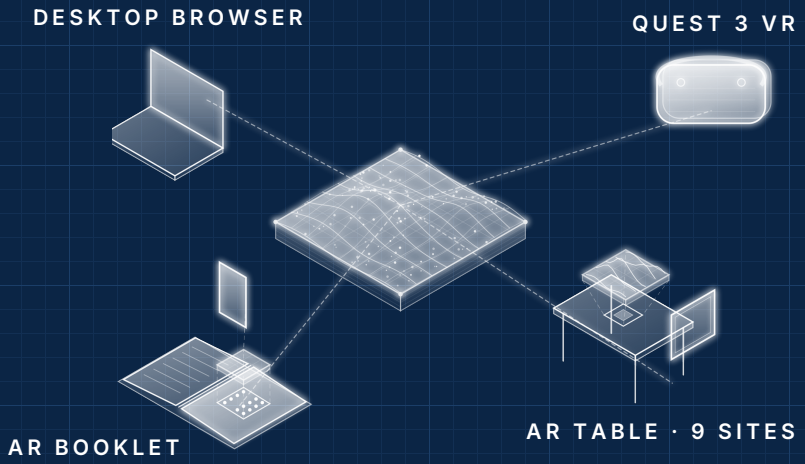
HARMONISE ONCE, SHOW ANYWHERE



Nine harmonised real-map tables feed four front ends: same data, same coordinates.



The AR booklet as a web flipbook: print it, scan a table, the model rises

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FROM ONE SITE TO EVERY SUPERSITE

CATCHMENTS

7 CATCHMENTS



SUPERSITES

9 SUPERSITES



Real-map tables for all 9 supersites with sensors, FMI, SYKE and WSFS-Vemala data. **Next:** satellite time layers (Sentinel-2 seasons, snowmelt), DestinE future climate, live SensorThings & CSC hosting.

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TAKEAWAYS

THREE THINGS TO REMEMBER



DATA-TO-XR DESERVES ITS OWN ARCHITECTURE

Harmonisation + streaming, both reusable



ORGANISE INFRASTRUCTURE BY XR-READINESS

Tiers turn a provider list into building blocks



THE PATTERN TRANSFERS ACROSS RUNTIMES

Unity on Quest 3 → WebXR · nine supersites from open national + European data

THANK YOU

Building cloud-native digital twins, spatial AI agents, or energy/infrastructure XR?

Let's connect!

LINKEDIN · SIAMAK BAZZAZ

R&D, Enterprise & Venture Partnerships

METAPARAMETRIC.COM

Blueprints, Live WebXR & Advisory

Digital Waters

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