M&S as a Service (MSaaS): Proof of concept development and integration of a Sensor-as-Service for a virtual flight training Eurofighter simulation

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Agenda

- Project Goal and link to NATO MSG-164 MSaaS
- Demonstrator System Overview & Components
- Demonstrator Implementation and Service Integration
- Example Scenario
- Summary / Way Ahead

Goal of the project

- **Evaluate how a MSaaS environment may support virtual simulator training by**
  - Apply state-of-the-art Cloud Technology to easily deploy and control the service environment
  - Support reusability and/or exchangeability of services among different simulators
  - Support fair-fight conditions through centralized services

- **Evaluate the feasibility on a Sensor-as-a-Service**
  - Simulate a physical infrared sensor
  - Using standardized interfaces
  - Evaluate cloud-based 3D rendering performance, delay and bandwidth

Linkage to NATO MSG-164

- **MSG-164 MSaaS Phase 2** targets to develop a service architecture providing rapid deployment of interoperable and credible simulation environments.
- Develop a proof of concept demonstrator to show the feasibility of a service based environment defined at MSG-164.
- Reuse and interoperability of national developments
  - **NATO MSG-136** (2014-2017) GER/NOR demonstrator for proof-of-concept of existing services easily reused and linked.
  - Extend it by capabilities designed by **German System Demonstrator VIntEL** (2008-2015) reusable architecture for distributed simulation environments with centralized services to tackle fair-fight problem and to increase the creditability of distributed testbeds.

Integration into Allied Framework for MSaaS

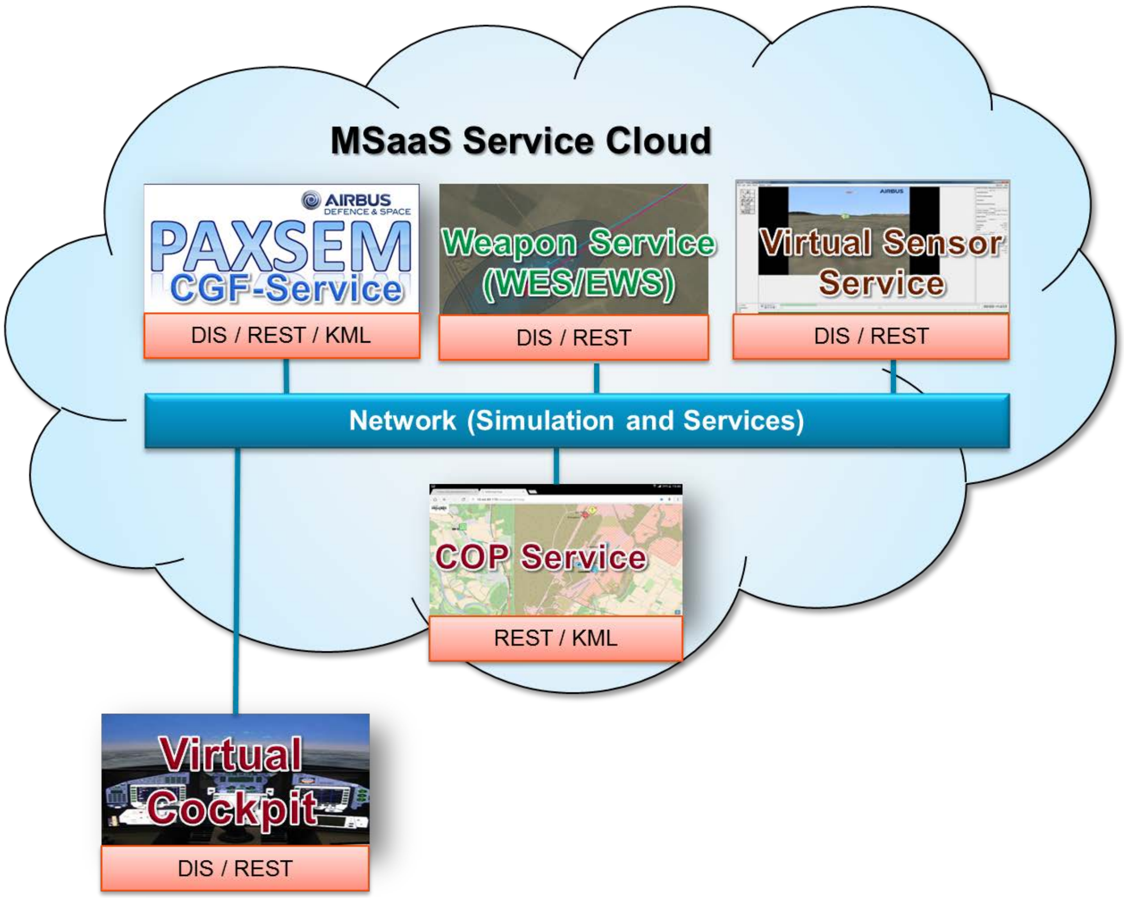
MSG-164 Demonstrator System Overview

Components:

- 5 services (+SES service)
- GE EF flight simulator + cockpit
- COP + Simulation Control

Interfaces & Standards*:

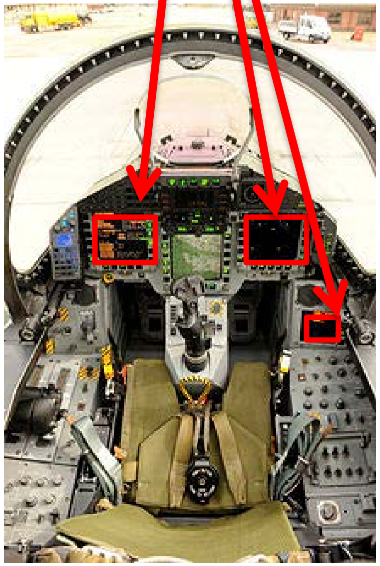
- DIS / HLA (RPR-FOM)
- OGC WMS
- OGC KML
- HTTP/REST
- STANAG 4609 Video



*Orientation on NATO AMSP-01 "NATO M&S Standards Profile"

Virtual Cockpit Simulator

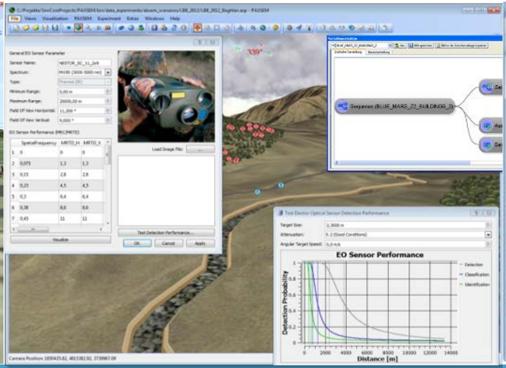
- Full virtual replicate of the conventional Eurofighter cockpit.
- incorporates 3 full color multi-function head-down displays (MHDDs), a wide angle head-up display (HUD) as well as other command and control elements to interact with the Eurofighter.
- The targeting pod contains a high-resolution, forward-looking infrared (FLIR) sensor that displays an infrared image of the target to the pilot.

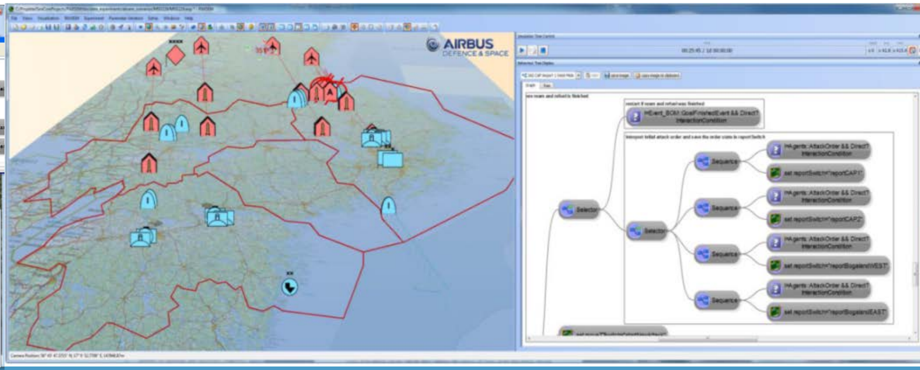


Source:https://de.wikipedia.org/wiki/Datei:Cockpit_of_RAF_Typhoon_Fighter_MOD_45152531.jpg

CGF Service

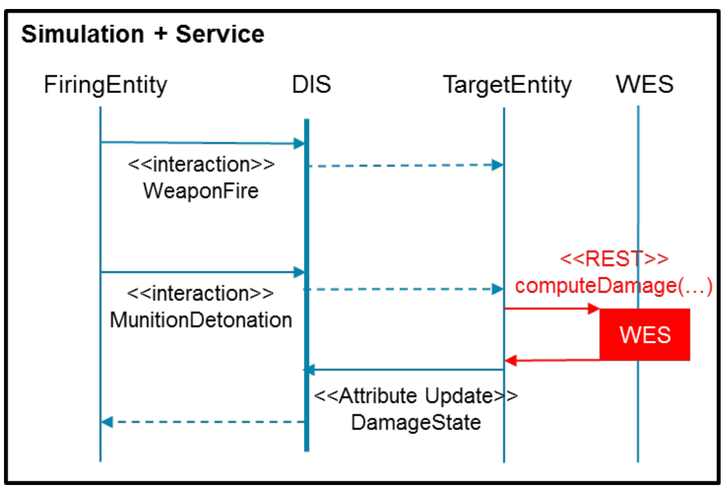
- Based on the Airbus simulation "PAXSEM" – a 3D agent based simulation model for analyses of operational scenarios on a tactical & technical level
- Detailed physical models of sensors, weapon and platform characteristics
- PAXSEM was developed by Airbus for the following two use cases:
  - ➢ PAXSEM as a constructive faster-than-realtime simulation within the Data Farming process (e.g. MSG-124) for operational analyses
  - ➢ PAXSEM as a scenario generator in distributed simulation environments. Link to multiple operational interfaces like NFFI, ASTERIX, STANAG 4609/4545, GMTI
- Deployable as a Windows / Linux Docker container

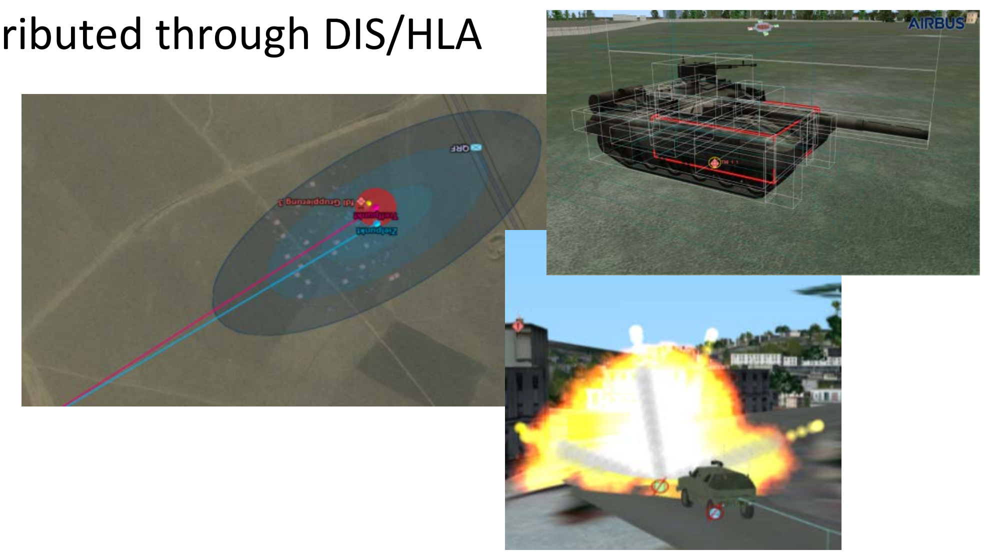




Weapon Effect Service

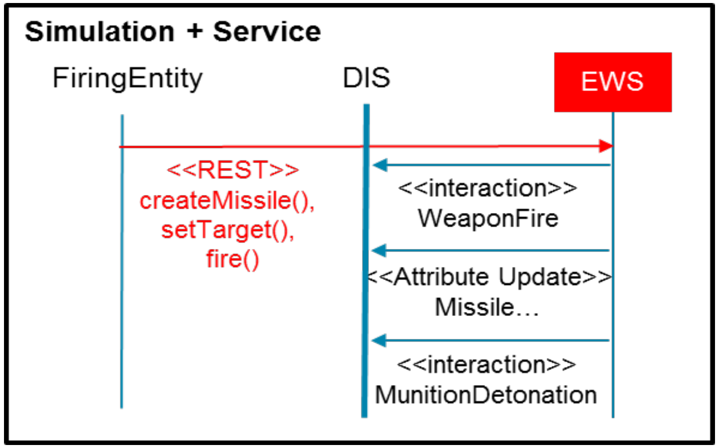
- is able to monitor a DIS/HLA federation in order to centrally compute weapon effects on simulation entities in order to help to solve fair-fight problems.
- evaluates the geographic position of the munition detonation and calculates the resulting direct and indirect damage state of the requesting simulation (target) entity.
- It implements the damage model VEMAG ("Verwundbarkeitsmodelle für AGDUS und GefÜbZ H")
- Weapon Effect Interactions are distributed through DIS/HLA





Exterior Weapon Service (EWS)

- EWS models whole process of weapon usage:
  missile creation, aiming, fire/flyout until the detonation.
- Two-step process of aiming and firing:
  1. Create missile object
  2. Set target and fire: target information is processed (launch success zone) and munition is released towards the target position.
- Depending on the missile model, the missile flight is modelled including the sensor, flight dynamics and warhead. The missile is published through DIS/HLA and ends with a MunitionDetonation interaction

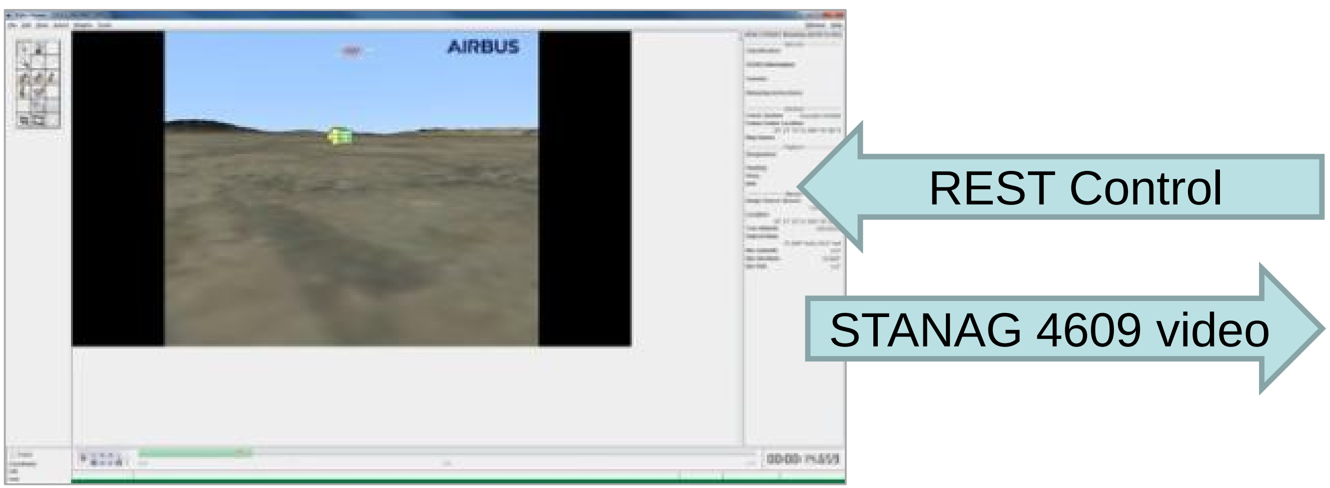


COP Service

- is a javascript based Web Client (html)
- Uses *OpenLayers* to display all types of maps using Web Map Service (WMS)
- COP service may be used as a static scenario editor through MSDL
- Connection to CGF service to load, start and stop the simulation scenario via HTTP REST interface
- Display the dynamic scenario in COP using a KML-service provided by CGF-Service

Virtual Sensor Service

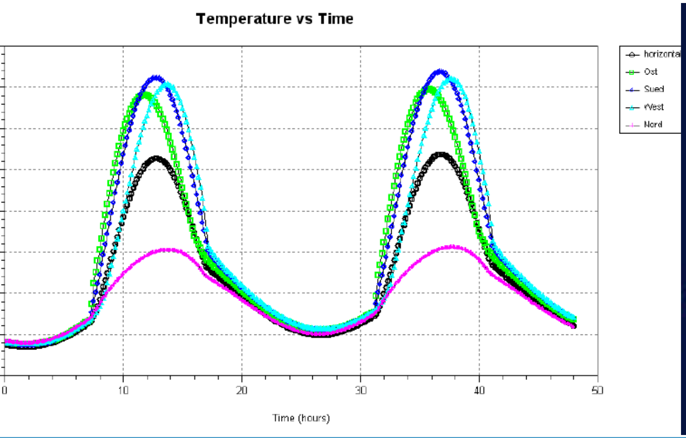
- enables to attach a virtual sensor to an entity of interest and to stream using STANAG 4609 that specific camera view to the requestor.
- Sensor has a fixed location or is mounted on a (movable) simulation entity.
- Sensor observes simulation entities (e.g. from DIS/HLA) in a synthetic environment (from SES).
- Multiple sensor types can be modelled: e.g. Optical sensor, IR sensor, radar sensor etc.

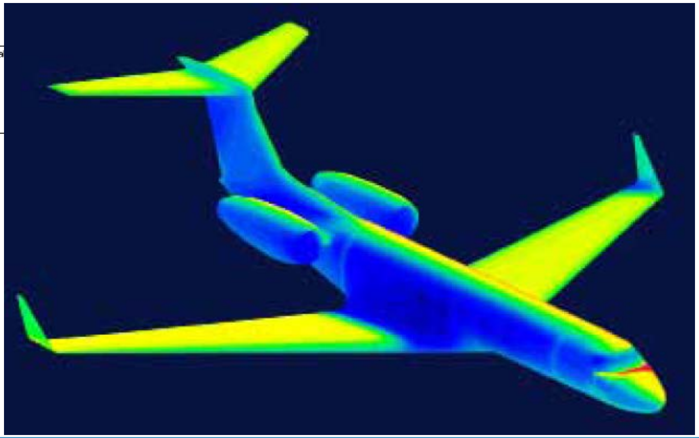


IR Sensor Module

- Integration of a physics-based sensor model „EMIT“ from MBDA
- EMIT was primarily developed for **HIL testing** of missiles such as PARS-3.
- IR generation workflow supports atmospheric models (MODTRAN) thermal models (Thermos, RadThermIR) to provide realistic and accurate IR views.
- IR sensor model allows to define arbitrary sensors, atmospheric and weather conditions and place 3D objects in the scene.

MBDA MISSILE SYSTEMS

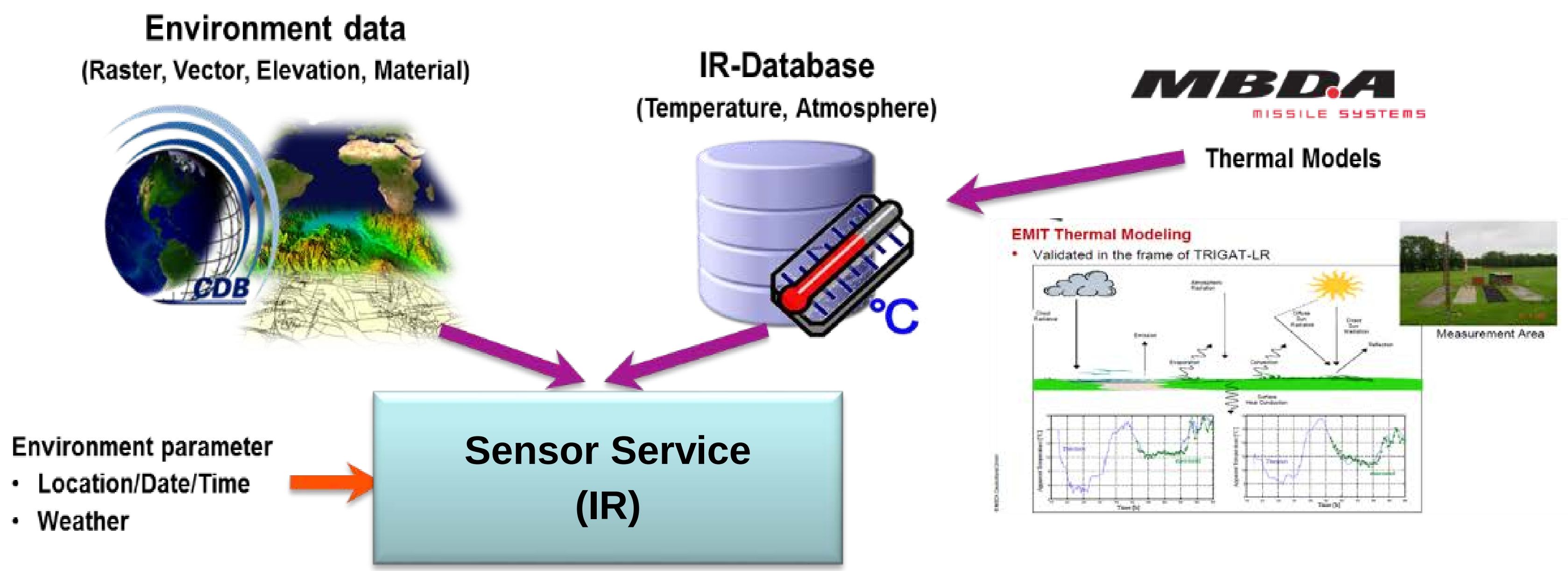




Sensor Service Implementation

Two phases:

- **Preparation** of the CDB workflow as **offline repository**
- **Application** of the sensor service in **runtime context (with current weather & temperatures)**

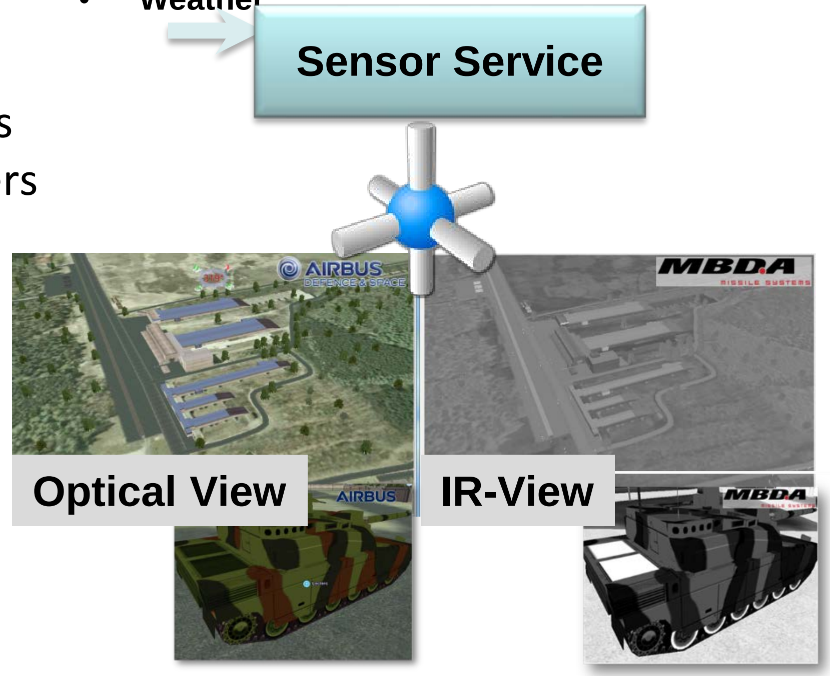


Sensor service in runtime context

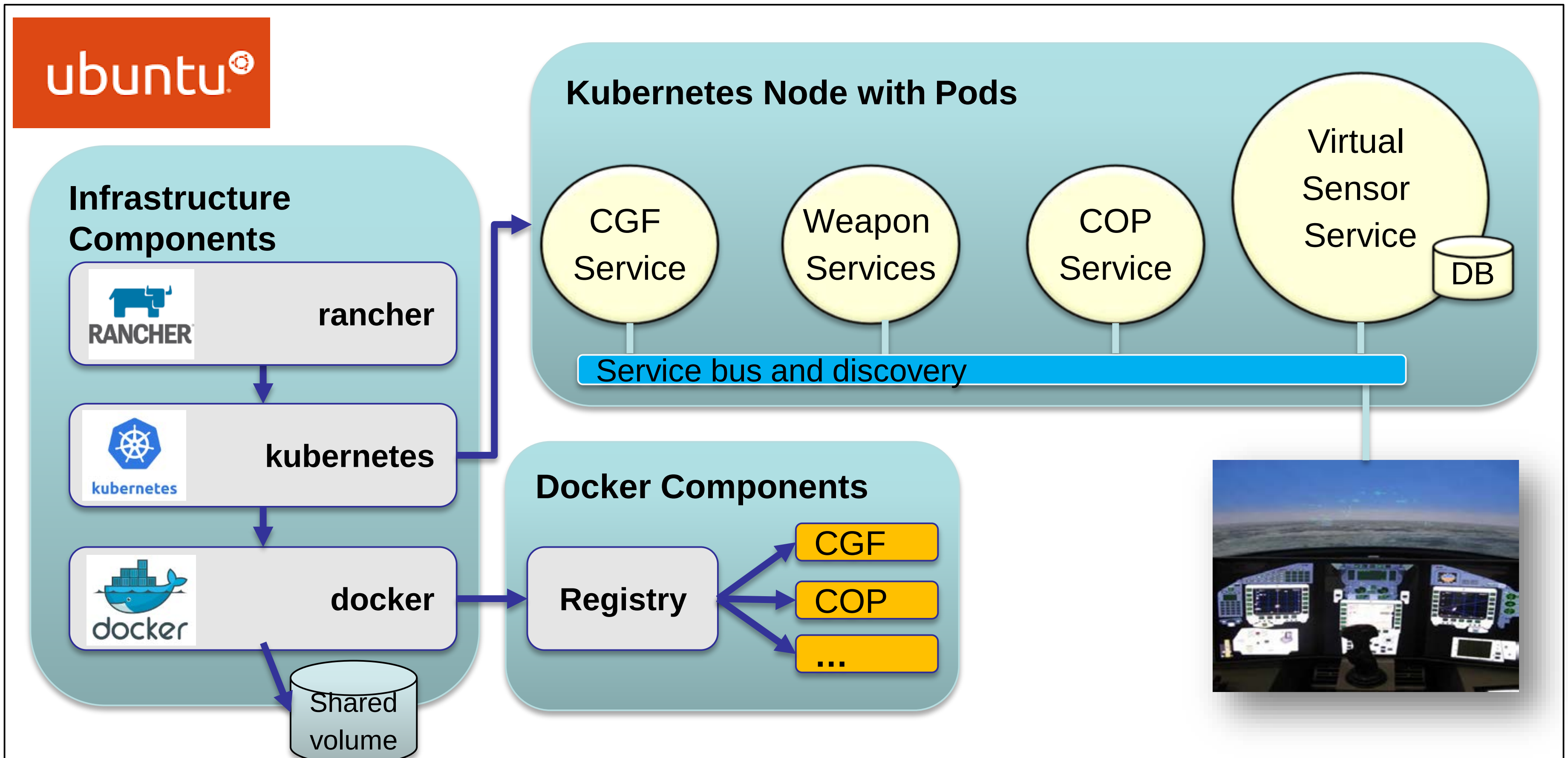
- sensor service **loads a scenario** (gaming area)
- scenario includes the **environmental parameters** like weather condition, exact date and time and the corresponding location.
- calibrated sensor through a **sensor configuration** which specifies the parameters like field of view, wave length and effect filters
- **thermal information** of the IR database is merged into the runtime context
- sensor service waits for **incoming requests** to serve the **video stream**.

Environment Conditions

- **Location/Date/ Time**
- **Weather**

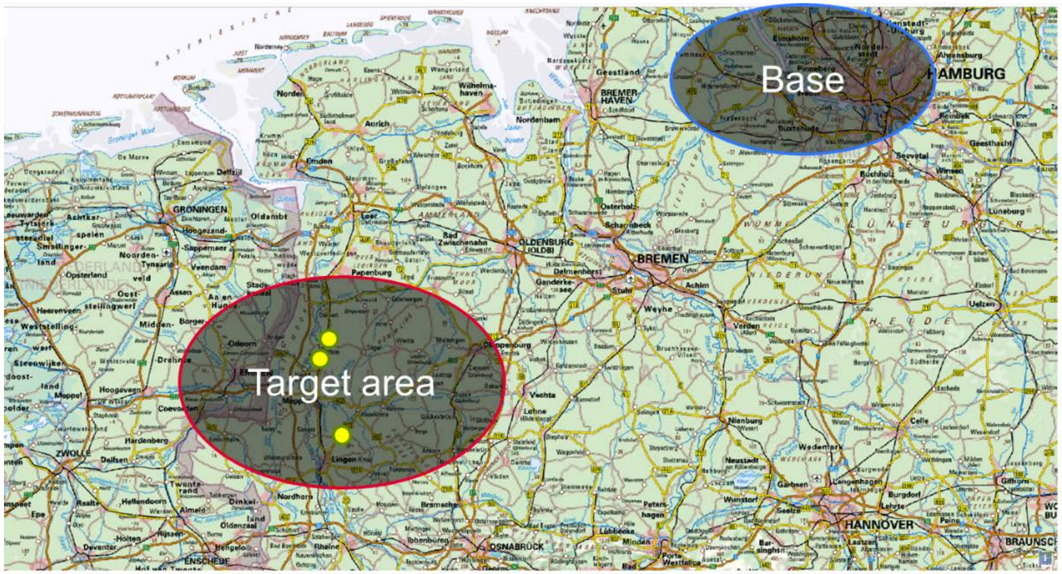


Cloud/Docker-Backbone: Kubernetes



Demonstrator Scenario

- Air units are tasked to conduct a reconnaissance mission.
- Mission starts from „Base“ towards „Target area“.
- Suspicious ground units are discovered and reported.
- Hostile weapon fire – Engagement through air units.
- Return to base



Scenario Course of Events

1. All services are required to **initialize with terrain** data through a shared data cloud.

2. The **COP service** requests through its OGC WMS interface to a **2D map service**.

3. The **scenario operator** starts the **CGF service** through the COP service, loading a reconnaissance scenario with air- and ground-based simulation entities.

4. The **CGF service** tasks a simulated air track to conduct a reconnaissance mission together with the virtual Eurofighter simulator.
   The updated picture is displayed in the **COP service** in parallel.

5. The air units arrive at the target area and detects some suspicious ground units. One of the ground units is attacking the air unit on its mission using the **EWS**. The weapon effect and damage state for the air unit are calculated by the central **WES**, if any.

Scenario Course of Events

5. As a result, the **virtual cockpit operator** prepares to engage the enemy forces. During the movement, the HUD is displaying the optical image that is requested from **virtual sensor service** as well as the MHDD is displaying the infrared information.

6. The **virtual cockpit operator** targets to the enemy forces and shoots missile which is calculated by the central **EWS**. Depending on the engagement results, the service sends a munition detonation or not.

7. The weapon effect of the missile and damage state for the ground units are calculated by the central **WES**.

8. After successful engagement, the **air unit returns** to home base and ends mission.

Summary & Way Ahead

- Demonstrator has showed the feasibility of the **MSaaS service based approach** for M&S in an operationally relevant training environment.
- Existing services could be integrated in a complex Docker container environment.
- Apply **standardized interfaces** (e.g. DIS, KML) and **lightweight services** (HTTP/REST)
- It's envisaged to verify the advantages of containerisation solutions such as **rapid setup and deployment of simulation experiments** as well as **reusing container services to foster scaling effects**.

Way Ahead:

- Finalize implementation and verify the results, e.g. wrt the sensor service performance
- Integrate the demonstrator results into **CJSE 2020** experiment participation by MSG-164 through 2 aggregated complex service:
  - ISR reconnaissance service
  - Combat service

Thank you!
Any questions?

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