Your systems.
Working as one.

Building Distributed LVC Simulations with Data Distribution Service (DDS)

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Agenda

- An Overview of DDS
  - DDS Principles
- Differences between DDS and HLA/DIS
- Using DDS in MS&T Systems
  - A DDS to HLA demo system
- Conclusions

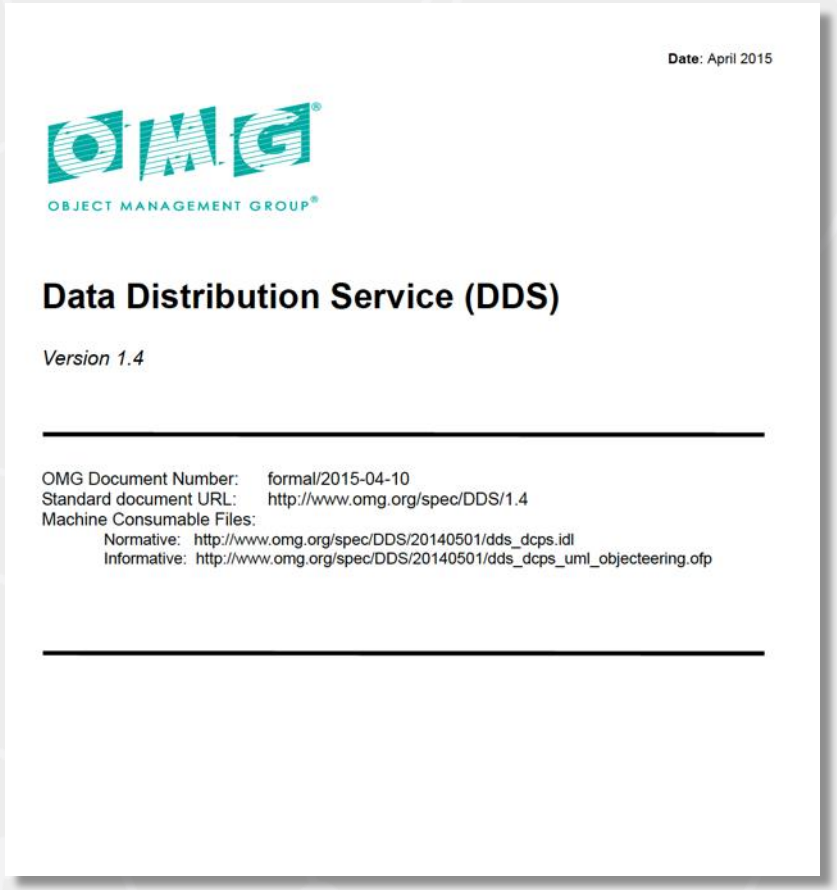
RTI in the Industrial IoT

- RTI is the largest connectivity middleware vendor
- 1350+ designs, many real-world programs across industries
- Full DDS, tools, services, support, secure and certified versions
- ~200 people

An Overview of Data Distribution Service (DDS)

OMG Data Distribution Service

- First version of the DDS standard was released in 2004
- Most recent version (v1.4) was released in April 2015
- “Data-Centric Publish-Subscribe model for distributed application communication and integration”


Date: April 2015

OBJECT MANAGEMENT GROUP

Data Distribution Service (DDS)

Version 1.4

OMG Document Number: formal/2015-04-10
Standard document URL: http://www.omg.org/spec/DDS/1.4
Machine Consumable Files:
Normative: http://www.omg.org/spec/DDS/20140501/dds_dcps.idl
Informative: http://www.omg.org/spec/DDS/20140501/dds_dcps_uml_objecteering.ofp

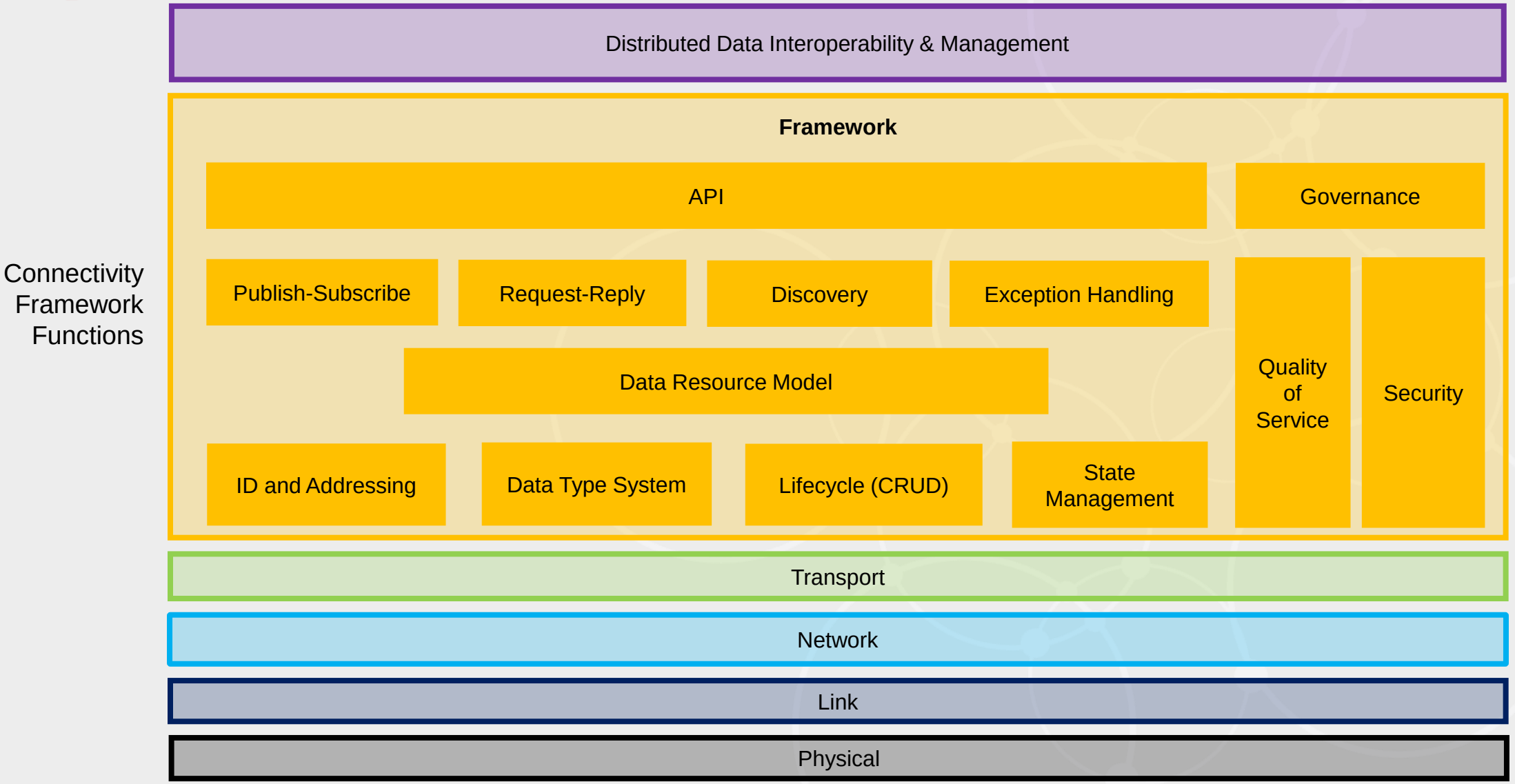
What is the Data Distribution Service ?

- DDS is an **open-standard** managed by the Object Management Group® (OMG)
- DDS is at the heart of many **OA** initiatives in A&D
- DDS is a connectivity framework technology for **real-time** systems that allows interoperability of **any CPU, language, and operating system**
- Operates a **Publish-Subscribe** paradigm, enables location transparency and is decentralized and dynamically scalable
- DDS takes a **Data-Centric** approach that simplifies connectivity management and improves scalability and code reuse while also reducing development cycle times

What is the Data Distribution Service ?

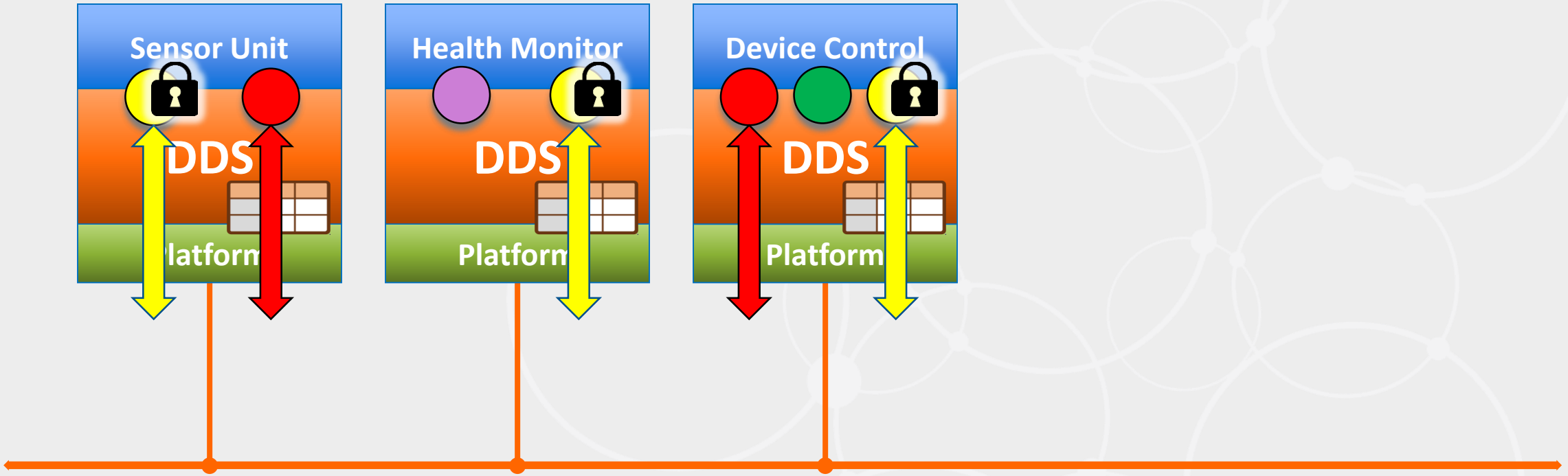
- DDS is **TRL 9** technology used widely in the "**L**" parts of **LVC** systems
- DDS was originally designed for mission critical systems
- DDS is ideally suited to applications that are required to share large amounts of data in a fast, secure, scalable and reliable way
- Because it's an open standard it's been adopted in numerous defense related projects (especially for the MOD and DOD)
- It's widespread use in military systems has led to strong interest in the simulation and training market

Connectivity Framework Layer

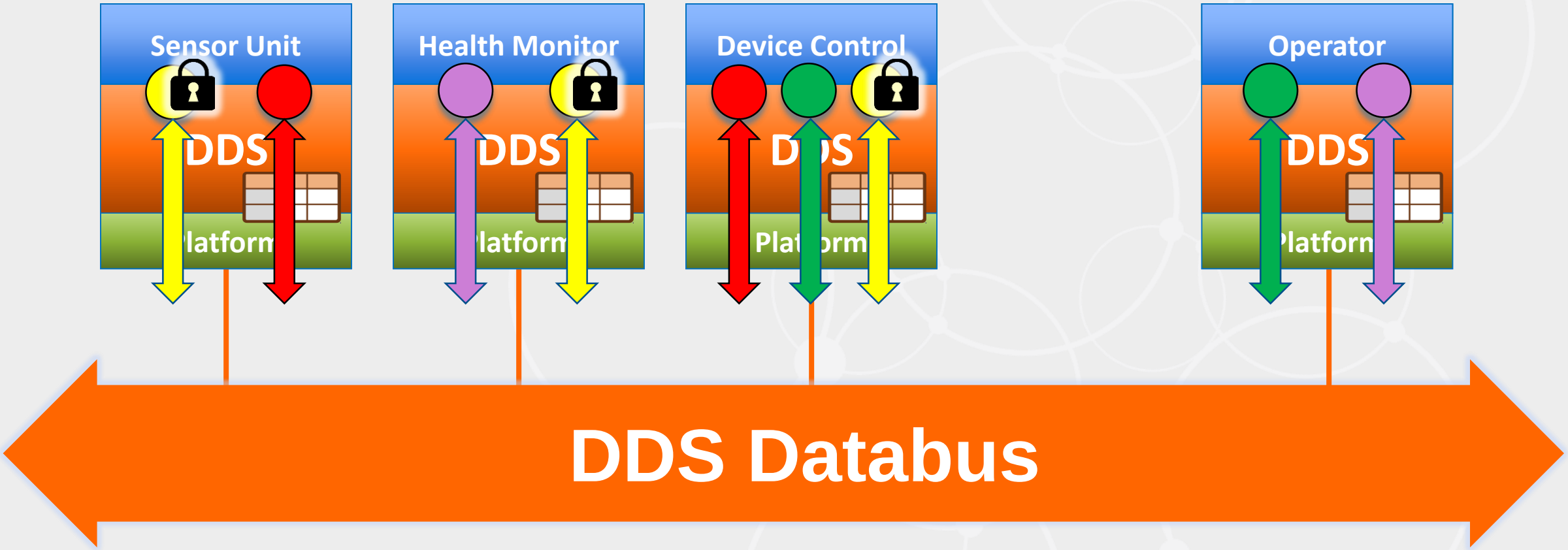


Connectivity Framework Functions

Connection via the DDS Databus…



Connection via the DDS Databus…

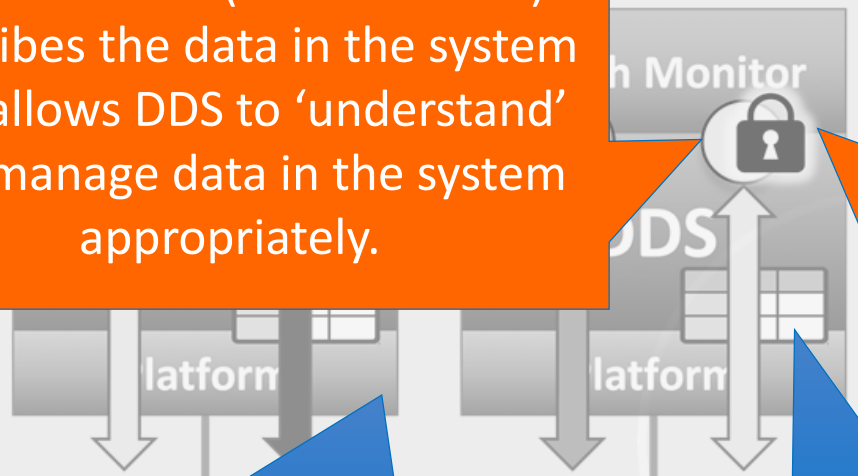


Connection via the DDS Databus…

A Data Model (written in IDL) describes the data in the system and allows DDS to 'understand' and manage data in the system appropriately.

DDS provides an API to the programmer (which RTI wrap in language bindings) to enable data-centric access to your data

Data flows are configured via Quality of Service settings that define how data is delivered between nodes in the distributed system. In DDS terminology these data flows are called Topics.



DDS abstracts the application away from the Operating System making the application less complex, more portable and transport agnostic.

Data is cached at endpoints by DDS (based on the QoS settings); the application always has the data it requires when it requires it.

DDS optimises network usage by filtering data appropriately (at either source or destination) and only delivering data when and where it is needed.

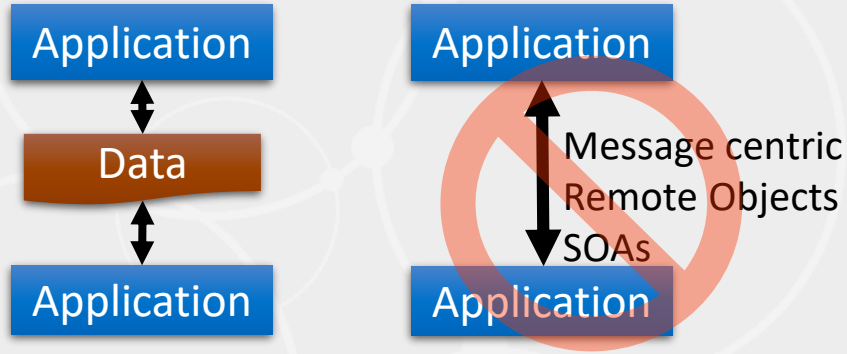
About Data Centricity

Data Centricity Definition

a) The interface *is* the data.

b) The infrastructure understands that data.

c) The system manages the data and imposes rules on how applications exchange data.



Database

Data centric storage and searching of old data

```
SELECT * FROM ShapeData
  WHERE color='RED' AND shapesize > 10;
```

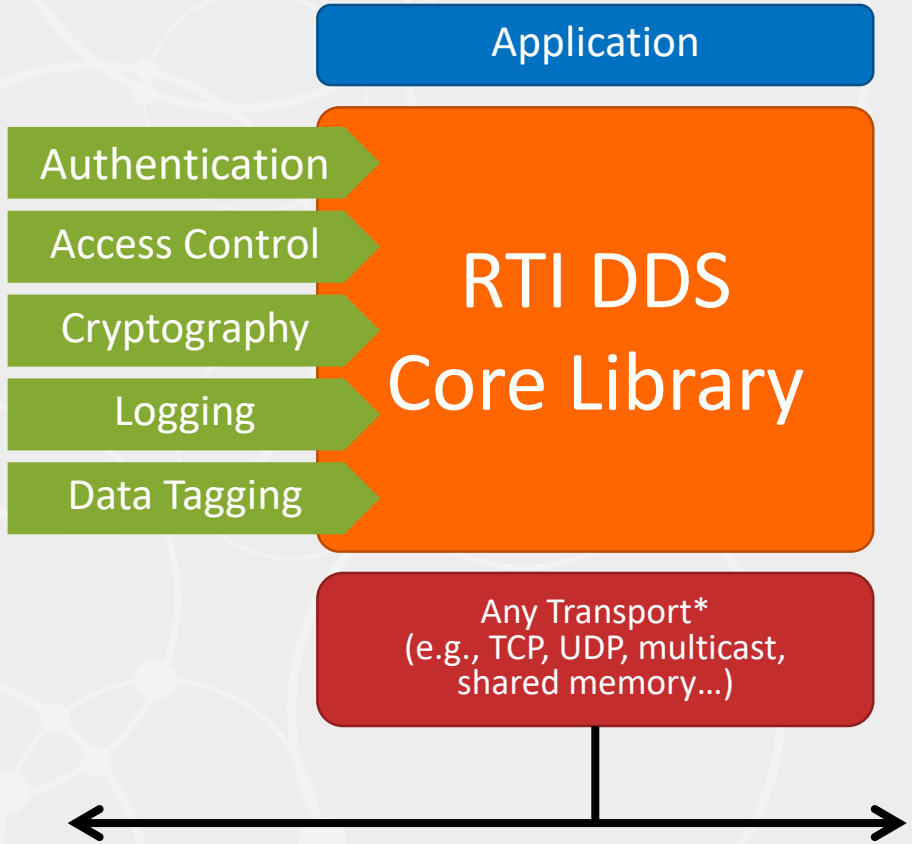
DDS Databus

Data centric sharing and filtering of future data

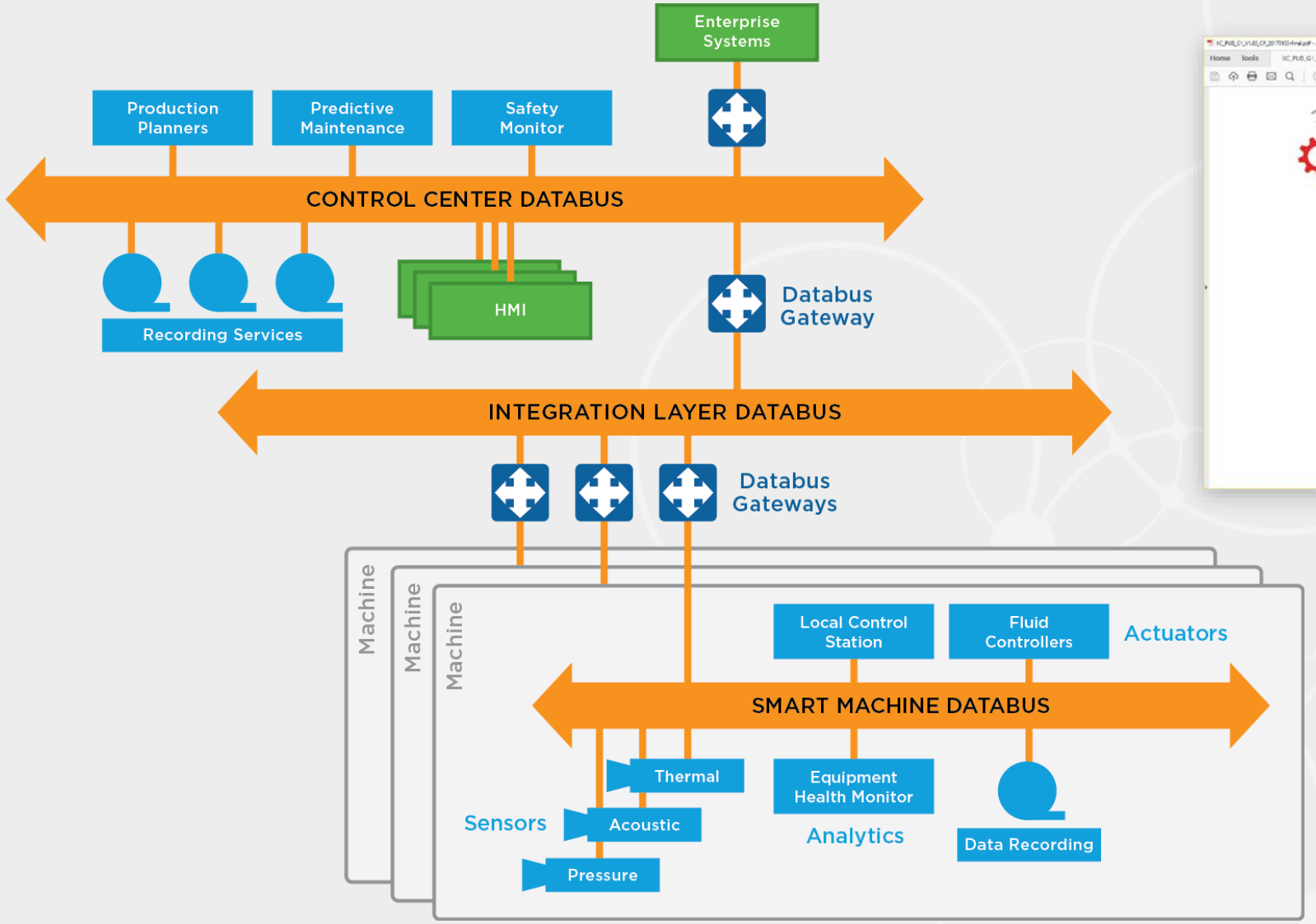
```
cft = create_contentfilteredtopic_with_filter(
  "MyFiltered_topic", ShapeData_topic,
  "(color MATCH 'RED') AND (shapesize > 10)", … );
```

DDS Security Plugins

- Based on OMG DDS Security spec
- Built-In Plugins
  - Little to no change required to DDS applications
- Optional SDK available to customize plugin behavior
- Runs over any transport
  - Does not require TCP or IP
  - Secure Multicast for scalability, low latency
- Completely decentralized
  - High performance and scalability
  - No single point-of-failure



The IIC Layered Databus Architecture Pattern



Why DDS ?

Data-centric	Resiliency	Performance	Faster development	Standards based
Naturally modular	High reliability	Minimum latency	SOA-like architecture	No vendor lock-in
Naturally scalable	Maximum up-time	Maximum throughput	Code re-use	Future proof

Differences between DDS and HLA/DIS

DDS & HLA/DIS Differences

- Interoperability Wire Protocol
  - DDS has a standard Interoperability protocol (RTPS)
  - DIS has a standard wire protocol (IEEE-1278)
  - HLA has no wire protocol
- API
  - DDS has standard APIs (DDS-DCPS)
  - DIS has no standard for consistent APIs
  - HLA has a “Run-Time Infrastructure” API
- Real-Time Quality of Service
  - DDS has comprehensive support for more than 20 QoS policies
  - HLA/DIS have no real support for QoS (only area of interest, some reliability and rate-reduction)

DDS & HLA/DIS Differences

- Presence & Discovery Services
  - DDS supports full presence, discovery and introspection of all participants, entities, types, QoS
  - HLA has limited support: Declaration Management and Disconnect notifications
- Simulation Services
  - DDS does not offer services specific to simulation
    - Although Time and Federation can be modeled in DDS
  - HLA supports simulation services:
    - Federation, Time, and Ownership Management

DDS & HLA (non-functional) Differences

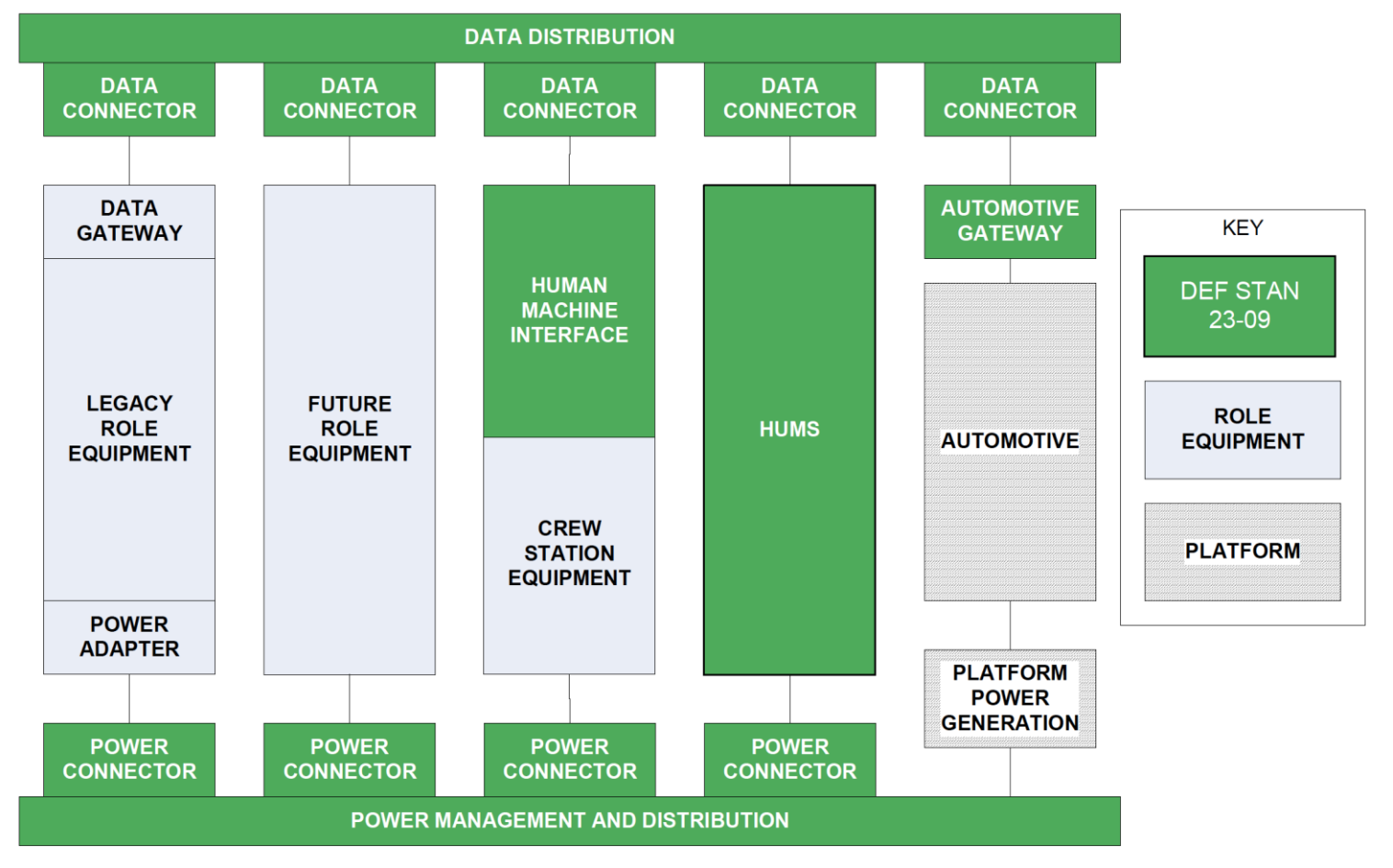
- Performance
  - DDS implementations have been benchmarked to have 40 usec one-way latency in standard Gbit Ethernet and throughput (for 256 B messages) close to the theoretical maximum of 1 Gbit/sec
  - HLA one-way latencies range from 300 usec to 30 msec and throughputs (for 256 B messages) on the order of 60 Mbit/sec
- Scalability
  - DDS implementations have benchmarked scalability up to 4000 participants (processes) with minimal degradation in throughput
- Applicability & Adoption
  - DDS is broadly applicable to real-time systems and is in use in many markets beyond simulation and A&D
  - HLA has more limited applicability limited to the simulation domain

Using DDS in Modeling, Simulation & Training Systems

Why use DDS within distributed LVC simulations?

1) Take advantage of increased DDS performance
   - Superior DDS performance (e.g. versus HLA) translates into better simulation performance
2) Take advantage of DDS Security in new distributed simulations
   - Secure training and simulations over WAN and Cloud
   - Role based access allows for joint exercises between Coalition forces
3) Enables leveraging/integration of existing system software
   - Hundreds of A&D systems (Land, Sea and Air) are already being built using DDS
4) Enables leveraging of recorded mission data
   - Recorded data from actual mission execution could be combined with simulation data and be used for training

UK MOD General Vehicle Architecture



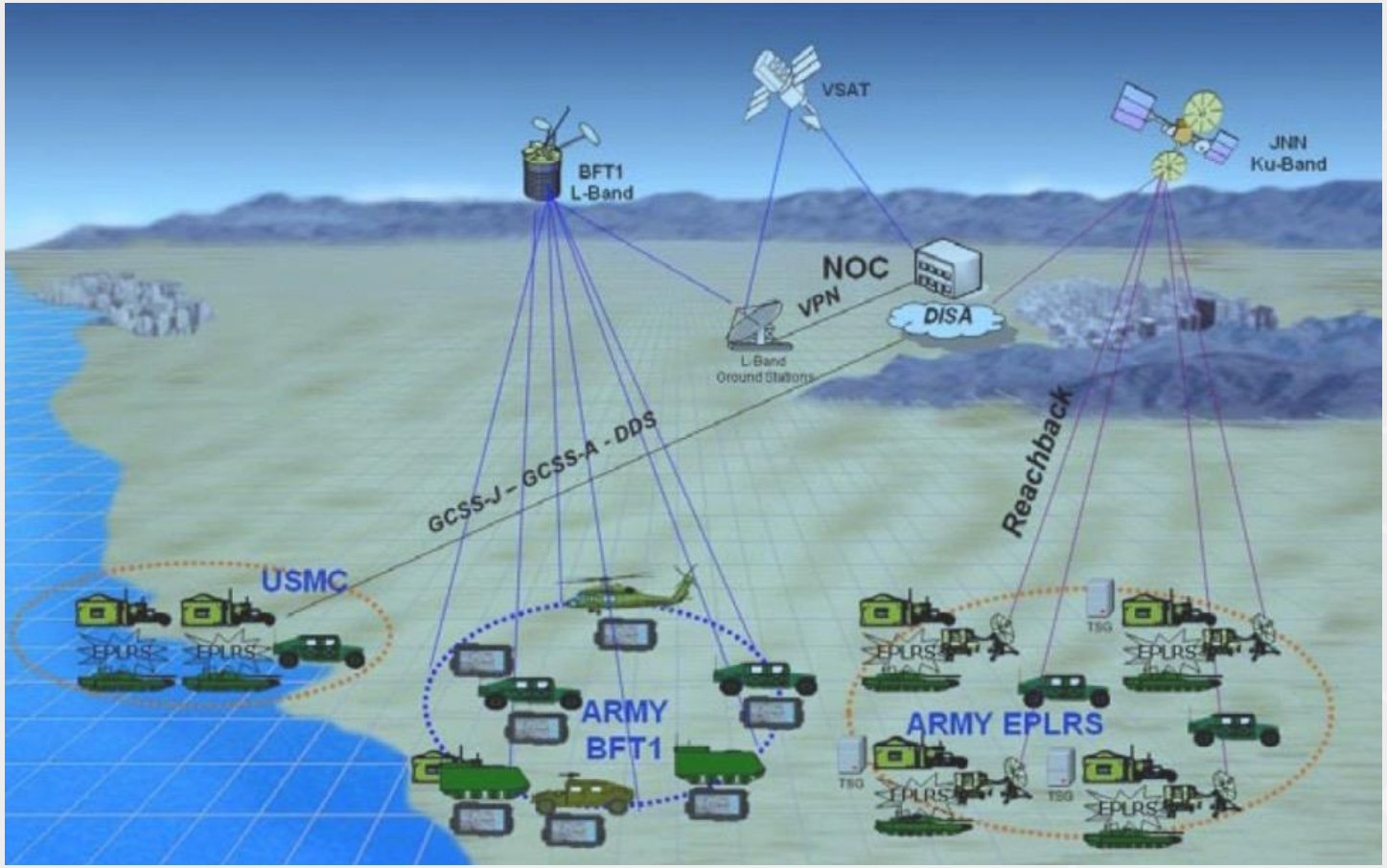
GVA Interfaces and Boundaries (taken from Def-Stan 23-09)

- GVA mandates standards for common interfaces
  - Electronic
  - Power
  - Mechanical

US Navy Zumwalt DDG-1000

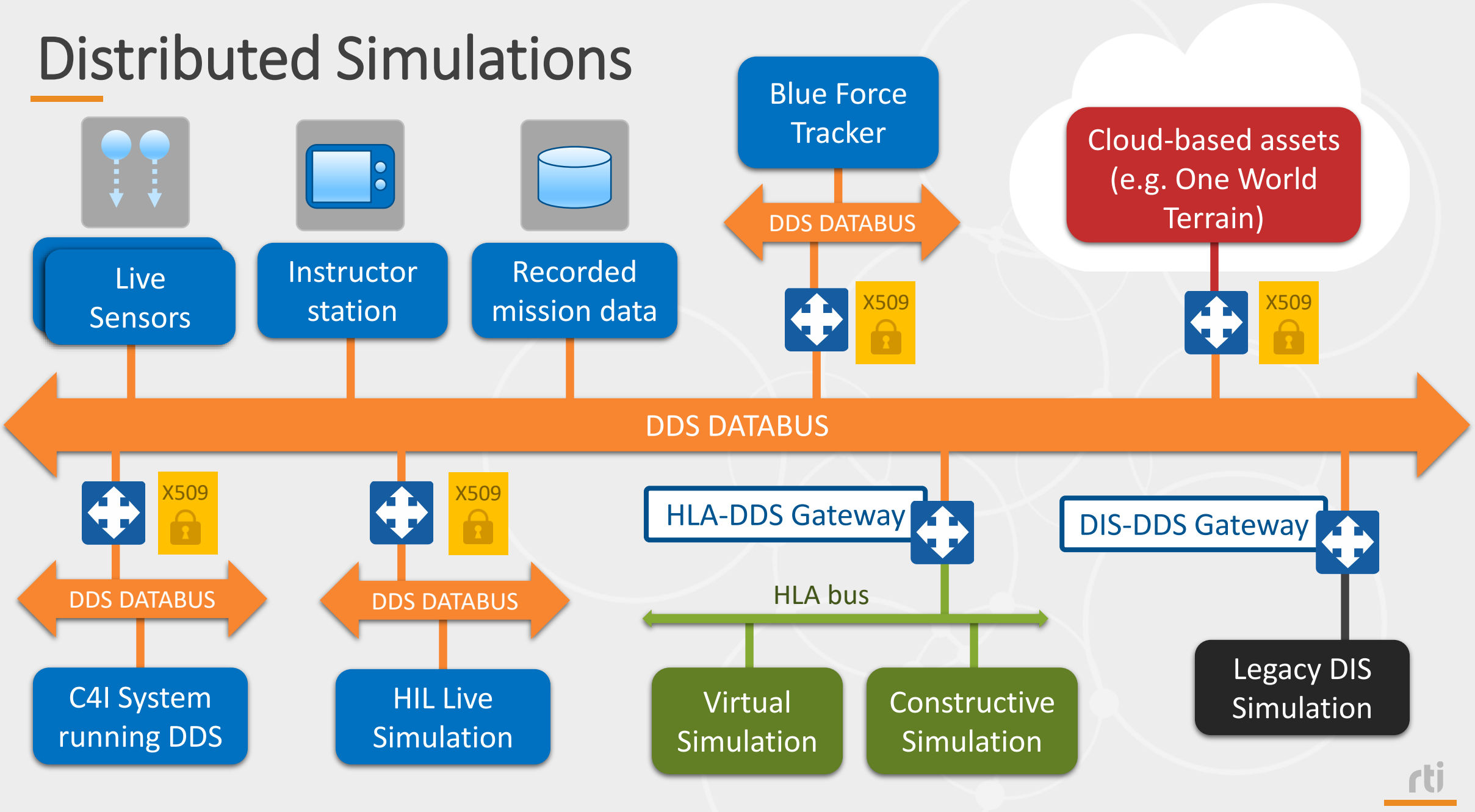
- Raytheon uses RTI middleware to control the Zumwalt Class Destroyer (DDG-1000)
- RTI DDS coordinates and manages complex, diverse onboard hardware and software systems
- RTI connects hundreds of computers, thousands of applications, and more than 10 million publish-subscribe pairs

Blue Force Tracker (JBC-P)



- The US Army's “Blue Force Tracker” collects tracking information vehicles and other assets over a wide area.
  - Able to track 250,000+ assets in real-time
  - Created to replace a less performant, proprietary system
- The DDS-based system analyzes all the tracks in a private cloud.

Distributed Simulations



Connecting HLA and DDS

VT MAK
A company of VT Systems

F18 HLA Federate

VR-Vantage Stealth

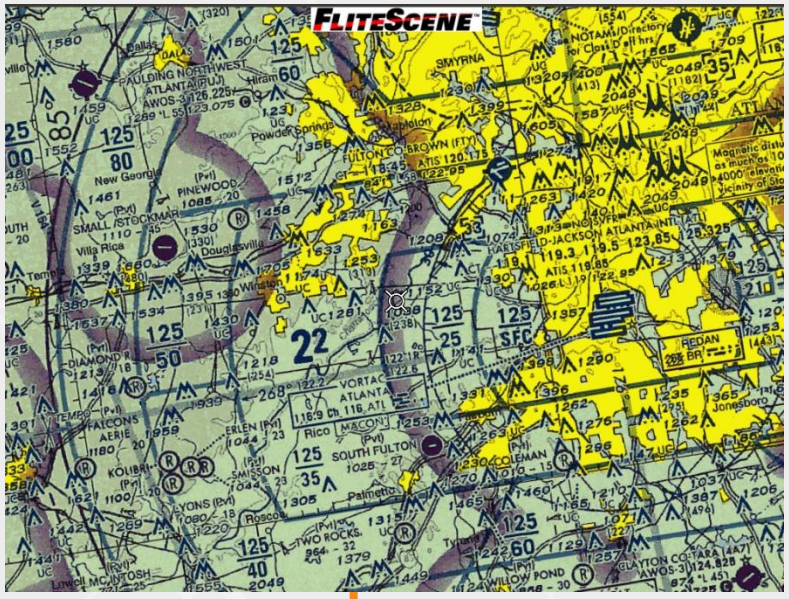
HLA Federation

VR-Exchange

HLA – DDS gateway

DDS Databus

Simulated F18 data to Harris FliteScene FACE UoC through RTI's DDS and FACE TSS



This Routing Service serves as a gateway that:

- Bridges between two domains
- Converts between cartesian and lat-long coordinates

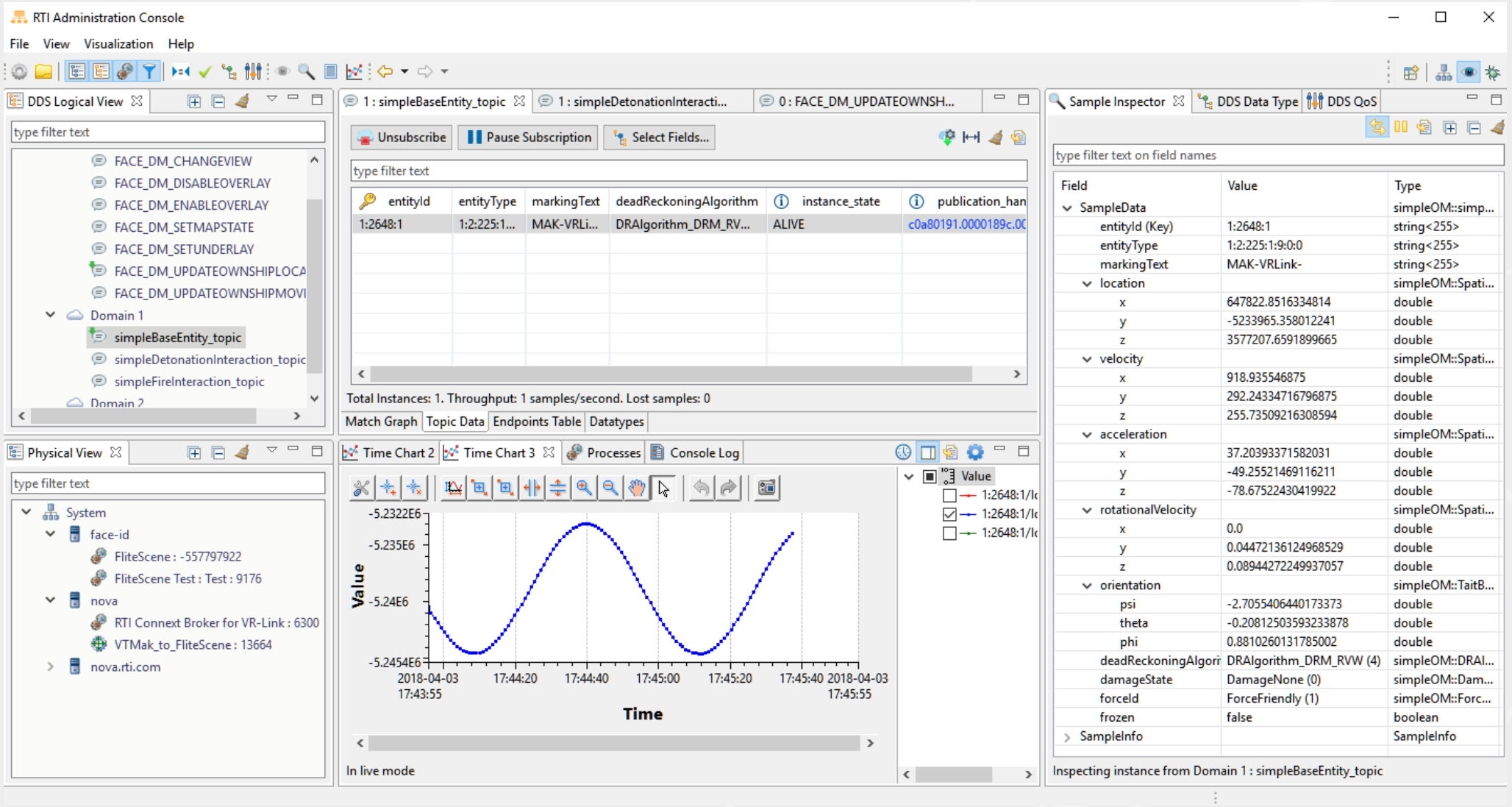
FACE
Future Airborne Capability Environment

FACE TSS

DDS Databus

rti

simpleBaseEntity visualization



Conclusions

- DDS is a mature standard from OMG
  - Focuses on efficient data-distribution for real-time and high-performance systems
  - Mandated and Deployed worldwide in Military systems and other Demanding real-time applications
  - Platform neutral, with a Portable API and Interoperable Wire Protocol
  - Deployed DDS Security Specification
- DDS is an ideal platform for integration of training systems
  - Superior performance
  - Granular data security with pluggable architecture for customized protocols
  - Flexible & Evolvable Type System
  - Highly Tunable via Quality of Service (QoS)
  - Can easily integrate and reuse system software and mission data
- DDS could be used in combination with HLA/DIS types as a data-dictionary
  - Would leverage existing simulation object models plus DDS benefits

Thank You