# Building with the Most Trusted Autonomous Vehicle Platform

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Senior Market Development Director, Autonomous Systems

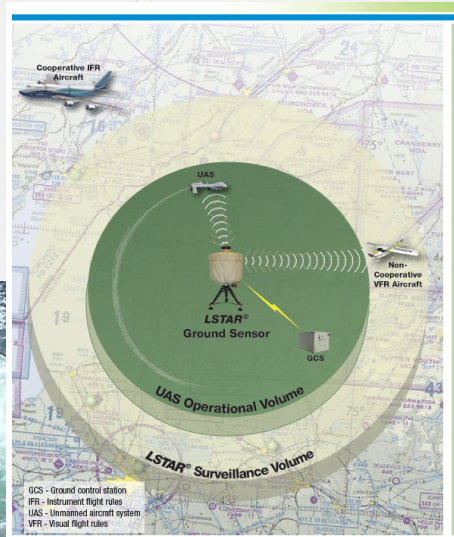rti — Your systems. Working as one.

SINGAPORE Connext® 2019

# Why Choose Connext?

# Autonomous Systems Challenges

- Manage complex data flow and state
- Ease system integration
- Ensure reliable data availability
- Guarantee real-time response
- Allow any network
- Build in security from the start
- Make deployment flexible
- Ease safety certification
- Adapt Intelligence
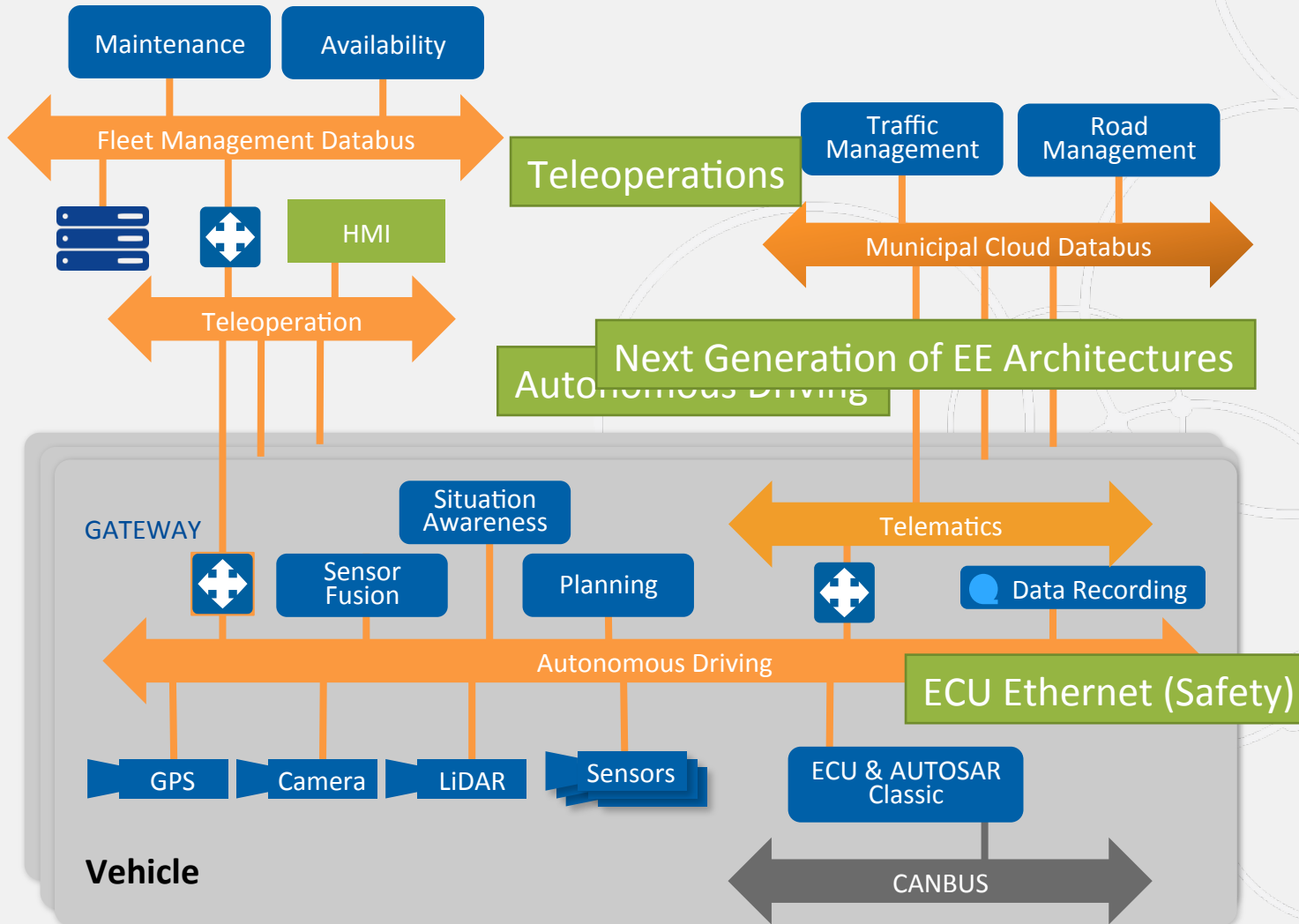- Connect Vehicle/Cloud Systems

# 200+ RTI Autonomous Vehicle Programs!

- 50+ commercial systems
  - 10+ Passenger vehicles
  - 10+ EV startups
  - 5+ Software platforms
  - 8+ Trucks, mining vehicles, forklifts
  - 2 Flying taxi services
  - 2 Hyperloop & other
  - 2+ Autonomous ships
  - 2+ Underwater robots

- 100+ defense systems (land, sea, air)

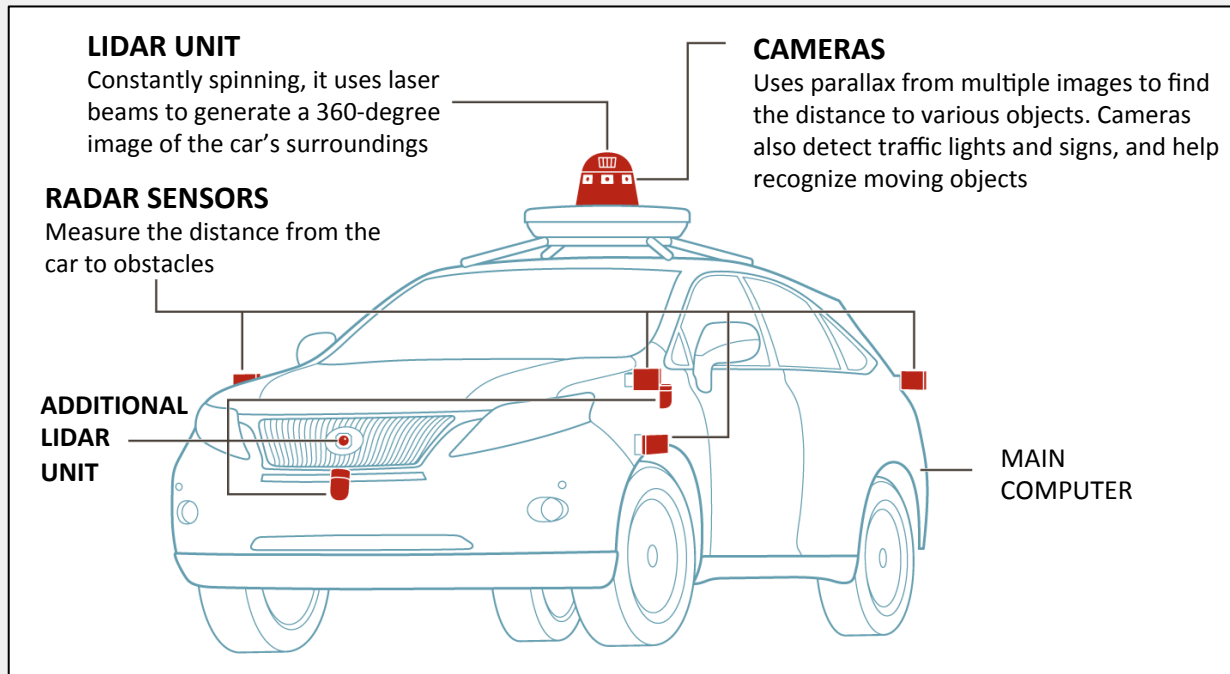- 75+ research programs (companies, universities, etc.)
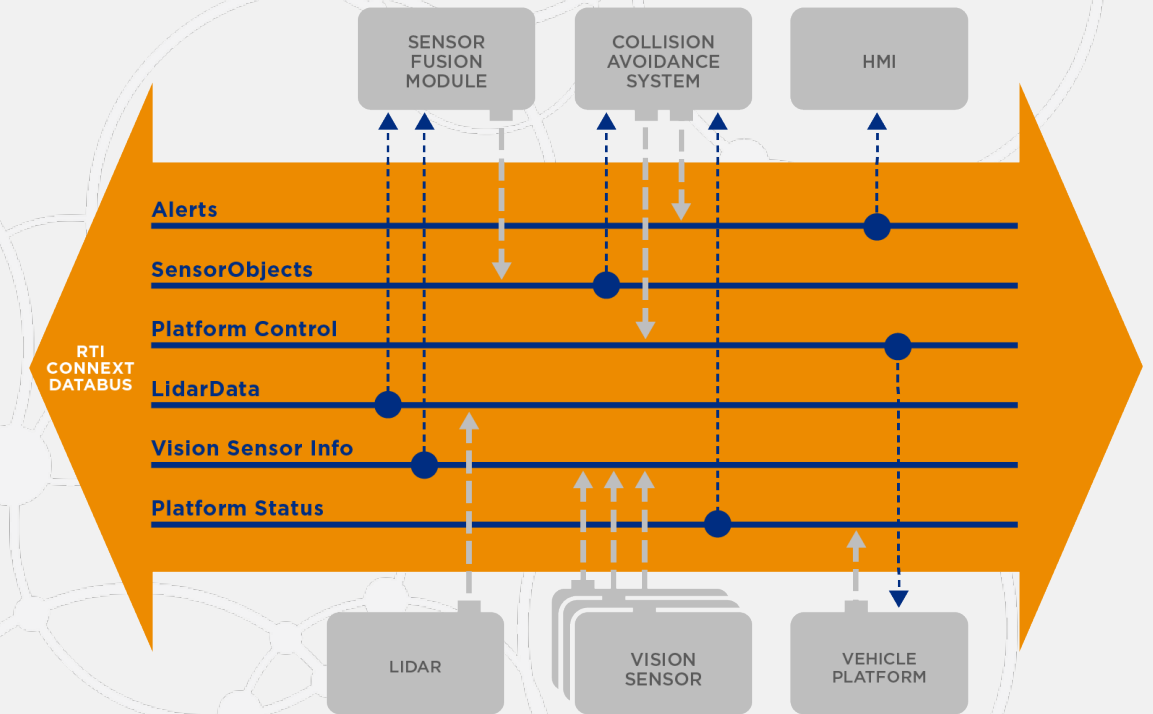
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# Autonomy Use Cases



National Operations Center of Excellence



Fleet Management Weekly



Maintenance

Availability

Fleet Management Databus

Traffic Management

Road Management

Teleoperations

HMI

Municipal Cloud Databus

Teleoperation

Next Generation of EE Architectures

Autonomous Driving

GATEWAY

Situation Awareness

Telematics

Sensor Fusion

Planning

Data Recording

Autonomous Driving

ECU Ethernet (Safety)

GPS

Camera

LiDAR

Sensors

ECU & AUTOSAR Classic

**Vehicle**

CANBUS

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# Technical challenges

# Large Data Streaming

## Autonomous Driving



**LIDAR UNIT**
Constantly spinning, it uses laser beams to generate a 360-degree image of the car's surroundings

**CAMERAS**
Uses parallax from multiple images to find the distance to various objects. Cameras also detect traffic lights and signs, and help recognize moving objects

**RADAR SENSORS**
Measure the distance from the car to obstacles

**ADDITIONAL LIDAR UNIT**

**MAIN COMPUTER**

By Guilbert Gates | Source: Google

SENSOR FUSION MODULE
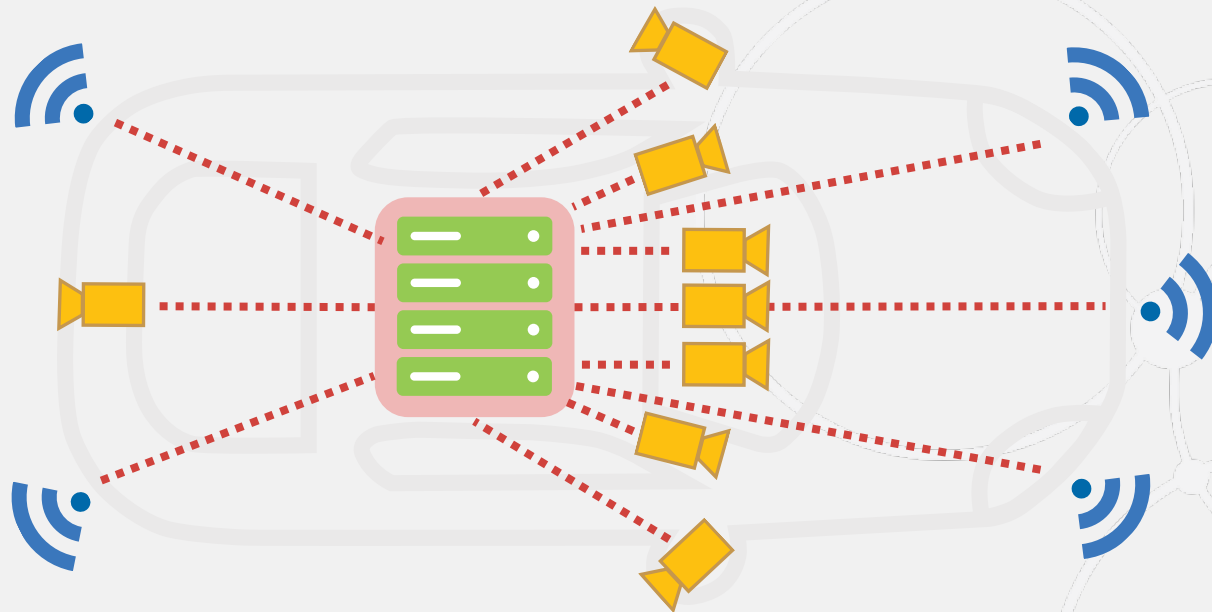
COLLISION AVOIDANCE SYSTEM

HMI

RTI CONNEXT DATABUS

Alerts

SensorObjects

Platform Control

LidarData

Vision Sensor Info

Platform Status

LIDAR

VISION SENSOR

VEHICLE PLATFORM

# Autonomous Dataflow Challenge

| Data Source | Data Type | Data Volume | Data Frequency |
|---|---|---|---|
| Cameras | Video Stream | | |
| Lidar | Data List | | |
| Radar | Point List | | |
| GPS | Bin data struct | | |
| Control Cmd | Bin data struct | | |
| Error | Text String | | |

QoS

- Many different dataflows
  - Volume
  - Frequency
  - Latency
  - Reliability
  - Destination

- **A single Databus that can handle all greatly simplifies the system**

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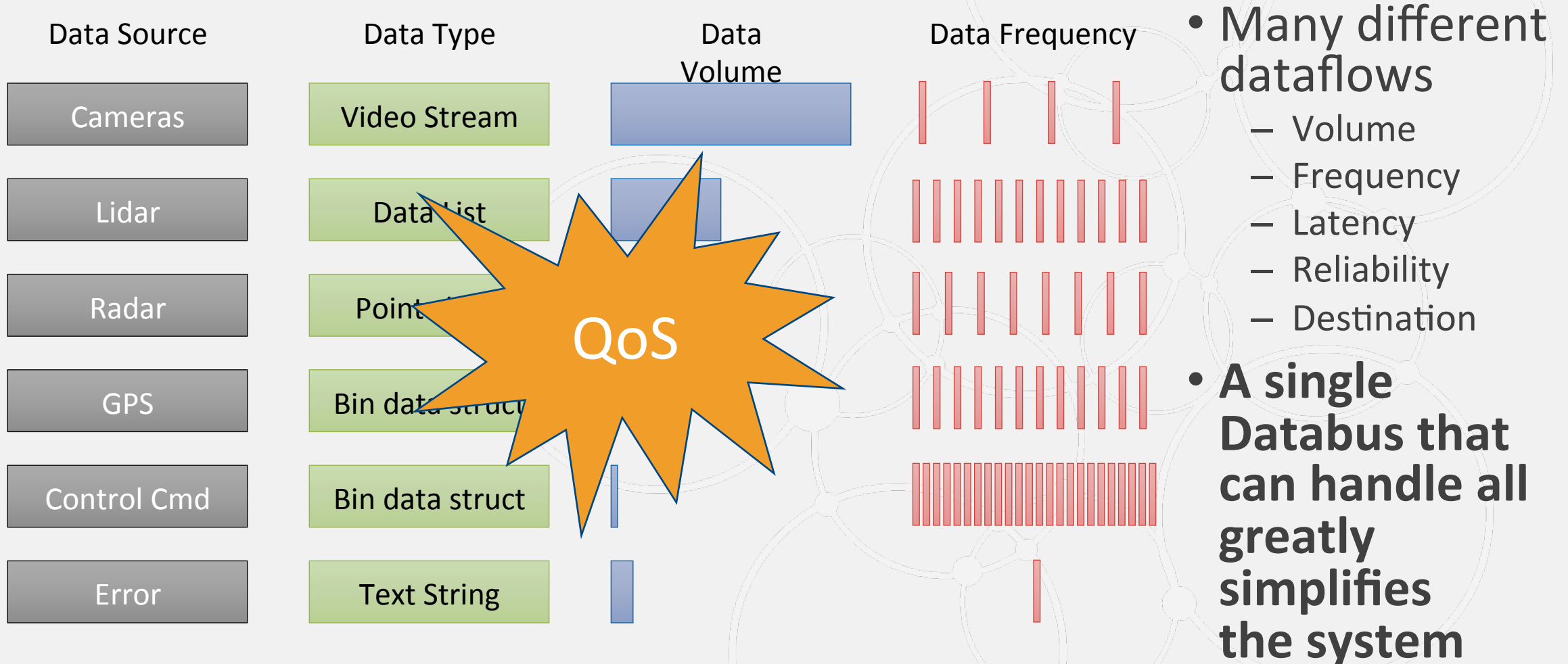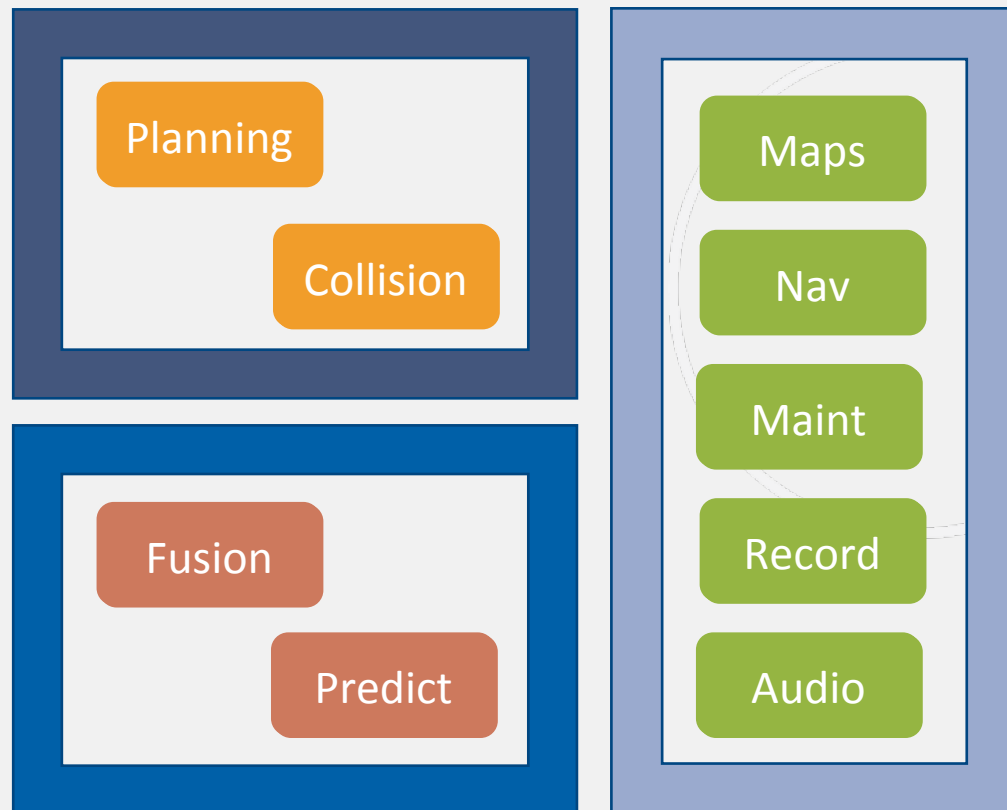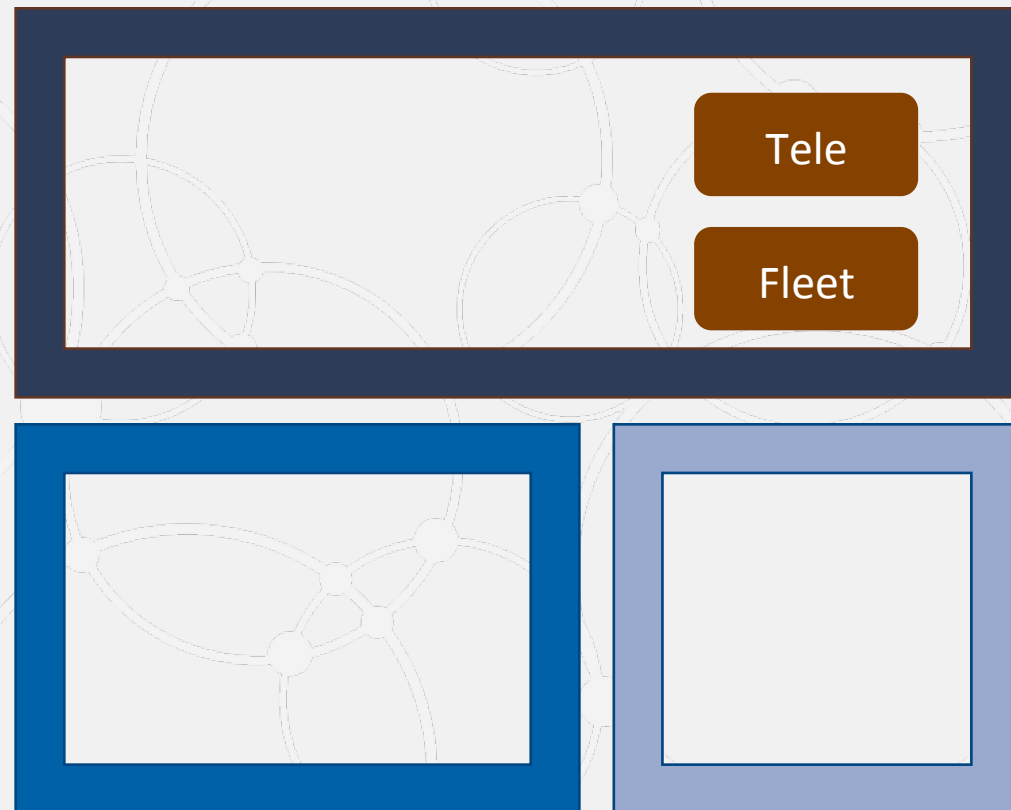
# Evolving Architectures
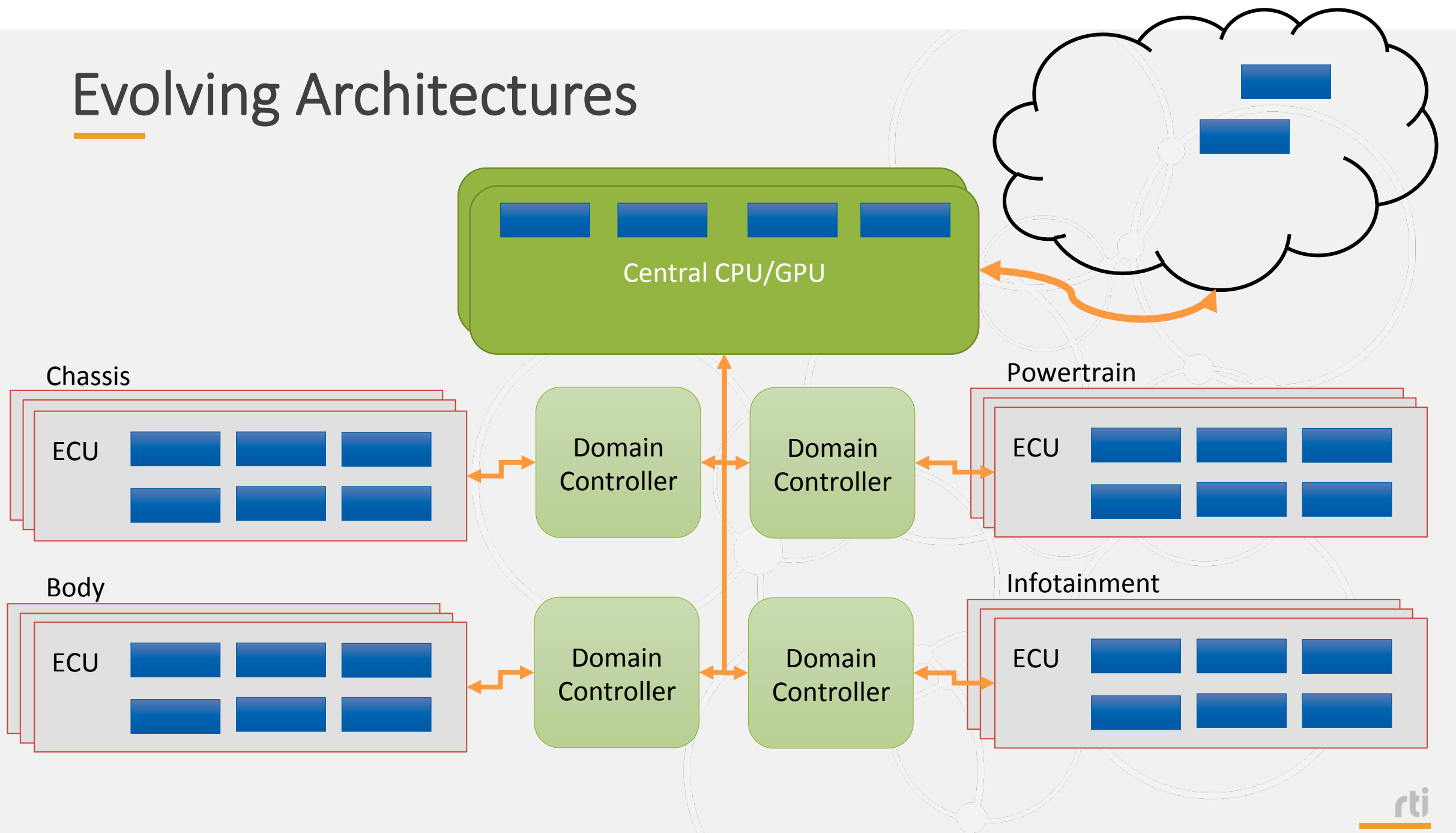
# Dynamic Hardware and Software Configuration

**Premium Electric Vehicle**
**Level 2+ Autonomous Vehicle**

**Ride Share**
**Level 4 Autonomous Vehicle**

Planning

Collision

Maps

Nav

Maint

Record

Audio

Tele

Fleet

Fusion

Predict

# Safety and Security

- ☑ Robust
- ☑ Reliable
- ☑ Secure
- ☑ Certified

# Safety and Security



Image Frames

Command

Location

High Powered CPU

Connext Databus (2nd Domain)

Safe Processor

Connext Databus (Ethernet 1)

QoS: Liveliness, Reliability, Ownership, History, Etc, . .

Connext Databus (Serial/Ethernet 2)

Safety Certified

Front Cameras

Side & Rear Camera

Lidar

Radar

V2X

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# Fine-Grained, DDS Security

## Data Flow Security, by Topic



**Application**

Authentication

Access Cont

Encryption

Data Tagging

Logging

Image Frames

RTI

Location

Commands

**Any Transport**
(e.g., TCP, UDP, multicast, shared memory, )
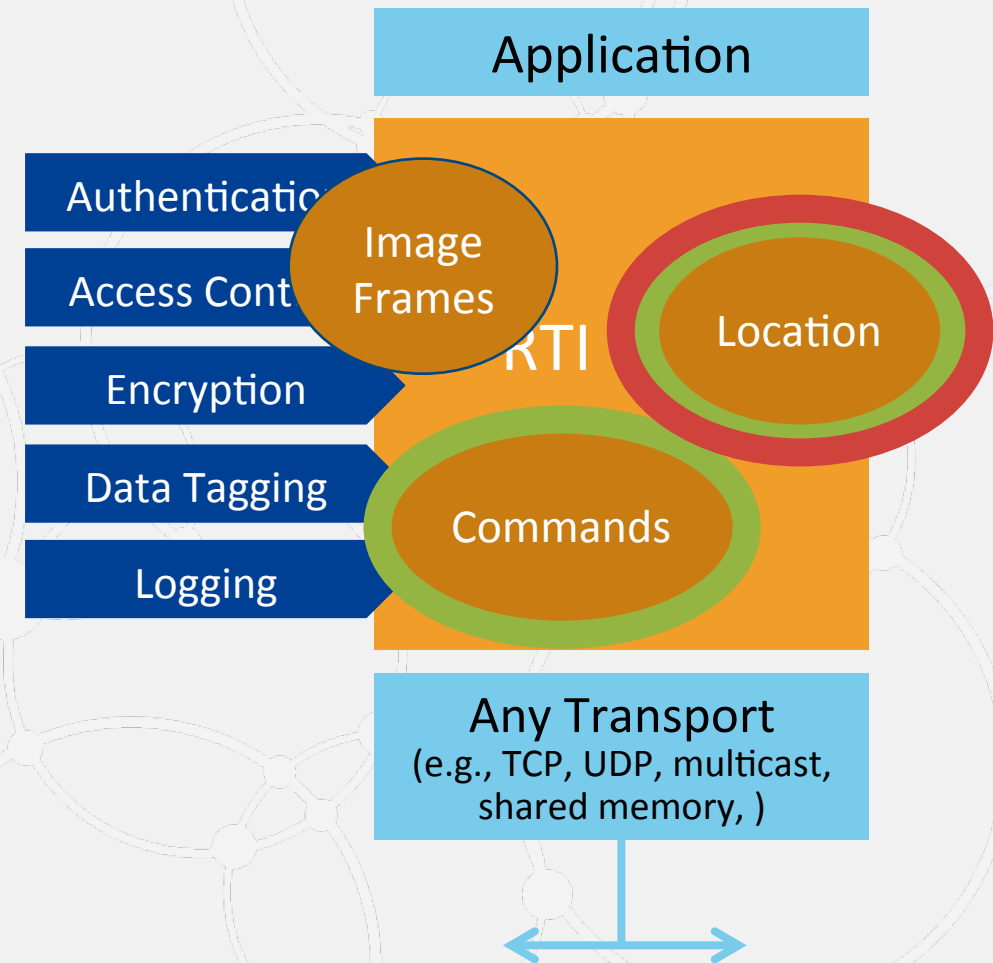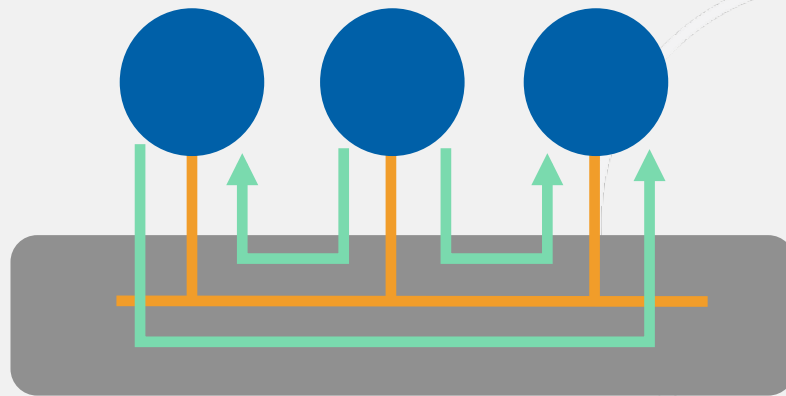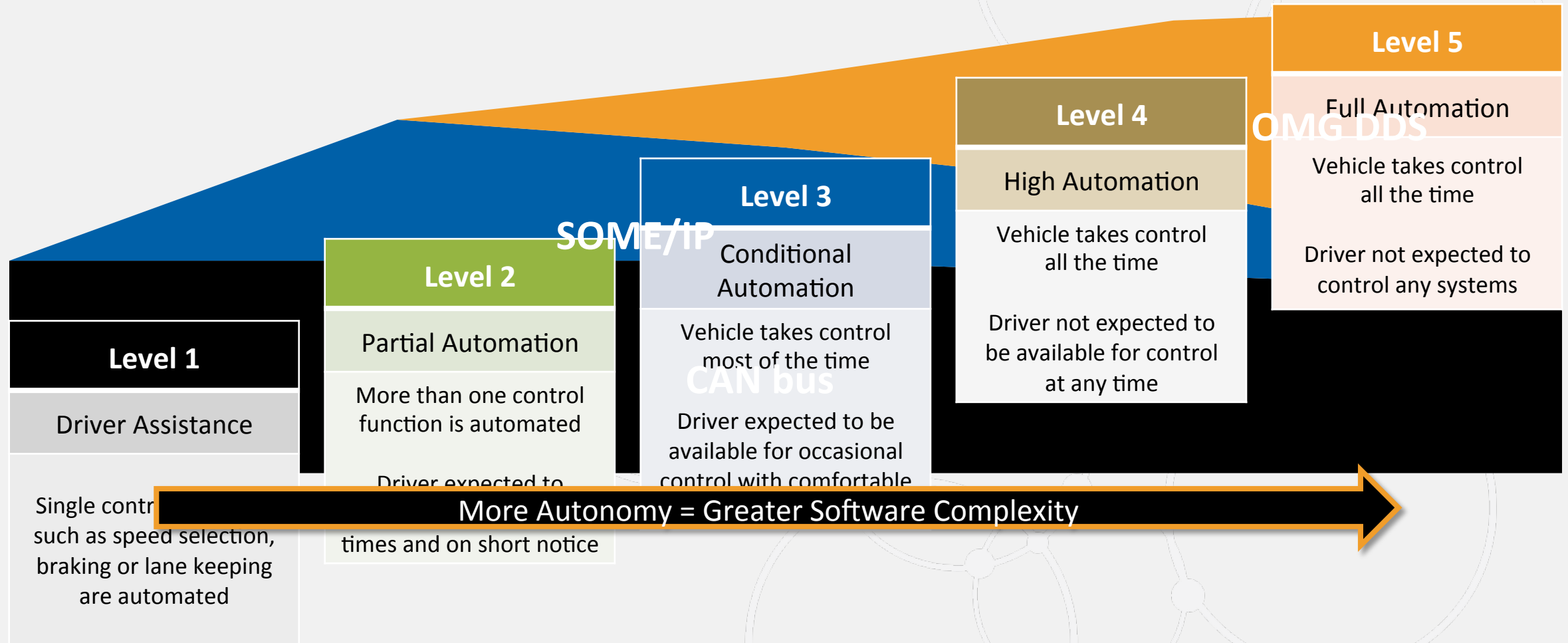
# Providing a Pathway to Safety Certification

Meets the demands of highly autonomous systems,
with a roadmap to ISO 26262 ASIL-D certification
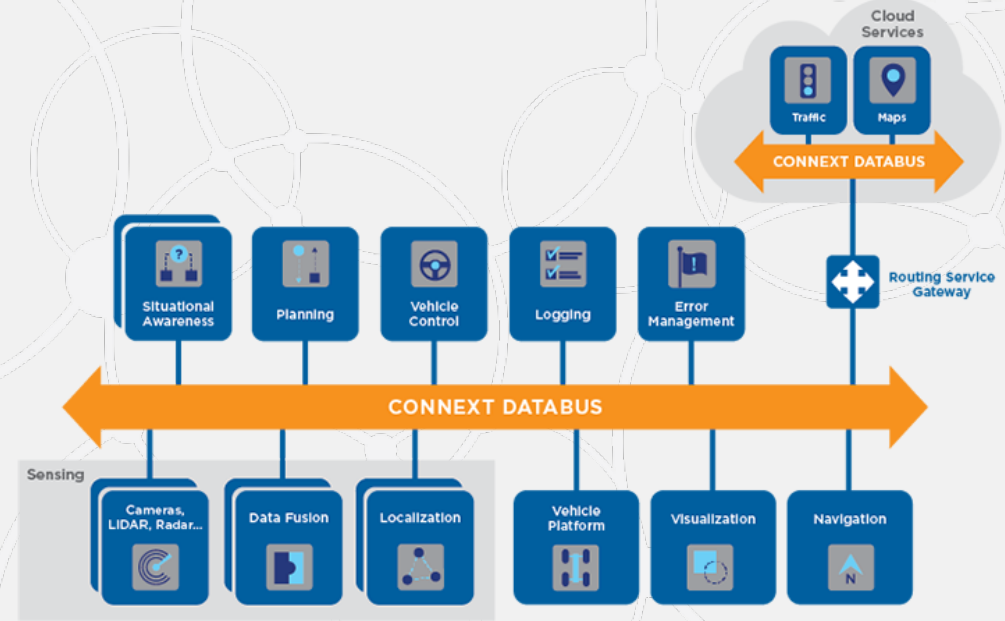
# Connectivity at Different Levels



**Level 1**

Driver Assistance

Single control such as speed selection, braking or lane keeping are automated

**Level 2**

Partial Automation

More than one control function is automated

Driver expected to times and on short notice

**Level 3**

Conditional Automation

Vehicle takes control most of the time

Driver expected to be available for occasional control with comfortable

**Level 4**

High Automation

Vehicle takes control all the time

Driver not expected to be available for control at any time

**Level 5**

Full Automation

Vehicle takes control all the time

Driver not expected to control any systems

SOME/IP

CAN bus

OMG DDS

More Autonomy = Greater Software Complexity

# Non-Functional Challenges

# Research to Production



- State-of-the-art isn't good enough (functional)
  - Innovation arms race
- Still can't forget the "-ilities" (non-functional):
  - Reliability, Durability, Manufacturability, Serviceability, Maintainability, Flexibility, Scalability, Extensibility, Portability, Security, Reusability, Compatibility, Interoperability, …

**AUTONOMOUS SYSTEMS MUST HANDLE BOTH**

# Future Proof
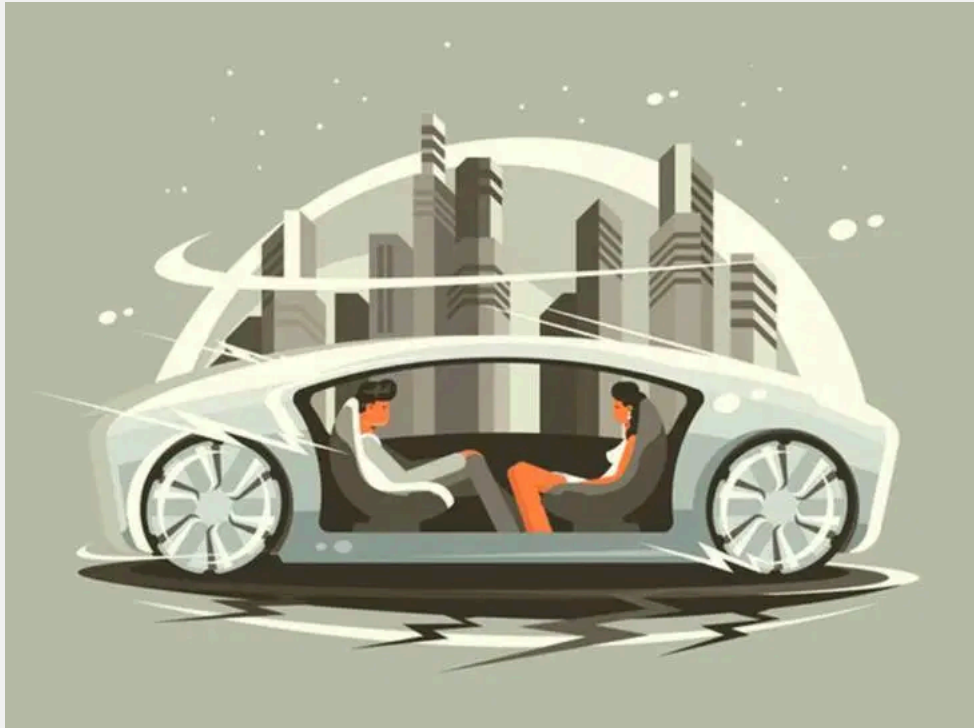
Technology Risk is Significant. Predicting what the architecture will be in 5-10 years is impossible.

- Multiple Platforms, ,rapid innovation on the high end
- No Clearly Dominant ecosystem, instead there is a mix
- Fundamental physical and logical architecture is still evolving
- Building a platforms that works for L3 to L5, and is scalable

# Design for the Future
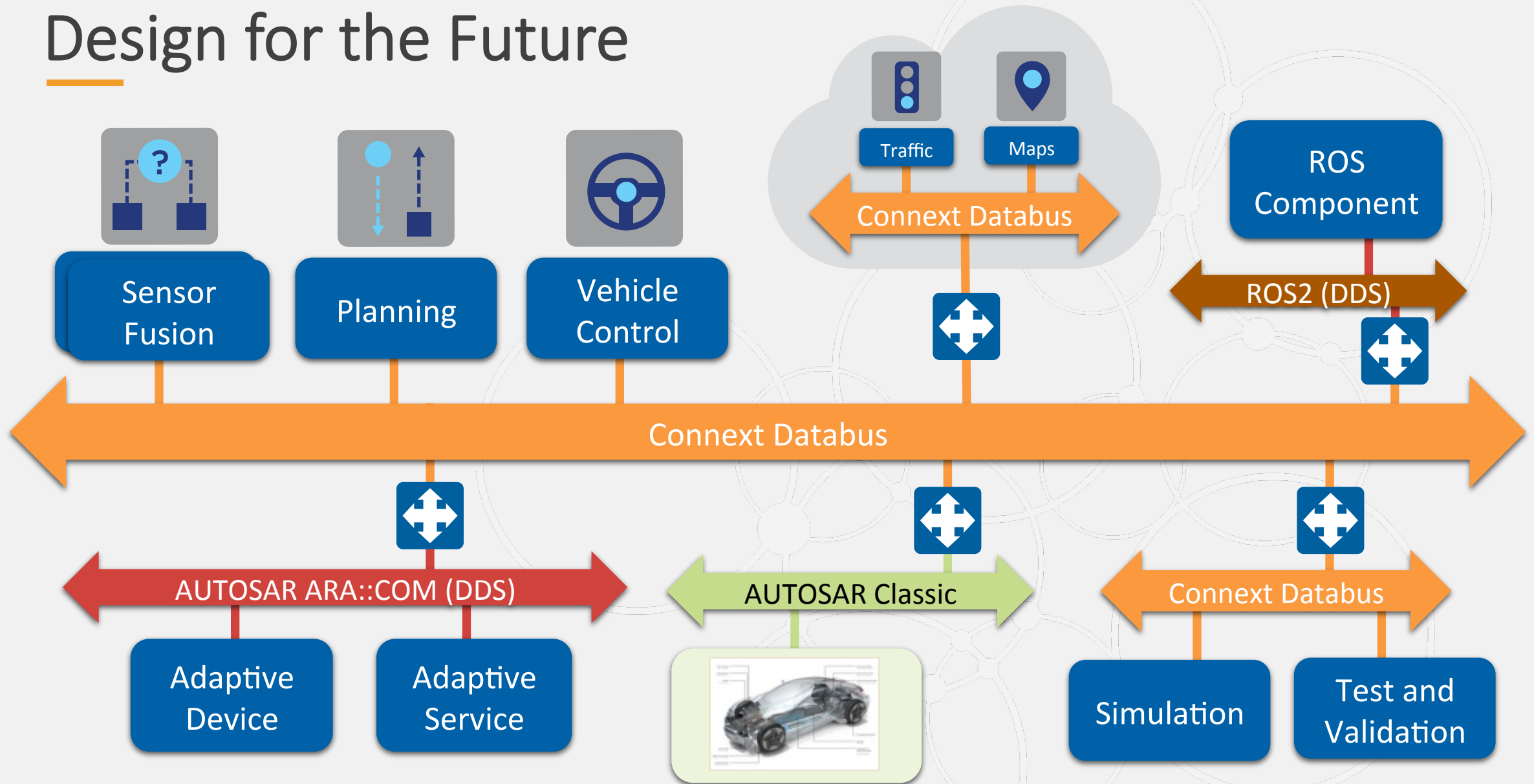
# Changing Landscape

- Importance of software is new
- Business models are changing rapidly
  – Many new revenue streams
- Competition
  – Electric cars have drastically lowered the barrier of entry to the market
  – MaaS is changing the relationship with the customers
  – Software has created new revenue streams, with multiple non-traditional players

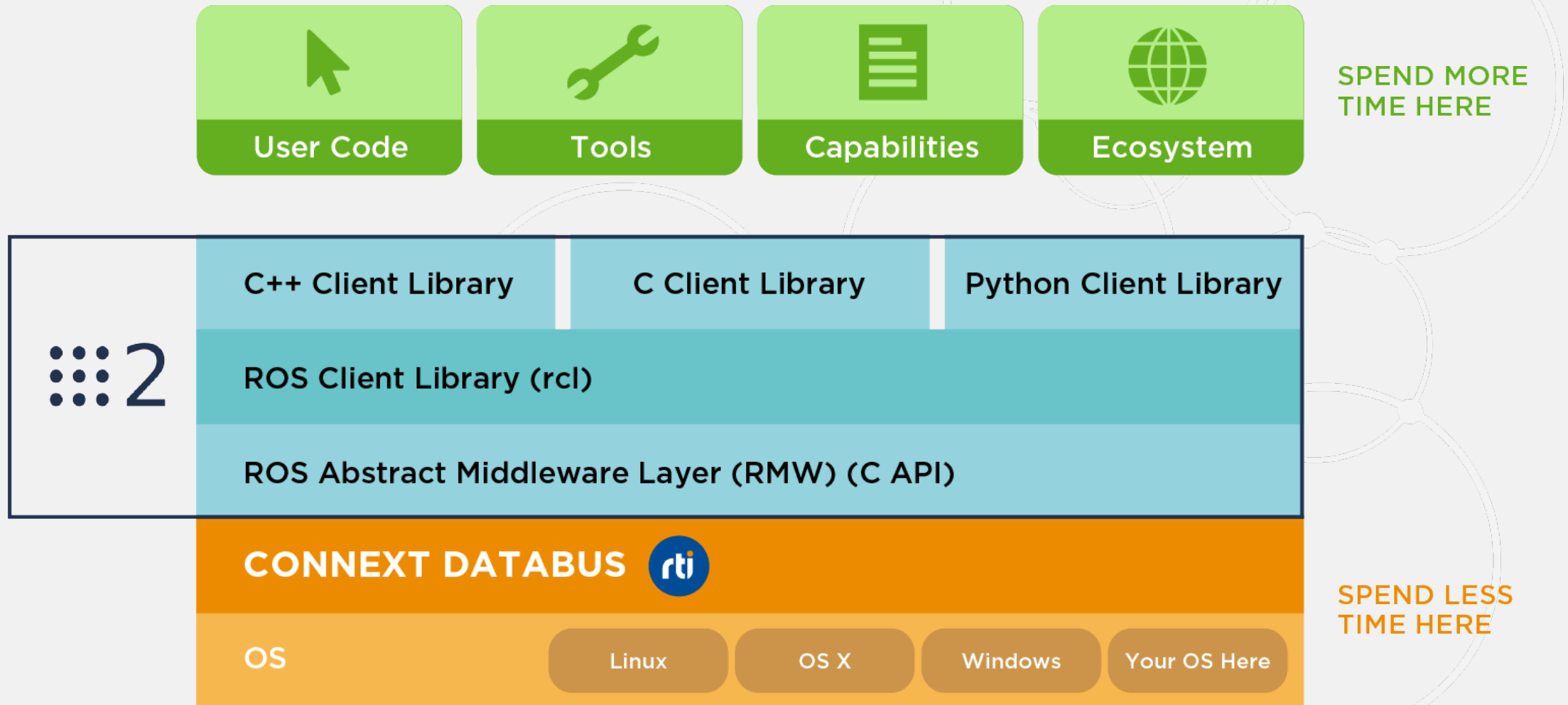# The Network is the Car

AUTONOMY — PERFORMANCE — SECURITY — SAFETY

# Options for using DDS in Automotive

# DDS in ROS2

| User Code | Tools | Capabilities | Ecosystem |

SPEND MORE TIME HERE

| C++ Client Library | C Client Library | Python Client Library |

**∷2**

ROS Client Library (rcl)

ROS Abstract Middleware Layer (RMW) (C API)

**CONNEXT DATABUS** rti

**OS**

| Linux | OS X | Windows | Your OS Here |

SPEND LESS TIME HERE

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# Why choose ROS?

- Large ecosystem, used extensively in R&D and Academia
- Large suite of tools and modules to get started quickly
- Easy to use, built for robotics
- Low barrier to entry (low cost and minimal effort)

But,

- Limited support, Open Source, not a standard
- Middleware abstraction limits scalability
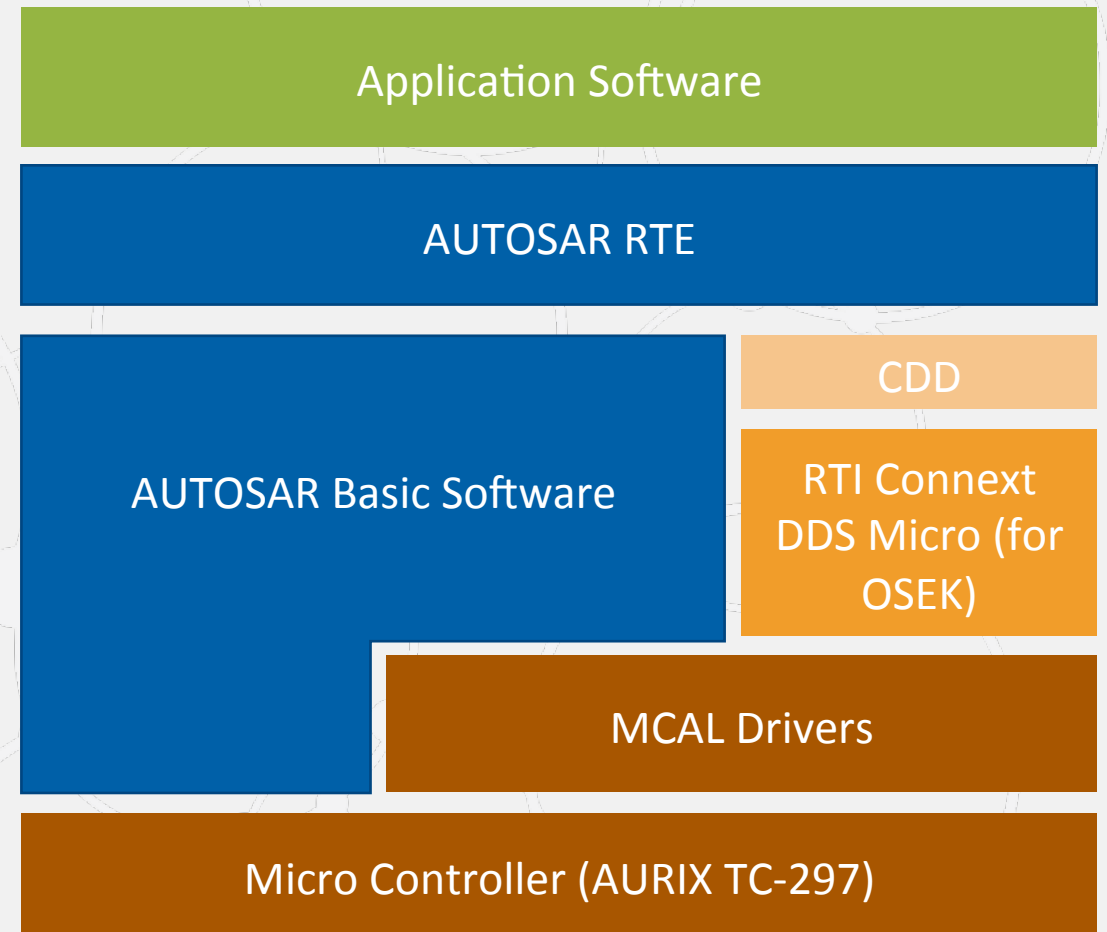- Abstraction of DDS limits performance and some features

# Adaptive AUTOSAR



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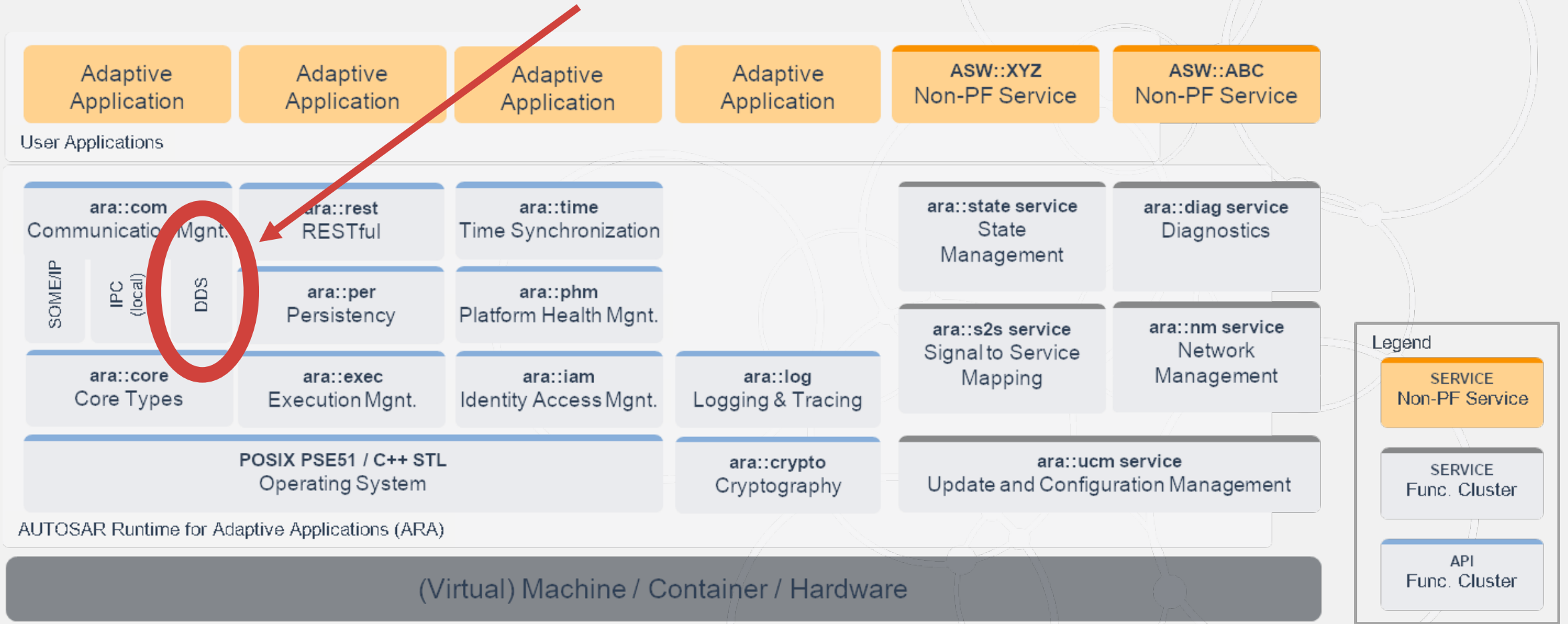
# Autosar Classic

- RTI will provide customers with
  - A generic port of RTI Connext DDS Micro for AUTOSAR OSEK
  - A Complex Device Driver (CDD) wrapper for the Connext DDS Micro
- Can be complied in to a AUTOSAR Classic application using any compliant stack.
- Customer can optionally access Connext DDS
  - Directly, using the DDS APIs,
  - Using the CDD wrapper provided, or
  - By integrating it with the AUTOSAR RTE (not provided by RTI)

| Application Software |
|:---:|
| AUTOSAR RTE |

| AUTOSAR Basic Software | CDD |
|:---:|:---:|
| | RTI Connext DDS Micro (for OSEK) |

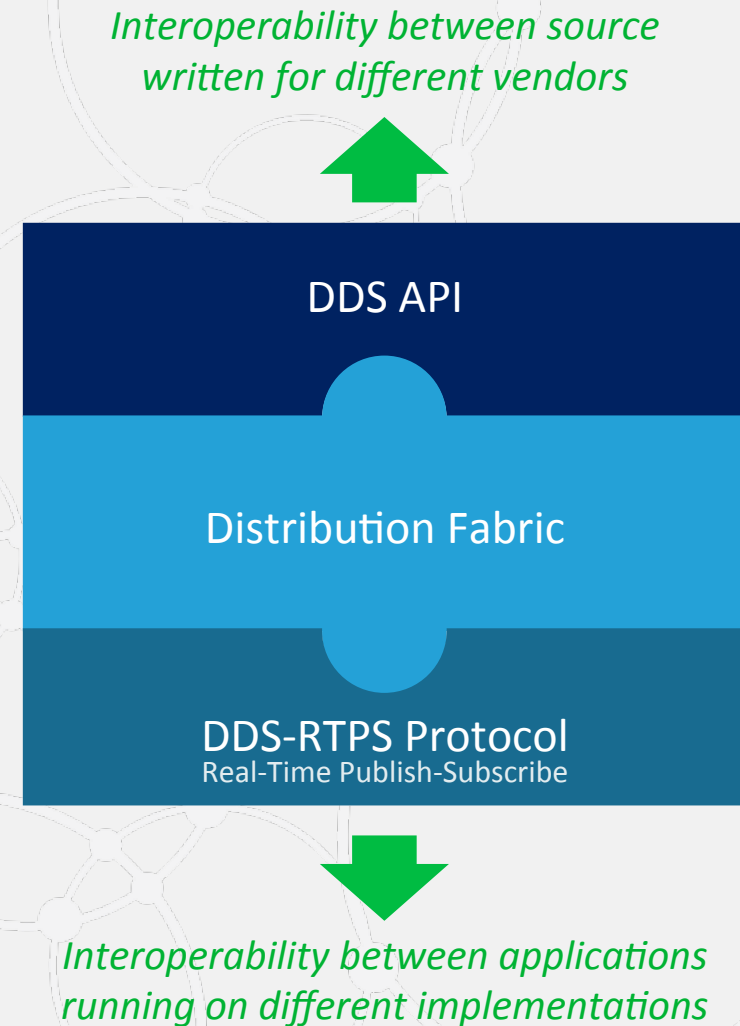| MCAL Drivers |
|:---:|
| Micro Controller (AURIX TC-297) |

# Why choose AUTOSAR?

- Common interface standard in Automotive
  - Automotive only standard
- Large ecosystem, supported by many established HW and SW vendors
- Standard specified interfaces support interoperability and portability between implementation
- AUTOSAR Adaptive supports dynamic applications

But,

- Not a data-centric architecture paradigm
- Service architecture limits scalability and modularity
- Abstraction of DDS limits performance and access to some features

# DDS APIs

- DDS is the Proven Data Connectivity Standard for the IoT

- OMG: world's largest systems software standards org
  - UML, DDS, Industrial Internet Consortium

- DDS: open and cross-vendor
  - Open Standard and Open Source
  - 12+ implementations

*Interoperability between source written for different vendors*

| DDS API |
| Distribution Fabric |
| DDS-RTPS Protocol<br>Real-Time Publish-Subscribe |

*Interoperability between applications running on different implementations*

# Choosing DDS as the Connectivity Framework

Many near and long-term benefits to directly using the Connext Databus vs. AUTOSAR Adaptive or ROS2

- Lower latency and higher bandwidth performance
- Better modularity, due to abstraction of the Databus
- Many-to-many publish-subscribe
- Lower development costs
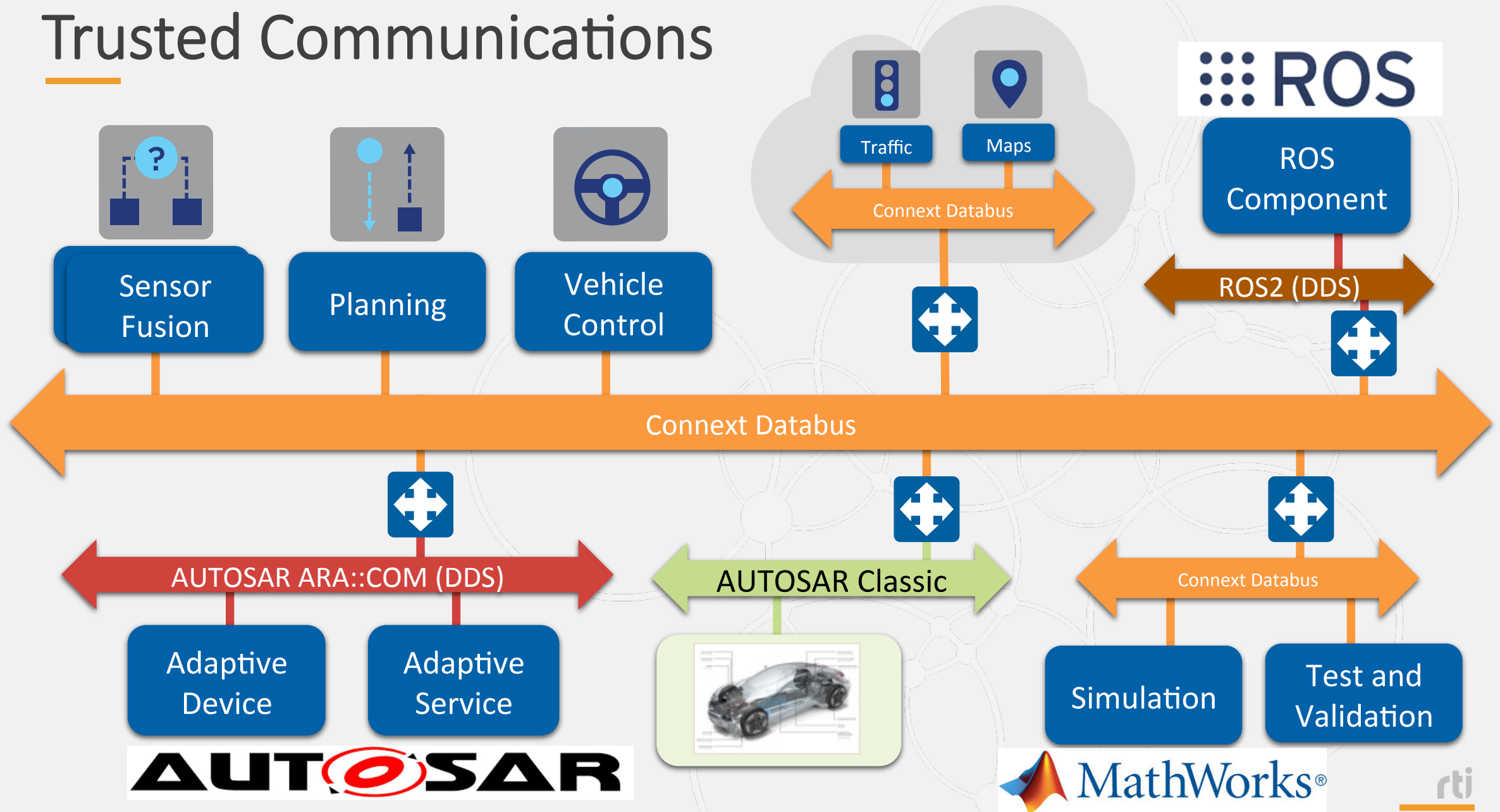- Exploit Connext Databus features not exposed by ara::com

And,

- Can support interfaces to both ROS2 and AUTOSAR Adaptive applications, maintaining interoperability with those ecosystems
- Many tools directly support DDS including MathWorks, Gazebo, dSpace, etc.
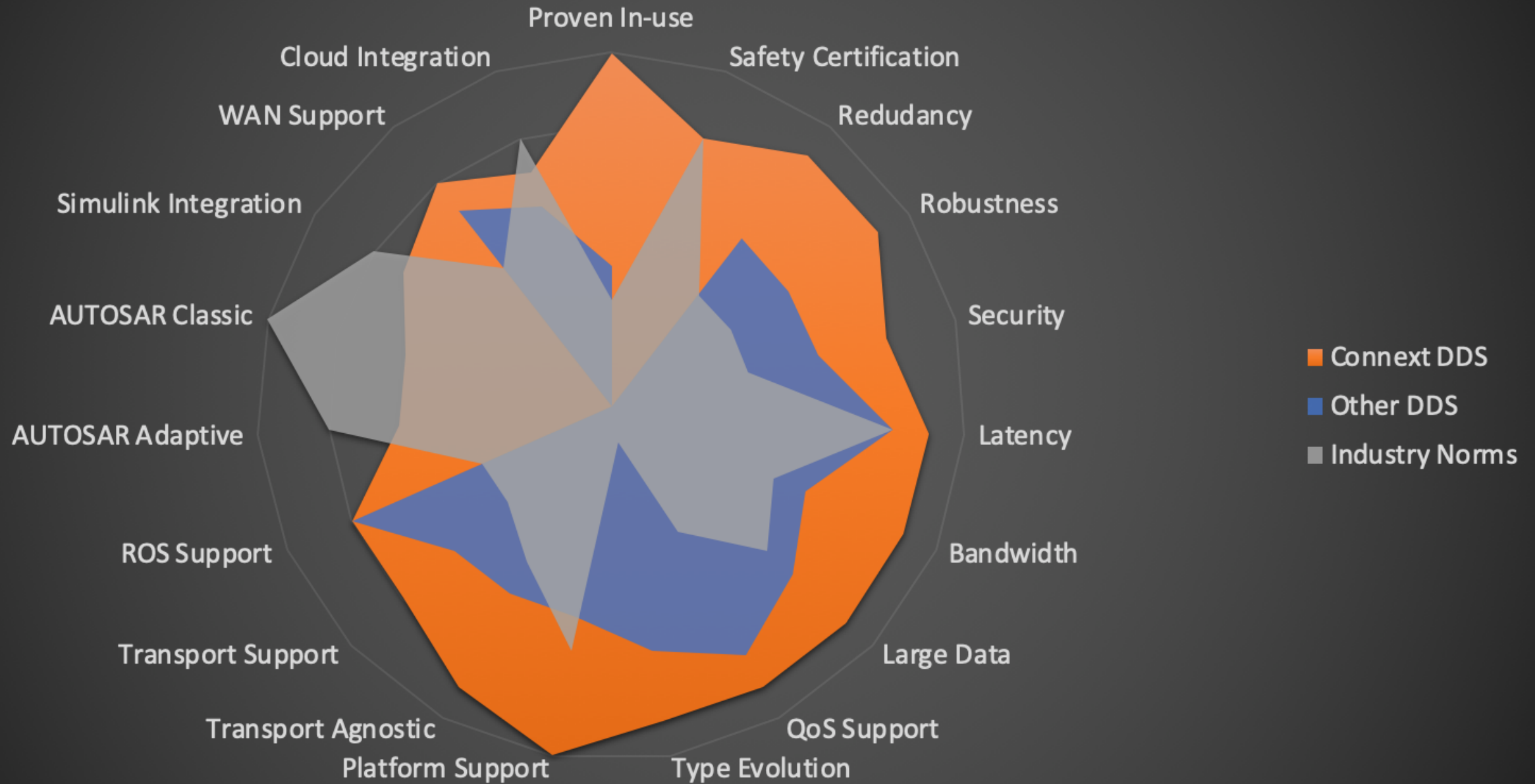
Who trusts Connext DDS?

Trusted Communications

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Commercial Connectivity Framework Software for Autonomous Systems

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# Sensor-to-Cloud

- End-User Applications
- Connect with RESTful/Web Sockets

*Public Internet*

- Teleoperation
- Traffic and Road Management
  - Environmental & Road Conditions
  - Traffic Light Control
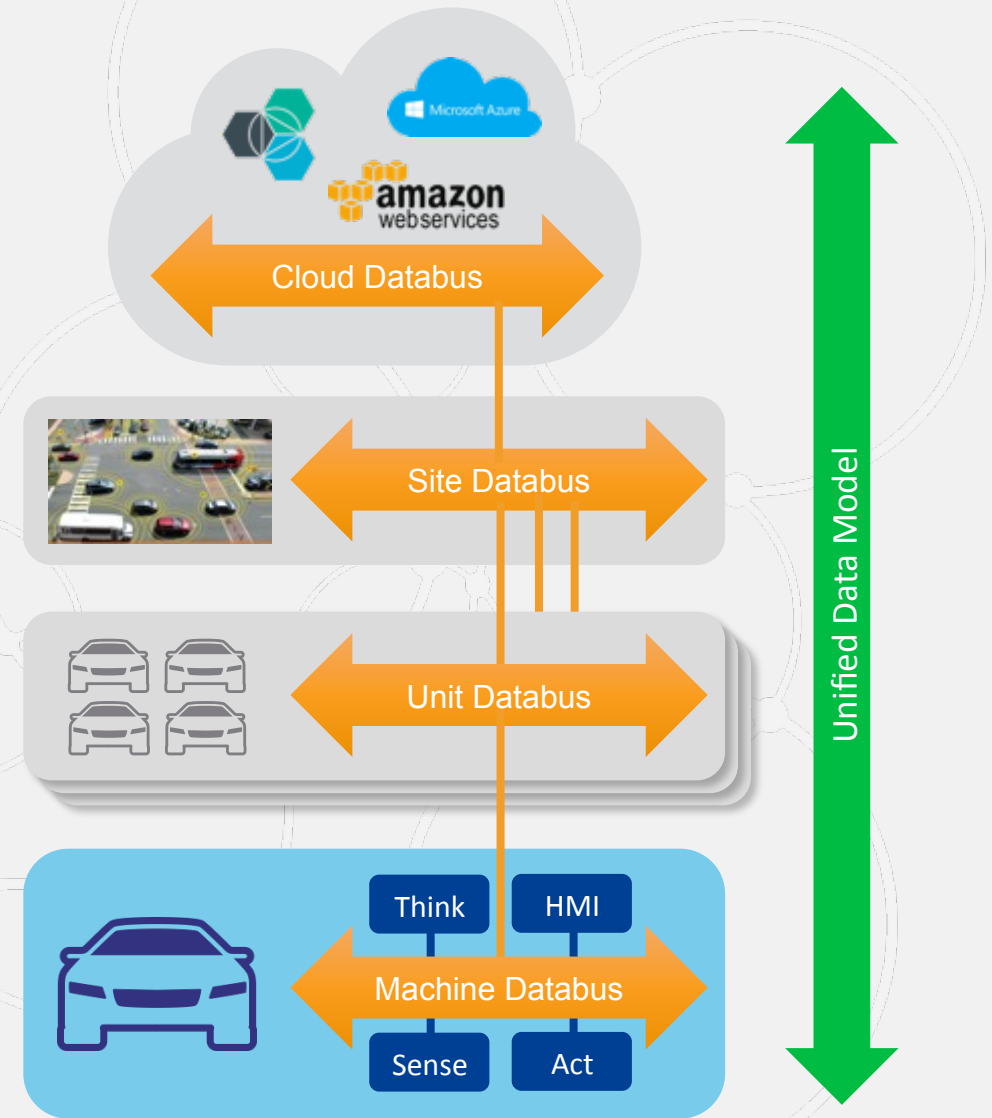  - Congestion Management

*Fleet Management*

- Probe Data Collection (Sensors)
- Environmental Weather
- Dynamic Vehicle Location

*V2I & V2X*

- Collision Avoidance
- Navigation
- Safety Certified

*In-Car Platform*

Microsoft Azure

amazon webservices

Cloud Databus

Site Databus

Unit Databus

Think | HMI

Machine Databus

Sense | Act

Unified Data Model

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# Thank you

**Bob Leigh**

Senior Market Development Director

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| RTI | Examples, forum, papers | IIC | DDS portal |
|---|---|---|---|
| www.rti.com | community.rti.com | www.iiconsortium.org | portals.omg.org/dds/ |

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