



# C-ITS - THE HYBRID COMMUNICATION PROTOCOL

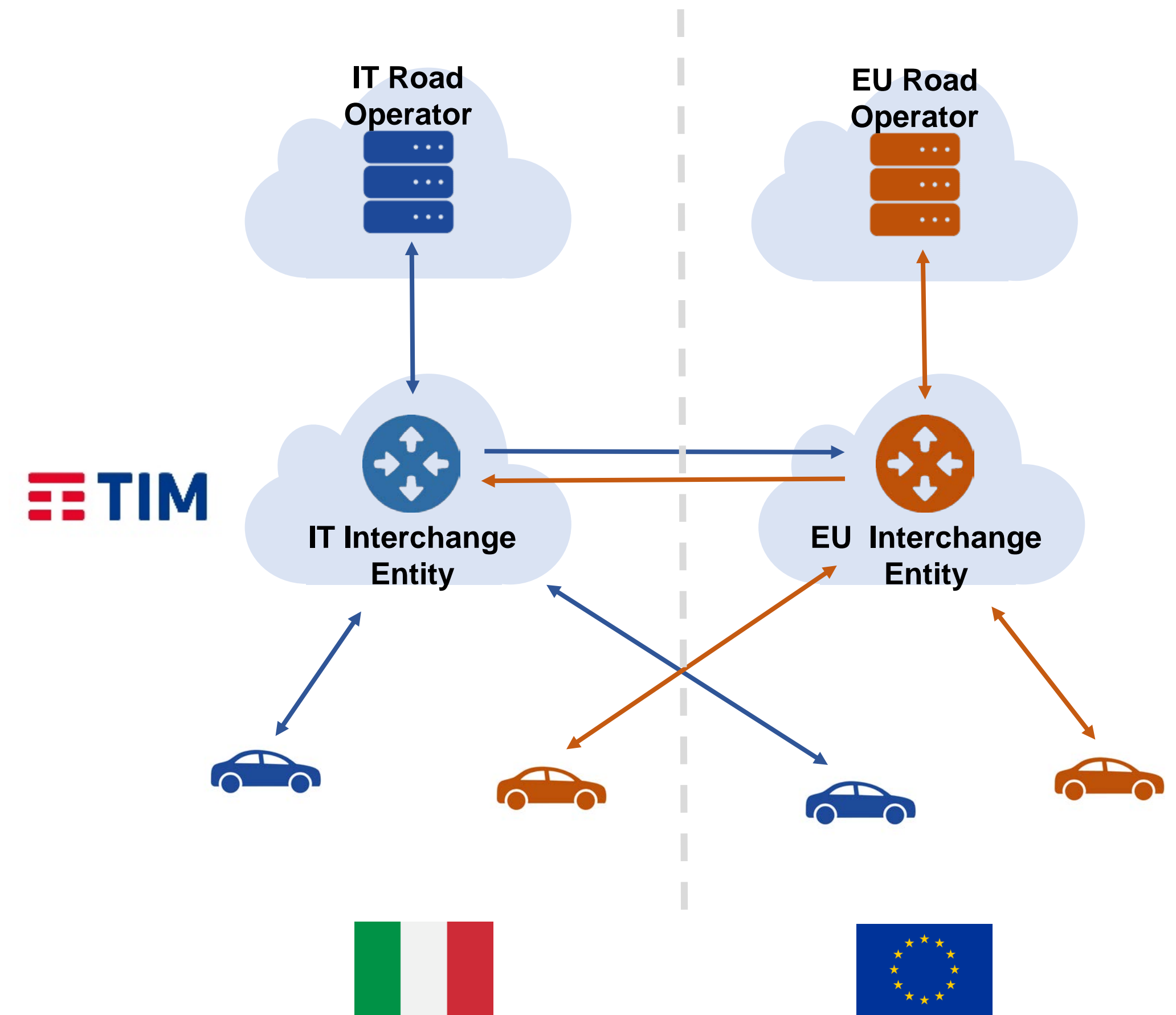
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Innovation Area Manager  
TIM Services Innovation



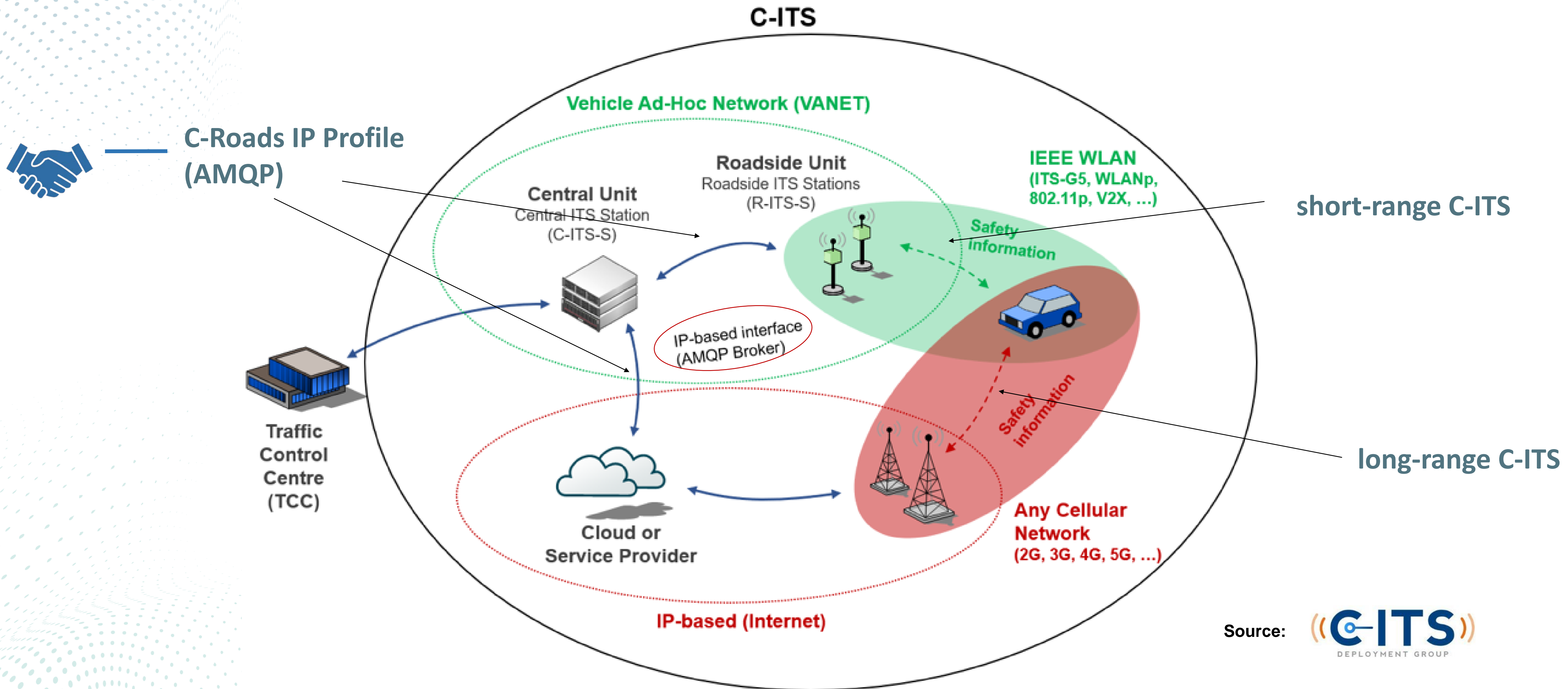
Co-funded by  
the European Union

# TIM ROLE IN C-ROADS ITALY 2

- Development of the Italian **Interchange Entity**, as defined by TF4's **IP-based Interface Profile**
- Core member of TF4 (**Hybrid Communication**)
- Supporting member of TF2, TF3, WG2
- Field trials support (Italian pilots and cross-border testing)



# HYBRID COMMUNICATION



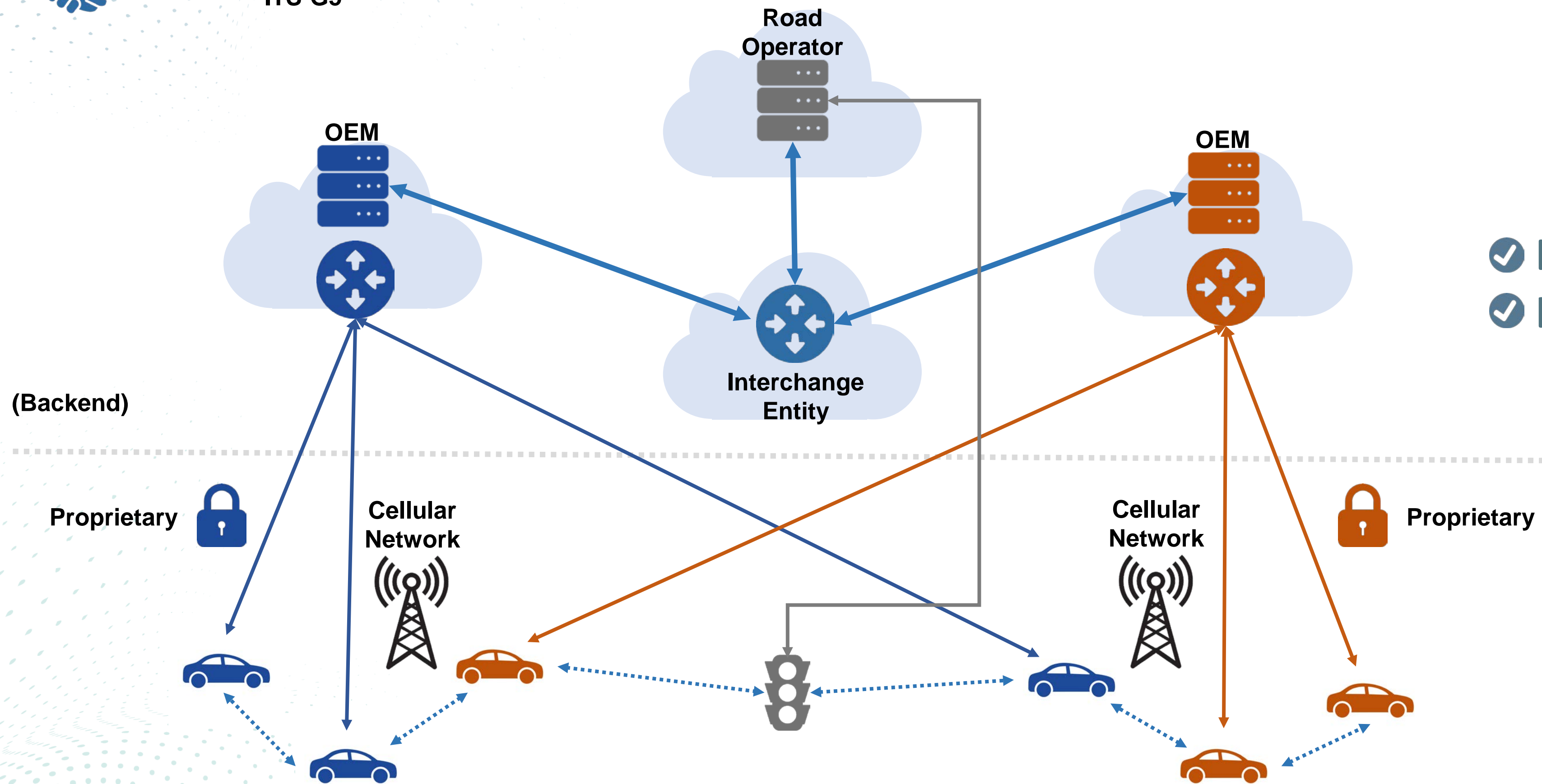


# C-ROADS HYBRID ECOSYSTEM (EU PLATFORM)



— C-Roads IP Profile (AMQP)

⋯ ITS-G5

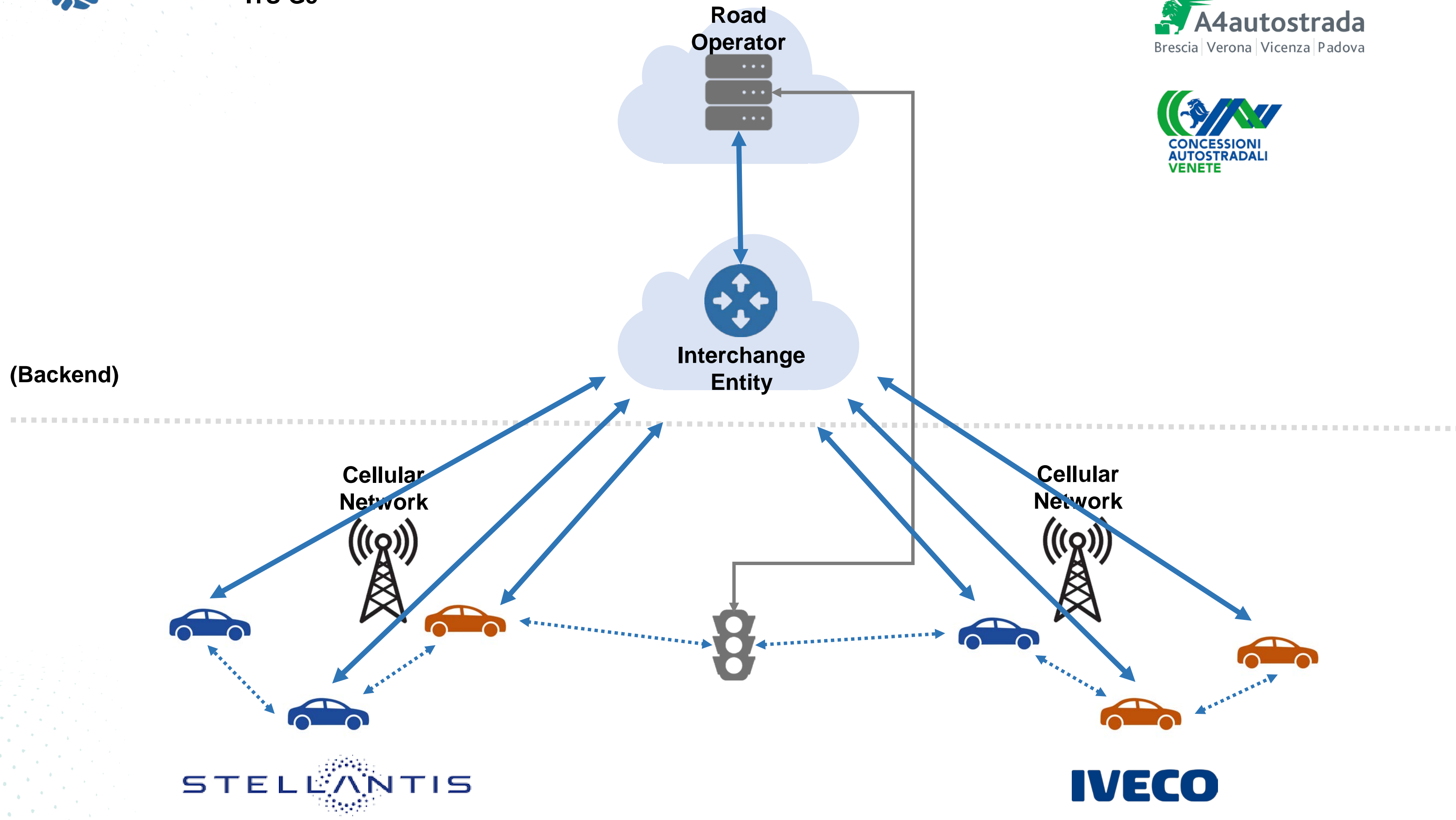


- ✓ Backend Interoperability
- ✓ Long-range X-border C-ITS

# C-ROADS ITALY 1-2-3 ARCHITECTURE

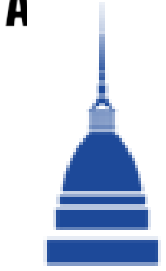


— C-Roads IP Profile (AMQP)  
 ..... ITS-G5



**A22** Autostrada del Brennero SpA  
 Brennerautobahn A<sup>22</sup>

**Almaviva**



Torino

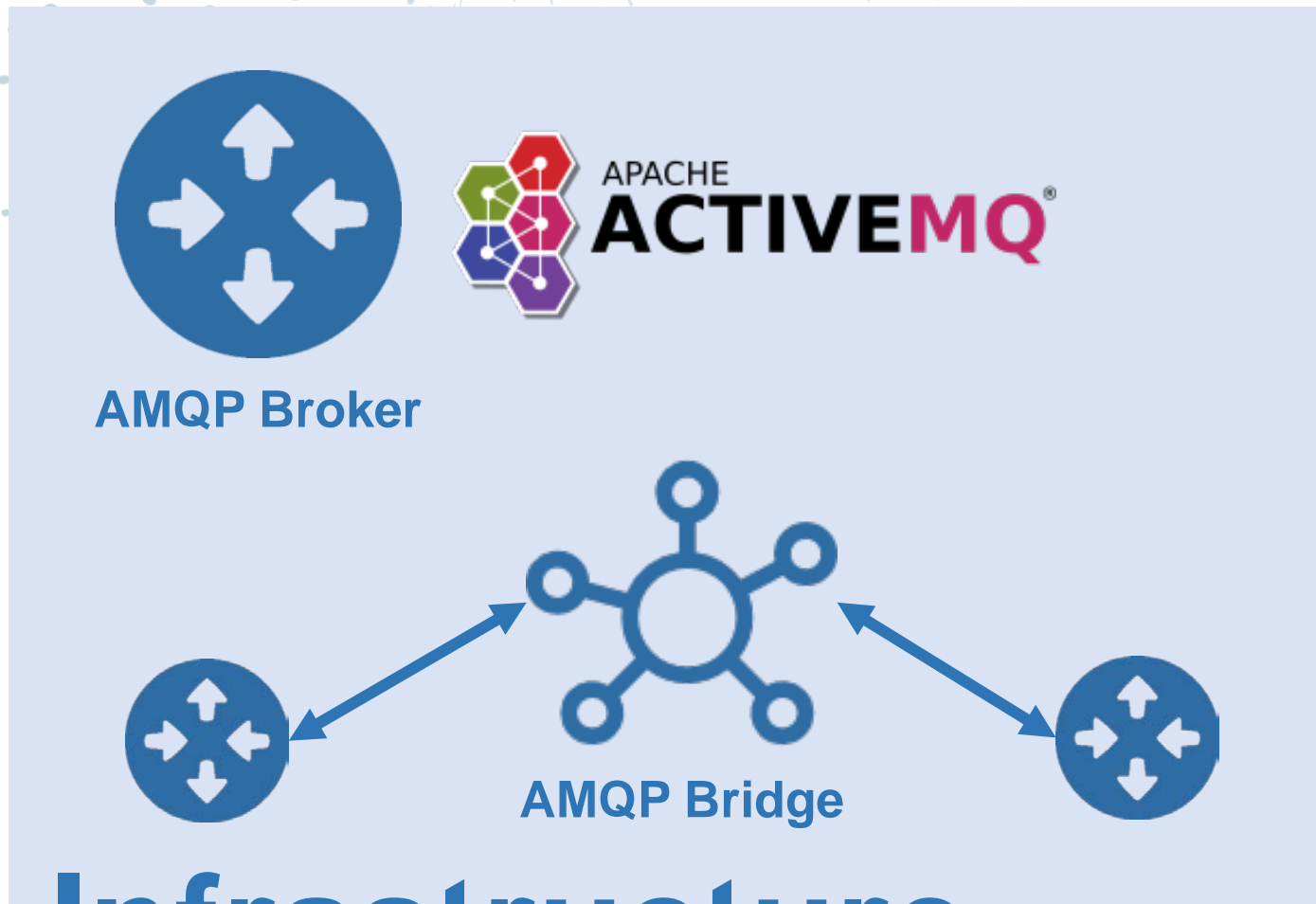
Trento

Verona

**A4autostrada**  
 Brescia | Verona | Vicenza | Padova

**CONCESSIONI  
 AUTOSTRADALI  
 VENETE**

# TIM'S INTERCHANGE ENTITY



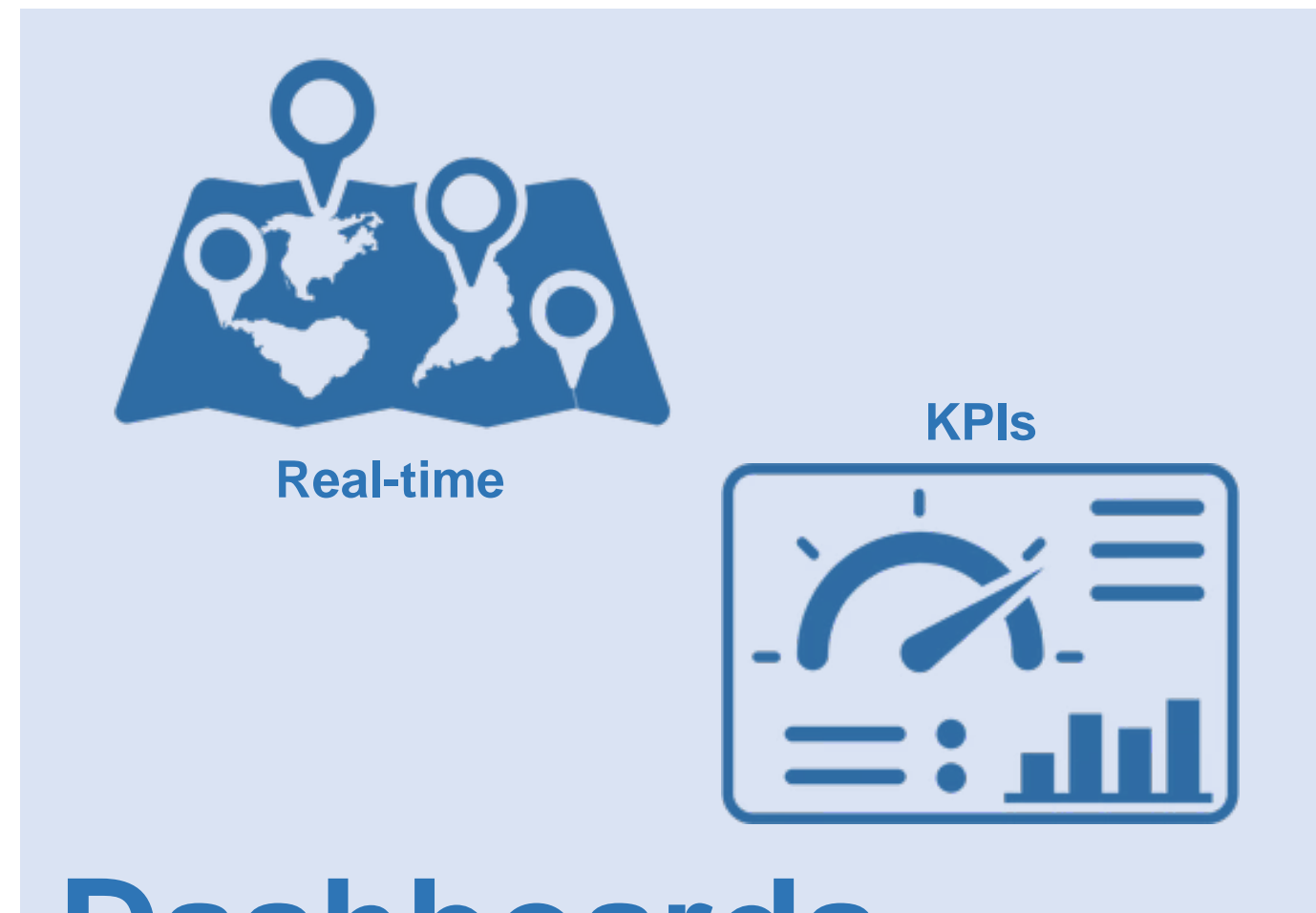
## Infrastructure



## Monitoring



## Load-testing

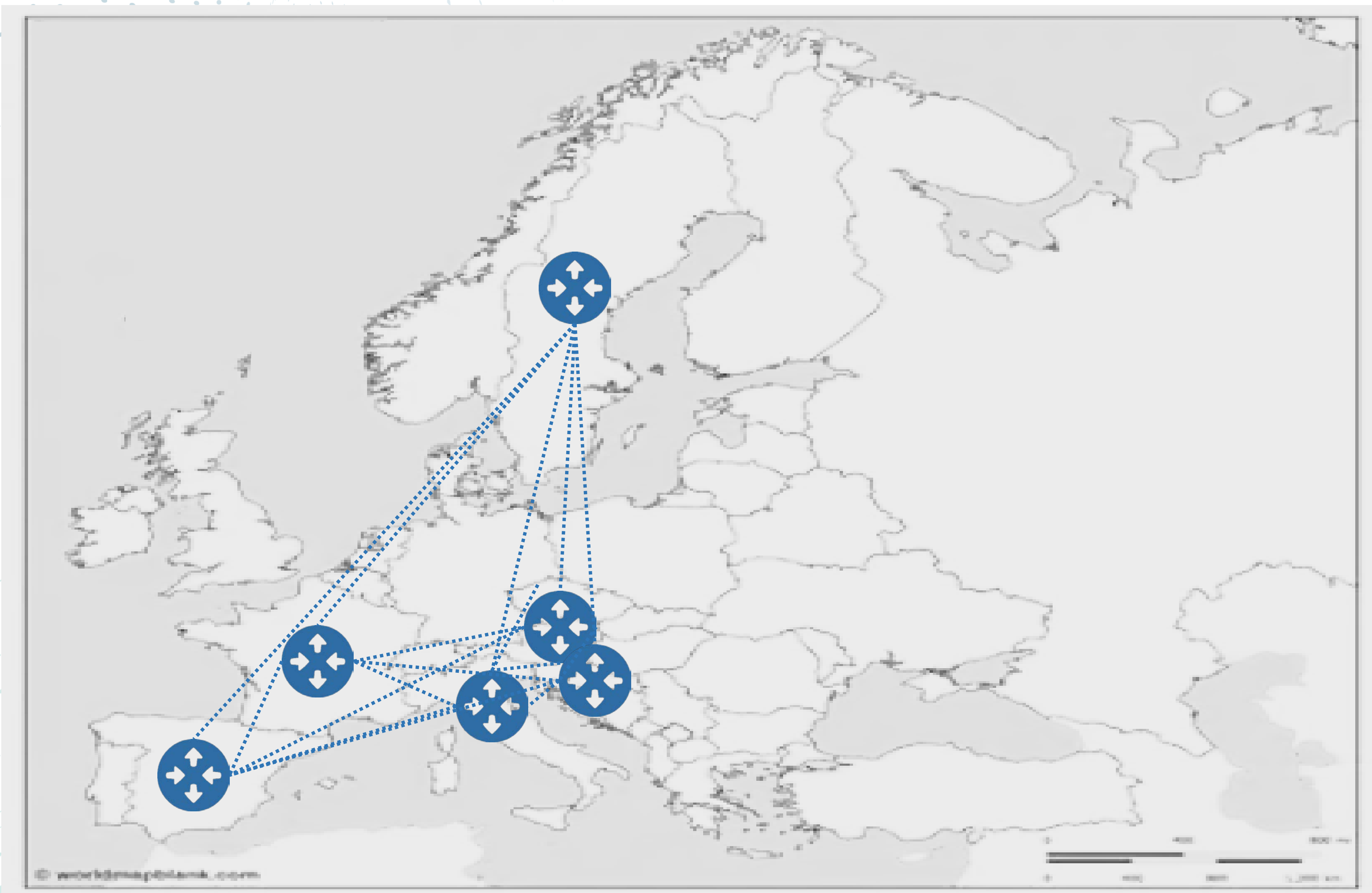


## Dashboards

Deployed in TIM Cloud  
(Self Data Center)



# AN EUROPEAN BACKBONE FOR X-BORDER C-ITS



## Hybrid Testing Group

- Austria
- France
- **Italy\***
- Slovenia
- Spain
- Sweden (+Norway)

*\*already fully connected*



# CONTROL ROOM V2X

**C-ROADS**  
Control Room V2X

EVENTI ITS VEICOLI

- Adverse Weather Condition\_ Precipitation: heavy Rain 6:11:16 PM
- Adverse Weather Condition\_ Extreme Weather Condition: strong Winds 6:11:16 PM
- [DENM] C-Roads [IT00001]
- Vehicle Breakdown 6:11:31 PM
- Roadworks 6:11:33 PM
- Roadworks 6:11:33 PM
- Hazardous Location\_ Obstacle On The Road 6:11:33 PM
- Roadworks 6:11:33 PM
- Adverse Weather Condition\_ Adhesion 6:11:33 PM
- Hazardous Location\_ Obstacle On The Road 6:11:33 PM
- Adverse Weather Condition\_ Adhesion 6:11:33 PM
- Adverse Weather Condition\_ Adhesion 6:11:33 PM
- Hazardous Location\_ Obstacle On The Road 6:11:33 PM
- Hazardous Location\_ Obstacle On The Road 6:11:33 PM

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usr\_croads | ITS

Web console for real time visualization of messages sent through TIM C-ROADS 2 Interchange Entity

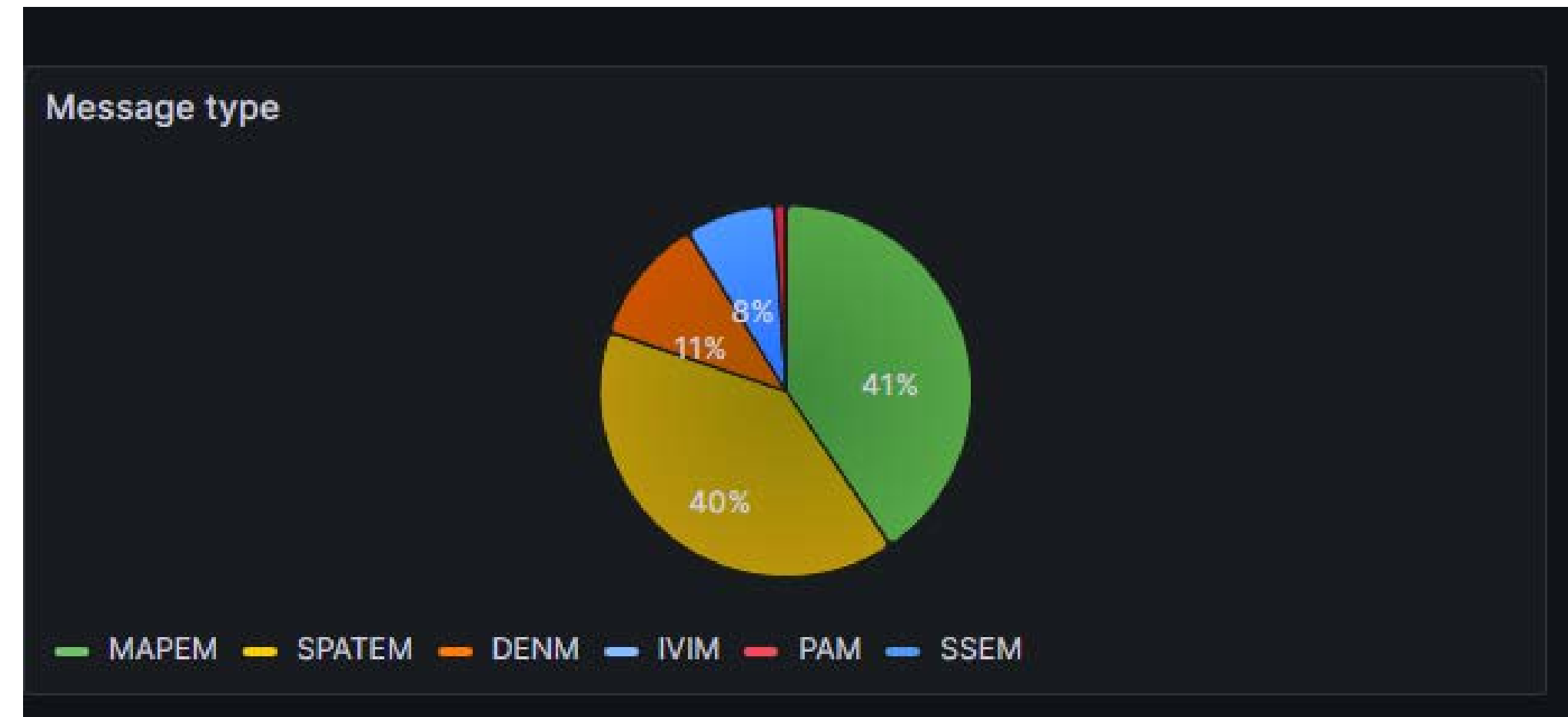


# HISTORICAL DATA WEB CONSOLE





# HISTORICAL DATA SINCE SEPTEMBER 1st 2023 (HIGHLIGHTS)

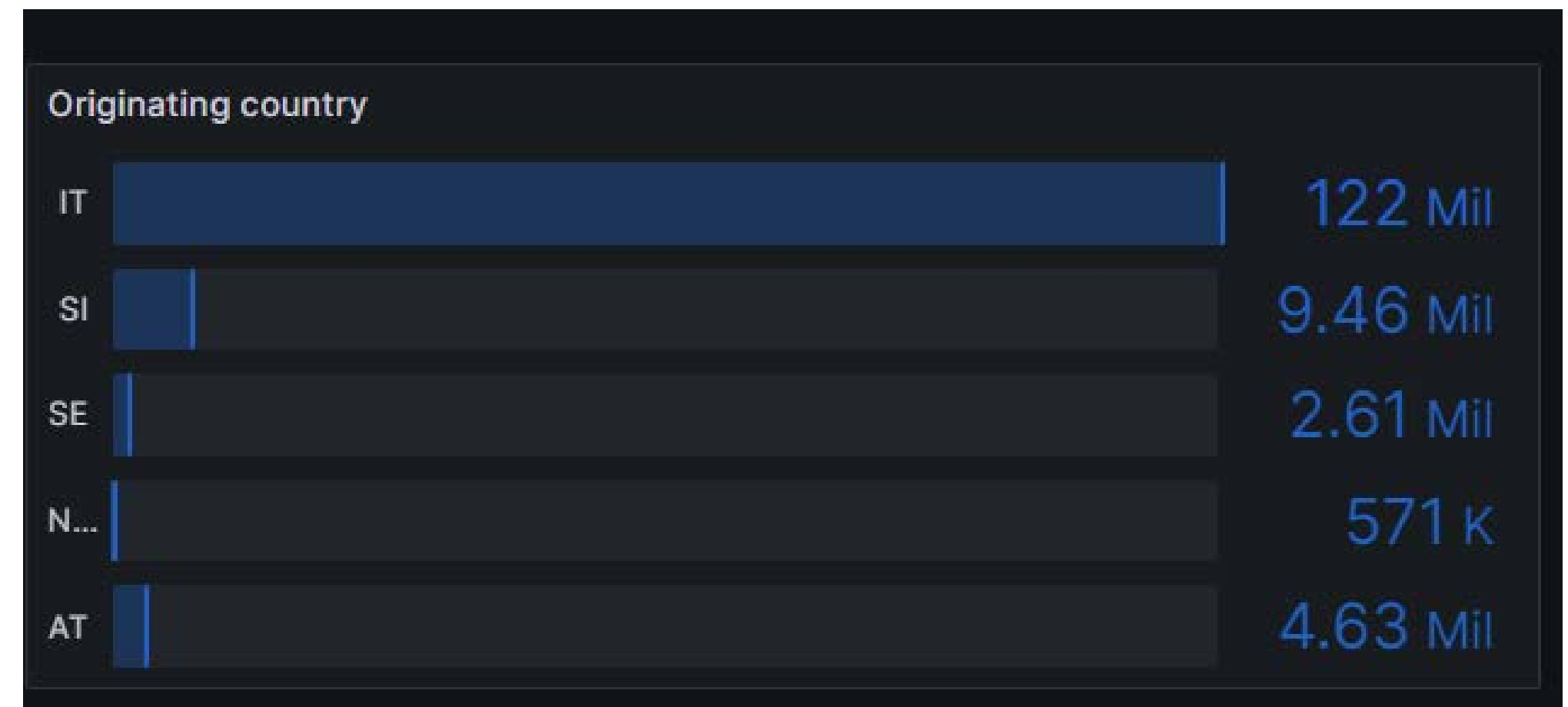


Distribution by message type

140 Millions messages since 9/1/2023



Week working days data burst



Messages distribution by country



# COMPLIANCE TO LATENCY REQUIREMENTS (TF4 IP-BASED PROFILE)

**Requirement IP\_013/8** - A broker shall be able to route 5000 messages with a payload size <500KB in <1000ms, defined as the time interval from message arrival (on broker target) to message availability (on broker source).

## Test condition

- The AMQP broker is hosted on a business-oriented public cloud (TIM's Self Data Center offering)
  - VM hardware configuration: 4-core CPU, 8GB RAM, 40GB HD, Linux OS
- \*\*\*\*\*
- AMQP messages are numbered and timestamped
  - Out-of-order delivery is counted as message loss
  - Latencies measured on the consumer side include the logging process
  - The 95% confidence interval is calculated as mean + 2(standard deviation)

## Results

The AMQP broker satisfies the BI requirement:

**with ca. 5500 msg/sec and 5 producer-consumer couples:**

the avg latency is **42,4 msec**

the 95% confidence interval is **242,6 msec**

**no message loss**

**with ca. 5300 msg/sec and 10 producer-consumer couples:**

the avg latency is **94,5 msec**

the 95% confidence interval is **530 msec**

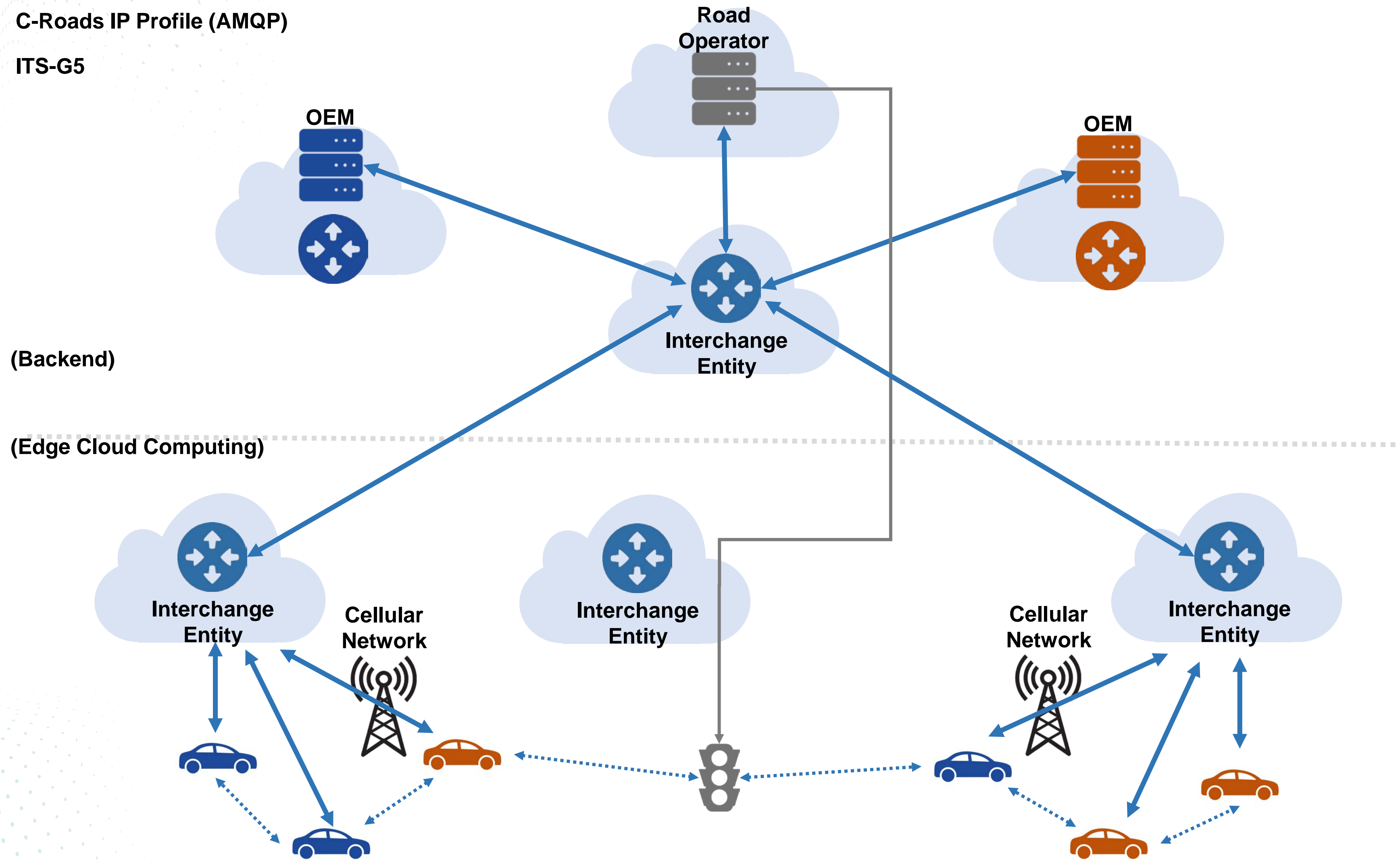
**no message loss**

The broker is even able to manage **ca. 10000 msg/sec** without loss, but the latency may go off the rails (the avg latency is ok but the 95% confidence interval is over 2 seconds)

# LOOKING FORWARD: A 5G DISTRIBUTED APPROACH



— C-Roads IP Profile (AMQP)  
 ..... ITS-G5





# CONCLUSIONS

- The TIM's Interchange Entity prototype has well supported all the Italian pilots conducted so far (C-Roads Italy 1, 2 and 3), proving to be suitable for the current scale of the task
- It meets the current latency/load requirements
- From a telco perspective, the current architecture of the brokering platform could evolve towards a distributed approach, capitalizing on edge cloud computing and the lower latency offered by 5G to better address V2V scenarios