TIME IN THE CONNECTED VEHICLE ECOSYSTEM

WORKSHOP ON SYNCHRONIZATION AND TIMING SYSTEMS

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Agenda

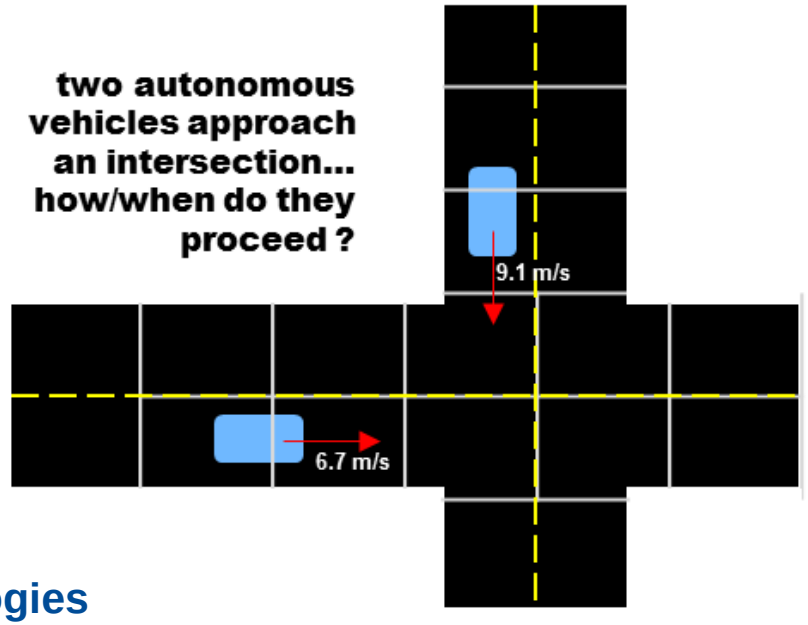
Introduction to the Automotive Industry

Automotive Platform Architectures

Automotive Timing Use Cases and Requirements

The Automotive Industry is in a Period of Evolution

The automotive industry has traditionally been composed of disparate technologies, with significant technical differences between vehicle platform architectures and supporting infrastructure



Technology convergence on the vehicle platform is being driven by…

- V2X Communications
- Autonomous Technologies
- Automotive Cyber Security

Timing Technologies are Key Enablers

Integration of time into automotive platform architecture must be done securely to ensure consumer safety

The Connected Vehicle Ecosystem

Components
Powertrain, Body, Safety, Infotainment, Chassis Systems

Network Interfaces
Internal Networks
Wired
Wireless

Features & Services
Safety Features, Software, Infotainment, Convenience, Communications Services

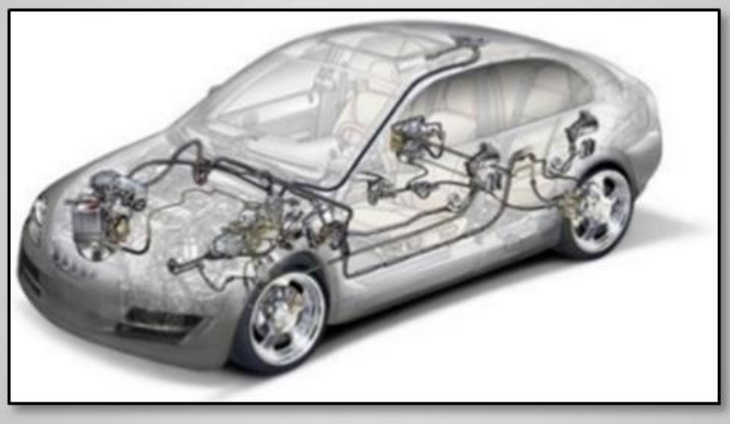
Connected Vehicle

Enabling Infrastructure

External
Energy Infrastructure
Transportation Network
Financial Services
Cellular Networks
Cloud Providers
Civic Services

Internal
IT Infrastructure
Manufacturing Network
Dealership Network
Call Centers
R&D Labs

Customer Experience



Key Influencers

Consumers
Individual, Corporate

Government
National, Regional, Local

Adversaries
Hacktivists, Criminals, Nation States, Insiders

Auto Industry
Suppliers, Affiliates, Partners, Competitors, Associations

Vehicle Lifecycle

Plan
Design & Test
Source & Supply

Manufacture
Market
Deliver

Sell
Service & Monitor
Resale/Dispose

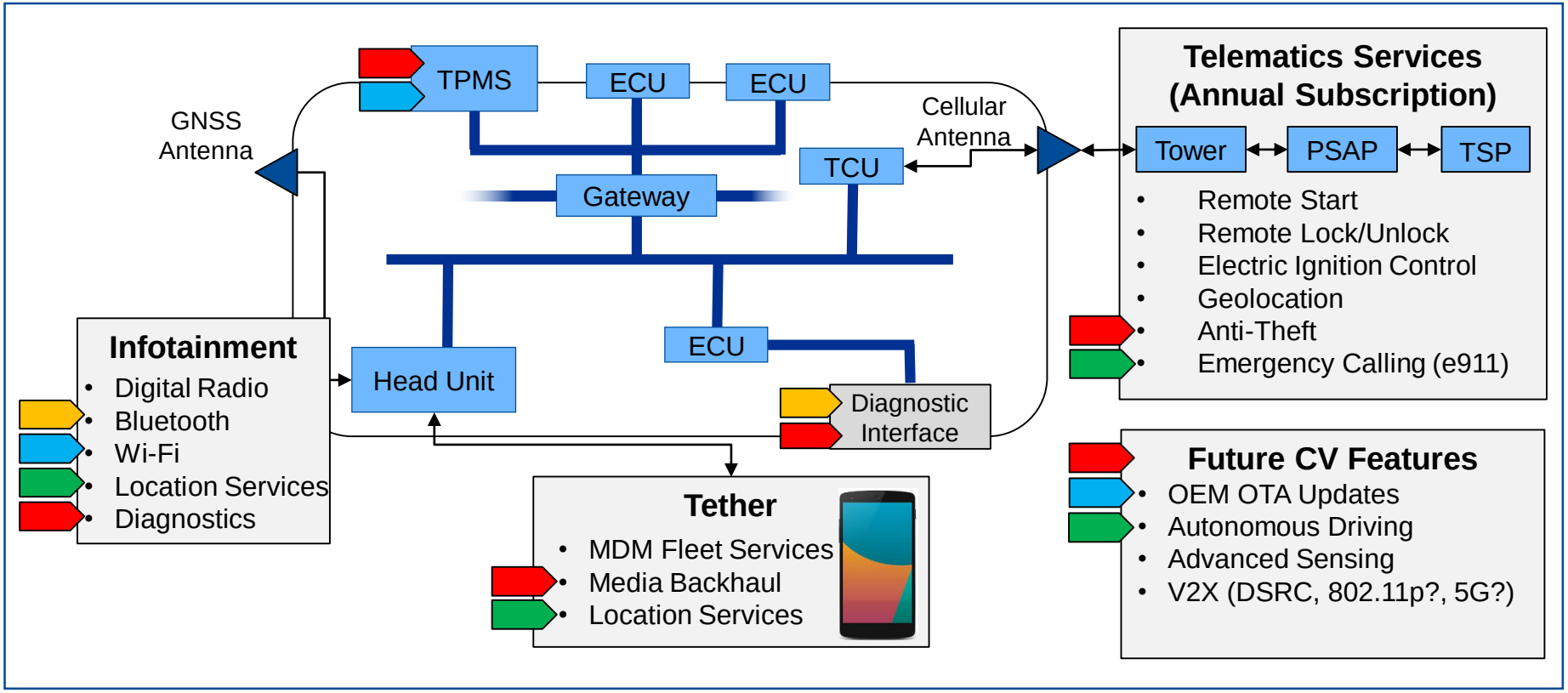
Core Elements of Connected Vehicle Platform

Time is Everywhere

Electronic Control Unit (ECU)	ECU is a generic term for an electronical system in a vehicle. A typical connected vehicle may have 60-120 different ECUs inside. ECUs may be relatively simple sensor systems or complex multi-functional subsystems
Head Unit	A primary consumer interface to the vehicle. The head unit may contain Bluetooth, Wi-Fi, analog Radio, and Cellular connectivity. It may allow cellular device pairing, visualization for many other ECU networks (e.g. LIDAR-awareness or TPMS alerts)
Gateway	A special-purpose ECU that filters automotive bus traffic between "connected" components such as a head unit and other electrical systems. Gateways also interconnect different types of automotive bus networks.
Telematics Control Unit (TCU)	A special-purpose ECU that enables telematics services to the vehicle platform by providing special cellular connectivity. Typically contains at least one common baseband chip
Telematics Service Provider (TSP)	Provides managed telematics services to vehicles. Telematics services include remote lock/unlock, geolocation, etc. May reside internally within OEMs organization, or be offered as a service.

Connected Vehicles Integrate Many Technologies

Notional Connected Vehicle Platform Architecture



External Interface Classification

- Electromagnetic/RF
- Cyber-Physical
- Physical
- Network/IP-Based

The Connected Vehicle Platform Supply Chain

Today		The Future
Automotive OEMs		
• Participation in Automotive ISAC • Participation in AUTOSAR	**Organizational Evolution** →	• Maturation of Cyber Strategies • Integration of Connected Services • Convergence of Technologies • Automotive Platform as Experience
Tier 1 Suppliers		
• Large reliance on CAN bus • Little to no secure processing • Deploying deprecated technologies	**Tighter OEM Coupling** →	• Alternative Digital Buses • Standardized Architectures • Integration of Mobile Supply Chain
Tier 2+ Suppliers		
• Decoupled from OEMs • Lowest-Cost ECUs Required	**Technology Convergence** →	• Signed Firmware • Strong Cryptographic Management • Time-Aware Hardware

Opportunities for Timing Vendors

Motivating Precision Time in Automotive Platforms

Precision Time in Automotive Platforms

There may exist many different types of time in an automotive context and use cases are driving technology convergence:

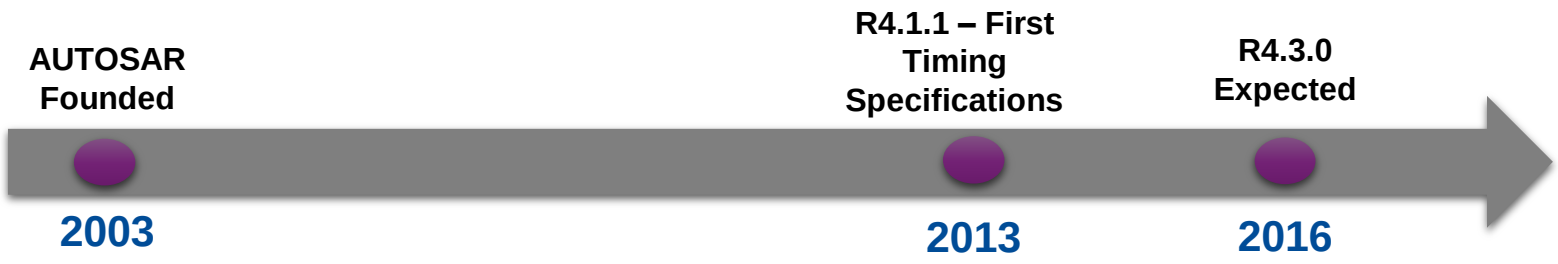
- V2X communications may require UTC time
- A free running clock may trigger events after a certain number of cycles
- Disparate sensor systems may require a common time base so their individual measurements may be integrated

Each application may require time to a different level of precision and may not require time referenced to UTC

The Automotive Community is engaged in a development partnership called Automotive Open System Architecture (AUTOSAR)

- OEMs and suppliers are investing in an open source and secure electrical architecture (AUTOSAR)
- AUTOSAR R4.1.1 defines a Global Time Synchronization Mechanism to distribute one or more master time bases across various bus systems.
  - Directly addresses automotive use cases
  - Specified time transfer protocols for FlexRay, Ethernet, CAN buses
  - Allows for multiple, independent, Time Domains in an automotive platform
- AUTOSAR may be mandated at the OEM level, will be implemented by Tier 1 and 2 Suppliers

AUTOSAR Timeline



Time in the Automotive Platform

Time Distributed Across Different Bus Types to Systems

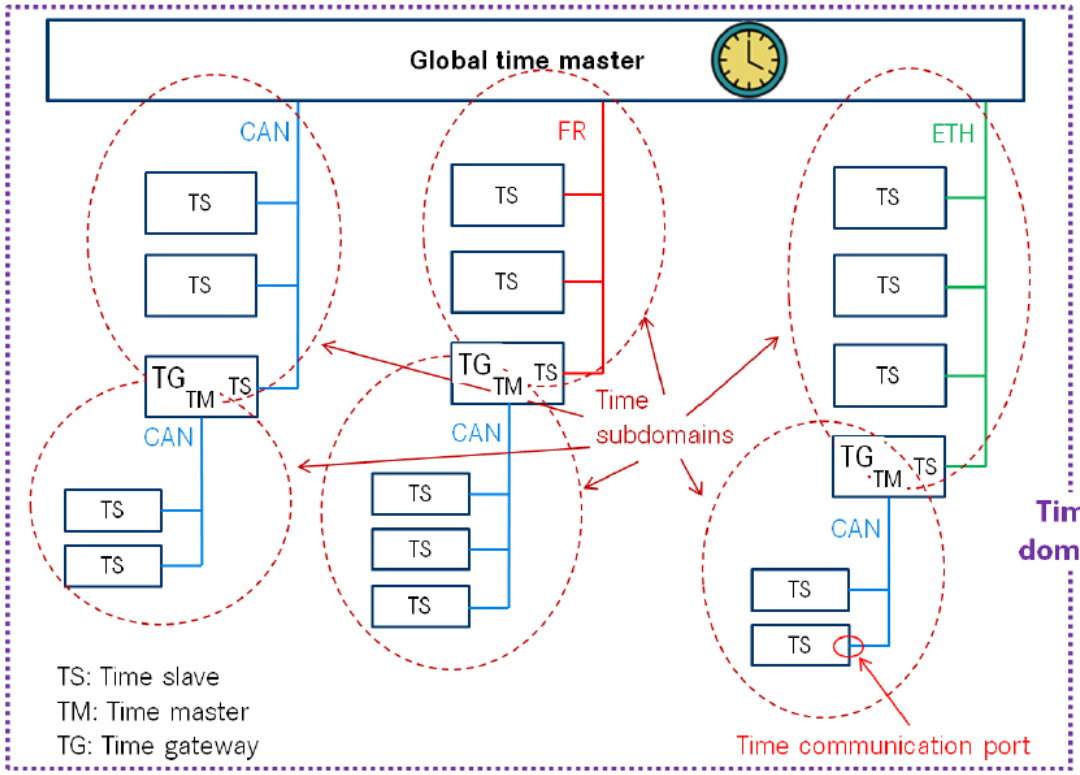


Figure taken from AUTOSAR_SWS_SynchronizedTimeBaseManager Specification

AUTOSAR Definitions

Global Time Master
Global owner and origin for a certain time base and on the top of the time base hierarchy for that time base.

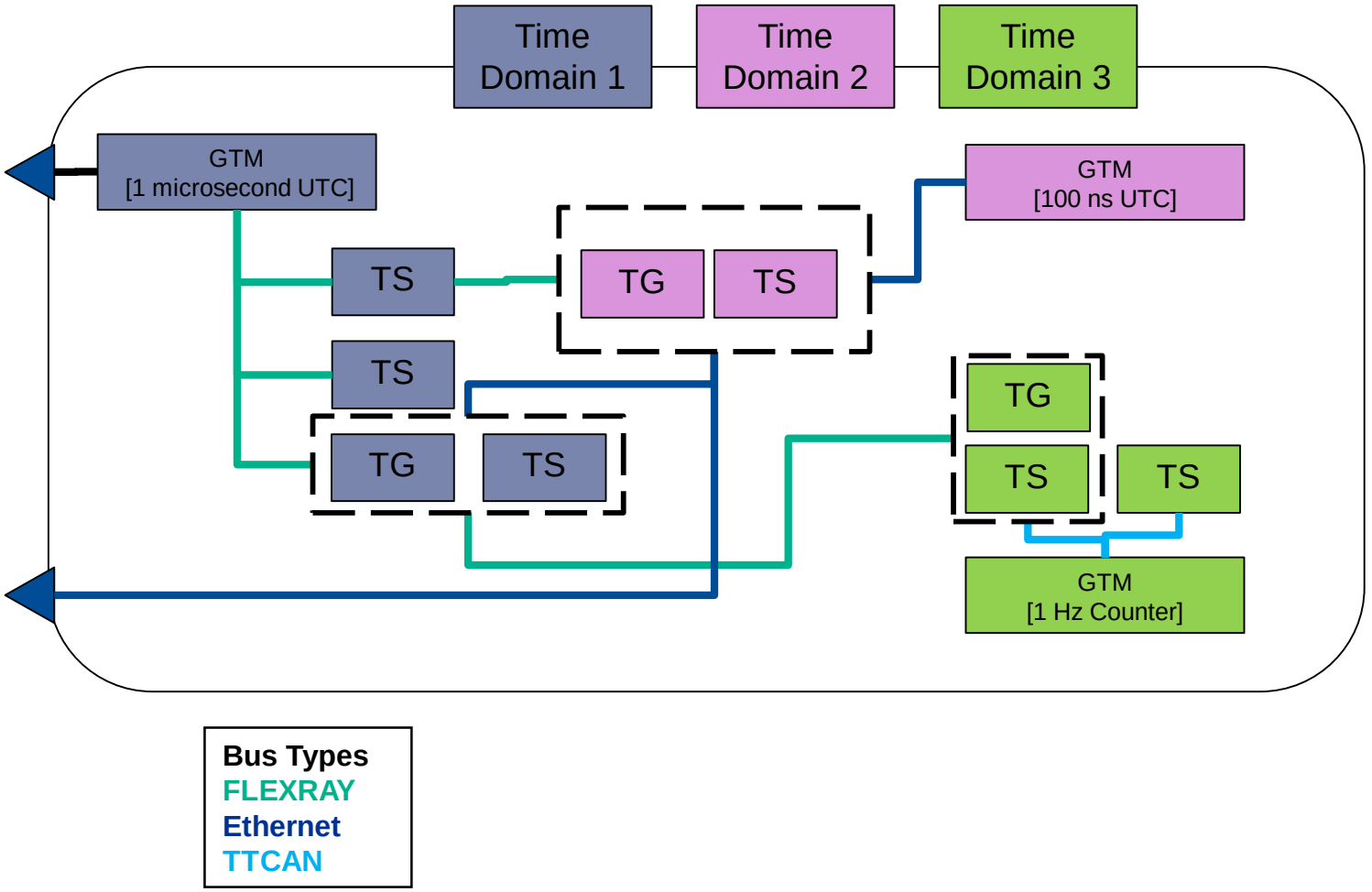
Time Domain
Denotes which components (e.g. nodes, communication systems) are linked to a certain time base. A Time Domain can contain no or more than one Time Sub-domains. If the timing hierarchy of a Time Domain contains no Time Gateways, i.e. all nodes are connected to the same bus system, then there is no dedicated Time Sub-domain which otherwise would be equal to the Time Domain itself.

Time Gateway
A set of entities where one entity is acting as time slave for a certain time base. The other entities are acting as time masters which are distributing this time base to sets of time slaves. A TimeSync ECU can contain multiple time gateways. A time gateway can be connected to different types of bus systems (e.g. the slave side could be connected to a FlexRay bus whereas the master side could be connected to a CAN bus system).

Time Master
An entity which is the master for a certain time base and which propagates this time base to a set of time slaves within a certain segment of a communication network, being a source for this time base. If a time master is also the owner of the time base then he is the global time master. A time gateway typically consists of one time slave and one or more time masters. When mapping time entities to real ECUs it has to be noted, that an ECU could be Time Master (or even Global Time Master) for one time base and Time Slave for another time base.

Time in the Automotive Platform

A Time-Centric Perspective of an Automotive Electrical Architecture



Common Automotive Buses

Automotive Buses

	Controller Area Network (CAN)	FlexRay	Time Triggered CAN	Ethernet
Interface				
Technical Notes	• Contention/Priority Based • Broadcast Network Configuration • Inexpensive • Extremely Mature Technology	• TDMA-based • Time triggered events to the microsecond • More expensive than CAN • Priority based traffic	• Evolution of CAN Standard • Defines a time master on the CAN network that periodically transmits a reference message • Time specified in microseconds	• Network topology and configuration does not change in automotive use case • Can leverage existing Ethernet technologies (e.g. 1588)
Use Cases	• Inexpensive network interface used extensively in automotive industry	• Deterministic bus • Possible to determine time of transmission with high precision	• Time Triggered CAN: Periodic transmission of a reference message by a time master that defines a bus-wide network time that can be used to trigger events	• Perceived as expensive and possibly unnecessary • Limited adoption in automotive • Addresses timing, security, and throughput

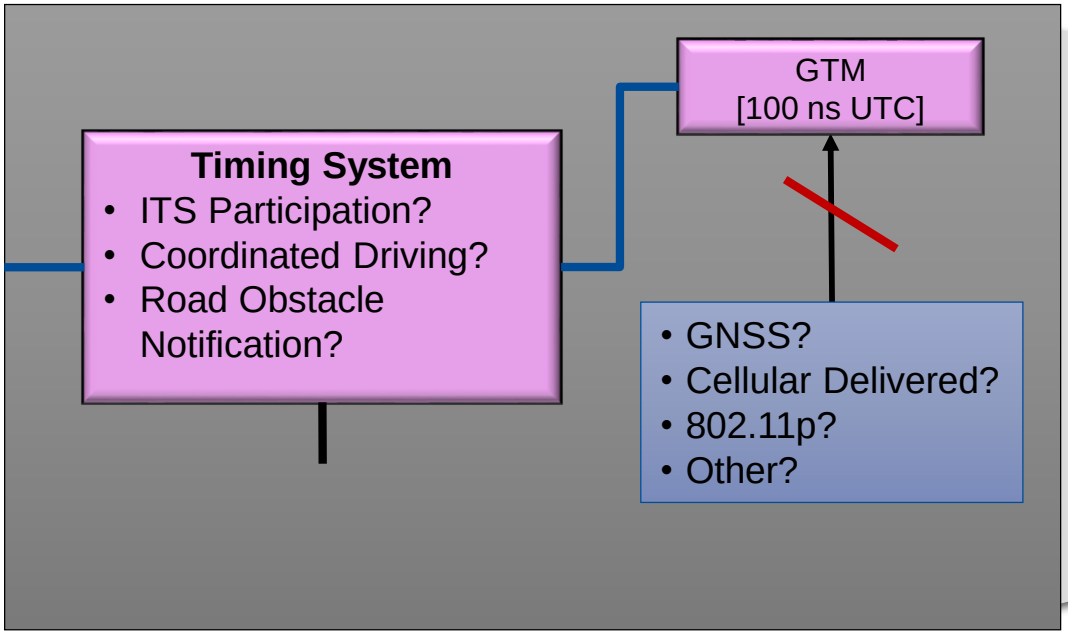
Timing Dissemination Sources and Technologies

Selected Candidate Technologies for Automotive Time Reference Sources

Timing Source	UTC Traceability	Scale	Availability	Comments
GNSS	Yes	< 100 ns	Global	Not appropriate for all environments; may be denied
GSM NTIZ	No	~1s	Regional	Will not meet timing requirements of CV
CDMA2000 Sync	Yes	1 ms	Regional	
Free-Running Clock or other Relative Source	No		On Platform	Si through CSAC
DSRC (802.11p)			Under Development	
LTE R11+ SIB 16	Yes	10 ms		Not widely deployed. 10 ms may not be sufficiently precise.
Iridium Time (Satelles)	Yes	< 100 ns	Global	Paid Service; May have higher availability than GNSS
eLoran	Yes	< 100 ns	Europe, Asia, Middle East	Not global coverage (yet…)

Time Aware Connected Platforms May be a Safety Issue

What Timing Systems Might Require 100 ns UTC?



Safety Concerns

- Lack of understanding around the effects of intentional or incidental disruption of a timing service to a process making real-time decisions and the **impact to passenger or pedestrian safety**.
- Secured timing services are **not widely available**.
- Automotive timing services could become **regulated.**

Connected Vehicle Platforms Present Opportunities for New Business Models and Integrated Technology Solutions

- Time is not a mature technology on the automotive platform
- Automotive industry understands their use cases, and will look to adjacent industries for solutions

CONNECTED VEHICLE USE CASES	ENABLING TECHNOLOGIES
• Car-to-X • Autonomous Driving • Commoditized SW • Cybersecurity	• Small Sensor Packages • Mobile Supply Chain • **Precision Timing Technologies** • Cloud Computing • Commoditized Software

Customer Vehicle Experience