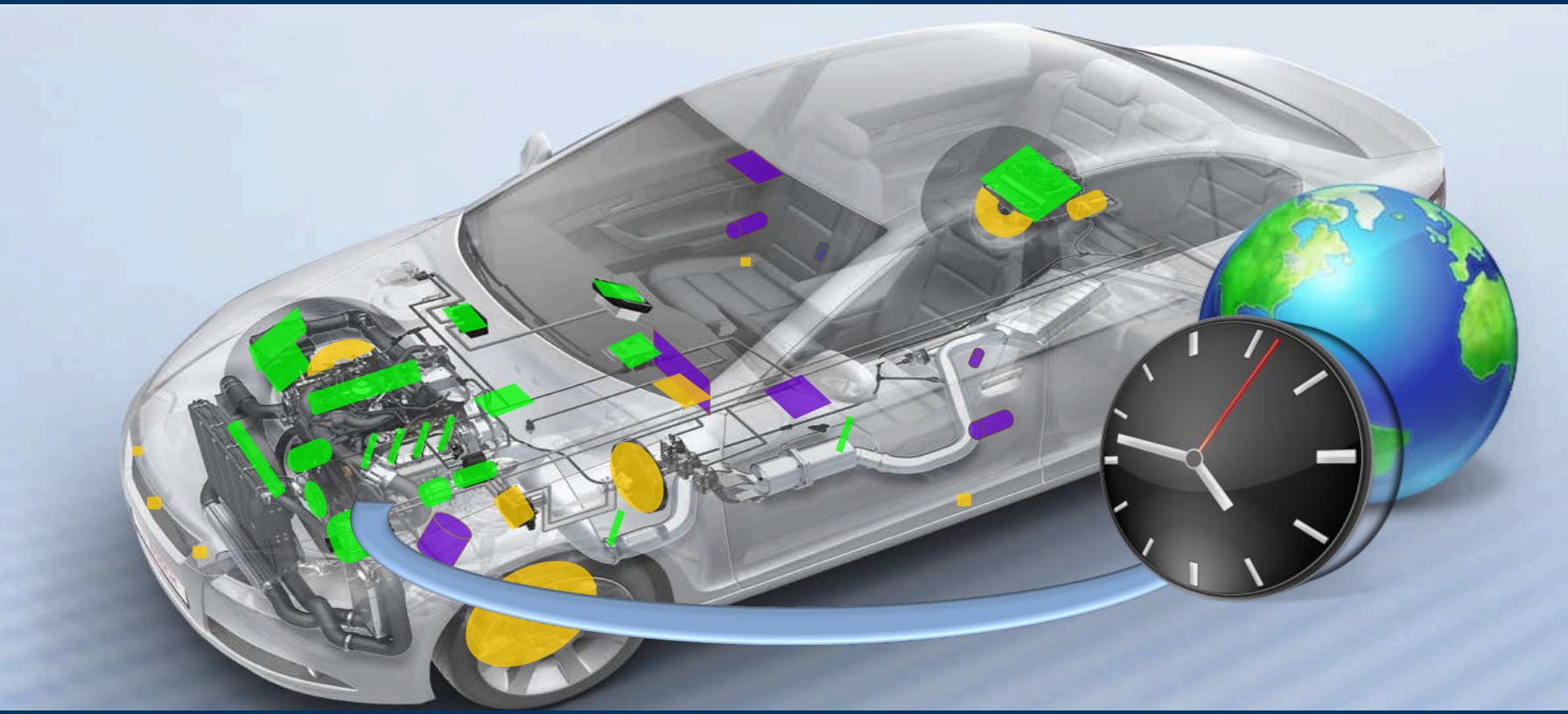

In-Vehicle Global Synchronization

IEEE 802.1 Plenary Meeting - Geneva - 2013.07.16

Aboubacar Diarra – Robert Bosch GmbH

Outline

- Global Synchronization Goal
- Global Synchronization Use-Cases and Scenarios
- Global Synchronization Basics
- Global Synchronization Mechanisms
- Next Steps ?

Global Synchronization Goal

Goal ?

➔ Define a Common Global Time Reference for all In-Vehicle Networks

What is the Purpose of that ?

➔ Make all automotive Time Sensitive Systems work on a same Time Base when exchanging data between each other, even though they belong to different domains with different Communication Bus Systems (CAN, FlexRay, Ethernet, etc . . .)

➔ Make all automotive Time Sensitive Systems have a complete & correct view of Time

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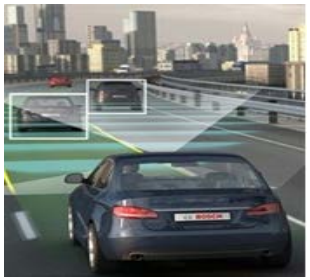
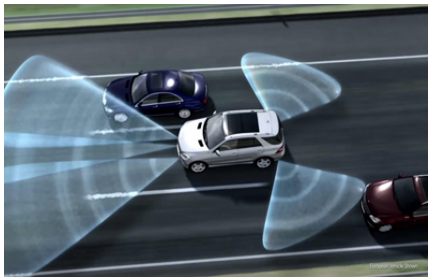
Global Synchronization Use Cases and Scenarios

Improvements on Sophisticated Automotive Advanced Drivers Assistance Systems like:



Adaptive Cruise Control

Lane Departure Assist



Blind Spot Assist

Brake Assist

- These Systems need support of different Sensors and ECUs for Cameras, Radars, Motor, Brakes etc ...
- From Sensors Data Fusion to the Control of Brakes, Steering Systems, Motor etc . . . , Data are exchanged between different Sub-Networks which should be time-correlated
- In addition, for ADAS Recording , Event Data Recording, System Analysis Recording, an Absolute or Universal Time Perspective needs to be added to Synchronization Perspective, on top of Working or Relative Time Apprehension
- This trend leads to high Synchronization Demands

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Global Synchronization Basics (GW E/E A)

2 Time Scales for an effective view of time

Absolute or Universal Time

e.g.: 2013-05-13 at 09hrs, 30min, 50sec

Relative or Working Time

e.g.: 40 min, 15.3 sec

On Time Master for each Time Scale

- Absolute (Universal) Time Master
  - Head Unit (Access to GPS)
- Relative (Working) Time Master (2 Possibilities)
  - Central Gateway for a GW based E/E Architecture
  - One of the DCUs* for a Backbone E/E Architecture

→Remark: These 2 Time Masters play the roles of Global Time Masters

Concept of Local Time Masters

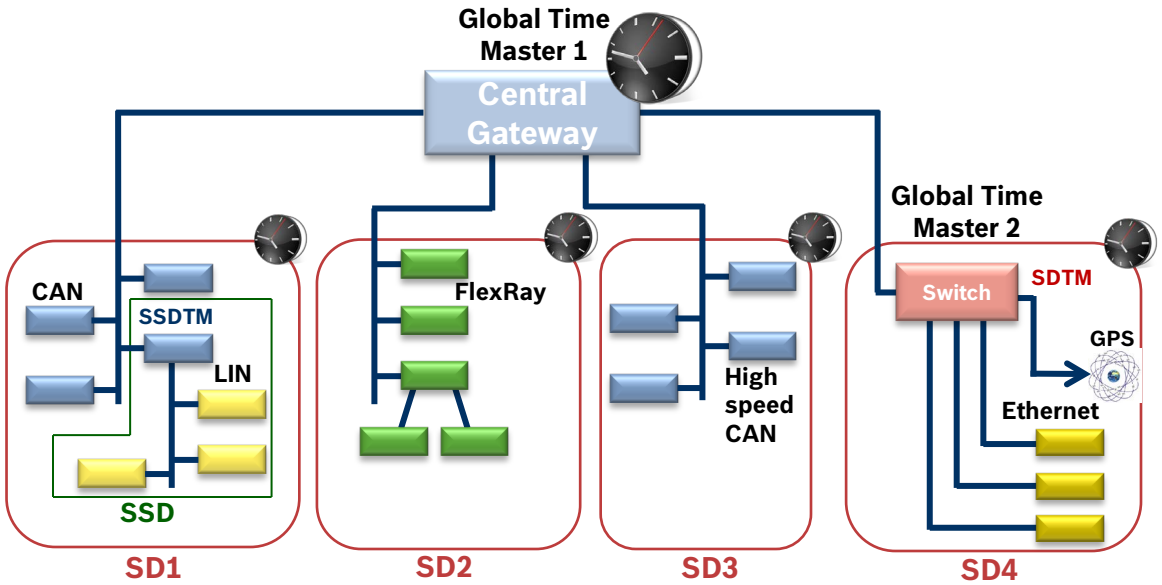
- Role: Forward Time Information (Absolute or Relative) in Sub-Network
- Central Gateway as Local Time Master in each Sub-Network
- Each DCU is a Local Time Master in its corresponding Sub-Network

* DCU: Domain Control Unit

Problematic

- How will the coexistence of 2 Time Scales be handled in in-vehicle networks ?
- How can different ECUs based on different Communication Systems have the same view of Absolute Time and Relative Time ?
- Alternative:
  - →Introduction of PTP Mechanisms on CAN & FlexRay
  - Support for 2 Time Scales on TSN

Global Synchronization Basics (GW E/E A)

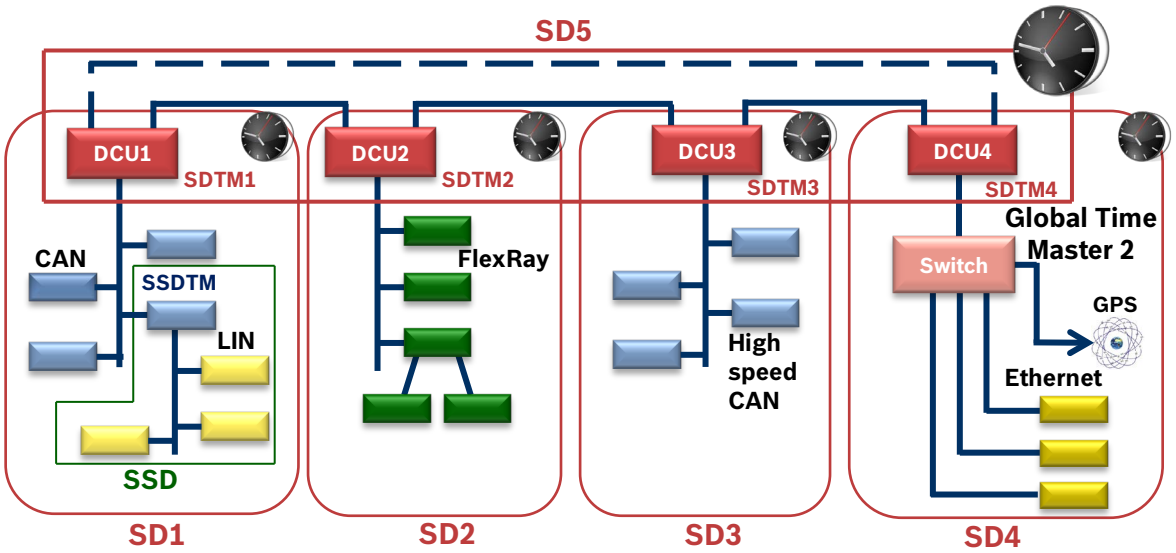


SDi: Synchronization Domain i
SDTM: Synchronization Domain Time Master
SSD: Synchronization Sub-Domain
SSDTM: Synchronization Sub-Domain Time Master

Remarks:

- The Central Gateway is the Relative Time Master.
- The Switch linked to the GPS can provide the Absolute Time. It is then the Absolute Time Master.

Global Synchronization Basics (Backbone E/E A)



SDi: Synchronization Domain i

SDTMi: Synchronization Domain Time Master i

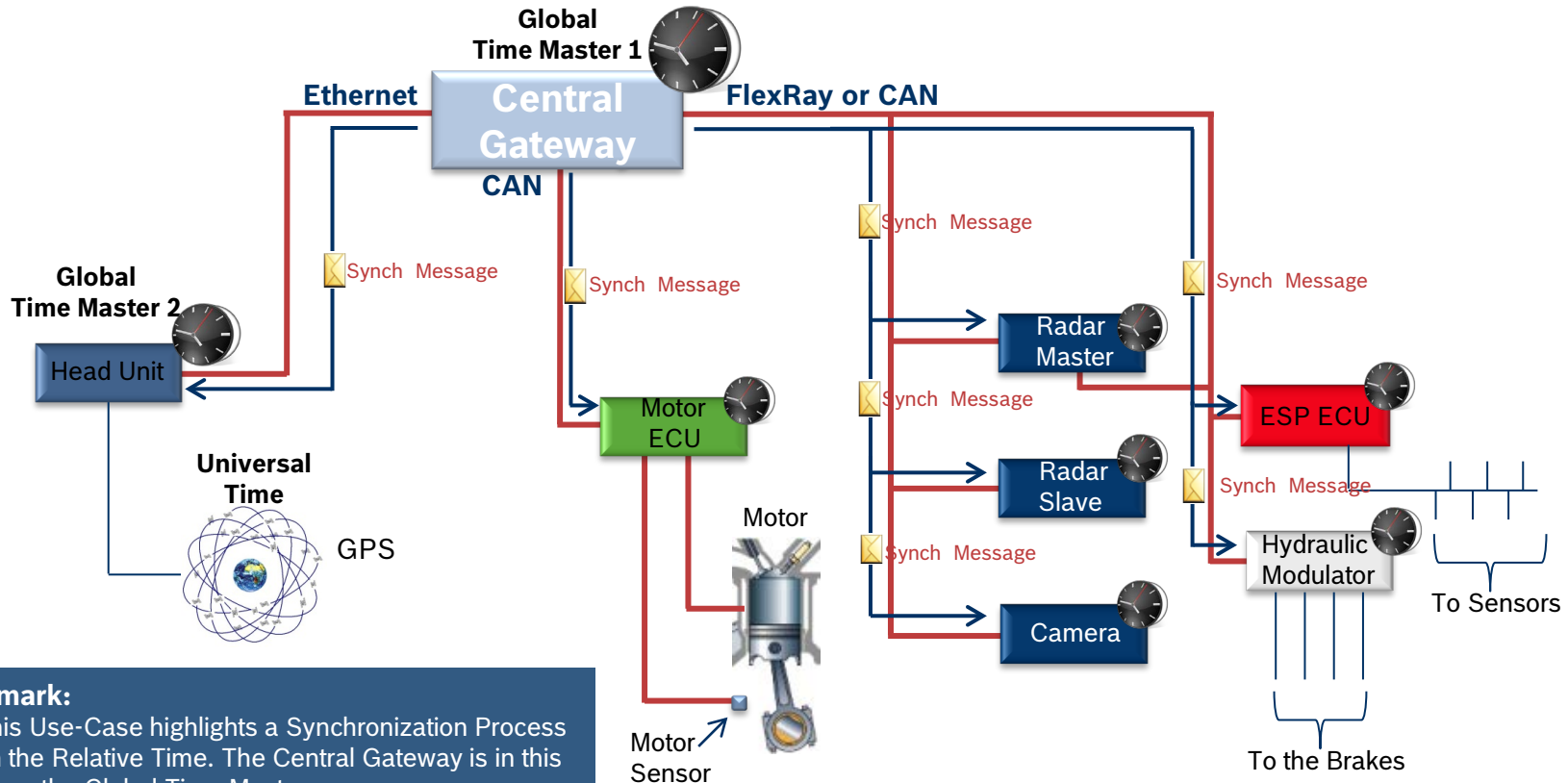
SSD: Synchronization Sub-Domain

SSDTM: Synchronization Sub-Domain Time Master

Remarks:

- One DCU is the first Global Time Master. It is also the Relative Time Master. The other DCUs are synchronized to it.
- Each DCU is the Local Time Master in its Synchronization Domain excepted the SD5 where one DCU is the Time Master (The first Global Time Master)
- The Switch linked to the GPS can provide the Absolute Time. It is then the Absolute Time Master. The other DCUs are synchronized to it.

Global Synchronization Example on ACC System (1)



Remark:
This Use-Case highlights a Synchronization Process on the Relative Time. The Central Gateway is in this case, the Global Time Master

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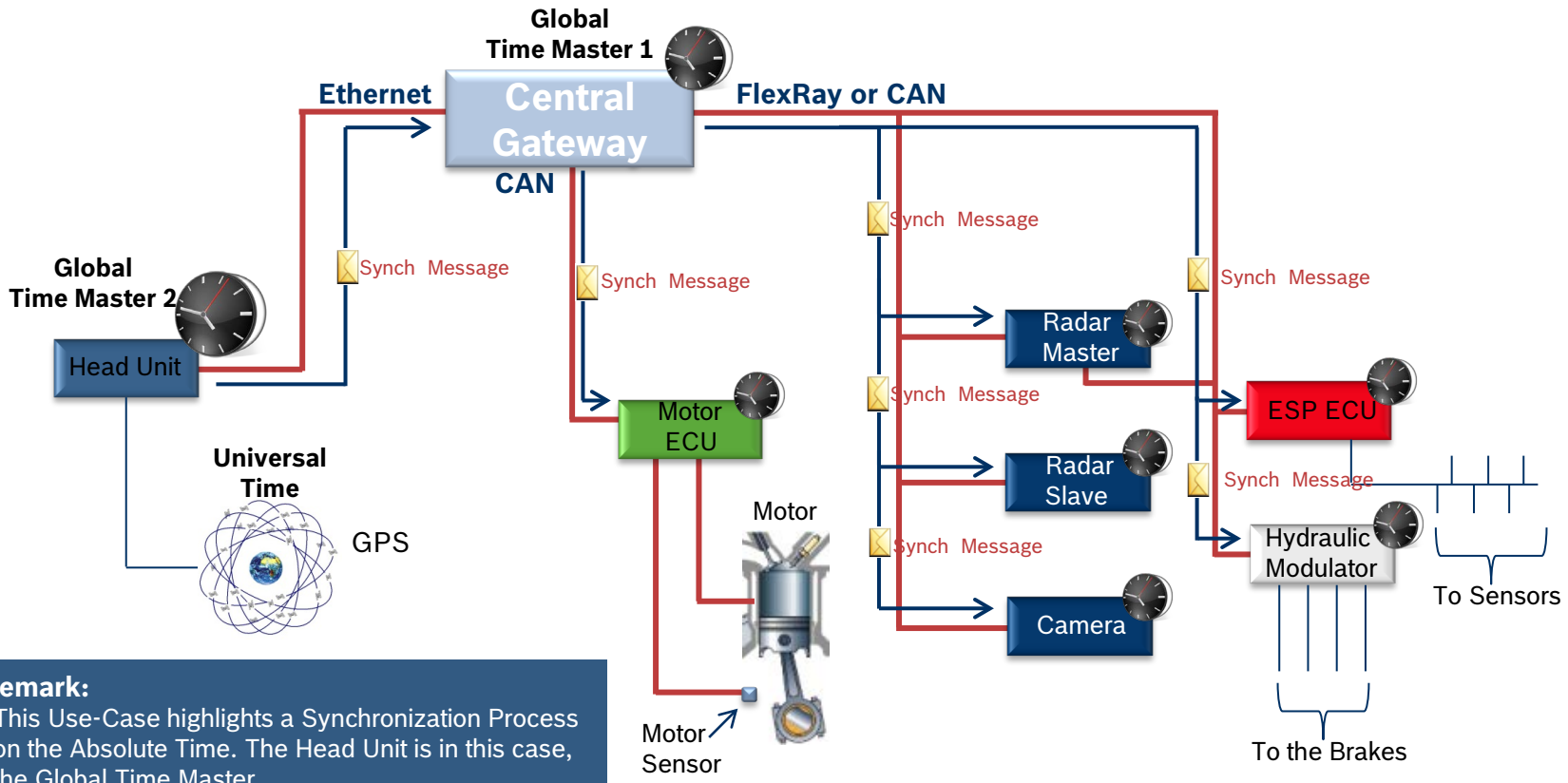
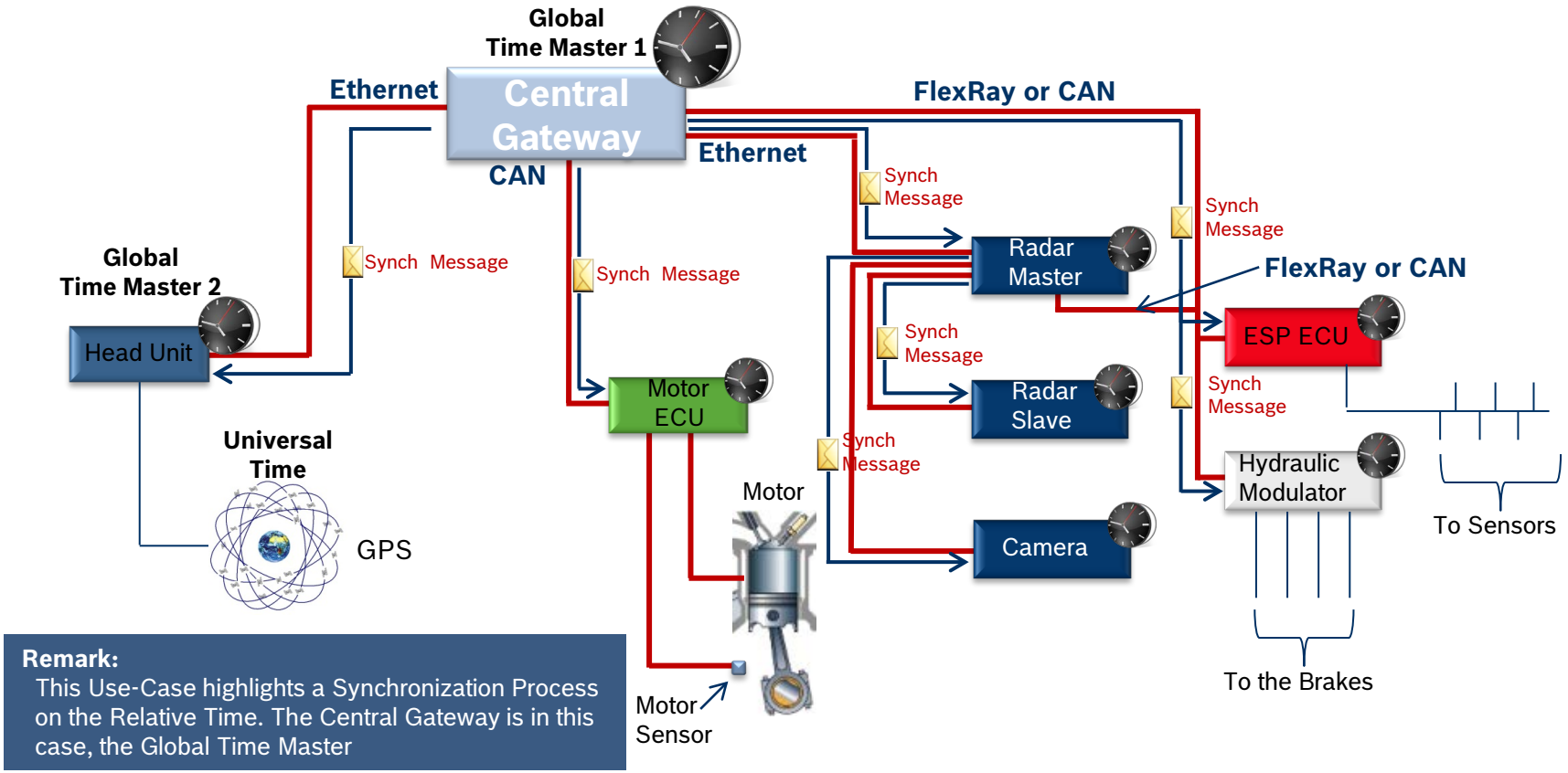
Global Synchronization Example on ACC System (2)



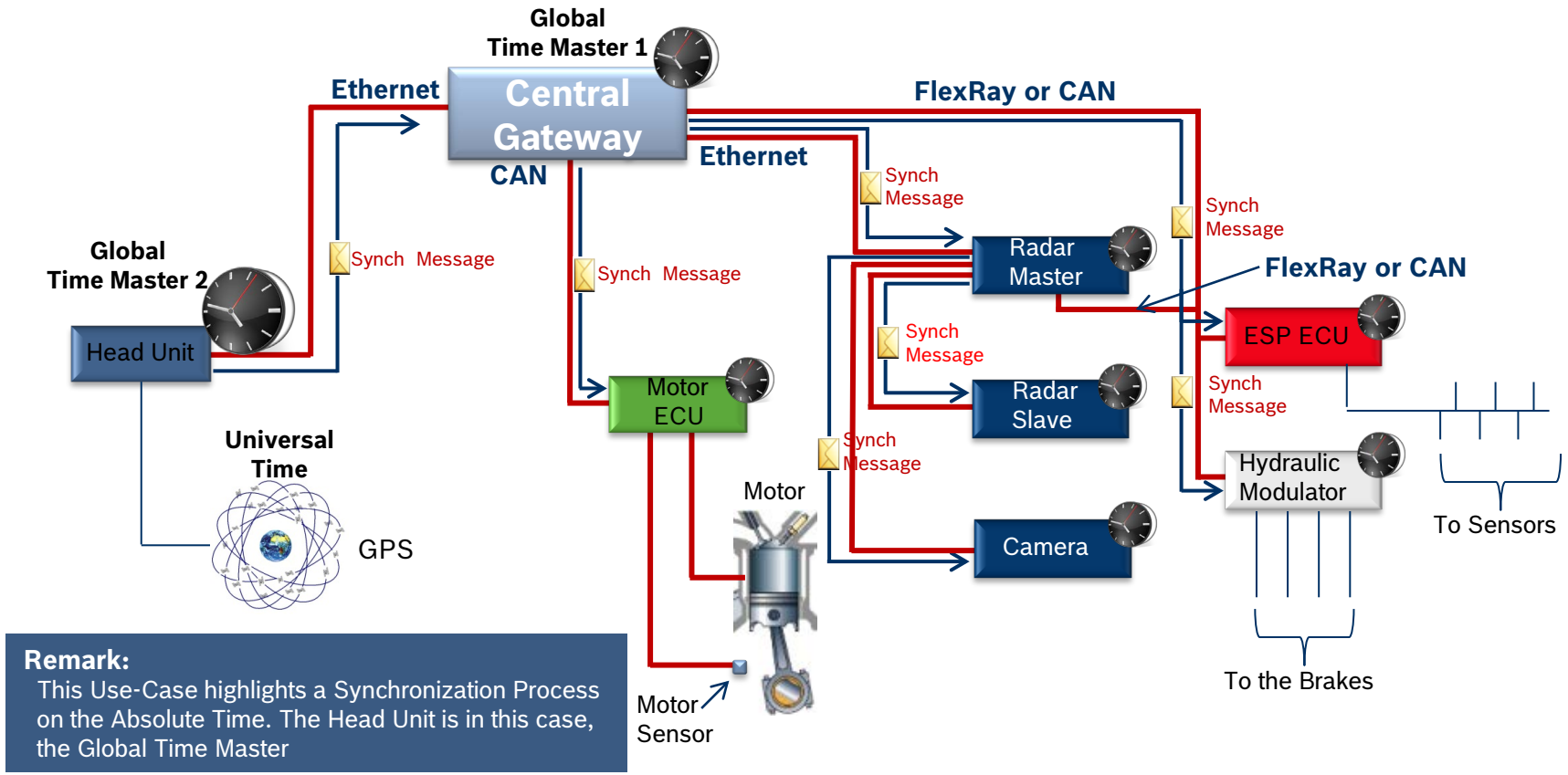
Remark:
This Use-Case highlights a Synchronization Process on the Absolute Time. The Head Unit is in this case, the Global Time Master

Global Synchronization Example on ACC System (3)



Remark:
This Use-Case highlights a Synchronization Process on the Relative Time. The Central Gateway is in this case, the Global Time Master

Global Synchronization Example on ACC System (4)



Remark:
This Use-Case highlights a Synchronization Process on the Absolute Time. The Head Unit is in this case, the Global Time Master

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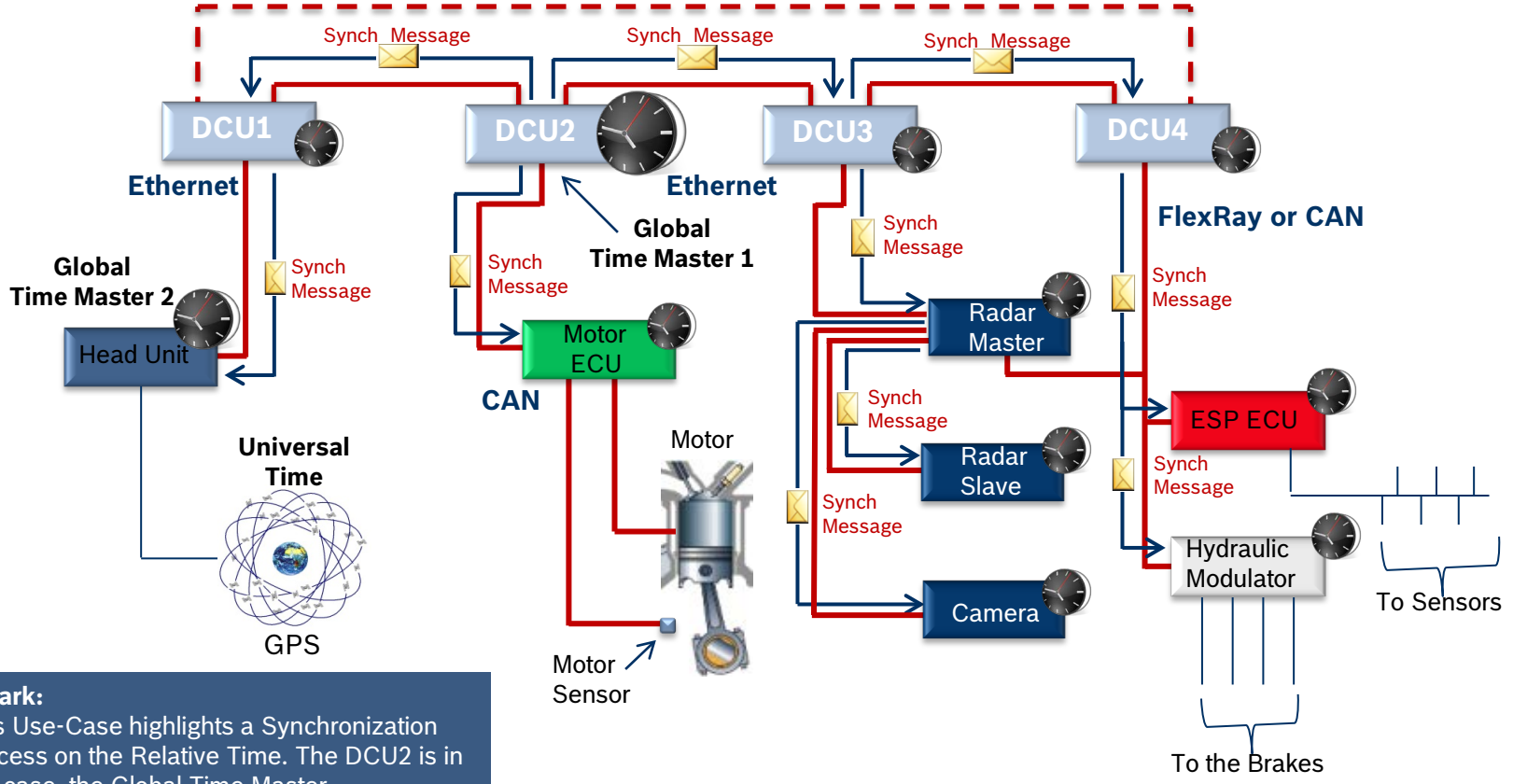
Global Synchronization Example on ACC System (7)



Remark:
This Use-Case highlights a Synchronization Process on the Relative Time. The DCU2 is in this case, the Global Time Master

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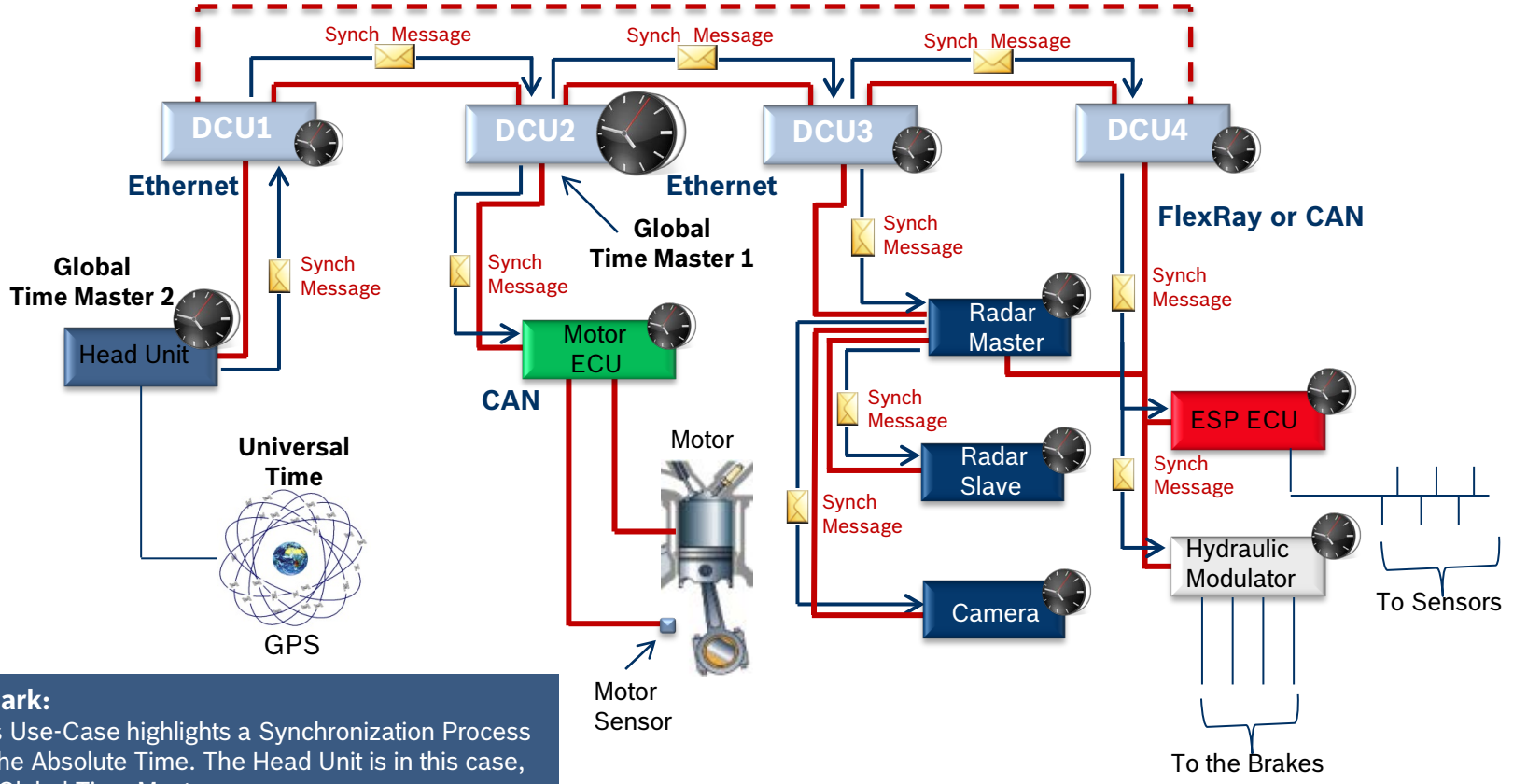
Global Synchronization Example on ACC System (8)



Remark:
This Use-Case highlights a Synchronization Process on the Absolute Time. The Head Unit is in this case, the Global Time Master

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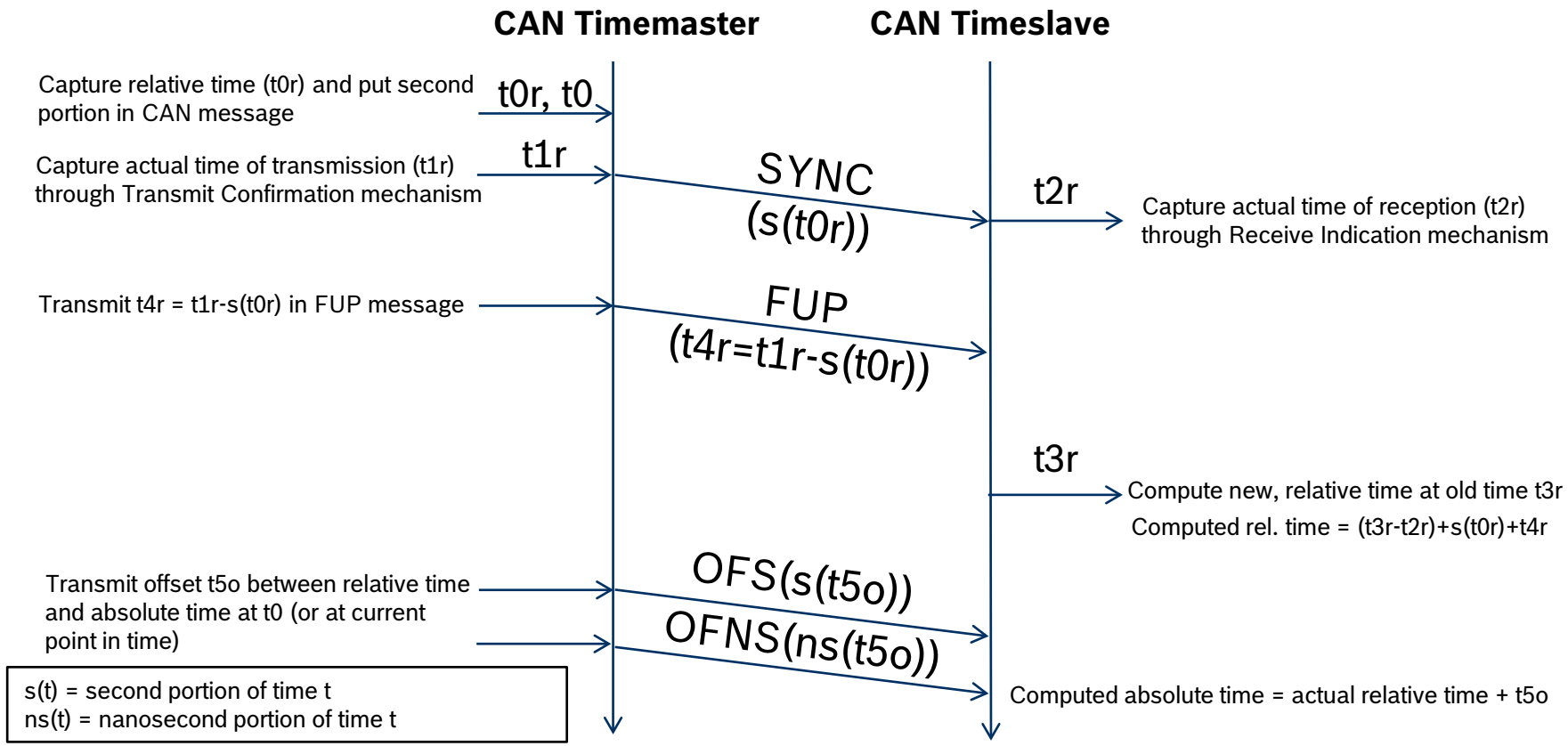
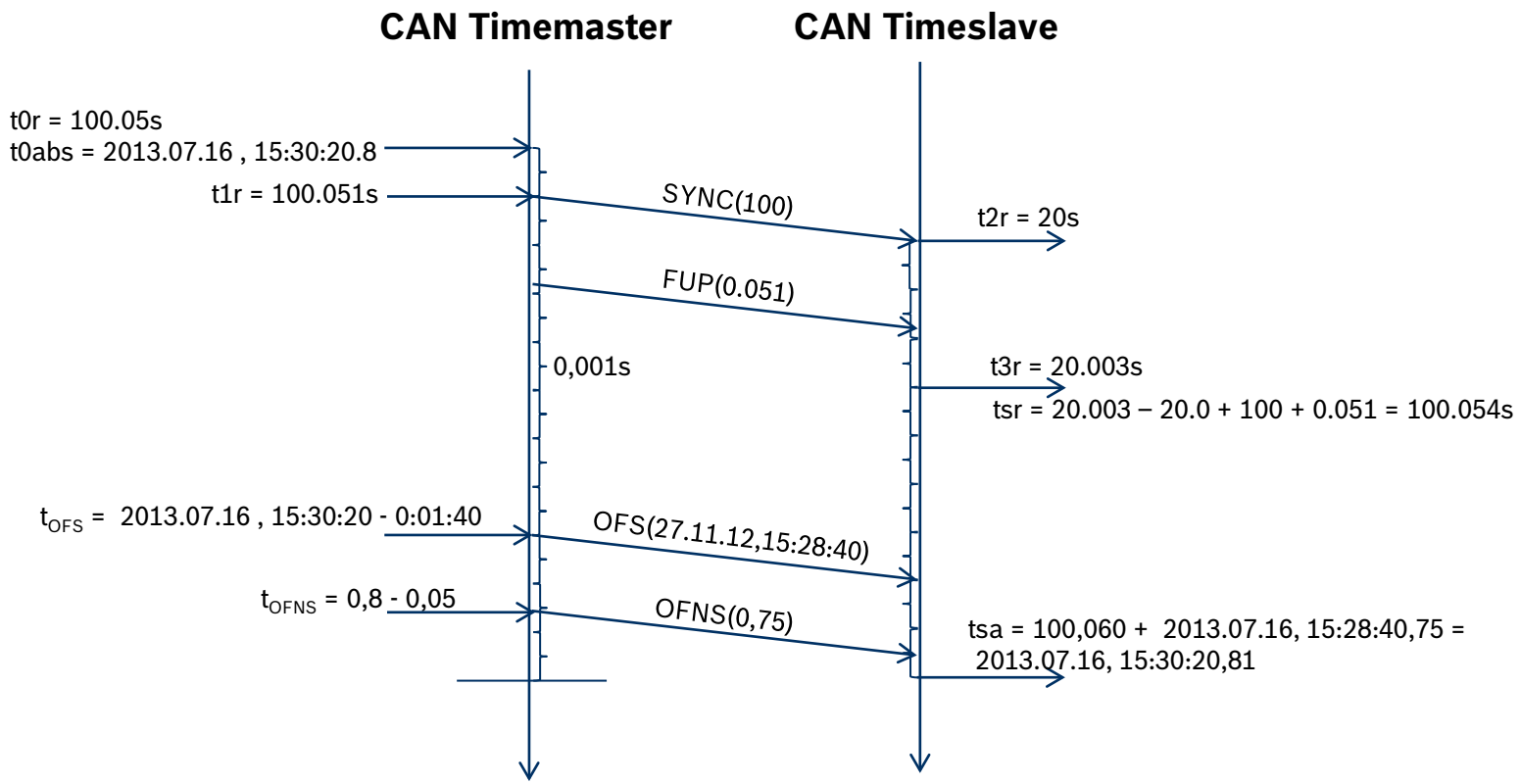
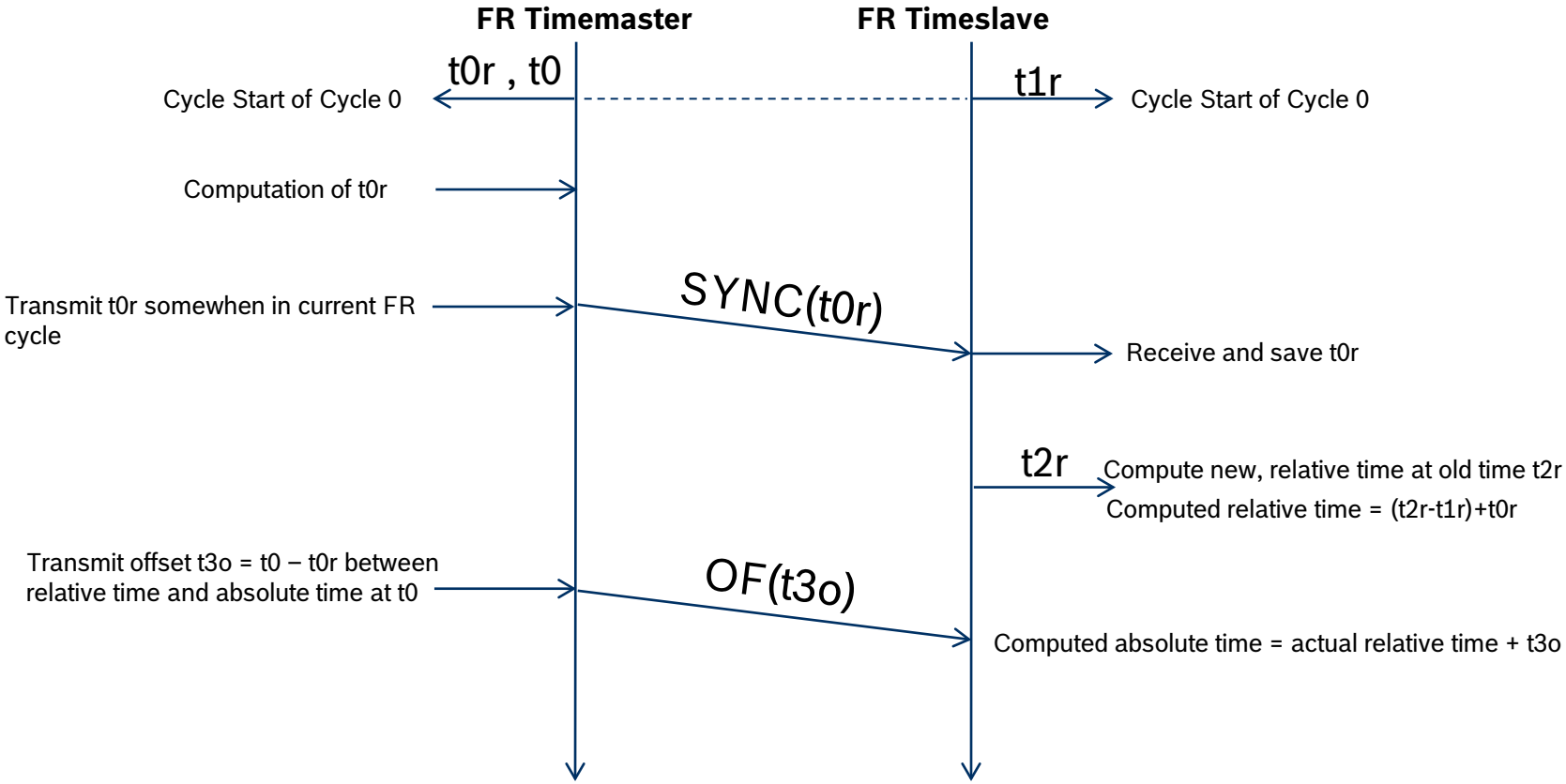
CAN Global Synchronization PTP Mechanisms (Proposed in AUTOSAR)



CAN Global Synchronization PTP Mechanisms (Proposed in AUTOSAR)



FlexRay Global Synchronization PTP Mechanisms (Proposed in AUTOSAR)



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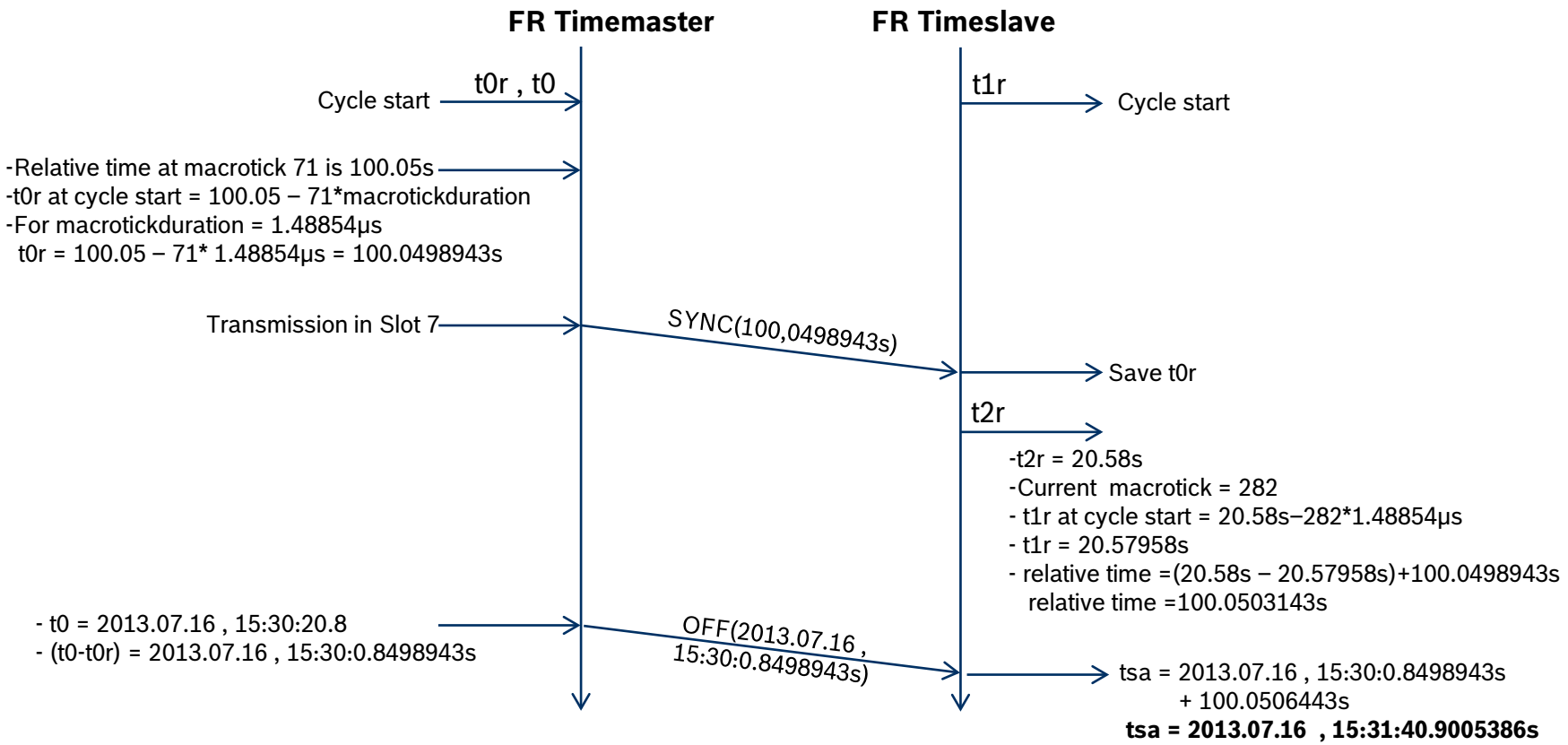
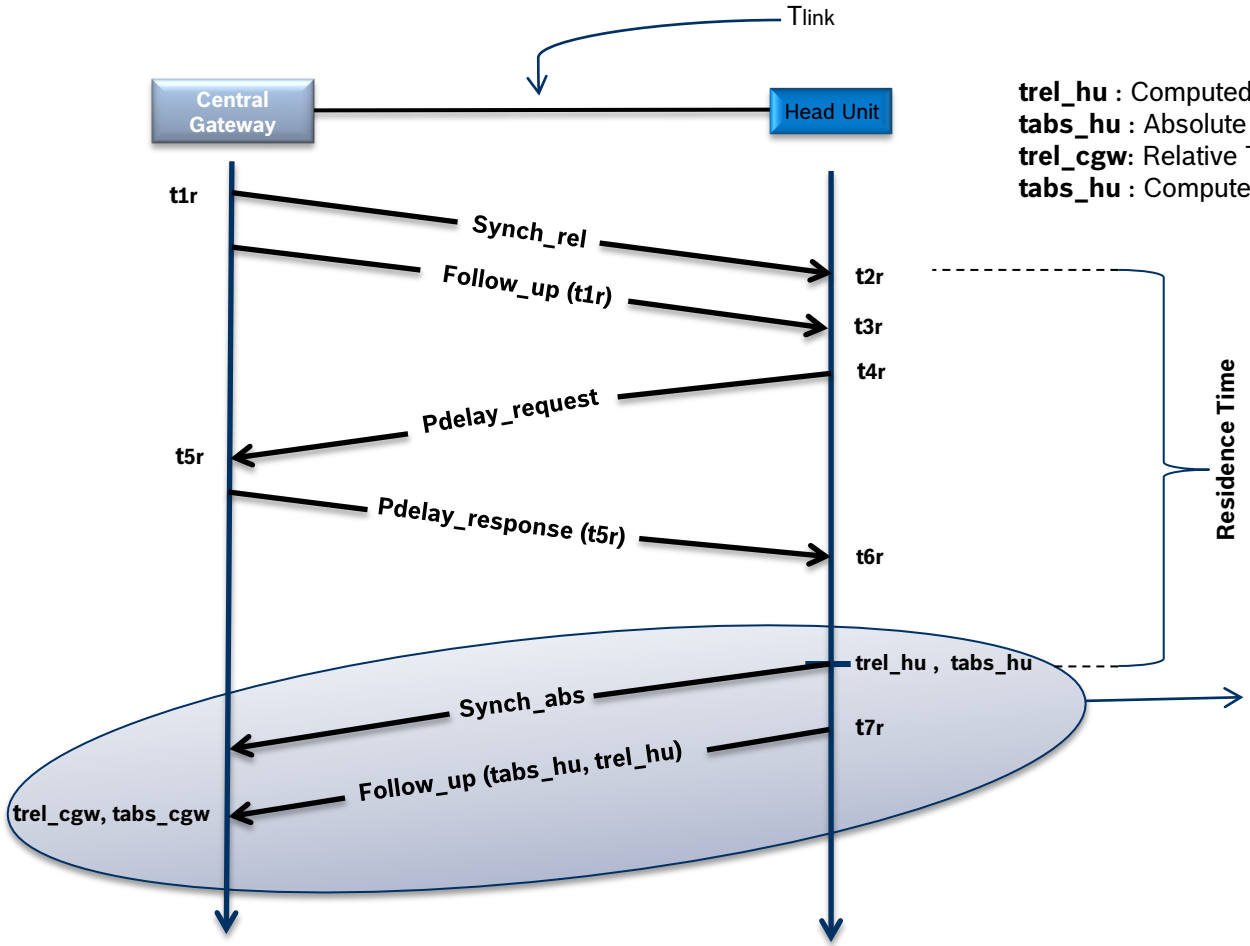
FlexRay Global Synchronization PTP Mechanisms (Proposed in AUTOSAR)



Ethernet Global Synchronization PTP Mechanisms (1)



trel_hu : Computed Relative Time on Head Unit
tabs_hu : Absolute Time on Head Unit
trel_cgw: Relative Time on Central Gateway
tabs_hu : Computed Absolute Time on Central Gateway

trel_hu = t1r + Residence Time + Tlink

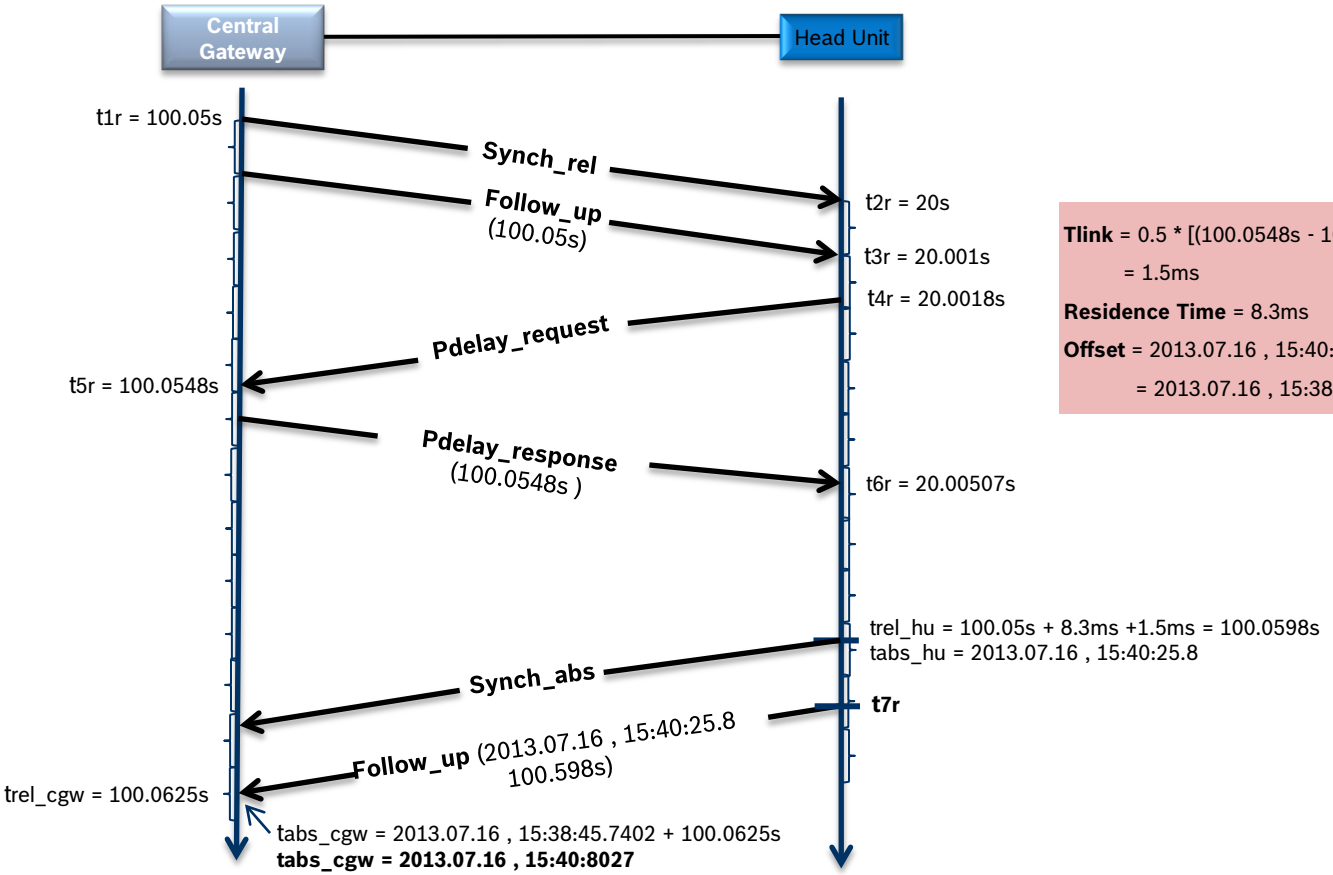
offset = tabs_hu - trel_hu

tabs_cgw = trel_cgw + offset

Time Master Switchover :
Head Unit becomes the Time Master !

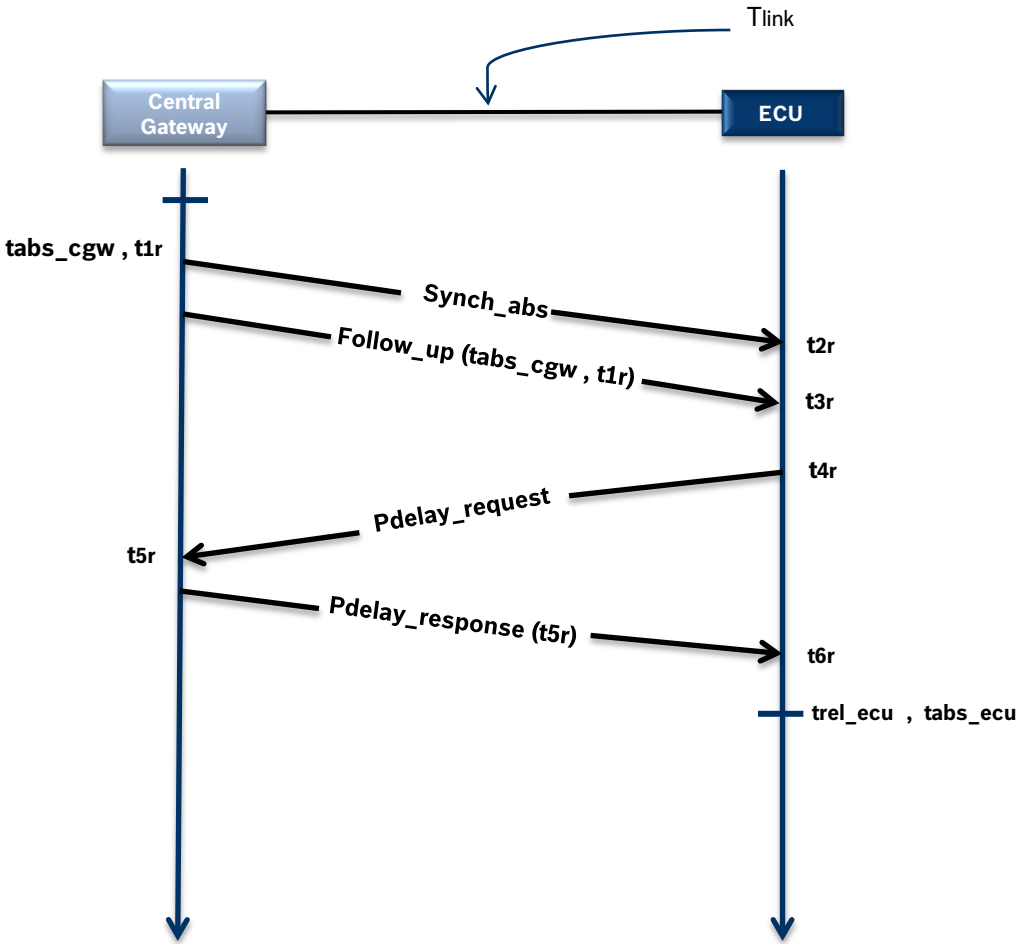
Add-on:
The "Follow_up" Message contains Absolute Time on top of Relative Time

Ethernet Global Synchronization PTP Mechanisms (2)



Tlink = 0.5 * [(100.0548s - 100.05s) - (20.0018s-20s)]
= 1.5ms
Residence Time = 8.3ms
Offset = 2013.07.16 , 15:40:25.8 - 100.0598s
= 2013.07.16 , 15:38:45.7402

Ethernet Global Synchronization PTP Mechanisms (3)



tabs_cgw : Absolute Time on Central Gateway
trel_ecu : Computed Relative Time on ECU
tabs_ecu : Computed Absolute Time on ECU

trel_ecu = t1r + Residence Time + Tlink

offset = tabs_cgw – t1r

tabs_ecu = trel_ecu + offset

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Next Steps ?

- Requirements Analysis on:
  - Synchronization Accuracy for Absolute Time & Relative Time
  - Synchronization Intervals for Absolute Time & Relative Time
  - Clock Difference between 2 Nodes on 2 different Sub-Networks (e.g.: Clock Difference between a node based on CAN and Another one based on Ethernet)
  - Time Master Switchover Handling
  - Time Scale Switchover Handling
  - Absolute and Relative Clock Availability
  - Redundant Synchronization Paths and Grand Masters necessity
  - Etc . . .
- Synchronization Frames Formats Definition (e.g.: Need of a field to indicate the Time Scale in which a Synch Info is transmitted)

Thank You for your Attention
Any Questions ?