



# TECHNICAL TRAINING

Open Course: Core TSN Topics

# Time Matters.

# Open Course: Core TSN Topics

- Course Overview:**

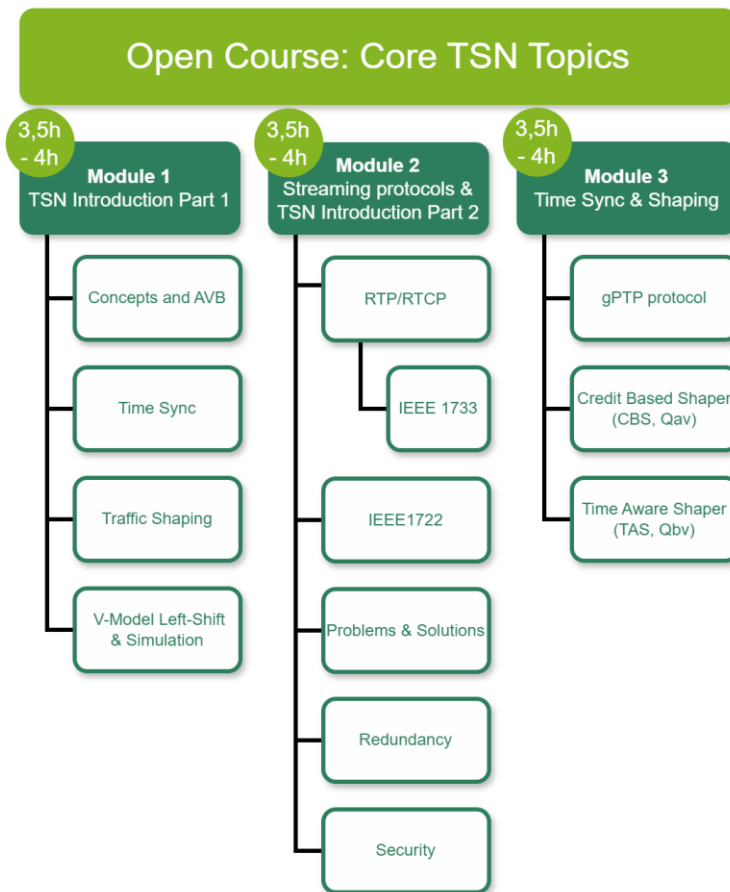
Our open course “Core TSN Topics” offers a thorough and practical introduction to Time-Sensitive Networking (TSN).

The course is designed for developers, system architects, and test and validation teams who wish to understand, evaluate, and implement TSN-based systems.

The course has a modular structure and consists of three coordinated modules that cover both fundamental concepts and key IEEE standards.

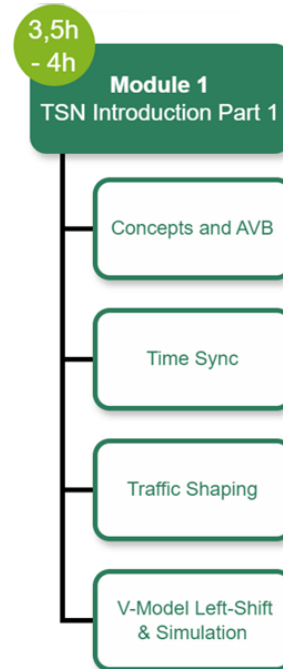
- Learning Outcomes:**

The goal is to provide a comprehensive understanding of deterministic communication over Ethernet—from the basics to specific shaping and synchronization mechanisms.



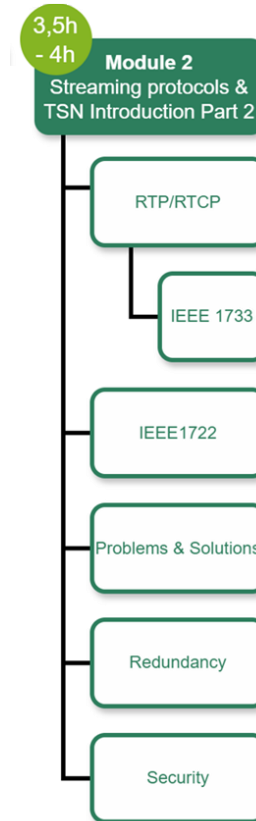
# Modul 1: TSN Introduction Part 1

- **Concepts and AVB:**  
TSN is initially presented, and a simple and easy overview of the topic is given.
- **Time Synchronization:**  
A first introduction to the topic of time synchronization: Clocks, timing concepts, gPTP, media clocks and synchronization in relation to automotive architectures are explained.
- **Traffic Shaping:**  
Shaping is introduced and an initial glance at shapers is provided.
- **V-Model Left-Shift & Simulation:**  
An overview of the potential Left-Shift strategy, including Simulation, will be presented.



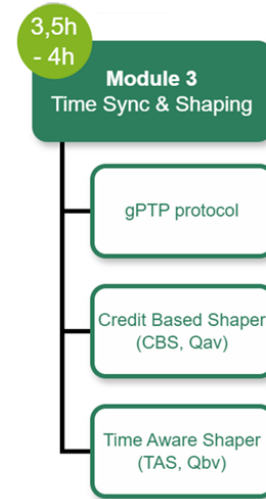
# Modul 2: Streaming protocols & TSN Introduction Part 2

- RTP/RTCP:**  
 RTP and RTCP are explained and reasoned. The packet structure is described in basic terms and a few words are said about stream synchronization.
- IEEE 1733:**  
 1733 is introduced and its relationship to RTP, RTCP and the AVB standards. The changes in the packets are discussed and reference is made to the media clock.
- IEEE 1722:**  
 The motivation and requirements for 1722 are explained, the AVTP Base Protocol is talked about including media clock and introduction of media clock recovery. CRF is also covered as well as a few important AVTP formats.
- Problems & Solutions:**  
 Some of the problems we have encountered in practice are highlighted and the appropriate solutions are presented.
- Redundancy:**  
 Various solutions for creating redundancy in Ethernet and their advantages and disadvantages are discussed.
- Security:**  
 Several security mechanisms are described at a basic level.



# Modul 3: Time Synchronization & Shaping

- gPTP protocol:**  
 The fundamental terminology is defined, the functionality of gPTP is explained in detail and some practical applications such as automotive PTP and security aspects are highlighted.
- Credit Based Shaper (CBS):**  
 The reasons for using the CBS are discussed. Its functionality is then explained in detail and a look is taken at validation options.
- Time Aware Shaper (Qbv):**  
 The operation and configuration of the Time Aware Shaper is described, and practical considerations are given for engineering a schedule. Validation options are also discussed.



# Example slides

### Validation in different Architectures

**Zone architecture**  
Data & system time driven, link oriented, network centric, correlation is needed

Comment: Validation must in addition also focus on scalable time sensitive data. Test points for each domain will be set across the whole network. This will require scalable, synopt testing solutions.

64

### gPTP basics: Sync Transport

Instance B can calculate its offset to the GM:

- Offset: compare sync arrival time with T2

And its rate ratio with respect to the GM

- rate ratio:  $\text{rateRatio1} * \text{nr}$

40

### CBS: How CBS works

30

### Why use PSFP?

"Babbling idiot":

- Does not follow rules
- Faulty hardware/software
- Malicious attacks (DoS)
- Consumes too much bandwidth
- Sends at the wrong time

Bandwidth/latency not guaranteed!

11

### gPTP basics: Message Format

- Event Messages:
  - Sync
    - conveys time
  - Pdelay\_Req
    - requests pdelay measurement
  - Pdelay\_Resp
    - responds to pdelay measurement

Bits		Octets	Offset							
7	6	5	4	3	2	1	0			
majorField		messageType		1		0		1		0
minorVersionPTP		versionPTP		1		1		1		1
messageLength		domainNumber		2		2		2		2
minorSdoId		flags		1		4		1		5
controlField		sequenceId		4		16		4		16
sequenceId		sequenceId		10		20		2		30
controlField		logMessageInterval		1		32		1		33
				1		32				33

50

### Implementing ATS - Transmission selection algorithm

Comment: The first part of ATS has now been explained and an eligibility time has been assigned to the packets. Let's take a look at the second part of the ATS, the transmission selection algorithm. Note: All queues could be ATS shaped or a combination with other shapers or strict priority could be used.

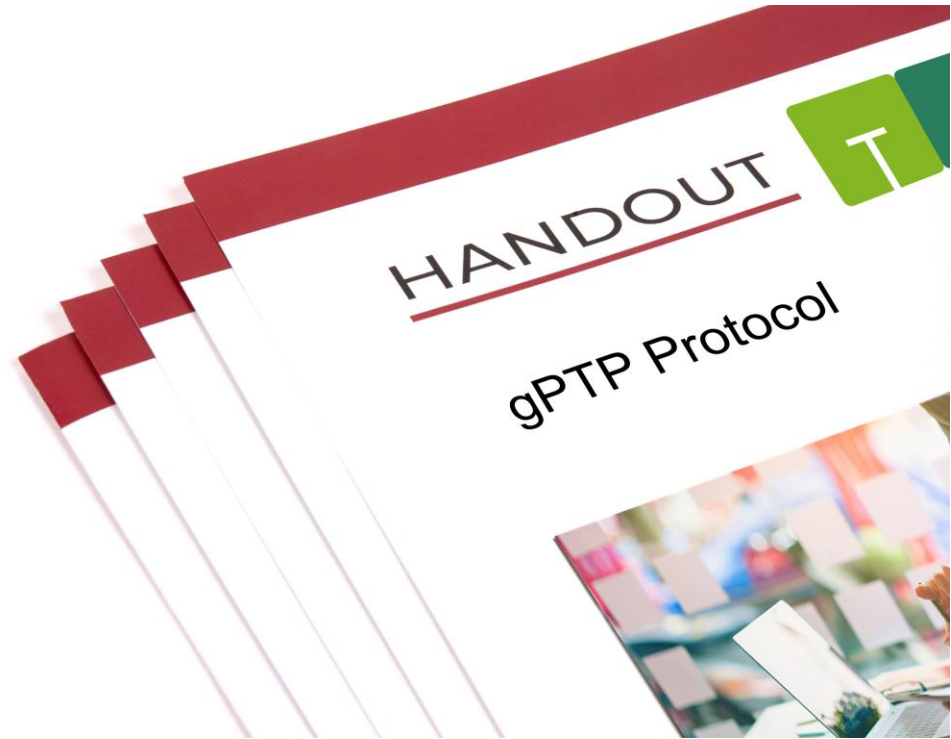
7

# Digital Handouts

## Digital Handouts to all Courses:

We will supply personalized PDFs as digital handouts after each session, encompassing the presentation's content along with extra details and remarks.

Furthermore, we offer "Quick Reads" on specific topics, which are concise summaries highlighting key facts and providing an overview of essential subjects.



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