Probing the FBAS event signaling via the WR timing network

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https://www-acc.gsi.de/wiki/Timing/Intern/ProbingMPSEventSignalling

Agenda

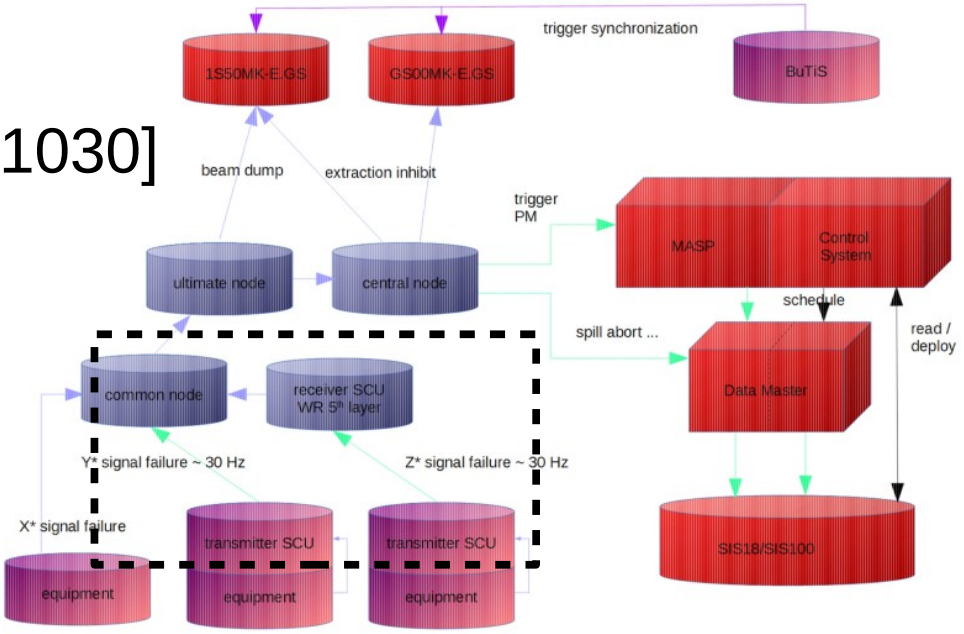
- Introduction
- SIS100 MPS class 2 network
- Timing system basics
- Tests & measurements
- Summary

Introduction

- FBAS event signaling
  - via the Timing network
  - according to Technical Concept “Conceptual Design of the SIS100 Fast Beam Abort System (MPS)” (F-TC-C-03e)
- MPS classes regarding reaction time
  - very fast (1) – reaction time at min. 40 us
  - **fast (2)** – reaction time a few ms (for FBAS 1 ms)
  - slow (3) – reaction time within 100 ms

SIS 100 MPS class 2 network

- FBAS events [MPS_FS_040/110/700]
  - CMOS signals from equipments
  - timing events from Data Master
- FBAS logic modules [MPS_FS_1030]
  - DSP MPS card
  - transmitter SCU
  - receiver SCU
  - common node

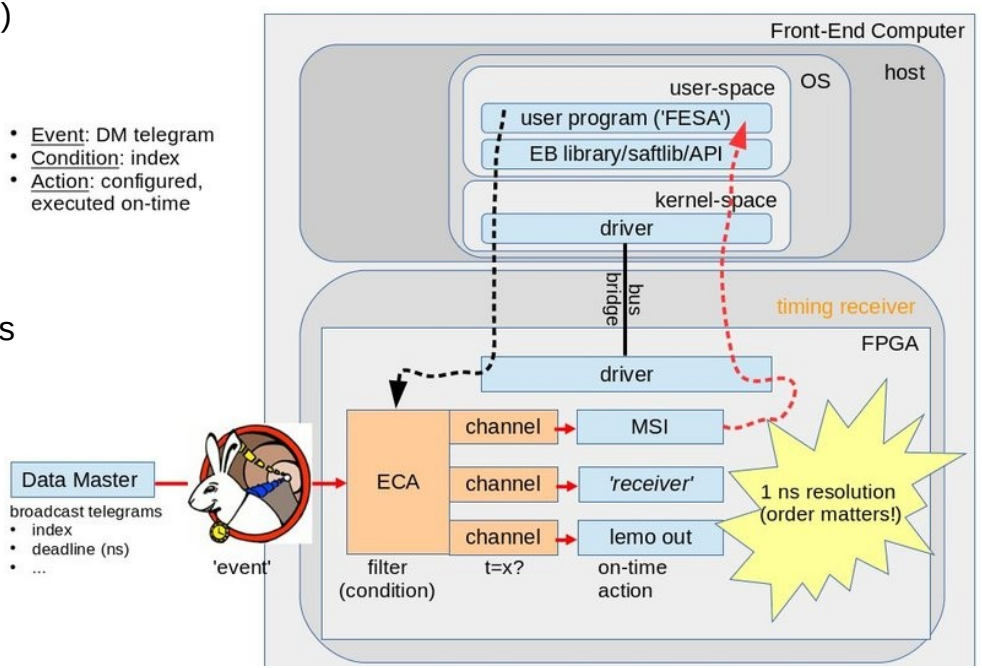


Timing system basics

- General Machine Timing (GMT) system
  - timing event distribution
    - uses White Rabbit (WR), EtherBone (EB)
    - key components
      - WR switch (WRS): for network infrastructure
      - Clock Master (CM): WR switch with time reference (GPS)
      - Data Master (DM): WR node that broadcasts timing messages
      - Timing Receiver (TR): WR node that is capable to execute local action on timing event

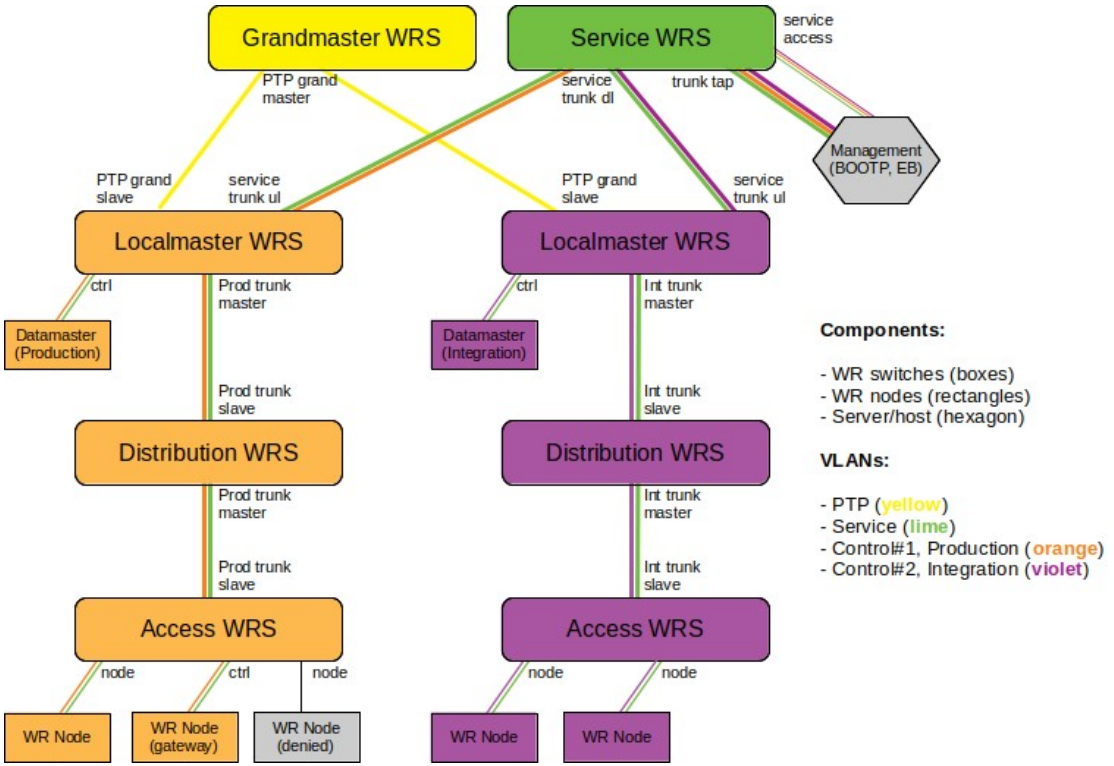
Timing system basics

- Timing event
  - Data Master (DM)
    - broadcasts the scheduled commands (timing messages)
  - Timing Receiver (TR)
    - embedded in FEC
    - interprets the incoming events and
    - trigger actions at the designated time
  - inside TR
    - ECA is responsible to execute action on incoming events
    - actions are
      - pulses on LEMO port
      - host interrupts
    - ECA needs to be pre-configured
      - by user-space program in host



Timing system basics

- WR timing network
  - promises
    - low latency (100 us/layer)
    - packet loss 10^{-12}
  - organized in VLANs
    - WRSs are aware of VLAN
      - tagging/untagging frames
      - forward/drop frames
  - supports
    - traffic isolation
    - node authentication
    - priority is possible

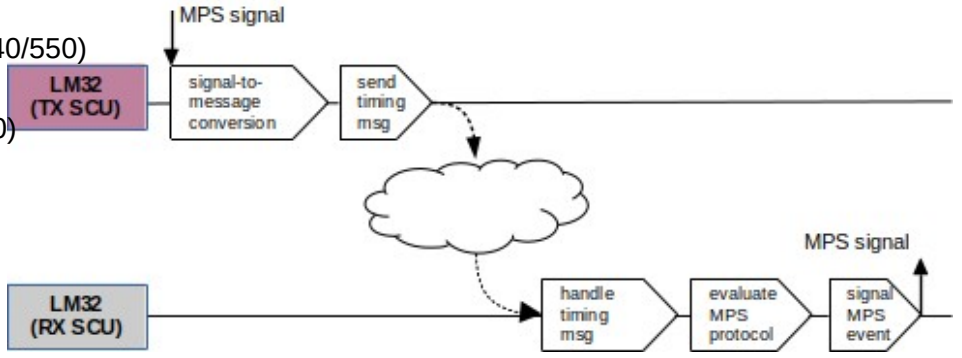


Tests & measurements

- Check timing network performance as initial step
- FBAS requirements [MPS_FS_580]
  - low latency: 1 ms
  - event loss: 10^{-4}
  - data rate of receiver SCU: 300Kb/s

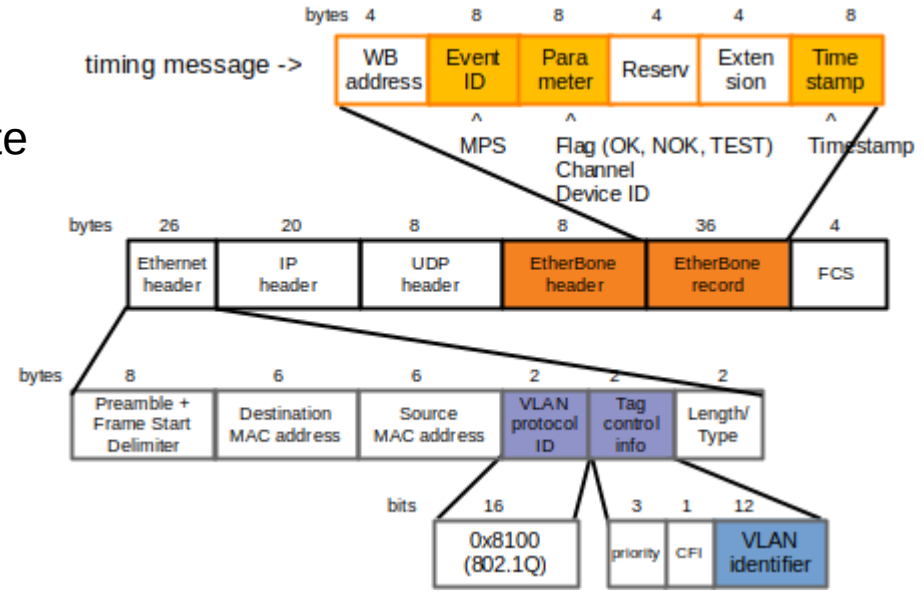
Tests & measurements

- Test components
  - SCUs with special LM32 firmware
    - transmitter SCU
      - convert logic signal to MPS protocol data (MPS_FS_510/520/540/550)
      - send MPS protocol data (MPS_FS_530/560)
      - handle timing messages of DM (MPS_FS_620/700/730/740/750)
    - receiver SCU
      - handle timing messages of transmitter (MPS_FS_560/590)
      - evaluate MPS protocol data (MPS_FS_640)
      - monitor interval failure (MPS_FS_600)
      - handle timing messages of DM (MPS_FS_630/700/730/750)
  - WRSs with special configurations
  - Data Master for broadcasting pseudo MPS protocols
  - XenaBay for network traffic generation and analysis



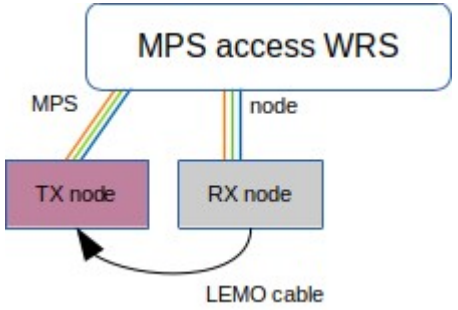
Tests & measurements

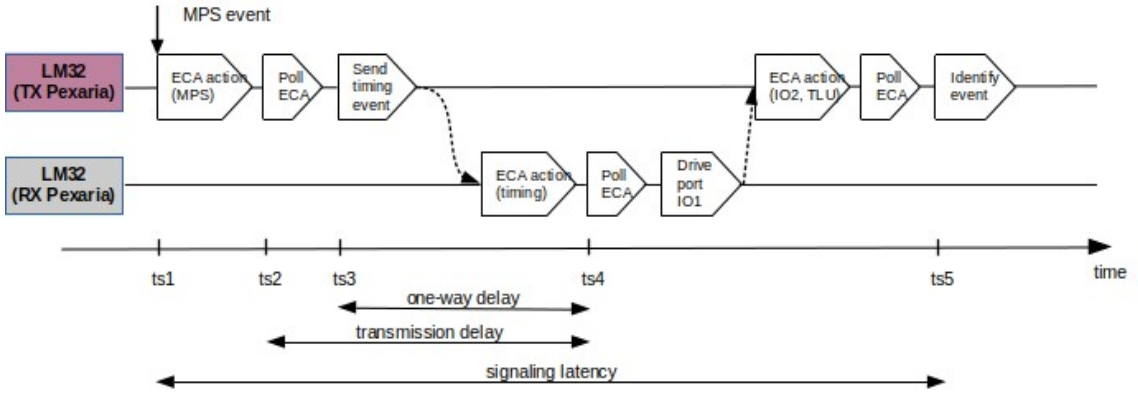
- Pseudo MPS protocol [MPS_FS_520]
  - timing message, 44 bytes
    - event ID: 0x1fcbfcb0 (group = 0xfcb, event = 0xfcb)
    - parameter
      - MPS flag: 1 byte
      - (suggestion) MPS channel: 1 byte
      - device ID (MAC): 6 bytes
    - timestamp: 8 bytes
  - Ethernet frame, 110 bytes
    - incl. interframe gap of 8 bytes



Tests & measurements

- #1: FBAS signaling latency
  - timing delays
    - one-way (timing msg -> ECA)
    - transmission (MPS flag -> ECA)
  - use timestamps (tim. msg vs ECA)





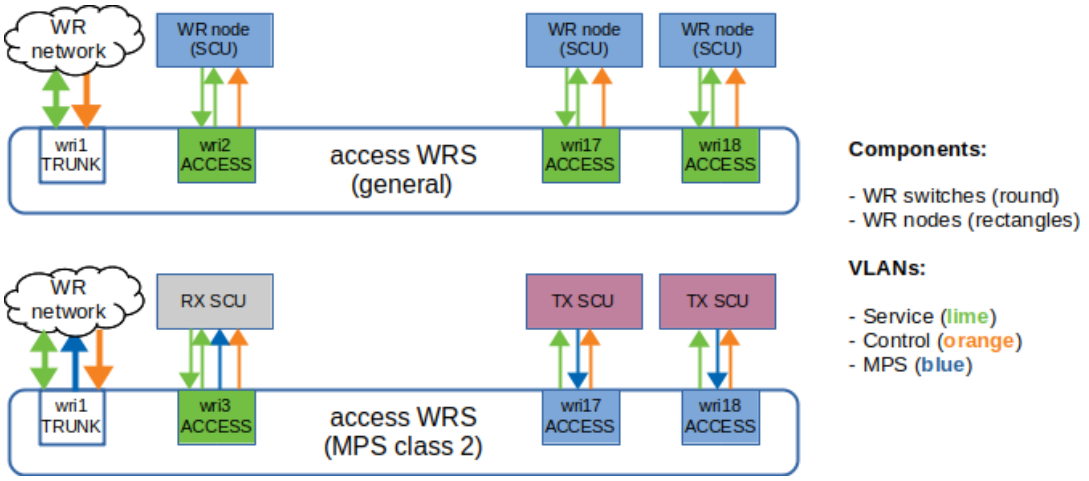
Tests & measurements

- #1: FBAS signaling latency
  - result: avg/max latency 45/136 us

delay/latency	**avg, ns**	**min, ns**	**max, ns**	**RX/TX timing msg**
signaling latency	44702	40856	136320	1999/1999
transmission delay	29018	27864	123152	1999/1999
one-way delay	22994	20872	78384	6659/6659

Tests & measurements

- #1: FBAS signaling latency
  - access-layer WRS configuration
    - special configuration: similar for B2B

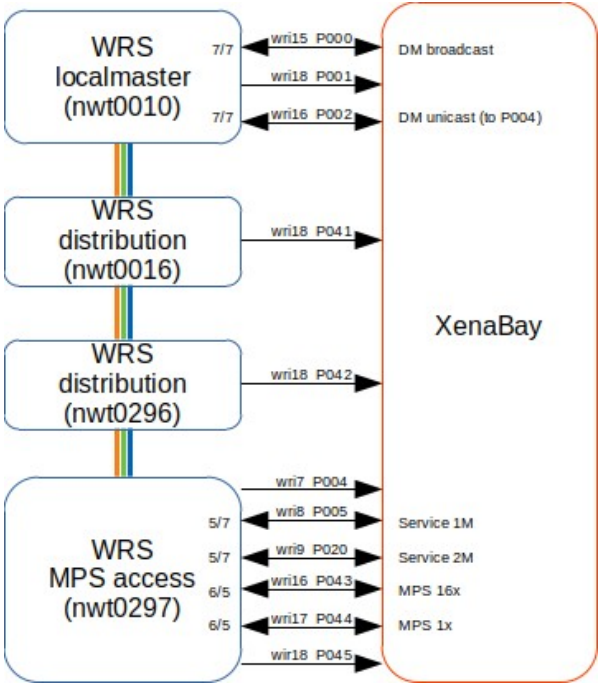


Tests & measurements

- #2: WR network traffic latency, loss
  - 4 physical layers of WRSs
    - 3 VLANs
  - traffic generated by XenaBay:
    - DM (110 byte, VID 7, prio 7)
      - broadcast (100 Mb/s)
      - unicast (10 Mb/s)
    - service (64-1518 byte, VID 5, prio 7, 1/2 Mb/s)
    - MPS (110 byte, VID 6, prio 5)
      - 1x protocol (26,4 Kb/s)
      - 16x protocol (422,4 Kb/s)

Tests & measurements

- #2: WR network traffic latency, loss



Tests & measurements

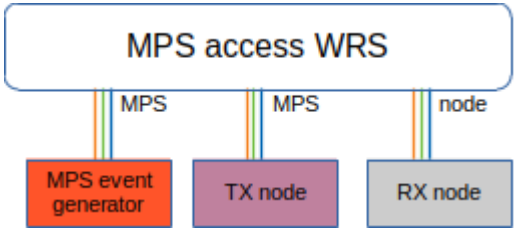
- #2: WR network traffic latency, loss
  - result: no traffic loss
    - avg/max latency
      - DM: 11/35 us (broadcast), 11/32 us (unicast)
      - MPS protocol: 14/47 us (16), 11/34 us (1)

layer	avg latency, us	max latency, us	avg jitter, us	max jitter, us	DM traffic
1	3	25/16	0,02/002	22/13	broad/uni
2	5	27/19	0,03/002	22/15	broad/uni
3	8	30/21	0,03/003	22/13	broad/uni
4	11	35/32	0,21/004	24/22	broad/uni

layer	avg latency, us	max latency, us	avg jitter, us	max jitter, us	MPS protocol
1	5/3	37/25	0	34/22	16/1
2	8/5	40/28	0	35/23	16/1
3	11/8	43/30	0	35/23	16/1
4	14/11	47/34	0	35/23	16/1

Tests & measurements

- #3: message loss
  - simultaneous traffic (XenaBay)
    - message rates: 30-5000 Hz (24-4000 Kb/s)
    - injected into remaining 15 ports of WRS
  - lost: messages received later than 1 ms or dropped



Tests & measurements

- #3: Message loss
  - result: message loss at 2500 Hz with additional 15 transmitters

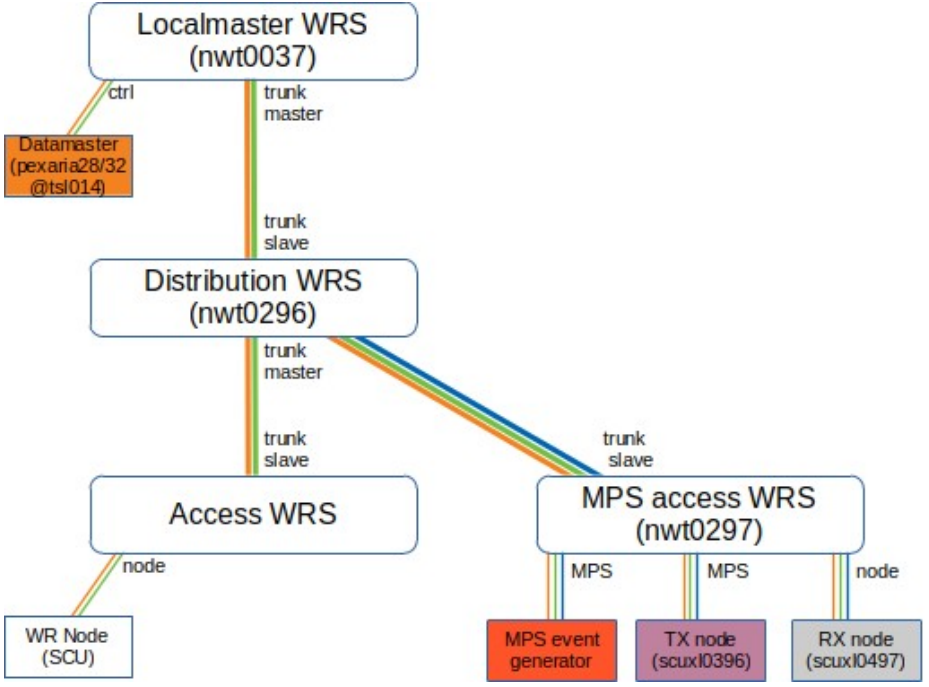
msg rate, Hz (data rate, Kb/s)	avg one-way delay, us	min one-way delay, us	max one-way delay, us	RX/TX timing msg	message loss of TR
30 (24)	76,31	20,46	139,24	32207/32207	no
120 (96)	76,40	20,47	145,66	122493/122493	no
400 (300)	76,38	20,45	150,33	378385/378385	no
800 (600)	77,04	20,44	159,94	754186/754186	no
1250 (1000)	81,36	20,64	173,21	1255368/1255368	no
2500 (2000)	92,10	20,58	1271,94	2509332/2509332	yes
5000 (4000)	3570,69	20,53	4568,64	3439252/5017884	yes, dropped

Tests & measurements

- #4: data rate of receiver
  - criteria: overflow of ECA queue
  - message rates: 300 Hz - 100 KHz
  - 1/3/16 MPS protocols per timing message
  - 6K MPS protocols sent by DM

Tests & measurements

- #4: data rate of receiver



Tests & measurements

- #4: data rate of receiver
  - result
    - LM32 firmware (TR): 20 KHz (17,6 Mb/s)
    - complete SW stack (TR+host): 1 KHz (880 Kb/s)

Summary

- verified network performance considering MPS_FS_580
  - signaling latency (1 ms)
    - max. 136 us (avg. 45 us) MPS signaling latency, 1x message, 1 physical layer of WRS (test #1)
      - max. one-way delay 78 us (tim. msg -> ECA)
    - max. 25 us (avg. 3 us) network latency, 1x message, 1 physical layer (test #2)
      - around 3 us for each layer
      - max. 34 us (avg. 11 us), 4 physical layers
  - message loss (10^{-4}) and receiver data rate (300 Kb/s, corresponds to 11 messages)
    - no network packet loss (test #2)
    - max. message rate of TR
      - max. 1250 Hz: 16 senders, 1 message, 1 physical layer (test #3)
      - max. 20 KHz: 1 sender, up to 16 MPS protocols, 3 physical layers (test #4)
- tiny testbed
  - covers timing system parts (not SCU/host)

Summary

- Determine next steps
- Uncertainties in Technical Concept
  - transmitter/receiver/common SCUs
    - shared, stand-alone
  - MPS event generation [MPS_FS_490]
    - DSP MPS card
    - other
  - MPS protocol data [MPS_FS_520/590]
    - format: VLAN ID, sender’s MAC, channel
  - building a common channel [MPS_FS_640]
    - effective logic output
  - configuration [MPS_FS_700/710/720/1890]
    - format of MPS signal masks, parameters
    - operation modes/states (test, normal, configuration)
  - service VLAN is shared for service and control traffic
  - other