RUAG

SAVOIR

space avionics open interface architecture

Recommendations for use of communication links within SAVOIR

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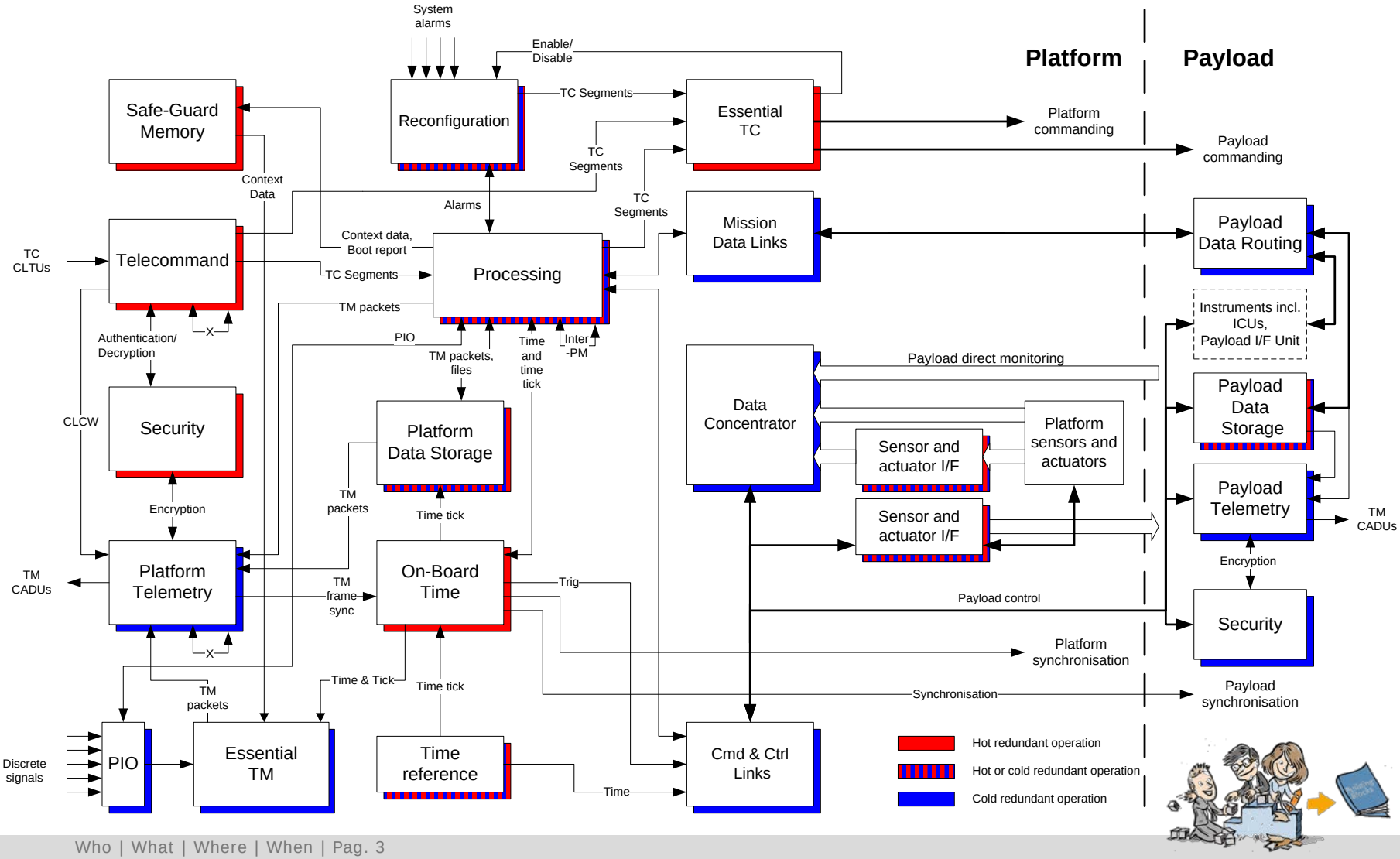
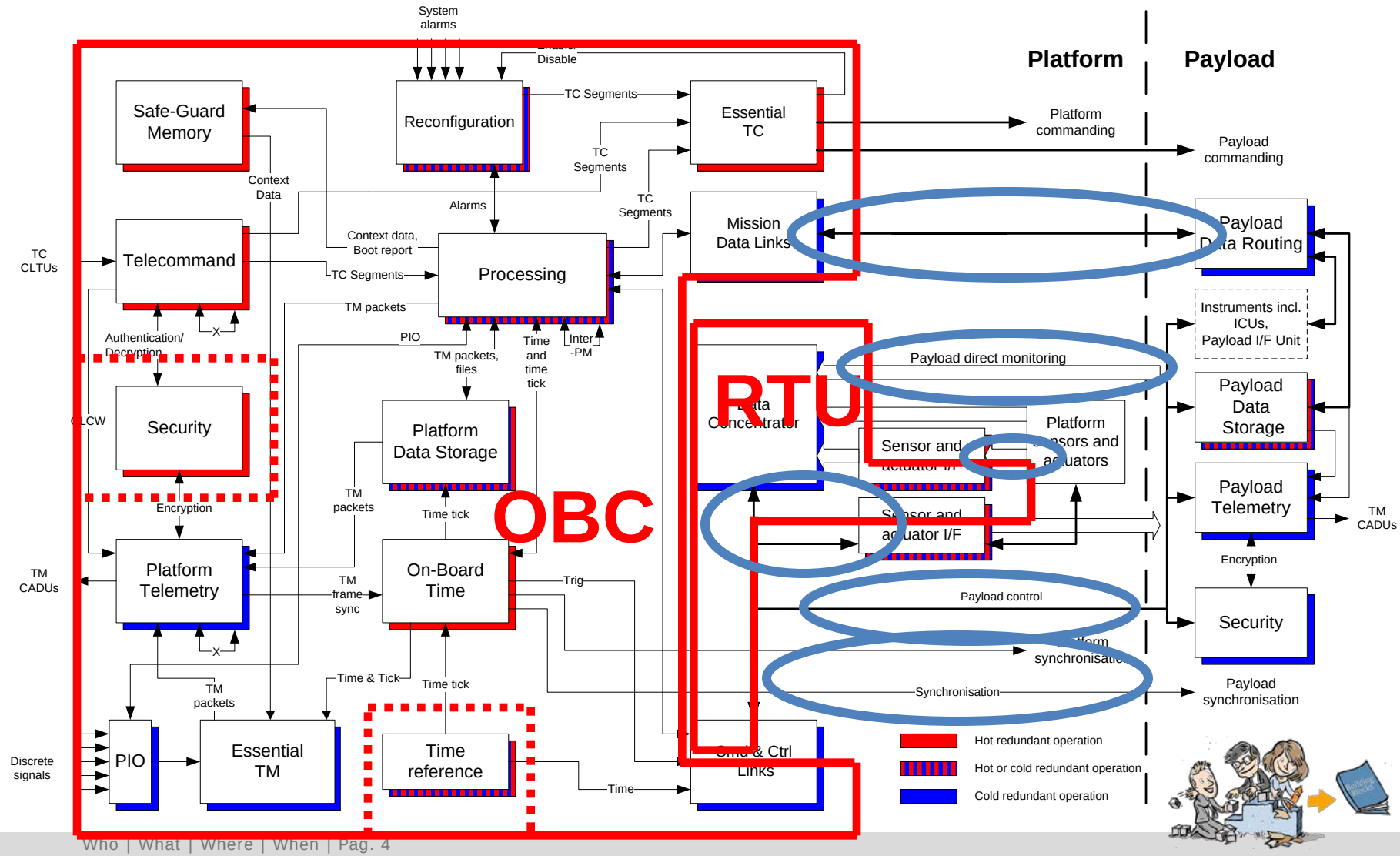
Communication links within the SAVOIR architecture

- Communication links are the glue between functions and between physical units, thus communication link standardisation is of utmost importance to allow reuse of products in different programmes.
- There are several links being identified for the SAVOIR architecture:
  - SpaceWire (point-to-point and network)
  - MIL-STD-1553B data bus
  - CAN bus
  - UART point-to-point links
  - Serial digital lines according to ECSS-E-ST-50-14C
  - Discrete signals according to ECSS-E-ST-50-14C
- Future extensions are possible with other links like:
  - SpaceFibre
  - SPI, I^2C or other simple instrumentation bus
  - Wireless

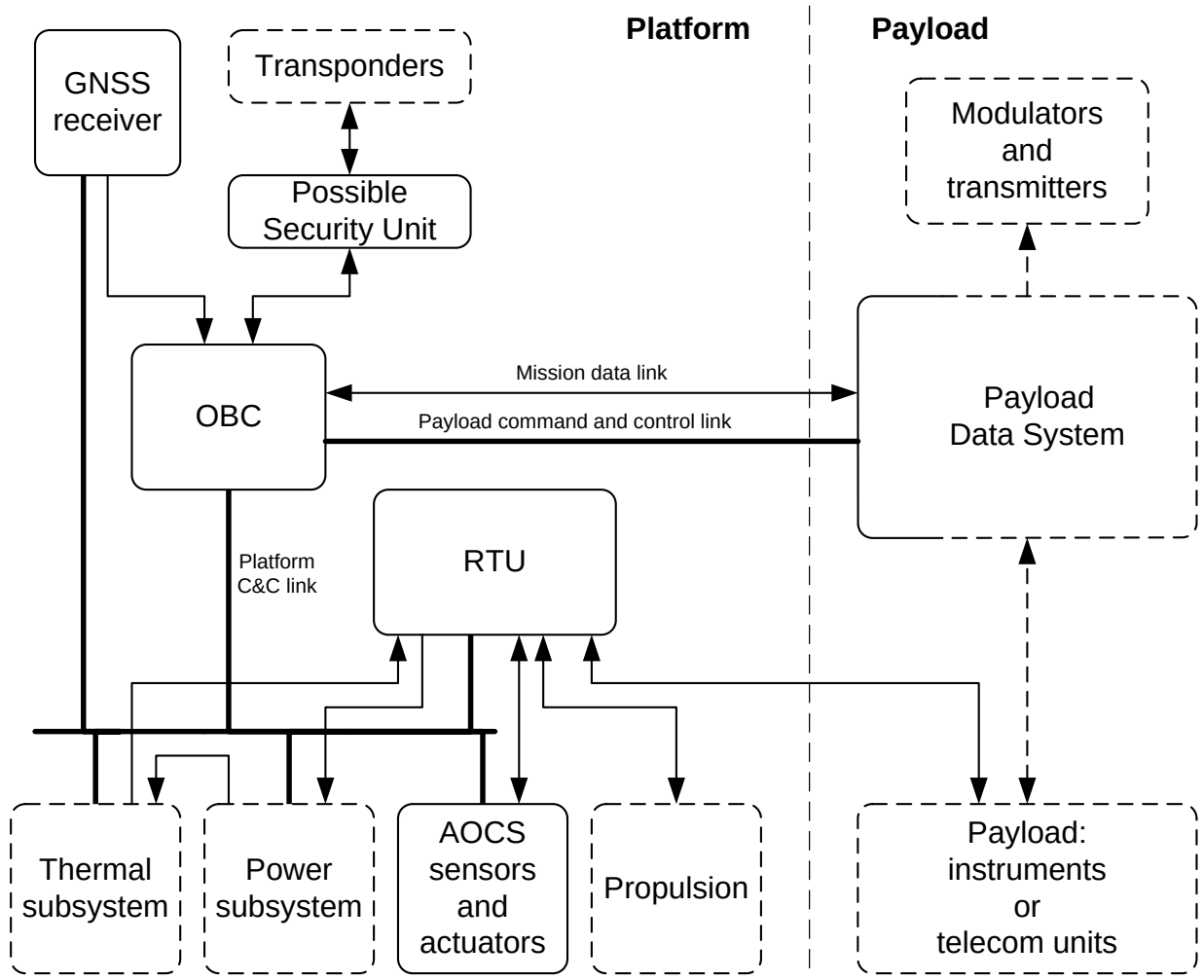
Recalling the Avionics functions ...



... and their mapping on units and links



Typical view of the avionics and its links



Dashed functions and interfaces are outside of SAVOIR perimeter

Recommendations from the ASRA study, platform interfaces

- OBC – Transponder
  TC: Cross-strap in the harness
  TM: Cross-strap inside the OBC
  Electrical characteristics according to ECSS-E-ST-50-14C clause 8.8
- Platform C&C link
  1553 now, SpaceWire in the future with the router inside the RTU
- Synchronisation lines
  Discrete pulses with electrical characteristics according to ECSS-E-ST-50-14C clause 8.8
- RTU secondary links
  UART or CAN
  ECSS-E-ST-50-14C serial and discrete interfaces
- **Sensor supplier problem still remains:**
  Shall I use SpaceWire, 1553, CAN, UART, SPI, or ECSS serial lines for my sensor? Or must I have all interfaces to fulfill top down "mission needs"?

Recommendations from the ASRA study, Platform – Payload interfaces

- Payload C&C link:
  - 1553, CAN — P/F provides nom and red bus; P/L units interface both
  - SpaceWire — P/F provides four links; P/L units interface one, two or four links
- Mission data link — As for SpaceWire C&C link
- Synchronization signals — P/F provides nom and red for each pulse; P/L units interface one or both
- Discrete pulse commands — P/F provides nom and red for each pulse; P/L units interface one or both
- Discrete monitoring — P/F provides nom and red for each signal; P/L units interface one or both

- Full cross-strap capability from the platform
  Full freedom for payload redundancy except for the buses

Guidelines for link selection (1)

- Base the interface selection for a device on:
  - The data rate needs
  - The total quantity needed in the spacecraft
  - The device characteristics
- SpaceWire
  - Used when data rates are above 100 kbps for a single device
  - Used when the total quantity of platform sensors/actuators having a SpaceWire interface is less than 10 – 14
    - Large SpaceWire routers is needed to extend the capability beyond this number
    - Today there are very few platform devices with a SpaceWire interface
  - Used for devices where low power consumption and low mass is important
  - Beware of: Routing data from many SpaceWire devices via a single router will most likely require buffering in the transmitting device to handle routing priority

Guidelines for link selection (2)

- 1553
  - Used when data rates are below 100 kbps for a single device
  - Used when the total quantity of platform sensors/actuators having a 1553 interface is less than about 25
    - Maximum 31 addressable units on a 1553 data bus, PCDU and some other units may need 2-6 RT addresses.
    - Typical spacecraft usage is today 10 – 15 units connected to a 1553 bus
  - Used for devices where 3W peak power consumption can be tolerated or where galvanic isolation is required
  - Beware of: Total 1553 bus capacity is 700 kbps if all devices use maximum size messages and goes down to 200 kbs if all devices only use 16 bit data words

Guidelines for link selection (3)

- CAN
  - Used when data rates are below 50 kbps for a single device
  - Used when the total quantity of connected devices is more than 20-25
    - Advantage compared to 1553 that has a limited addressing capability
    - The number of nodes in a telecom payload or a SAR with many tiles can easily exceed 25.
  - Used for devices where 3W peak power consumption cannot be tolerated.
  - Beware of: Total CAN bus capacity is about 480 kbps if all devices use maximum size messages (8 bytes) and goes down to 190 kbs if all devices only use 16 bit data words (or just the ID field). Due to the bit stuffing mechanism these values can be slightly reduced if lots of zero data is transferred.
  - Beware of: Total CAN capacity depends on the C&C link used to the RTU. If 1553 is used the total CAN traffic must be included in the overall 1553 traffic.

Guidelines for link selection (4)

- UART
  - Used when data rates are below 100 kbps for a single device
  - Used when the total quantity of platform sensors/actuators having a UART interface is less than about 20
    - UARTs are point-to-point links and require more hardware in the RTU and more harness for each device than a data bus
    - Typical spacecraft usage today is less than 5 units.
  - Used for devices where low power consumption and low mass is required
  - Beware of: Total UART capacity depends on the C&C link used to the RTU. If 1553 is used the total UART traffic must be included in the overall 1553 traffic.

Guidelines for link selection (5)

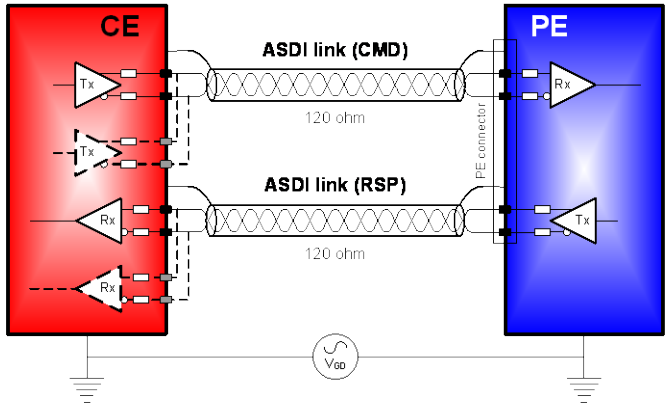
- ISD/OSD/BSD according to ECSS-E-ST-50-14C
  - Used when data rates are below 1 kbps for a single device
  - Used when the total quantity of platform sensors/actuators having an ISD/OSD/BSD interface is less than about 10
    - ISD/OSD/BSD are point-to-point links and require more hardware in the RTU than the UART interfaces, including more connectors, and more harness for each device.
    - Typical spacecraft usage today is less than 5 units.
  - Used for devices where low power consumption and low mass is required
  - Beware of: Total ISD/OSD/BSD capacity depends on the C&C link used to the RTU. If 1553 is used the total ISD/OSD/BSD traffic must be included in the overall 1553 traffic.
  - **Shall we keep this interface for future applications?**

UART protocol study

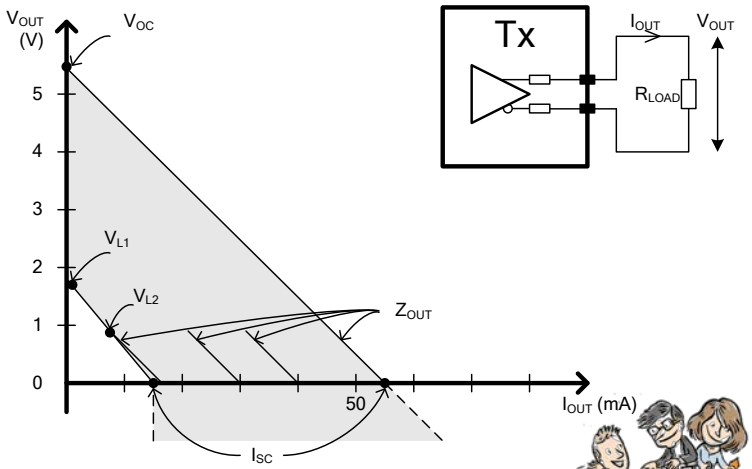
- Objective to define physical and data link layer requirements as input to an update of the ECSS-E-ST-50-14C standard
- Ongoing study performed by RUAG and TERMA
- Started Q1 2013, planned end Q1 2014
- Two tasks completed:
  - Survey of existing protocols and collection of user requirements
  - Preparation of physical and data link layer requirements, including test bench definition
- Test bench manufacturing and requirements verification task remains
- User needs survey performed and user requirements and draft physical and data link layer requirements distributed to the survey responders interested in following the work.

UART physical layer

- Based on ECSS-E-ST-50-14C terms and clause 8.8 physical layer:
  - Relaxed impedance matching and ground displacement voltage requirements (±1 V)
  - Drive current characteristics more detailed
  - Up to 16 m cable
  - Recommend to use a 9-pin connector at PE side
  - Optional cross-strapping at CE side to simplify sensor/actuator design



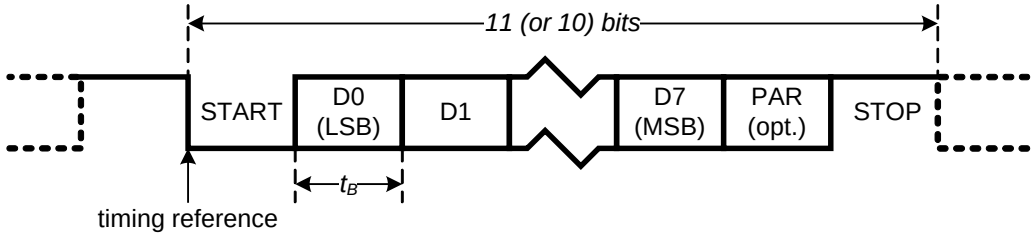
CE = Core Element
PE = Peripheral Element
ASDI = Asynchronous Serial Digital Interface

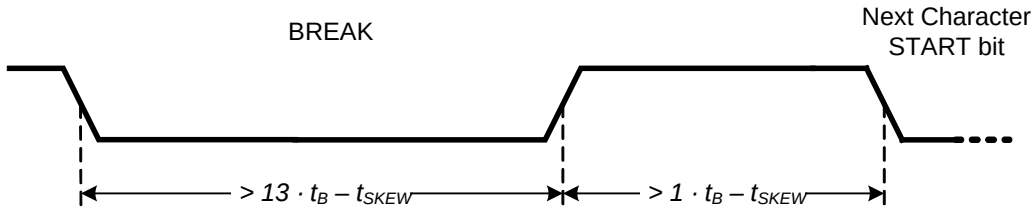


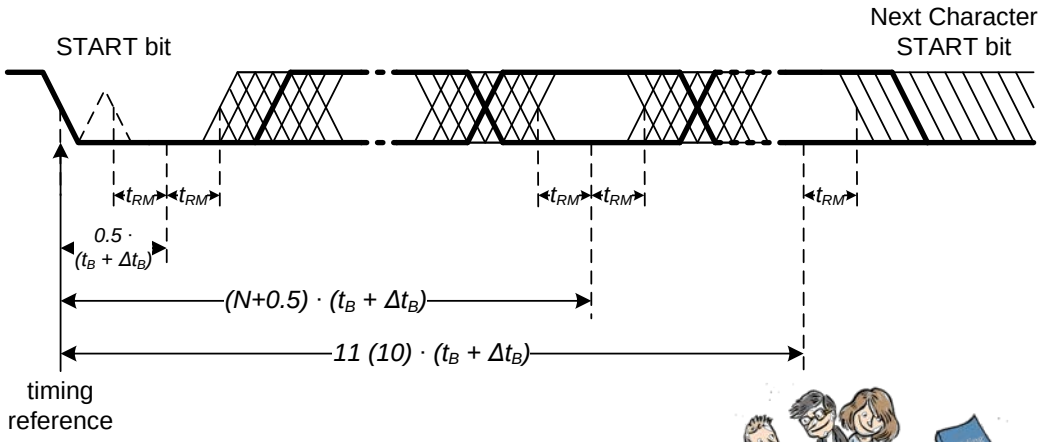
UART character layer
(part of data link layer)

- Characters and BREAK defined.
- Even parity recommended
- Baud rates of 19,2k, 115,2k and 460,8k recommended. 9,6k, 38,4k, 57,6k and 230,4k allowed

- Baud rate tolerances, start bit transients, skew, signal transition oscillations and receiver margins defined in detail

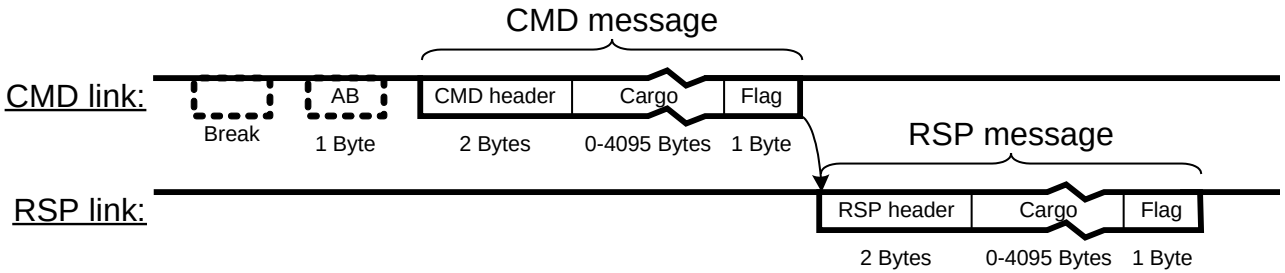


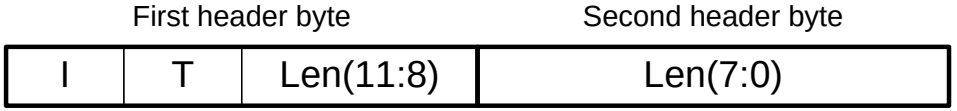




UART frame layer
(part of data link layer)

- Master/slave communication
- Delimited by header and end flag (FE_H)
- BREAK used as communication synchronisation





I = Instruction/information code

	CMD	RSP
00:	Command	Normal response
01:	Not used	Error response
10:	Reserved	Reserved
11:	Reserved	Reserved

T = Transaction ID, copied from CMD to RSP

UART frame layer - upper layer interface

- The CE Frame Layer interface to upper layer includes the following:
  - Cargo of CMD messages for transmission
  - Transaction ID for transmission
  - Cargo of RSP messages received
  - Received Transaction ID
  - Frame Layer RSP error events
  - Command communication synchronisation (BREAK)
  - Command AB Sequence (including BREAK)
  - Command AB Character only
- The PE Frame Layer interface to upper layer includes the following:
  - Cargo of CMD messages received
  - Cargo of RSP messages for transmission
  - Frame Layer CMD error events

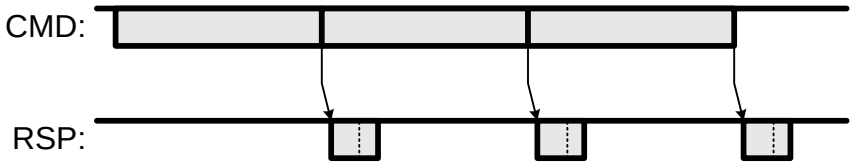
UART frame layer options

- Pipe-lining allows full bandwidth utilisation with relaxed timing constraints for instance when loading or dumping PE memory.
  Note: BREAK cannot be used

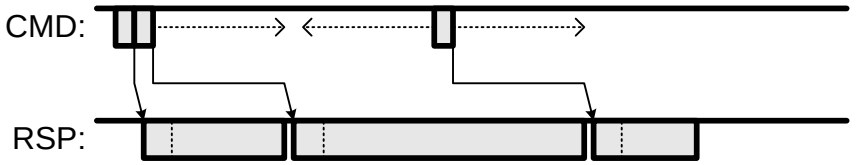
- Future protocol extensions using the reserved I-field values 10_B and 11_B are for instance:
  - Addressing multiple PEs on a single RS-485 link
  - Adding data field headers

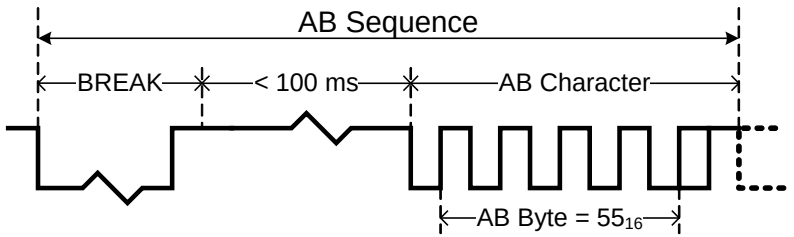
- Auto-baud function using BREAK + 55_H character allows for simple oscillators in the PE

Load memory:



Dump memory:





Contact

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