Satellite Networks: MIL-STD-1553

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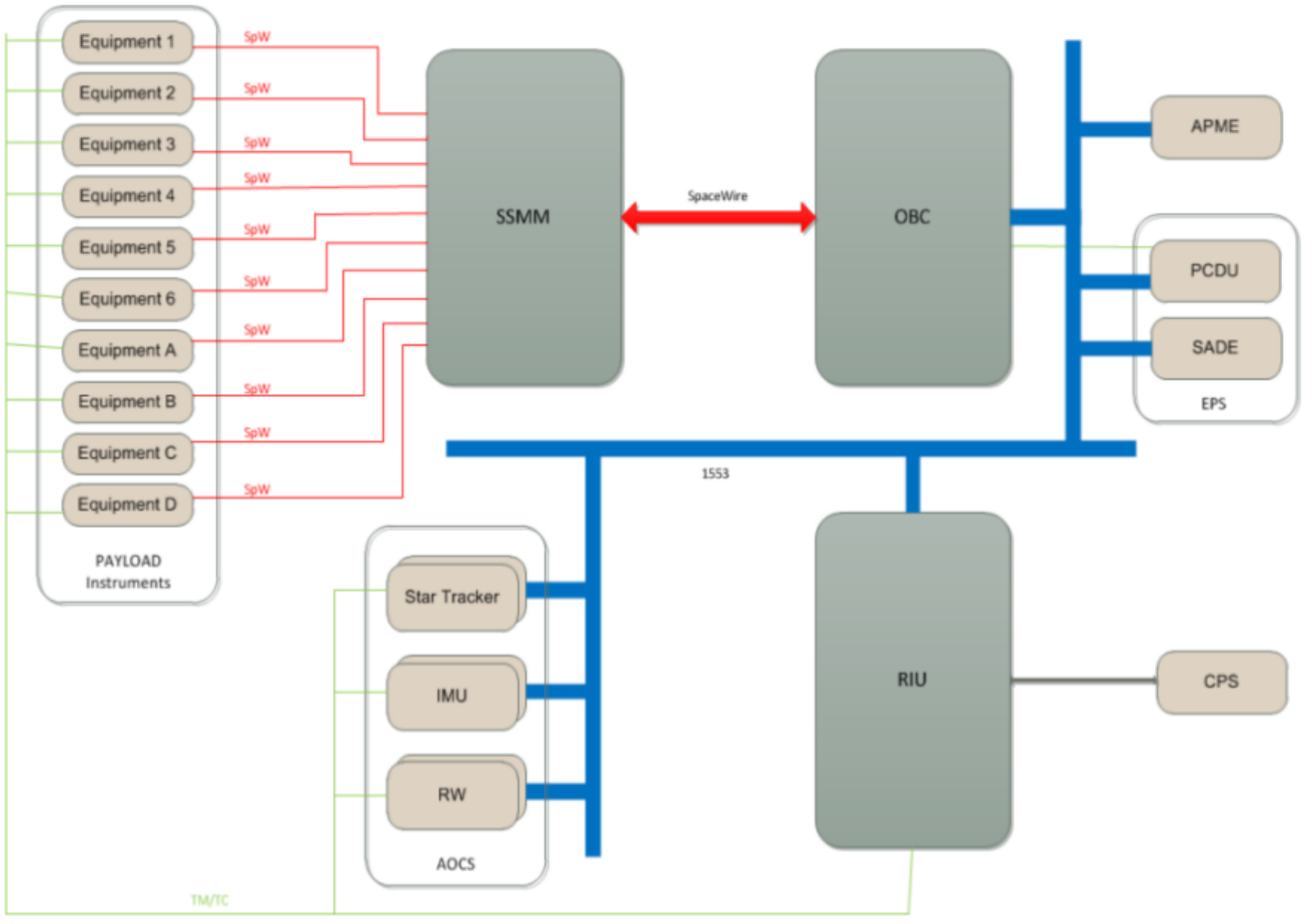
Plan

Agenda

Introduction

MIL-STD-1553

Nowadays typical scientific spacecraft architecture



(Source: O. Notebeart, Airbus Defence and Space)

On-board communications needs

Vehicule guidance and control

- Data related to vehicule guidance, navigation, orbital control, altitude,
- Orientation of antennas and instruments,
- **Low data rate** but **high determinism**.

Payload data transfer

Data measured by the various instruments have to be transferred to mass memory.

- Data are high resolution images, radar data, etc. . .
- Requires large throughput from instruments to mass memory.
- Data flow is continuous, generally.

Communication constraints needs

Contraints on data transfer

- Compression and storage of instrument data is mandatory.
- Satellite functions may require a common clock: synchronization required.
- Security and robustness: ciphering, command authentification, no computing errors.

Resistance to radiations

- Space environment is harsh: electronic age faster with space particules blasts, messages get corrupted (random error).
- New material, resistant to cosmic radiations, are required (e.g. SOI)
- Complex system and expensive!

Agenda

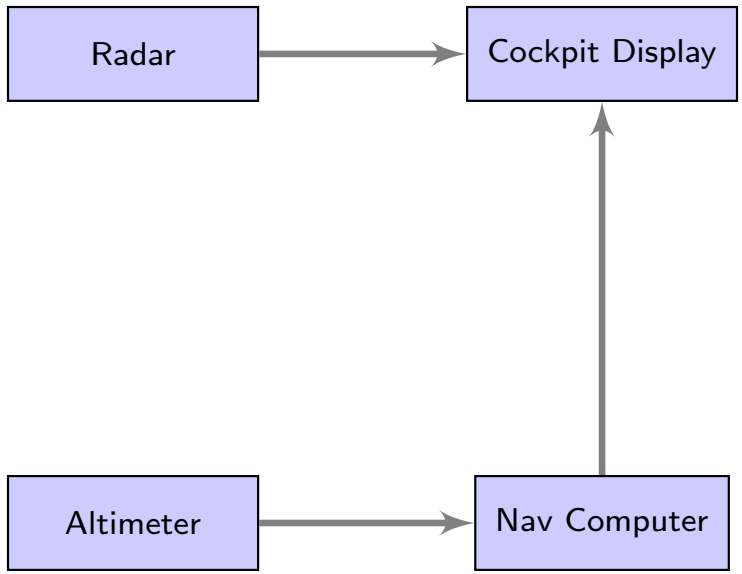
Introduction

MIL-STD-1553

A bit of history ...

Military planes in the 50s

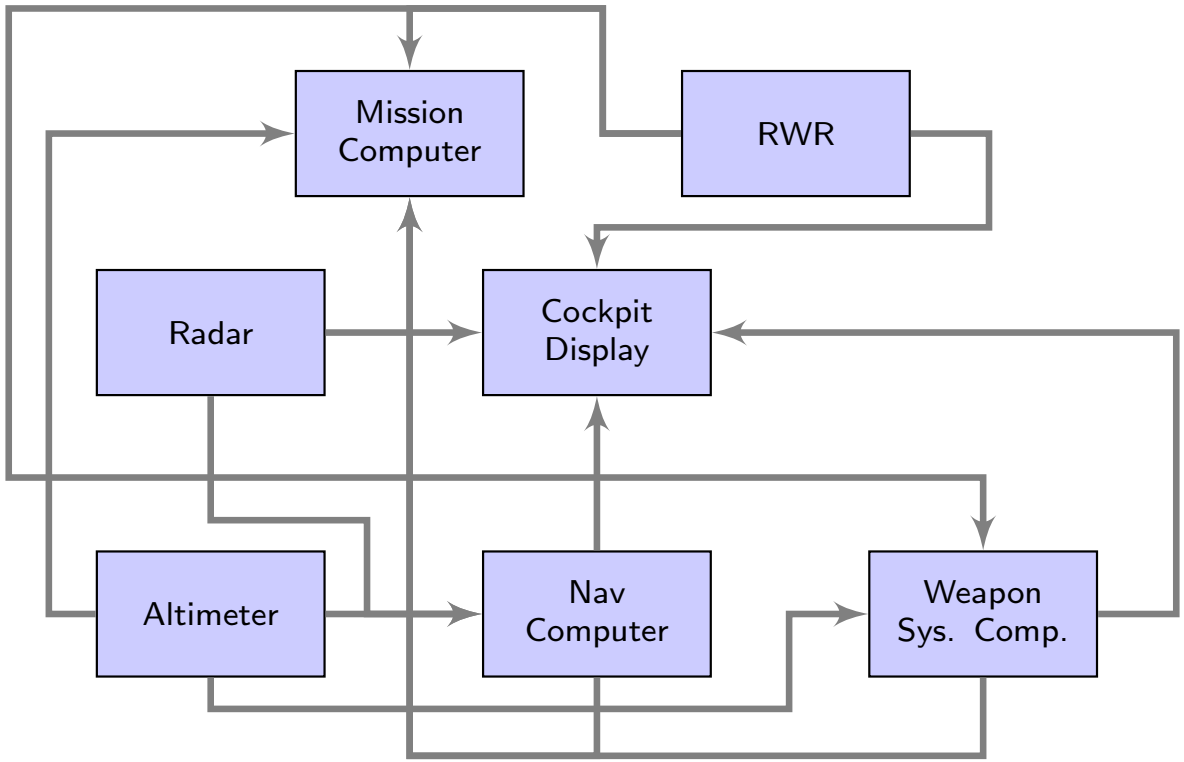
- Dispatched analogic systems (Radar, Cockpit Display, Navigation, ...)
- Interconnected by dedicated analogic wires



A bit of history ...

Military planes in the 60s

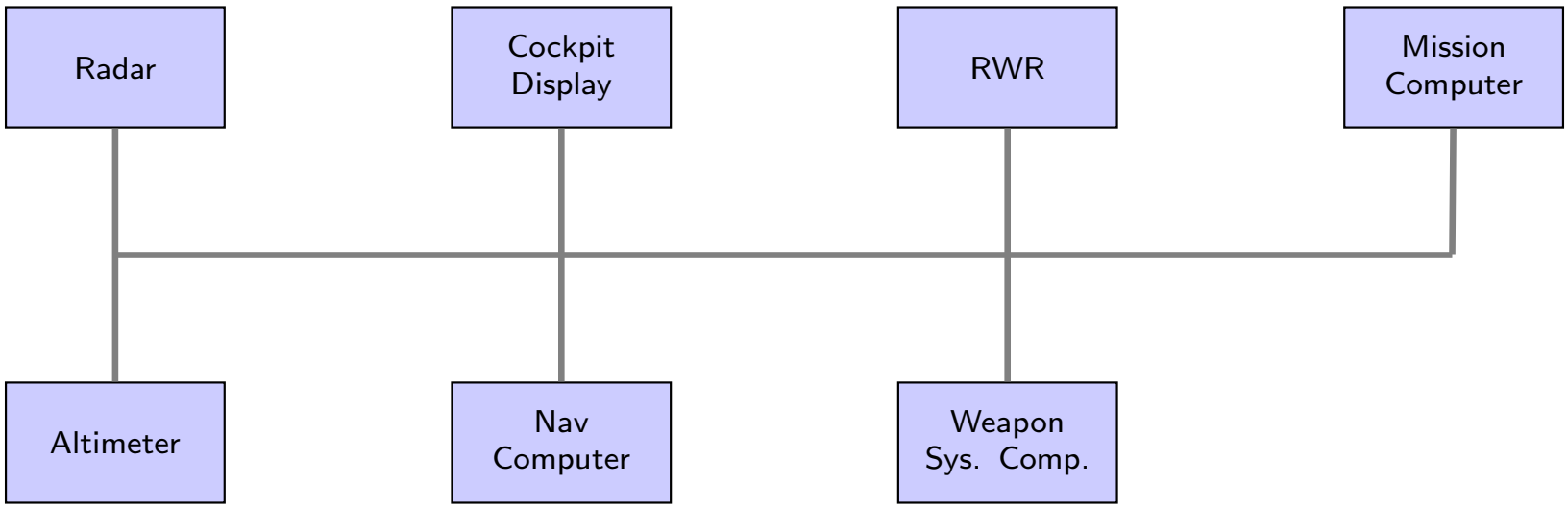
- More complex systems, number of systems increases
- First digital buses



A bit of history ...

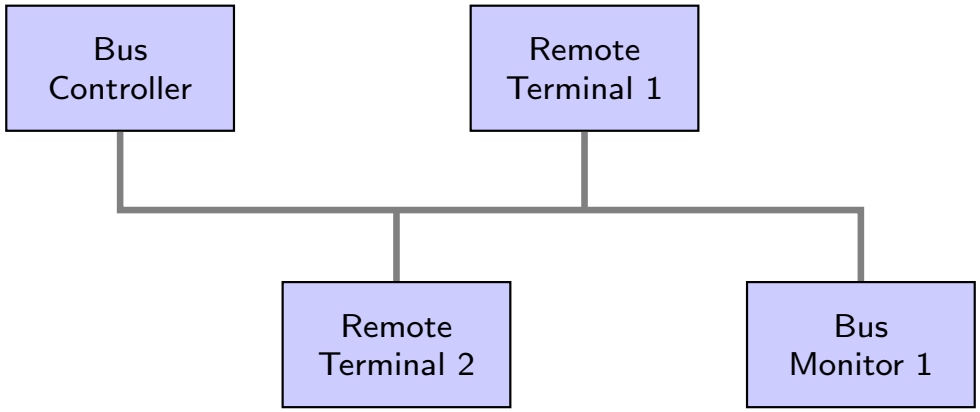
Military planes from the 70s

- Shared buses between the systems
- Reducing the number of wires, reducing of the weight and simplified maintenance
- Communications between all the systems



MIL-STD-1553B Standard

- Defined in 1978 (MIL-STD-1553 in 1975)
- Initially for military planes
- twisted wires (FO possible in MIL-STD-1553)
- Network architecture:



Architecture 1553

Bus Controller

- Bus access control $\rightarrow$ Command/response system
- Controls the state of the Remote Terminals

Bus Monitor

- Reads data on the bus
- No data transmission

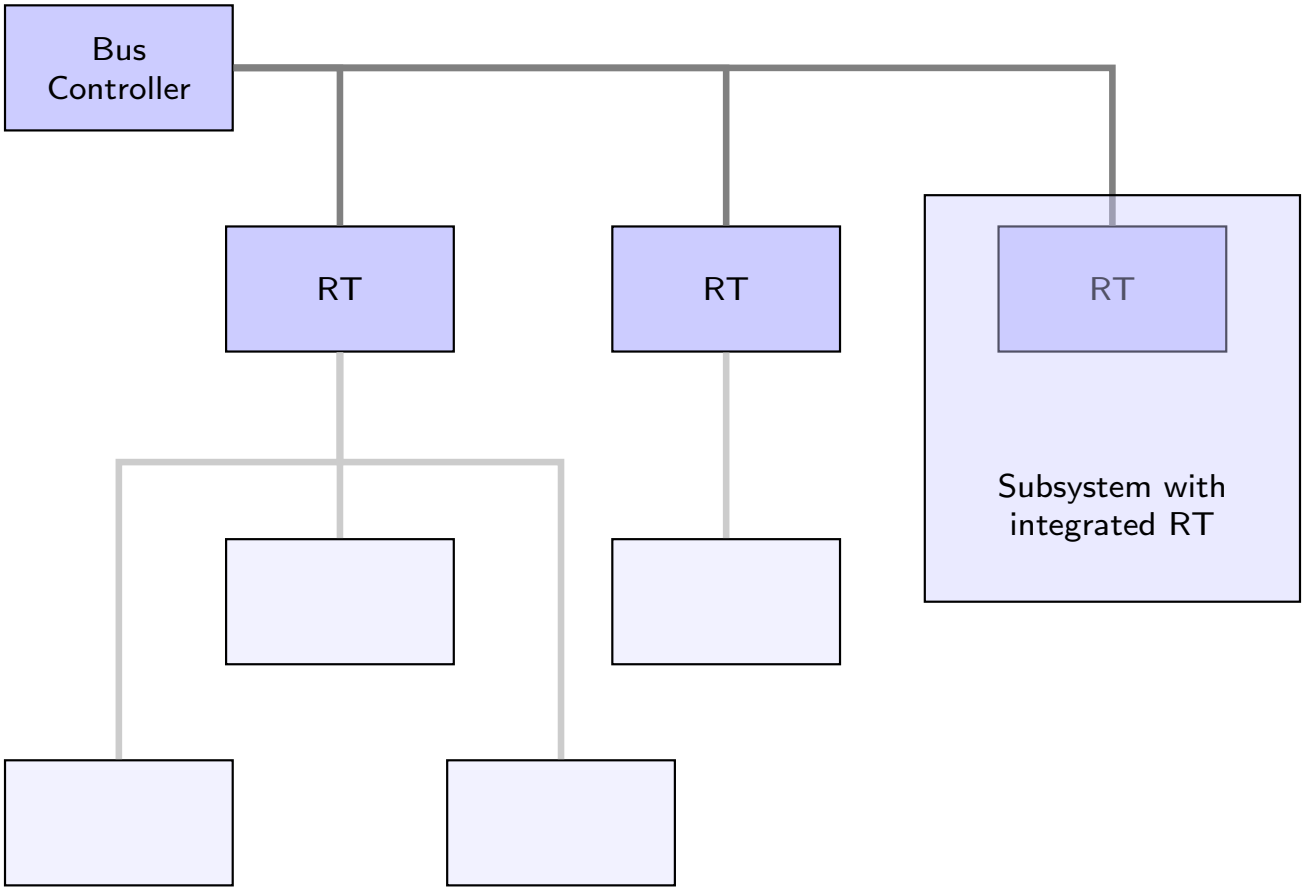
Architecture 1553

Remote Terminal

- Waits for BC commands
- Can receive data from BC or other RT
- Can send data to BC or other RT
- Up to 30 RT
- Can be an interface for:
  - a unique system
  - a set of subsystems

  or integrated into a system

Architecture 1553



Exchanged data format

3 types of word (= exchanged data between the systems)

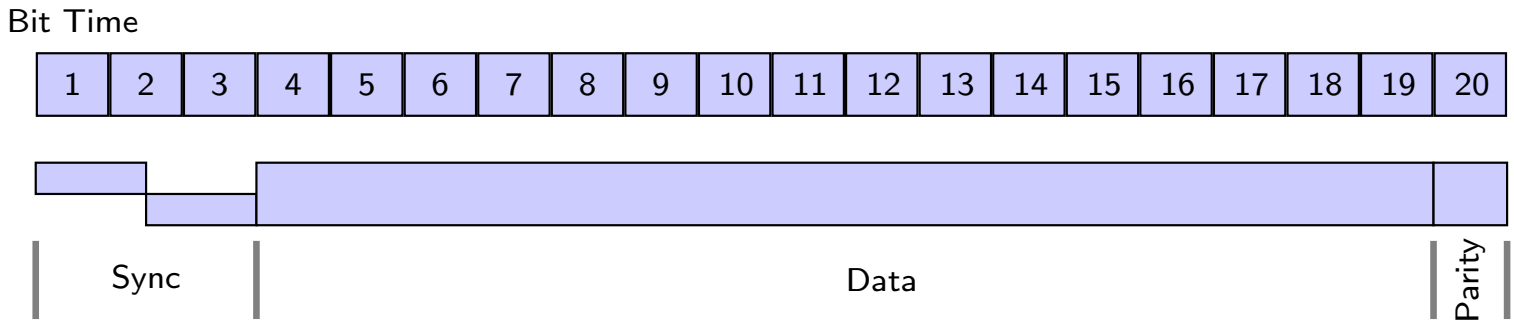
- Command words : action to be executed by RT, sent by BC
- Status words : response from a RT to a command sent by BC
- Data words : data transmission on the bus

RT Addresses

- Terminal Address : Address of RT known by the BC, value between 0 and 30 (31 = broadcast)
- Terminal Subaddress : identify the transmitted data, up to 30 variables can be sent and 30 variables can be received

Exchanged data format

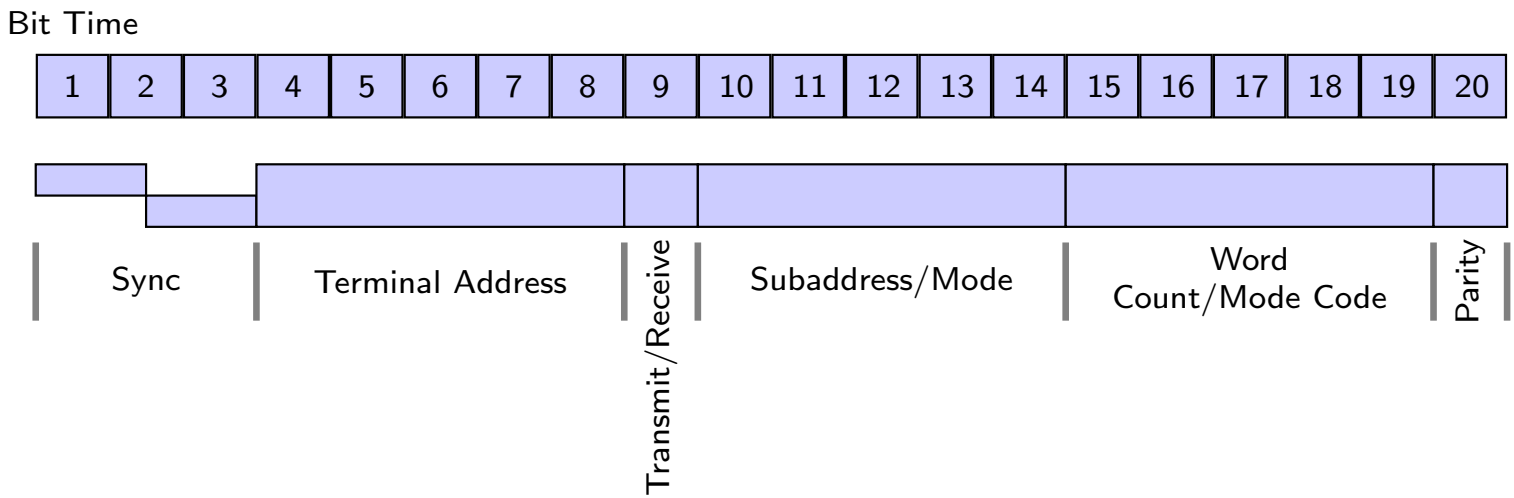
Data word format



- Sync : synchronization of the transmission clocks
- Data : 16 data bits without specific type
- Parity : for error detection

Exchanged data format

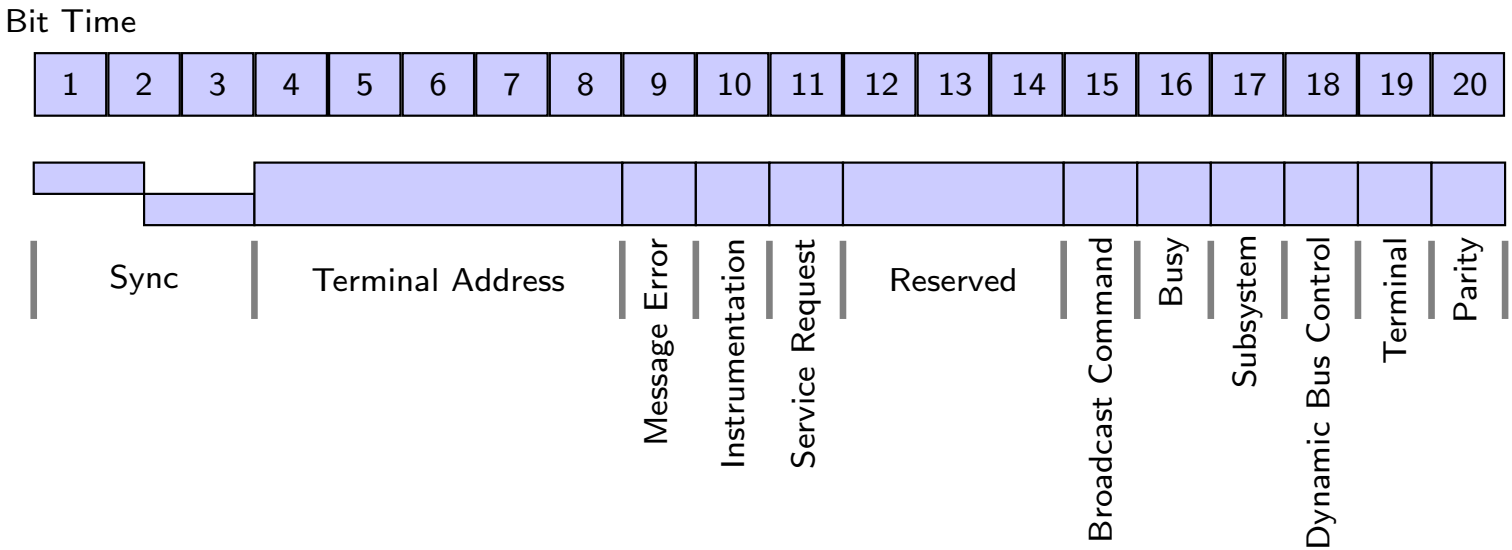
Command word format



- Terminal Address : Identify the RT
- Transmit/Receive : Transmission or Reception command for the RT
- Subaddress/Mode : Identify the subsystem of the RT
- Word Count/Mode Code : Number of words following the command word / Command code

Exchanged data format

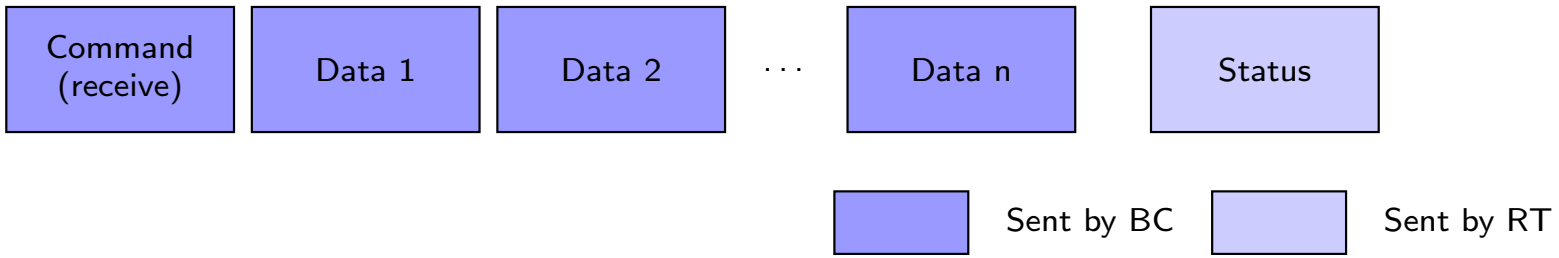
Status word format



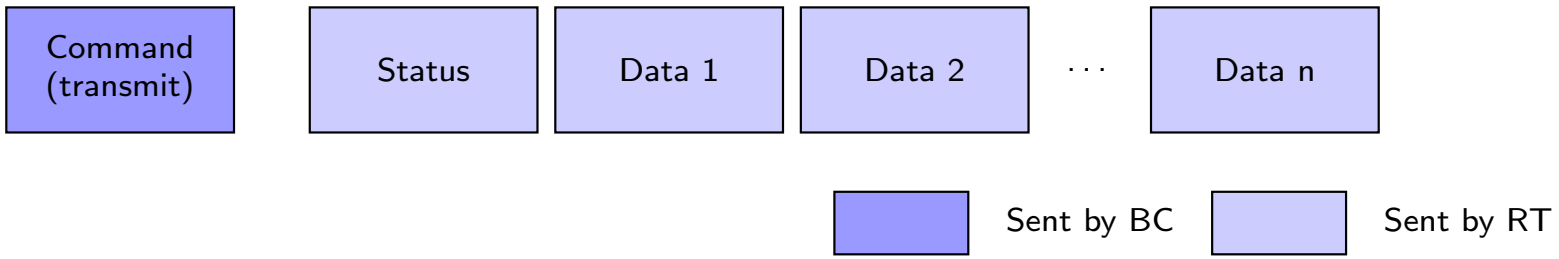
- Message Error Flag : Transmission error
- Busy Flag : Flow control
- Subsystem Flag : Subsystem error
- Terminale Flag : Hardware error

Exchanged data format

Communications from BC to RT

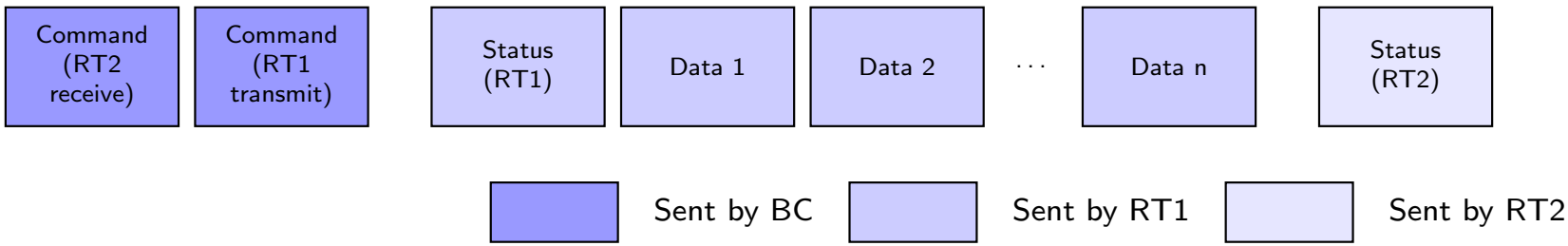


Communications from RT to BC



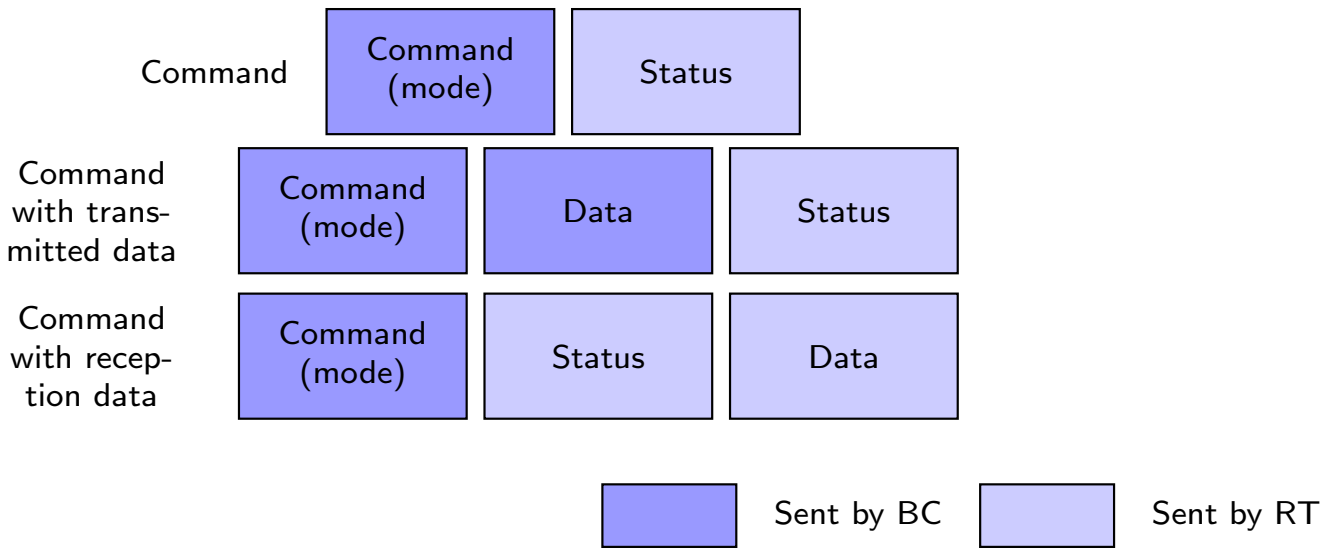
Exchanged data format

Communications between RT



Exchanged data format

Command messages from BC



Conclusion on 1553

- MIL-STD-1553 : well adapted to control data on board satellites
  - a few amount of data but deterministic traffic
  - command/response bus $\rightarrow$ well adapted to real time constraints
- But specific point to point links for measurements equipements (high amount of data $\rightarrow$ high bandwidth)

Problem

- Increase of embedded functions on board of satellites
- $\Rightarrow$ Lots of point to point links
- $\Rightarrow$ Increase the complexity and the cost of the satellite

Solution

Another onboard network: Spacewire