Mapping of CCSDS SOIS services on 1553 Bus

Olivier Notebaert – ECSS-E50-13 Convenor - Astrium

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Context

- 1553 Bus is well adapted to spacecrafts Data-Handling
  - Very good reliability characteristics
  - Allows deterministic and efficient real-time command/control
  - Lot of commercial products and test equipments
  - Large return on experience in space applications
- Used for many European space applications and still good perspective
  - Launcher avionics on Ariane 5 and Vega
  - Spacecrafts command and control for platforms and payloads
  - Attitude and Orbit Control systems
  - In-Orbit infrastructure and manned flight for ISS and ATV
  - Evolutions are foreseen to allow higher bandwidth and lower power consumptions

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Communication services on 1553

- The Mil-Std-1553B Standard defines physical and data-link requirements to transfer data
  - This does not defines how to transfer Periodic data and Large data units (i.e. packets), how to distribute time, synchronise nodes, monitor nodes and manage the bus
- Consequently, users define upper layer protocols adapted to their requirements
  - The number of different data transfer and bus management protocols increase
  - Even with a reuse policy, there are variants and options for each project
  - However, analysis of existing protocols show that services provide similar functions

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Objective of ECSS Working Group on 1553

- Objective
  - Minimize the future variations across spacecrafts using the 1553 data bus in order to guarantee interface compatibility and better reusability across projects.
  - Capitalize the acquired experience on 1553 based systems
- Scope
  - Physical layer and Data link layers are well defined by the Mil standard but there are several usage variants
    - ➢Identify best practices for harmonization
  - Several project defined services and communication protocols exist with similar properties
    - ➢define a standard set of services and protocols suitable to most 1553 based space systems

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ECSS-E-50-13 Working Group activity

- 9 members involved in on-board 1553 systems from major European space agencies and industry
  - In 2006, data has been collected on needs and experience from many ESA and industrial spacecraft systems, equipments and components products
  - The service to be handled by the standard have been defined
  - Emphasis is given on existing proven concepts
  - Non already proven requirements shall be verified through modelling or prototyping before being released
  - Detailed requirements drafting is now in progress → a first draft shall be issued in March 2007 for review by designated experts
  - Mapping on CCSDS/SOIS is an objective
  - Draft Standard is to be released end of 2007 for public review

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ECSS-E50-13 – Services identification

- Transfer data
- Time distribution and synchronisation
- Communication synchronisation
- Get Data
- Set Data
- Bus Management
- Remote Terminal Health Monitoring
- Event Notification
- Terminal Configuration
- Device Discovery

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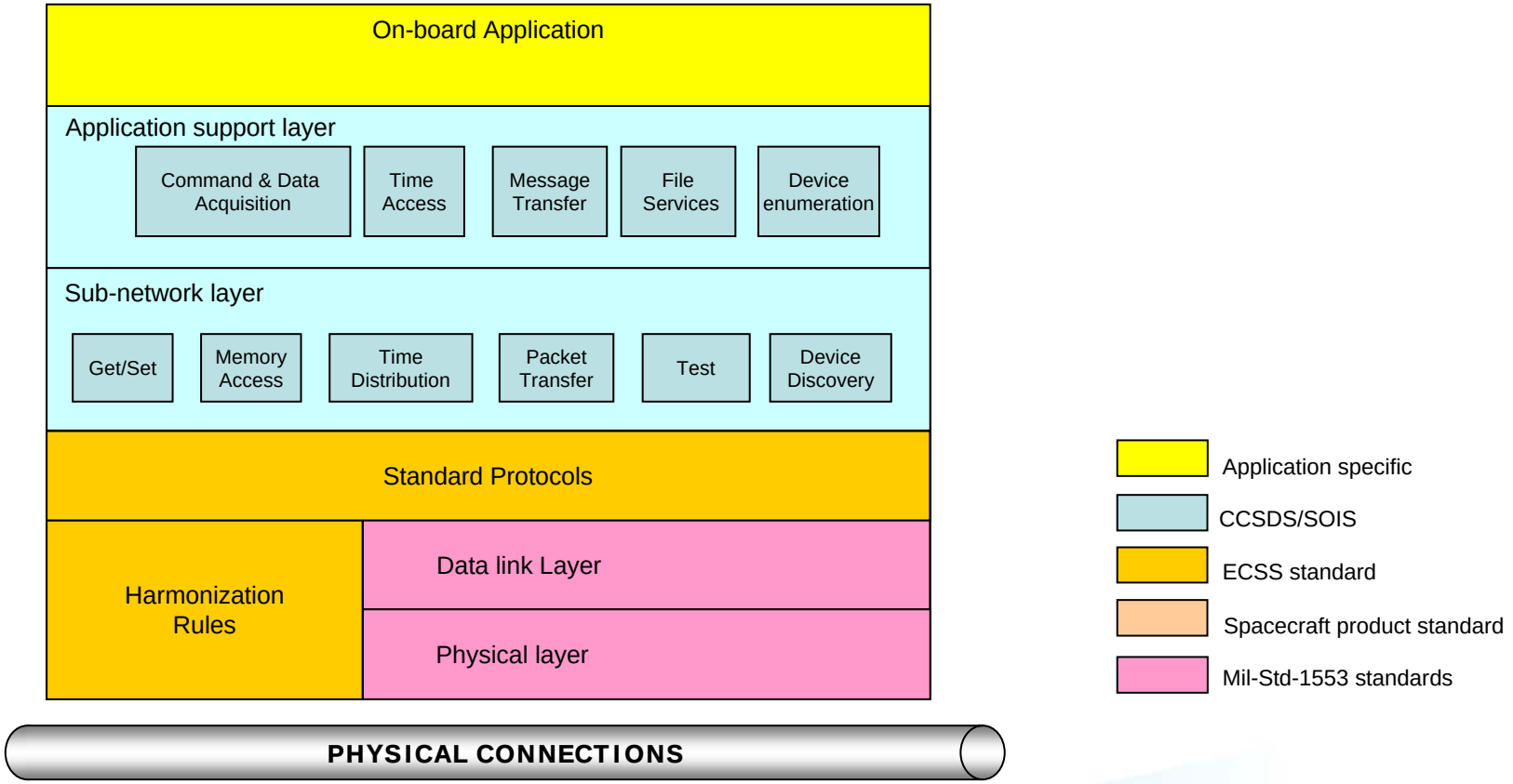
On-board communication standards



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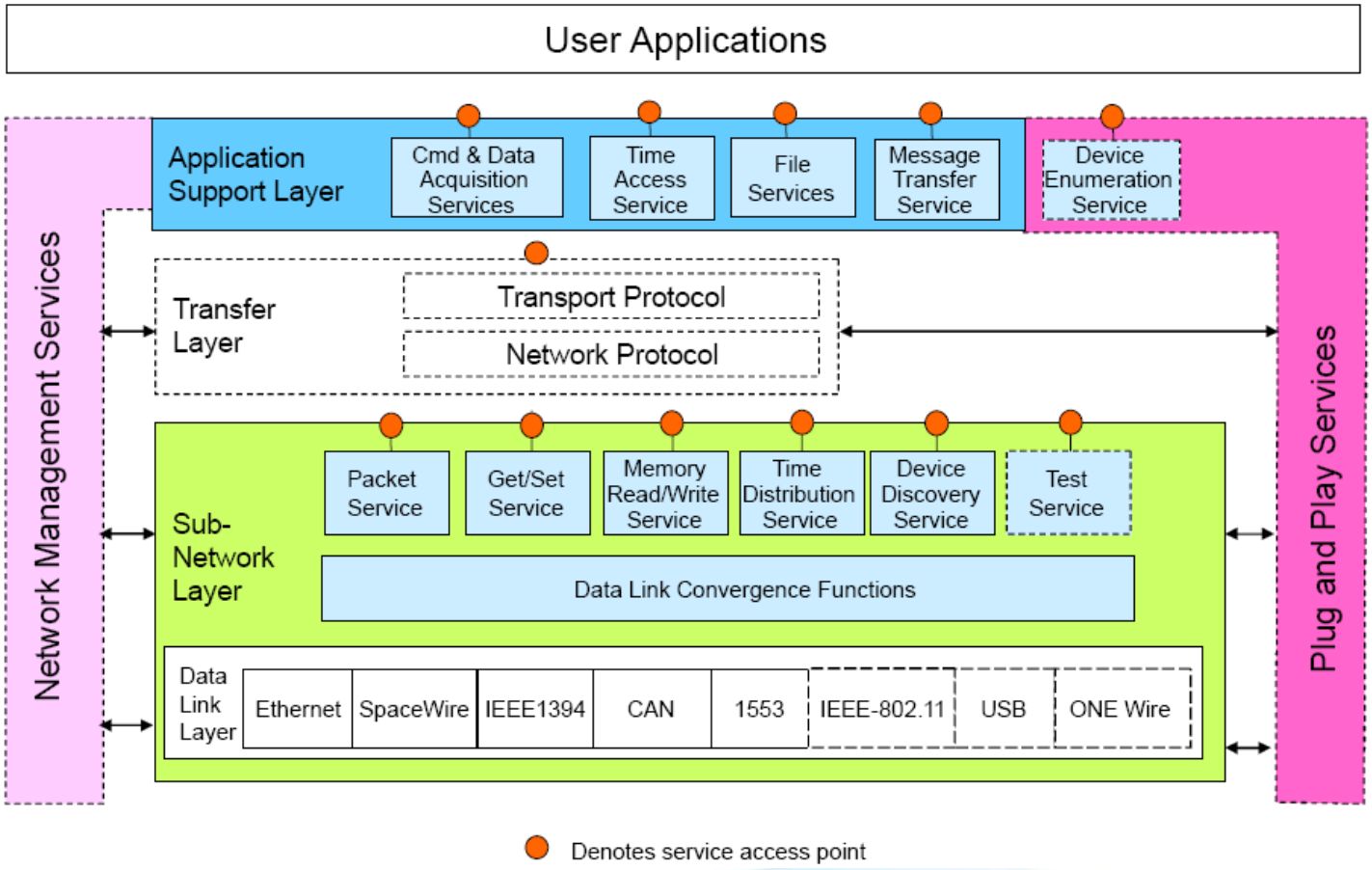
CCSDS SOIS architecture



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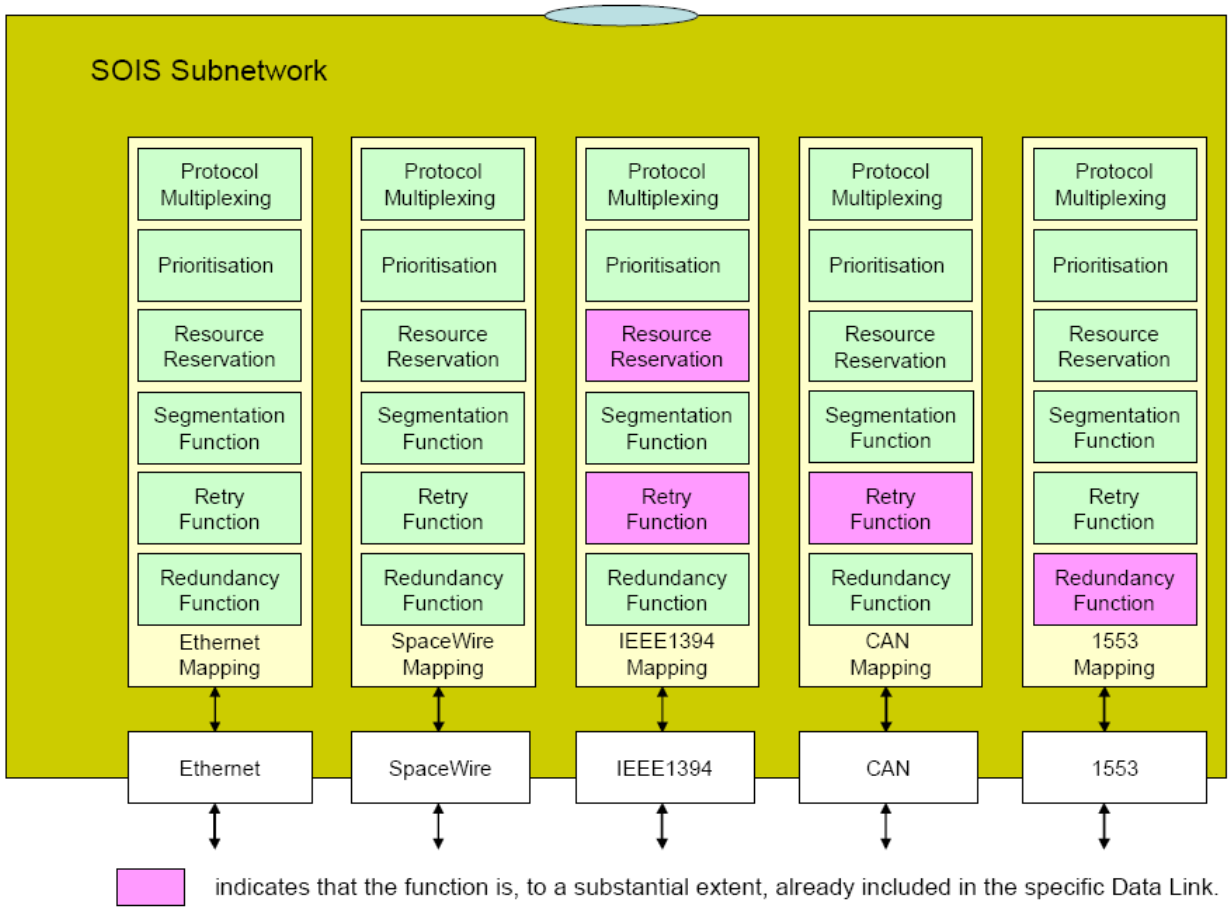
CCSDS SOIS Sub-network functions



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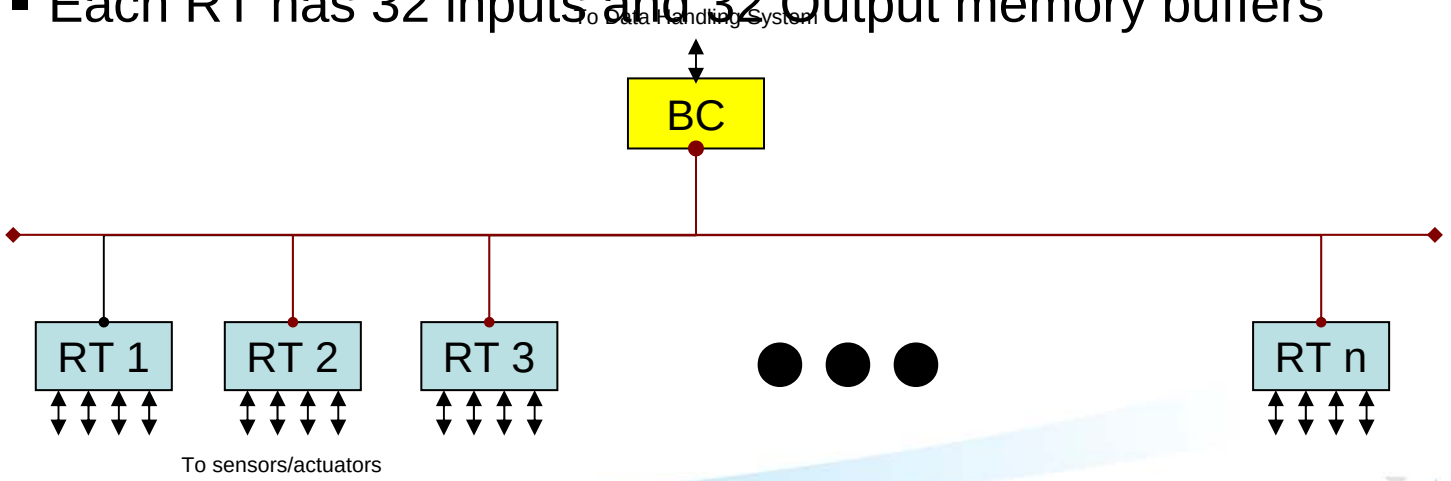
Very short overview of 1553 bus

- Master/Slave concept with 2 types of nodes
  - One Bus Controller (BC)
    - Act as a master on the bus: Unique initiator for data transfers and able to control and manage the bus configuration through specific commands
  - Up to 31 Remote Terminals (RT)
    - Act as slaves: cannot emit data on the bus without BC request
  - Each RT has 32 inputs and 32 Output memory buffers



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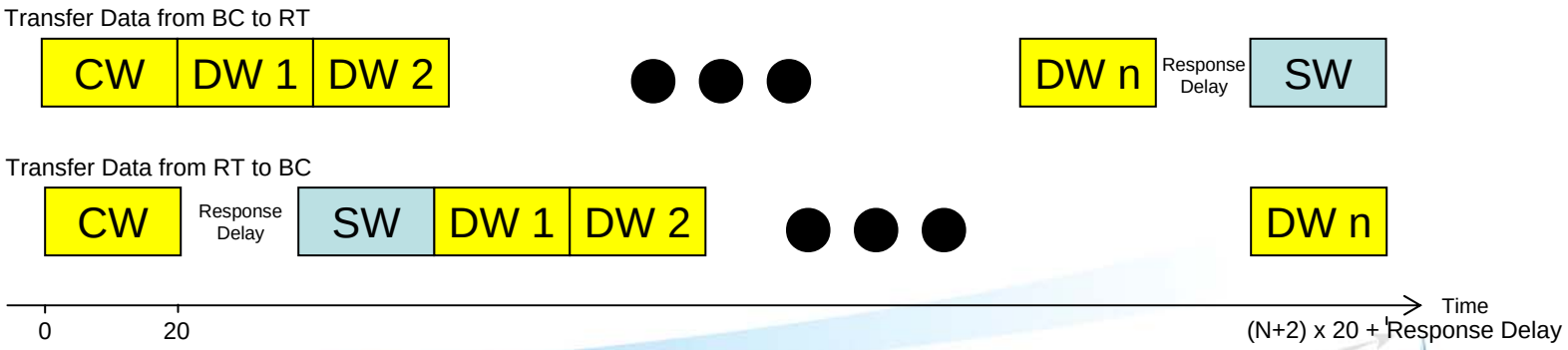
Very short overview of 1553 bus

- Layout of data transfers
  - One command word (from BC)
    - Defines the type of transfer (e.g. direction) and its characteristics (RT address, subaddress buffer, data length…)
  - Up to 32 data words (From BC or from RT)
  - One Status Word (From RT) to report on message transfer successfulness
  - Strict timing requirements 16 useful data bits per word transmitted in 20 µs (20 actual bits)



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Issues for mapping SOIS on 1553

- Asymmetry of the bus topology
  - Remote Terminals cannot transfer data at their own initiative
    - a mechanism to request servicing from BC has to be proposed in the adaptation layer in order to hide this limitation to the end user
  - Various mechanism are currently used for RT>BC data transfer
    - The 1553 standard defines *immediate* servicing tools (Service request bit, transmit vector word…)
      - Recommendation is to reserve such mechanism for event/alarm notification
    - Direct polling of transfer data buffer provides very deterministic characteristics but is wasting bandwidth in case of sporadic needs
      - Recommended for cyclic data acquisition only
    - Polling requests to schedule an asynchronous RT to BC transfer will match the SOIS requirements for asynchronous data transfers
      - A RT output buffers (subaddress) must be reserved at least for this service request – and a format defined
      - This is subject for standardisation

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Issues for mapping SOIS on 1553

- Synchronisation issue
  - The SOIS communication view is mostly asynchronous
    - Data is fetched upon need – network should be hidden to the user who should not have to care how it is fetched on the data link to end terminal
  - Except for very simple systems, there is no direct access to the full memory on 1553 terminals: data must be ready in the output buffer when the BC request for acquisition occurs
  - In most 1553 systems, this results in the definition of synchronous acquisition protocols
    - Reception of a 1553 Standard synchronisation command on a RT triggers the sensor data acquisition process.
    - The delay between the Synchronisation command and the data acquisition defines the real-time performance (e.g. latency, jitter…) of the data transfer
  - Such protocol should be included within the adaptation layer

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Issues for mapping SOIS on 1553

- Retry issue
  - Retry function is included in the 1553 standard
    - It is not often used by space projects for several reasons such as:
      - In systems used cyclic scheduling (90%), a retry modifies the cyclic scheduling of the bus unless the retry transfer is systematically included within the frame which has a high bandwidth cost
      - The error rate on 1553 is very low – experience shows that retry's are almost always application errors and the retry also fails
      - It is often a system choice to handle errors and retries within the FDIR function (at application level)
      - In most applications, the highest proportion of the traffic is acquired data which is rescheduled periodically and the system application is tolerant to one acquisition failure (even 2 or more). Retrying does not make sense
    - As a result, the ECSS standard will not map the retry function related to the SOIS quality of service on the 1553 standard retry
    - Some applications use a retry mechanism at segment level for long data units transfers that can be suitable for the packet transfer service.

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Issues for mapping SOIS on 1553

- Resource Reservation
  - High determinism requirements result in the definition of fully or partially pre-defined acquisition frames
  - Such mechanism are very well supported by HW products providing automatic scheduling functions
  - Transfers defined within an automated *bus profile* provides at least a “reserved traffic” class of resource reservation
  - Associated with the retry mechanism of the packet transfer service, it reaches the class “guaranteed traffic”
  - Transfer without pre-scheduled will have to share the remaining bandwidth will be “best effort” or “assured” traffic class

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Conclusion

- Mapping of SOIS services on 1553 is an element of the ECSS 1553 standardisation process
- The 1553 Working group uses the CCSDS/SOIS Green book as an input to stabilize the related requirements
- Focus is on data transfer services and handling of the functions defined in the sub-network layer
- Issues are to be discussed within the WG and can be coordinated with CCSDS through ESA representatives

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