The EXOMARS CAN bus solutions

Maurizio Caramia

ThalesAlenia Space
A Thales / Finmeccanica Company

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The EXOMARS Mission

The ExoMars mission is split into two launches:

- The 2016 mission consists of a Trace Gas Orbiter (TGO) and an EDL Demonstrator Module (EDM)
- The 2018 mission consists of a Rover accommodated inside a Descent Module (DM) carried to Mars by a Carrier Module (CM)

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CAN + CANOPEN

The EXOMARS CAN busses

- **The CAN bus has been selected as the system and payload bus for three of the five EXOMARS modules:**

2016 mission

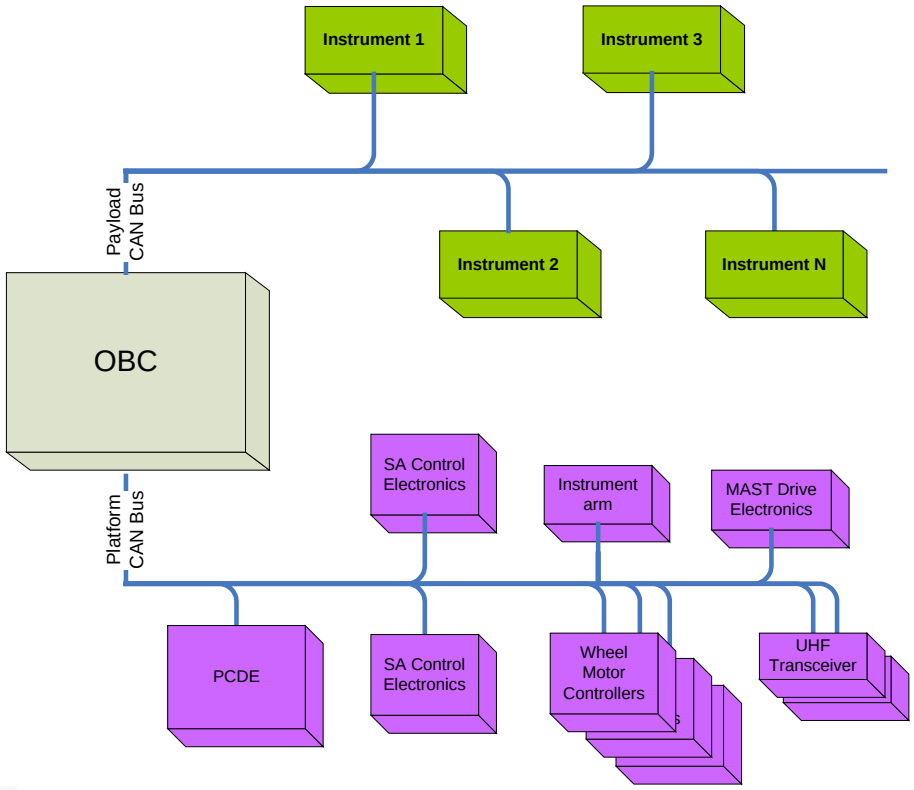
- The Entry Descending and Landing Demonstrator Module (EDM)
  - Propulsion Bay Bus => 3 slave nodes
  - Central Platform Bus => 3 slave nodes

2018 mission

- The Rover Module
  - Platform Bus => 15 slave nodes
  - Payload Bus => 7 slave nodes
- The Descending Module
  - Platform secondary bus=> 2 slave nodes

- **The main drivers for selecting CAN bus are:**
- Low power consumption
- Low mass requirements
- Very robust error detection and correction mechanisms
- European technology available
- Widely used and validated in terrestrial applications

The EXOMARS CAN nodes

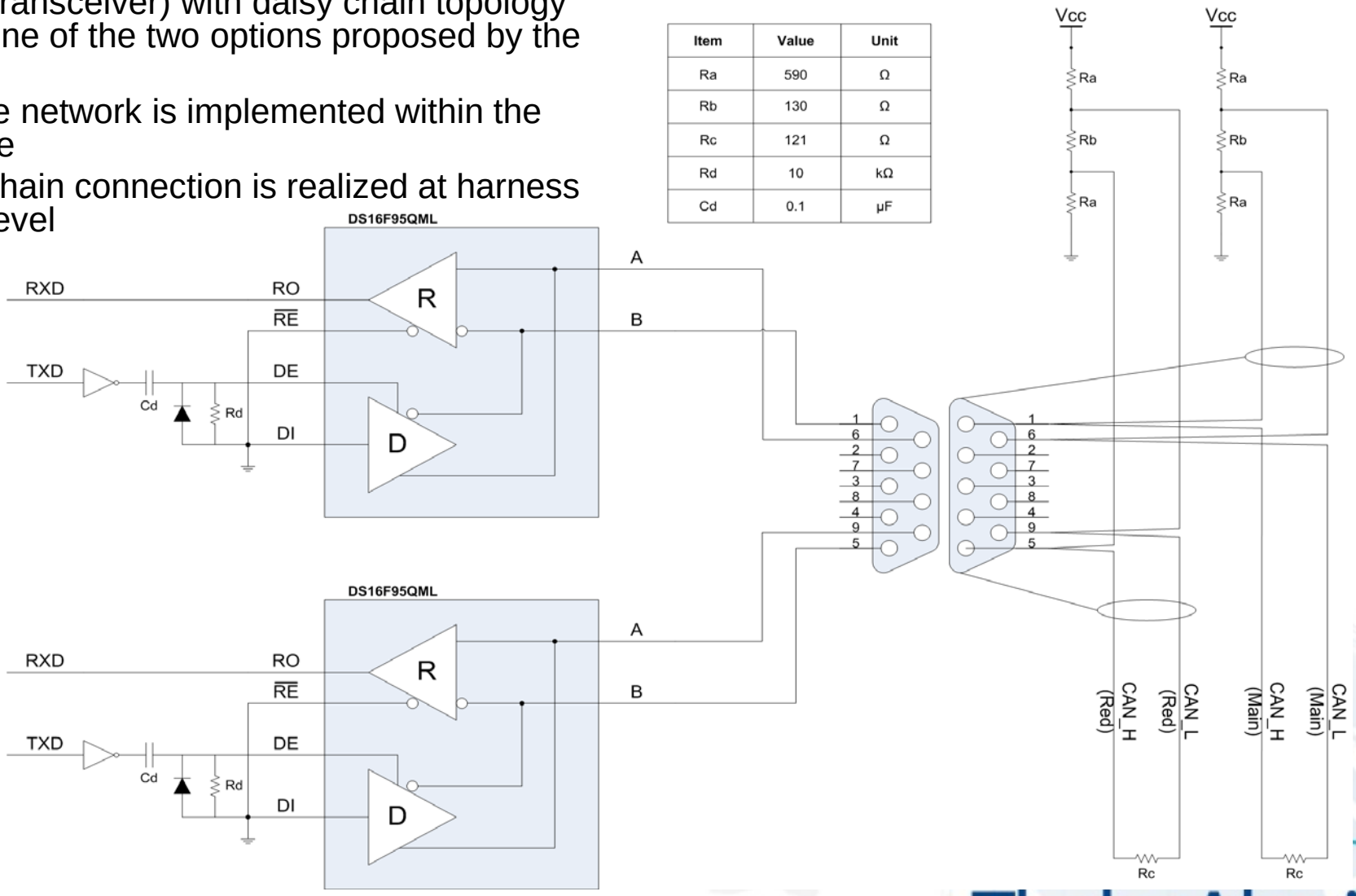


- **CPU-less:** nodes with no processing capability. They have to manage both the CAN bus DATALINK and Application Layer totally in Hardware.
- **Microcontrollers:** nodes equipped with some processing capability and therefore volatile and not-volatile storage capability. Those nodes can implement the CAN application layer within the firmware or in Hardware.
- **CPU:** nodes equipped with a uP running an application software. The bus Application layer can be easily managed by the SW but in some cases may be necessary to save some processing power and therefore the bus Application layer can be implemented in HW.

Physical Layer

- The Selected physical layer is the RS485 (DS16F95 transceiver) with daisy chain topology according one of the two options proposed by the CAN ECSS
- The fail safe network is implemented within the master node
- The daisy chain connection is realized at harness connector level

Item	Value	Unit
Ra	590	Ω
Rb	130	Ω
Rc	121	Ω
Rd	10	kΩ
Cd	0.1	µF

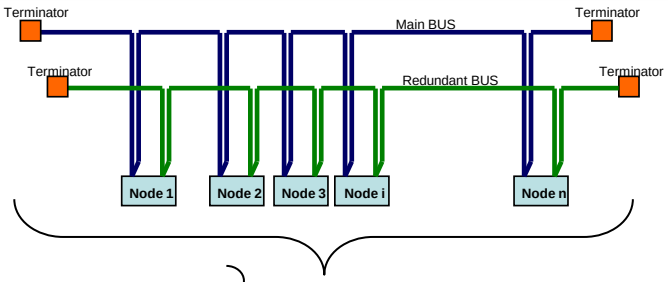


Date 13/01/09

EXOMARS CAN Protocol

- The main CAN protocol requirement was:
  - All the EXOMARS CAN nodes shall implement the same protocol on top of the CAN data link Layer.
- The selected protocol is the CANOPEN:
  - Wide variety of already defined services
  - Largely used in industry
  - A draft ECSS standard was already available
  - Wide availability of commercial development tools
- A full HW implementation of the EXM CANOpen protocol:
  - A VHDL IP Core (Canopen Controller IP Core) has been implemented (by SITAEL) to allow the connection of CPU-less nodes to the EXOMARS CAN networks.

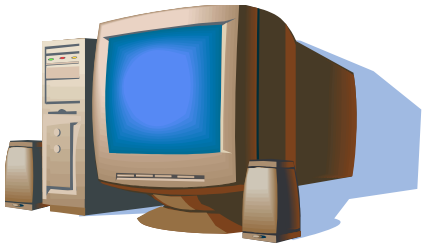
Development Path



EDS

List of TPDO => TM
List of RPDO => TC
OD definition => TC/TM DB

CANoe tool



CAN nodes model

CAN USERS

DCF

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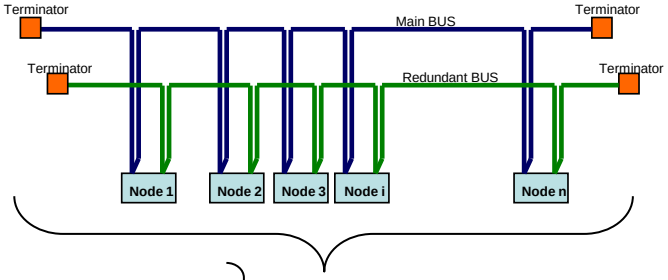
Development Path



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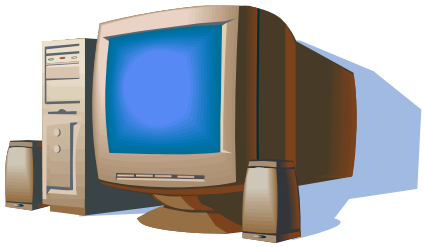

CAN nodes model

CAN USERS

DCF

FPGA developer

IP-CORE

Detailed CANOPEN CONTROLLER IP-CORE specification

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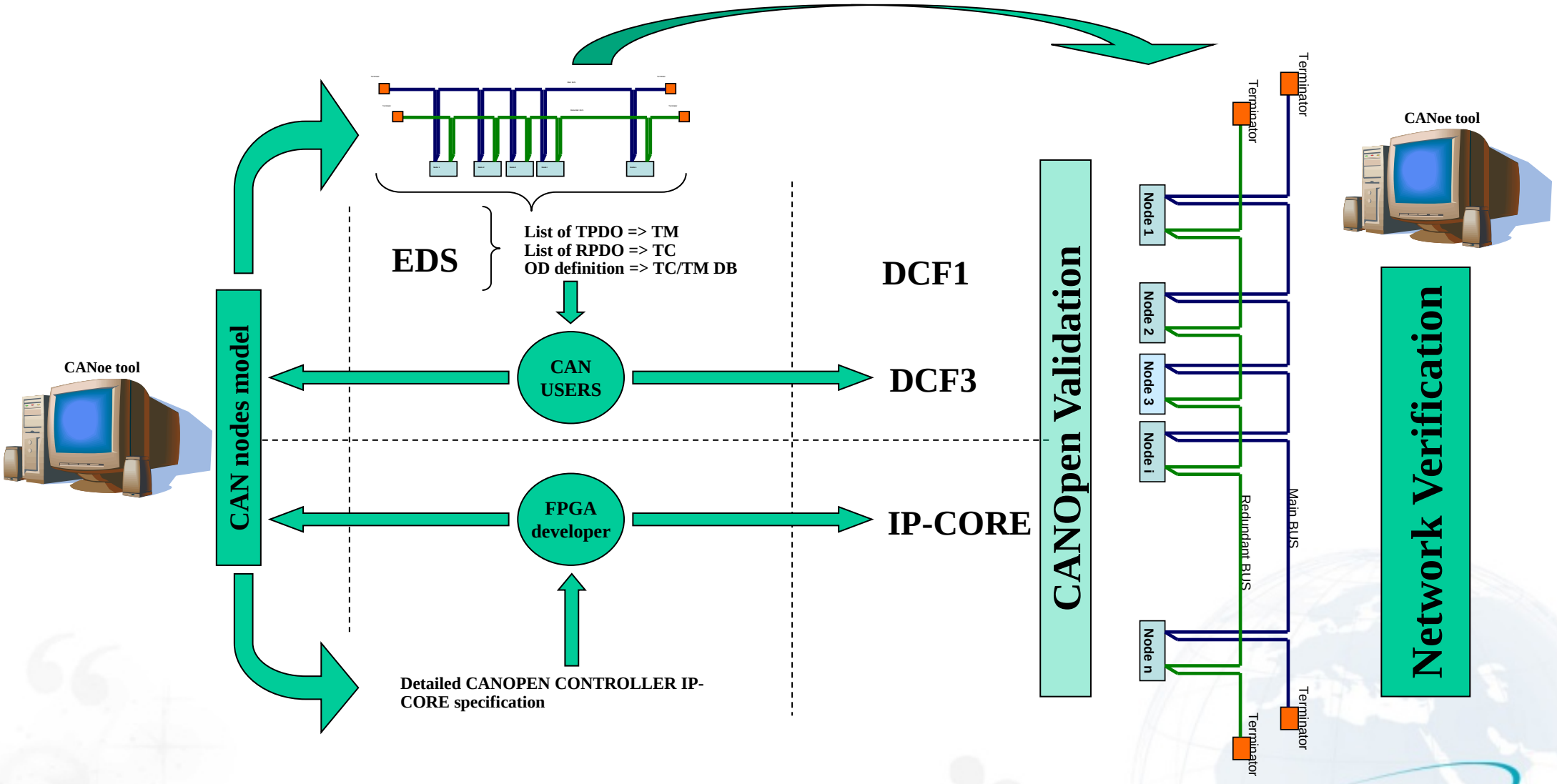
THALES ALENIA SPACE INTERNAL

Development Path



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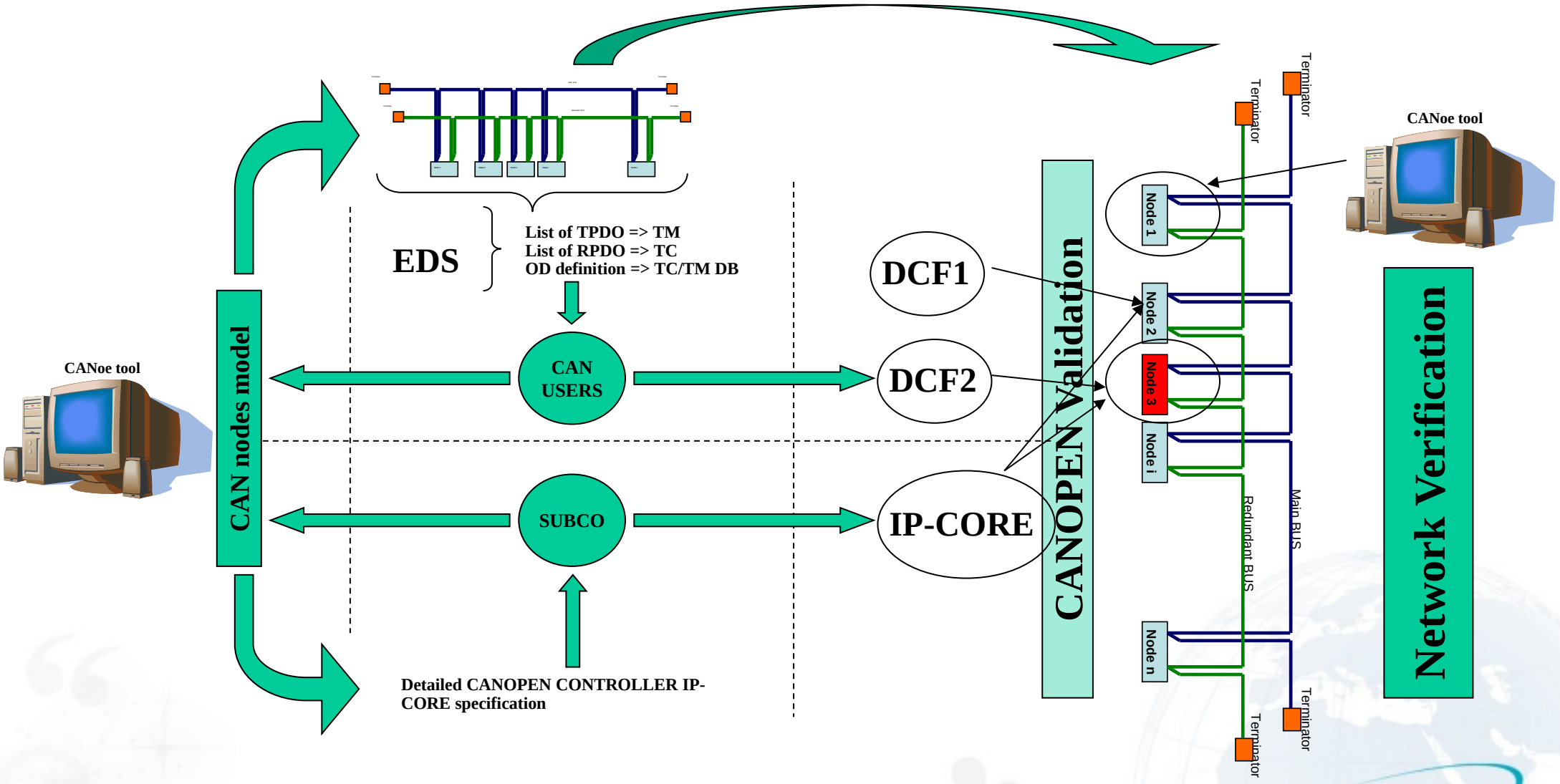

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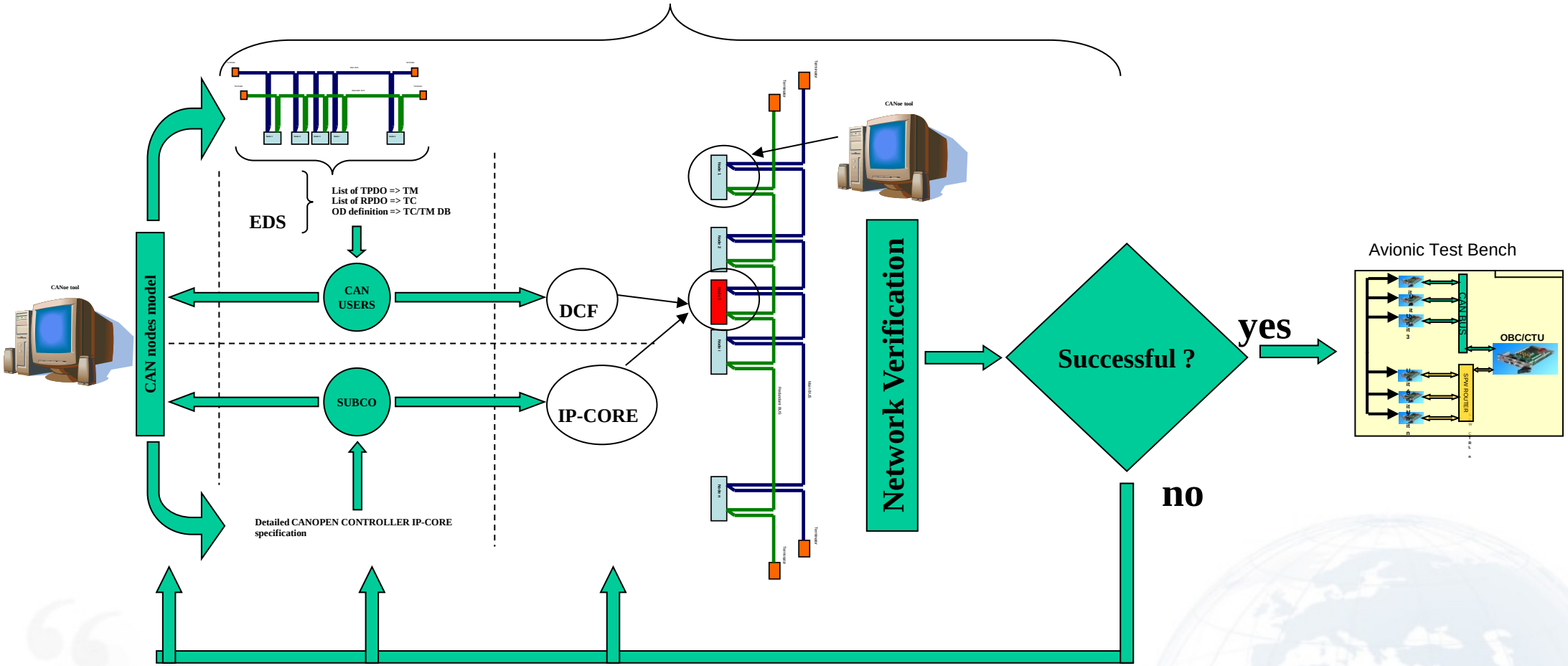
Development Path

Input to CAN ECSS



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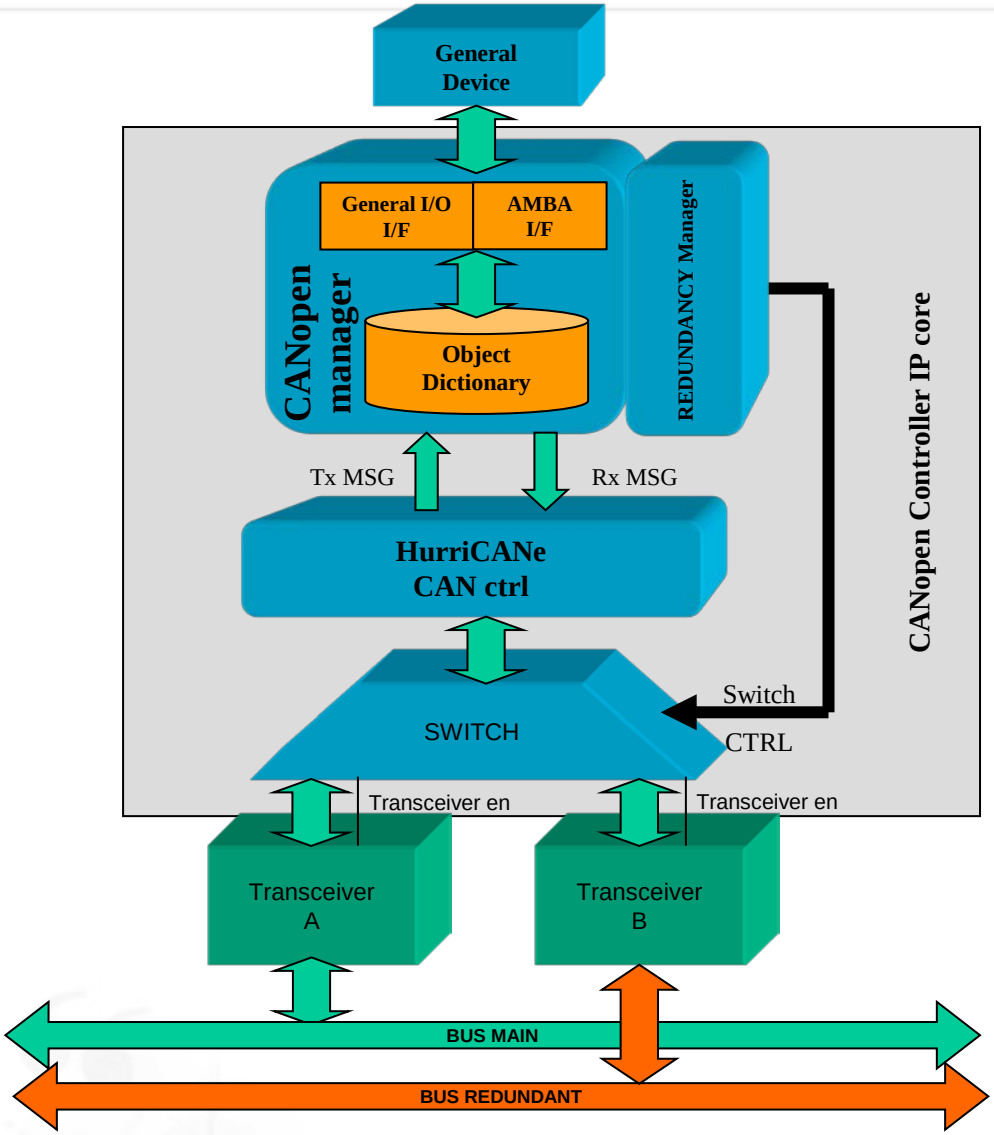
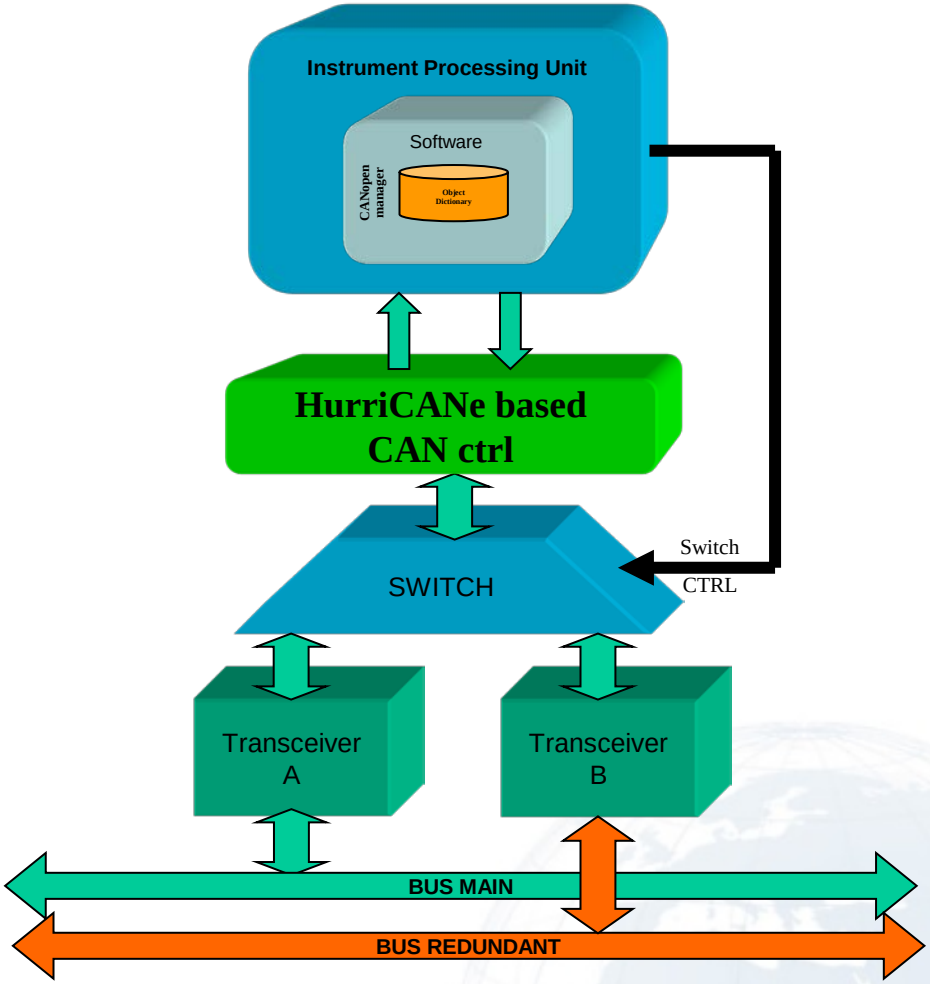
EXOMARS CANOPEN Implementation





The CANOPEN Controller IP Core

The CANOPEN software Stack

EXOMARS CANOPEN SERVICES

- SDO :
  - Master node shall implement the SDO clients.
  - Slave nodes shall implement no more than one server SDO.
  - Expedited, segmented or block SDO transfer can be implemented.

- PDO :
  - A maximum number of 1016 PDOs are available for the whole CANopen network therefore the number of PDOs will be distributed between the slave nodes :
    - RS-485 : 32 PDOs max (16 TPDO and 16 RPDO) are allocated to each slave node
  - The nodes PDO mapping shall be hard-coded into the Object dictionary and not in-flight modifiable (according specific CAN ECSS requirement).
  - Synchronous data transfer shall be performed using synchronous PDOs.

EXOMARS CANOPEN SERVICES

- Synchronization Object (SYNC)
  - All nodes requiring synchronous communication shall implement a SYNC object
  - Slave nodes shall be only SYNC consumers
  - The network master shall be the only SYNC producer.

- CANopen Emergency Object (EMCY)
  - The EMCY object is not specified by the CAN ECSS and not used in the proposed EXOMARS implementation.
    - The ECSS removed the CANOPEN Emergency service in favor of the redundancy management service.

- CANopen Time Stamp Object (TIME)
  - The TIME object is not specified in the CAN ECSS and not used in the EXOMARS implementation
  - According CAN ECSS requirements the SCET will be distributed only via standard PDO

EXOMARS CANOPEN SERVICES

- Network Management Objects (NMT) :
  - Heartbeat service :
    - All nodes shall implement the Heartbeat Protocol
    - The Network Master shall be Heartbeat producer.
    - All Slave nodes shall implement the Heartbeat Consumers.
    - All Slave nodes shall implement the Heartbeat producer.
  - According the CAN ECSS the following CANOPEN services have not been implemented:
    - Node Guarding Event
    - Life Guarding Event

EXOMARS CANOPEN SERVICES

- CCIPC features (only for Slave Nodes):
  - Object Dictionary (mandatory according CAN ECSS)
  - RPDO handler (not Mandatory according CAN ECSS)
  - TPDO handler (not Mandatory according CAN ECSS)
  - SDO handler (not Mandatory according CAN ECSS)
    - expedited (not Mandatory if the PDO service is configured)
    - expedited + segmented
    - expedited + block
  - NMT state machine (mandatory according CAN ECSS)
  - SYNC consumer (not Mandatory according CAN ECSS)
  - Heartbeat producer (mandatory according CAN ECSS)
  - Heartbeat consumer (mandatory according CAN ECSS)
  - Redundancy Manager for selective bus access architecture
    - According the ECSS the redundancy manager is implemented
    - The selective bus access architecture proposed by the ECSS has been implemented

- Vector SW stack feature (only for Master Node)
  - Full compliance with the CANOPEN protocol
  - Redundancy management algorithm added according CAN ECSS requirements

Conclusions

- Under the EXOMARS contract a full CANOPEN solution have been implemented.
- The EXOMARS experience have been used as a case of study for the CAN ECSS WG actives.
- A full Hardware implementation of a CANOPEN slave node (compliant with the CAN ECSS) have been implemented.
  - The CCIPC can be reused in other missions guaranteeing the compliance with the CAN ECSS protocol layer and redundancy specification.
- The EXOMARS experience and the CCIPC are currently reused in the frame of the CABCOM study which has the goal to validate a CANOPEN solution for the SATCOM applications.

Questions?