CAN bus for Telecom Avionics

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Data Handling System for Telecom Spacecraft applications

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ThalesAlenia Space
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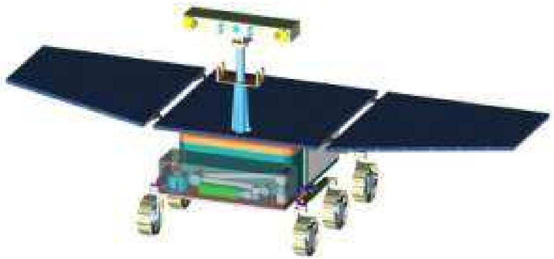
From Science to TLC

- **TAS is currently in charge of the CAB-COM (CAn Bus Solution for satCOM payload and platform management); this study has the goal to specify and validate a CAN bus solution dedicated to Telecom spacecraft.**
- **Both physical and protocol layer will be specified and validated in a dedicated testbench that will be set-up in the frame of the study.**
- **To reach these goals the TAS Torino know-how in the CAN network development has been merged with the TAS Cannes experience in the SATCOM architecture.**



Objectives

- **The objective of this activity is the development of a 'CAN solution' to be used in platform and payload avionics of telecom satellites.**

- **A 'CAN Solution' for satcom satellites is defined as:**
  - **detailed definition of physical layer characterization, redundancy management, fault tolerance**
  - **detailed definition of a standard CAN protocol layer**
  - **definition of test practices and related GSE/test environment**
  - **definition of a set of 'known good' practices for AIT/V**

- **The activity also includes:**
  - **development of a breadboard system fully representative of the electrical architecture proposed for CAN, with RS-485 and ISO transceivers, representative redundancy, data traffic, noise and faults injection capability. This breadboard system will allow to pre-qualify the CAN solution proposed.**

Industrial Team

- **Partnership between 3 Thales Alenia Space entities :**
  - **TAS Italy Turin : Study leader, CAN specialist, involved in related ECSS working group.**
    - **Currently implementing CAN on ExoMars project.**
    - **To upgrade ExoMars IP core taking into account Telecom needs.**
    - **To define Validation Plan.**
    - **To perform Integration and Validation.**
  - **TAS France Cannes (Telecom) : Telecom integrator, Geostationary platform avionics.**
    - **To provide Return from experience from previous platforms (Spacebus 4000, Alphabus),**
    - **To specify system Requirements.**
  - **TAS Italy Rome (Telecom) : Telecom integrator.**
    - **To support Validation Testing.**

System requirements and Avionics architecture for Telecom spacecraft

SB4000 Data Bus Architecture

- **Current Spacebus 4000 Telecom Platform avionics makes extensive use of Digital Data Bus.**
- **2 standards are currently used on SB4000 :**
  - **OBDH-485 :**
    - **OBDH is well adapted to spatial requirements, but poorly known outside Europe.**
    - **RS-485 allows removal of coupling transformer, replaced by differential interface.**
    - **SMU V1 computer provides 6 electrical buses, therefore theoretical capacity to connect 180 RT.**
      - **On Board Software is designed to handle 100 payload units at most.**
  - **Mil-std-1553B :**
    - **Not especially devoted to spatial, well known from manufacturers worldwide.**
    - **Protocol is significantly more complex than OBDH.**
  - **In both cases, bus is deterministic : exchanges are managed by a Bus Controller (BC). Subscribers (Remote Terminal = RT) are passive.**

SB4000 Data Bus Architecture

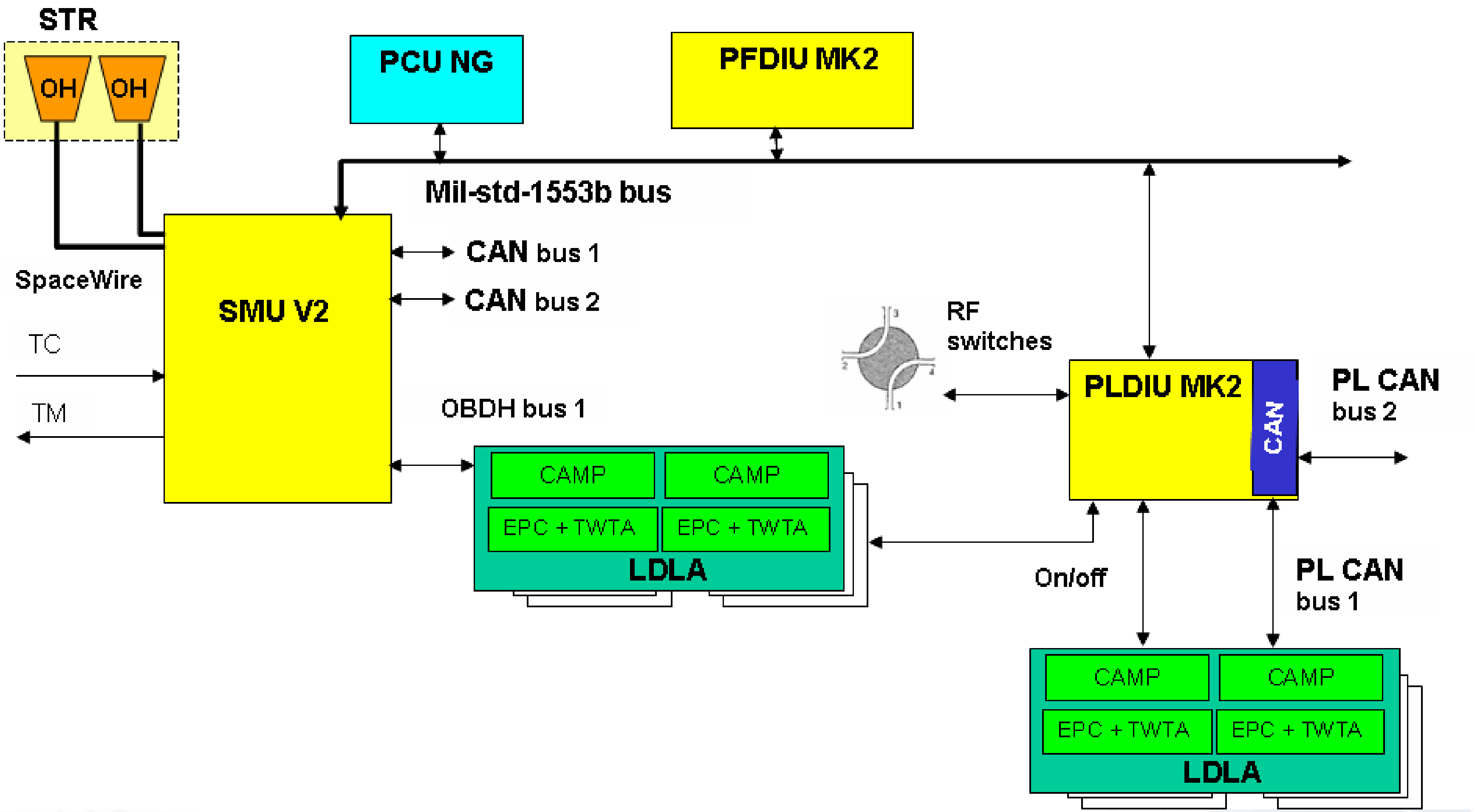
- **Although satisfactory flying (more than 20 spacecrafts), this architecture suffers well known drawbacks :**
  - **OBDH RS485 is a TAS specific data bus, adapted from elder ESA OBDH Standard. An open data bus standard should be preferred, to take obviously advantage of industrial standardization : available IPs, Test equipment, product lines multi-compatible with different platforms.**
  - **OBDH RS485 RT components (hybrids) will face obsolescence; their recurring cost remains significant.**
  - **RS485 drivers (DS16F95…) fan out limit to 32 RT connected to one bus section.**
    - **A Telecom S/C may embed up to 100 payload units, therefore requiring to split the bus into distinct physical sub-sections, handled by the same controller.**
  - **Master / Slave communication principle constraints ground testing : requires to have a Bus Controller (On Board Computer or mockup) to get data from S/C units.**

Transition to CAN

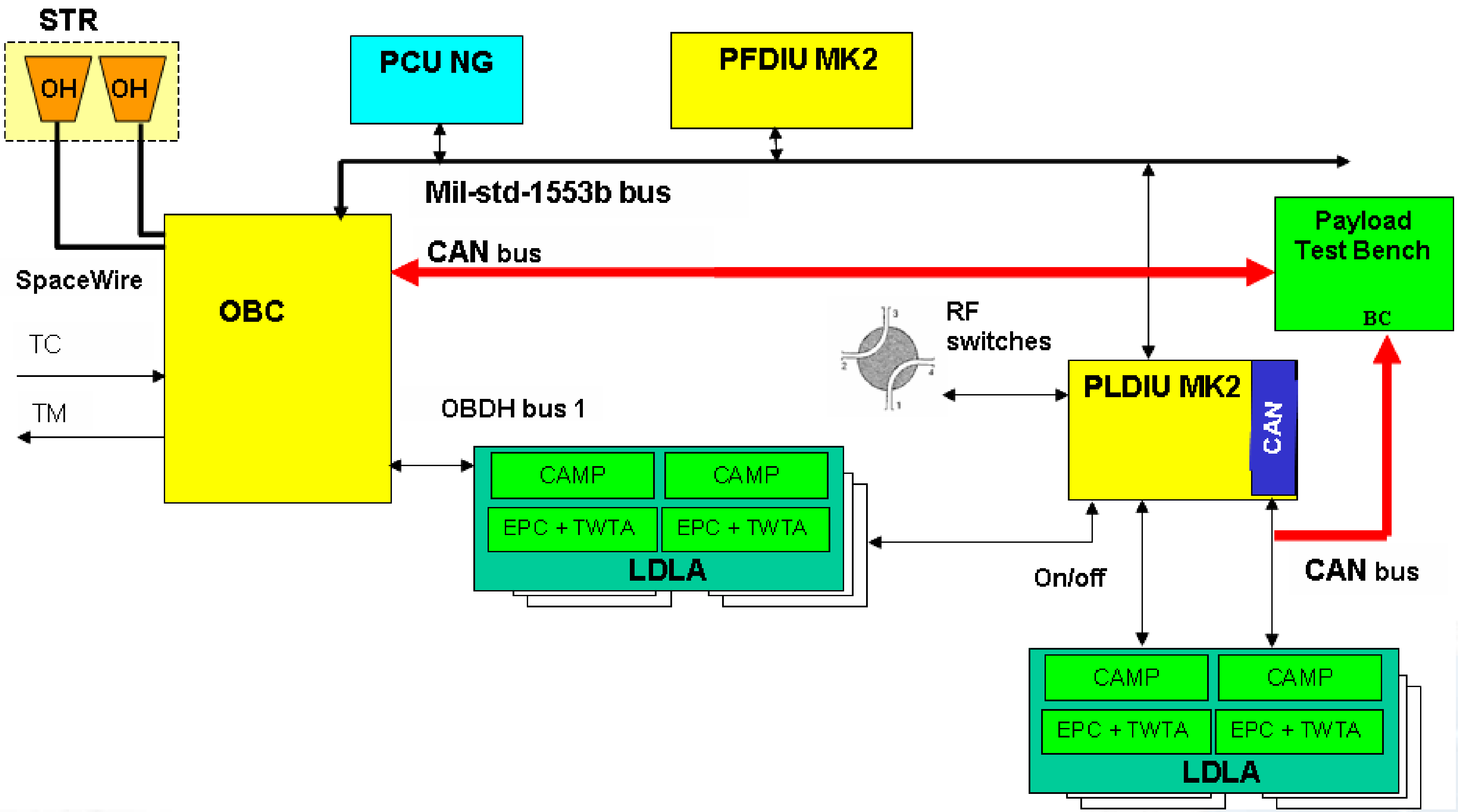
- In search for a new Data Bus standard for Telecom spacecrafts, CAN appears as a very relevant candidate :
  - Well known in industrial world, many components, test tools available.
  - Performance : data rate, length… well suited to spacecraft bus requirements.
  - Communication protocol more advanced than OBDH, but light enough to be implemented into a programmable component, ASIC or FPGA.
  - Multi master capability offers interesting opportunities for Payload ground testing.

- In order to adapt to the different missions configurations, CAN implementation shall be robust to topology variations : number of units, harness length…
  - Without requiring re-qualification (BER…) needs for each spacecraft.

Telecom S/C Avionics architecture using CAN



Spacecraft AIT improvement



AIT Testing improvement :

- Using the multi-master capability of CAN allows an efficient solution: AIT Test Bench can be connected directly on the operational data bus, as a bus master, and perform by itself data acquisition from payload units, in particular high rate acquisitions.
  - Test bench is high priority BC CAN in order to test one RF equipment connected to CAN Bus at high speed.
  - PLDIU is low priority BC CAN in order to acquire and command all RF equipment connected to CAN Bus, for Command / Control handled by OBC.
  - All RF Equipment connected to CAN Bus are RT.
- The SMU shall also be connected to the AIT Test Bench via its own CAN bus interface, in order to send data from units not available from the payload CAN bus:
  - Units directly handled by the PLDIU through discrete signals : typically RF switches.
  - Previous generation units connected to the OBC by OBDH bus.
  - …
- This principle is first foreseen for Payload units testing, as, due to the high number of such units, any optimization appears as strategic.
- When CAN Platform units become available, this can be directly transposed to PlatForm and PFDIU.

CAN Building Blocks for Telecom Spacecraft

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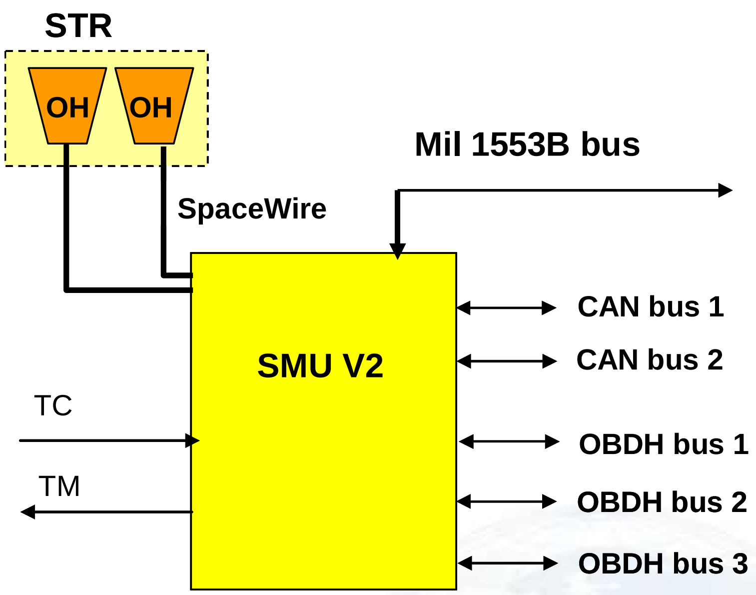
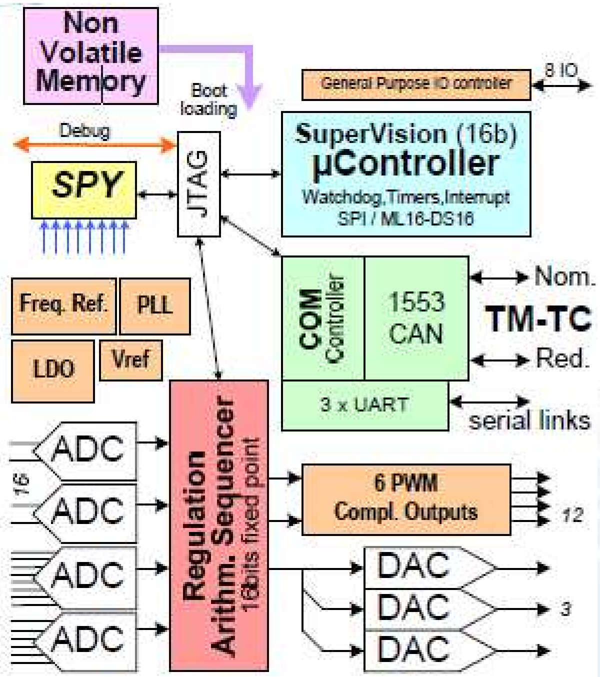
Building Block 1 : SMU V2 On Board Computer

- **A first step, for embedding CAN, assumes using a more advanced On Board Computer (OBC) embedding CAN interface.**
  - **SMUV2, based on LEON3FT processor IP, embeds 2 x CAN controllers based upon CAN_OC core, which is a Philips SJA1000 compatible CAN core with a AHB slave backend.**
  - **Note that this controller does not embed DMA feature, which limits the maximum throughput.**
  - **Only the data link layer is implemented in this controller, which means that the On Board SoftWare shall implement the application layer.**



Building Block 2 : Distribution & Interface Unit Mk2

- **An alternative is to embed CAN controllers into Platform / Payload Distribution and Interface Units (PFDIU / PLDIU).**
  - **While current units have limited processing capability, next generation ones (Mark 2) are foreseen to make extensive use of DPC mixed ASIC embedding µ-controllers, which easily allows embedding CAN bus controller capacity.**
  - **Availability of this interface naturally led to the choice of CAN as PFDIU & PLDIU units backplane data bus.**

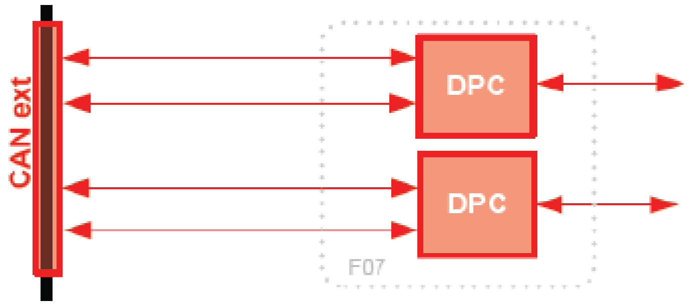


Building Block 2 : Distribution & Interface Unit Mk2

- **PLDIU Mk2 will embed an external CAN bus interface in order to manage 4 bus of up to 100 subscribers each.**

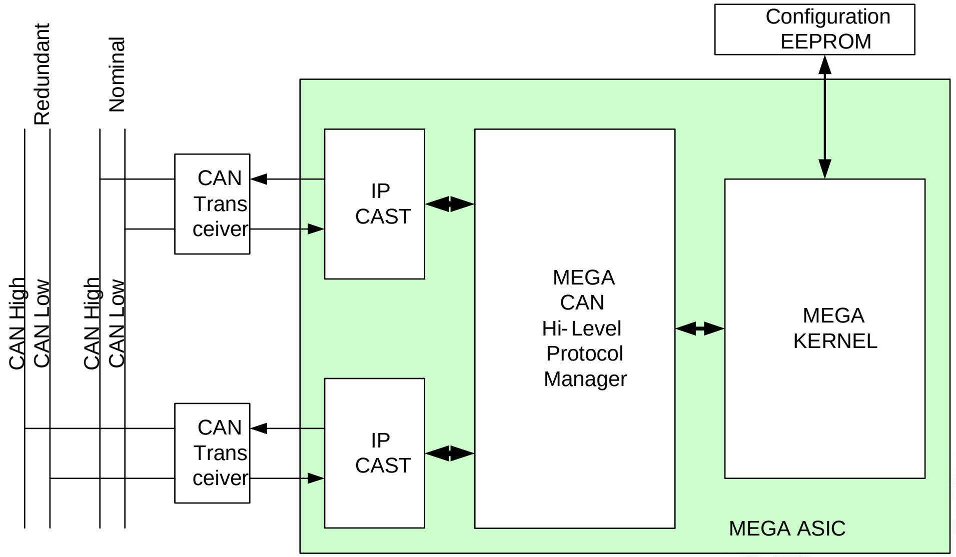
- **On each PLDIU main interface board ("STUB" module), 2 x DPC ASIC will interface each 2 CAN external Buses.**
  - **Redundancy is achieved by implementing nominal and redundant STUB modules.**
  - **X-strap is performed at subscriber level.**

- **This interface is able to manage acquisition of each RT connected to the CAN bus at 32 sec, manage one TC each 2 sec and have a capacity to make acquisition at 1 sec of one RT.**



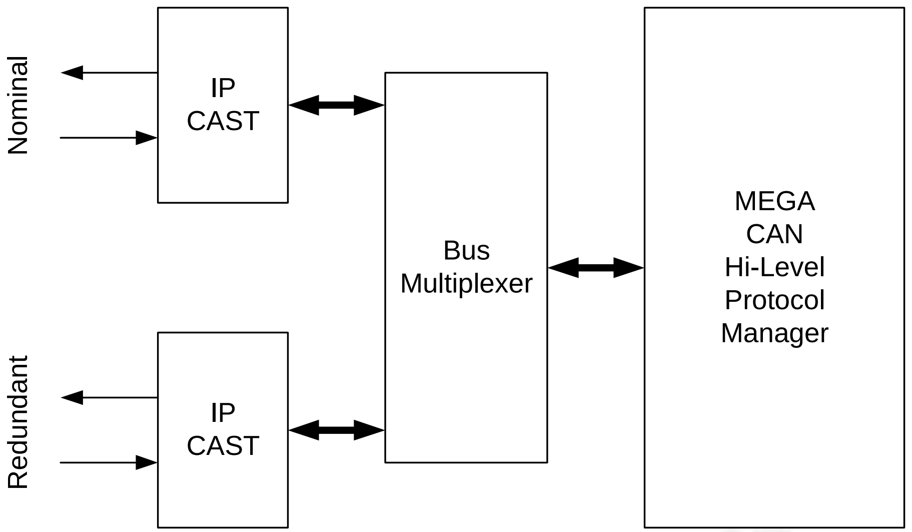
Building Block 3 : MEGA ASIC

- **During the MEGA ASIC development for Hyper frequency products line, decision was taken to include CAN Bus communication standard.**
- **The final TAS choice of the CAST IP allows to manage both CAN versions:**
  - **Standard Format - CAN 2.0A - 11 bits identifier**
  - **Extended Format - CAN 2.0B - 29 bits identifier**
  - **The application layer has been added between the IP and the existing MEGA Kernel in order to adapt the CAN protocol to the internal MEGA protocol without impact on the existing VDHL code.**



Building Block 3 : MEGA ASIC

- **MEGA selects the active CAN Bus in dynamic mode, under a valid frame detection criteria (even if the frame is not addressed to MEGA) and remains on this bus until a valid frame is detected on the other bus.**
- **No Time-out automatic switch mode is implemented.**



- **MEGA design implements a CAN node with the following characteristics :**
  - **The node address can be configured from 1 to 7 bits**
  - **The position of the node address on the BaseID or ExtendedID field can be configured on EEPROM**
  - **The Function field (Command code) can be configured from 4 to 7 bits**
  - **The position of the Function field on the BaseID or ExtendedID field can be configured on EEPROM**
  - **A second “Logical” Address (different form the physical one) can be configured on MEGA to identify Broadcast on Network management commands**

CAN bus for Telecom Avionics : Conclusion

- **CAN appears as the best candidate for replacement of obsolescent standards, for at least 2 scopes of application :**
  - **Payload data bus**
  - **Backplane data bus for Complex Interface Unit**
- **TAS is pushing forward development of 3 major Building Blocks allowing deployment of CAN onto Telecom Spacecrafts :**
  - **SMU V2 On Board Computer**
  - **PFDIU and PLDIU Mk2, embedding DPC µ-controller**
  - **MEGA ASIC for integration into Hyper frequency products**
- **CAB-COM study allows opportunity to converge towards a standard of CAN application for Telecom Spacecraft, allowing easy components connexion and interchangeability.**

Thank You for your Attention !!