DEFENCE AND SPACE

CAN in Space, a little history

Can In Space Workshop 2017
Mola di Bari, Italia

Olivier Notebaert

14th June 2017

AIRBUS

CAN in Space, a little history

I. Prehistorical age	*During these ancient times, electronic was based on analogical signals, there was no data buses nor networks and communications were carried on discrete lines…*
II. Birth and growth	*and Bosch created the CAN bus, and He could see that It was all good…*
III. Revolution	*About abolition of slavery and promotion of Democracy…*
IV. Going to Space	*and the Magic bus learned how to fly…*

DEFENCE AND SPACE

I - Prehistorical age

During these ancient times, electronic was based on analogical signals…

CAN in Space, a little history

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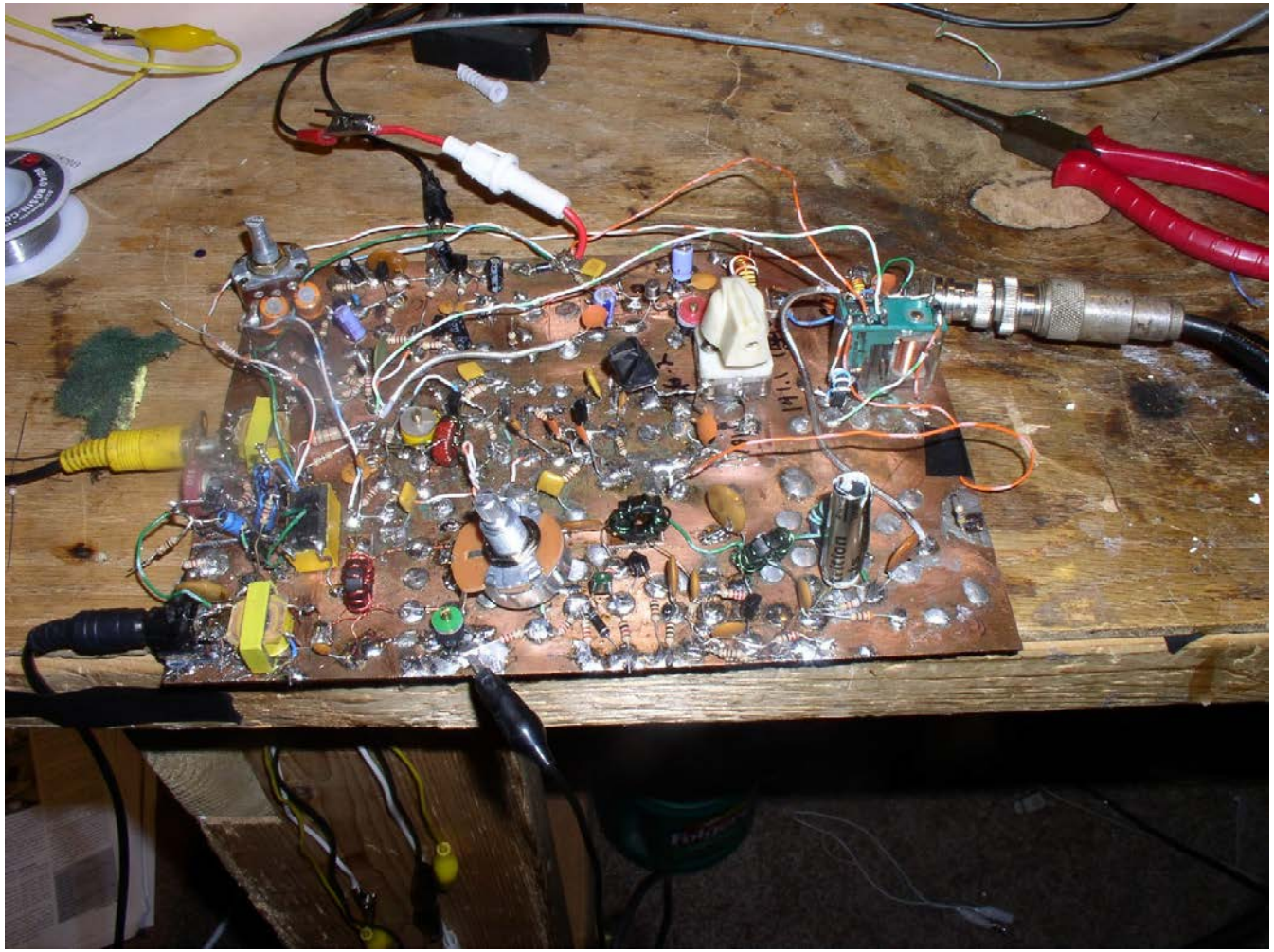
I - Prehistorical age

During these good old time, electronic was based on analogical signals…

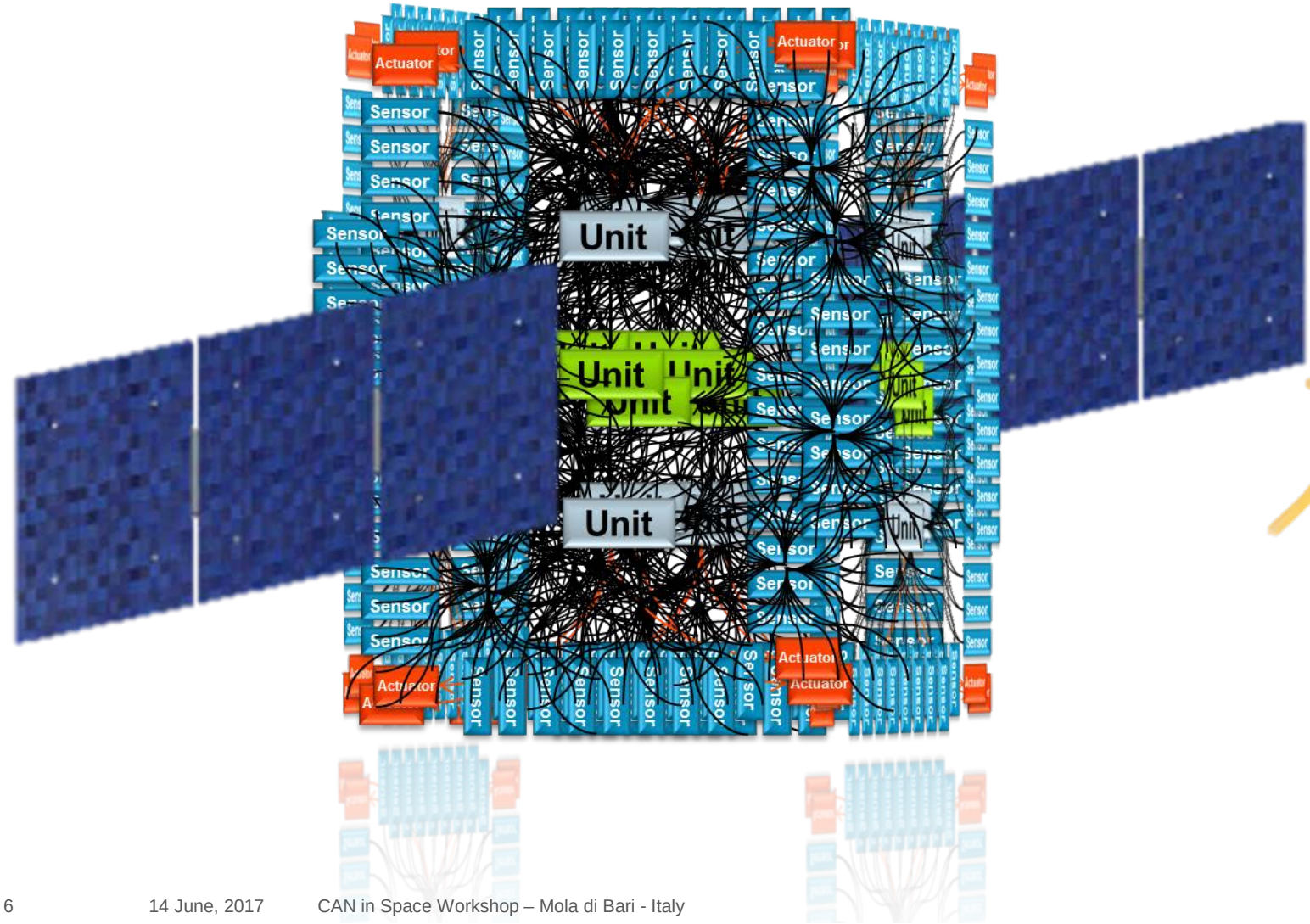


I - Prehistorical age

there was no data buses nor networks and communications were carried on discrete lines…

I - Prehistorical age

Spacecraft data handling architecture



DEFENCE AND SPACE

II - Birth and growth

and Bosch created the CAN bus,
and Bosch could see that it was good

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II - Birth and growth

and Bosch created the CAN bus, and Bosch could see that it was good

Karlsruher Institut für Technologie

BOSCH

INTERNATIONAL STANDARD

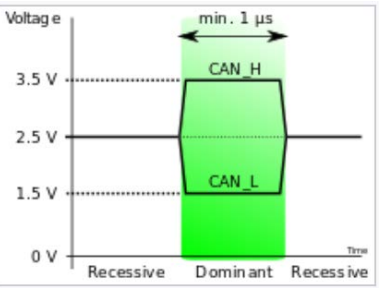
ISO 11898-2

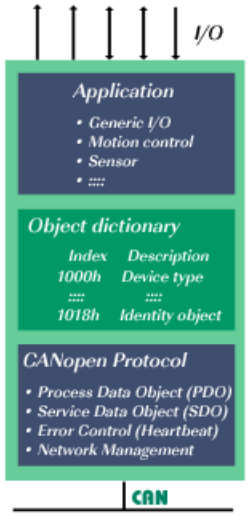
Road vehicles -- Controller area network (CAN)
– Part 2: High-speed medium access unit

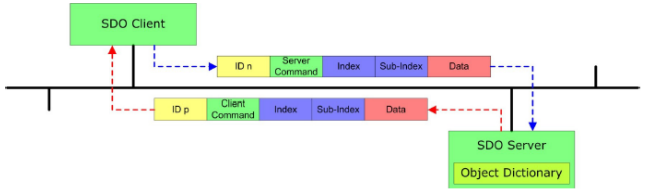
Electronics and cars

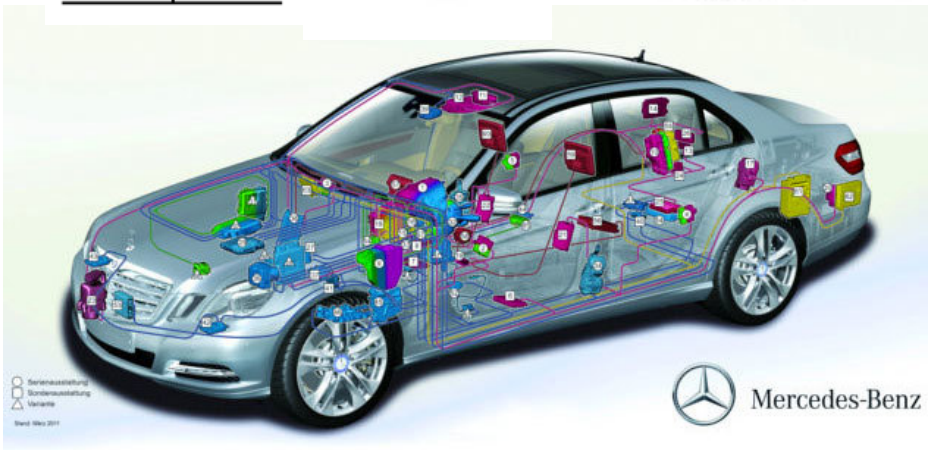
ISO

© ISO









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Billions of CAN devices !

Space

Aeronautics

IoT

Maritime transport

communications

Public ground transports

robotics

Medical

BOSCH

Automotive

Labs

ISO Standards

Consumer electronics

KIT Karlsruher Institut für Technologie

SAE Standard

1983

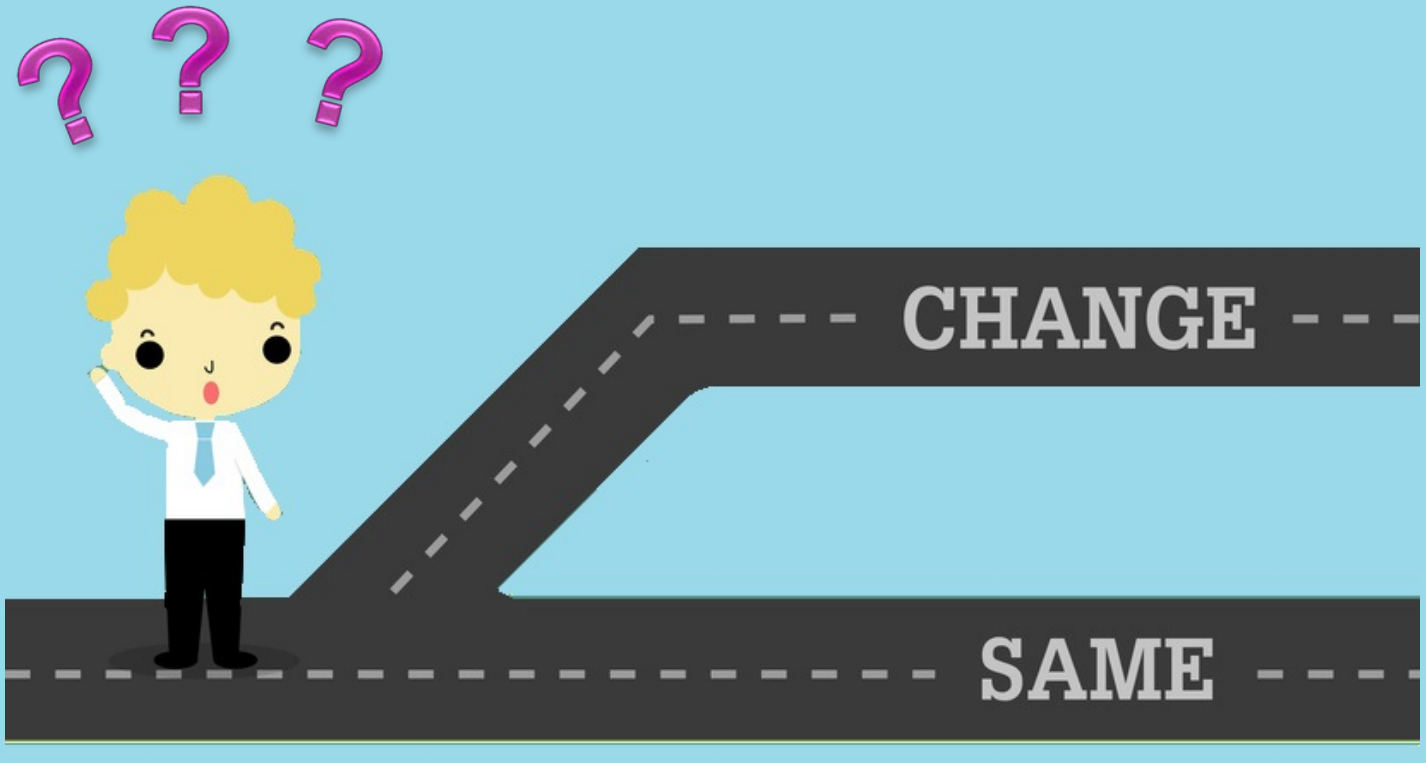
1986

1993

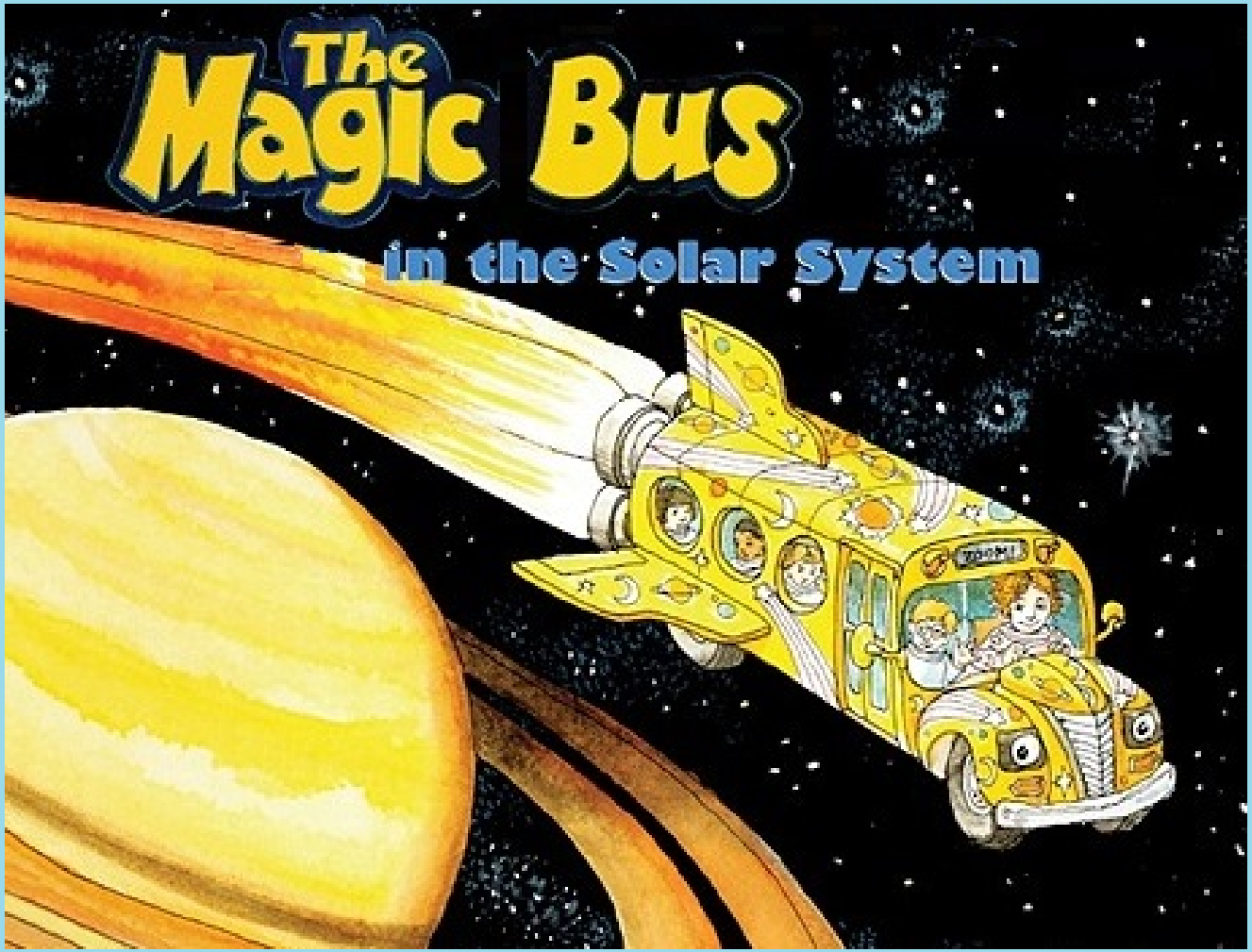
1995

Factory automation

Meanwhile in the Space industry



Meanwhile in the Space industry: Data Buses



CAN bus on Smart-1

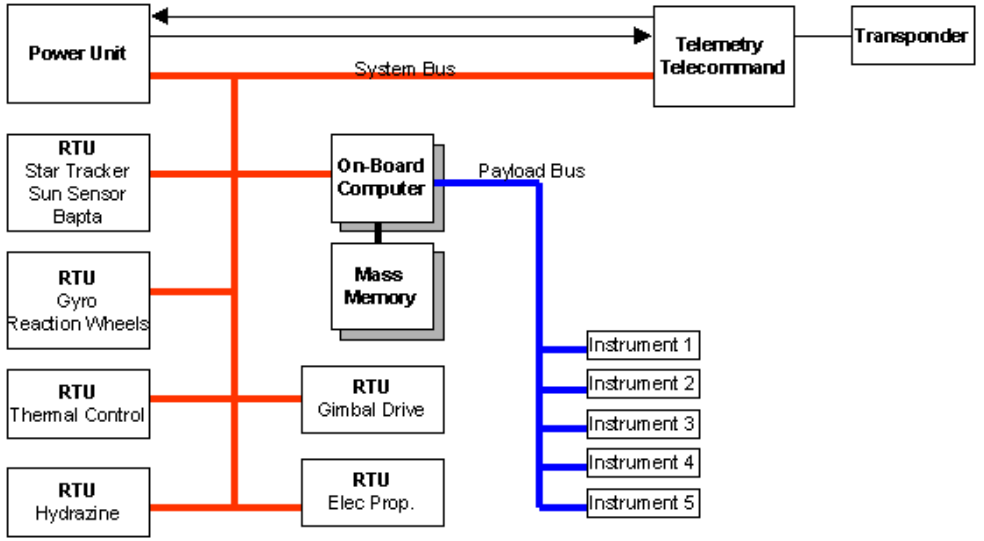
a mission to the Moon with a small spacecraft featuring CAN bus and CANopen

Very successful ESA mission with the Swedish Space Corporation

- CAN bus over RS-485
- CANopen based
- System and Payload bus

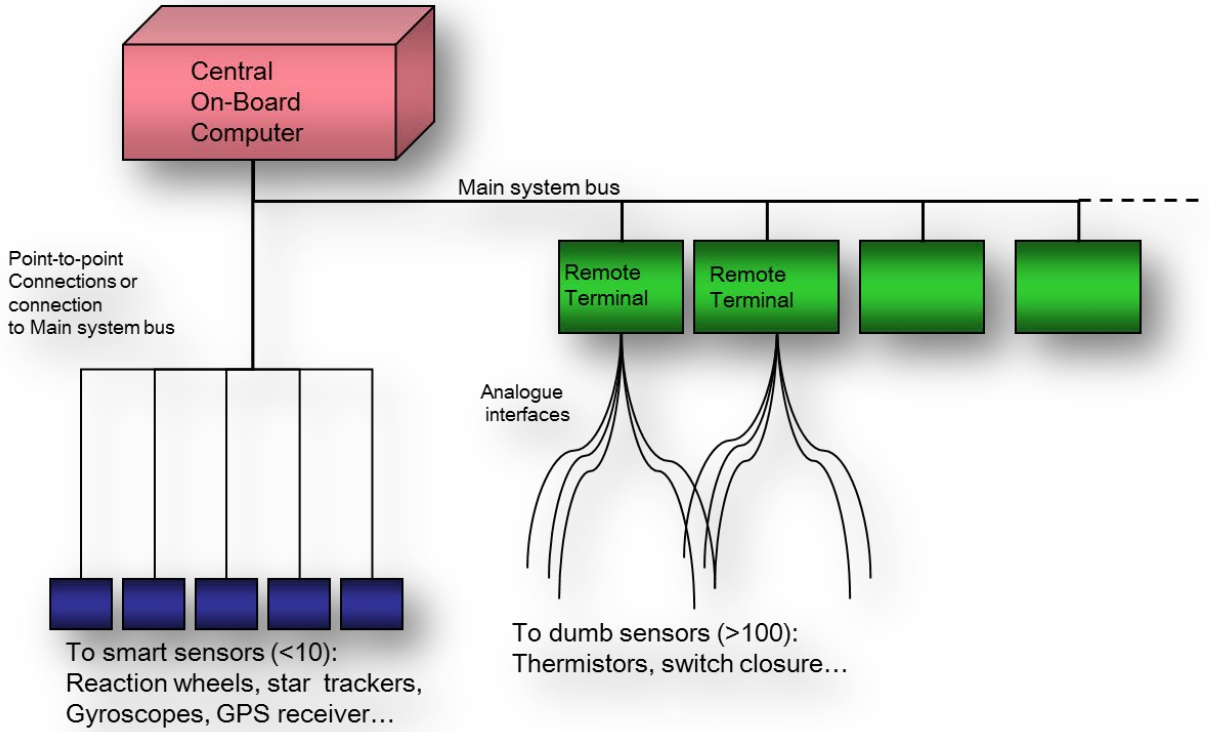
► **Good feedback w.r.t. CAN bus and CANopen**

- Motivation and reference for ECSS std.



Mil-Std-1553B

- Master/Slave Protocol
- Bounded topology (1 Controller, 31 remote terminals)
- Bounded memory exchange (32 sub addresses)
- Redundancy and bus management functions



1553 bus used on most spacecraft

- As system bus on Launchers Ariane 5 and Vega
- as system bus on many spacecraft platforms
- As Payload/instrument command and control bus

OBDH or CAN bus also used on few spacecraft

► Does not really solve the issue

DEFENCE AND SPACE

III - Revolution

About abolition of slavery and promotion of Democracy…

CAN in Space, a little history

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Mil-Std-1553B

- Master/Slave Protocol
- Bounded topology (1 Controller, 31 remote terminals)
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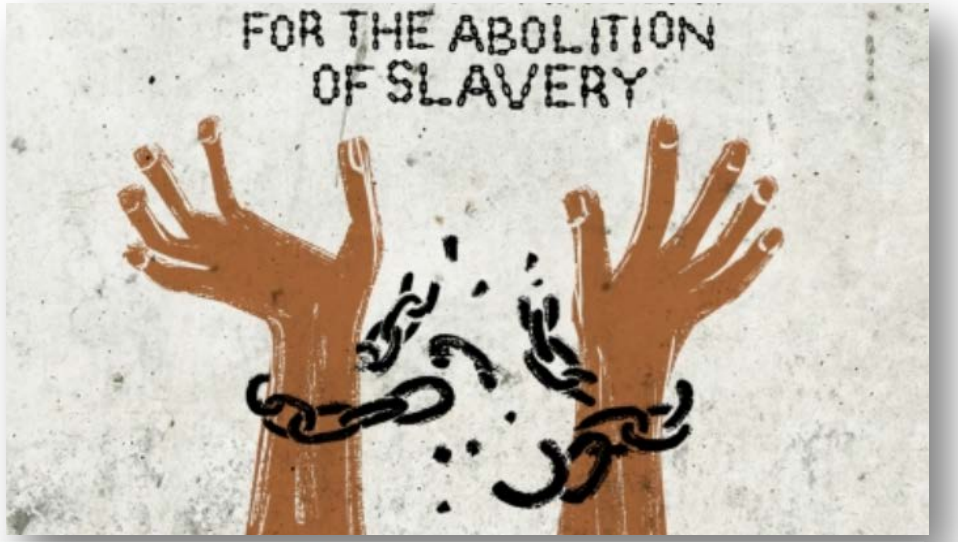
► **Deterministic**



OPEN

Mil-Std-1553B

- Master/Slave Protocol
- Bounded topology (1 Controller, 31 remote terminals)
- Bounded memory exchange (32 sub-addresses)
- Redundancy and bus management functions

► **Deterministic**

- Multi-Master Protocol
- Allows large topologies
- Flexibility

► Democratic !

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ECSS CAN bus working group

First round (~2002 - 2004)

- **Low adherence to ECSS process**
  - CANopen fans
    - techno push approach
    - good level of creativity
    - proposing for the replacement of 1553B by CANopen for platform control
  - Industry representation
    - Conservative for 1553 (just becoming a product) and pushing for its standardisation in ECSS
    - A bit dubious about CANopen
    - no industrial use case except ExoMars

→ Standard remained a draft document

CAN bus flight heritage

Ten years ago

esa

Flight Heritage Summary

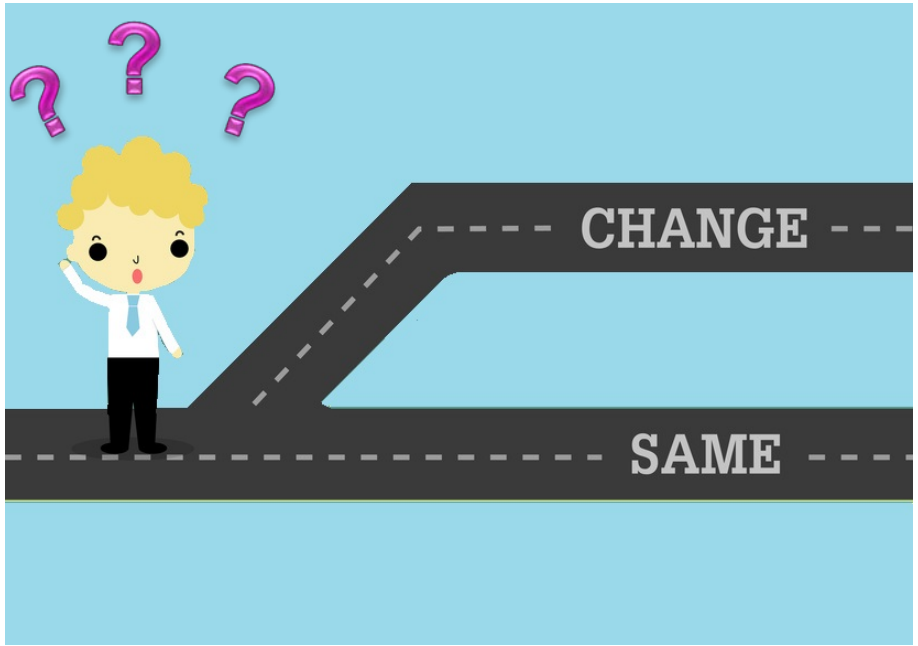
- **SMART-1 (Earth to moon transfer with Electric Propulsion)**
  - Controller: Bosch IP in Actel FPGA
  - Transceiver: Modified RS-485
  - No Galvanic Isolation Needed
  - HLP: Custom
  - Redundancy: 2x cold own dvp.
- **ATV (LEO)**
  - Controller: CASA2
  - Transceiver: Modified RS-485
  - Optocouplers Agilent HCPL 6231
  - HLP: Custom
  - Redundancy: 4x cold own dvp.
- **MATROSHKA (ISS - LEO)**
  - Controller: CASA2
  - Transceiver: Modified RS-485
  - Optocouplers
  - HLP: Custom
  - Redundancy: 2x hot own dvp.
- **GIOVE-A (Galileo, MEO)**
  - Controller: CASA2
  - Transceiver: Philips TJA1050
  - No Galvanic Isolation Needed
  - HLP: Custom
  - Redundancy: ?
- **SSTL LEO Satellites**
  - Controller: Several commercial devices
  - Transceiver: Philips TJA1050, 82C251
  - No Galvanic Isolation known
  - HLP: Custom
  - Redundancy: 2x single controller

D/TEC-EDD

21/35 Monday, 12 June 2007

esa ESTEC

Francisco Tortosa Lopez



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DEFENCE AND SPACE

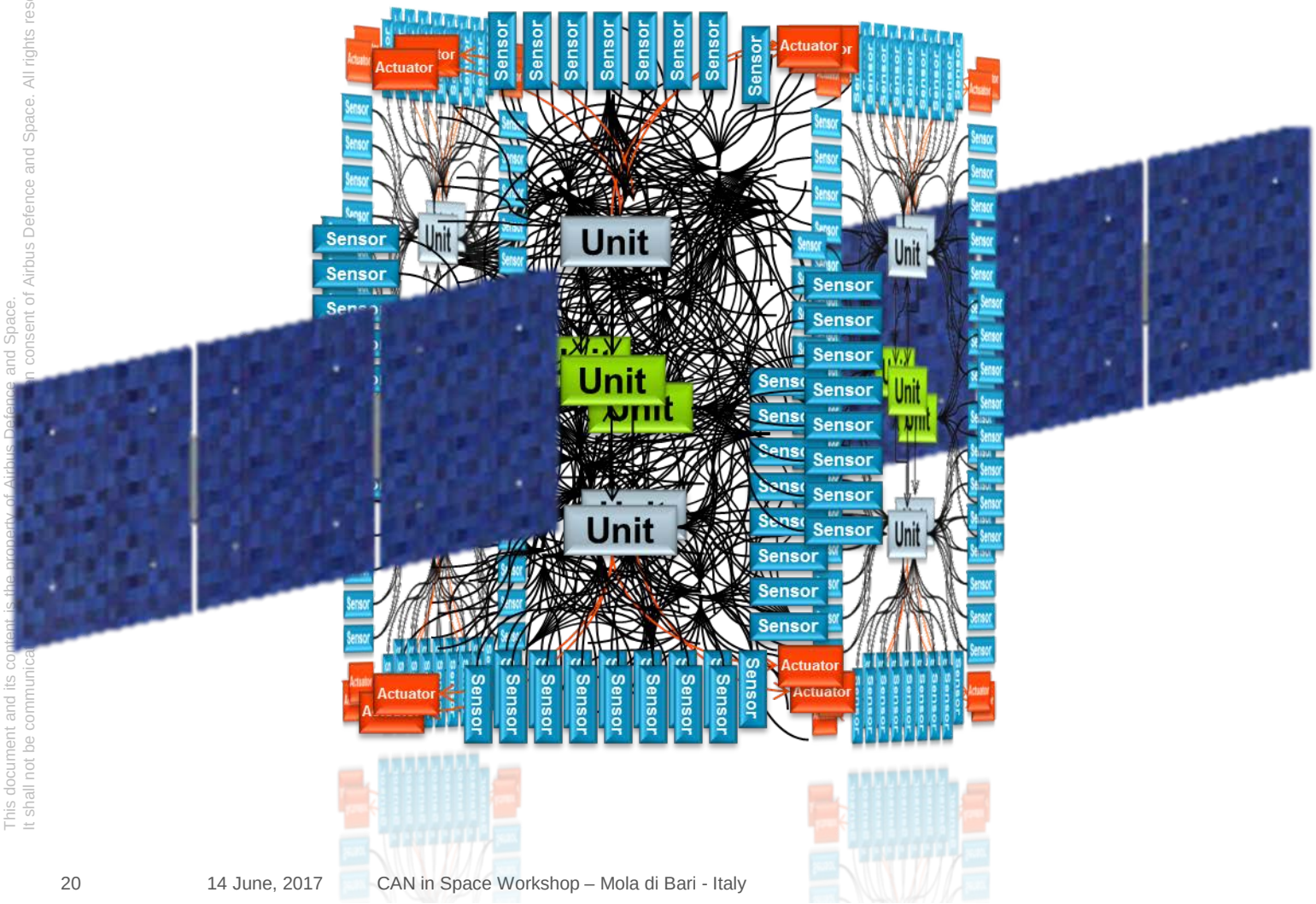
IV - Going to Space

and the Magic bus learned how to fly…

CAN in Space, a little history

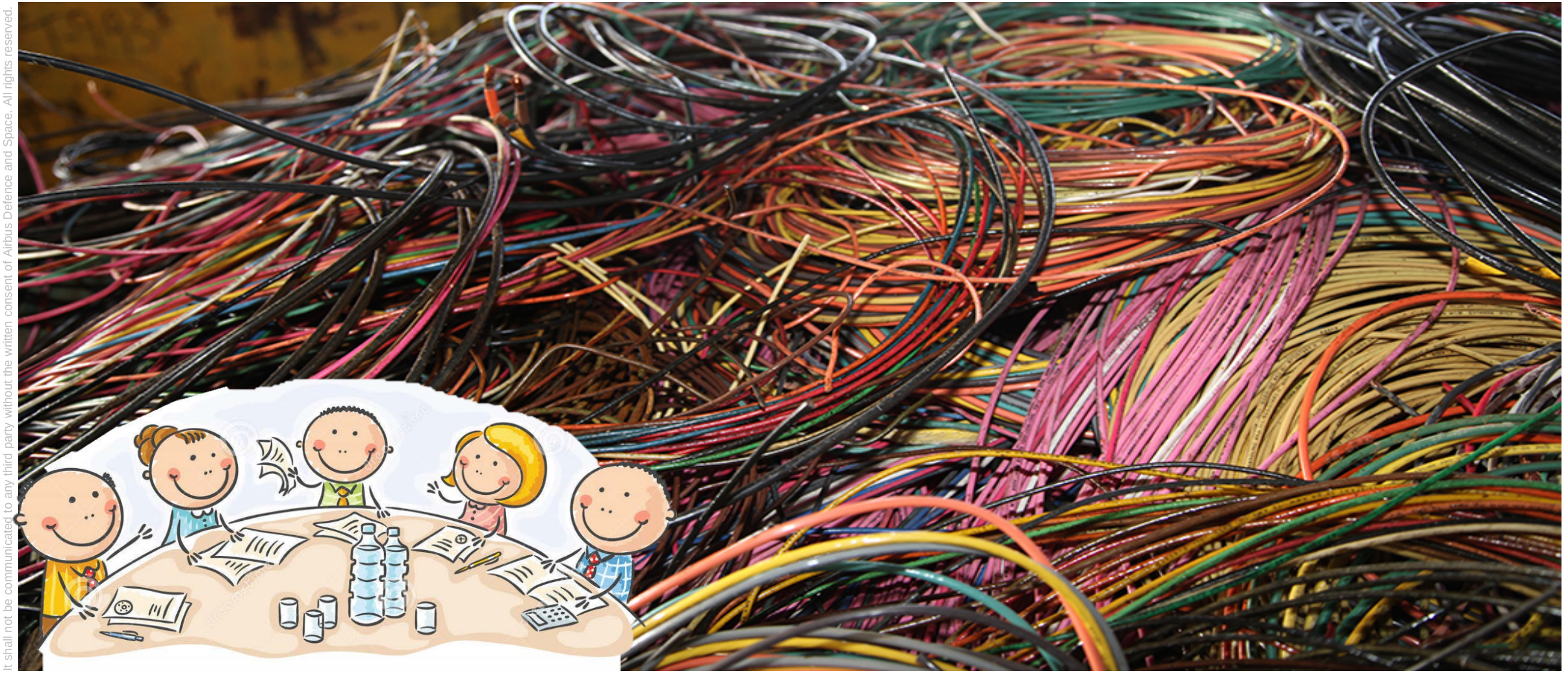
IV - Going to Space

Spacecraft data handling architecture – a main system bus does not solve fully solve the cables issue



Round-Table and workshop on sensor busses

May and October 2003 in ESTEC



Round-Table and workshop on sensor busses

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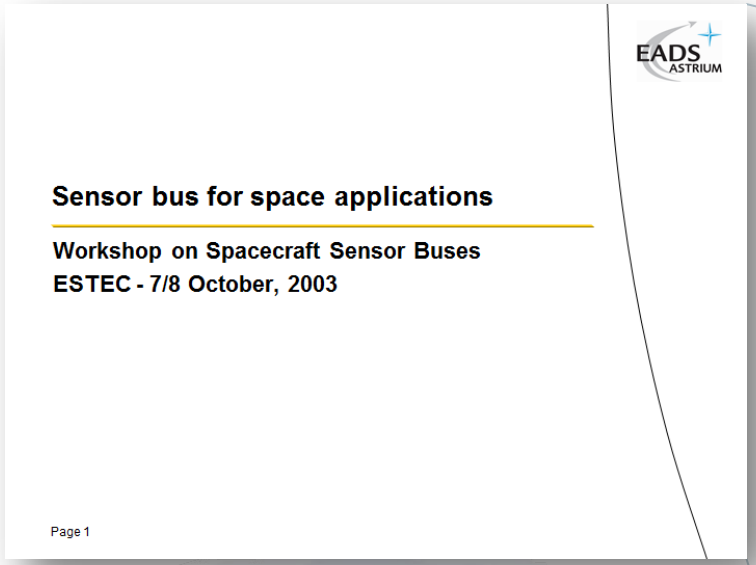


Sensor busses on future spacecraft… Some expectations (1/2):

EADS ASTRIUM

- Sensor bus system would decrease harness and central control equipments complexity and weight
  - Bus topology is simpler than star or web architecture
  - Controller I/F limited to bus management (versus a number of I/O Hardware boards)
- Sensor bus system can allow centrally monitored and controlled
  - better system definition / simulation / observability / testability
  - Monitoring & control scheme could be more standardized and reused on different applications / subsystems
  - Could allow system controlled configurability (ranges, control low, monitoring frequencies…)

Round-Table and workshop on sensor busses

May and October 2003 in ESTEC

EADS ASTRIUM

Sensor bus for space applications

Workshop on Spacecraft Sensor Buses
ESTEC - 7/8 October, 2003

Page 1

Sensor busses on future spacecraft…
Some expectations (2/2):

EADS ASTRIUM

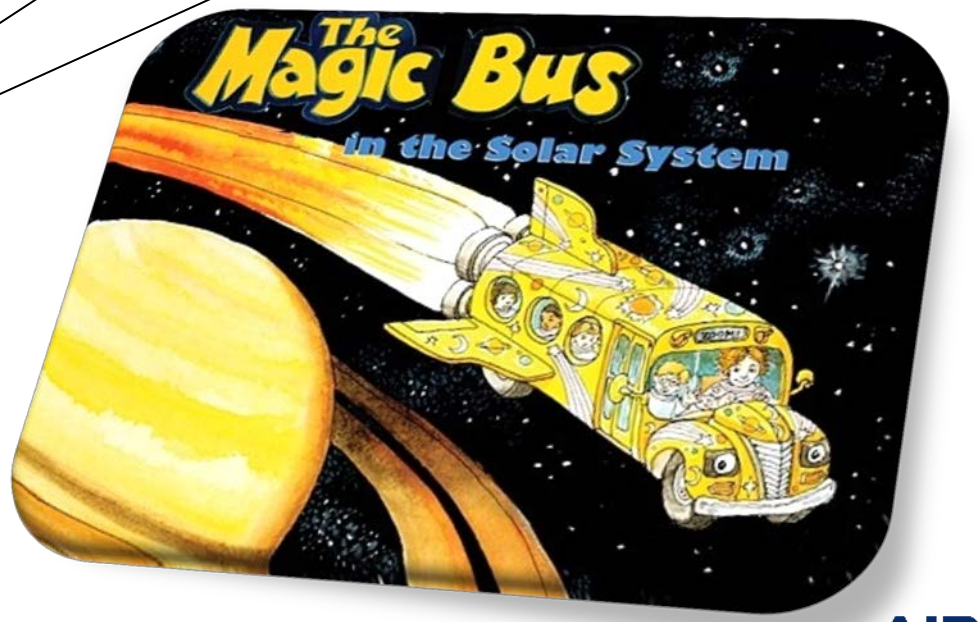
- Standardized I/F modularity will increased reusability and inter-operability
- Existing ground concepts could allow important cost reductions
  - Reuse of standard IP's
  - Test tools available at lower costs
  - Large engineering knowledge
  - Potential usage of widely used civil or military applications products in software and hardware
- Power distribution through data lines
  - Increased harness reduction

Round-Table and workshop on sensor busses

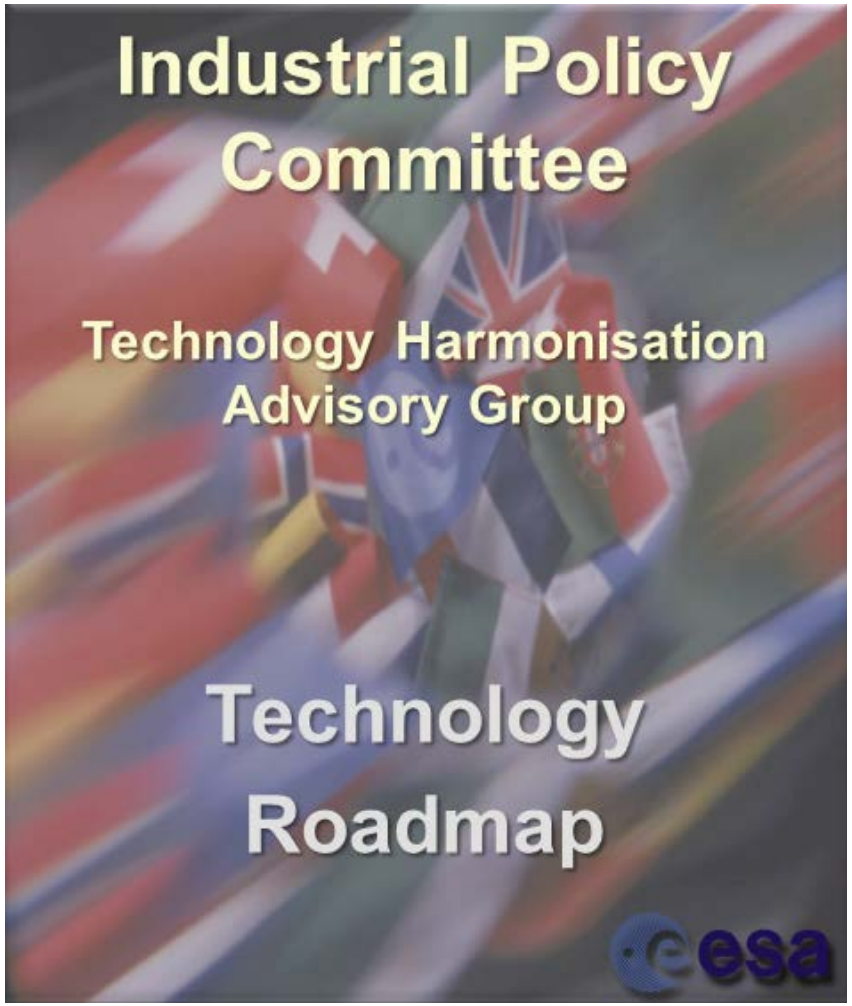
May and October 2003 in ESTEC

analogue data acquisition is the most critical since it reaches as much as 50% of the spacecraft's harness for low speed and slow dynamic acquisitions (e.g. temperature)

a generic solution so called "sensor bus" deserves R&T efforts focused on utilization in space of proven and low cost ground technology



Technology developments

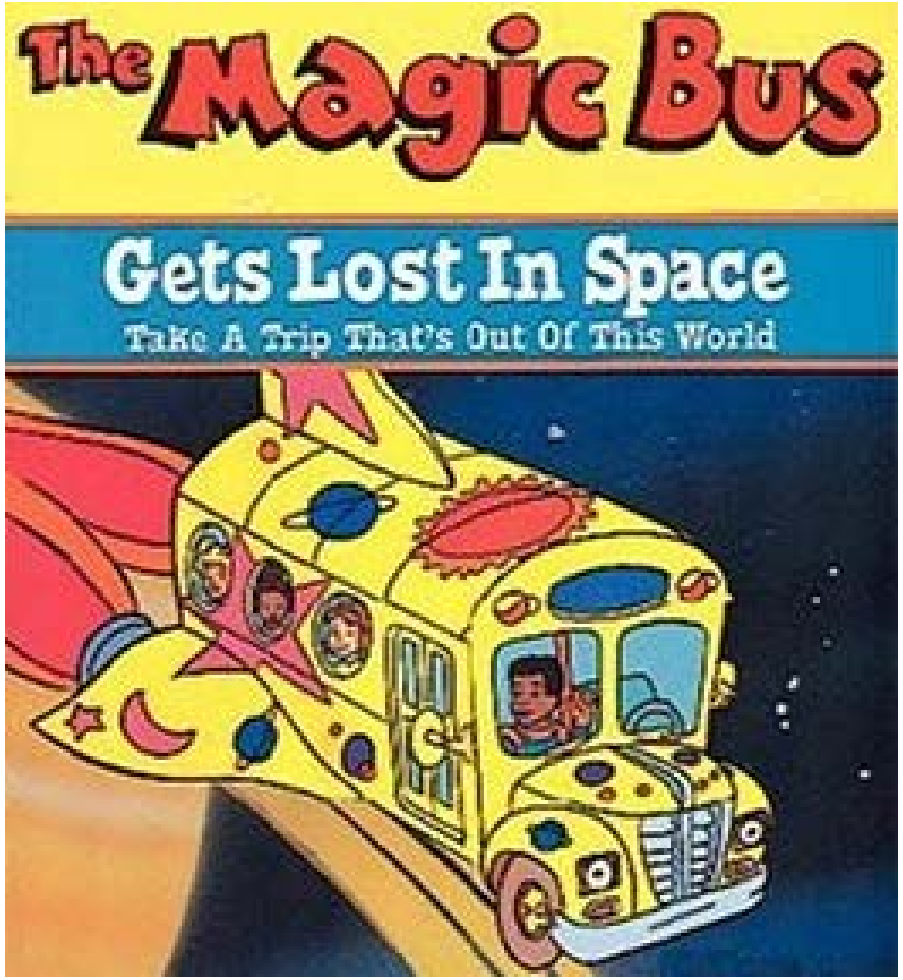


Development of space solutions Sensor buses and Wireless

- TRP: Technology Research Programme
- GSTP: General Support Technology Programme
- ARTES: Advanced Research in Telecommunications Systems

→ Supported by ECSS

Wireless



Demonstration test bed for efficient on board sensor networks

ESA TRP study (2007/2009)

Objective

- technology survey and critical evaluation of commercial serial buses
- define and prototype a solution for sensor networks
- to perform a proof of concept with a resulting demonstrator.
- ESA study with ACRA control and Rovsing in Ireland

Sensor Bus

OneWire
Profibus
CAN Bus
I^2C
LIN
Powerlines
Wireless
…

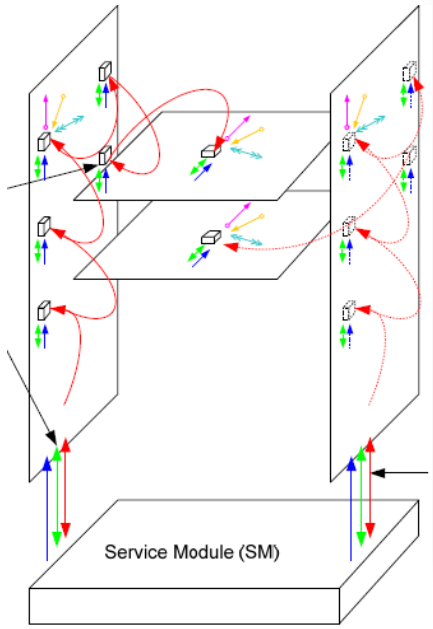
Review of TM/TC System architecture

ESA ARTES study (2009/2013)

Objective

- Improvement of TM/TC architecture for Satcom (Eurostar 3000)
- Sensor Bus Trade off to replace the LSSB (Low Speed Serial Bus)
  → CAN bus selected
- Demonstrator
- Development roadmap

→ Paved the way to introduce the CAN Bus in
  – E3000 product line
  – NeoSat
  – And follow ons…



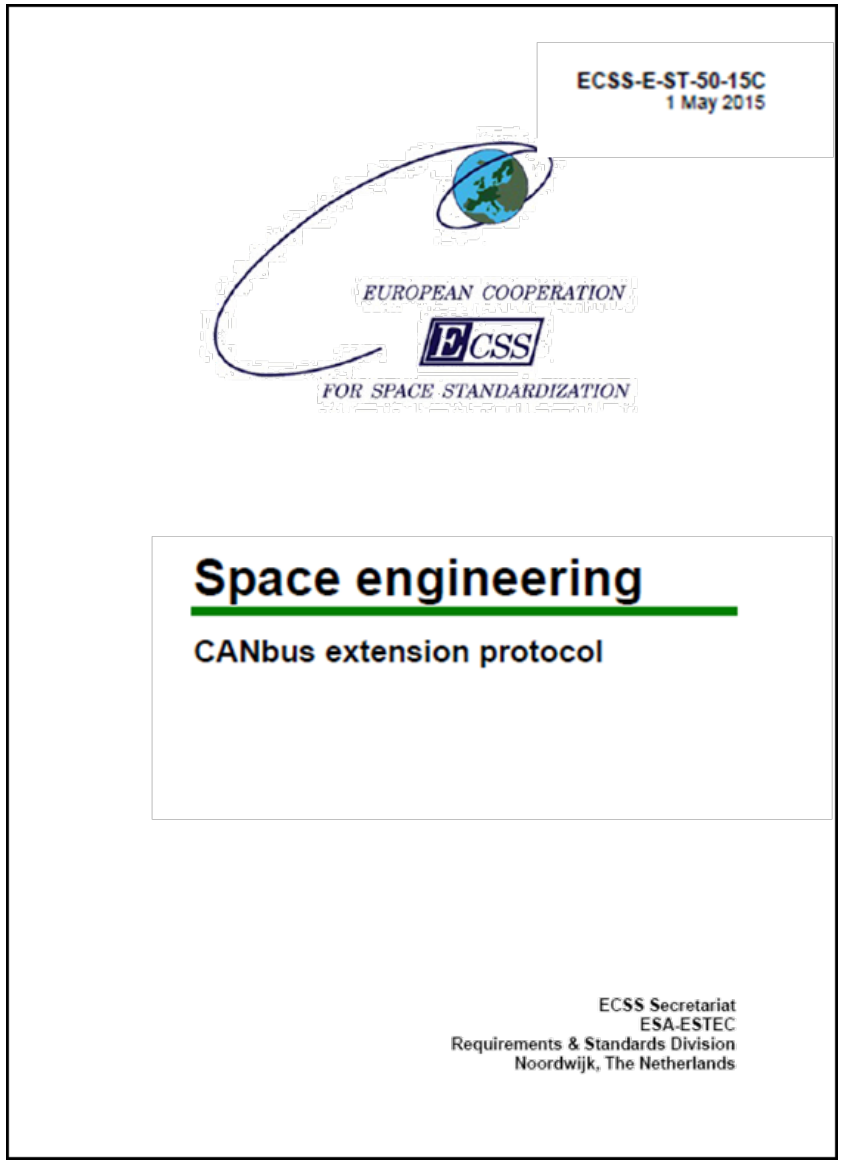
	LSSB	CAN
Type	Synchronous	Asynchronous
Wires	5 pairs	1 pair
Bandwidth	16 Kbit/s	1Mbit/s
Error control	1parity bit	▪ CRC 15 bits ▪ Monitoring of the emission ▪ Check of the frame structure ▪ Check of stuffing ▪ Error frame
Addressing scheme	1 msg → 1 receiver	▪ Priority system ▪ Multicast possible

ECSS CAN bus working group

Second round (2008-2015)

- **Adherence to ECSS process**
- **Equilibrate membership**
  - Agency
  - Primes
  - technology and equipment suppliers
- **Background**
  - Preparatory studies
    - TRP, GSTP, ARTES
  - Industrial use cases
    - ExoMars and robotics
    - Telecom Payload → E3000 and NeoSat

► ECSS standard published in May 2015 !



As a summary

Now CAN bus in Space is

- An ECSS standardized reference data link
- Used on various missions
- with an increasing devices catalogue
- with more return on experience
- and in NG SatComs product lines
- …

► And much more to be discussed at this workshop !

Thank you for your attention