Earth Observation, Navigation and Science

Modular Payload Computer Concept applied to on-orbit space debris detection

HJ Herpel, et.al.

OBC-SA On-Orbit Processing of Reflected GNSS Signals for Maritime Target Detection

A. Helm, et. al

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Requirements

Design space exploration

Solution

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Requirements

Achim

Requirements

Design space exploration

Solution

Juergen

AIRBUS

User requirements mapped to HW/SW requirements

Use Case 1: Space Debris Detection

- **Functional blocks**
  - Camera
  - Communication Module (COMM)
  - Processing Module (CPM)
  - Storage Module (SBMM)
  - Downlink Module (DLM)
  - Power Supply (DC/DC)
- Image size: 2k x 2k x 14bit
  - Memory req. 60 MBit
- Frames per second: 0.67 Hz
  - Data rate: 43 Mbit/s
  - Processing time: 1.5 sec (Segmentation, ..)
- **Matlab Model: 12sec**

Use Case 2: Maritim Target Detect.

- **Functional blocks**
  - Antenna Array
  - RF Frontend
  - GNSS Receiver (GNSS)
  - Communication Module (COMM)
  - Processing Module (CPM)
  - Storage Module (SBMM)
  - Downlink Module (DLM)
  - Power Supply (DC/DC)
- „Image size“: 64 x 256 x 16bit * 12
  - Memory req. : 6 Mbit x n (n = 1 …600)
- Frames per sec. 10Hz
  - Data rate: 60 Mbit/s
  - Processing time:: < 10sec
- **Matlab Model: TBD sec**

Common functional blocks

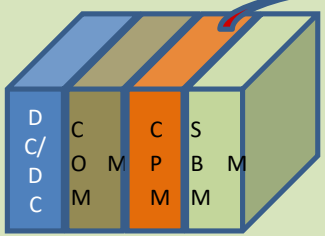
Design space exploration

HW Architecture	Dedicated Box	Modular			
Standards	--	SpaceVPX	cPCI SerialSpace	TCA	
Implementation	Software	Mixed	Hardware		
Proc. Unit.	CPU MC GPU	Soc	FPGA	ASIC	
Communication	Dedicated Serial Links	SpW	SpF	Ethernet	
In orbit algo. Replacement	Memory patch	Time and Space Separation			
OS Aspects	RTOS	Separation Kernel			
OS	RTEMS	VxWorks	VxWorks653	PikeOS	xTratum	AIR
SW Architecture	Single process	App oriented	Learning		

Criteria:

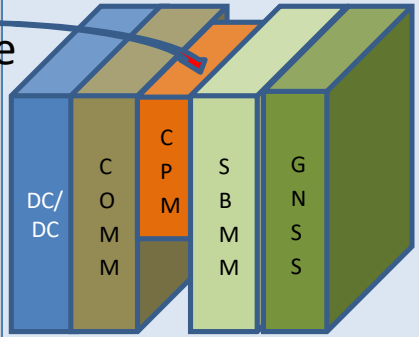
- **Optimized wrt. techn. solution**
- Reuse
- Risk reduction
- Availability
- Experience/ Background

Use Case 1: Space Debris Detection



Reuse

Use Case 2: Maritime Target. Detect.



Design space exploration

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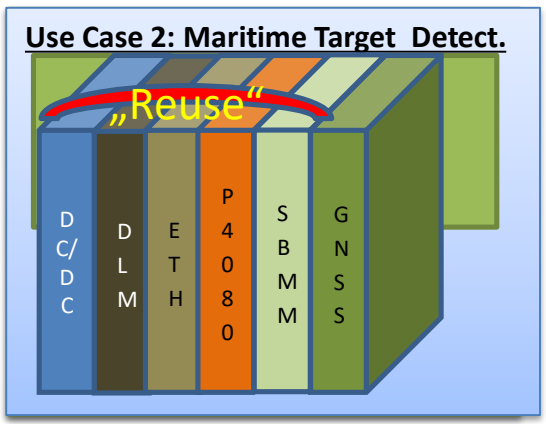
SW Architecture	Single process	App oriented	Learning		

Criteria:

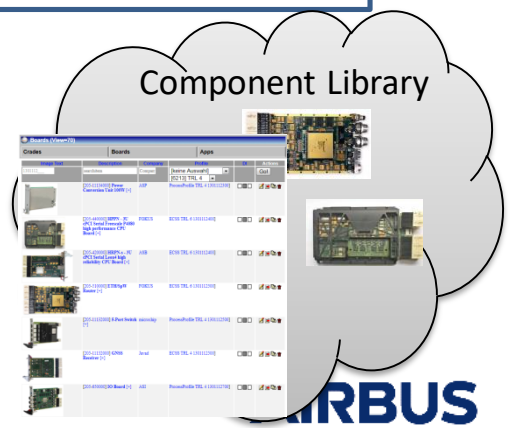
- **Cost**
- **Scalability / Modularity**
- Flexibility
- Commonality with COTS
- Availability
- Experience/ Background

Use Case 2: Maritime Target Detect.

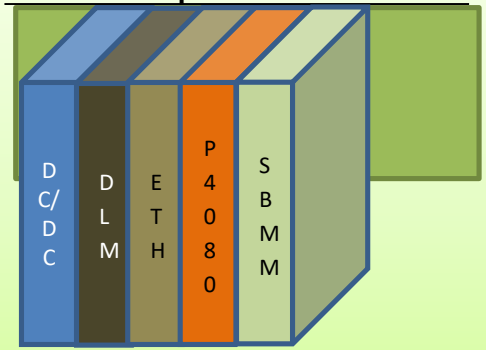


PICMG

Compact PCI Serial Space

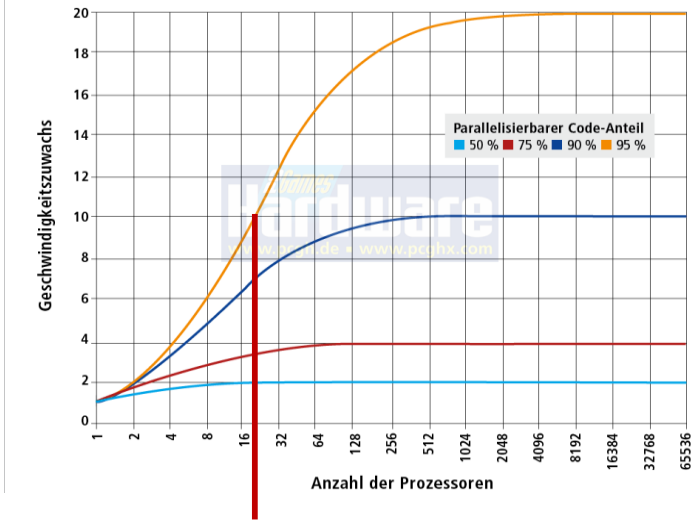


Use Case 1: Space Debris Detection



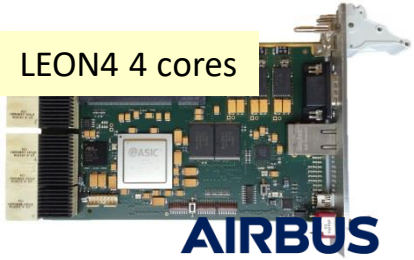
From **12sec** to **1.5 sec**, i.e. speedup of 10

Amdahls Law



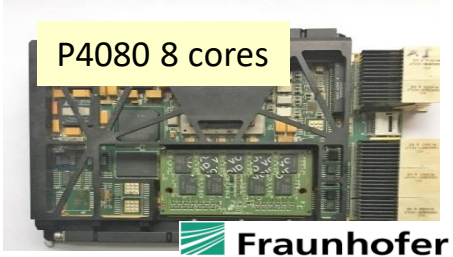
20 cores!

LEON4 4 cores



AIRBUS

P4080 8 cores



Fraunhofer FOKUS

RTG4

Fraunhofer FOKUS

From Serial to parallel code …

Matlab Model

↓

Generate C Code
emmtrix Code Gen. (eCG)

↓

„Serial“ Code

↓

Optimizing Serial Code

↓

Optimzed „Serial“ Code

↓

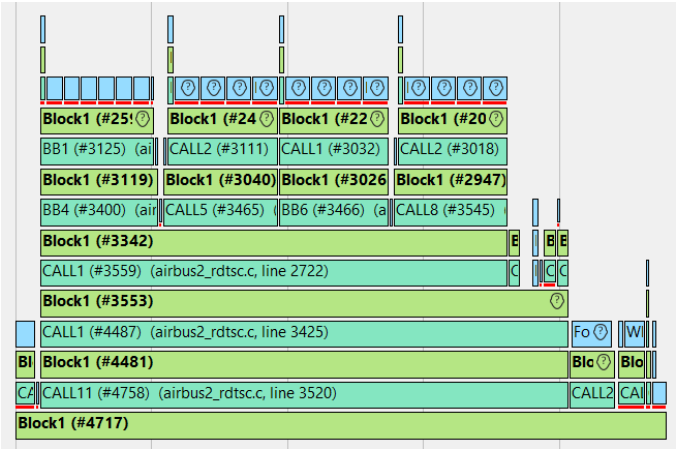
Parallelise Code
emmtrix Parallel Studio (ePS)

↓

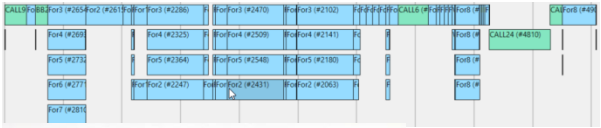
Optimzed „Serial“ Code

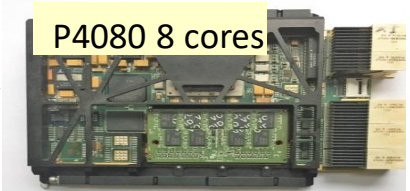
→

Hierarchical Task Graph



Parallel Schedule





Use Case 1: Space Debris Detec.

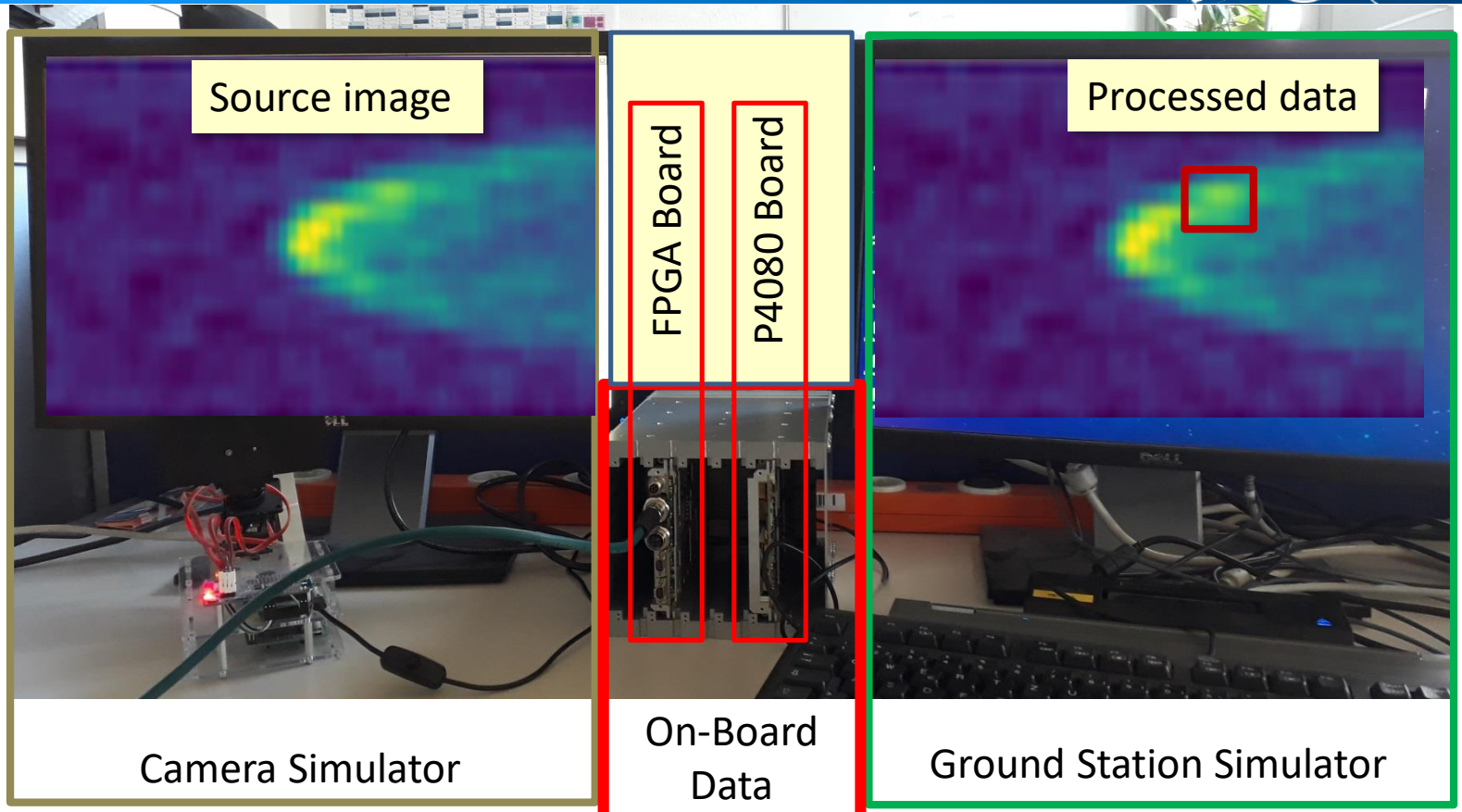
12 sec

10 sec

5 sec

1.5 sec

Test Setup


Source image
FPGA Board
P4080 Board
Processed data
Camera Simulator
On-Board Data Processing Unit
Ground Station Simulator

Modular Payload Data Processing Unit:

- cPCI Serial Space compliant
- Up to 5 slots
- 5 Kg
- Input voltage: 28 VDC
- 20 – 35 W

Thanks for your attention …

Questions? **OR** **Darts?**

Dr. Achim Helm
Airbus Defence and Space GmbH
Claude-Dornier-Str.
88090 Immenstaad
Germany
Phone +49 7545 8 3092
Email: achim.helm@airbus.com

Hans Juergen Herpel
Airbus Defence and Space GmbH
Claude-Dornier-Str.
88090 Immenstaad
Germany
Phone +49 7545 8 2482
Email: hans-juergen.herpel@airbus.com

AIRBUS

P4080 HP-CPM

cPCI Serial Space® compliant High Performance Core Processing Module

- Space-qualifyable single board computer in 3U form factor, CPCI S.1
- CPU: P4080 (NXP, 8x e500mc), 60 GIPS, 12 GFLOPS
- Memory: 2 x 4GB DDR3, EDAC
- Survival Module RT ProASIC®3 (Microsemi) RadHard
- Communication: 2x Gb Ethernet, 2x SpaceWire, 2x PCIe x2, 2x CAN
- Operating System: PikeOS, Linux

FPGA Board

cPCI Serial Space® compliant Rad Hard FPGA board

- Space-qualifyable FPGA board in 3U form factor, CPCI S.1
- Radiation-hard RTG4 FPGA
- Communication: 8x Gb Ethernet, 10x SpaceWire, CAN, I²C, SPI
- 8W power loss, 450 g

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