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
Requirements
Design space exploration
Solution
Achim

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Juergen

Requirements

Design space
exploration

Solution

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 * 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

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<th>Modular</th>
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<td>App oriented Learning</td>
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### Criteria:
- Optimized wrt. techn. solution
- Reuse
- Risk reduction
- Availability
- Experience/ Background

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**Use Case 1: Space Debris Detection**

**Use Case 2: Maritime Target. Detect.**

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**Reuse**
## Design space exploration

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

### Use Case 2: Maritime Target Detect.

**Compact PCI Serial Space**

Component Library

**Reuse**
Challenges

Use Case 1: Space Debris Detection

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

**Amdahl's Law**

20 cores!
From Serial to parallel code ...

**Use Case 1: Space Debris Detection**

- **12 sec**
- **10 sec**
- **5 sec**
- **1.5 sec**

- Matlab Model
  - Generate C Code (emmtrix Code Gen. (eCG))
  - "Serial" Code
  - Optimizing Serial Code
  - Optimized "Serial" Code
  - Parallelise Code (emmtrix Parallel Studio (ePS))
  - Optimized "Serial" Code

- **Parallel Schedule**
- **Hierarchical Task Graph**
Test Setup

- **Camera Simulator**
  - Source image

- **FPGA Board**
  - On-Board Data Processing Unit

- **P4080 Board**

- **Ground Station Simulator**
  - Processed data
Modular Payload Data Processing Unit:
- cPCI Serial Space compliant
- Up to 5 slots
- 5 Kg
- Input voltage: 28 VDC
- 20 – 35 W

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Questions?

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Thanks for your attention ...
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, PC, SPI
- 8W power loss, 450 g