A fault-tolerant AI processor to accelerate onboard computer vision workloads

A key enabler for safety-critical AI functions

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MAGICS

About
Magics Technologies NV

Located in Geel, Belgium, Magics Technologies is a fabless semiconductor supplier focused on creating innovative solutions for the space and nuclear industry.

Magics utilizes a rad-hard-by-design methodology and library to continuously improve its product lines. This approach has resulted in the development of five ITAR-free product lines: Motion, Time, Power, Vision and AI.

The strong growth drivers in Magics' niche markets - communication and real-time imaging in new space and space markets, and obsolete components in the nuclear sensor market - present tremendous opportunities for the company to expand its business.

With the aspiration to become the leading supplier of rad-hard semiconductors for the Energy, Space, and Defense markets, Magics has doubled its staff and revenue almost annually.

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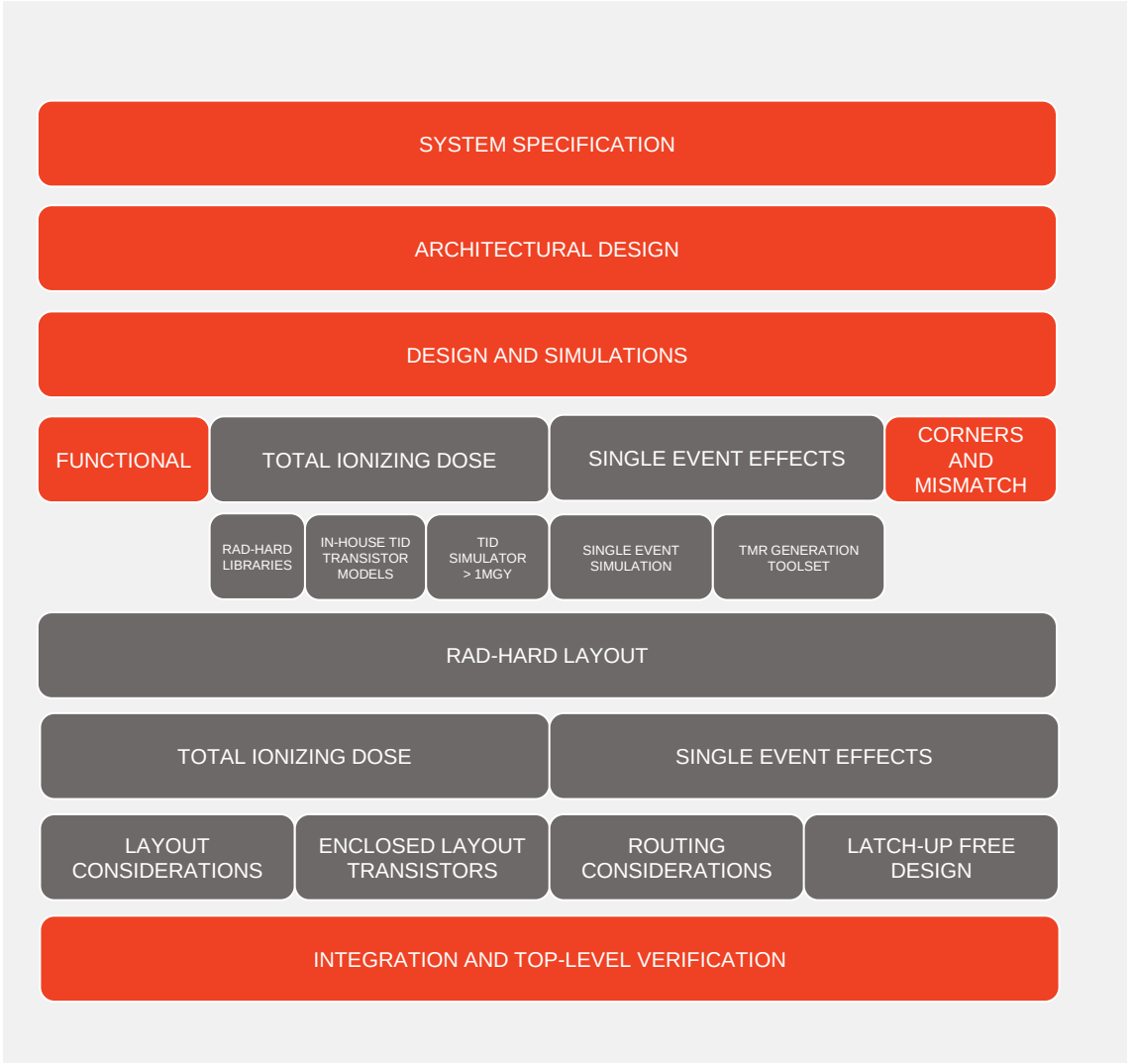
How? Radiation “Hardening” by design

A radiation hardening by design methodology to achieve first-time-right designs and high reliability without physical shielding:

- Industrial standard EDA tools for: model simulation; schematic edit, simulation and layout; digital design and implementation; physical verification and sign-off.
- Experimentally verified transistor radiation model for TID (total-ionizing-dose) simulation.
- In-house proprietary TMR (triple modular redundancy) generator and SET simulator for single-event simulation.
- A wide range of qualified rad-hard analog/mixed-signal IP blocks (e.g., PGA, ADC, PLL, Clock reference, Bandgap, LDO, Temperature sensor, etc.)



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Reliable computer vision is essential when servicing uncooperative targets

- Autonomic capabilities needed for safely operating remote handling systems in space
- For uncooperative targets this will require computer vision or related techniques
- Computer vision algorithms (neural networks) will need to operate reliably in space (edge)
  → AI results will interact with AOCS
- Many algorithmic considerations to be made
  → not the scope of this presentation
- **But also need for a reliable hardware platform**

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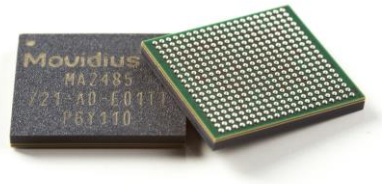
AI processors for space applications – state-of-the-art

- Mostly upscreened COTS that exhibit radiation-tolerance characteristics



Intel Movidius Myriad X VPU

Teledyne e2v QLS1046

OCE Technology HISAOR03A

AMD Xilinx Versal XQRVC1902

power consumption

- Possibility to make use of rad-hard FPGAs
  → at the cost of a lower power efficiency and increased design complexity
- Use of rad-hard CPU or non-AI-optimized DSP
  → only feasible for low-complexity workloads
- **No rad-hard-by-design dedicated high-performance AI accelerator is currently available**

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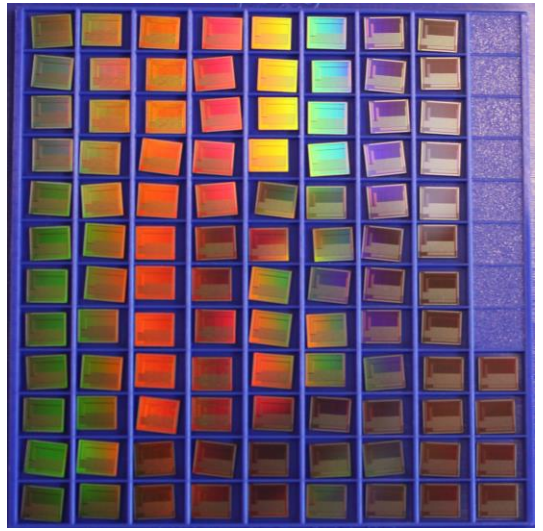
AI series – computer vision AI edge processors

Dedicated to empowering self-contained, autonomous space and defence applications, even in the face of challenging power constraints and/or demanding computational needs

- MAG-AIA00001-IC
  power optimized for battery-powered applications with restrictive power budgets
- MAG-AIA00101-SC – rad-hard by design
  power efficiency optimized for high-performance applications requiring passive thermal control and/or limited power budgets
- MAG-AIA30001
  power-optimized softcore product
- MAG-AIA30101 – rad-hard by design
  power efficiency optimized softcore product



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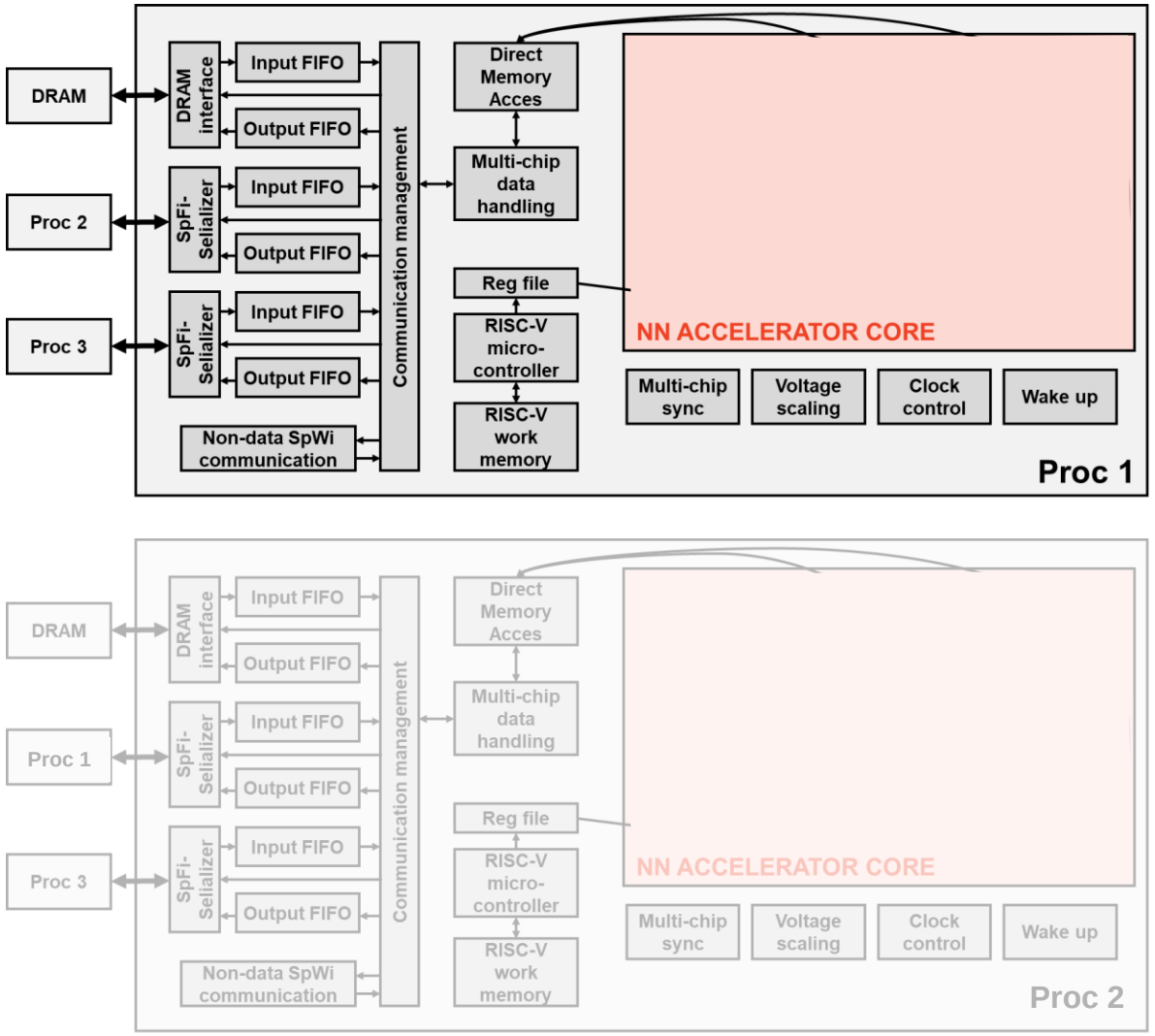
AI series - MAG-AIA00101-SC

- **Up to 10 TMACs/s per die**
- **TID: 120 krad (Si) – SEL: < 90 MeV.cm²/mg**
- **SEU mitigation in hardware**
- Typical active power consumption: 1 W
- Dynamic power scaling: 10 mW – 1 W
- 4 MB L1 weights and activation cache
- Programmable RISC-V microcontroller
- Vector engine to support pre-processing
- Wide range of peripherals for space and defence applications
- Size scalable up to 40 TMACs/s and 16 MB L1 cache @ 4 W



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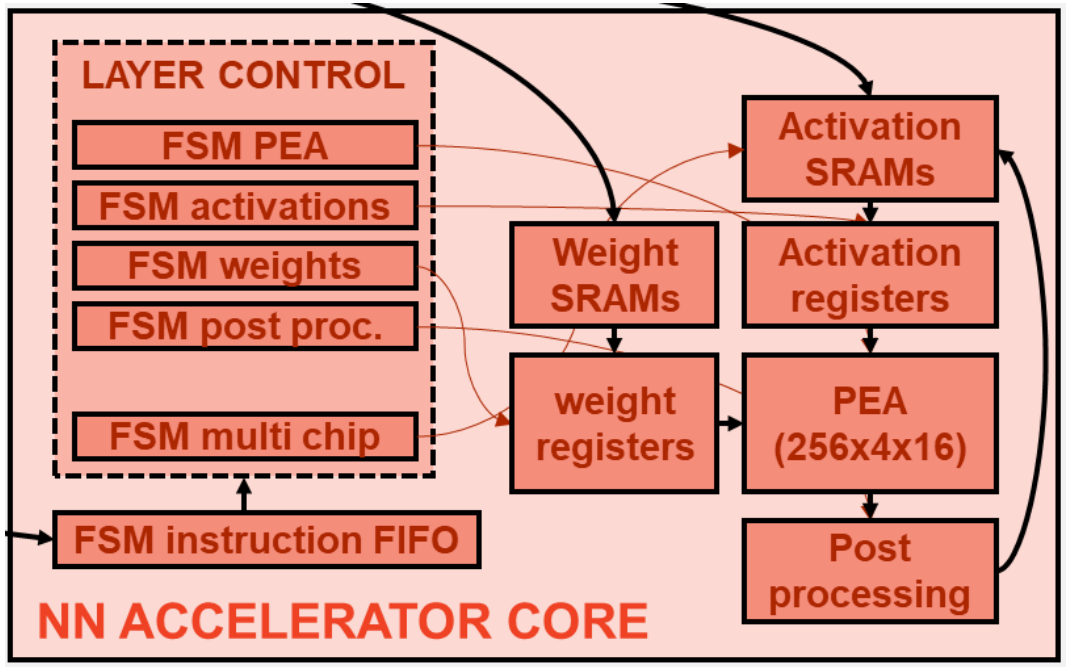
AI series – MAG-AIA00101-SC: accelerator core

- 16384 8-bit MAC units
- Memory configuration
  - 2 MB weight memory
  - 1 MB activation memory
  - 1 MB configurable memory
- Layer support
  - Conv2D / Depthwise-Pointwise convolutions
  - Fully-connected
  - Residual / additive
  - Skip connections
  - Maximum / Average pooling
- Activation functions: Linear, (Leaky ReLU), arbitrary LUT-programmable
- Generic matrix multiplication
- Depth-first scheduling support in hardware



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AI series – MAG-AIA00101-SC: RISC-V frontend

- Open-source ISA and open-source implementations
- **No external export restrictions in force**
  → sovereign use in European strategic domains such as space
- Open-source implementation has been radiation-hardened by Magics
  - 64-bit processor
  - Linux and RTOS capable
  - Own memory subsystem with ECC
- Vector engine co-processor implemented for generic pre-processing

"The movement is not happening because some benchmark ran 10% faster, or some implementation was 30% lower power with 20% smaller area."

"The movement is happening because **new business model** changes everything"

- Pick ISA first, then pick vendor or build own core
- Add your own extension **without getting permission**

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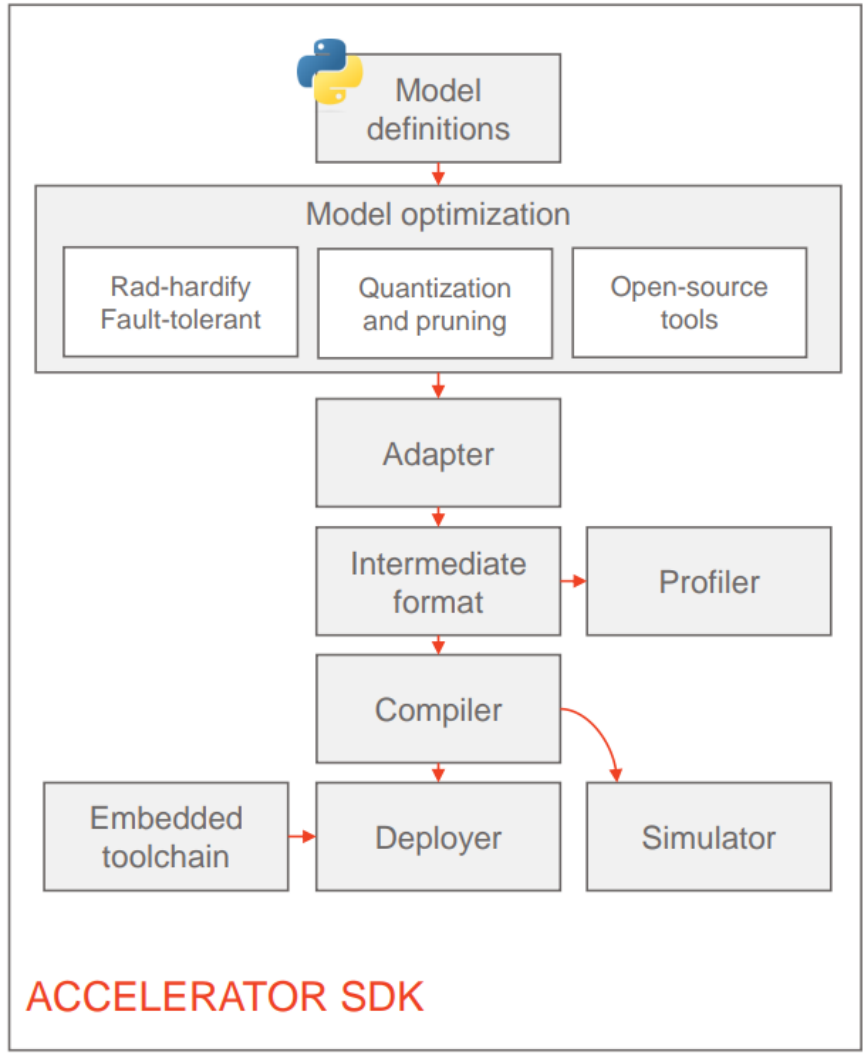
AI series – software ecosystem

- Integration into Apache TVM
  - Open-source machine learning compiler framework
  - Input: high-level AI model
  - Output: low-level optimized MCU code and runtime
- Hierarchical operator mapping
  - Accelerator optimized routines
  - muRISCV-NN (CMSIS-NN port for RISC-V)
  - Plain C operations
- Support for a wide range of frontend frameworks
- Ahead-of-time compilation with static memory planning
- RTOS compatible (e.g., RTEMS)



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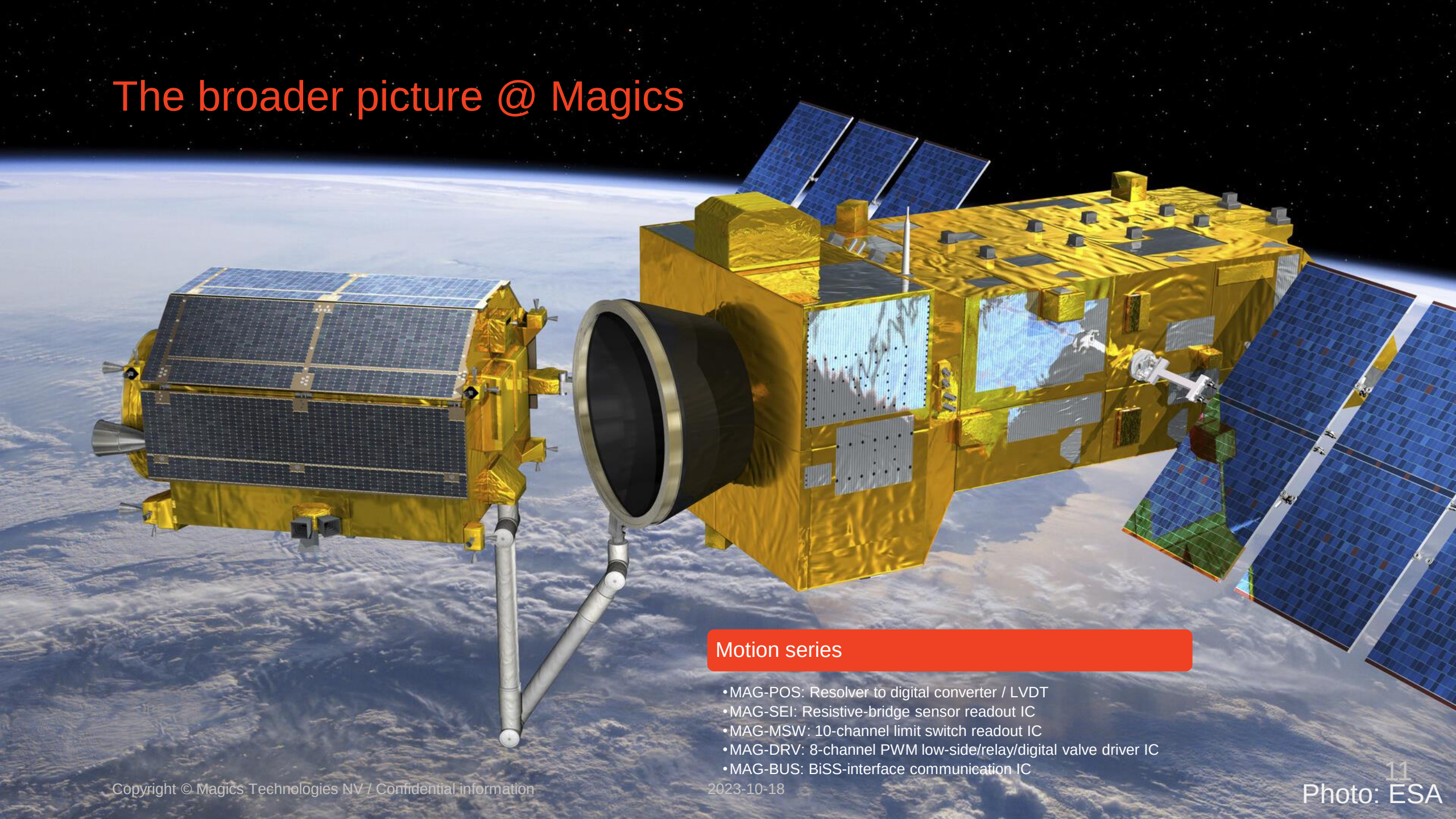
The broader picture @ Magics



Motion series

- MAG-POS: Resolver to digital converter / LVDT
- MAG-SEI: Resistive-bridge sensor readout IC
- MAG-MSW: 10-channel limit switch readout IC
- MAG-DRV: 8-channel PWM low-side/relay/digital valve driver IC
- MAG-BUS: BiSS-interface communication IC

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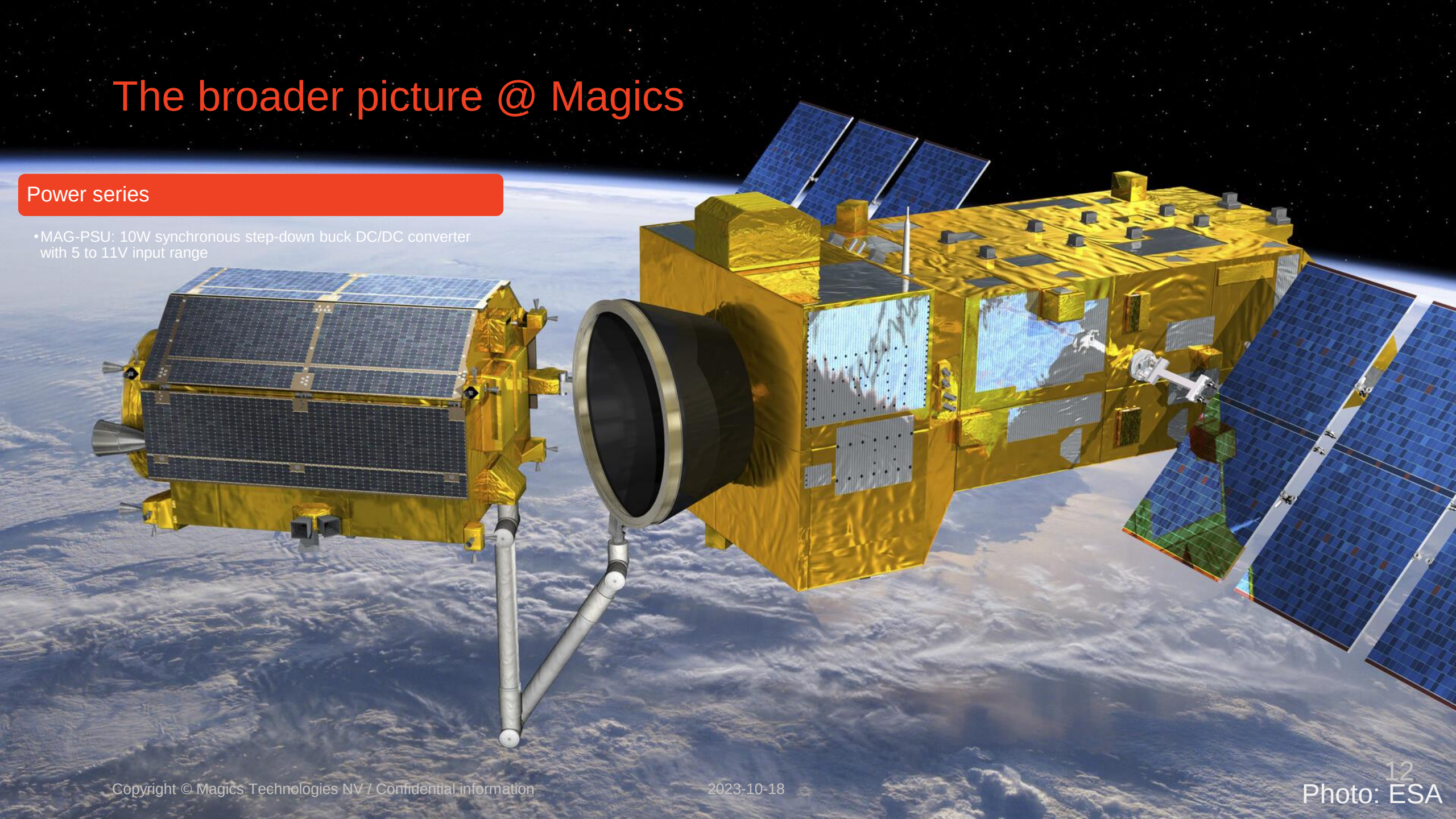
The broader picture @ Magics

Power series

- MAG-PSU: 10W synchronous step-down buck DC/DC converter with 5 to 11V input range



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Time series

- MAG-PLL: 1MHz to 5 GHz frequency synthesizer / clock generator
- MAG-TDC: Time-to-digital converter with <8ps single-shot precision

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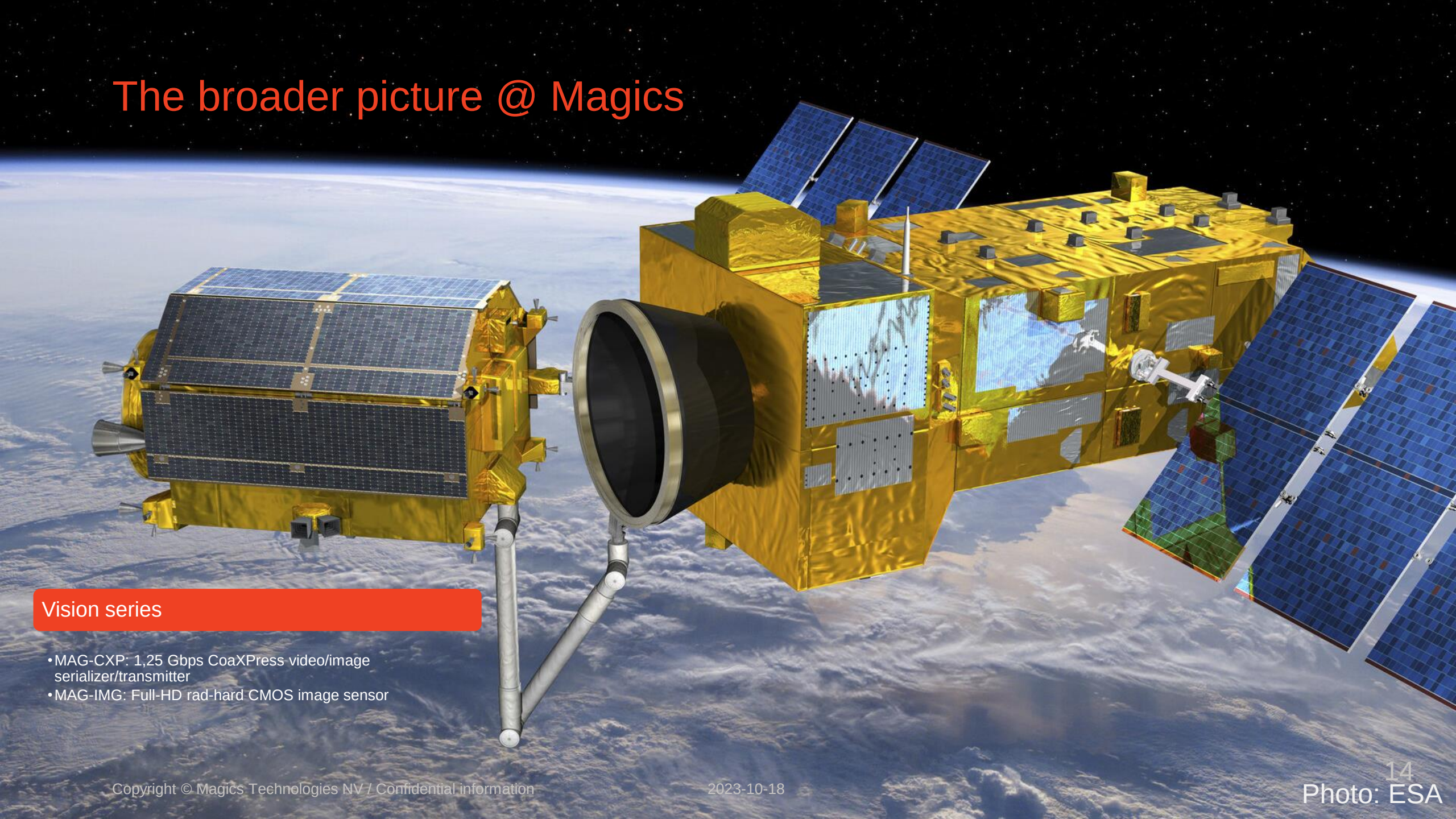

Vision series

- MAG-CXP: 1,25 Gbps CoaXPress video/image serializer/transmitter
- MAG-IMG: Full-HD rad-hard CMOS image sensor

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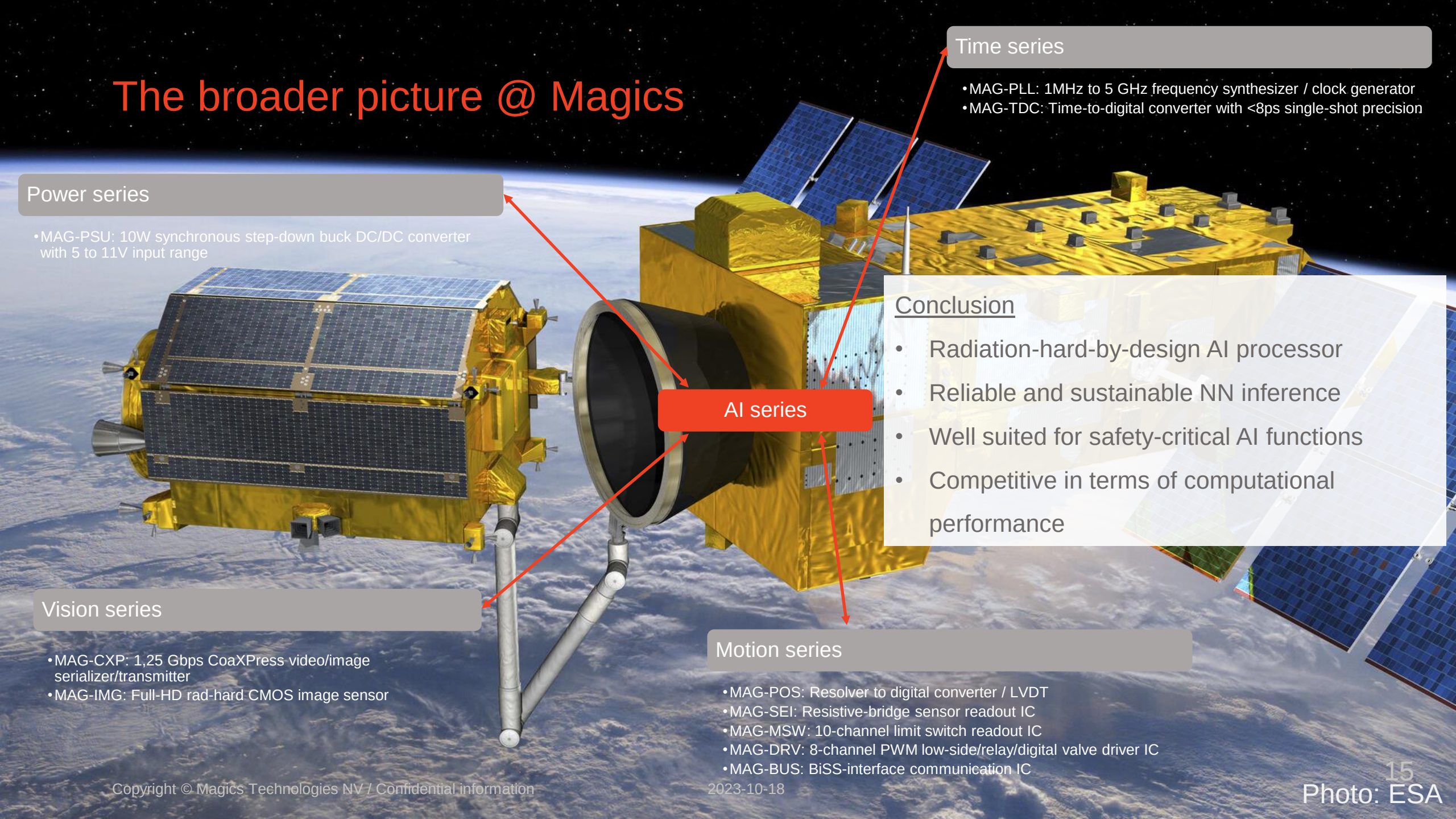

AI series

Conclusion

- Radiation-hard-by-design AI processor
- Reliable and sustainable NN inference
- Well suited for safety-critical AI functions
- Competitive in terms of computational performance

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DREAM BIG.
START SMALL.
SUCCEED.

WANT TO KNOW MORE?

GET IN TOUCH

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