NG-Ultra, the European rad-hard SoC + FPGA suitable for future space applications

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AIRBUS

Key Messages Summary

NG-Ultra is unique in the landscape of available Rad Hard components

It is the only European FPGA solution with a SoC

It offers performances & robustness breakthroughs with Huge FPGA + High performance processing

Tools are (now) at good maturity level and continue to improve

NG-Ultra selected as technical baseline on several Airbus D&S on-going projects

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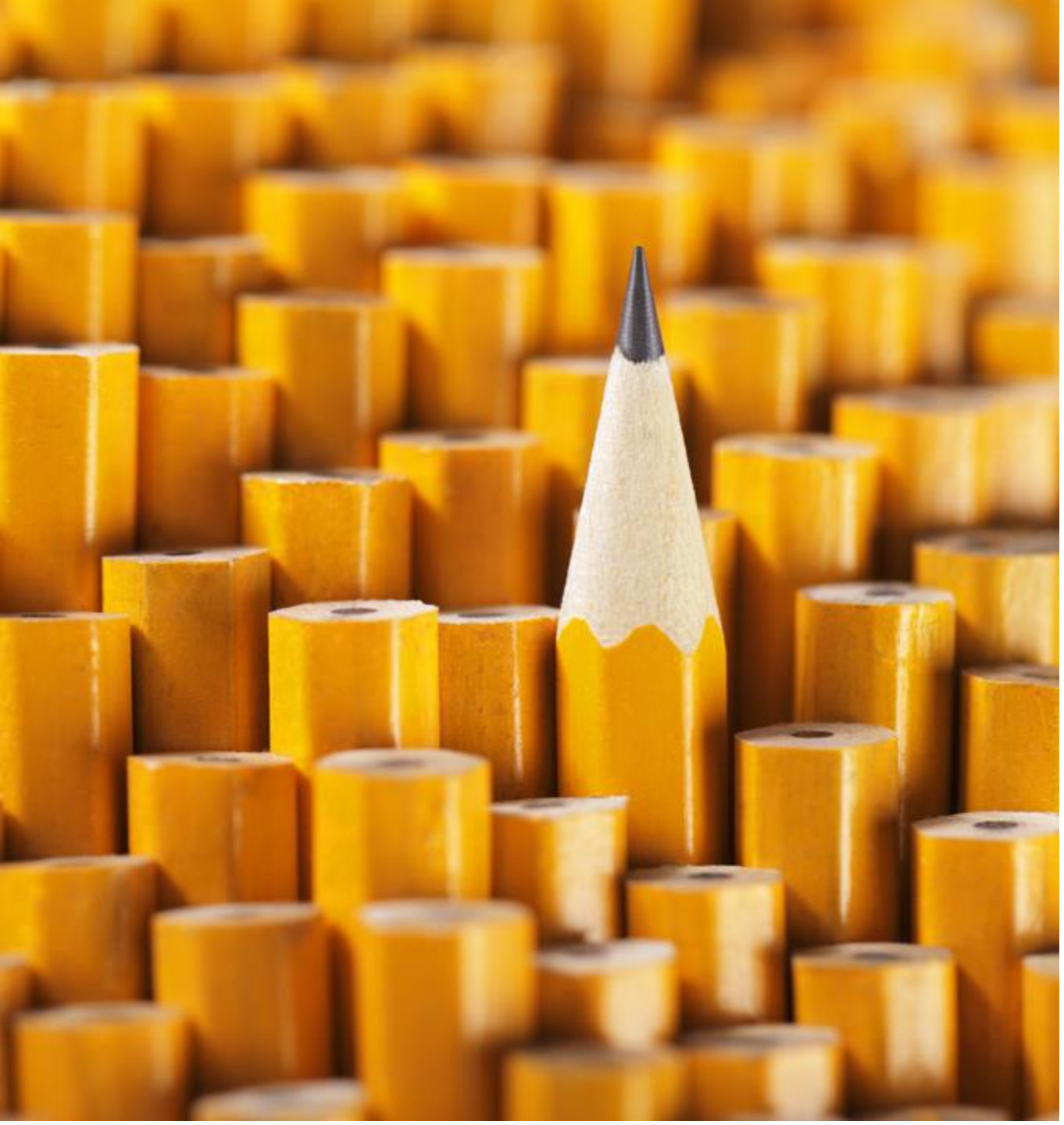


Why NG-Ultra is unique in the landscape of available Rad Hard components?

Introduction

Performances Status

Ecosystem Status

Use Cases

Conclusion

Context

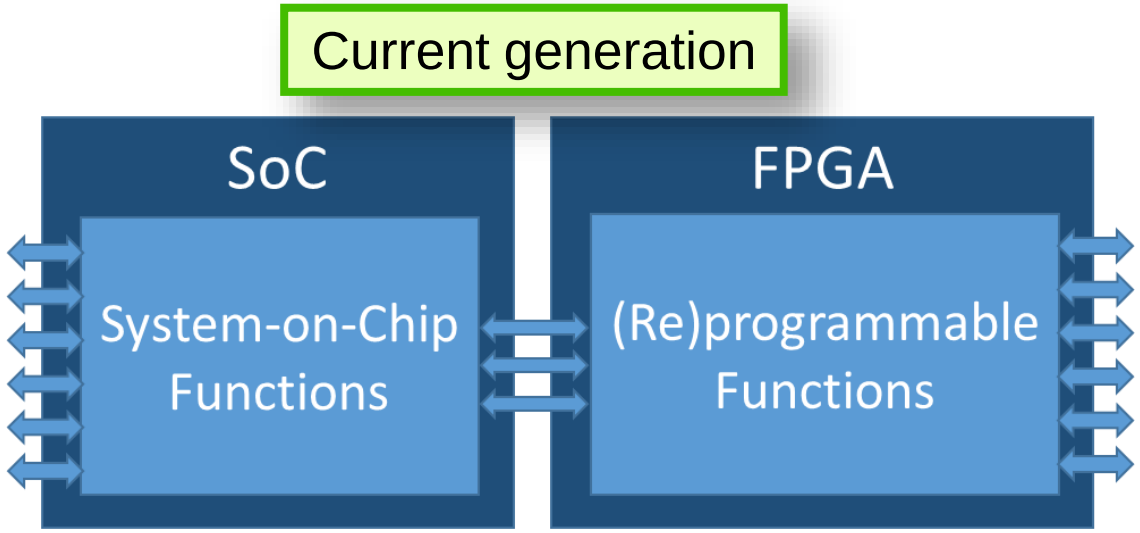
Initiated by CNES, collaboration between Airbus and TAS to develop a European chip supported by H2020

NanoXplore is the company owning and commercialising the NG-Ultra manufactured by STMicro in 28FDSOI

NG-Ultra = SoC + FPGA

Horizon 2020 was the EU's research and innovation funding programme from 2014-2020

To integrated SoCs and beyond



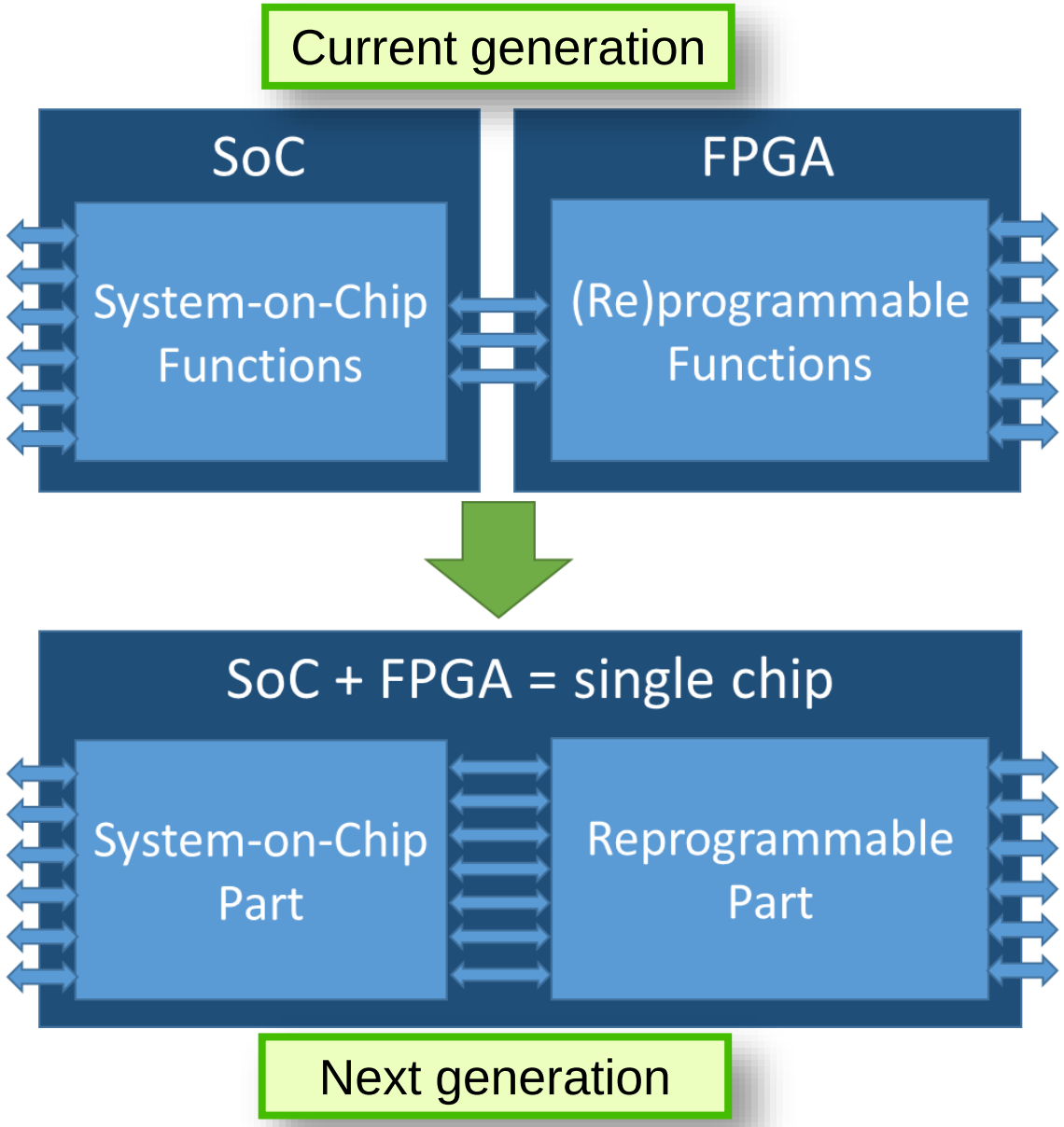
Integrated SoC+FPGA

‡ Consistent with the design of processing boards

‡ Optimized interfaces SOC Å ÆFPGA

‡ Key enabler for more integrated designs & cost reduction

To integrated SoCs and beyond



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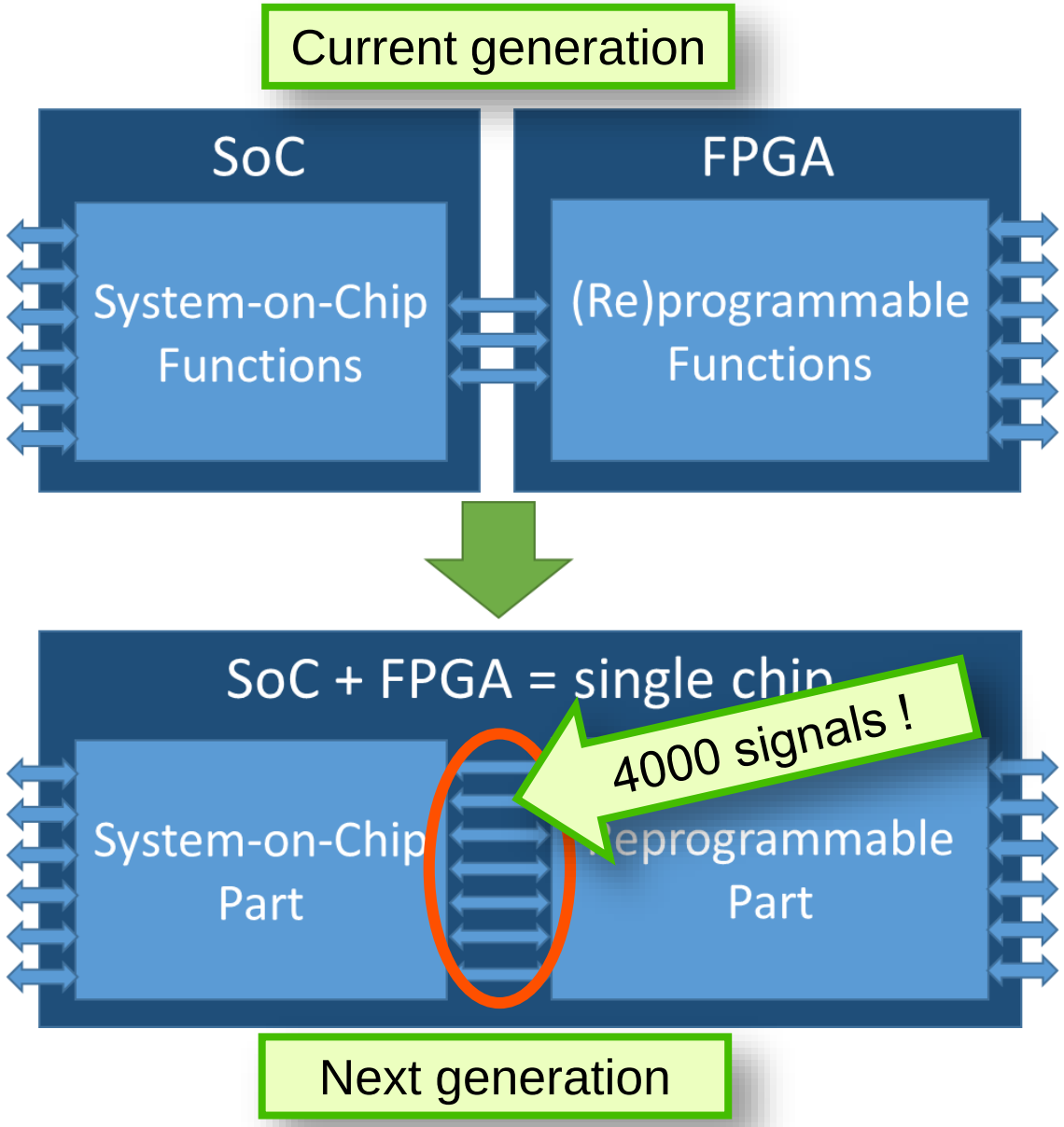

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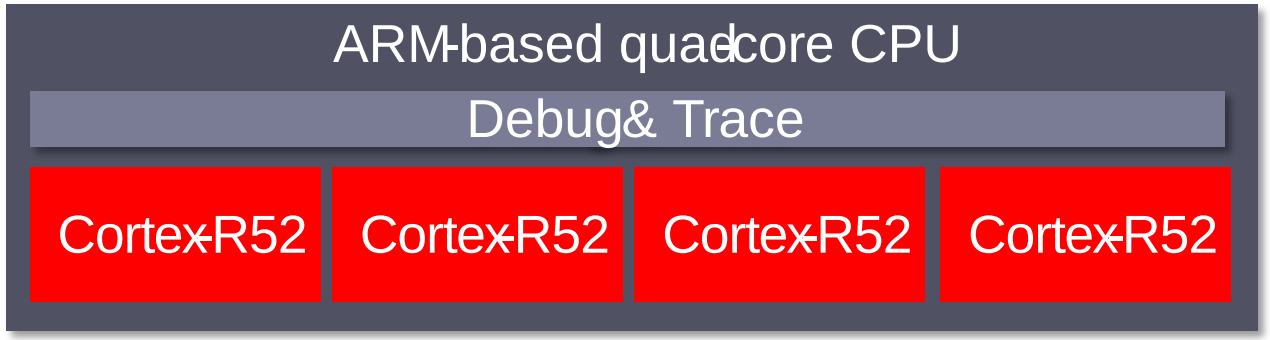
Features ±Processing



- Quad-Core ARM R52 @ 600 MHz > 4000 DMIPS
- FPU (SP/DP) + NEON SIMD
- Compatibility with ARM Debug & Trace ecosystem

FPU : Floating Point Unit / SP/DP : Single/Double Precision / SIMD : Single Instruction Multiple Data Co-processing

Features ±Memories

On chip Memory

- eRAM
- eROM

External Memory

- DDR
- FLASH

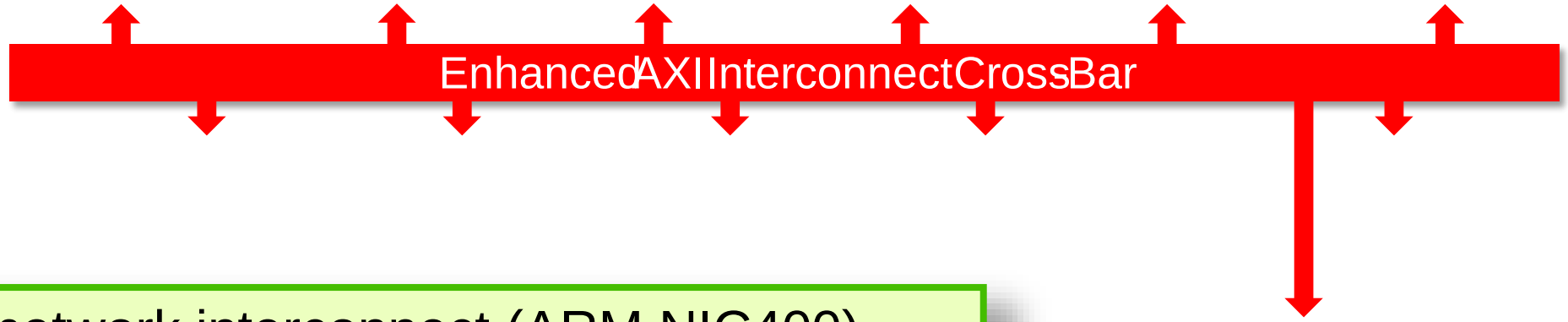
16 channels DMA

ÆBoot eROM + 2 MBytes eRAM w/ ECC
ÆMemory interface (volatile) ÆDDR2/DDR3/DDR4
ÆMemory interface (non volatile) ÆBoot NOR Flash
Æ16 channels DMA to support memory transfers

DAHLIA

ECC : Error Correcting Code- / DMA : Direct Memory Access

Features ±Interconnect



ÆAXI network interconnect (ARM NIC400)
ÆQuality of Service (QoS)

Features ±FPGA matrix

Embedded FPGA

- More than 500 KLUTs programmable matrix
- HSSL in the FPGA
- Additional on-chip services
- Security features (e.g. bitstream encryption)

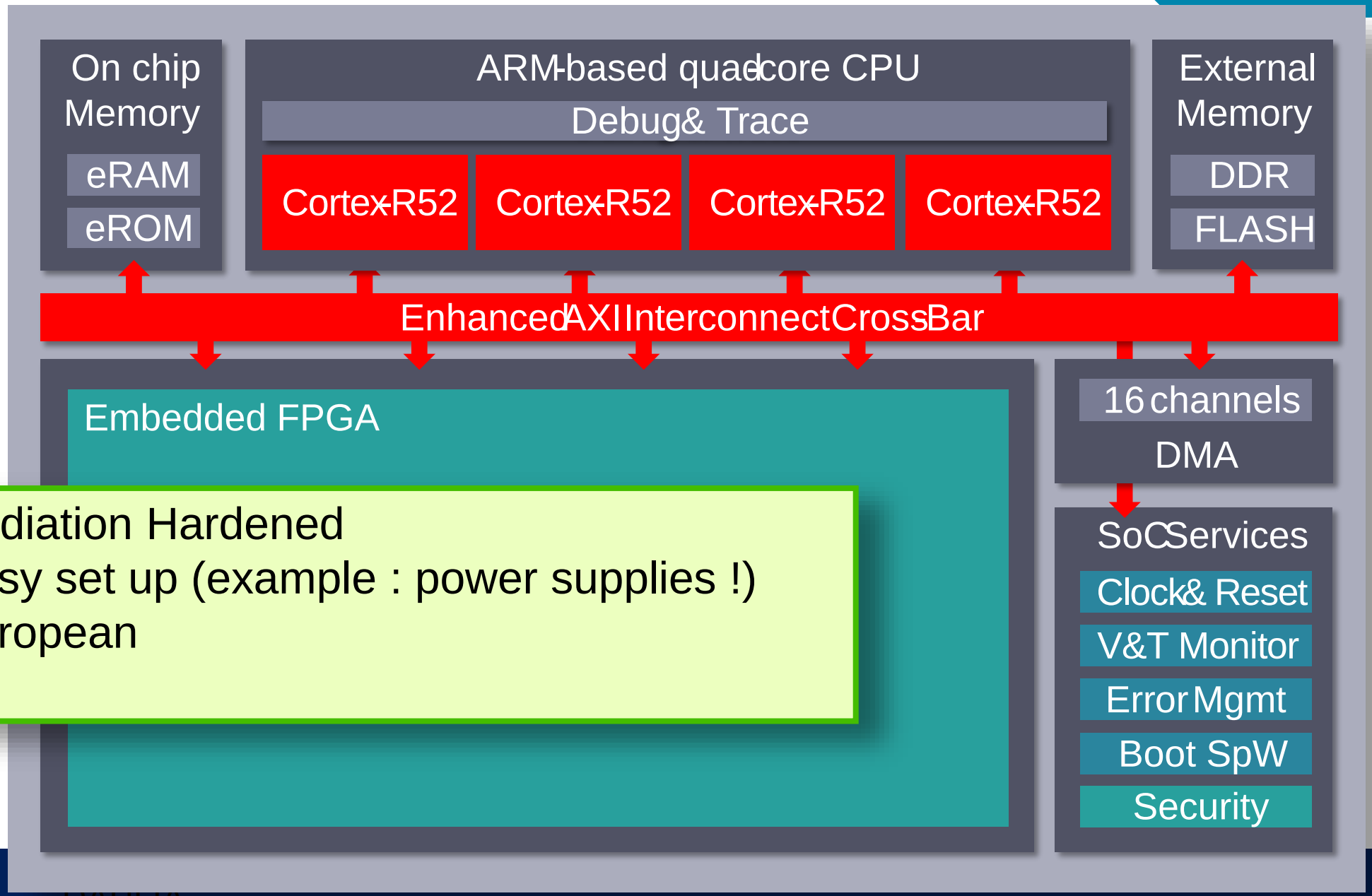
SoC Services

- Clock & Reset
- V&T Monitor
- Error Mgmt
- Boot SpW
- Security

DAHLIA

LUT : Look Up Table / HSSL : High Speed Serial Link

Features ±What else ?



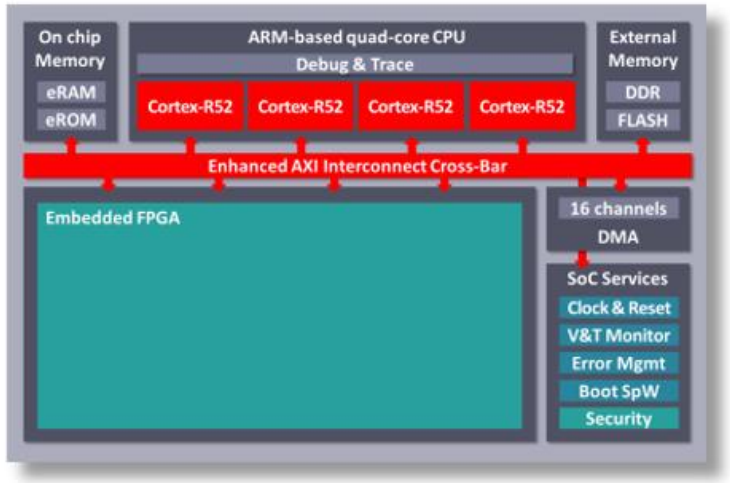
- Radiation Hardened
- Easy set up (example : power supplies !)
- European
- «

What are the breakthroughs (*) of NG-Ultra architecture and detailed performances ?

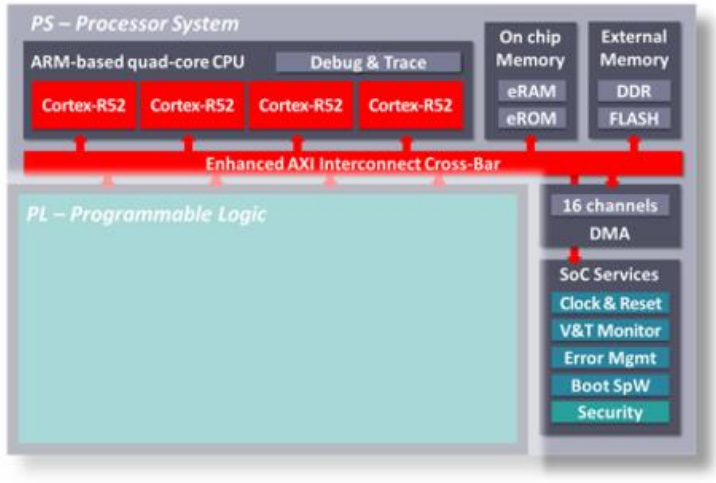
(*) for a rad-hard component

High level performances comparison

SoC + FPGA



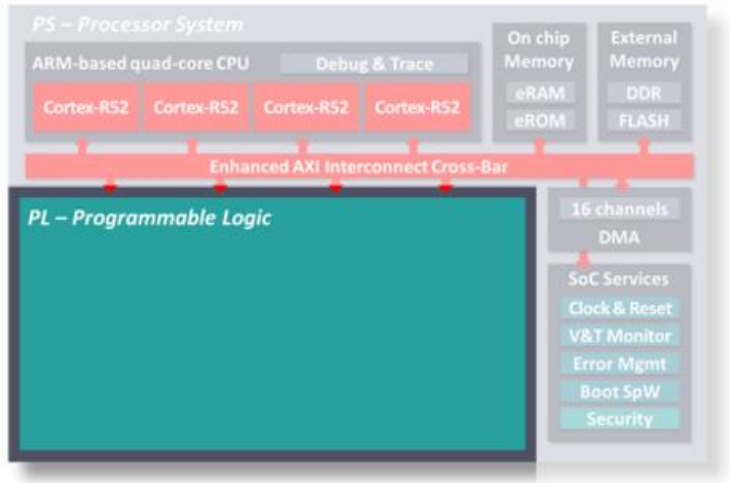
SoC only



NG-Ultra processing perfo
1 818 CoreMark / core
1 250 DMIPS / core

CPU Performance
Æ40 x SCOC3
Æ2 x GR740

FPGA only



NG-Ultra FPGA capacity
~530 KLUT

FPGA Capacity
Æ2 x RTG4 (*)
Æ25 x RTAX2000 (*)

(*) estimation of realistically useable FPGA size at Q1/2023 date, twice more to be expected considering theoretical LUTs resources and the strong momentum deployed on tools improvement

High level performances comparison

Table: Power Supply Ramp Time

Symbol	Description	Min	Max	Units
T_{VCCINT}	Ramp time from GND to 95% of V_{CCINT}	0.2	40	ms
T_{VCCINT_IO}	Ramp time from GND to 95% of V_{CCINT_IO}	0.2	40	ms
T_{VCCINT_VCU}	Ramp time from GND to 95% of V_{CCINT_VCU}	0.2	40	ms
T_{VCCO}	Ramp time from GND to 95% of V_{CCO}	0.2	40	ms
T_{VCCAUX}	Ramp time from GND to 95% of V_{CCAUX}	0.2	40	ms
$T_{VCCBRAM}$	Ramp time from GND to 95% of V_{CCBRAM}	0.2	40	ms
$T_{MGTAVCC}$	Ramp time from GND to 95% of $V_{MGTAVCC}$	0.2	40	ms
$T_{MGTAVTT}$	Ramp time from GND to 95% of $V_{MGTAVTT}$	0.2	40	ms
$T_{MGTVCCAUX}$	Ramp time from GND to 95% of $V_{MGTVCCAUX}$	0.2	40	ms
$T_{VCC\_PSINTFP}$	Ramp time from GND to 95% of $V_{CC\_PSINTFP}$	0.2	40	ms
$T_{VCC\_PSINTLP}$	Ramp time from GND to 95% of $V_{CC\_PSINTLP}$	0.2	40	ms
T_{VCC_PSAUX}	Ramp time from GND to 95% of V_{CC_PSAUX}	0.2	40	ms
$T_{VCC\_PSINTFP\_DDR}$	Ramp time from GND to 95% of $V_{CC\_PSINTFP\_DDR}$	0.2	40	ms
T_{VCC_PSADC}	Ramp time from GND to 95% of V_{CC_PSADC}	0.2	40	ms
T_{VCC_PSPLL}	Ramp time from GND to 95% of V_{CC_PSPLL}	0.2	40	ms
$T_{PS\_MGTRAVCC}$	Ramp time from GND to 95% of $V_{CC\_MGTRAVCC}$	0.2	40	ms
$T_{PS\_MGTRAVTT}$	Ramp time from GND to 95% of $V_{CC\_MGTRAVTT}$	0.2	40	ms
T_{VCCO_PSDDR}	Ramp time from GND to 95% of V_{CCO_PSDDR}	0.2	40	ms
$T_{VCC\_PSDDR\_PLL}$	Ramp time from GND to 95% of $V_{CC\_PSDDR\_PLL}$	0.2	40	ms

Comparing performances is important but not enough. Many other criteria shall be considered such as package, radiation hardening, cost, hardware setup (memories, power supply « K D U G a Z d D U H software ecosystem, U L V N P L W L J D W L R Q R I H [S R U W F R Q W U R O O L P L W D

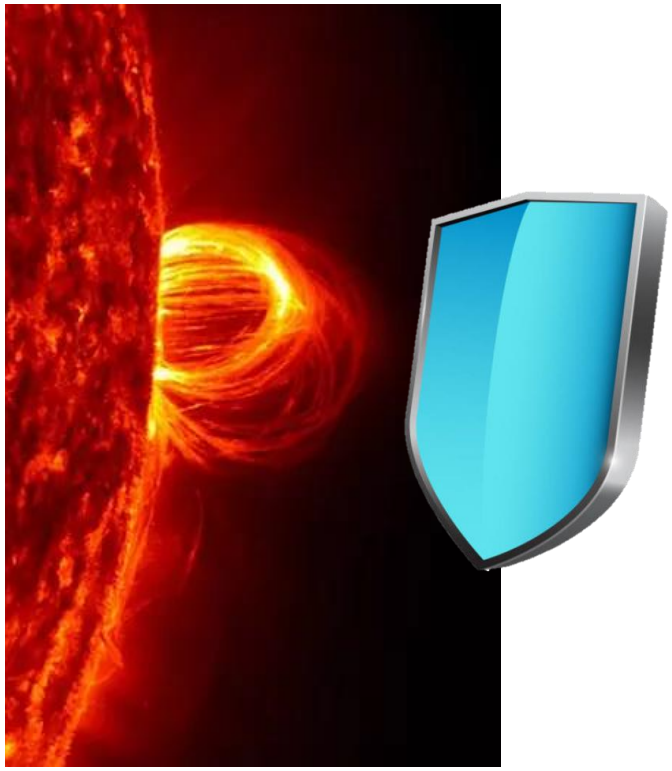
Space environment is hostile - Radiations

NG- 8 O W U D U D G L D W L R Q U R E X V W

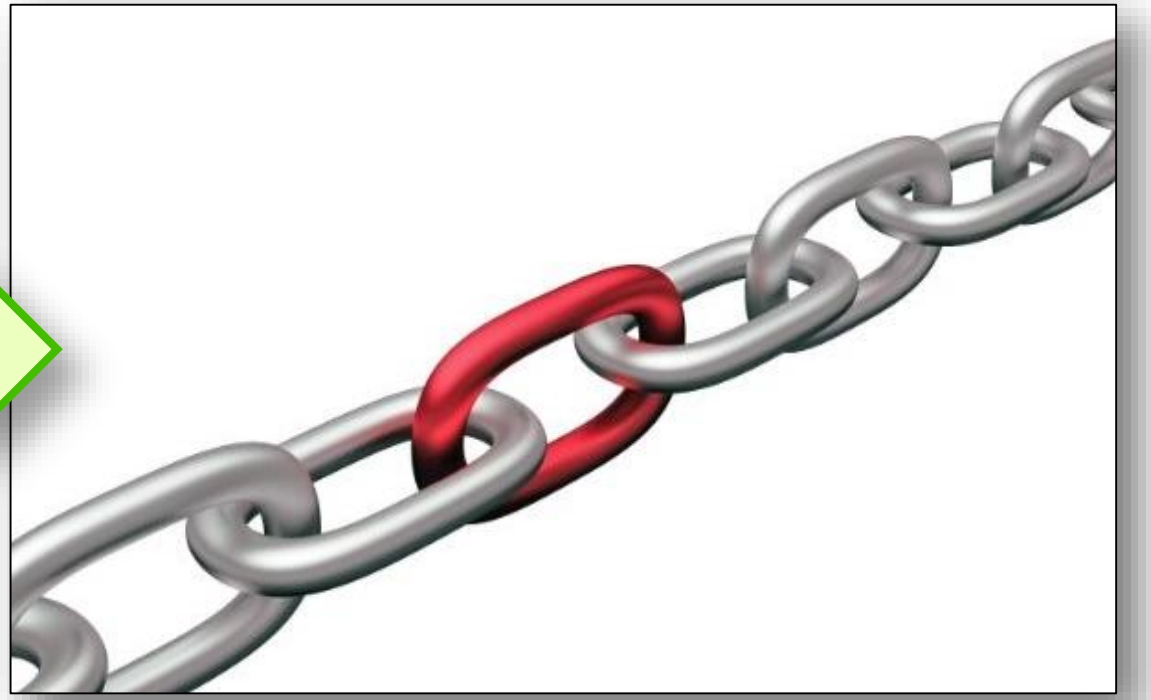
- ‡28FDSOI technology intrinsically latch-up immune Æno SEL
- ‡NG-Ultra tested during 2 radiation campaigns Æno SEFI
- ‡Robustness confirmed (no SEU, no SEFI) on v1, v2 launched

DDR memory protection Æa game changer

- ‡Supporting DDR2, DDR3 and DDR4 / 8-bits & 16-bits devices
- ‡Reed-Solomon for SEU high level of memory protection
- ‡Robustness against SEFI up to the loss of two 16-bits devices



NG-Ultra architecture approach ±No « weakest link »



Having a high performance and very robust component is not enough, because if it is associated to sensitive components (such as peripheral memories), the overall U R E X V W Q H V V Z L O O G H S H Q G V R Q W K H [3] As an example, if you need to reboot each time you have an upset in a memory, this will drive the way you R S H U D W H \ R X U S U R F H V V L Q J P R G X O H « W K L V L V D Q L V V X H «

NG-Ultra solves this issue, since (1) it offers a robust Radiation Hardened By Design (RHBD) chip and (2) it provides unprecedented protection mechanisms for all of its peripheral components (Flash, DDR) allowing to X V H L W Z L W K R X W U L V N R I L Q W U R G X F

What about the ecosystem to develop with NG-Ultra ?

NG-Ultra ±OPERA Study Status

European Commission

Horizon 2020 was the EU's research and innovation funding programme from 2014-2020

OPERA project objectives were to assess the performances that can be achieved by some designs in NG-ULTRA technology and compare it with performances achieved in reference technologies.

Several designs from low to higher complexity synthesized on both NG-Ultra and RTG4 targets

‡Synthesis

- 9Synthesis time Æsimilar performance on both technologies
- 9Clock frequency Æsimilar performance ~100MHz, Libero/RTG4 slightly better handles complex design
- 9Resource utilization Æperformance in favor of NG -Ultra factor of 1.5 in nb of LUT, factor 2 improvement on large memories due to NG-Ultra larger BRAM, larger DSP width +++ for algo

‡Place and Route

- 9Not easy to obtain a good layout in one run whatever the target Æsimilar performance

NG-Ultra relevance confirmed for ADS future projects !

What about first use cases targeted by Airbus with NG-Ultra ?

NG-Ultra already on ADS Projects - Platform OBC-Ultra

NG-Ultra present in both platform & payload ADS roadmaps

‡Several boards under development ÆQ2 2023 / NG-Ultra+DDR4 demo, Q3 2023 / OBC use case demonstrated with OLYMPE processing board «

‡One main component = simplified board design

NG-Ultra-based OBC

‡High performances multicore processing @600MHz, FPGA @80MHz

‡NAND Flash + DDR4 Memory + High Speed Serial Links

‡Enhanced Security features / Bitstream encryption included

‡ADHA-compatible format

Highly integrated OBC-Ultra

‡Gain in performances confirmed through studies

‡More than 500kLUT compared to ~20kLUT for previous generation with RTAX2000

‡More embedded functionalities

‡Very compact product

NG-Ultra on ADS Projects - Payload Missions

Payload missions requirements analysis

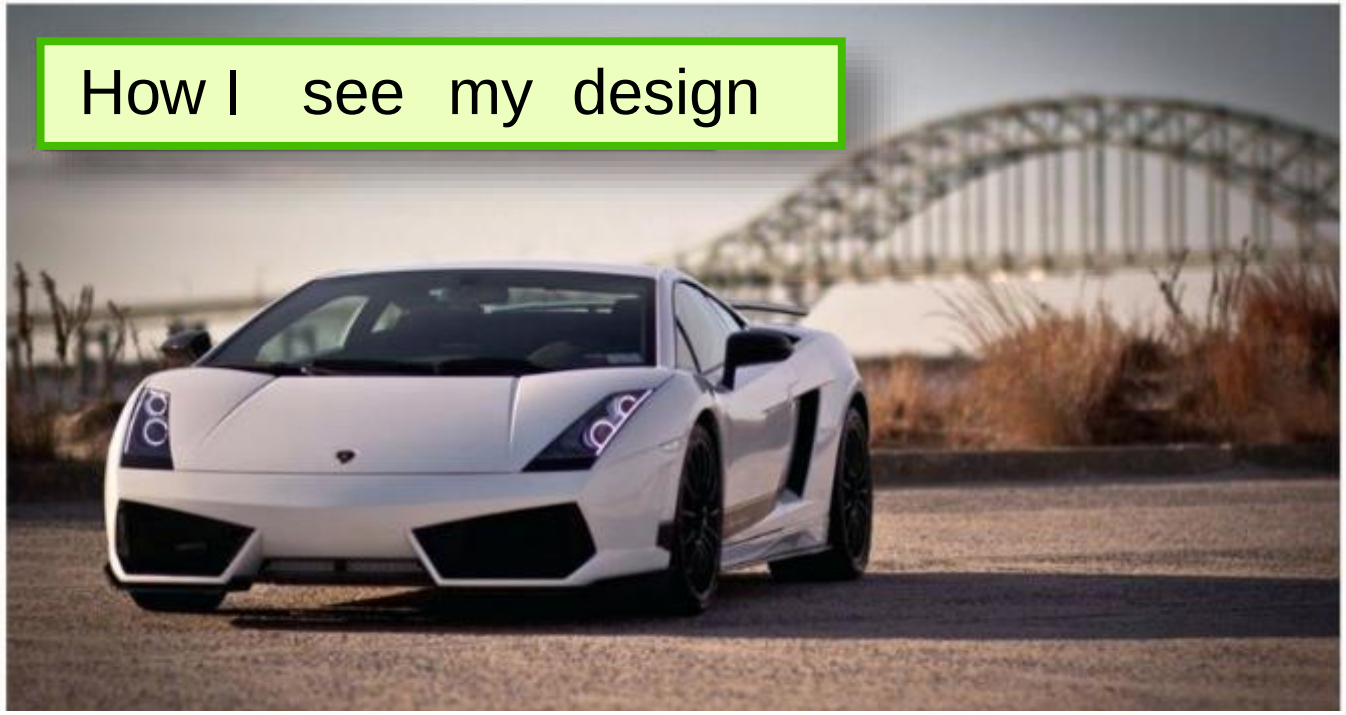
‡Very performant FPGA (fast clocking, huge matrix)
‡High DDR bandwidth
‡High Speed Serial Links

NG-Ultra suitability ? Confirmed !

‡Huge 500k LUT matrix
‡> 1000 Large DSPs
‡DDR4 100Gbps
‡HSSL

NG-Ultra-based board for payload processing under development at Airbus

‡Ground demonstrator ready for Q4 2023



What can be concluded considering the overall picture and status on NG-Ultra ?

Key Messages Summary

NG-Ultra is unique in the landscape of available Rad Hard components

It is the only European FPGA solution with a SoC

It offers performances & robustness breakthroughs with Huge FPGA + High performance processing

Confidence in tools capacity to meet performances for complex designs use cases (cf OPERA)

NG-Ultra selected as technical baseline on several Airbus D&S on-going projects

Questions ?