ESCCON 2021
ESTEC 11-13 March 2021

CNES Strategic Components activities

Florence MALOU, David DANGLA, Jérôme CARRON, Leny BACZKOWSKI,
Jean-Luc ROUX, Julien MEKKI, Pierre TASTET

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

CNES Budget

Actors

Key technologies and Supply chain

COTS radiation assessment

CNES Budget : R&T, Strategic Components

R&T –Microtechnologies, Components, Expertise axis

- **Activities on all electronic components & technologies**
  - Survey & Assessment of COTS
  - Innovative assembly & mounting solutions, PCB
  - New technologies (UDSM, GaN, SiGe, optical connectors, etc.)
  - Radiation studies : Environment, Effects on components, Test means …
  - Expertise lab

TRL 2→5

3M€/year

30 to 200k€/activity

RCS – Strategic Components

- **Key technologies Development, Evaluation, Market introduction**
- **Supply chain audit**
  - ASICs (ATMEL-MICROCHIP, STMicroelectronics)
  - FPGA NG (NanoXplore, STMicroelectronics)
  - MicroProcesseurs (ATMEL-MICROCHIP)
  - Data Conversion (E2V-TELEDYNE)
  - Standard Products STMicroelectronics (diodes, transistors, LSI,…)

TRL 4→7

2,8M€/year

100k€ to 1M€/activity

Strategic Components

COORDINATION

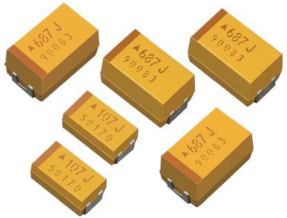
- CTB (ESCC) ➔ roadmaps
- EDA / DGA
- COSPACE/SGDSN
- Multipartenariat (MOIs-F)
- International (JAXA)

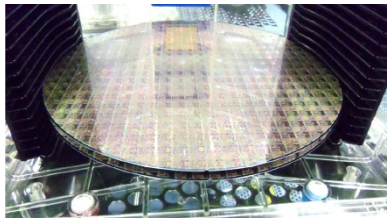
OBJECTIVES

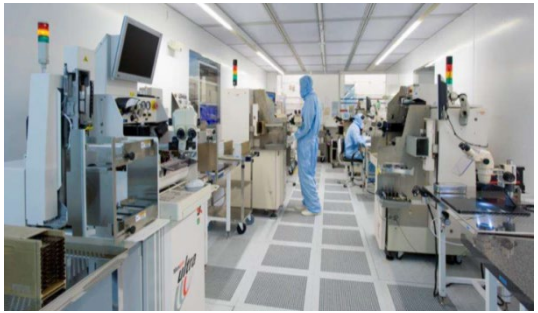
- European Non dependance
- Europe's industrial competitiveness
- Components offer adapted to customers needs (HiRel, NewSpace) to ensure manufacturers competitiveness
- European/French sustainable supply chains for critical techno
- Space qualification of existing commercial/automotive techno
- Performances & Key technologies

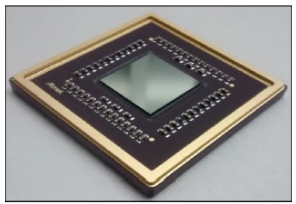
Components Manufacturers in France

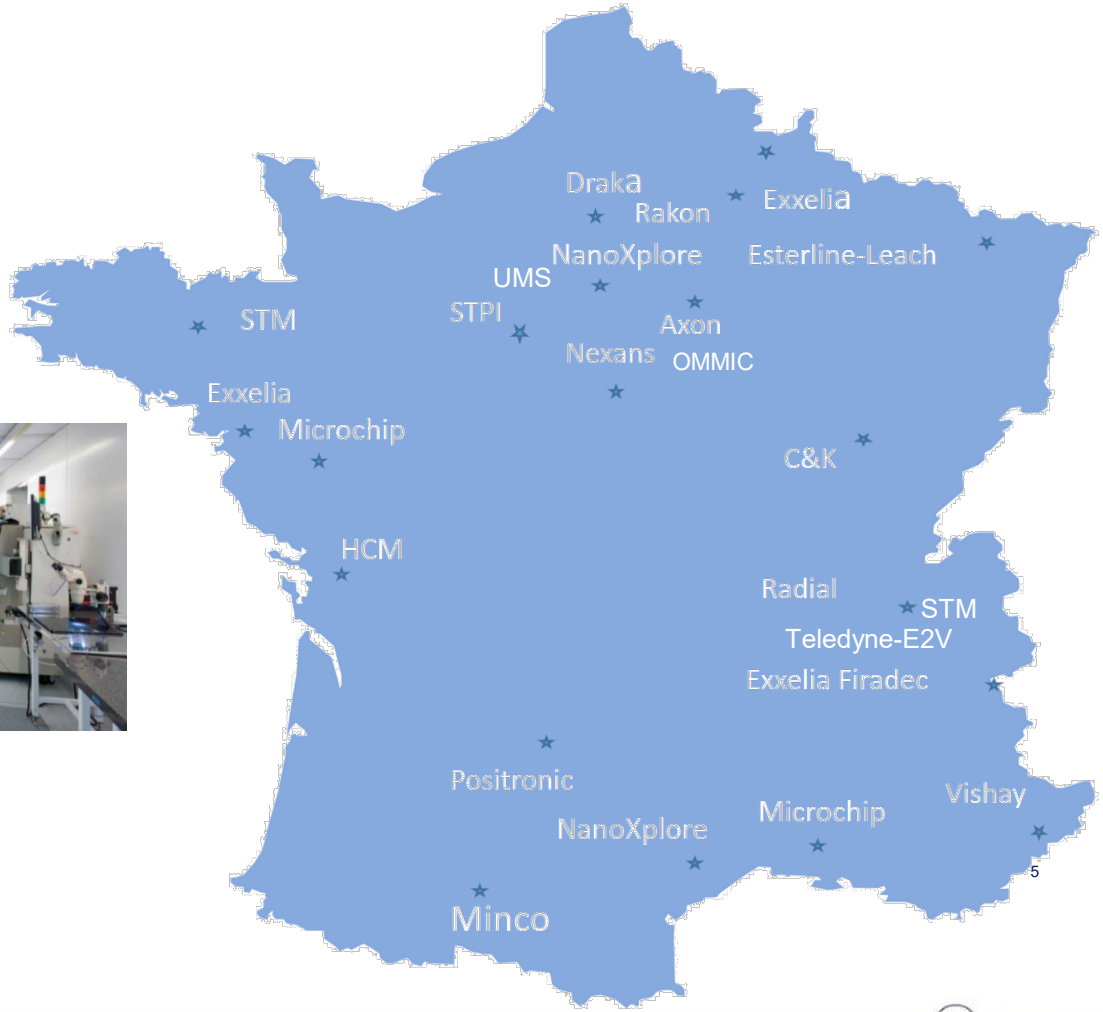
➢ Wide range of products



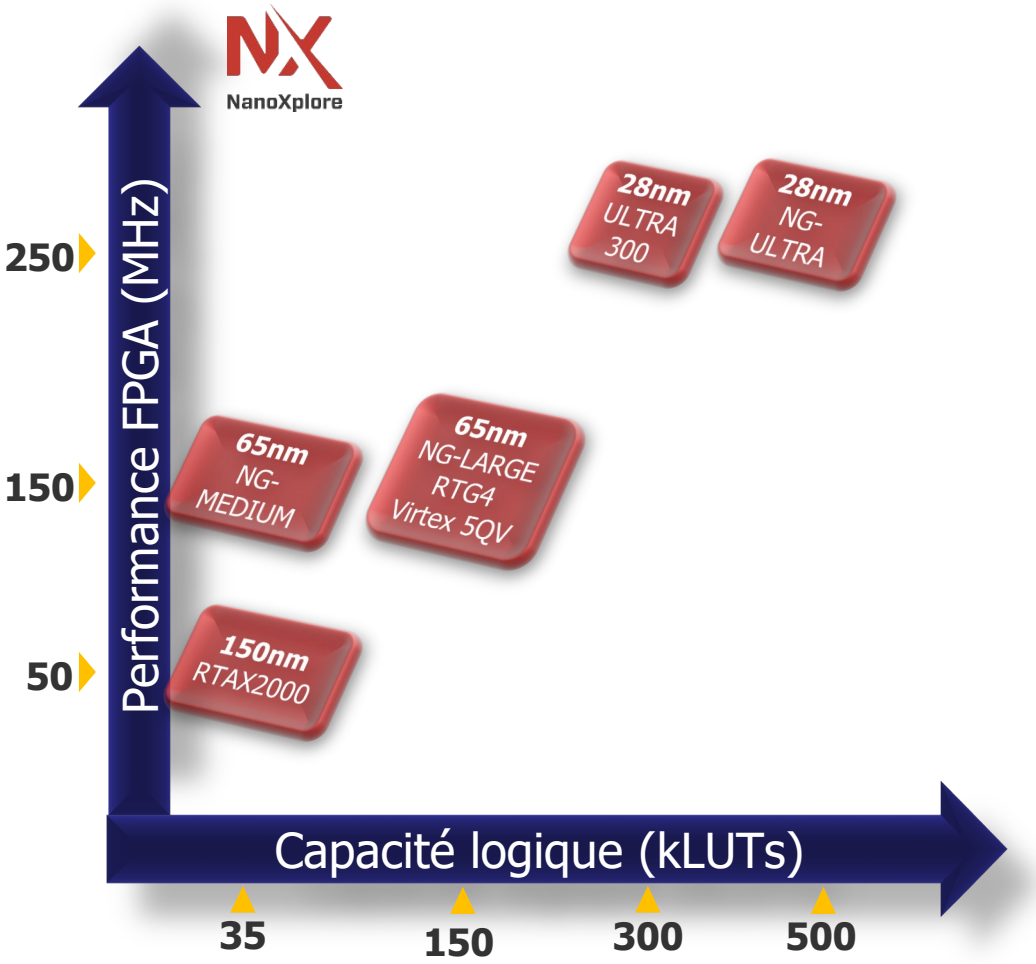








FPGA-NG : NanoXplore offer

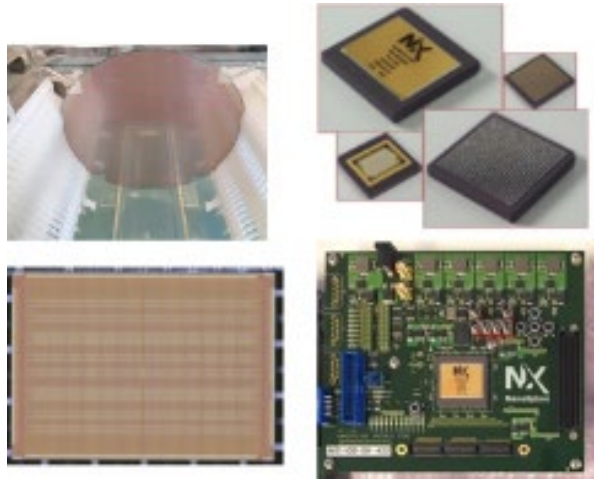


	DEVICE	NX1H35AS	NX1H140TSP	NX2H540TSC	NX2H300TSA
FPGA	TECHNOLOGY	CMos Planar	CMos Planar	FDSOI	FDSOI
	Process Lythography	65nm	65nm	28nm	28nm
	ASIC Gates	550 000	1 900 000	8 000 000	4 000 000
	LOGIC MODULES				
	Register	32 256	129 024	505 344	273 408
	LUT4	**34 272**	**137 088**	**536 928**	**290 496**
	Carry	8 064	32 256	126 336	68 352
	EMBEDDED RAM	**2,8Mb**	**9,7Mb**	**33,9Mb**	**21,8Mb**
	DPRAM	2 688	9 216	32 256	21 504
	Core Register File	168	672	2 632	1 424
	Core Register File bits	168kb with ECC	672kb with ECC	1480Kb Hardened	801Kbit Hardened
	CLOCK Domains / PLL	24 / 4	32 / 4	50 / 7	50 / 7
SoC	ADDITIONNAL FEATURES				
	SpaceWire PHY (8 IOBs)	16	20	20	20
	DDR PHY (11 IOBs)	16	20	20	20
	DSP Blocks (S)	**112**	**384**	**1344**	**896**
	SpaceWire link I/F 430 Mbps	1	1	1	1
	SERDES Tx/Rx (T)	-	**24**	**32**	**16**
	Hard IP Processor core (P)	-	1	4	-
	SoC Peripherals (C)	NO	NO	YES	NO
	ADC / DAC (A)	-	-	-	**4 / 4**
	DESIGN SECURITY	NO	NO	YES	YES
IOBs	INPUTS/OUTPUTS	**374**	**674**	**740**	**544**
	I/O Simple Bank	5	14	4	4
	I/O Complex Bank	8	10	10	10
	I/O Service Bank	1	1	1	1
		-	-	1	2
		-	-	2	1
PACKAGING	PACKAGES	**4#**	**3#**	**3#**	**4#**
	CQFP-352 (CQ352)	192	-	-	TBD
	CLGA-484 / CCGA-484 (LF484) / (CG484)	-	-	-	TBD
	PBGA-484 (FF484)	-	-	-	TBD
	CLGA-625 / CCGA-625 (LG625) / (CG625)	374	-	-	544
	PBGA-625 (FG625)	374	-	-	544
	CLGA-1752 / CCGA-1752 (LF1752) / (CF1752)	-	674	740	-
	FCBGA-1752 (FF1752)	-	*674*	-	-
	FCBGA-1760 (FF1760)	-	-	*740*	-

FPGA NG-Medium

CTB RM : Si14

- Rad-Hardened by design SRAM-Based FPGA
- NX design, C65SPACE ST techno, CQFP-352 & CCGA-625



- Supply chain :

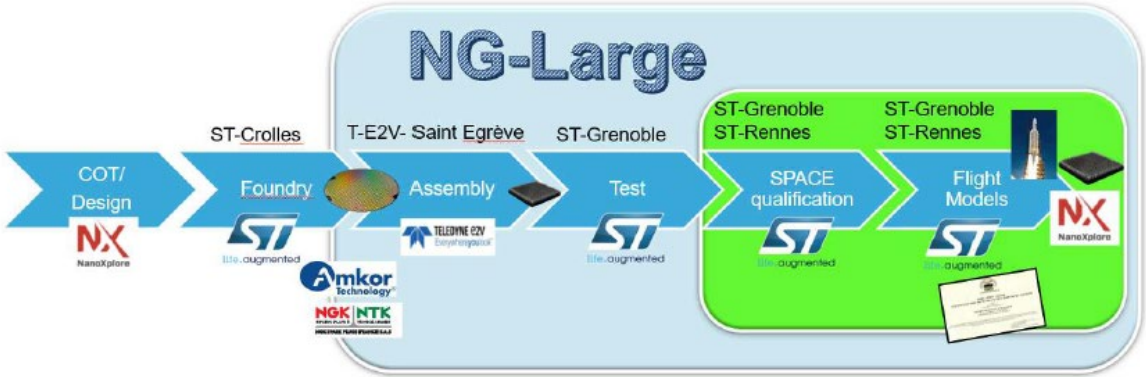
- CQFP-352 Flight models available

FPGA NG-LARGE

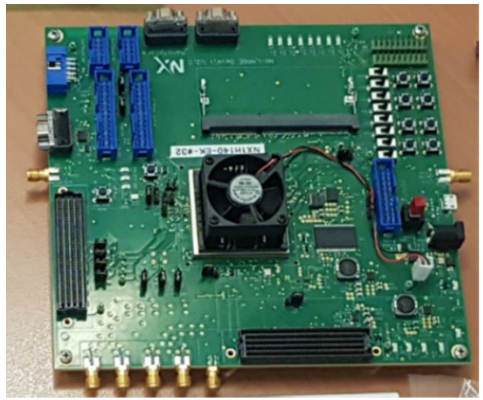
CTB RM : Si75

- Rad-Hardened by design SRAM-Based FPGA
- NX design, C65SPACE ST techno, CCGA-1752

- Supply chain :



- Eval Kit bring-up done
- Derisking Hermetic Flip-Chip assembly : Good results



NG-LARGE Eval kit

→ Next : Qualification (H2020 OPERA)

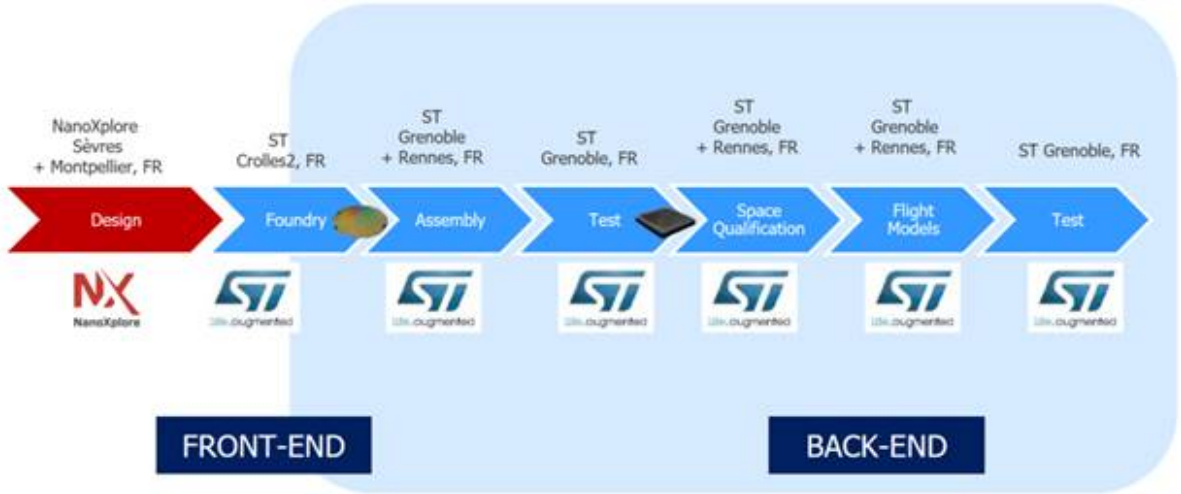
FPGA NG-ULTRA

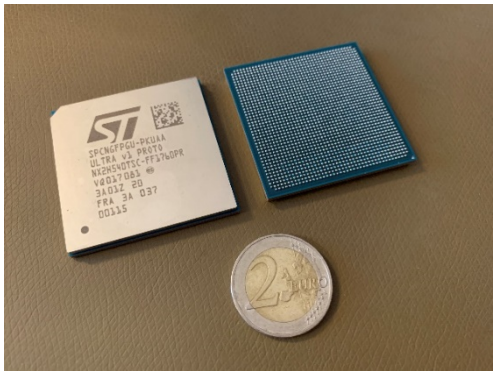
CTB RM : SI17

- Rad-Hardened by design SRAM-Based FPGA
- NX design, ST 28FDSOI techno, ST Non-hermetic Flip-chip BGA1752

- Supply chain :

The NG-ULTRA is based on SME technology from NX but 100% industrialised by a fully trusted space supply chain from ST



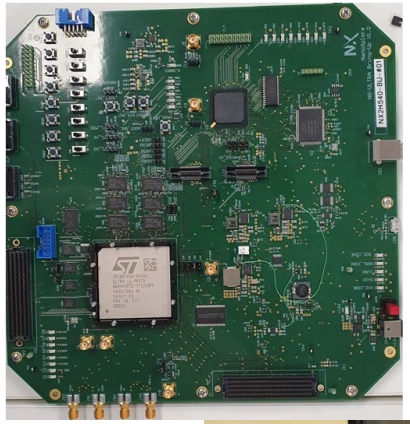


FPGA NG-ULTRA

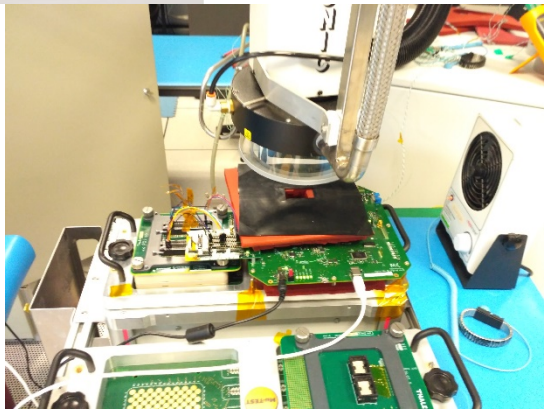
➢ Development strategy with 2 Tape-Out:

CTB RM : SI17

- **NG-Ultra V1:**
  - Launched in fab in February 2020,
  - **First prototypes received on September 21st,**
  - **Bring-up on-going by NX/ST, CNES, end-users**
- **NG-Ultra V2:**
  - To be launched in fab in Q2/2021,
  - **FM equivalent (screened parts): July 2021**
  - End of Qualification:
    - Organic Flip-Chip FF1752: Q1/2022
    - Ceramic hermetic Flip-Chip CCGA-1752: Q2/2022



➢ Derisking Non Hermetic Flip-Chip assembly in progress



NG-ULTRA Eval kit during CNES bring-up

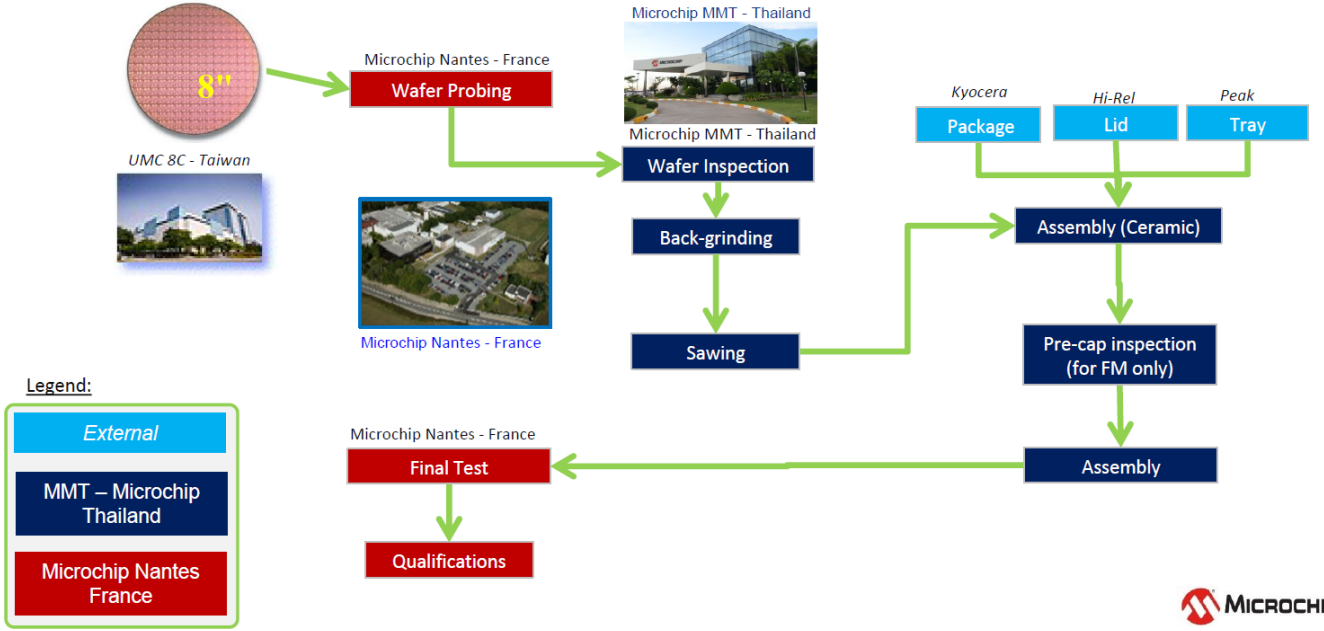
→ Next :

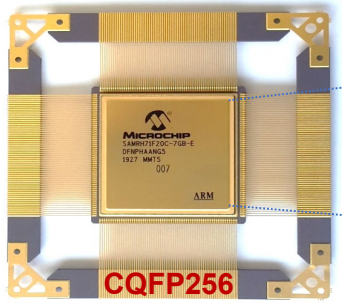
- **FPGA Programming Tools improvements** — CTB RM : Si115
- **NG-ULTRA Qualification (ARTES & H2020 HERMES)** — CTB RM : Si18
- **NG-ULTRA-300 intermediate capacity : Tape-out in Q1/21** — CTB RM : Si72

Microchip Microprocessors

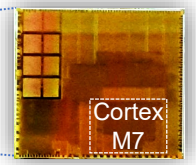
- SAMRH71 : First Rad-Hard by design ARM Cortex M-7µP
- MCHP design, 150nm ATMX150RHA techno, CQFP256

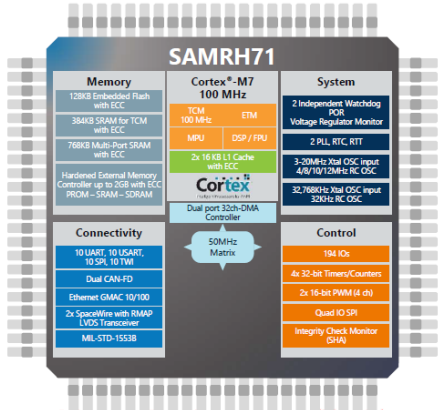
- Supply chain :





CTB RM : Si107





SAMRH71 Architecture

Radiations
TID 150krad (Flash limited to 20krad)
SEL immune up to 62 MeV
SEU LET >20Mev.cm2/mg (Xsection <10-9 cm2/word)

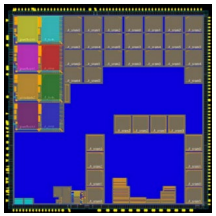
- ESCC evaluation completed : Good results
- Flight models available

Microchip Microprocessors

→ Next :

- SAMRH71 in plastic version

CTB RM : Si107



- SAMRH707 development and evaluation (ESA)

CTB RM : Si99, Si100

- Next generation multi-core ARM Rad-Hard µP development on UDSM technology

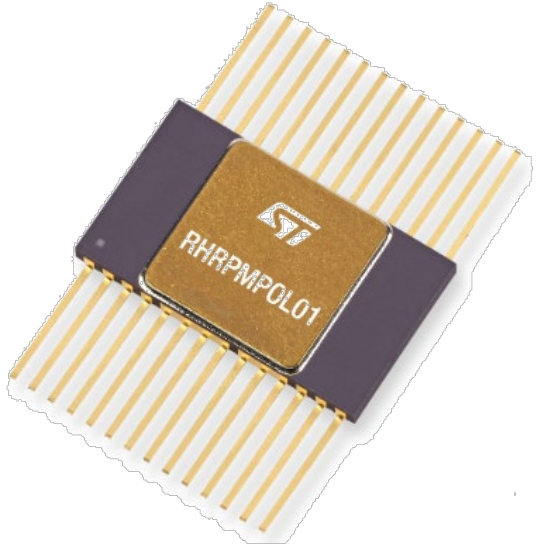
CTB RM : Si109

ST PoL

➢ RHRPMPOLS01 : Rad-hard 7A point-of-load synchronous step-down regulator

ESA contract for product development ; CNES contract for ESCC evaluation

- Monolothic silicon step-down regulator based on **BCD6s-SOI** technology
- 3V to 12V input voltage range (radiation performance guaranteed at **VCC up to 7 V**)
- **0.8V** to (0.85xVIN) output voltage range
- **Up to 7A** output current
- Integrated N-channel MOSFETs ; overcurrent & overvoltage protection
- **Flat-28 CuW** hermetic package
- **Radiation report available on demand :**
  - Total ionizing dose up to **100krad** ; **ELDRS-free**
  - **SEL-free** up to 70MeV/mg.cm² (@ VCC up to 7V)
  - **SEU-SEFI** characterized up to VCC=7V
  - **No performance degradation** due to **SET**
- **QML-V qualified : SMD 5962-20208, Flight models available**



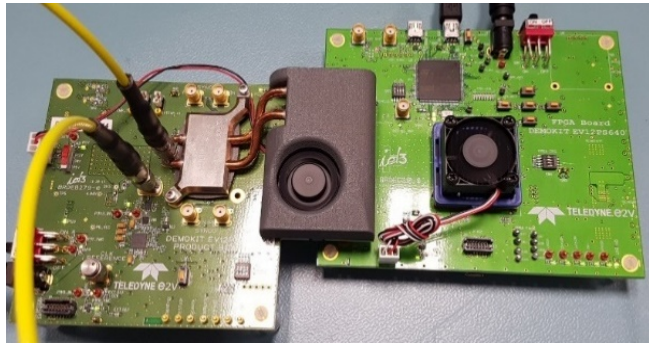
life.augmented

Designed to supply FPGA, DSP, MCU and ASICS for space use

Teledyne E2V- Direct conversion solution

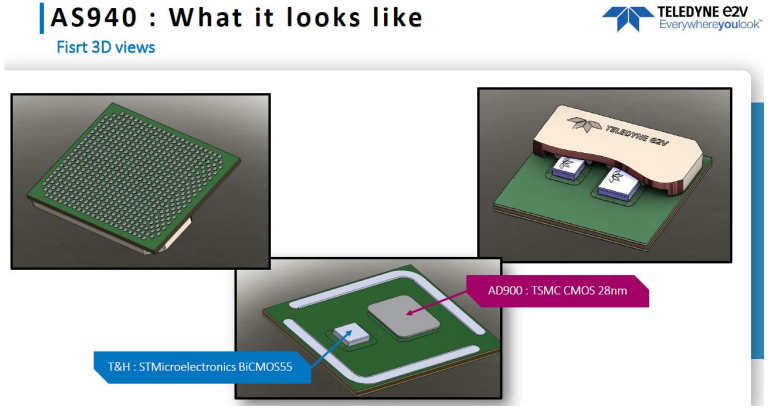
- **Proof-of-Concept of Direct Conversion to address new challenges :**
  - To design a data converter up to Ka band with more than 6.5 effective bits (ENOB at FS) with a very low power consumption
  - To develop Die-Package Co-design skills
  - To realize first SiP in Non-hermetic SiP Flip-chip assembly
  - Based on new TH design + 2 EV12AQ600 ADCs
  - Validation of the Concept on Eval kit
- **Next : AS940 Direct conversion module**
  - Design in progress → CDR : Q2/21
  - Performances to reach : Ka BW, 12Gsps, 2.5W…

CTB RM : Si74



PoC Eval kit during CNES bring-up

CTB RM : Si06



Supply chain :

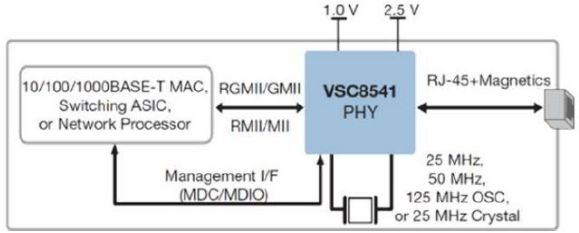
Design : T-E2V → Wafer fab : ST, Other → Assembly : T-E2V → Test & Qualification: T-E2V

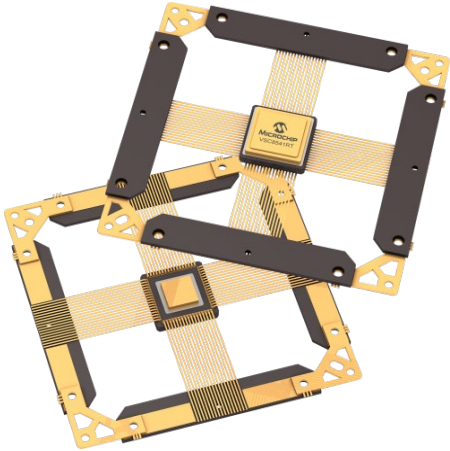
New Space : Microchip Rad-Tol Ethernet solution

CTB RM : SI104

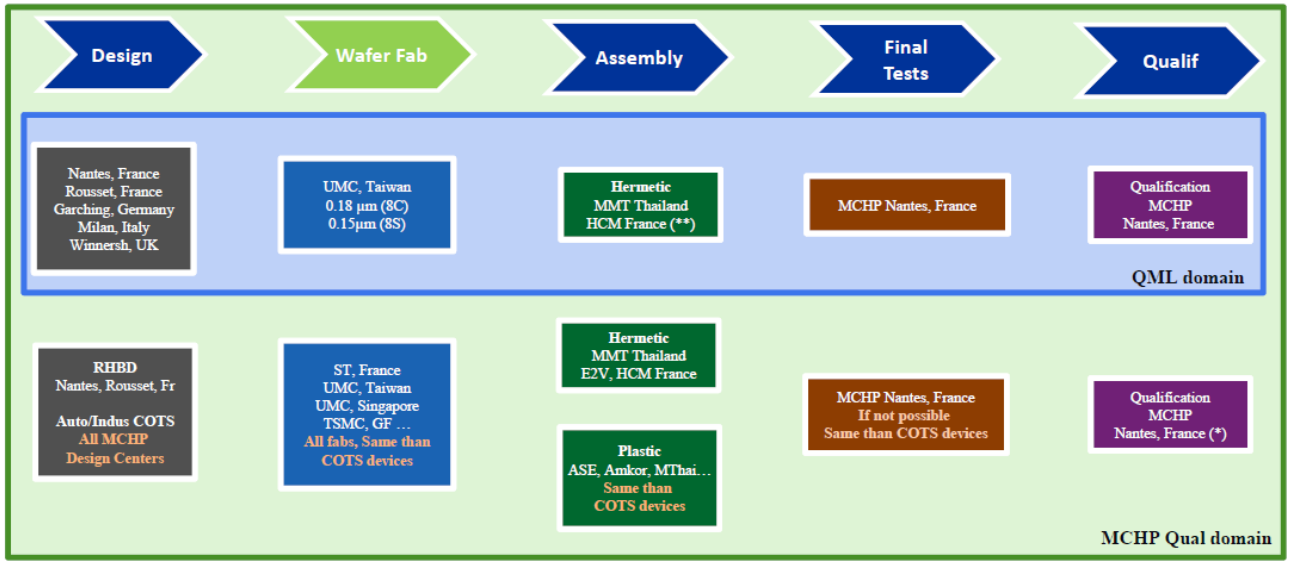
- Rad-Tolerant products from MCHP COTS catalog : Low cost offer
- Radiation evaluation & Qualification up to « New Space » levels (SEL free, 50krads min)
- Qualification according Space standards

- VSC8541RT Mbit/Gbit Ethernet PHY
  → Samples & Flight Models available





- Supply chain :



New Space : ST LEO offer

CTB RM : Si101, Si102

- Rad-Tolerant products from ST : Low cost offer
- Radiation evaluation & Qualification up to « New Space » levels (SEL free up to 45MeV/mg.cm², 50krads)
- Qualification according ST specification

❖ LOGIC:

→ LEOAC14, 00, 244 Flight Models available

→ Coming soon : LEOAC74,32, 08

❖ LVDS transceiver

→ LEOLVDSRD FM available

❖ Analog to Digital Converter

→ LEOAD128 FM available

❖ Power supply

→ Next : LEO3910 & LEOPOL01

CP	Function
LEOAC14	HEX SCHMITT INV
LEOAC00	QUAD 2-in NAND
LEOAC244	BUS TRANSCEIVER
LEOLVDSRD	LVDS Dver/Rver
LEOAC74	DUAL D FLIP FLOP
LEOAC32	QUAD OR
LEOAC08	QUAD 2-in AND

COTS Radiation assessment

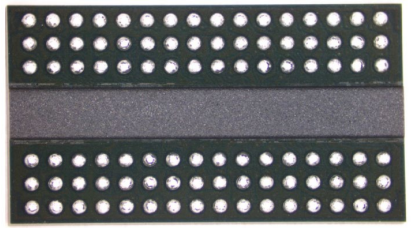
CTB RM : Si35

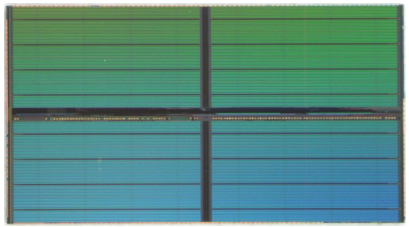
➢ Radiation assessment of DDR4 COTS Memories

➢ SEE and TID tests

	Référence	Description	Boîtier	Mfr.
1 bis	MT40A256M16LY-062E IT:F	DDR4 4Gbit (x16)	FBGA-96	Micron
2	K4A4G165WE-BITD (CL19)	DDR4 4Gbit (x16)	FBGA-96	Samsung
3 bis	H5AN8G6NCJR-VKI	DDR4 8Gbit (x16)	FBGA-96	Hynix
4	NT5AD256M16D4-HRI (CL19)	DDR4 4Gbit (x16)	FBGA-96	Nanya
5	MT40A512M16JY-075E AIT:B	DDR4 8Gbit (x16)	FBGA-96	Micron

→ Most of the parts are SEL free
→ SEU sensitive, Stuck bits observed
→ SEFI sensitive
→ Good behaviour under TID up to 100Krads





→ **Detailed Results will be published at RADECS21**

➢ Radiation assessment of FPGA SoC COTS

➢ See CNES presentation « Feedback on radiation test on SoC Components which can be very challenging regarding the complexity of such devices”

UMS GaN GH15

➢ SEE Radiation assessment of GH15-10

CTB RM : MW054

➢ GH15-10 is based on SiC substrate and is well-suited for a wide range of applications up to 35GHz. It enables the design of high power, high linearity and high PAE products.

On state : **32.5V @ 200 mA/mm** demonstrated

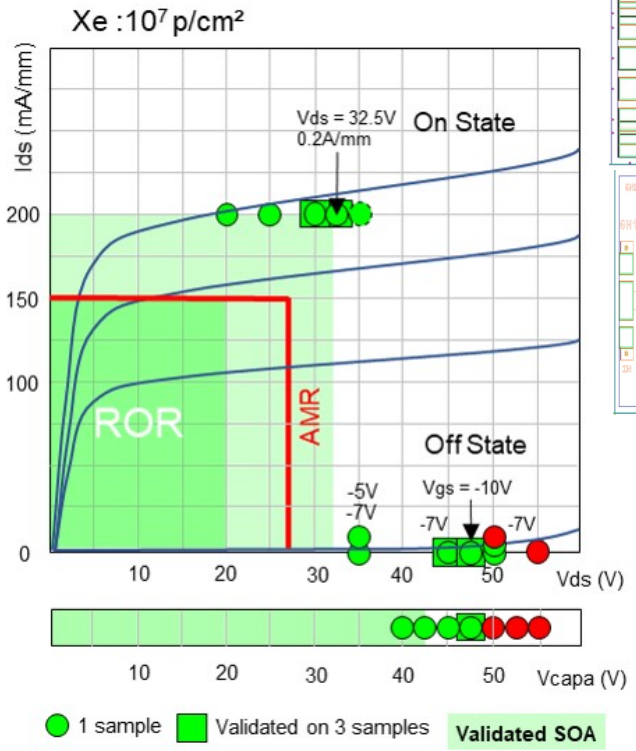
Off state : 47.5V demonstrated: probably limited by the capacitor placed on the drain of the DEC

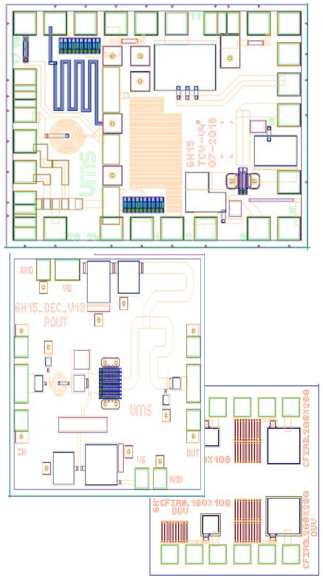
Biasing conditions	SEB - failure	SEB validated	ROR	AMR
On state (Vds / Ids)	No failure up to 35V	**32.5V** @ 0.2A/mm	20V @ 0.15A/mm	27V @ 0.15A/mm
Off state (Vds / Vgs)	1st failure at 50V/-7V	**47.5V**/-10V Vdg = 57.5V	Vgs = -15V Vdg = 65V	Vgs = -15V Vdg = not defined

Standard Transistor Rad Hard Operating Area and Maximum Rating

Electrical parameter	SEB - failure	SEB validated	Max rating for space	ROR	AMR
Capacitor voltage	1st failure at 48.5V	47.5V	**42.5V**	80V	130V

MIM capacitor Rad Hard Operating Area and Maximum Rating





Test structures used

United Monolithic Semiconductors

→ Next : EPPL Listing

Thank you for your attention !