

Digital Programmable Controller (DPC) : radhard die in low cost plastic package.

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Analogue and Mixed-Signal Integrated
Circuits for Space Applications
Leuven 18-20th June



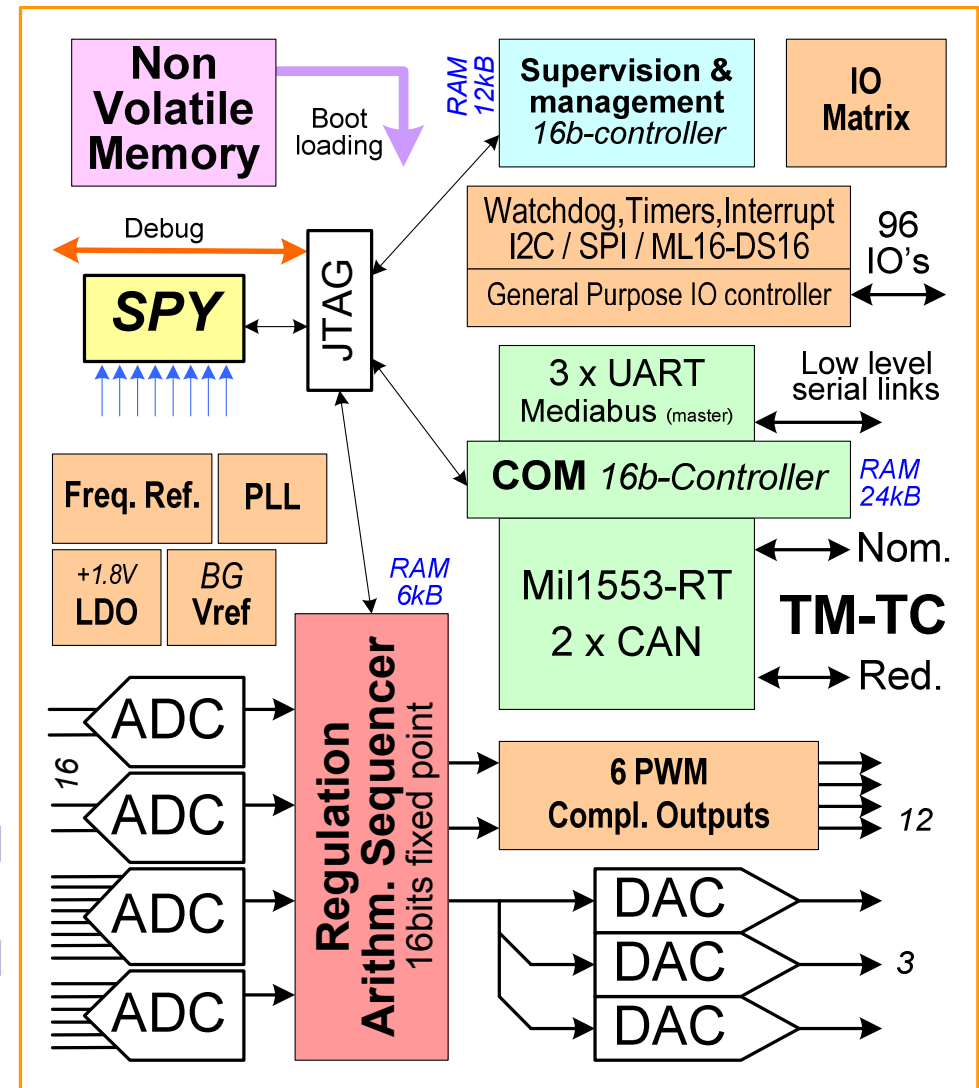
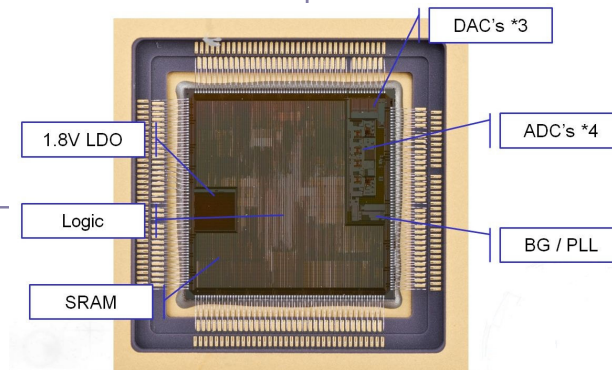
Overview

On chip :

4x CPU 16bits OpenMSP430
No OS / One CPU = one task
42K memory
RC oscillator + 120MHz PLL
LDO +1.8V
Bandgap
13bits ADC + input MUX
12 Bits DAC

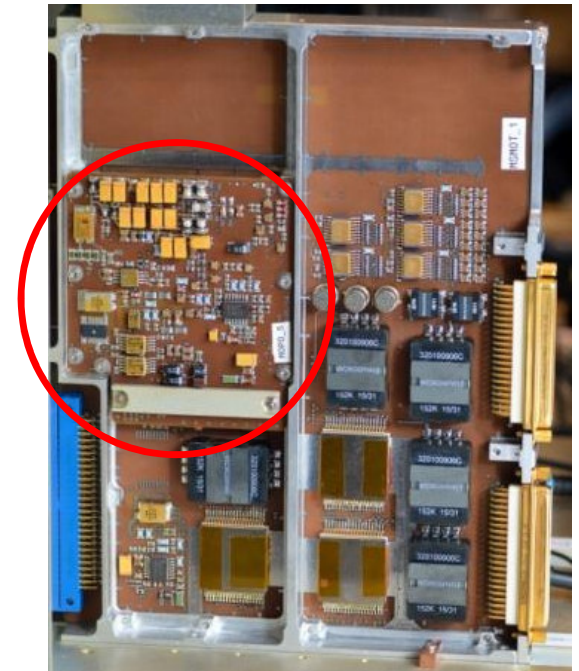
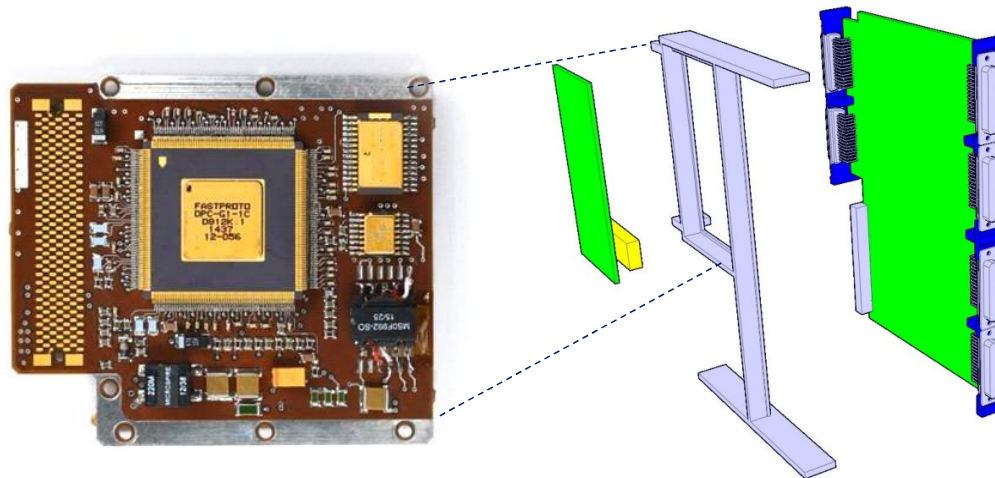
Off Chip:

E2prom
+3.3V regulator
DARE on UMC 0,18μ
CQFP 256 pins



RTU product based on DPC Plugin Module

- DPC mezzanine (DPM) in all modules
- Very efficient implementation
<10% of module surface
- CFI for partnership
- Standardized « CAN » client based on DPC.



CAN bus in backplane

- Maximum use of DPC component
 - Scheduler of CAN bus & RT each board
 - Unit front end to OBC (1553 IF management)

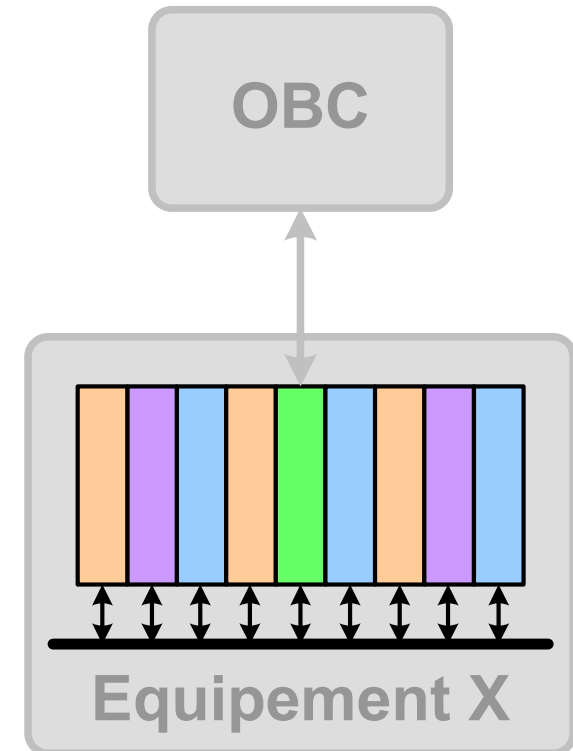
The data link layer

- Variety of standard **off-the-shelf** IPs
- Take care of the message transmission &

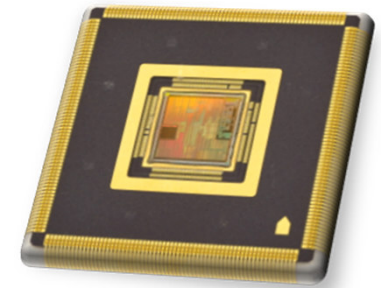
The service layer « CANopen » (optional)

- Up to now, TAS-B has used:
 - Object dictionary
 - COB-ID for service addressing
 - PDO/SDO messaging protocols
 - SYNC for TM/TC synchro between modu
 - TIME for TM time stamping

OSI Model Layer	Function	Relevant services
7. Application	Access to the services	TC transfer
6. Presentation	Data management	TM acquisition
5. Session		Object Dictionary
4. Transport	Communication management	CANOpen SDO
3. Network	Access to modules	Expedited Domain transfer
	Acceptance filtering	Block Up/Download
	Data encapsulation	Framing
2. Data Link	Frame coding (stuffing)	
	Acknowledgement	CAN ISO 11898-1
	Specification variation (STD/EXT)	
1. Physical	Bit Encoding/Decoding	
	Synchronization	Physical transport
	CAN High Speed	



DPC G1 CQFP 256 : status



- is **qualified** according to ESCC9000 since Feb 16th, 2017
- is **RadHard**
- is **free of any US control**: no risk if US export regulation change again
- is **available** without restrictions for all **ESA** projects
- is **available for space community**

- Gyro with ONERA
- Robotics with DLR
- RTU with QinetiQ Space
- And many more to come



2 1 8

FM produced

1 5

Application SW that successfully passed CDR

1 0 2

Hours under harsh radiation environment

0 1 6

Months since qualification according to ESCC 9000

0 5 1

Months since first on board integration

0 8

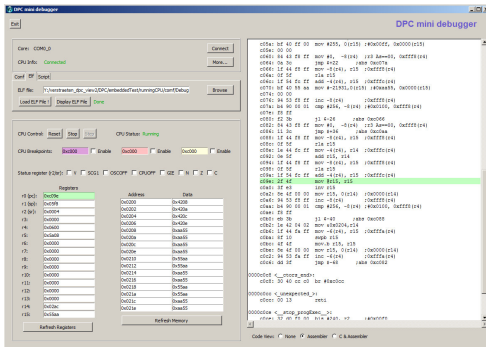
Companies & institutions using DPC

4 0 0 0

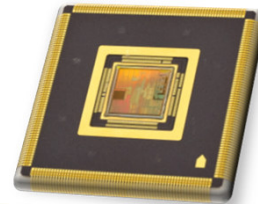
Extended life test



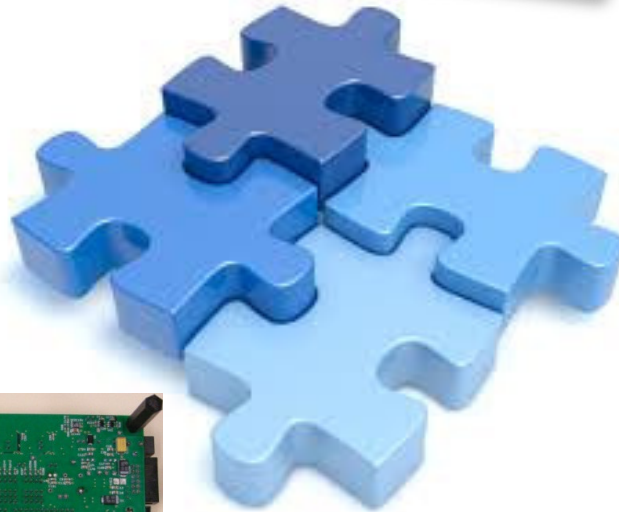
DPC product line : a complete set



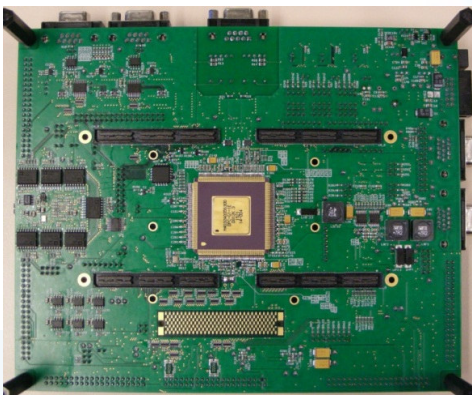
Easy-to-use SW
development kit



Qualified Hermetic ASIC



FM Grade Plugin module

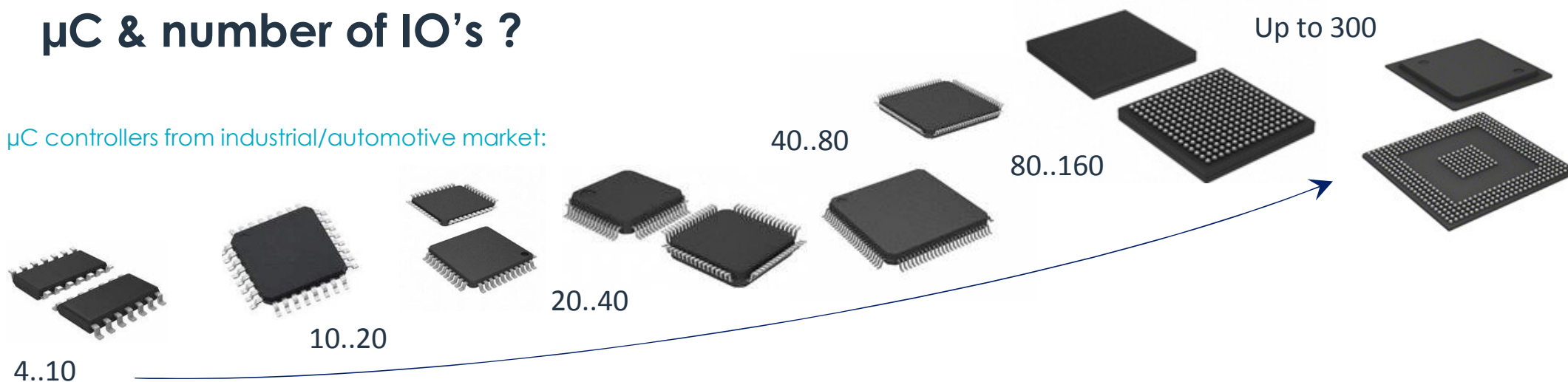


Fully equipped Lab Reference kit
(Evaluation board)



μC & number of IO's ?

μC controllers from industrial/automotive market:



Reason = exact scaling to real needs

- Save money
- Save area on PCB
- Save power consumption
- Easier assembly

In space applications ...

- Low volumes ...
- Super high investment for individual qualification of each variant

➡ $\frac{\sim 1 \text{ Mio€}}{\sim 1000 \text{ pcs}} = \text{too high !}$

➡ “who can most can least” ...
256 pins
108 digital + 22 analog IO's
Clock gating on un-used features
Use IO extenders ... ☹

CQFP 256



New target: New Space customers

Lower cost

Lower footprint on PCB

DARE non-hermetic packaging ?

CCGA / PQFP / PBGA / QFN / CSP ???

Selecting the Right Mitigation for BGAs and QFNs

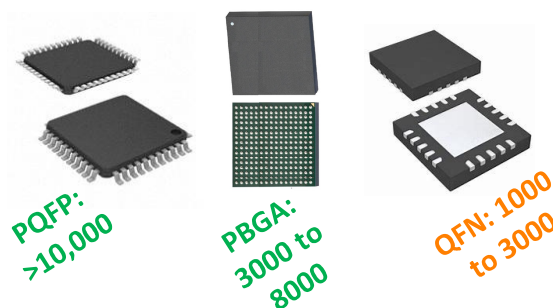
Presentation · May 2016

DOI: 10.13140/RG.2.2.12499.78880

Craig Hillman & Nathan Blattau

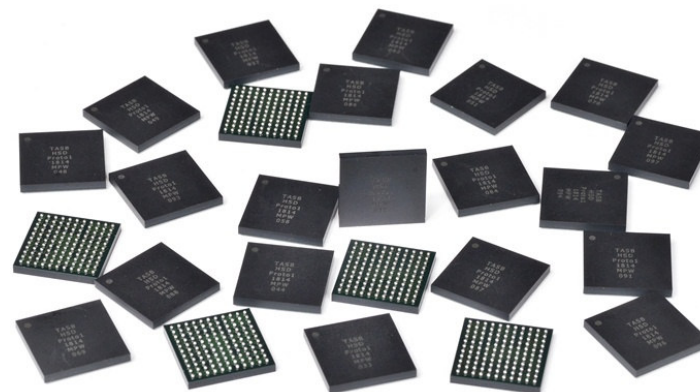
DFR Solutions

cycle to solder failure due thermal cycling from -40°C to 125°C



Flip-chip CSP
< 1000

Let's go



Effect of Area Array Package Types on Assembly Reliability & Comments on IPC-9701A

Reza Ghaffarian, Ph.D.

Jet Propulsion Laboratory, California Institute of Technology Pasadena, CA

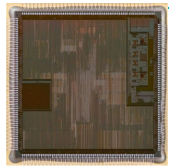
Reza.Ghaffarian@JPL.NASA.Gov, (818) 354-2059

Plastic package assemblies did not show failures to 2000 cycles whereas CCGA 560 I/O assemblies showed the first failure at 1075 cycles when they were subjected to -50/75°C cycle.



Towards BGA ...

DPC die



IMEC IClink
Design house



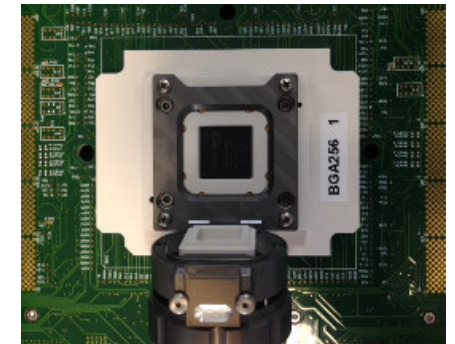
Substrate manufacturing,
assembly, molding & balling



BGA components



Performance
characterization



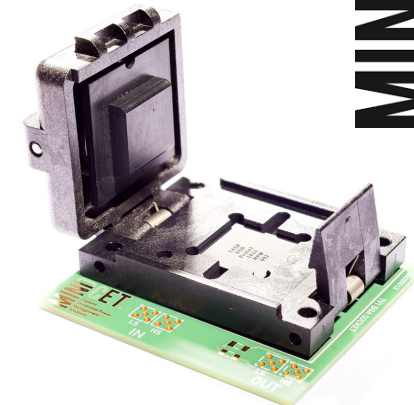
Design house, Substrate
manufacturing, assembly, molding
& balling

LAT, qualification & screening

BGA components



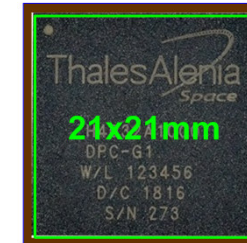
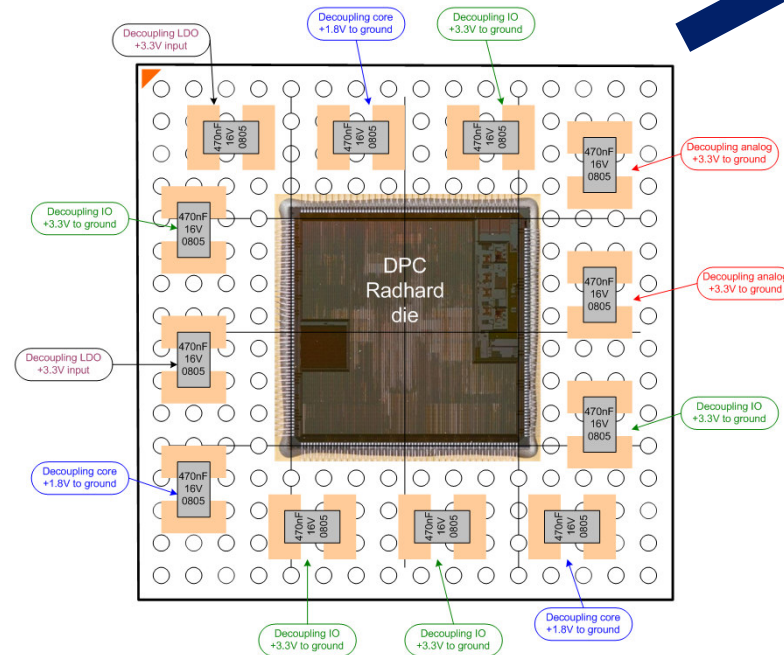
Performance
characterization



Reduced PCB footprint x5

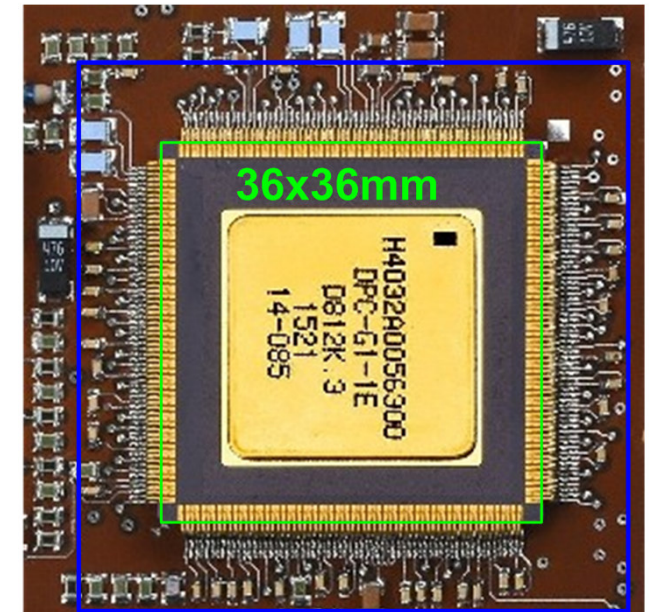
12 supply decoupling capacitors embedded inside package:

- Decoupling more efficient
- loop length -70%
- much lower serial impedance



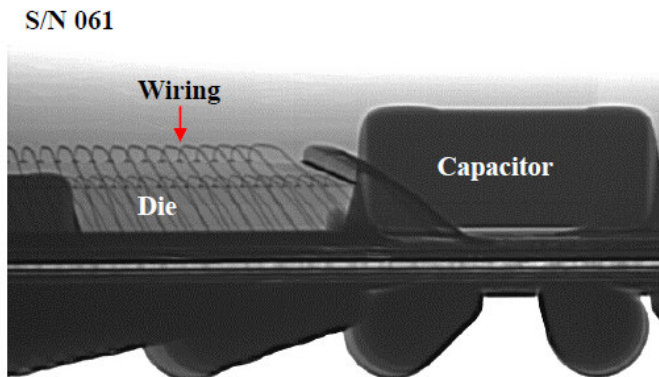
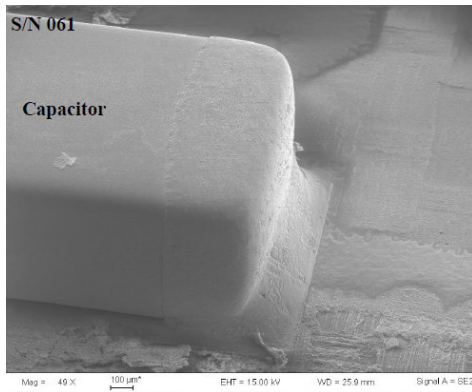
23x23mm

52x52mm

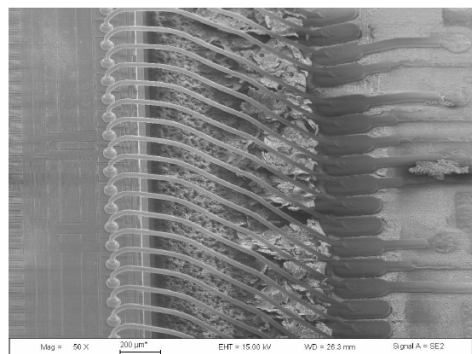


DPC BGA : Construction analysis

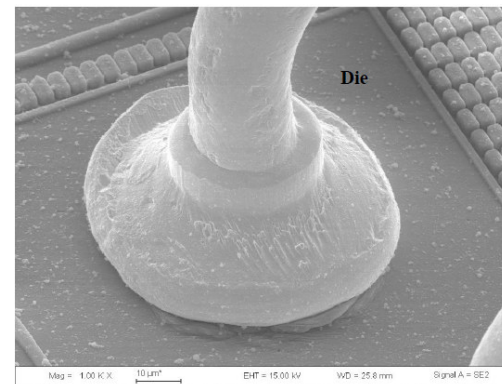
🚀 In depth construction analysis performed by a well-known independent lab



XRAY side View of assembly



SEM View of wire bonding



SEM tilted views of ball bond



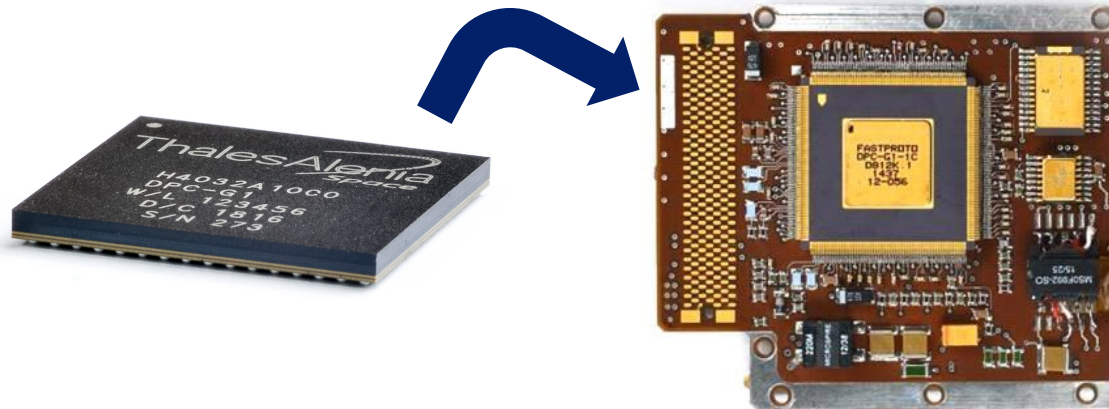
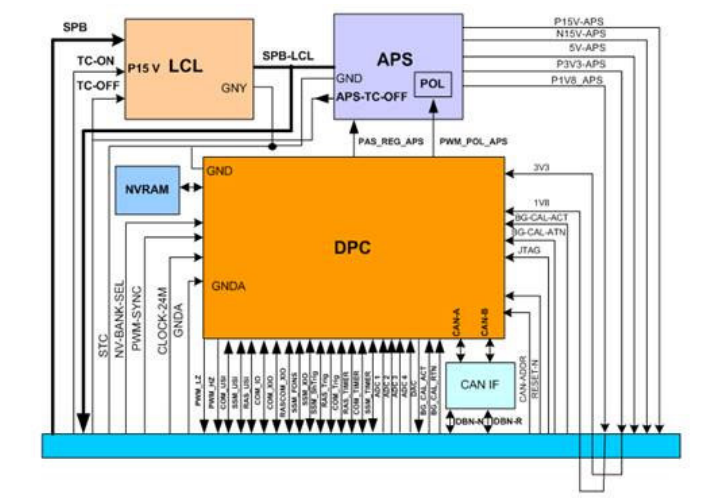
All inspection areas are correct and without anomaly



DPM = DPC Plugin Module

Use of existing building blocks:

- CAN interface (HW & firmware) ready
- No re-design: focus on new applications
- Standard & stable back-plane I/F
- Stable routing of complex function
- Firmware validation at DPM level



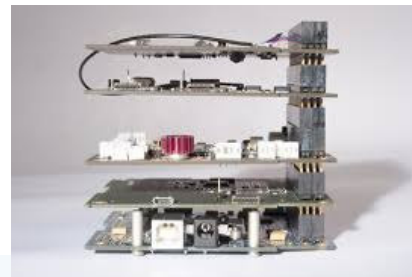
Ready for New Space
electronics

DPC BGA : first usage in Cubesat

- OBC Tasks
 - Subsystems control & TMTC
 - Sat monitoring
 - AX25 communication mngt with ground
 - Antenna management
 - Event logger
 - Time management and distribution
 - Selftest
 - ...



OBC with DPC BGA



2018 Thales Alenia Space

THALES ALLENIA SPACE OPEN

Ready for RH OBC on Cubesat



DPC G1 BGA 256 : status



- is **tested** as prototype
- is **RadHard** (same die than CQFP version)
- is **free of any US control**: no risk if US export regulation change again
- Is planned for a completed qualification **end 2019**



2	0	0
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Protos produced

0	3
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New TAS Products targetting DPC BGA

0	1
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Cubesats using DPC BGA

