EUROPEAN SPACE COMPONENT CONFERENCE

ESCCON 2011

THE EXPERIENCE OF COMMERCIAL COMPONENTS INSERTION IN PEM (GAIA PROGRAM)

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All the space you need

ASTRIUM
AN EADS COMPANY

WHY COMMERCIAL COMPONENTS ?

- The demanding performances of the GAIA-PEM (Proximity Electronic Module) made necessary the use of commercial components for several critical functions.

- Driving requirements for GAIA-PEM design are :
  - In first place, electrical performances :
    - Low noise
    - Power dissipation stability
    - Limitations in power dissipation
    - Very tight timing uncertainty
  - Limited volume and weight
  - Minimum interconnections

HOW COMMERCIAL COMPONENTS HAVE BEEN SELECTED ?

- The selection of these components has been made along the different R&D activities.
- During these studies it has been analysed many alternatives for each function looking for a radiation tolerant, at least evaluated or used in previous missions.
- The most relevant components have been included in different design alternatives, assembled and characterised with respect to their main relevant parameters influencing the PEM performances.
- No space or military qualified component has been identified to meet the PEM performances.

WHAT WE DID ?

- Collaboration within Astrium (Spain & France) for the selection, procurement and use of commercial components.
- Selection process based on procedures commonly built by the French multi-partnership :
  - Guidelines on the use of parts out of manufacturers specified temperature range (up rating) : RNC-CNES-Q-60-511
  - Selection procedure for electrical, electronics and electromechanical (EEE) commercial components intended to be used in space applications : RNC-CNES-Q-60-514
- Components selection :
  - Identification of commercial candidates (including back up)
  - Preliminary assessment
  - Risk analysis
  - Proposed commercial components baselines

WHAT TYPES OF COMMERCIAL COMPONENTS HAVE BEEN ANALYZED ?

- More than 60 video operational amplifiers, rail to rail and single supply voltage, providing very low noise and low input offset voltage and input bias current.

  Identified candidate : AD 8028

- More than 50 ADC's providing 16 bit or better resolution, preferably SAR architecture with no pipeline delay and with conversion time faster that 1,2 us.

  Identified candidate : AD 7621

- More than 15 analog switches, providing low R_{on}, fast switching time, and low and single supply voltage.

  Identified candidate : MAX 313, 1st back up candidate : ADG 451, 2nd back up candidate : SWI ISL43110

- Several fast clock drivers.

  Identified candidate : EL 7457

- Multiple, preferable octal or larger, 8-bits DACs.

  Identified candidate : MAX 521 (back up candidate : AD 7228)

GENERIC POLICY FOR COMMERCIAL COMPONENTS APPROVAL (1)

1) TO COMPLETE A JUSTIFICATION DOCUMENT (JD)

- To collect available data on the commercial components (general information, literature, supporting data on previous lots, data sheet)
- To define an evaluation plan (including radiation tests)
- To define the screening flow of the FM lot.

2) TO PROCURE THE FM LOT

- The FM lot is procured, according to manufacturer data sheet.

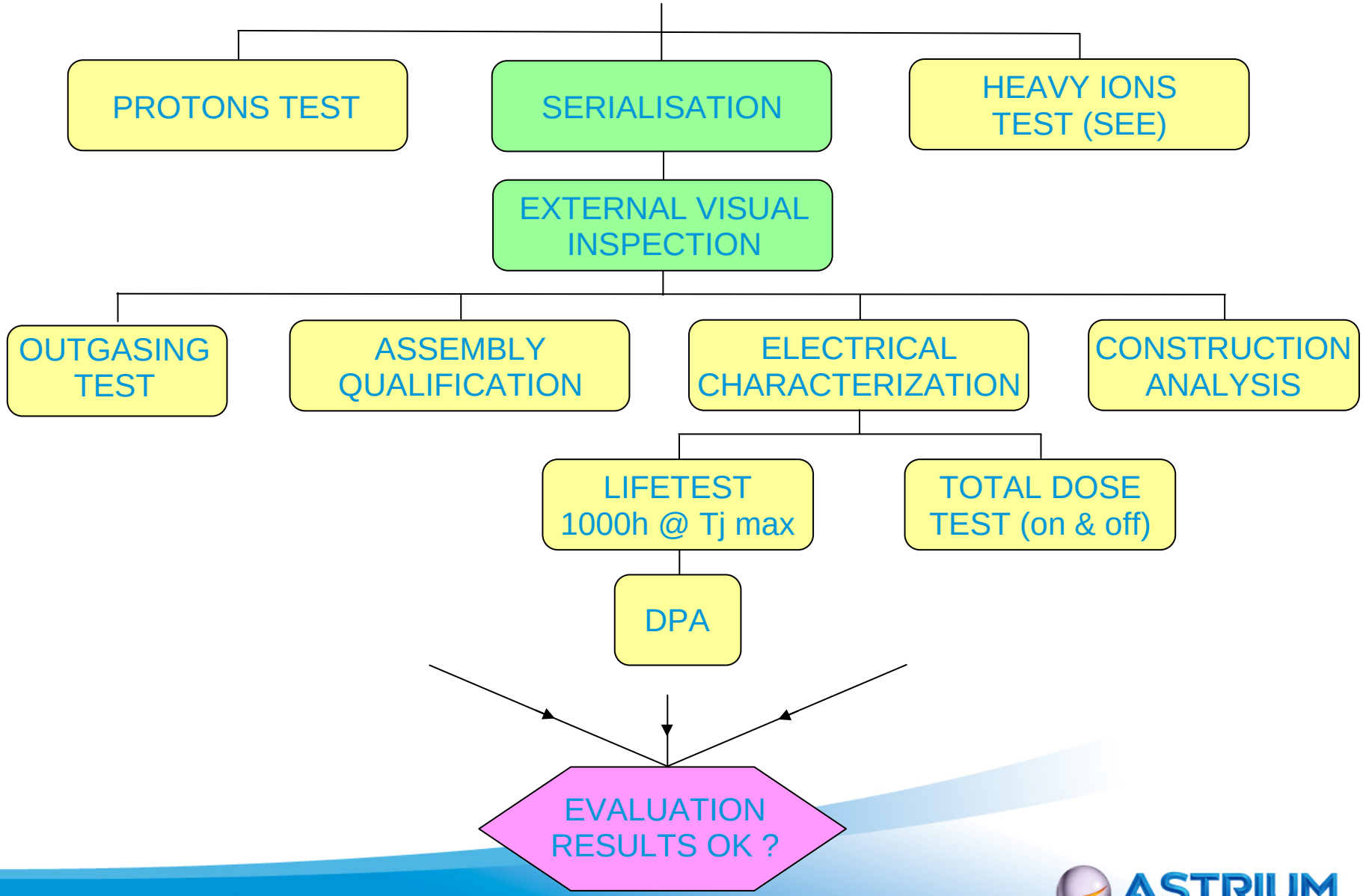
3) TO PERFORM AN EVALUATION OF THE FM LOT

- The evaluation of the FM lot is performed, according to the JD plan and to the risk analysis raised to identify the most urgent tests to be done (SEE, constructional analysis, life test, out gassing…).

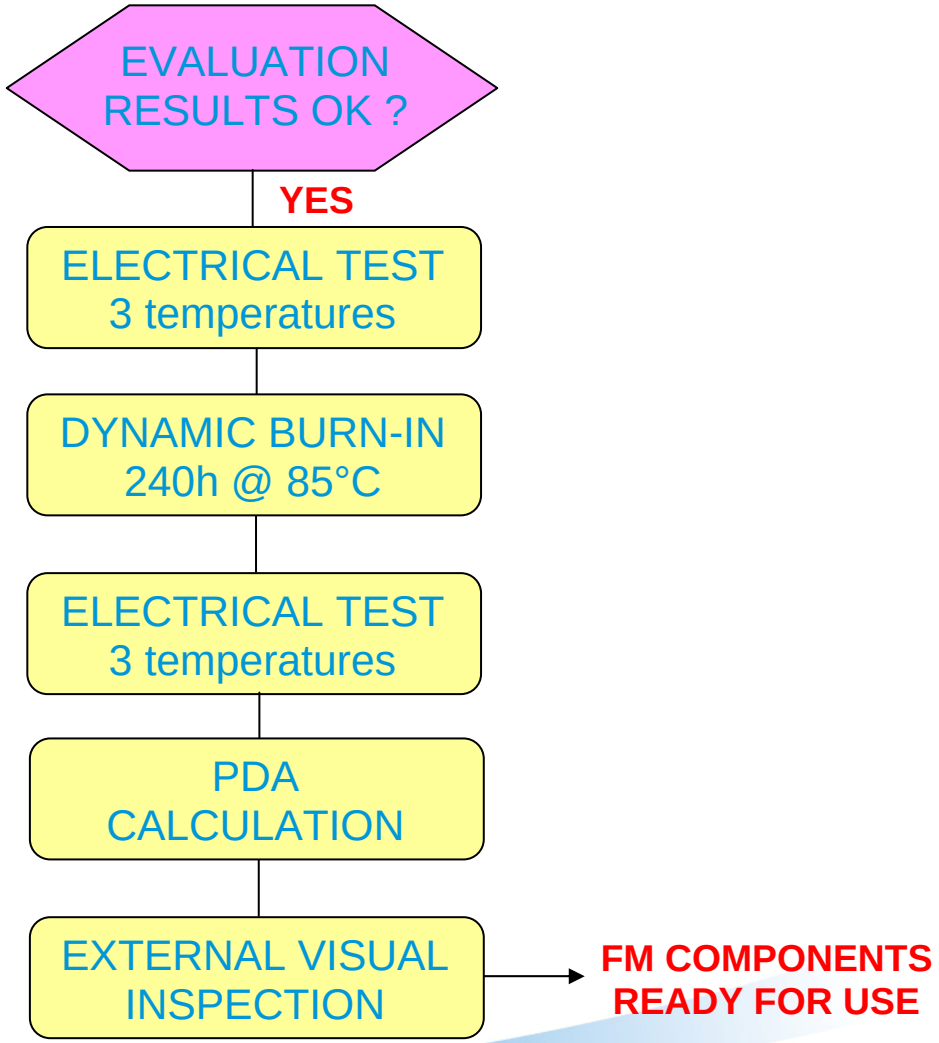
4) TO SCREEN THE WHOLE FM LOT

- The FM lot is screened by the user (based on the evaluation results)
- Since evaluation is done on the FM lot, no additional LAT is requested

GENERIC EVALUATION FLOW CHART



GENERIC SCREENING FLOW CHART (BY USER)



JUSTIFICATION DOCUMENTS
RESULTS OF THE SELECTION

FUNCTION	TYPE	MNFCT	CASE	TEMP RANGE	RISK ANALYSIS CONCLUSIONS
VIDEO AMPLIFIER	**AD8028AR**	AD / US	SOIC 8	-40°C/+125°C	- AD major manufacturer = no risk for front / back end - Transient sensitivity
ANALOG SWITCH	**MAX313L**	MAX / US	SOIC 24	-40°C/+85°C	MAXIM = risky manufacturer => CA to be anticipated
ANALOG SWITCH (Back up)	**ADG451BR**	AD / US	SOIC 16	-40°C/+85°C	- AD major manufacturer = no risk for front / back end - TID (at VLDR) - Transient sensitivity
CLOCK DRIVER	**EL7457CS**	INT / US	SOIC 16	-40°C/+85°C	Urgent CA to identify mask reference for SEL test
ADC	**AD7621AST**	AD / US	LQFP 48	-40°C/+85°C	AD major manufacturer = no risk for front or back end
DAC	**MAX521 BEWG**	MAX / US	SOIC 24	-40°C/+85°C	MAXIM = risky manufacturer => CA to be anticipated

EVALUATION RESULTS
DIE & PACKAGE

TYPE	PROCURED LOT	CONSTRUC-TION ANALYSIS	OUT GASSING	ASSY QUALIF	EVAL. RESULTS
AD 8028	One DC	OK	OK	OK	OK
MAX 313	One DC	FAILED	Not done	Not done	REJECTED
ADG 451	One DC	ACCEPTABLE	OK	OK	OK
EL 7457	One DC	OK	OK	OK	OK
AD 7621	One DC	OK	OK	OK	OK
MAX 521	One DC	OK	OK	OK	OK

EVALUATION RESULTS
ELECTRICAL & ENDURANCE

TYPE	ELECT. CHARACT. @ -40°C, 25°C, 85°C,125°C	DYNAMIC LIFE TEST	ELECT. TESTS AFTER LT @ -40°C, 25°C, 85°C,125°C
AD 8028	Acceptable	1000H @ 125°C	0 reject
ADG 451	Acceptable	1000H @ 125°C	0 reject
EL 7457	Acceptable	1000H @ 105°C	0 reject
AD 7621	Acceptable	1000H @ 115°C	0 reject
MAX 521	Acceptable	1000H @ 125°C	0 reject

EVALUATION RESULTS
TOTAL DOSE (RVT)

		DOSE RATE	TID RESULTS
VIDEO AMPLIFIER	**AD 8028 AR**	140 Rad(Si) / h	OK up to 30 Krad
ANALOG SWITCH	**ADG 451 BR**	LDR = 40 Rad(Si) / h VLDR = 3.3 Rad(Si) / h	LDR: Is (OFF) < 0.6 Krad VLDR: Is (OFF) < 0.3 Krad
CLOCK DRIVER	**EL 7457 CS**	40 Rad(Si) / h	OK up to 30 Krad
ADC	**AD 7621 AST**	140 Rad(Si) / h	OK up to 30 Krad
DAC	**MAX 521 BEWG**	40 Rad(Si) / h	OK up to 30 Krad

EVALUATION RESULTS
HEAVY IONS & PROTONS

	SEL or SEB/SEGR	SEU	SET	PROTONS
AD 8028	SEL Insensitive	Insensitive	Sensitive	Insensitive up to 190 MeV
ADG 451	SEL Insensitive	Insensitive	Sensitive	NA
EL 7457	SEB sensitive SEGR Sensitive	Insensitive	Sensitive	NA
AD 7621	SEL Insensitive	SEU sensitive SEFI sensitive	Insensitive	Insensitive up to 190 MeV
MAX 521	SEL Insensitive	Sensitive	Sensitive	NA

SCREENING RESULTS

	ELECTRICAL TESTS BEFORE BI @ 3 T°	DYNAMIC BURN IN	ELECTRICAL TESTS AFTER BI @ 3 T°
AD 8028	OK (1 reject)	240H @ 85°C	OK (0 reject)
ADG 451	OK (0 reject)	240H @ 85°C	OK (0 reject)
EL 7457	OK (1 reject)	240H @ 85°C	OK (0 reject)
AD 7621	OK (11 rejects)	240H @ 85°C	OK (7 rejects)
MAX 521	OK (0 reject)	240H @ 85°C	OK (0 reject)

SYNTHESIS OF EVALUATION AND SCREENING RESULTS

		PROC LOT	EVALUA-TION RESULTS	RVT	SEL or SEB/SEGR	SEU	SET	SCREE-NING
VIDEO AMPLI	**AD8028**	One DC	OK	OK up to 30 Krad	SEL Insensitive	Insensitive	Sensitive	OK
ANALOG SWITCH	**MAX313**	One DC	LOT REJECTED (MAVERICK LOT)					
ANALOG SWITCH	**ADG451**	One DC	OK	Sensitive (VLDR)	SEL Insensitive	Insensitive	Sensitive	OK
CLOCK DRIVER	**EL7457**	One DC	OK	OK up to 30 Krad	SEB/SEGR Sensitive	Insensitive	Sensitive	OK
ADC	**AD7621**	One DC	OK	OK up to 30 Krad	SEL Insensitive	SEU + SEFI sensitive	Insensitive	OK
DAC	**MAX521**	One DC	OK	OK up to 30 Krad	SEL Insensitive	Sensitive	Sensitive	OK

EXPERIENCE AFTER EQUIPMENTS MANUFACTURING

1) 110 FM Proximity Electronic Modules (PEM) manufactured

2) 96 FM PEMs already tested

3) Feed back after components mounting :
   - No problem during mounting

4) PEM electrical performances
   - PEM qualification : successful
   - No application temperature highest than Tmax :
     - +60ºC during qualification (QM)
     - +55ºC during acceptance (FM).
   - Electrical tests at PEM level showed no drift and a good reproducibility of performances

CONCLUSION - COST SYNTHESIS

- Cost of components selection : 350 K€ (27%)
  (Initial engineering activities, data collection, results analysis, Justification Document completion)

- Cost of components procurement : 50 K€ (4%)
  8 types & 8900 components procured
  5 types & 2688 available components for FM

- Cost of tests activities : 900 K€ (69%)
  (Evaluation, screening, radiations, …)

TOTAL AMOUNT 1300 K€
(cost of ownership)

CONCLUSION - OVERALL EXPERIENCE (1)

- The selection of commercial components has been done for performance reasons (access to high capacity or speed) results in higher performing, reduced size and lighter equipments with less interconnections.
- Successful approach by combining evaluation and lot acceptance test on the FM lot :

  => It reduces the risk of quick evolution of mask & technology between evaluation and procurement of flight components.
- In 5 of 6 cases => the lot qualification results have been successful.
- Successful management of traceability w.r.t. radiation.
- The use of commercial components induces a lot of engineering activities (selection, JD, evaluation, …) generating very high non recurring cost :

  => **don't use commercial components for cost saving !**

CONCLUSION - OVERALL EXPERIENCE (2)

The non-availability of high performing and high reliability EEE components for the GAIA mission imposed the use of commercial components.

This has been positively proven on a few types.

Strength	Weakness
▪ Electrical performances incomparable vs HI REL components ▪ Low mass and small packages ⇒ SMALLEST & LIGHTEST EQUIPMENTS	▪ Many products on the market ⇒LONG PRELIMINARY SELECTION ▪ Unknown reliability and radiation behaviour ⇒ BACKUP SOLUTIONS REQUESTED ⇒ HARD AND RISKY EVALUATION TO BE DONE ⇒ HIGH FINAL COST ⇒ SCHEDULE / DESIGN IMPACTS WHEN EVAL. FAILS ▪ Components storage (Nitrogen) ▪ Preliminary cost evaluation

DON'T BE AFRAID TO USE COMMERCIAL EEE COMPONENTS IN CASE YOU NEED HIGH PERFORMANCES

BUT

DON'T BELIEVE YOU WILL SAVE MONEY BY USING COMMERCIAL EEE COMPONENTS

THANK YOU FOR YOUR ATTENTION