

GR740 User Day

Conclusion

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Apollo AGC: 1961 – 1969 (first moon landing)

This development: 2009 – 2019 + a few more years to fly

→ Why did it take us so long...?

- Complexity
5 kGates for AGC → ~5 MGates GR740
- Technology Readiness
65 nm new in space → but 2-NOR-Gate ICs were new in the 60's as well
- Political constraints
AGC was strategic priority of a single nation – defense budget
ESA / GEO-return constraints – not all delegations supporting
Use European / ESA developed technology
- Budget
AGC: 75 units @ 200k\$ = 15 M\$ at its time (= 90 M\$ today)
NGMP / GR740: < 5 MEUR for the chip development
- Mistakes
Design errors
Wrong choices (flip-chip vs wire-bonding?)

Components Qualification: Valley of Death

Lower TRL's covered by R&D budgets

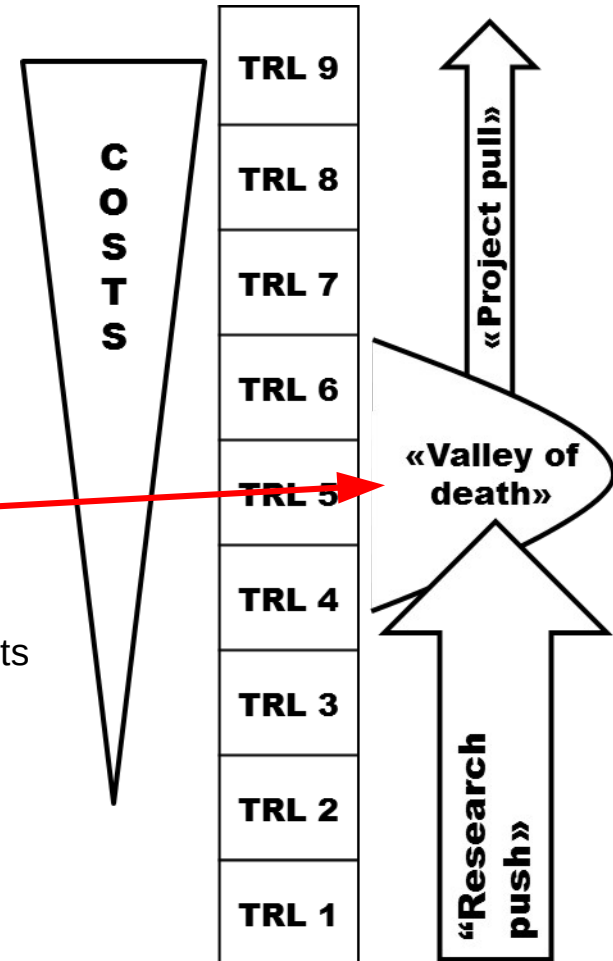
- At least that worked in the past
- Not sure about the future...

Highest TRL (sometimes) covered by user projects

- e.g. AT697E screening funded by Proba-2
- e.g. AGGA4 radiation testing funded by Metop

The Valley of Death

- Need to raise TRL to a level sufficient to be selected by projects
- Increasing complexity of components
 - project 'acceptance threshold' increases
 - valley gets wider (and deeper)
- No or not sufficient funding in R&D programmes
- ECI programme helped in the past - discontinued
 - GSTP requires national support → GEO-return constraints!



Source: ECSS-E-HB-11A DIR1 (TRL handbook)

European Space Agency

GR740 enhancements

- Cobham Gaisler plans as presented possibly supported in optional ESA programmes (GSTP, ARTES)
- Several SW (qualification) activities still planned / in progress

Long term: RISC-V

- Currently at R&D stage for ESA, only small funding allocated
- ITI activity “Introduction of Fault-Tolerant Concepts for RISC-V in Space” just completed
- PhD cooperation to add fault-tolerance to RISC-V planned, possibly test chip (KU Leuven)

Chip technology

- 28 nm FDSOI used for FPGA development, currently no open access
- 22 nm FDSOI used in an ESA project, space platform planned under EU funding
- 16 nm and below: ESA study just started

Industry

- Cobham Gaisler, ST Microelectronics as key suppliers for chip development and manufacturing
- Many other companies / institutes involved in supply chain, SW ecosystem or as consultants, early users / benchmarkers

ESA

- Several colleagues in my division, line management and TRP/GSTP office for pushing
- Contracts / Finance control helping with many contracts, CCN's, call-off-orders
- Swedish delegation supporting the qualification with major spending outside of their country
- Earth Observation programme for supporting the qualification

Special thanks...

- ... to André Pouponnot, initiator of the NGMP and coach in my early years at ESA