EUTELSAT PERSPECTIVE ON HIGH END DIGITAL PROCESSING ENABLED BY USING COTS

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Eutelsat is at the forefront of innovation and looks with interest at the introduction of new technologies into its satellites

Commercial Off The Shelf (COTS) high end digital components can be the way to go to dramatically improve On Board Processor performance, while providing SWaP and Quality features adequate for our GEO satellites

COTS – A RAW OVERVIEW

COTS

Documentation and standards: few available

Testing approach: statistical testing on high volume production, process control oriented

Risk management: local to Project

Reliability prediction: tools to be improved according to technological improvements

Space Qualified

Documentation and standards: MIL-STD, ECSS

Testing approach: parts testing and strict process control

Risk management: based on risk avoidance since early stages

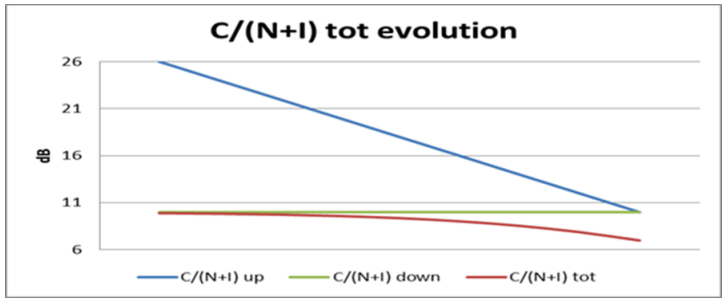
Reliability prediction: tools matured thanks to cumulated experience

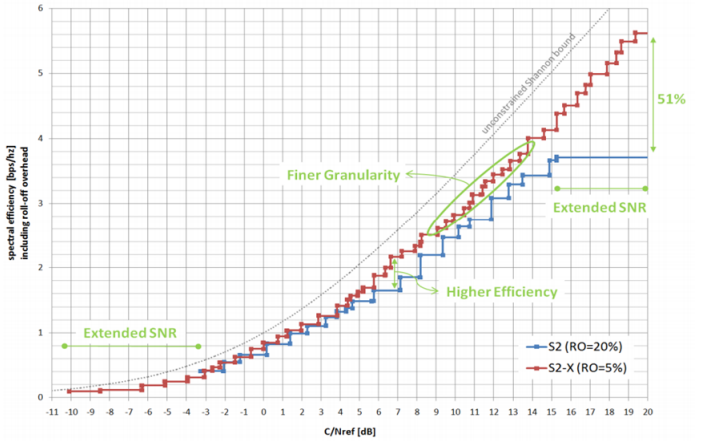
Affected areas

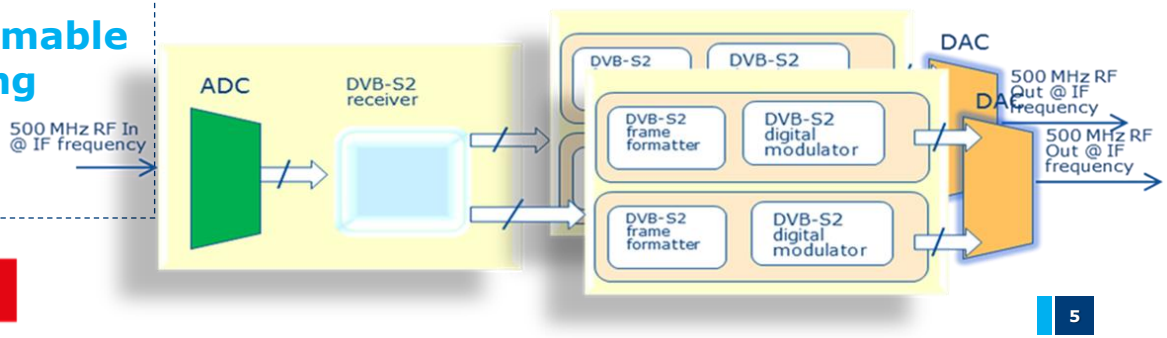
- Technology: die, packaging, soldering, testing, screening
- Engineering: procurement, up-screening, qualification and acceptance testing at board level and upper
- RAMS analysis: protection emphasized on circuit control & management section
- Trade–off: additional performance vs implementation cost

WHERE WE STARTED….

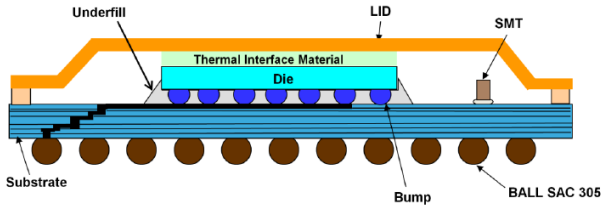
- **2015 RFI on "Gateway reduction by On Board Regenerative Processing"**
  - Idea was to be able to consistently reduce the number of Gateways in an HTS system for the same provided FWD capacity, thanks to superior up-link performance which can be translated into higher spectral efficiency;
  - By embarking a Regenerative Processor and taking into account the "natural" oversizing of the uplink feeder link, target of halving the number of Gateway was addressed;
  - Several response to the RFI from Satellites Primes and Digital Processor suppliers, backed by Technology providers, did show that the target was realistic for bandwidth sizes up to few hundreds of Gigahertz, however at the expense of a relevant portion of the S/C resources, mainly in terms of DC power;
  - One important requested feature was about reprogrammable devices, in particular for Tx section, to be future-proof towards evolution of DVB protocol;
  - General approach in the OBP design was to use ASIC for demodulation / decoding up-link branch and reprogrammable FPGA for the Tx section; several proposals were targeting usage of COTS for reaching / improving performances;

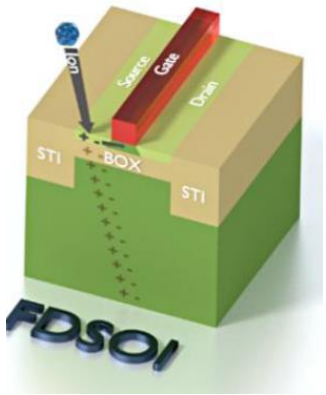


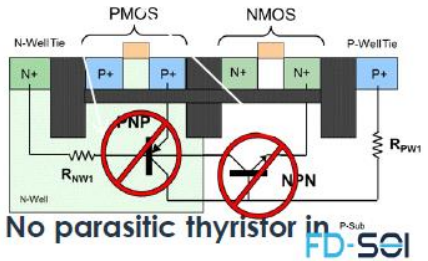




…WHAT WE UNDERSTOOD…







TAS credit

- ➔ **Last year Eutelsat has ordered Konnect VHTS to TAS;**
- ➔ **The DTP 5G represents the "core" of the entire Mission;**
  - → **Installed processing bandwidth in excess of 200 GHz, able to manage all traffic in both FWD and RTN directions, which represents the largest DTP ever embarked;**
- ➔ **Thanks to the advanced employed technologies, achieved SWaP performance is able to make Digital processing attractive with respect to employed S/C resources**
  - → **Overall, a figure of merit of ~ 8 W/GHz of processed bandwidth is achieved**
  - → **Modular architecture based on single general-purpose ASIC, incorporating all needed functions, specific thermal management;**
  - → **ASIC based on 28 nm FD-SOI "evolved" from Automotive market and up-screened following a specific radiation test program;**
    - more than 1600 mm² surface, with more than 1600 I/O;
    - more than 10 layers organic substrate and non-hermetic package;
  - → **HSSL optical transceiver achieving > 10 Gbps;**
    - Derisking and selection phase concluded 2017, followed by qualification on 2018;
    - screening on flight models on-going.

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…AND WHERE WE WANT TO GO

➔ We actually consider three axis of development around Digital Processing, a fourth one being synergically connected to achieved improvements:

1. Digital Transparent Processor: guidelines are to increase processed bandwidth (above 500 GHz), maintain full cross-connectivity (among hundreds of Rx/Tx ports), reduce bandwidth granularity (increase FFT size for finer Frequency Plan tuning up to ~ 1 MHz), achieve direct conversion from / to RF (Ka-band / 3 GHz processed bandwidth for both up- and down-link) while drastically reducing DC power and, possibly, mass and volume;

2. Regenerative Processor: achieve processed bandwidth and direct conversion as per the above, regeneration of up-link channels with spectral density > 4 bps/Hz (DVB-S2x high modcods or bespoke up-link communication protocol), Tx section able to provide connectivity to all beams / granularity of channels as above, reprogrammable Tx modulators for future-proof DVB evolutions; as per DTP, SWaP improvement in particular for what concern DC power;

→ Optical Feeder Link Regenerative Processor: assuming to be able to establish an up-link optical feeder link for V-HTS mission, one single active Gateway is deemed able to carry all capacity, thanks to Dense Wavelength Division Multiplexing (D-WDM) approach; all those optical bits need to be Optical/Electrical converted and then modulated onto RF channels for serving User Spots; all considerations drawn for Regenerative processor apply.

…AND WHERE WE WANT TO GO

3. **Digital Beam Forming: fully digital realization able to handle hundreds of Rx feeds and Rx beams, so as hundreds of Tx feeds and Tx beams; totals processed bandwidth as per DTP, maintaining full cross-connectivity and bandwidth granularity;**
   - Assuming Rx digital beam forming, ***all*** feeds need to be routed to ***all*** beam formers; then, BFN weighting factors are applied on each contribution, followed by polyphase FFT and routing of sub-channels;
   - Inverse approach on Tx side, where combined channels (to Tx beams) are sent to BFNs and, after combination, to ***all*** Tx feeds;
   - Specific ASIC designs may be needed just for data routing, being able to mux/demux the data streams which are in excess of Tbps;
   - Direct conversion and digital pre-processing (FFT / decimation) maybe relevant to improve data exchange inside the processor, possibly in a close-to-feed arrangement;