Digital transition for satcom payloads

On Board Data Processing 2019 workshop – ESTEC – 02/25/2019

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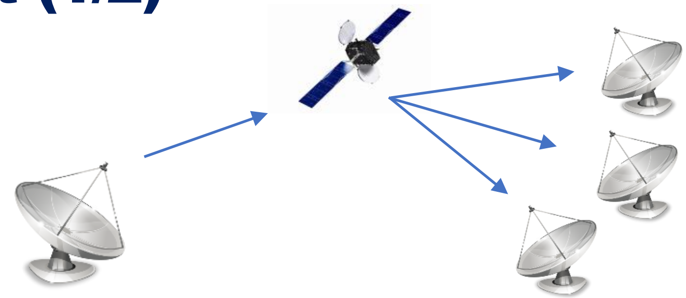
Agenda

- A growing and moving Telecom market
- From analog to digital satcom payload
- Past and current CNES activities
- Overview of future needs for satcom

A growing and moving Telecom market (1/2)

Broadcast (Linear TV)

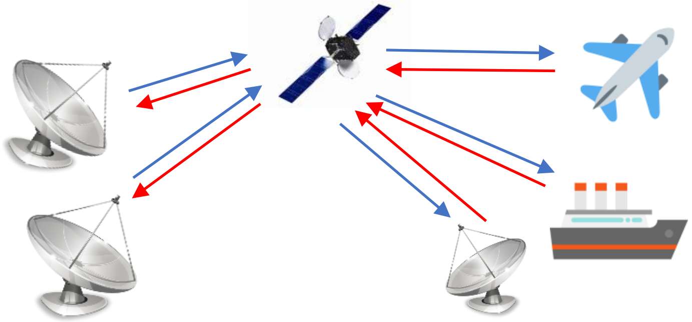
- Strong historical market (~ 300M suscribers worldwide in 2019)
- Stagnation or even decrease (in Europe & North America) of linear satellite TV market



- ➢ Unidirectional links
- ➢ Limited nb of TV channels but unlimited number of users

Broadband

- Historical : global telephony services, military connectivity
- Growing markets :
  - Fixed user (Residential & business) connectivity
  - Mobile user (Aero & maritime) connectivity
  - 3G/4G/5G cellular backhauling



- ➢ Bidirectional links
- ➢ Maximum number of users proportionnal to satellite capacity

A growing and moving Telecom market (2/2)

Broadcast (Linear TV)

- Progressive deployment of UHD TV channels, requiring more bandwidth for the same income
- Need for diversification of services : hybrid or generic satellite payload allowing to provide linear TV and broadband services

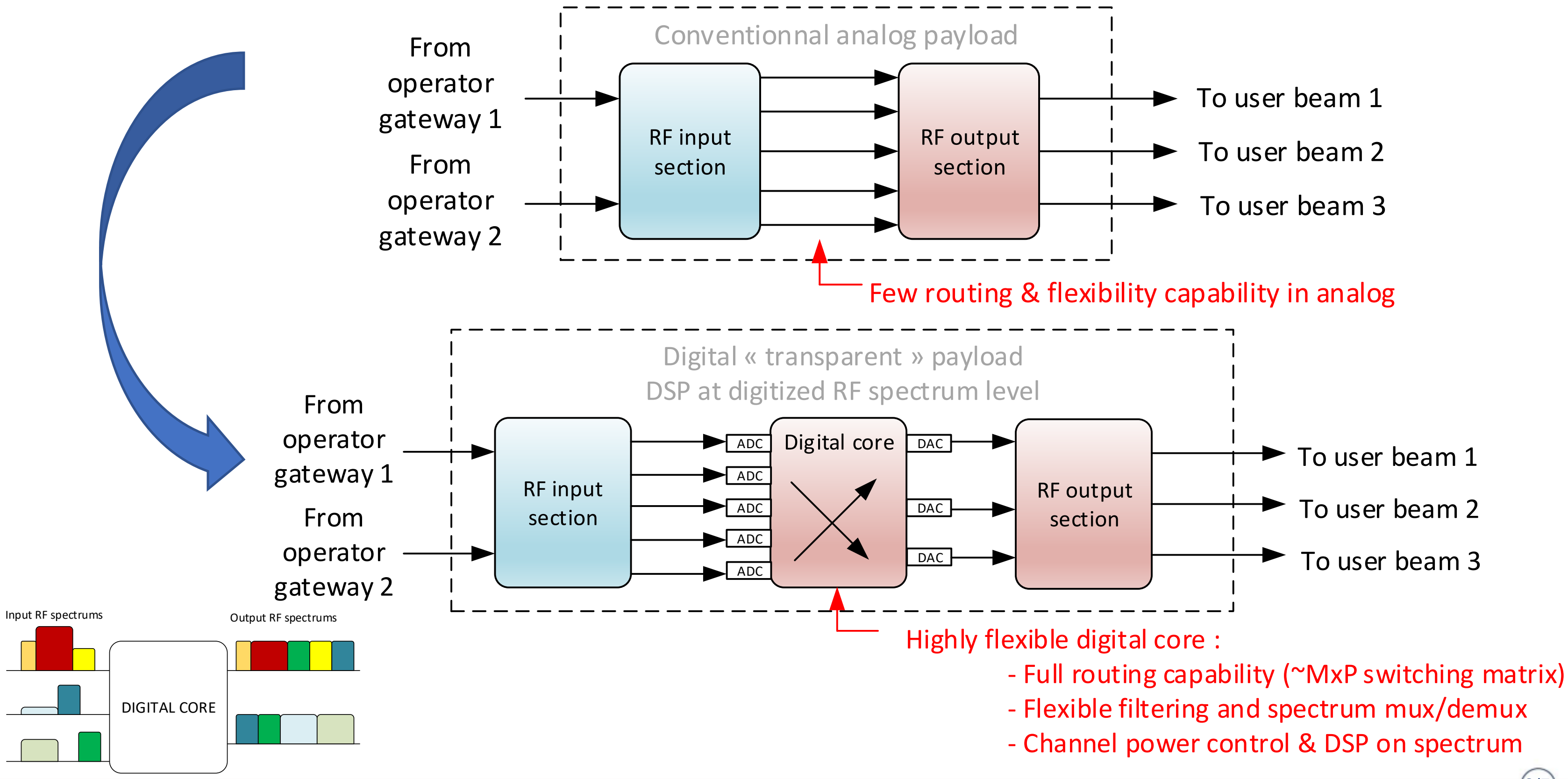
Broadband connectivity

- Increasing throughput per user at lower cost to meet needs and competition, requiring to increase offered satellite or system capacity
- Need for minimizing operator ground segment CAPEX & OPEX
- Need for optimizing capacity fill rate (objective : 1 Gbps offered = 1 Gbps used) in highly heterogeneous & variable bitrate demand in the service area

➢ **Need for highly efficient satellite system with large & flexible capacity**

From analog to digital payload (1/2)

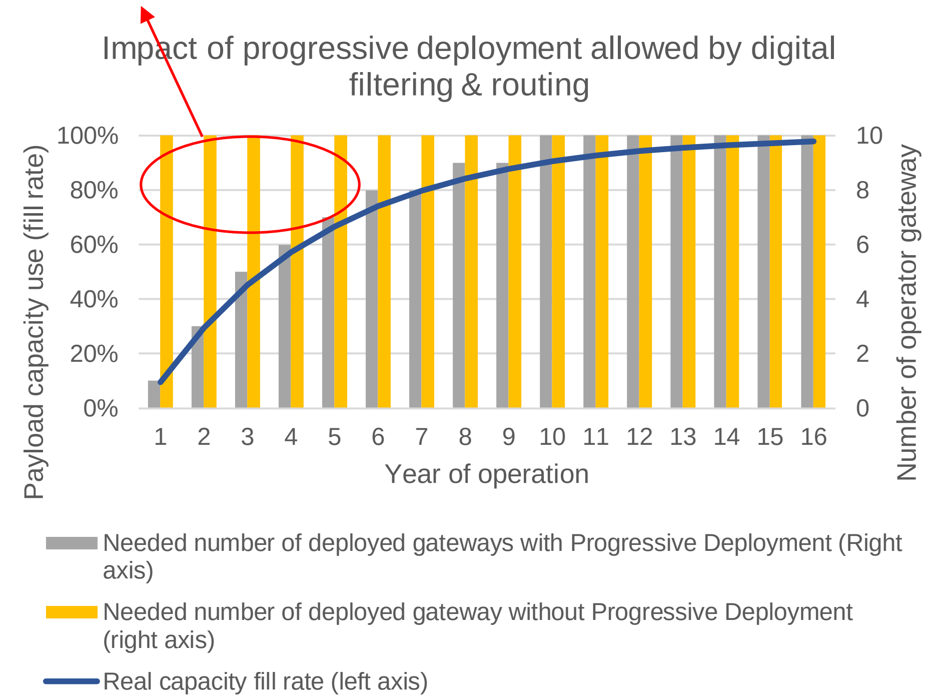
- An example of digital transition at RF spectrum level

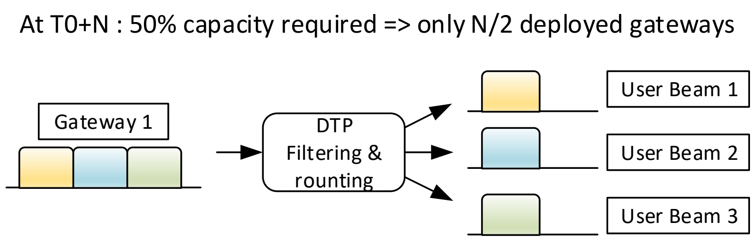


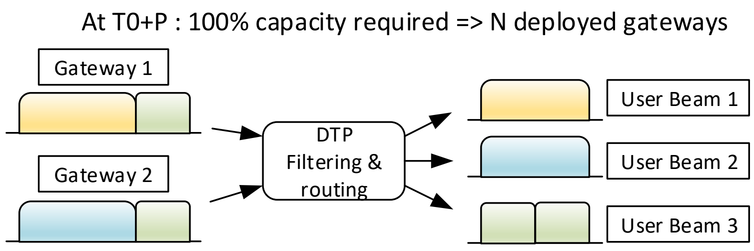
From analog to digital payload (2/2)

- Digital routing and filtering flexibility can be highly efficient in cost saving : example of Ground segment progressive deployment

Delaying and adjusting ground segment CAPEX at real need
Reducing ground segment OPEX



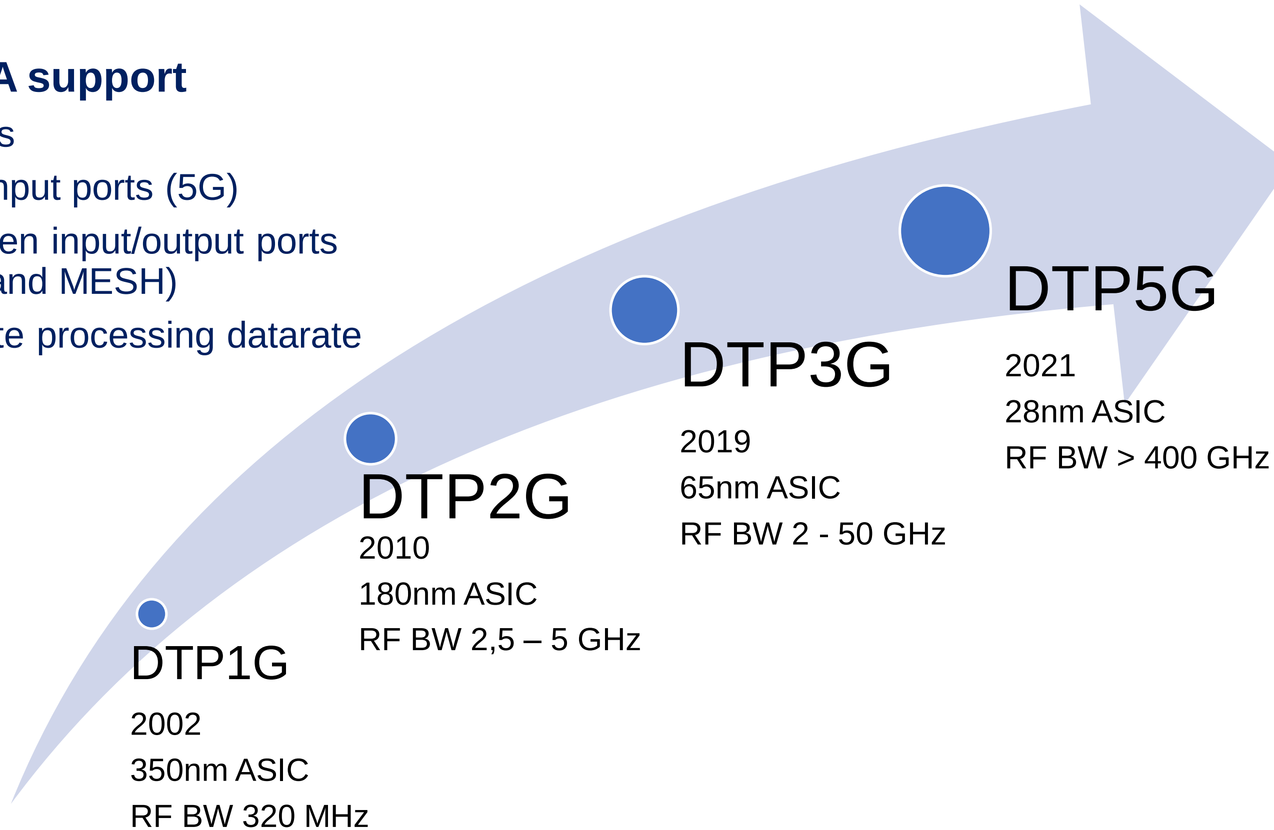




Past & current CNES activities for digital satcom (1/2)

❑ Product R&D example : Digital Transparent Processor family with Thales Alenia Space

- **Historical CNES & ESA support**
  - IF ADC/DAC ~2x12 bits
  - Up to 2,5 useful GHz input ports (5G)
  - Full connectivity between input/output ports (including FWD, RTN and MESH)
  - Up to 10Tbps aggregate processing datarate
  - Generic product :
    - Broadband mission
    - Broadcast mission
    - Military mission



Past & current CNES activities for digital satcom (2/2)

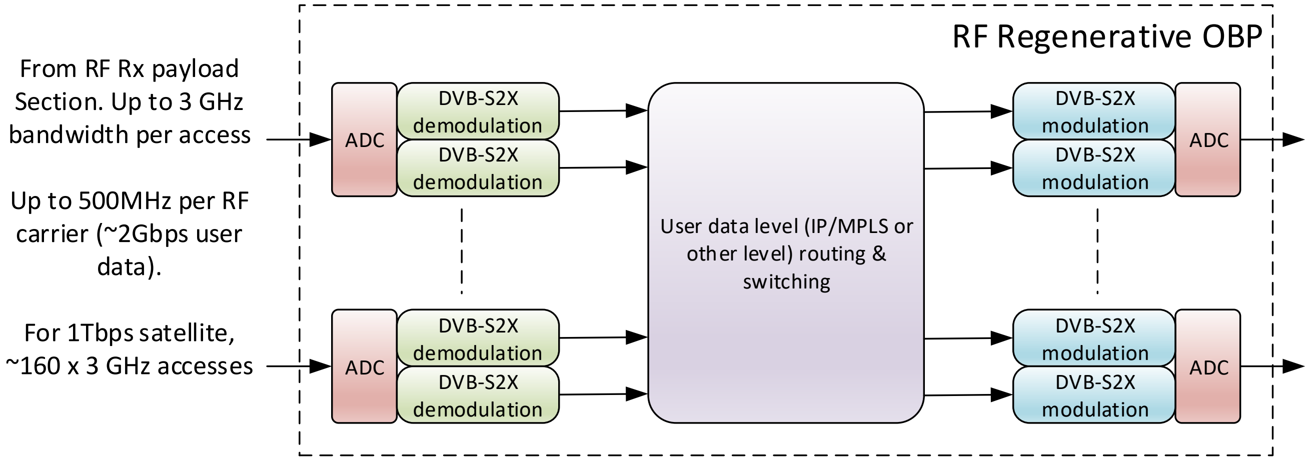
A wide range of topics internally studied and supported by CNES, including :

- ❑ **Avionics activities : Dahlia architecture & Hi-Rel NanoXplore FPGA**
- ❑ **Sotfware Defined Radio**
- ❑ **Optical HSSL**
- ❑ **Thermal control**
- ❑ **Packaging**
- ❑ **DC/DC function**
- ❑ **COTS parts**

Overview of future needs for satcom (1/4)

❑ RF regenerative On Board Data Processors

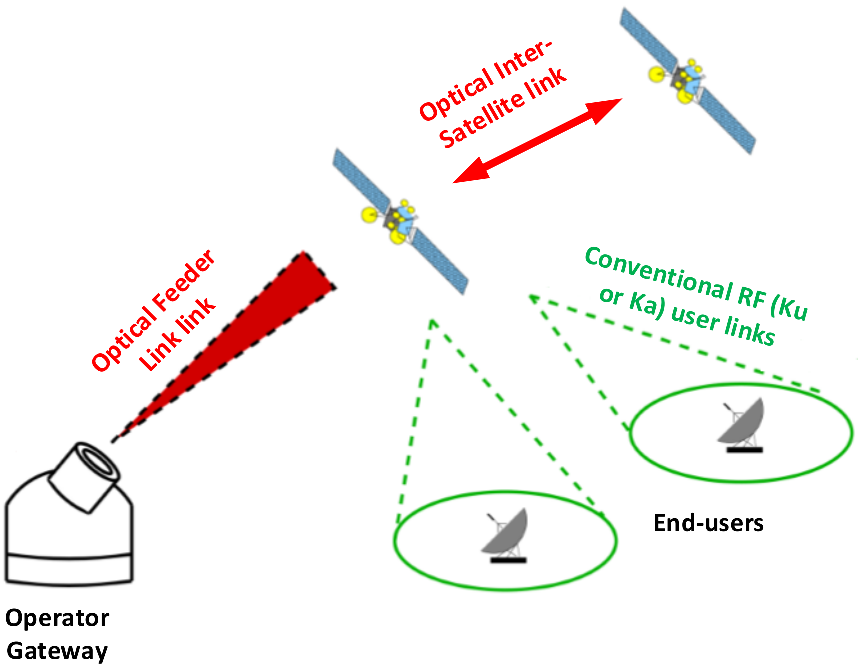
- ❖ Unlike transparent configuration with RF spectrum processing, user data is demodulated, processed and re-modulated
- ❖ Pros
  - Highly efficient and flexible way to route user data
  - Reduction of needed gateway sites by using improved spectral efficiency on feeder link
  - Improved overall ground-to-ground efficiency by cutting uplink and downlink budget links (with dedicated uplink decoding)
- ❖ Cons
  - Increased payload digital complexity versus digital transparent configuration (need for on board high speed demodulation & decoding, modulation & coding via ASIC or FPGA technologies, need for strong software capability to manage user data routing schemes…)
  - If ASIC technology is used for demodulation & modulation, feeder and user RF waveforms cannot be changed. If FPGA technology is used, risk of excessive DC consumption.



Overview of future needs for satcom (2/4)

Digital Processing Unit for Optical Link

- Optical feeder : partial ou full replacement of numerous RF feeder links (gateway/satellite) by fewer optical links
- Optical Inter-satellite : optical links between satellites to exchange data and create a space constellation-type network (LEO, MEO or GEO)



Main constraints for digital :

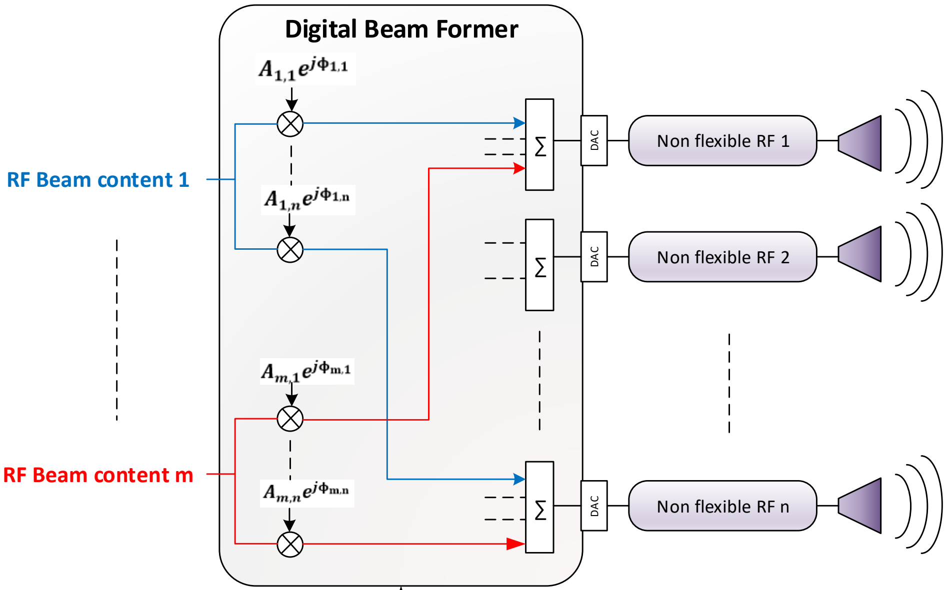
- Use of free-space optical transmission for feeder or inter-satellite links requires very high speed processing (incl. FEC), typ. up to 100Gbps per optical channel)
- In function of chosen optical transport, same cons as in RF regenerative OBP
- High speed memory for optical channel interleaving in FL application

cnes

Overview of future needs for satcom (3/4)

❑ Digital Beam Forming for Ka, Ku or Q/V Active antenna

- ❑ In HTS or VHTS multi-beam system, digital-based active antennas allow to change RF antenna pattern (in Rx or Tx) by only changing digital coefficients



Axx & ϕxx coefficients can be updated via :

- TM/TC at slow rate
- Cyclic table (high speed ~1kHz) for Beam Hopping application

- ➢ Requires m*n complex multiplications at sampling rate (typ. 3GHz)
- ➢ Requires m*(n to n) fixed routing (high speed interconnexion if DBFN if made of several chipset
- ➢ Concurrent to analog BFN implementation
- ➢ Can offer full spatial & frequency flexibility if combined with DTP/OBP routing capability (requires more than m*n coefficients)
- ➢ Requires reliable digital & RF calibration : delays or phase offset between paths strongly degrades pattern

Overview of future needs for satcom (4/4)

❑ Main trade-offs for each digital equipment

- **FPGA/ASIC trade-off for wideband processing**
  - COTS or HiRel component trade-off in case of FPGA choice
  - ASIC technology node in case of ASIC choice
- **CPU trade-off for software processing**
- **High speed interconnexions and overall routing strategy**
- **TM/TC, reconfiguration and calibration strategies**
- **ENOB and digital processing impacts on the equivalent equipment noise figure**
- **High-speed ADC & DAC component trade-off and input frequency trade-off (IF or RF)**
- **Thermal dissipation management**
- **Redundancy schemes for digital cores & boards in function of expected reliability**

❑ Main metrics

- **S(ize) W(eight) and P(ower) of equipment**
- **Cost**
- **Mission performances (noise figure, reliability, scalability & flexibility…)**

Thank you for your attention

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