Telecom Info Days 2006
RF Payload / Repeater

RF Payload Systems Division (TEC-ET)
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Payload/repeater targets

• Highly flexible (and efficient) payload architectures (power, bandwidth, coverage, connectivity)
  – Ka-band Broadband Multimedia multi-beam payloads
  – Ku-band missions (FSS/BSS) with several reconfigurable coverages
  – S-band reconfigurable mobile broadcasting missions
  – L/S-band mobile access payloads

• Payload simulation tools

• Advanced antenna/RF front-end concepts (AFR, DRA,…)

• High power and efficient RF power technologies (mini-TWT, GaN)

• Highly integrated front-ends supporting very large reflectors with a very large number of beams

• Highly integrated analogue processors/pre-processors (improvements in mass, accommodation, cost)

• High throughput power efficient digital processors (bent-pipe and packet switching)
Payload system targets

– ARTES 1 System and Payload Co-design for ACM Networks. Ongoing activity (Space Engineering)
  • Joint payload/system design for ACM systems
  • Impact of DVB-S2 (and therefore ACM) on regenerative processors
– ARTES 1 Analysis of Beam Hopping Techniques for Multibeam Satellite Systems
– ARTES 1 Complex Front-End RF Payload End-to-End System Simulator. Planned activity
  • Development of simulation framework to validate at system level equipment requirements in complex payload architectures
• **Flexible output sections: MPAs**
  – Demonstration of 4x4 Ka band MPA (ARTES 5, AAS-F, completed)
    • Implementation of a 4x4 MPA at Ka band
    • Flexible, non channelised (no OMUX) HPA architecture
    • Offers flexibility to cope with variable bandwidth and power to beam
    • TWTAs optimised for best tracking/MPA isolation performance
  – Depending on particular frequency plans, optimum backoff found to be close (or even less) than architectures using standard channelised amplification.
Flexible output sections: Flexible TWTAs

- Ku band (AAS-F/THALES/ETCA, ARTES 3, ongoing)
- Ka band flex (TESAT/THALES, ARTES 5, ongoing)

Applications:

- Usable in standard payload architectures (compensation of ageing and output loss spreads, optimisation of power after redundancy reconfiguration,…)
- In non-channelised Single Feed per Beam antenna/output sections, flex TWTAs offer flexibility on bandwidth/power to beam.
- In advanced Tx AFR antenna, flex TWTAs are an alternative to complex multimatrix architectures and allow the implementation of very simple output section without redundancy rings (ESA patent)
Advanced Payload Architectures using Enabling Technologies

- Ongoing ARTES 5 study (AAS-F). Study done at Ka-band
- Mini-TWTs:
  - Low RF power (i.e. 10 to 20 watt), low cross-section and high efficiency alternative to current SSPAs
  - Improvement of practical RF power capabilities of Tx DRA antenna
  - Possibility for “behind the feed” accommodation? Power level/mini TWT cross section vs. feed size
  - Need for specific thermal control hardware. Integrated heat pipes on TWT?
- GaN:
  - High RF power capability with good efficiency capability
  - High temperature operation possible
  - Enabling technology for Tx high frequency array antennas
  - Need for improvements on high temperature thermal control hardware
• **Digital Processors**
  – Digital Processors offer high level of on-board flexibility
    • Flexibility in bandwidth to beam allocation
    • Flexibility in beam shaping and coverage
    • Flexibility in connectivity
  – Fine granularity in demultiplexing architectures improves overall system efficiency
  – Bulkiness of analogue processing function make them sometimes impracticable (e.g. analogue beam forming with a large number of beams)
  – Burst Routing Capability
Digital Processors

- TRP High-speed bent-pipe processor demonstrator (TEB ongoing)
  - PoC of a highly flexible broadband processor that should extend architectures studied in ARTES 1 High Throughput Processor to support SFB, AFR, DRA antennas with a scalable and modular design
  - FPGA based
  - Demonstration of new digital advanced technologies (i.e. high speed serial link)
- New Pro: high-speed converters (development of low power 1.5 Gbps 12/10 bits DAC/ADCs)
- Software radio regenerative processor (Planned)
Payload/repeater targets

- **Repeater Analogue Technologies**
  - Advanced LO technologies
    - Physical layer using high order modulations will need improvements on LO phase noise
    - On board frequency tunable converters for future flexible payloads
    - SiGe technology offers potential for very low phase noise integrated frequency synthesizers
    - Ongoing TRP and ARTES 5 activities “High Frequency SiGe MMICs” on SiGe synthesizer and converter developments (Kayser-Threde, IHP, SAAB)
    - Planned ARTES 5 activity on “Converters and LO for flexible payloads”
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Payload Simulation tools (ARTES 1)

Payload system co-design for ACM systems (ARTES 1)

Analysis of Beam hopping Techniques (ARTES 1)

High Throughput Processor Demonstrator (TRP)

High Throughput Processor (ARTES 1)

Wideband Digital BFN (TRP)

Software-radio Based Regenerative Processor

2005 2006 2007 2008 2009
Highly Integrated IF Solid State Switch Matrix
S-band High Power Reconfigurable Front-End Demonstrator
Reconfigurable Input Multiplexers
Very Large Order Switch Matrices using MEMS Technology
Highly Integrated IF Solid State Switch Matrix
Converters and LOs for Flexible Payloads
Ka-band "mini" TWT Transmit Front-End

Switch Matrix
State of the art

SiGe/GaAs Technologies

Advanced TWT Technologies

Advanced Payload Architectures using Enabling Technologies (ARTES 5)

SiGe Building Blocks (TRP)

MEMS SPDT

AlphaSat Phase A
Trend: Integration

- Highly Integrated IF Solid State Switch Matrix
- S-band High Power Reconfigurable Front-End Demonstrator
- Converters and LOs for Flexible Payloads
- FBAR/SAW filters for S and C-band
- Very Large Order Switch Matrices using MEMS Technology
- Microwave Micro-machined Filters
- Drop-in Isolators for Output Sections of SSPA
- Very High Power Filter
- Microwave Photonics Distribution of Local Oscillators
- Ka-band “mini” TWT Transmit Front-End
Trend: Power / Security

- Advanced TWT Technologies
- HP Filter Technologies
- Atomic Clock Technologies
- GaN Technology

- Secure Systems Requirements
- Advanced Payload Architectures using Enabling Technologies (ARTES 5)
- ESA Patent

- $\text{S-band High Power Reconfigurable Front-End Demonstrator}$
- Ka-band “mini” TWT Transmit Front-End
- Very High Power S-band TWT
- Very High Power Filter
- Drop-in Isolators for Output Sections of SSPA
- Miniature Ultra Stable Oscillators for Secure Telecommunications
- GaN Technology for Robust Communications Receivers

Timeline:
- 2005
- 2006
- 2007
- 2008
- 2009

ESTEC 12th April 2006

TEC-ET / F. Deborgies
Software Radio based
Regenerative Processor

• Objectives:
  – Design, manufacture and test a regenerative processor for telecommunication applications implemented with software radio technology, after selection of the most appealing reprogrammable technologies (FPGA, DSP, Processor Arrays…)
  – Address potentially any regenerative processor of a telecommunication satellite. A reference baseline can be Skyplex, AmerHis or a point-to-point mobile processor.
  – Prove flexibility and reliability of this type of implementation to promote it to operators.

• Programmatic:
  – Budget: 1400 k€
  – Duration: 18 months
  – Planning: Q2 2006
Highly Integrated Solid State IF Switch Matrix

• Objectives:
  – Design, manufacture and test an EM of a highly integrated, low cost, modular solid state switch matrix
  – Improvement of current state of the art (integration and cost) on IF switch matrices
  – Use of advanced mixed analogue/digital MMIC (GaAs or SiGe) technology integrating several RF switch nodes and associated digital control circuitry on the same die

• Programmatic:
  – Budget: 1000 k€
  – Duration: 24 months
  – Planning: Priority 2 ⇒ ITT initiated on Delegation request
S-band High Power Reconfigurable Front-End Demonstrator

- **Objectives:**
  - Design, manufacture and test of a proof-of-concept of an advanced S-band high power reconfigurable RF front-end.
  - Application in future mobile broadcasting mission using multiple-shaped-beams
  - Flexibility on coverage and power to beam allocation

- **Programmatic:**
  - Budget: 1000 k€
  - Duration: 18 months
  - Planning: Q3 2006
Convertisers and LOs for Flexible Payloads

- **Objectives:**
  - Design, manufacturing and test of an EM of an advanced in orbit tunable converter and associated LO for future flexible payloads
  - LO with wide band tuning range, high frequency setting resolution and low phase noise
  - SiGe strong candidate for LO implementation

- **Programmatic:**
  - Budget: 2000 k€
  - Duration: 18 months
  - Planning: Q2 2006
Objectives:
- Design, manufacture and test of an EM of a Ka-band low power (10 to 50 watt) "mini" TWT
- Small size and footprint
- High efficiency, low dissipated power
- Power flexibility

Programmatic:
- Budget: 1000 k€
- Duration: 24 months
- Planning: Q3 2006
**Objectives:**
- Study, manufacture and test filters based on thin Film Bulk Acoustic Resonator (FBAR) technology
- Frequency capability assessment coverage: at least S-band and possibly higher frequencies
- Performance assessment w.r.t. SAW technology
- Breadboard at C-band

**Programmatic:**
- Budget: 350 k€
- Duration: 24 months
- Planning: Q2 2006
Objectives:
- Design, manufacturing and test of a breadboard demonstrator of a highly miniaturized, high order switch matrix using MEMS technology.
- Wideband and scalable.
- Advanced packaging
- MEMS reliability.

Programmatic:
- Budget: 750 k€
- Duration: 24 months
- Planning: Q2 2006
Microwave Photonics Distribution of Local Oscillators

- **Objectives:**
  - Demonstrate microwave photonics distribution of RF local oscillator
  - Design, manufacture and test of a breadboard able to handle a large LO frequency range from a few MHz to some GHz
  - Assessment of suitability of optical amplification and wavelength division multiplexing
  - Identify devices for later qualification

- **Programmatic:**
  - Budget: 500 k€
  - Duration: 18 months
  - Planning: Priority 2 ⇔ ITT initiated on Delegation request
• **Objectives:**
  – Design, manufacture and test of an EM of a very high power low-pass filter for a Ku-band output multiplexer
  – Multipaction-free design based on large gap filters
  – Significant mass saving on OMUX

• **Programmatic:**
  – Budget: 350 k€
  – Duration: 18 months
  – Planning: Priority 2 ⇒ ITT initiated on Delegation request
Objectives:
- Develop high power L- and S-band drop-in isolators
- Manufacture and test EM of the isolators
- Power handling in line with SSPA development for mobile applications and Galileo

Programmatic:
- Budget: 300 k€
- Duration: 18 months
- Planning: Q2 2006
GaN Technology for Robust Communications Receivers

- **Objectives:**
  - Identify and verify the improvement in robustness offered by the emerging GaN technology for secure communications receivers
  - Manufacture a breadboard of the critical elements and test in presence of high levels of overdrive signals
  - Assessment to be done in S, C, and X-bands for at least the LNA, the mixer and the automatic gain control

- **Programmatic:**
  - Budget: 500 k€
  - Duration: 24 months
  - Planning: Q3 2006
Microwave Micro-machined Filters

• **Objectives:**
  – Design, manufacture and test two breadboards of microwave filters (L/S-band and Ka-band) using micro-machining in combination with multilayer topology.
  – Demonstrate the flexibility of design of the 3D topology as well as the low loss of the membrane type structure

• **Programmatic:**
  – Budget: 400 k€
  – Duration: 24 months
  – Planning: Q3 2006
• **Objectives:**
  – Study and demonstrate the feasibility of a compact input multiplexer with adjustable “channel” bandwidth and selectable centre frequencies
  – EM of a three channel flexible input multiplexer at Ku-band will be designed, manufactured and tested

• **Programmatic:**
  – Budget: 500 k€
  – Duration: 18 months
  – Planning: Q2 2006
**Objectives:**
- Development of a miniature and low power consumption ultra stable oscillator based on atomic resonator technology
- Design, manufacture and test of prototype USO
- Initially focussed on user-terminals

**Programmatic:**
- Budget: 500 k€
- Duration: 24 months
- Planning: Priority 2 ⇒ ITT initiated on Delegation request
• **Objectives:**
  – Design, manufacture and test of generic very high power TWT technologies
  – Design, manufacture and test EM of a ~ 500W S-band TWT
  – Identify the design limits in terms of thermal, mechanical and electrical margins in comparison to existing designs (250W of nominal power)

• **Programmatic:**
  – Budget: 850 k€
  – Duration: 24 months
  – Planning: Priority 2 ⇒ ITT initiated on Delegation request