BroadCast

A Combined Satellite/Terrestrial UMTS Terminal Platform

ARTES-4 Contract No. 13830/99

L. Philips

Microelectronics Presentation Days
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Agilent Technologies

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Project Goals

- **Development of a wideband transceiver supporting CDMA-like air interfaces including S-UMTS related communications**
- **Use of a Software-Defined Radio approach**
- **Take into account standardisation and market evolution**
- **Perform realistic field trials**
- ***Note:* initial goal was a versatile IC - has been retargeted to FPGA platform**

Modem specifications

- **Programmable inner modem for oversampled chip-rate processing**
- **Flexible outer modem for FEC processing**
- **Flexible Analog FrontEnd (AFE) interface compatible with various radio's**
- **Be compatible with or easily upgradable to T-UMTS/FDD, S-UMTS related schemes, S-DMB reception, narrowband CDMA schemes**

Examples of Operational Modes

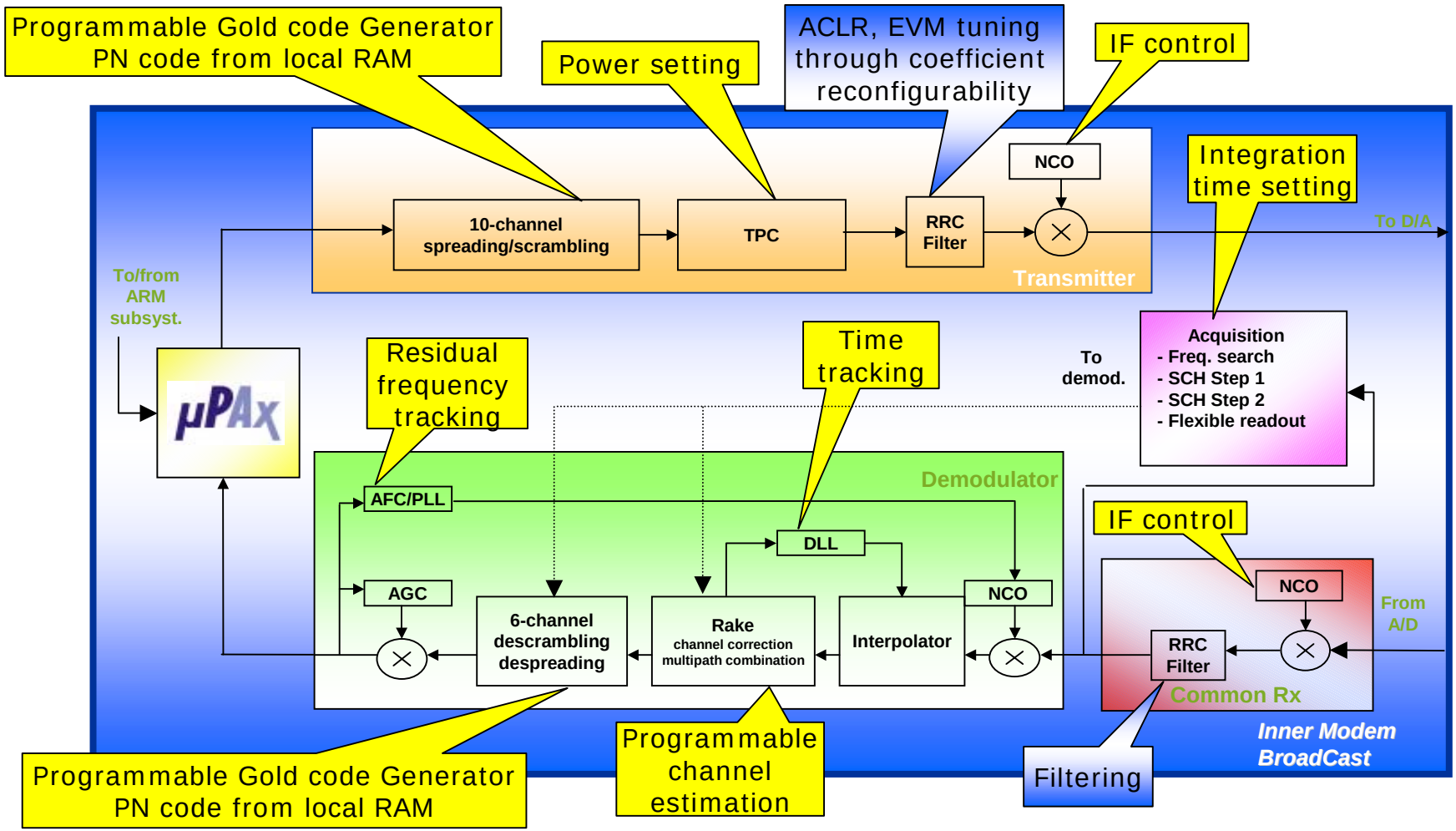
Test	A	B	C	D	E	F	G	H
Mode	**IS95A**	**IS95A**	**UMTS**	**UMTS**	**UMTS**	**UMTS**	**IS95A**	**IS95A**
Data rate 1	**9,6k**	**19,2**	**9,6**	**19,2**	**38,4**	**57,6**	**9,6**	**19,2**
Data rate 2	**0**	**0**	**320**	**320**	**320**	**320**	**0**	**0**
DCH1 bits/frame	300	600	96	192	384	576	300	600
DCH2 bits/frame	0	0	3200	3200	3200	3200	0	0
CRC1	16	16	16	16	16	16	16	16
CRC2	0	0	16	16	16	16	0	0
L1	16	16	16	16	16	16	16	16
L2	0	0	16	16	16	16	0	0
Rate	2	2	3	3	3	3	2	2
Coding	Conv.	Conv.	Turbo	Turbo	Turbo	Turbo	Conv.	Conv.
Max. Coder in	272	512	3341	3418	3571	3725	272	512
Max. Coder out	560	1040	10034	10265	10726	11186	560	1040
SF	128	64	8	8	8	8	64	32
Nr. DPDCH	2	2	1	1	1	1	1	1
Puncturing (%)	0,00	0,00	10,13	12,76	17,76	22,76	0,00	0,00
Input CRC 1	392	872	96	176	328	480	424	1024
Input CRC 2	0	0	3216	3216	3216	3216	0	0
Code blocks	1	1	1	1	1	1	1	1
Input coder	408	888	3344	3424	3576	3728	440	1040
Output coder	832	1792	10044	10284	10740	11196	896	2096
Puncturing bits	0	0	924	1164	1620	2076	0	0
2nd Fillers	8	8	0	0	0	0	4	4
PHY-Data	840	1800	9120	9120	9120	9120	900	2100
Punct. Pattern	none	none	2/21	2/15	2/12	2/9	none	none

-Flexibility for CDMA-like schem
e.g. IS95A and UMTS/FDD

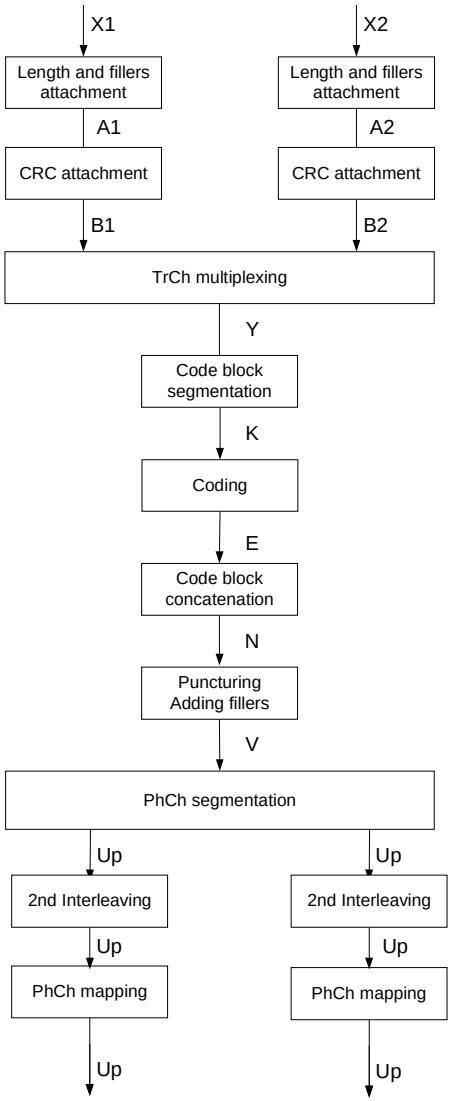
-Multi-channel coding possible

-Full inner and outer modem capability

BroadCast Inner Modem Block Diagram



BroadCast Outer Modem Block Diagram

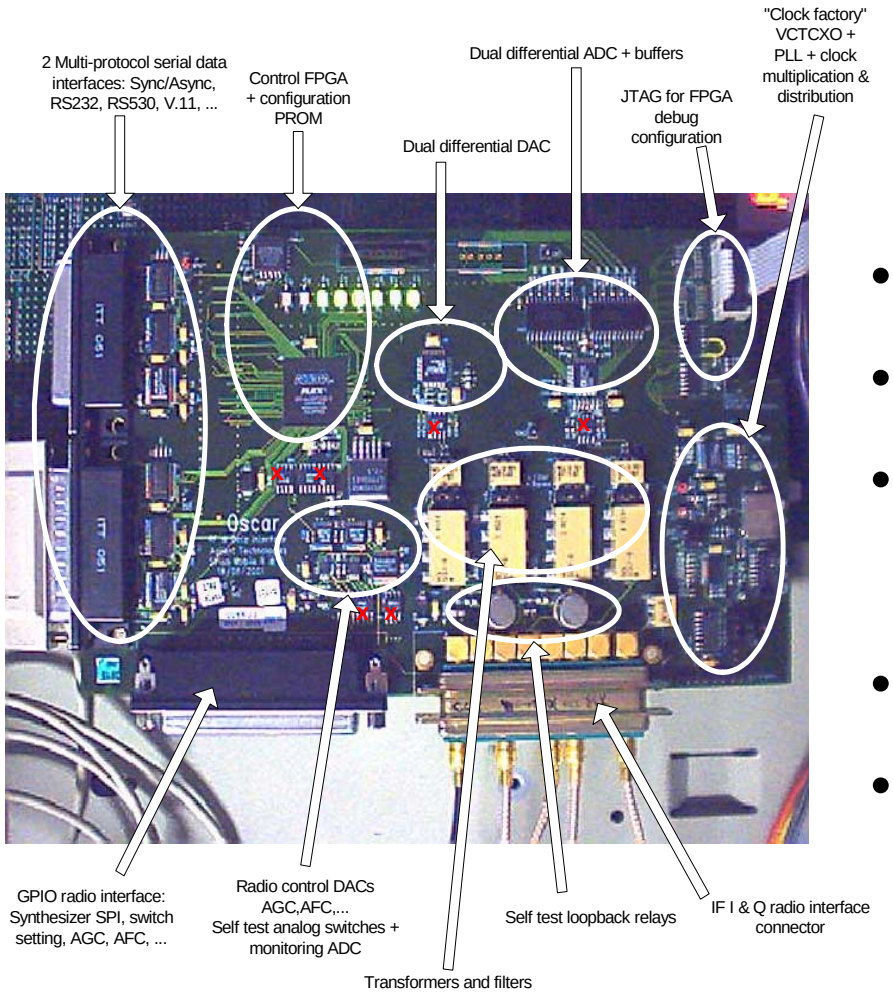


- CRC
- Multiplexing
- Coding: convolutional/Turbo
- Puncturing/Repetition
- Segmentation
- Interleaving

BroadCast Outer Modem

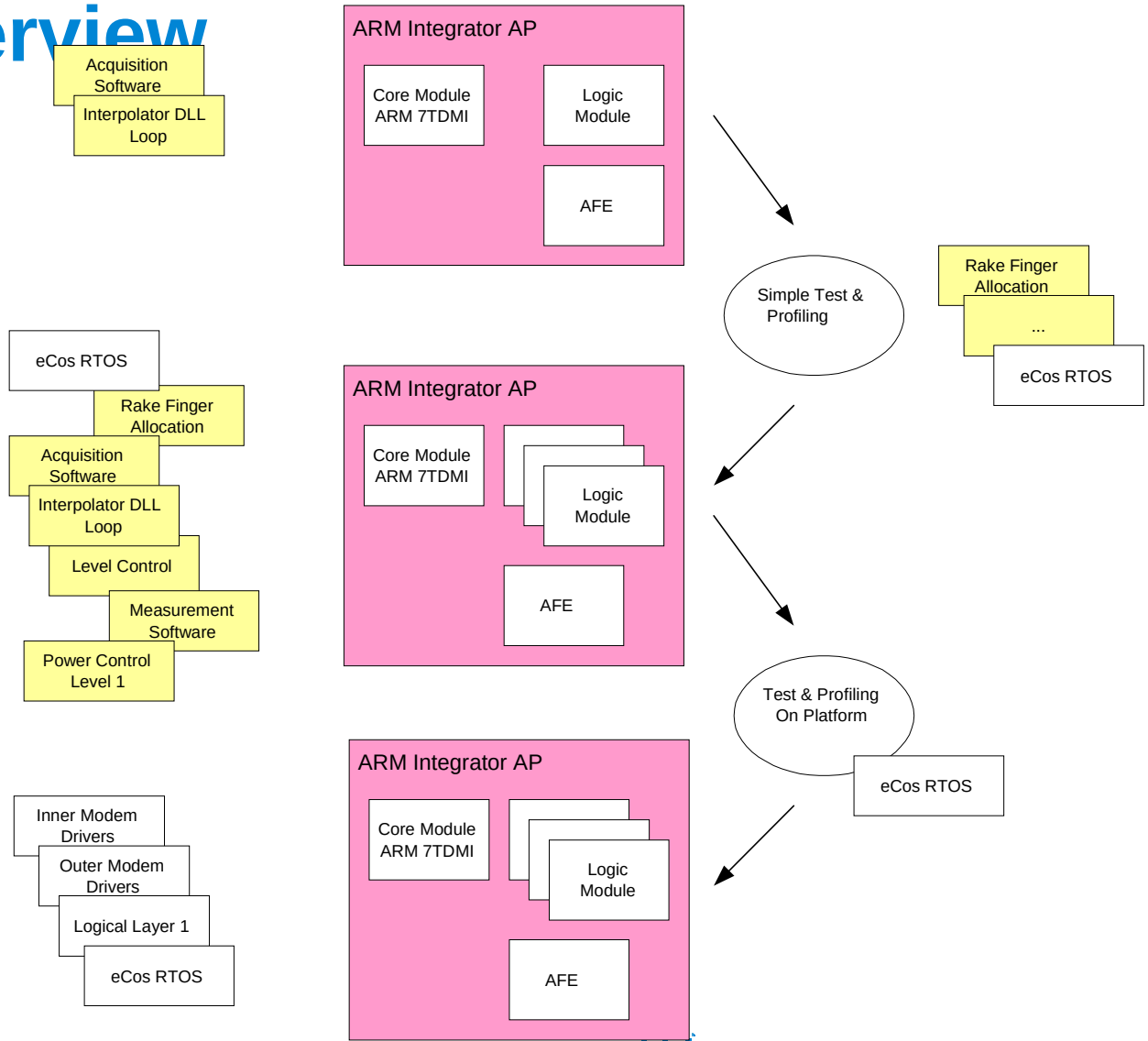
- **Turbo Decoder**
  - **Achieves a BER of 3e-7 at signal-to-noise ratio of 1.0 dB when performing 5 full iterations on a block of 5114 bits. (litterature: typ. 1e-6 under same conditions)**
  - **Max speed : 2 Mbit/sec @ 60 MHz**
- **Convolutional/Viterbi codec**
  - **Based on Viterbi algorithm**
  - **Supports block and blind-detection (≈streaming) mode**
  - **Easily extendable for higher code rates**
  - **Most efficient for constraint lengths >= 5**

Analog FrontEnd Interface



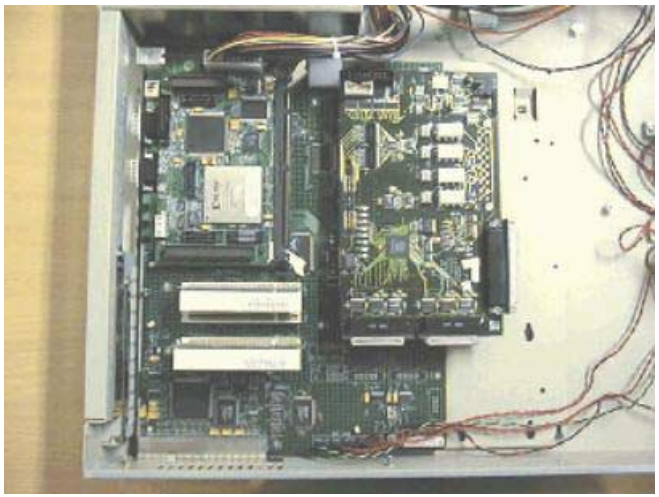
- **Dual ADC and DAC**
- **Clock factory**
- **Reconstruction and anti-alias filtering**
- **Control DACs: AGC, AFC, ALC**
- **Small FPGA for interface logic**

BroadCast SW Development Steps Overview



Baseband Platform

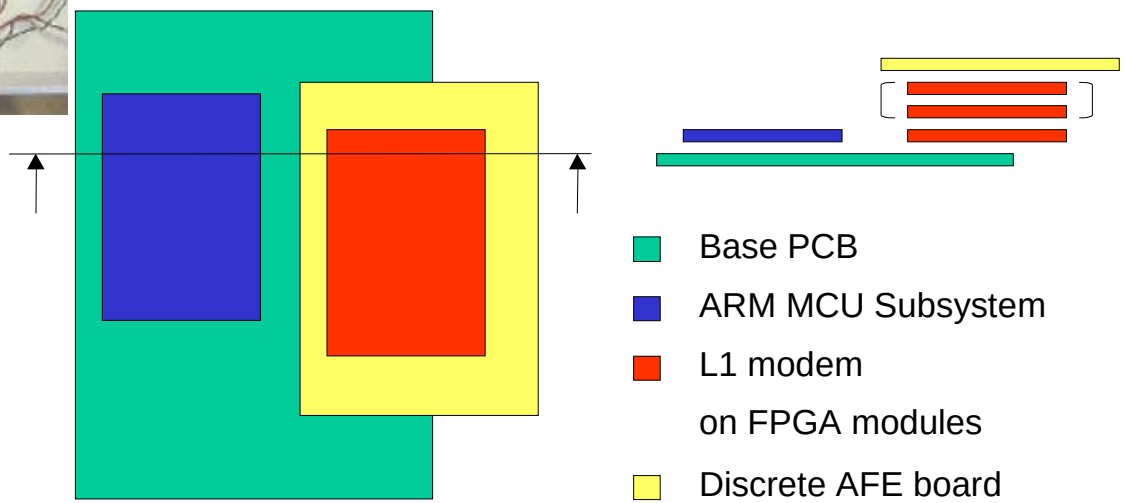
- **Baseband IP validation : real-time lab tests**



- ARM 7TDMI controlling the Modem subsystem

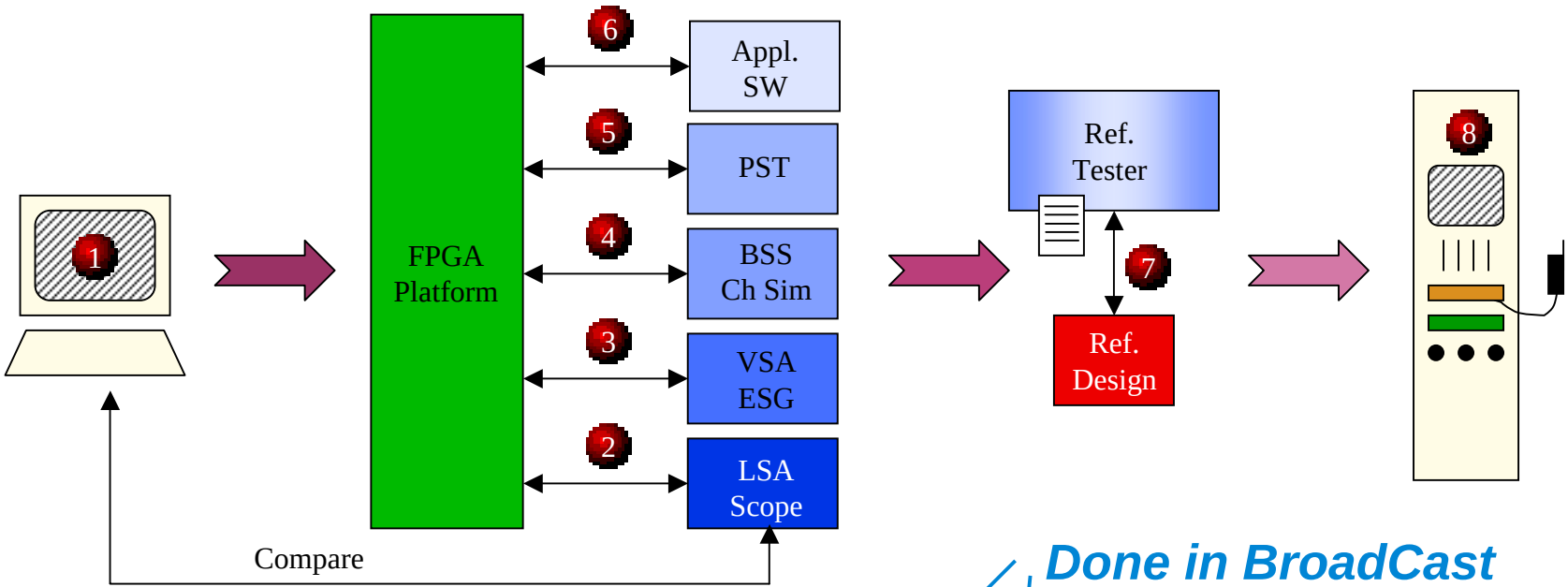
- Inner/Outer Modem implemented in Altera FPGAs

- Discrete AFE board added for analog interfaces (I,Q and real IF)



Verification

Step-by-step approach



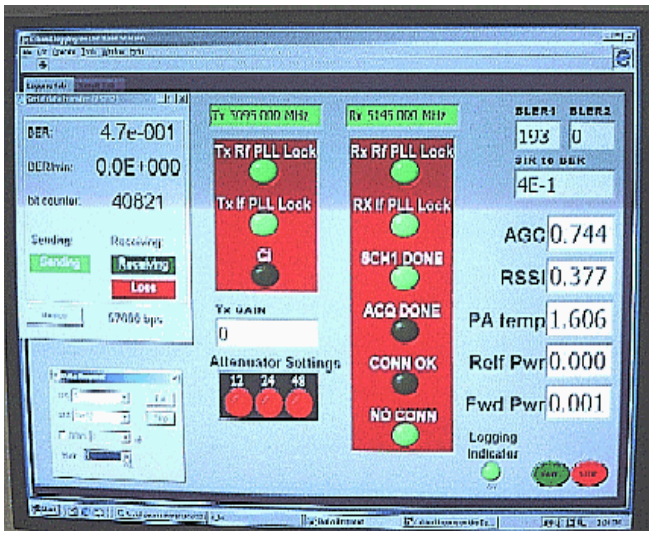
Done in BroadCast

1. 1. Simulations
2. 2. Functional Test of separate blocks
3. 3. Functional Test of system
4. 4. Conformance Test

5. Protocol Stack Test
6. Application SW Test
7. Reference Design
8. Manufacturing Test

Platform Test

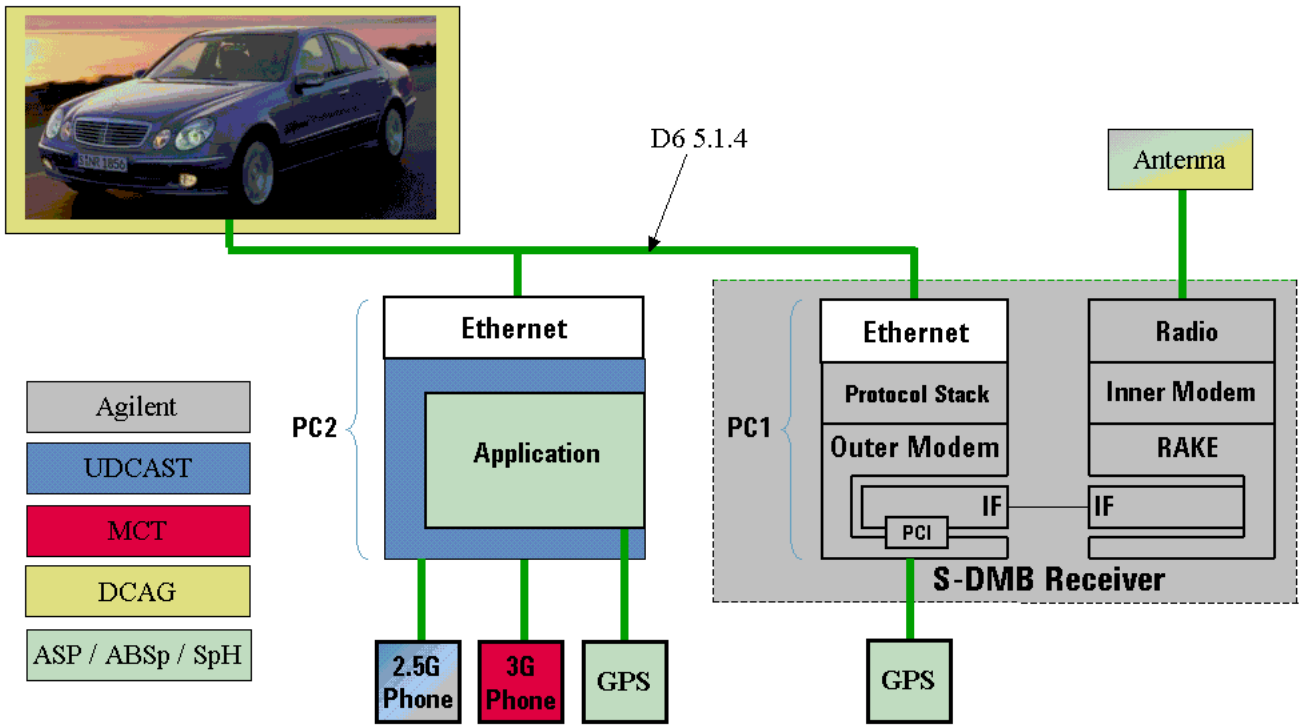
- **Baseband IP validation: real-time lab tests**
  - **Modem behavior identical to simulation**
  - **SW algorithms on ARM:**
    - **Rake fingers ctl SW**
    - **Power ctl SW (SIR, TPC)**
    - **RF ctl SW (AGC, synthesizers)**



- **Connected to 3 types of RF front-ends (C-band real-IF, VHF I,Q, 2 GHz real-IF)**
- **Sync, RF status, BER, FER logging**
- **GUI realized by IMEC (B)**

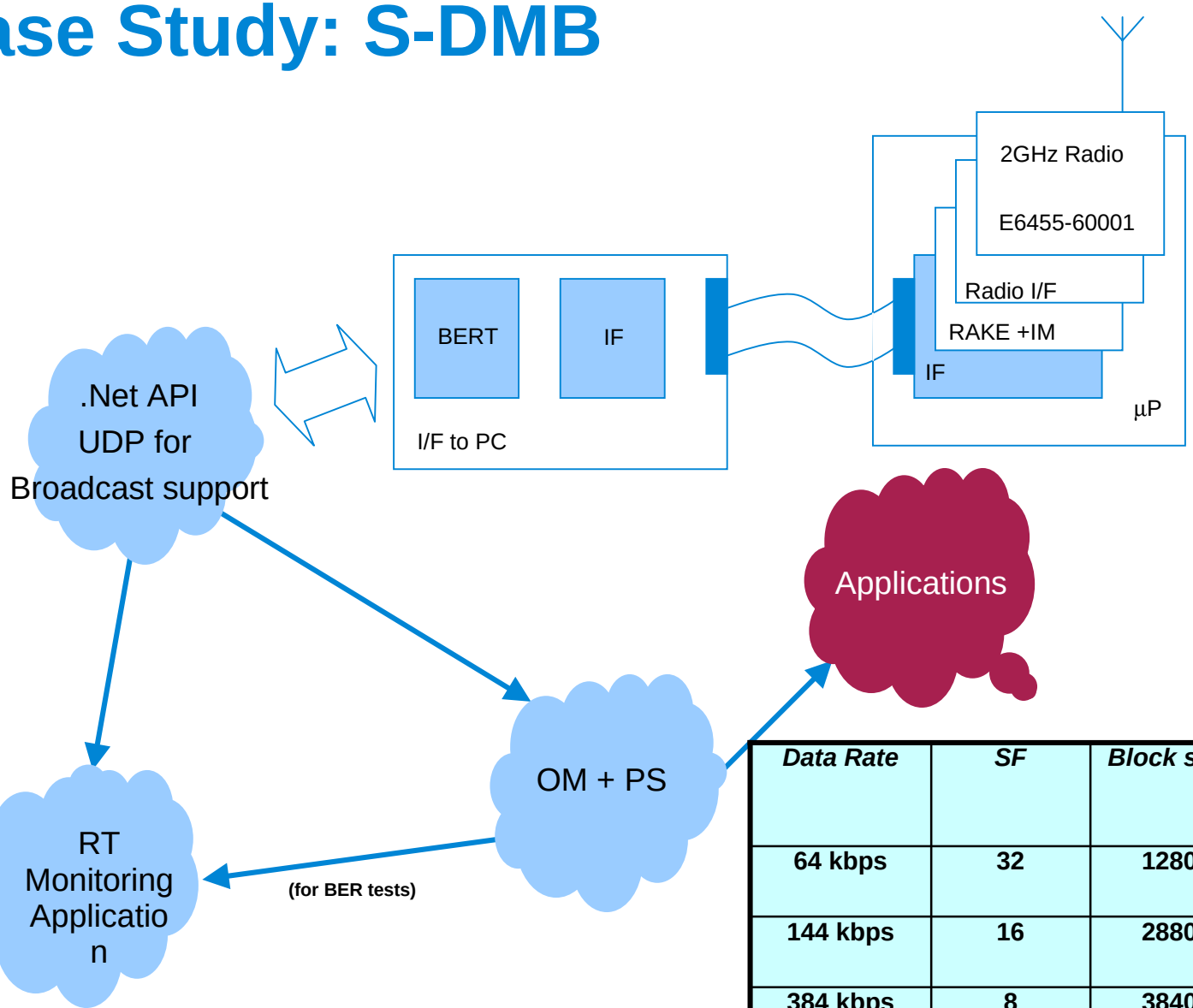
Case Study: S-DMB Receiver

Satellite Digital Multimedia Broadcast



Trial Network in IST-MoDis project

Case Study: S-DMB



Data Rate	*SF*	*Block size*	*Rep/Punc*
64 kbps	**32**	**1280**	**Rep 2.9%**
144 kbps	**16**	**2880**	**Punc 2.7%**
384 kbps	**8**	**3840**	**Punc 22%**

Case Study: S-DMB Trials

Balloon with 2 GHz band antenna, emulating satellite

ALCATEL SPACE

Feb, March 2003

S-DMB receiver + measurement equipment in car

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Case Study: W-CDMA Avionics

- ARM7TDMI-based baseband platform for IM + selected OM functions (channel codecs)
- Radio I/F board configured for real IF Interfacing or baseband I,Q

- C-band radio based on superhet architecture (5 GHz)
- VHF radio with baseband I,Q interfacing (140 MHz)

Case Study: W-CDMA Avionics

- **Flight tests in UK (Boscombe Down) and Azores**
- **Several data rate modes and extreme Doppler fading**
- **Very successful test campaign!**

EUROCONTROL

Oct, Nov 2002

Conclusions

- **SDR FPGA/SW platform available for CDMA-like air interfaces**
- **Results achieved:**
  - **All subsystems verified and tested**
  - **Field trials for S-DMB and avionics W-CDMA**
- **Future plans:**
  - **Protocol stack + network context**
  - **Integration towards products**