Patrick Longhi
Massimiliano Pingue
Area Progettazione MW

Mind is the first defence

Elettronica S.p.A.

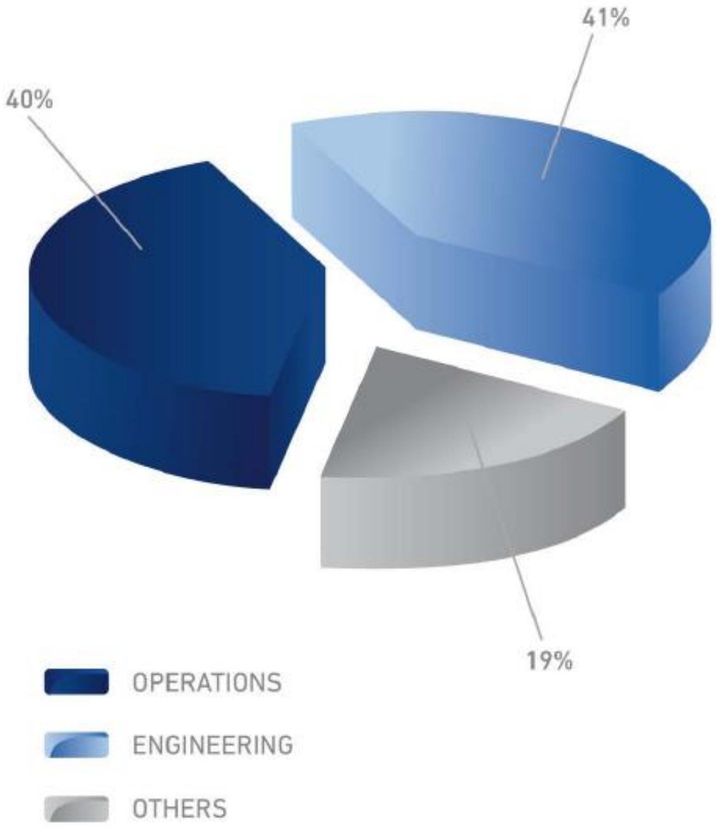
Principali prodotti:

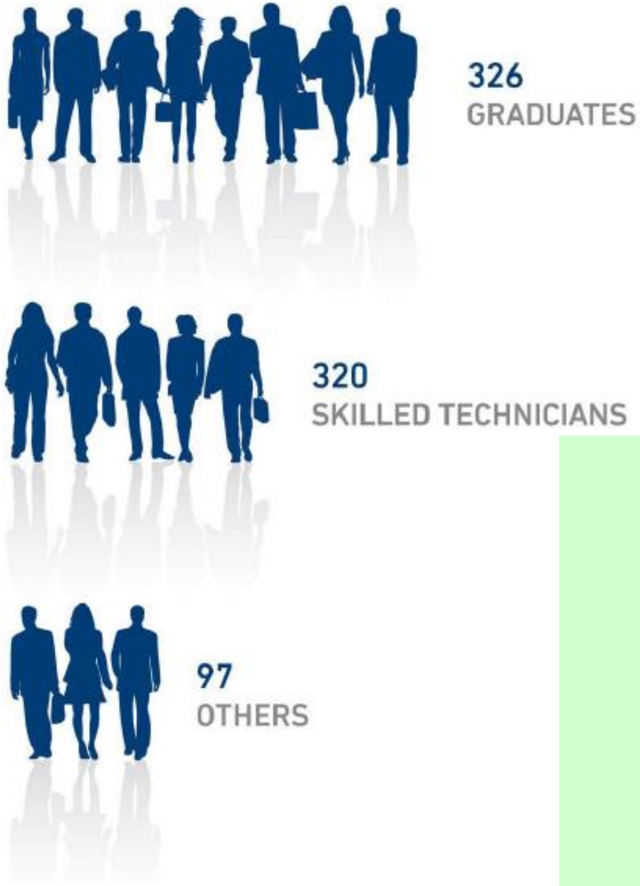
✓sistemi ESM (Electronic Support Measures)

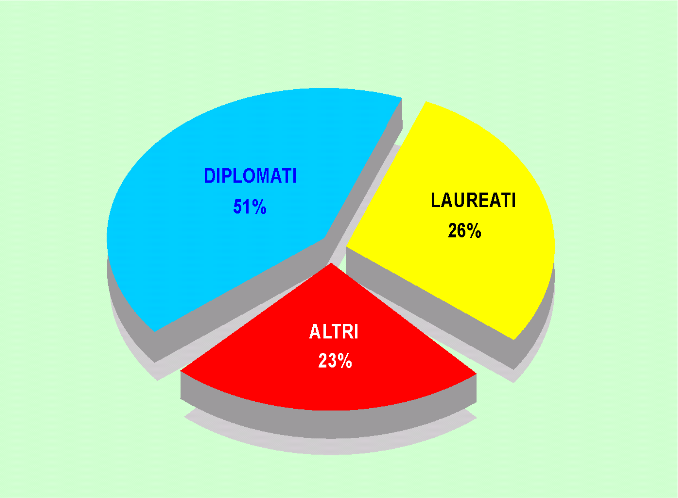
✓sistemi SIGINT (SIgnal INTelligence)

✓sistemi ECM (Electronic Counter Measures)

ELETTRONICA PERSONNEL







Argomenti

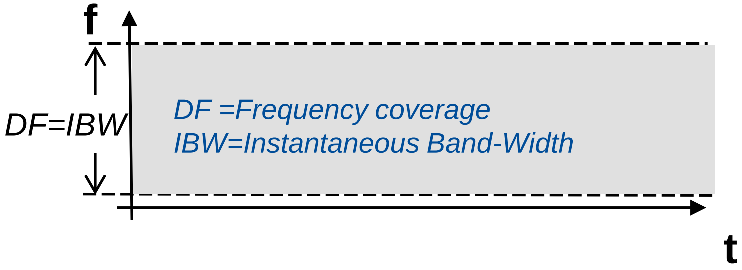
- I sistemi ELT- ESM
  - RWR (WO wide open receiver)
  - SIGINT/ELINT (SH super-het receiver)

- I sistemi ELT - ECM+ESM
  - Phased Arrays
  - Down-Up converters

- La progettazione microonde in ELT
  - Flusso di PROGETTO
  - Criticità & tecnologie
  - Esempio

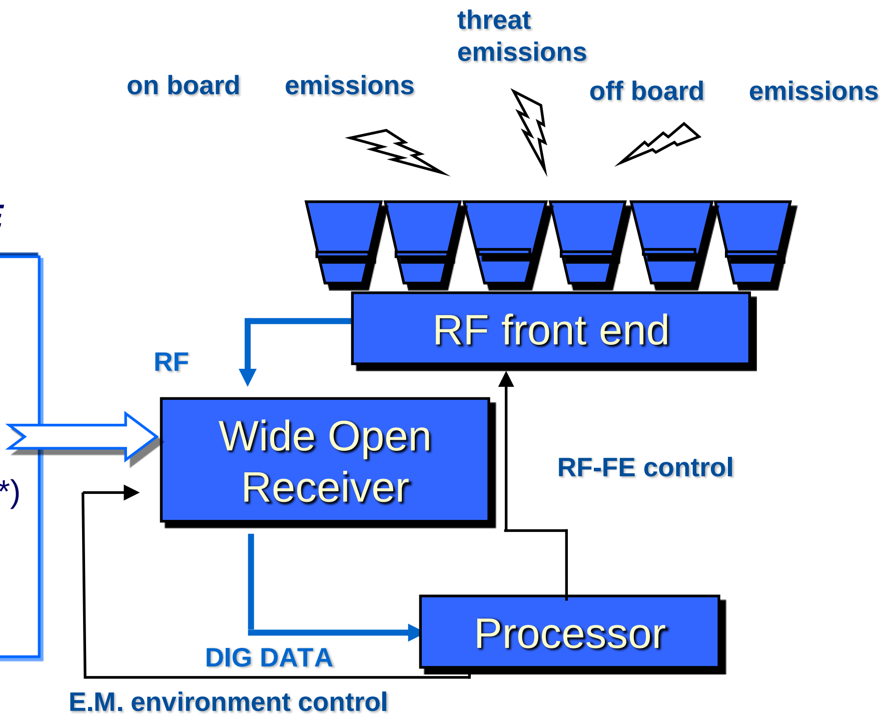
- Le tecnologie microonde in ELT

Receiver architecture vs E.M. scenario and mission: Wide Open Rx (ESM/RWR)



RWR & HPOI - SURVEILLANCE

- Full instantaneous band
- Instantaneous Inhibition on the interfering signal (CW)
- Fast response time
- Medium sensitivity −60 dBm
- AOA of mainbeam (up to HADF*)
- Emission analysis, mode determination
- Emitter identification



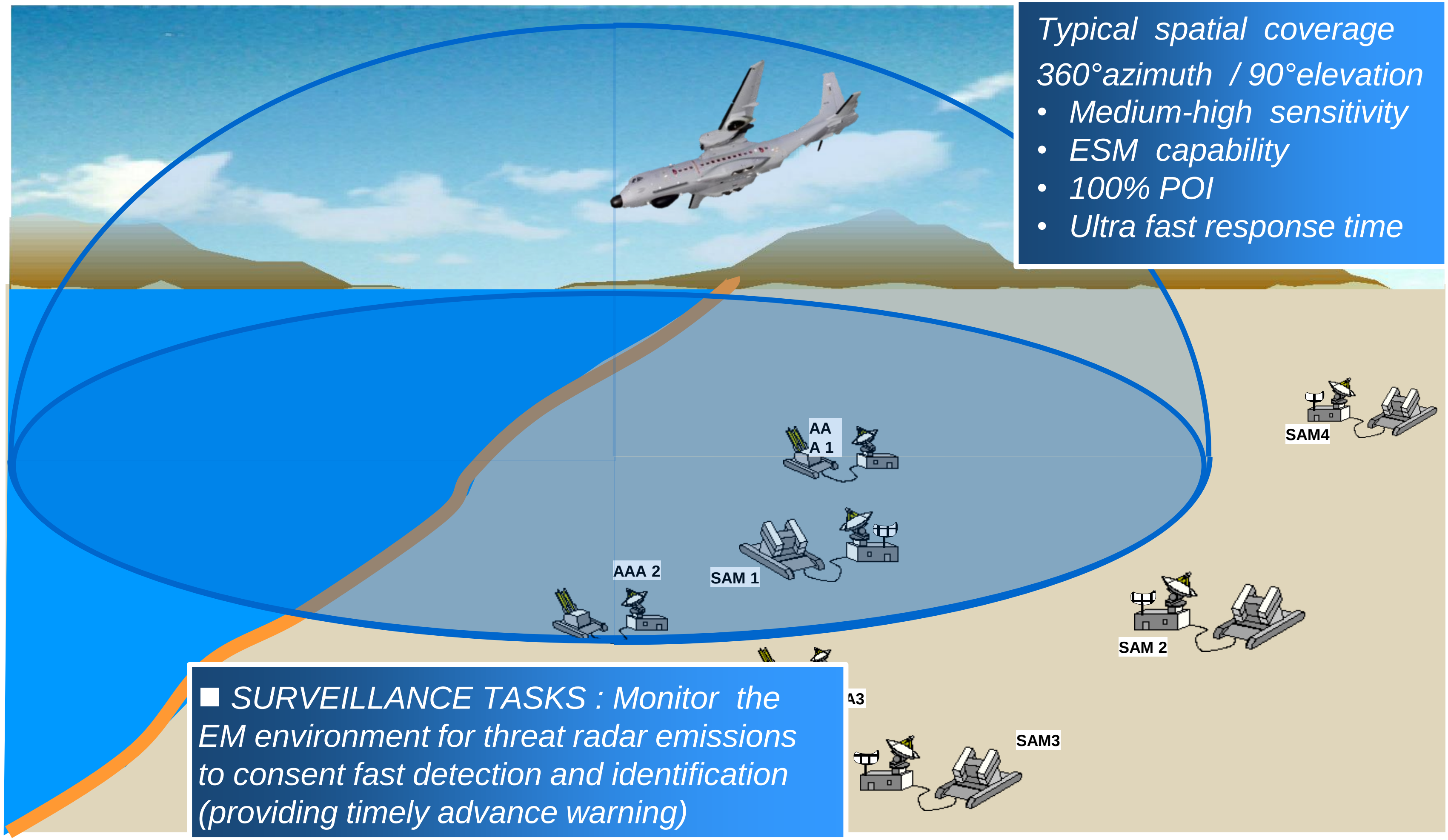
Missions requirements:

- threat alarm & avoidance, **even in partially unknown scenario**
- Surveillance, aid to situation awareness
- Electronic Reconnaissance
- ECM designation (if any)
- Emitter recording

*HADF, High Accuracy Direction Finding better than 1-2° RMS

- ***Platforms:*** *naval, airborne (large/medium body, tactical A/C), ground station & mobile vehicle*
- ***Missions****: patrolling, coastal surveillance, SAR (mainly utility helo & cargo), light combat*

HPOI Receiver spatial coverage



Typical spatial coverage

360°azimuth / 90°elevation

- *Medium-high sensitivity*
- *ESM capability*
- *100% POI*
- *Ultra fast response time*

POI
Probability of intercept

■ *SURVEILLANCE TASKS : Monitor the EM environment for threat radar emissions to consent fast detection and identification (providing timely advance warning)*

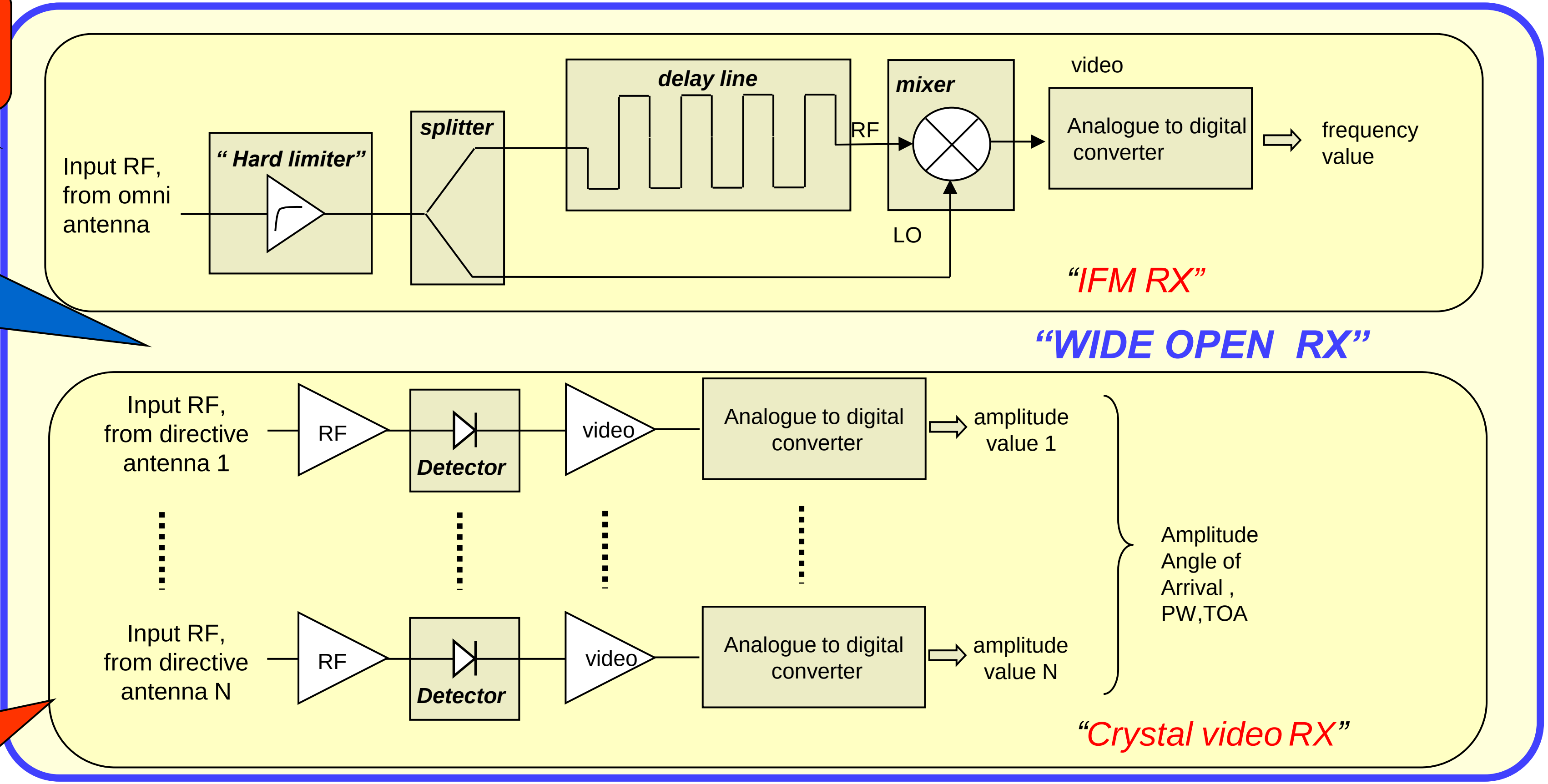
The WO analogue receiver: full band IFM Rx plus AM Crystal Video Rx

The EW analogue RX is typically based on an single-channel IFM (Instantaneous frequency measurement) receiver with a multi- channel crystal video-envelope detector providing Amplitude monopulse Direction finding

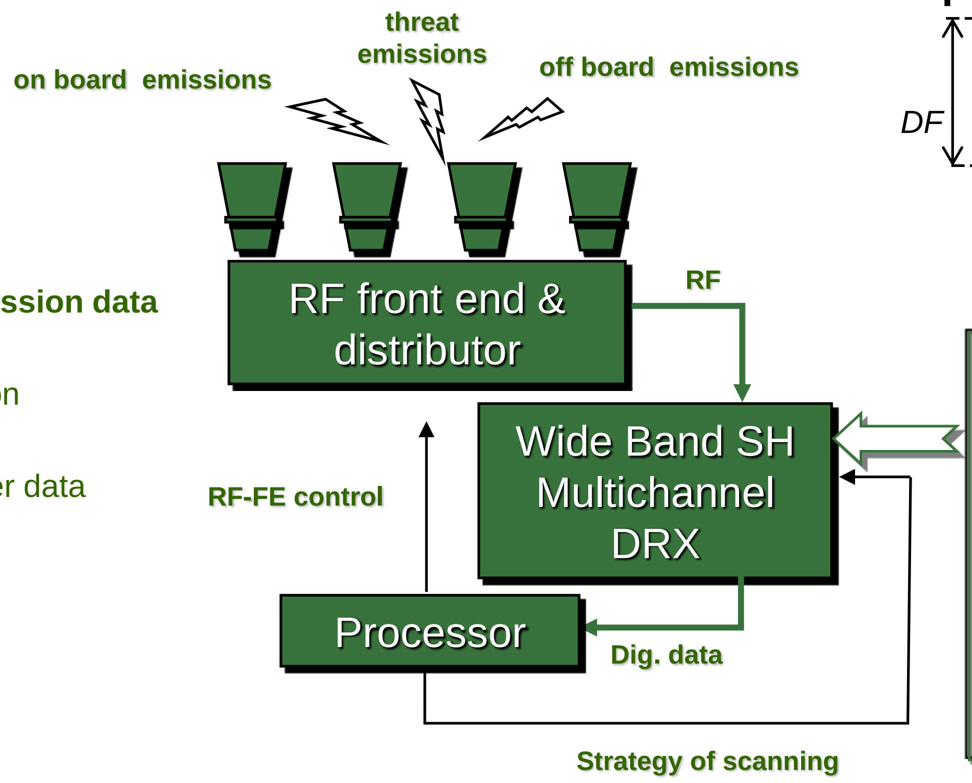
- *Relatively poor sensitivity*
- *Cannot sort simultaneous signals*

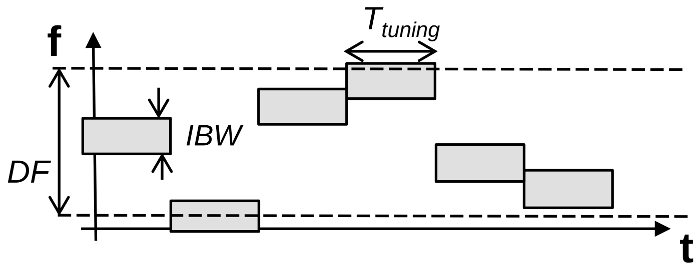
- *Simple,*
- *(relatively) inexpensive, instantaneous,*
- *High Probability of Intercept (POI) in frequency range*

- *Poor sensitivity and simultaneous signal performance*
- *Special design for CW is required*



Receiver architecture vs E.M. scenario and mission: Wide Band SH DRX (ESM/ELINT)





Missions requirements:

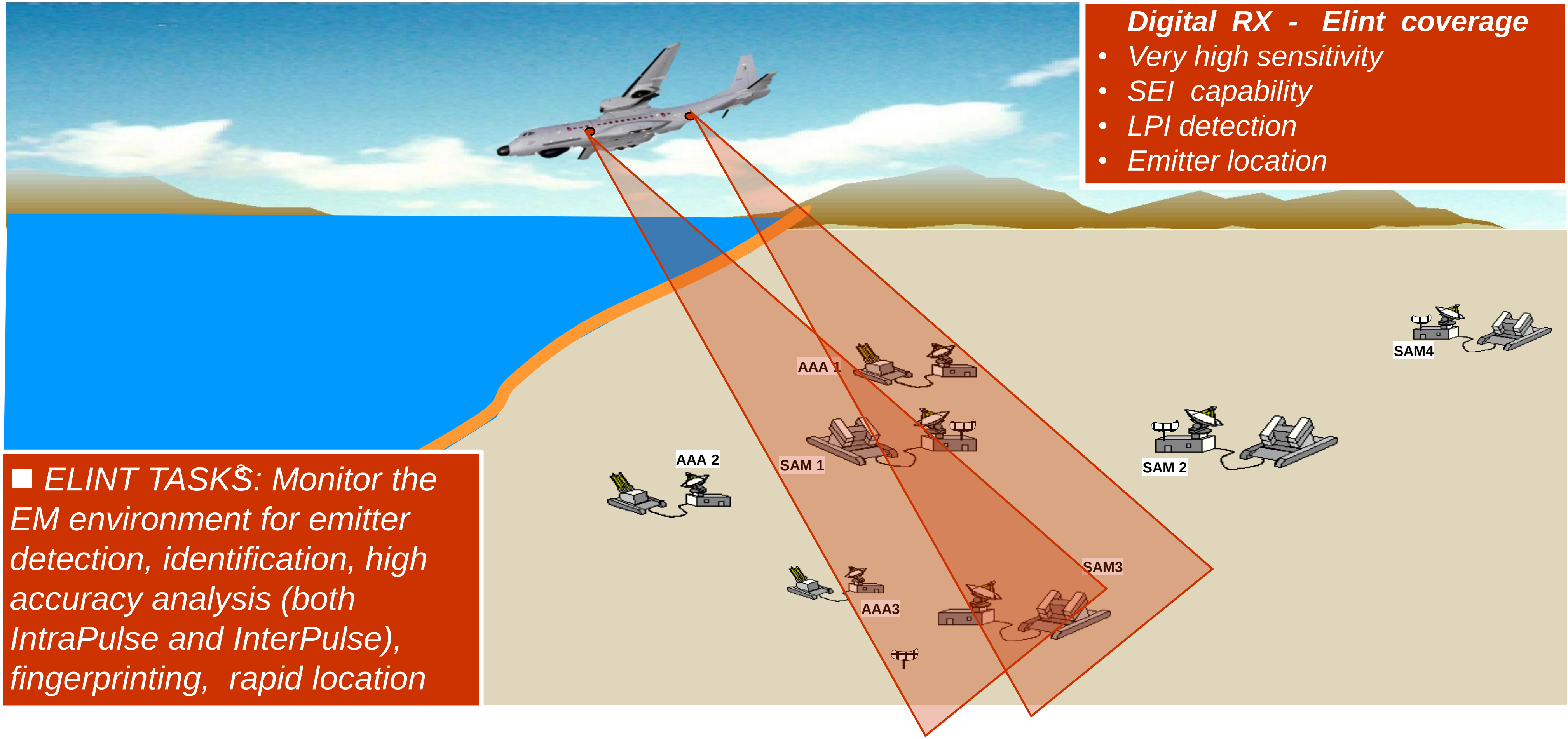
- threat alarm & avoidance, **on pre-mission data**
- Electronic Reconnaissance
- Emitter fast and accurate geo-location
- Real time ELINT analysis
- Collection of intelligence data/ Emitter data recording
- ECM designation (if any)

HIGH PERFORMANCE ESM & ELINT

- Wide instantaneous band RX
- Real time adaptive tuning on the required band (fine analysis, threat warning, search strategy)
- High sensitivity, -80/90 dBm
- HADF (typ 1°/2°)
- Accurate measurement of signal parameters and Specific Emitter Identification (fingerprinting)

Platform & mission : *ELINT/SIGINT naval, airborne (large/medium body) and ground fixed-mobile stations*

SH Digital Receiver spatial coverage



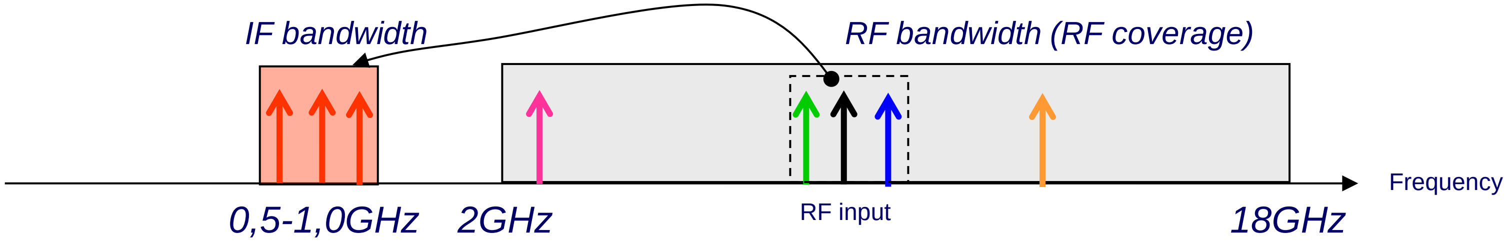
Digital RX - Elint coverage

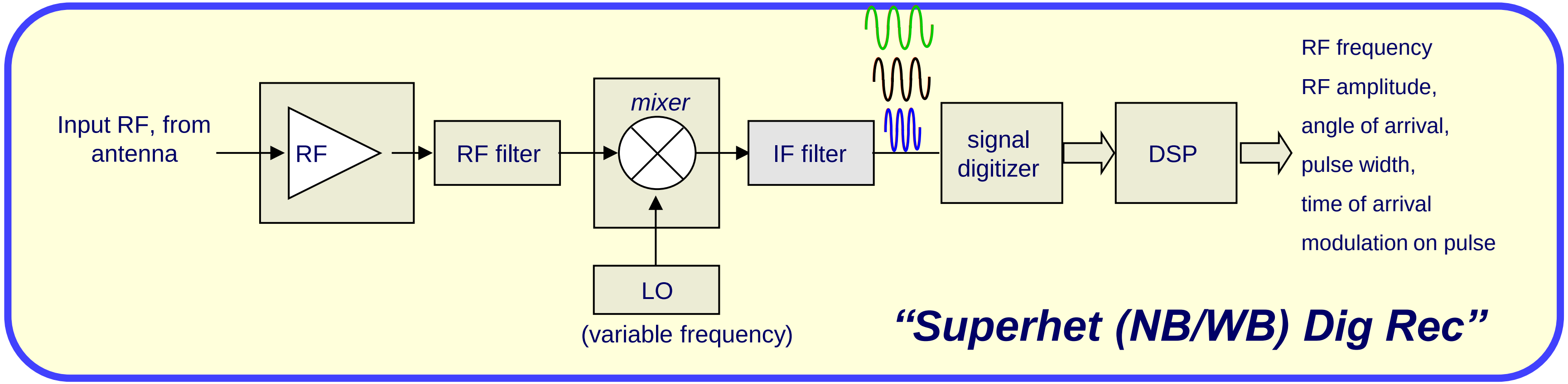
- *Very high sensitivity*
- *SEI capability*
- *LPI detection*
- *Emitter location*

■ *ELINT TASKS: Monitor the EM environment for emitter detection, identification, high accuracy analysis (both IntraPulse and InterPulse), fingerprinting, rapid location*

The "Superhet" narrow/wide band digital receiver

The **superheterodyne receiver** uses frequency mixing to convert a received BW of signal to a fixed lower frequency bandwidth, which can be conveniently sampled and processed using fully digital techniques

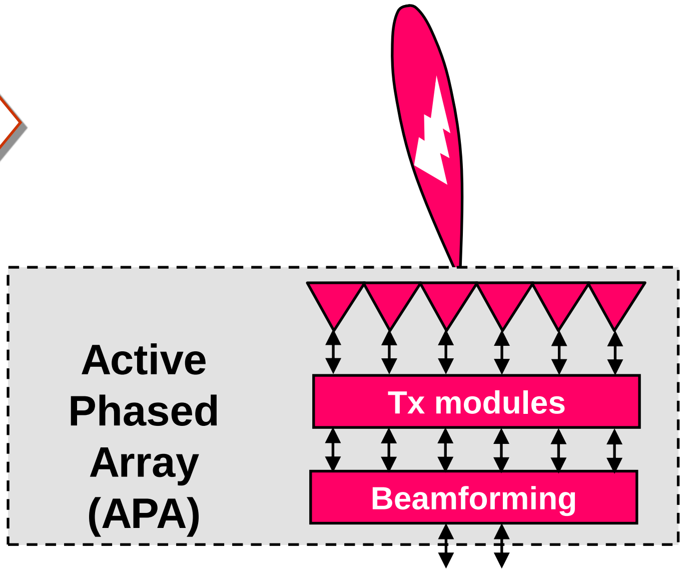




Advantages of Solid State transmitter technology - ECM

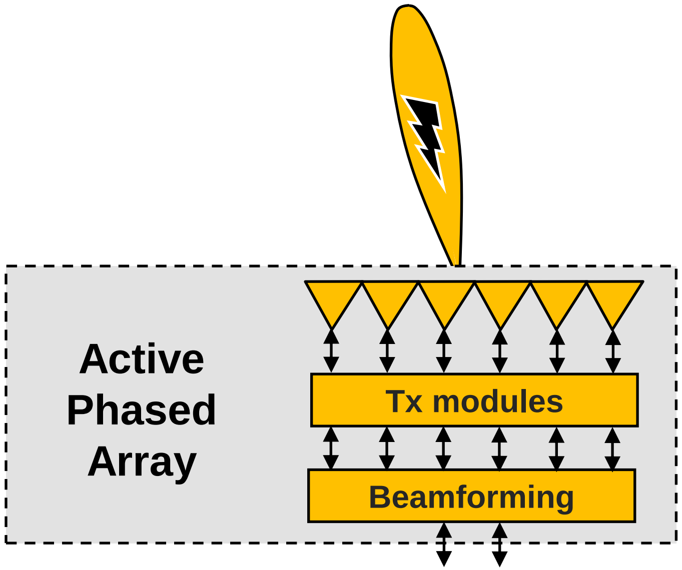
- **Very high ERP (Effective radiated power)**:
  - 100% duty cycle with ERP fine control
  - Capability to counter high peak power pulse as well as complex signals
- **Very large space coverage achieved by a single APA :**
  - single-aperture AND multiple-aperture
- **Very High ECM availability & Readiness:**
  - graceful array degradation, no warm up time
- **Full equipment compatibility:**
  - focused energy, low side lobes, predictable jamming
  - Low level of radiated power
- **Maintainability benefits:**
  - no High Voltage Power Supply; high Mean Time Between Failure
- **High ECM effectiveness and efficiency**
  - Multiple and different type of simultaneous threat (CW / pulse / pulse Doppler; simultaneous or very high fast time multiplexing)
  - Low weight & power consumption

Solid state transmitter benefits related with the Active Phased Array architecture



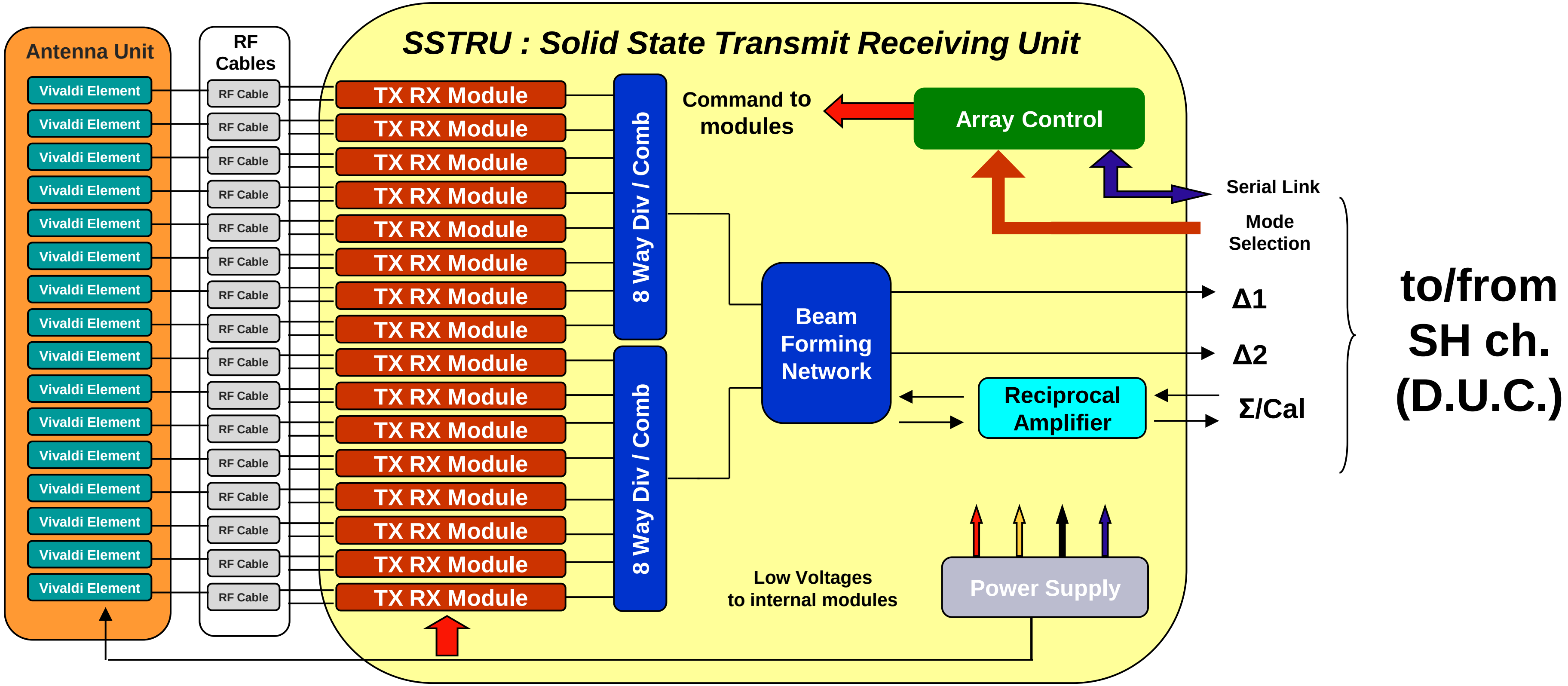
Advantages of high gain - ESM receiver technology

ESM receiver benefits related with the Active Phased Array high gain receiving architecture



- **Very high DOA Accuracy (typ <1° RMS degree depending on installation)**:
  - both in azimuth and elevation (planar APA) , narrow beam **mono-pulse measurement (phase or amplitude)**
  - better Situation Awareness
- **High ECM/ESM sensitivity:**
  - long range detection
- **Flexibility :**
  - Stand-alone operation
  - Designated by a low performance RWR
  - Self-pointing and self-stabilizing

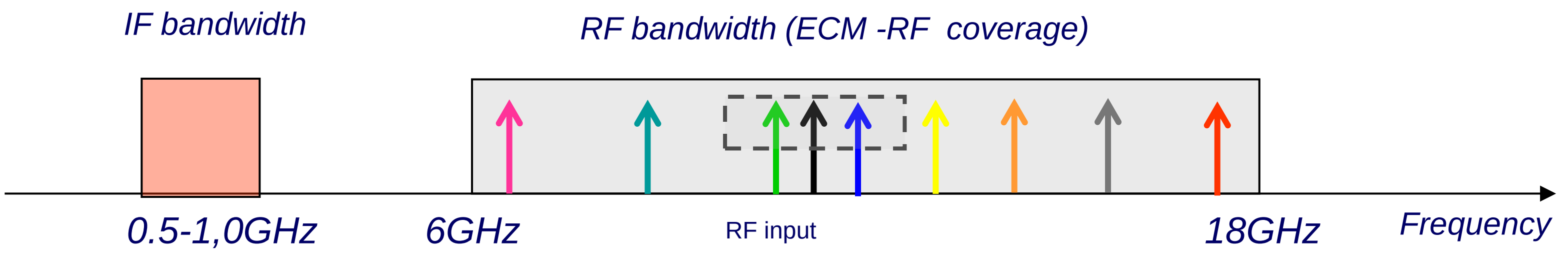
APA functional scheme

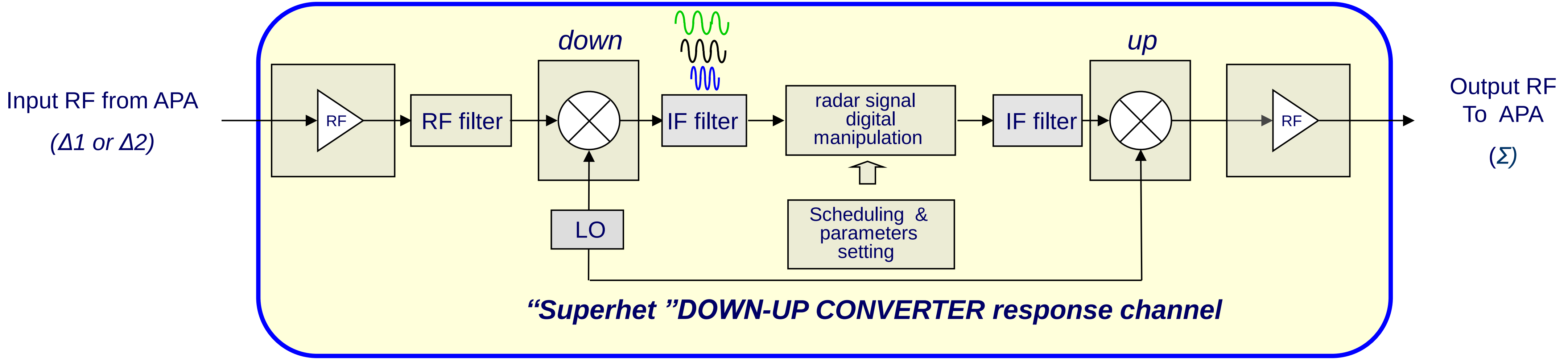


In modalità TX, il segnale è proventinete dal D.U.C e inviato al conettore Σ
In modalità RX, il il segnale da inviare al D.U.C viene prelevato dai connettori Δ1 e Δ2

The "superhet" response channel architecture

The superheterodyne selective receiver is the basic response channel architecture in any jammer system where a narrow band of signal has to be handled at time for jamming purpose

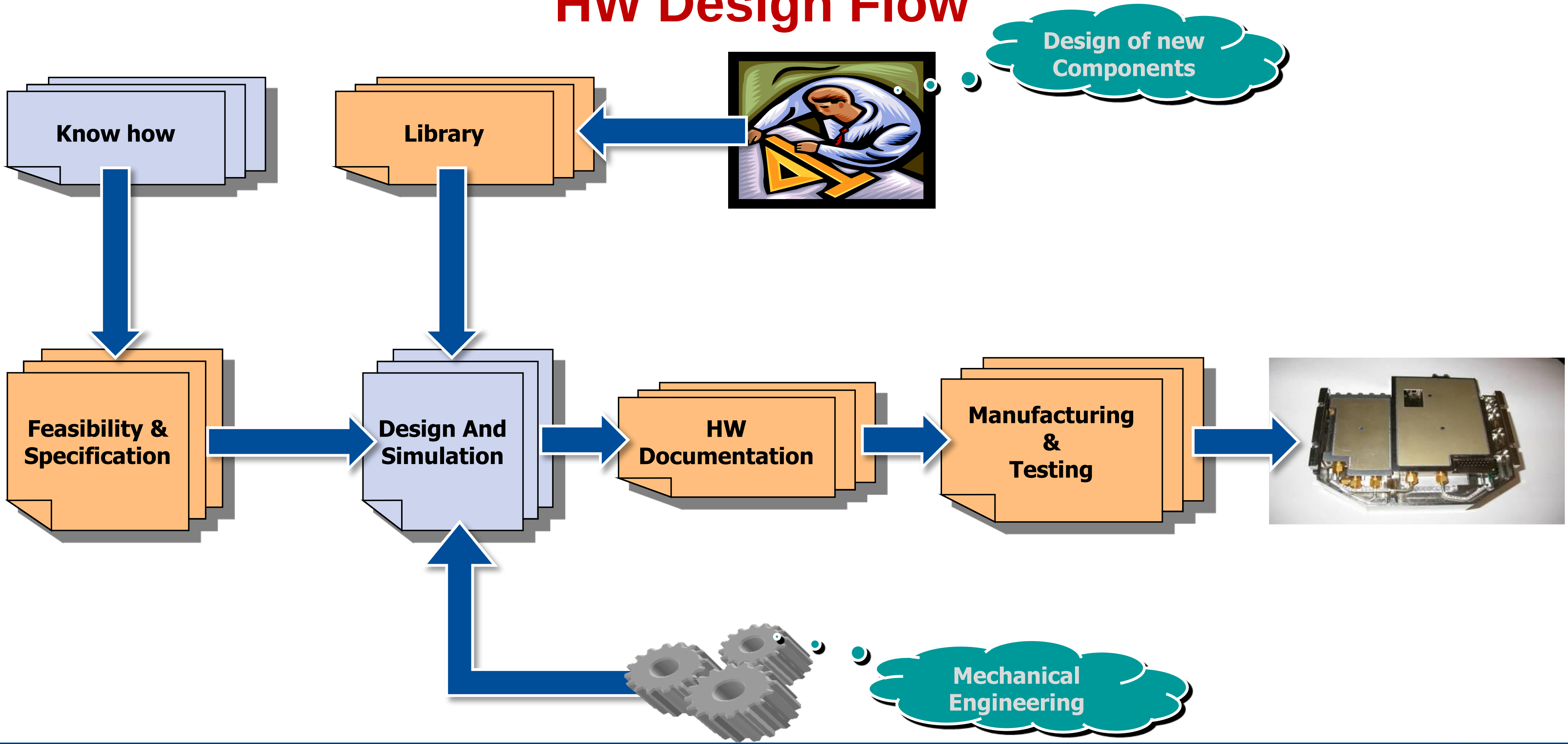




PROGETTAZIONE MW ELT

- **Flusso di PROGETTO**
- **Principali criticità & tecnologie**
- **Esempio di progetto HW**

HW Design Flow



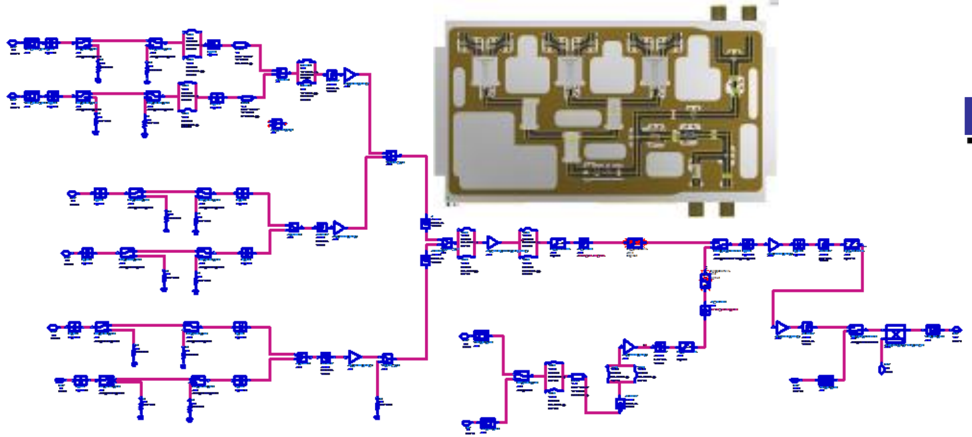
Critical Design Constraints:

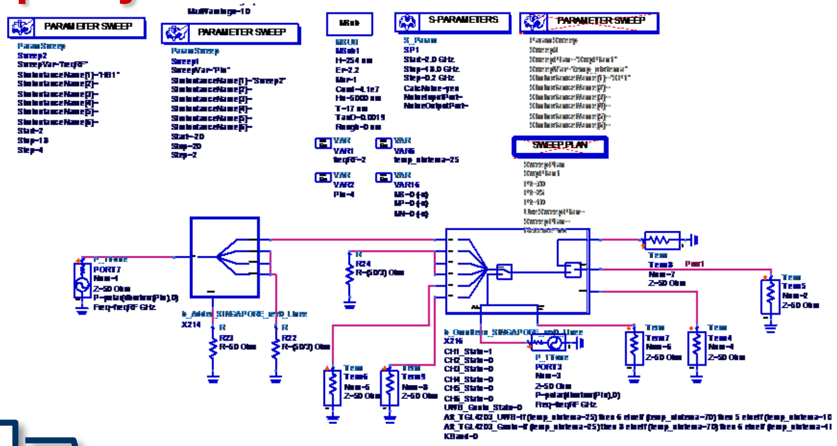
- *High levels of HW integration (RF&Digital)*
- *Time To Market*
- *Thermal and mechanical issues*
- *Technological upgrading*
- *Integration in company internal design flow*

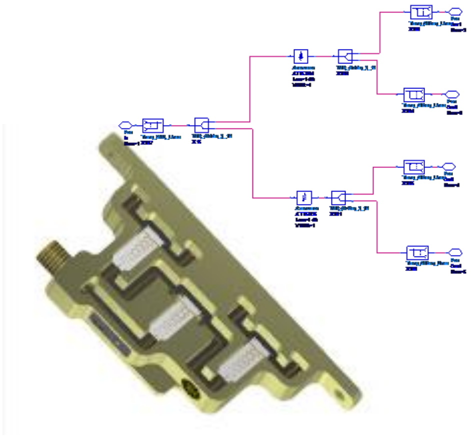
Microwave Technologies:

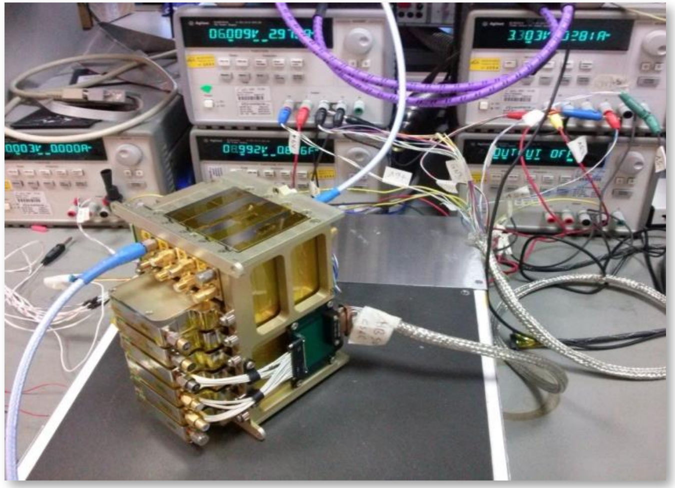
- *GaAs Monolithic microwave circuits (ELT design)*
- *GaN on SiC Monolithic microwave circuits*
- *Multilayer video/digital circuits*
- *Thin Film on alumina and teflon glass substrates*
- *Assembling processes*
- *M.M.C.M (Microwave Multi -Chip Module)*

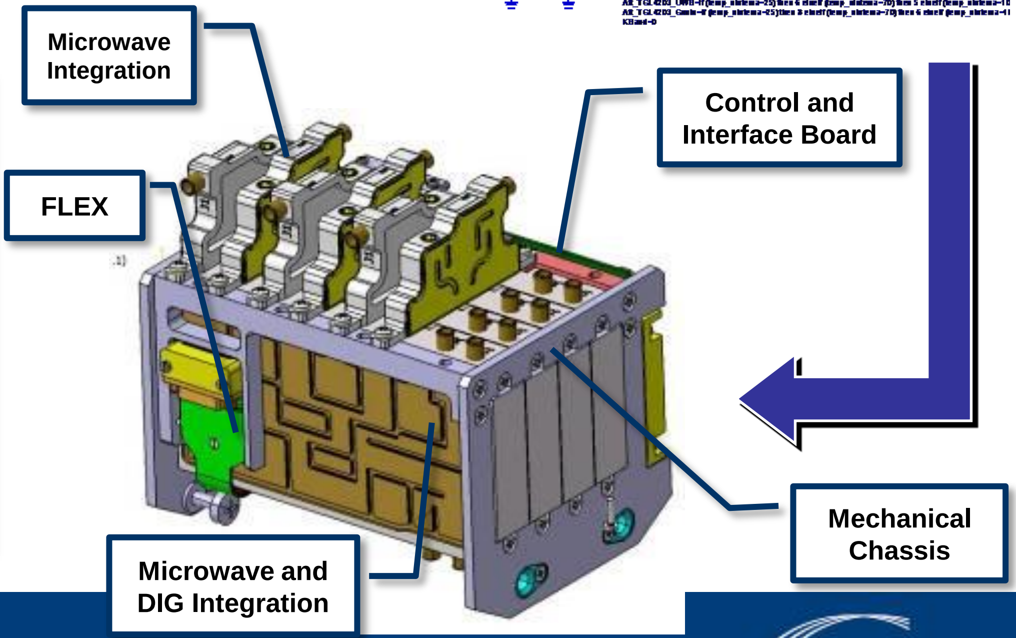
Example of hierarchical project

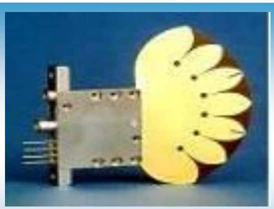




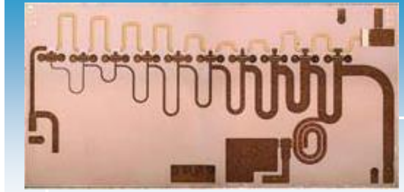


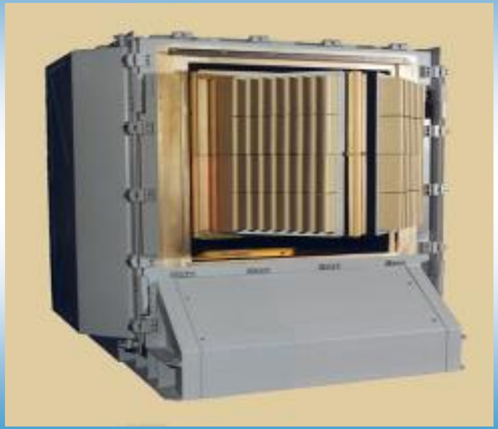


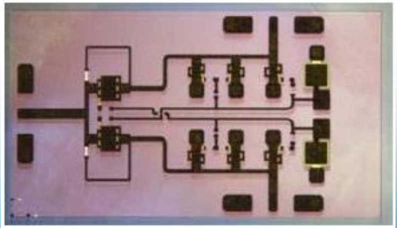




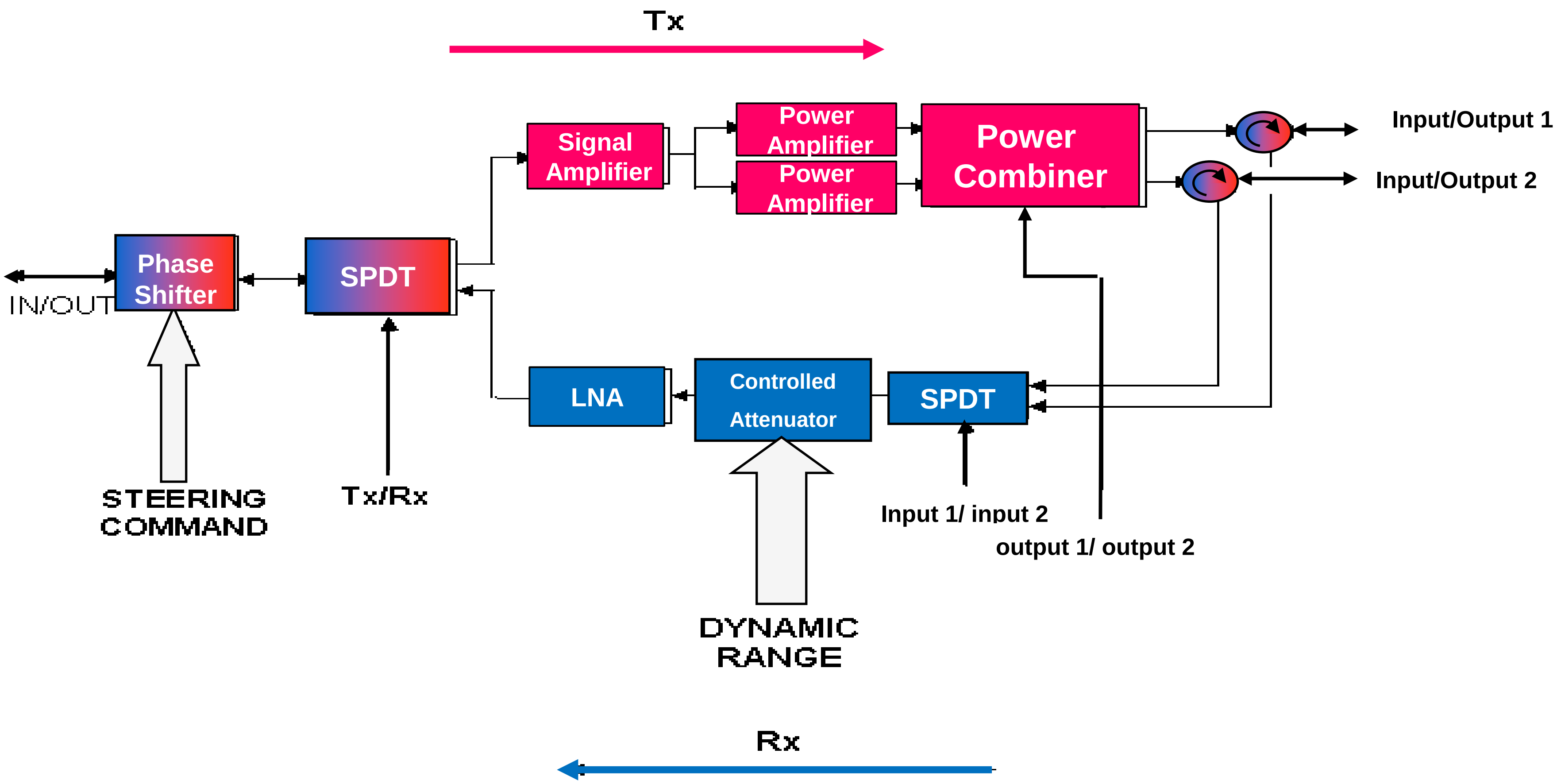
MW TECHNOLOGIES







Classic T/R module architecture (dual I/O)



Tx/Rx MODULE ROAD MAP

1993
Pout 0.5 W

1997
Pout 1.0 W

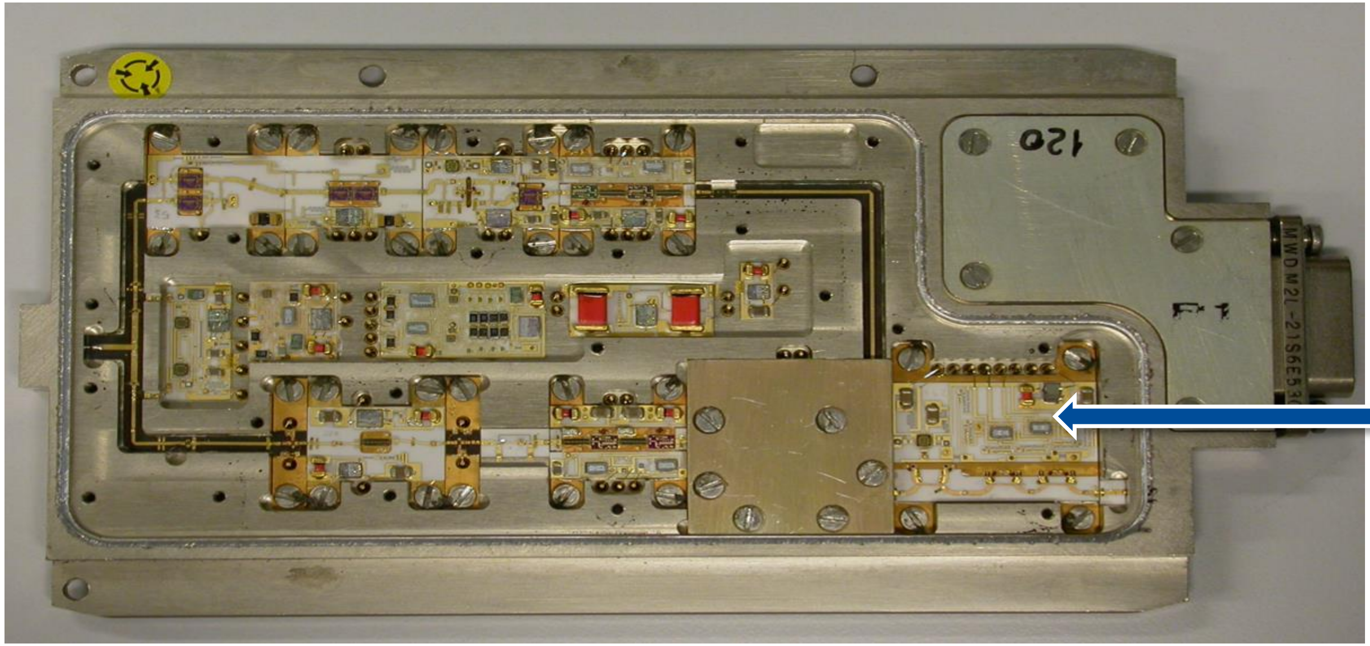
2001
Pout 4.0 W

2009
Pout 4.0 W

2012
Pout 8.0 W

Tx/Rx 1° Generation

TXRX 1Watt RFout - Avionic Application

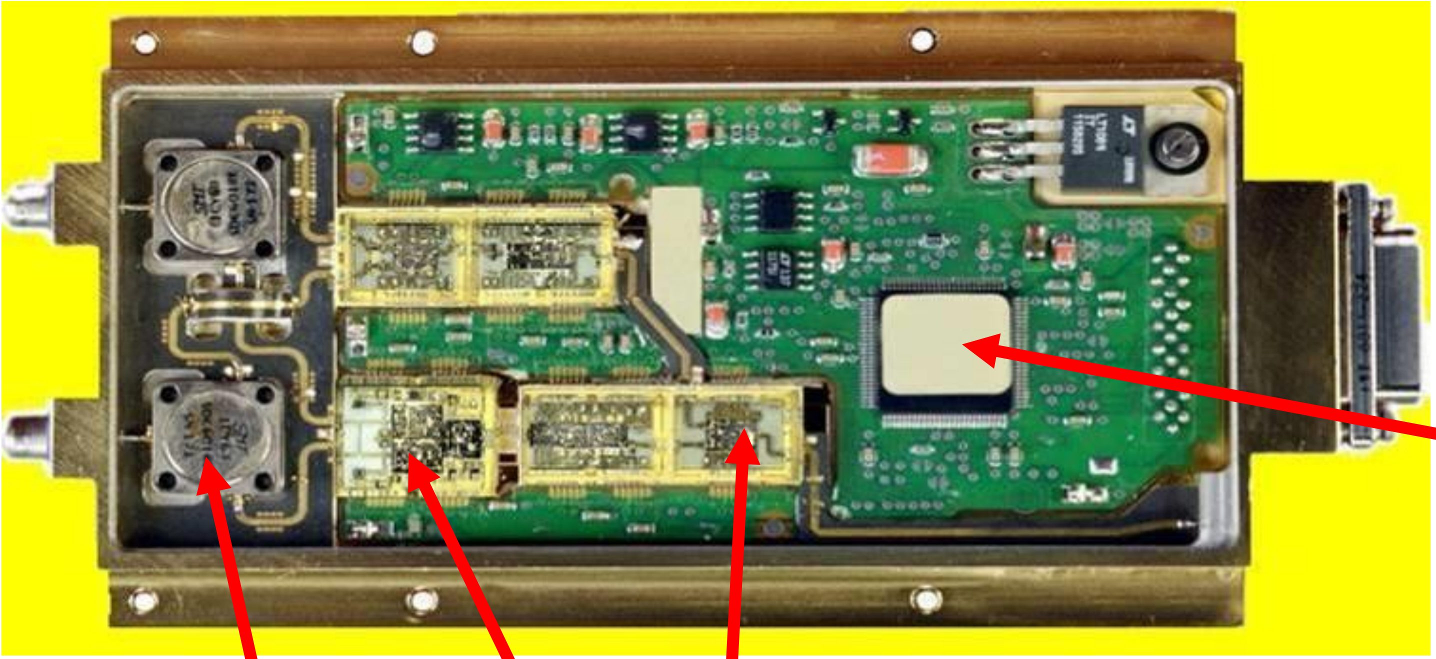


Phase shifter a componenti discreti (scarsamente ripetibili)

- Tecnologia ibrida con MMIC e stadi RF avvitati in cavità
- Driver di controllo dedicati ad ogni stadio
- Assenza di scheda di controllo con logica programmabile
- Utilizzo di Switch a diodi per la commutazione RX-TX

Tx/Rx 2° Generation

TXRX 4Watt RFout - Naval Application

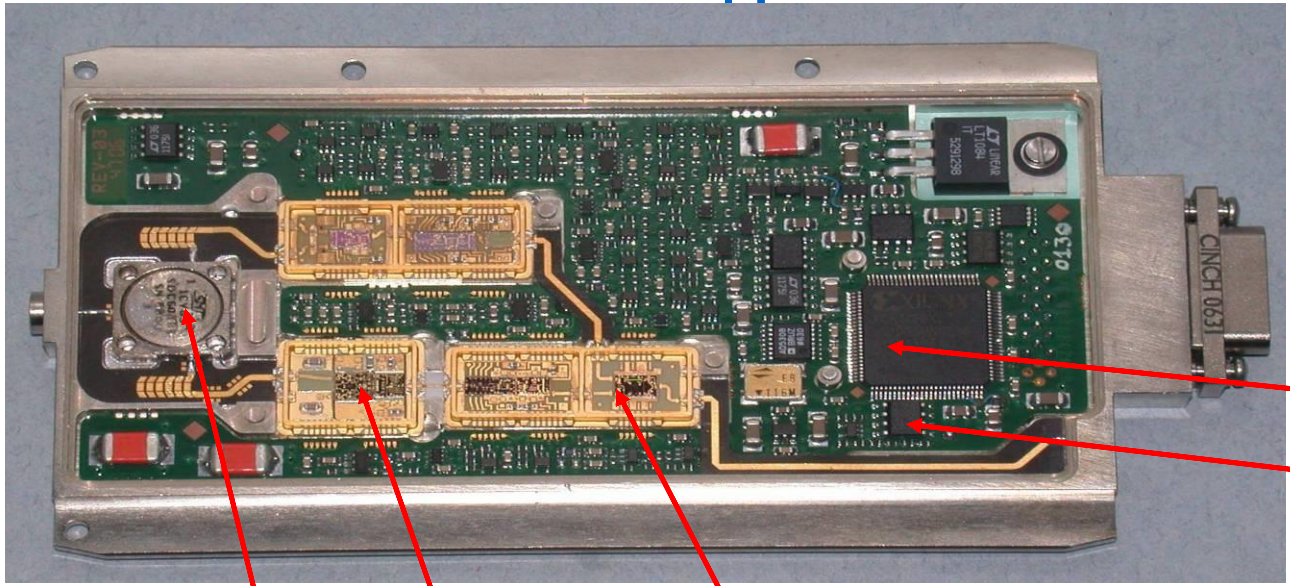


Impiego di un ASIC per la scheda controlli

- Tecnologia con micro-package per alloggiare il Chipset di MMIC
- 2 Circolatori 6-18GHz per isolamento RX-TX e doppia polarizzazione
- Phase Shifter in tecnologia MMIC

Tx/Rx 2° Generation

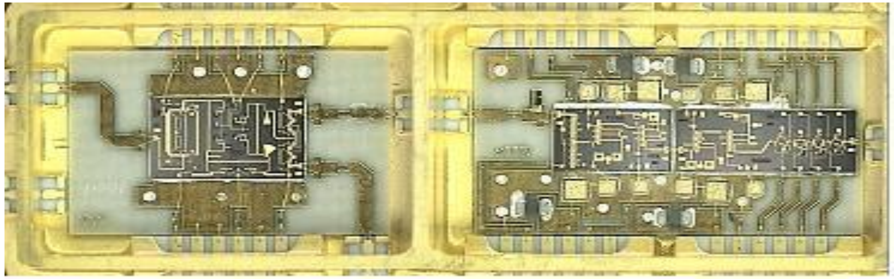
TXRX RFout - Avionic Application

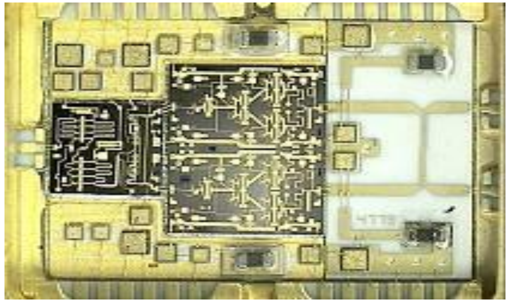


PLD e E^2Prom con DAC esterni per la scheda controlli

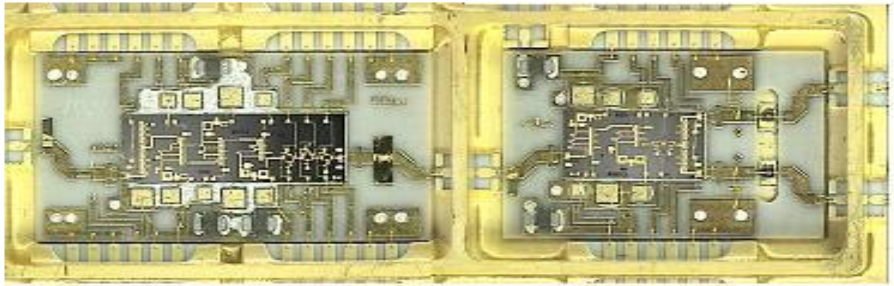
Tecnologia con micro-package per alloggiare il Chipset di MMIC
Impiego del circolatore 6-18GHz per isolamento RX-TX
Scheda con logica programmabile e controllo in temperatura

Multichip Packaging for High Integration T/R Module



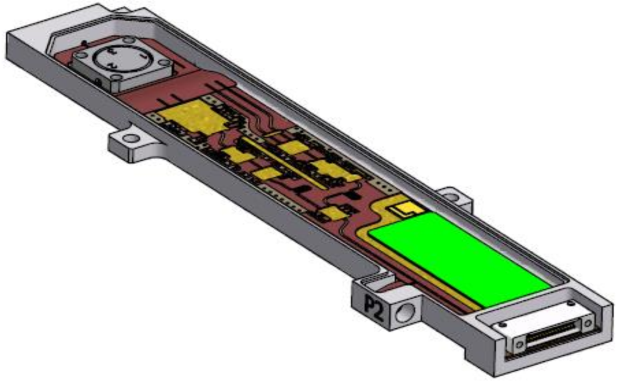


- More than 30dB gain
- Hermetically sealed sub-assemblies

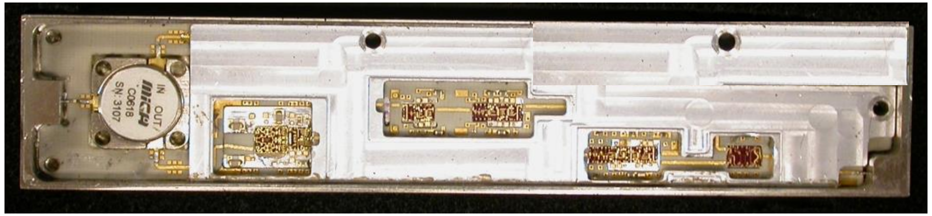


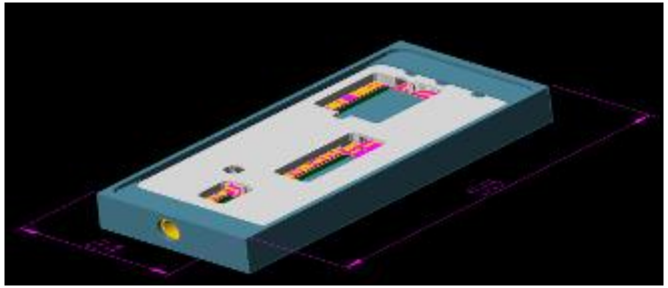
- $Cu_{20}Mo_{80}$ heat spreaders
- Microstrip-stripline-microstrip for RF I/O transitions
- Epoxy glued or brazed MMIC for best thermal dissipation;
- Internal bypass capacitors
- Automatic assembling compatible

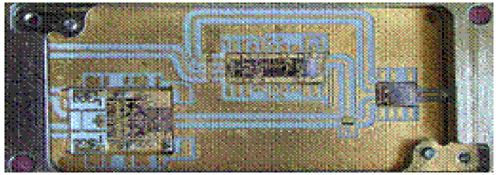
Tx / Rx – 3° generation of TR modules



First prototype



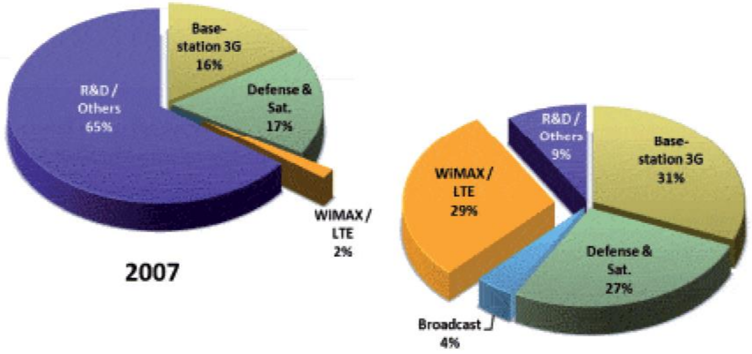


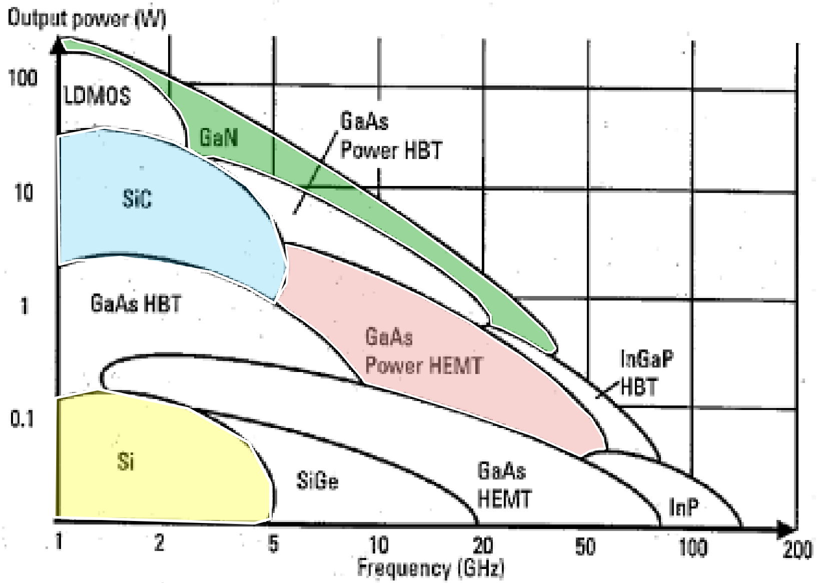


Multilayer Technology - RF and Digital circuit integrated on the same substrate.

Gallium Arsenide (GaAs) VS Gallium Nitride (GaN)

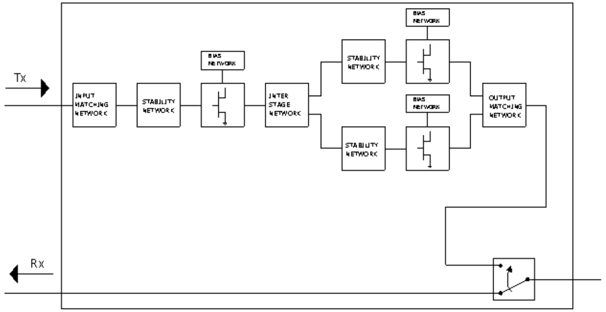
Parameter	Unit	SiC	Si	GaAs (AlGaAs/InGaAs)	GaN (AlGaN/GaN)
BandGap Energy	eV	3.26	1.12	1.43	3.44
Electric breakdown field	MV/cm	3	0.3	0.4	3.0
Saturated (peak) electrons velocity	$x10^7$ cm/s	2.0 (2.0)	1.0 (1.0)	1.0 (2.1)	2.5 (2.7)
Electron mobility	$cm^2/V \cdot s$	700	1500	8500	1000-2000
Thermal conductivity	W/cm·K	3.7 – 4.5	1.5	0.5	1.3 – 2.1
Relative permittivity	-	10.1	11.8	12.8	9.0



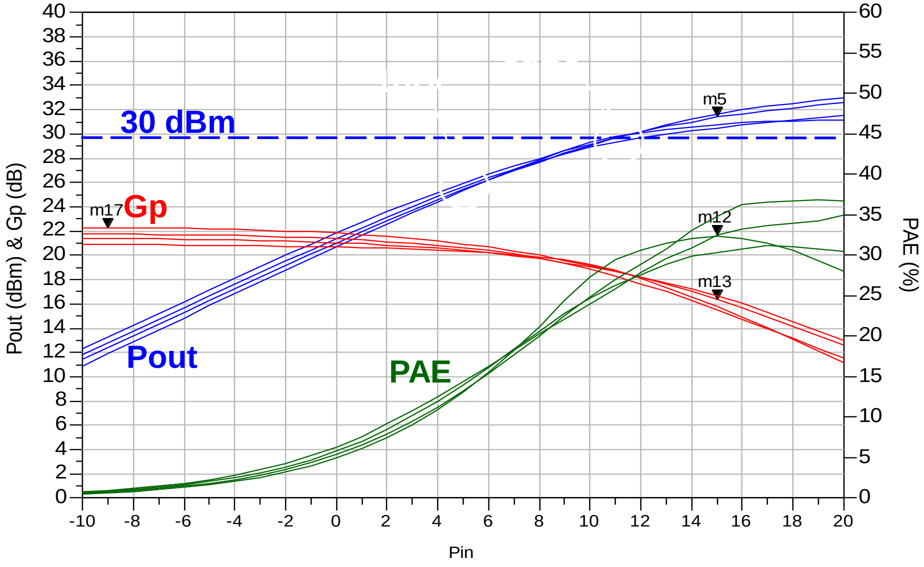


Why GaN Technology ?

- *High voltage supply (>30V)*
- *High current density;*
- *High power density; (>3W/mm)*
- *Efficiency;*
- *Thermal management;*
- *Survivability*



- *Pout 1W;*
- *High Efficiency: 33% average;*
- *High small signal gain: 20 dB;*
- *No drivers;*
- *Robust SPDT instead of ferrite circulators;*
- *Size: 3x4 mm.*

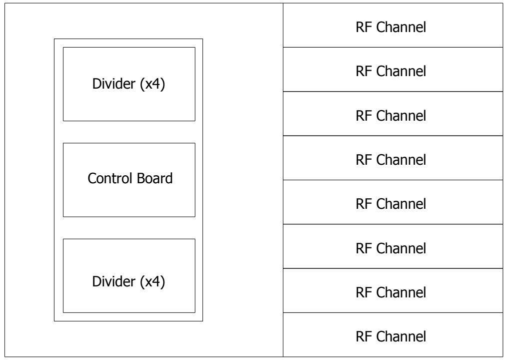


Innovation and applications of GaN - 4° generation of TR modules

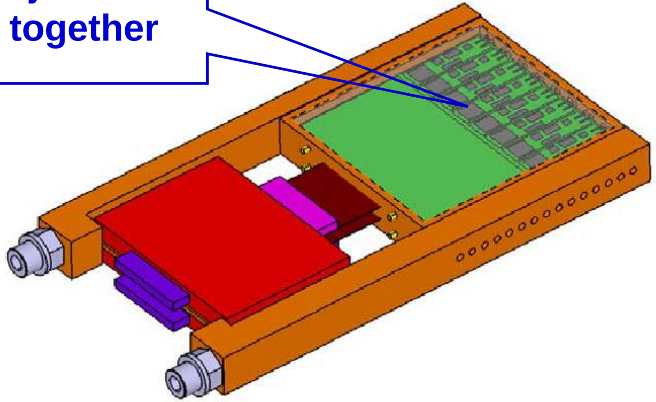
T/R modules

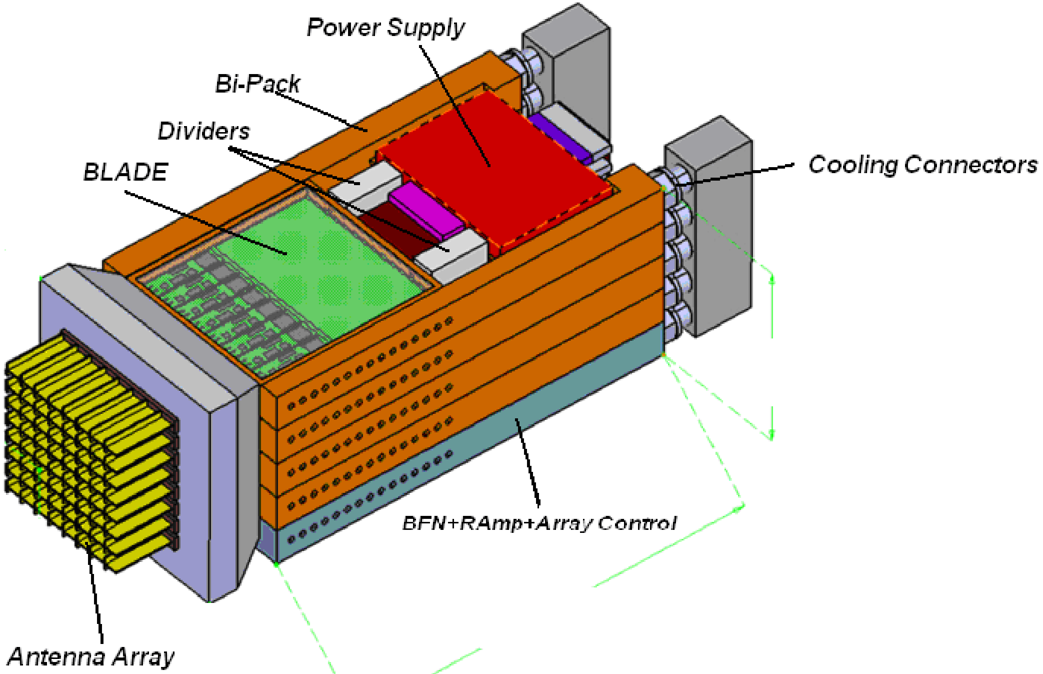
…x8…

VS



8 T/R joined together





- **MMIC Size reduction: 60 %**
- **Cost reduction: 60 %**
- **Efficiency increase: 90 %**
- **Cooling system lighter**
- **Losses reduction versus antennas**

MICROELECTRONICS CLEAN ROOM AREAS

AUTOMATIC TEST AREA

ENVIRONMENTAL TEST AREA

www.elt-roma.com

Letture di riferimento

- Microwave Receivers With Electronic Warfare Applications, James Tsui, WILEY
- Integrated Microwave Front-Ends with Avionics Applications, Leo G. Maloratsky, ARTECH HOUSE RADAR LIBRARY
- Fundamentals of Electronic Warfare, Sergei A. Vakin, Lev N. Shustov, Robert H. Dunwell, ARTECH HOUSE RADAR LIBRARY
- EW 101: A First Course in Electronic Warfare, David L. Adamy, ARTECH HOUSE RADAR LIBRARY
- EW 102: A Second Course in Electronic Warfare, David L. Adamy, ARTECH HOUSE RADAR LIBRARY
- EW 103: Tactical Battlefield Communications Electronic Warfare, David L. Adamy, ARTECH HOUSE RADAR LIBRARY