



THALES



MINISTRY OF DEFENCE

**EMRS DTC**  
Electro-Magnetic Remote Sensing (EMRS) Defence Technology Centre (DTC)

# **MULTI-FUNCTION RF SYSTEMS FOR UAVs**

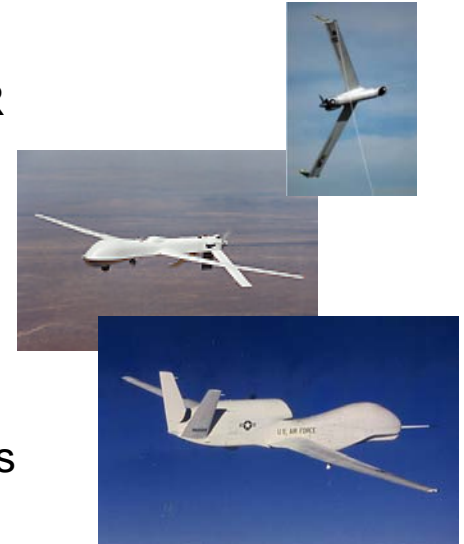
## ***REQUIREMENTS AND FUTURE DIRECTIONS***

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Selex Galileo

EMRS DTC Research Theme Leader  
*RF Systems*

# Future Trends in UAV Sensor Systems

- Current UAVs fall, broadly, into three classes:
  - Very small UAVs with sensor payloads under 10kg- mostly optical or IR sensors
  - Tactical UAVs with sensor payloads in the 30kg ~ 80kg bracket
    - High performance EO/IR sensors *OR*
    - SAR/MTI radar sensors *OR*
    - SIGINT sensors
    - Larger platforms may carry more than one sensor (federated architecture)
  - Large, strategic UAVs with long range radar, SIGINT and EO/IR sensors
- Numerous other RF systems are carried- comms, navigation, satcomms, datalinks etc.
- Future systems would benefit greatly from Multi-Function RF Sensor Payloads
  - More capable sensing in smaller platforms
  - Ability to deploy a multi-sensor capability simultaneously
  - Simplified logistics- smaller variety of sensor payloads, reduced number of equipment types (a big advantage on remote deployments)
- Technologies to support Multi-Function RF Sensors on smaller UAVs are now emerging



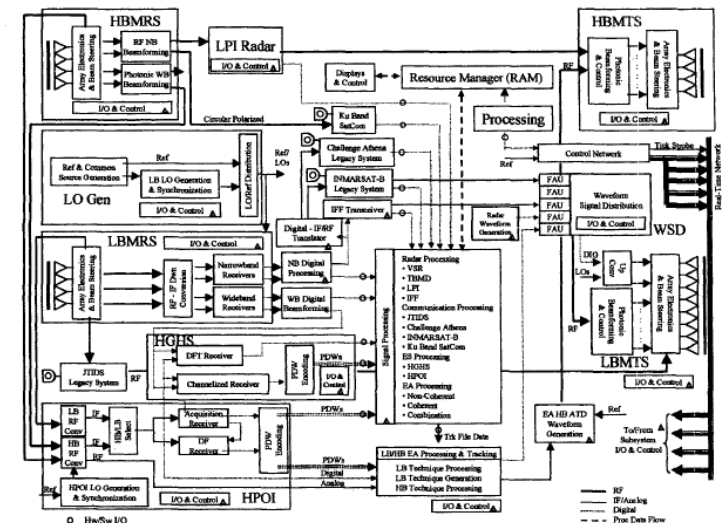
# Multi-Function RF Systems

- Significant research activity over last 10~15 years
  - Major activities on Naval systems- AMRFS in US, SMRFS in Europe
    - Prime motivation to reduce top weight
  - Airborne systems work has been more limited
  - True MRFS are still some way off practical realisation
    - Existing systems that claim the title are generally only narrow-band- e.g. multi-function radar (search/track), in-band missile datalinks etc.



Type 45 Destroyer

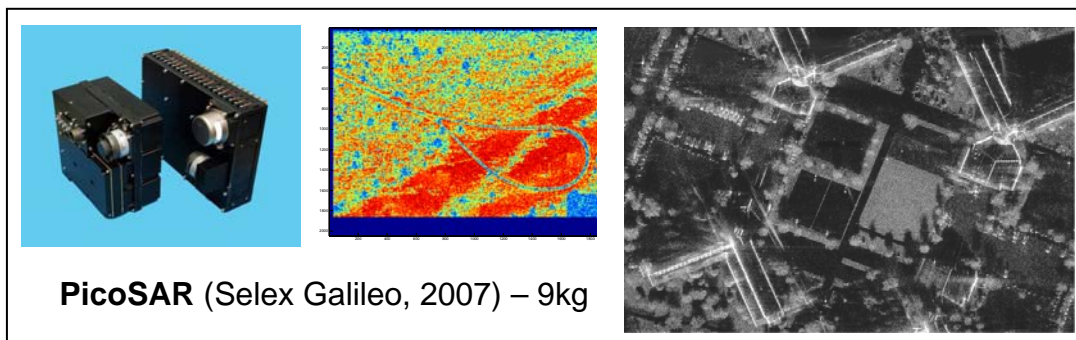
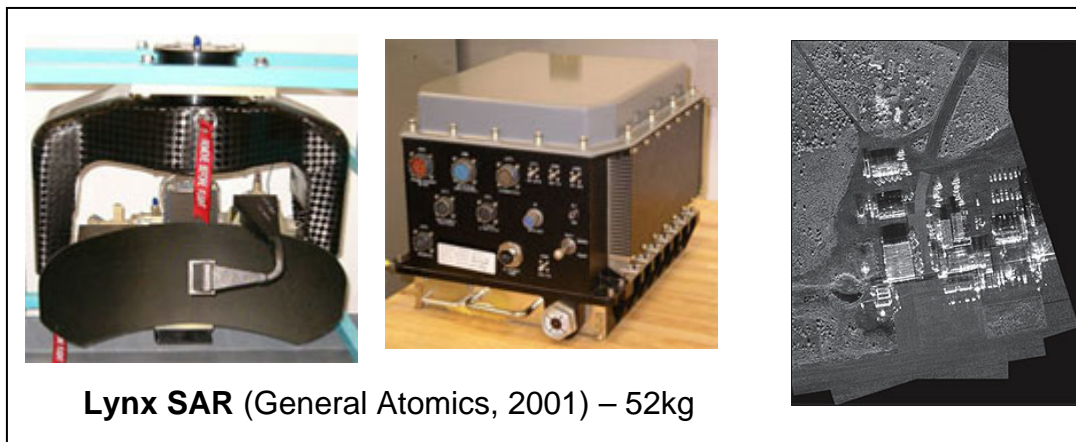
- In airborne systems, MRFS are likely to be primarily applicable to new platforms
  - Investment in federated systems on existing platforms is too large to be lightly discarded
- UAVs represent an ideal application
  - Imperative to reduce size, weight and cost
  - New platforms
  - ‘Sensor Craft’ – the sensor is the main part, the airframe is secondary



AMRFS ARCHITECTURE

# RF Sensors for UAVs – State-of-the-Art

- Technology for RF sensors has advanced rapidly in recent years:
  - Solid-state power
  - Phased array antennas
  - Digital waveform generation
  - Digital receivers
  - High performance, low power processing
  - Solid-state inertial reference systems
- Wideband technologies are now becoming mature- paving the way for Multi-Function systems

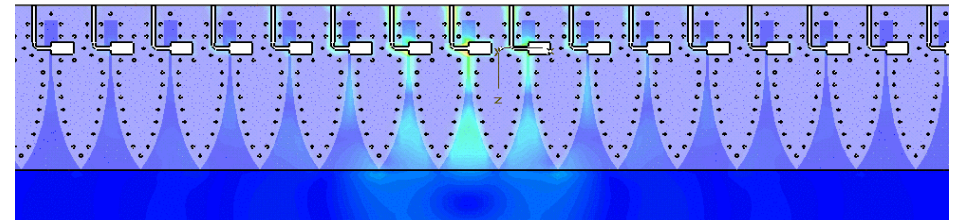


# Ultra-Wide Band Antennas – Current DTC Research

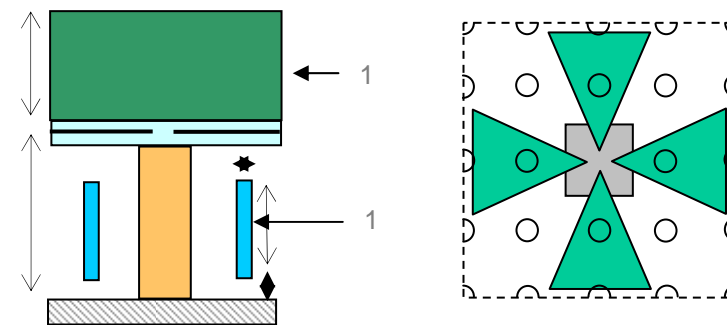
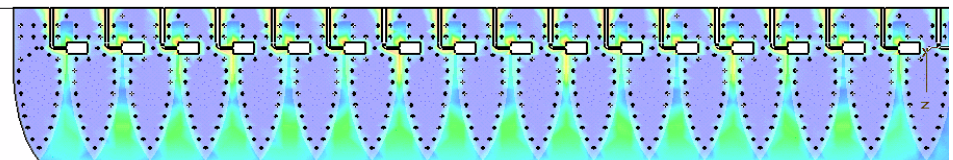


- Enabler for light-weight multi-functional RF systems
  - 4:1 bandwidth antenna will support a wide range of RF system functions with high gain 2D electronic scanning
- Radar
  - SAR/GMTI/Fire control/Surveillance
  - Frequency diversity allows
    - Improved EPM
    - Environmental frequency optimisation
- Electronic warfare
  - Radar and Comms ESM/ECM
- Communications
- ***Demonstration arrays to be evaluated in 2008/9 under EMRS-DTC funding***

The very wide bandwidth response of Selex's array is directly related to the extent to which power is coupled between individual elements



This highly coupled array can be used to propagate EM fields over a very wide bandwidth and thus transmit/receive waveforms into/from free space over a very wide range of frequencies and angles



Stripline Zo

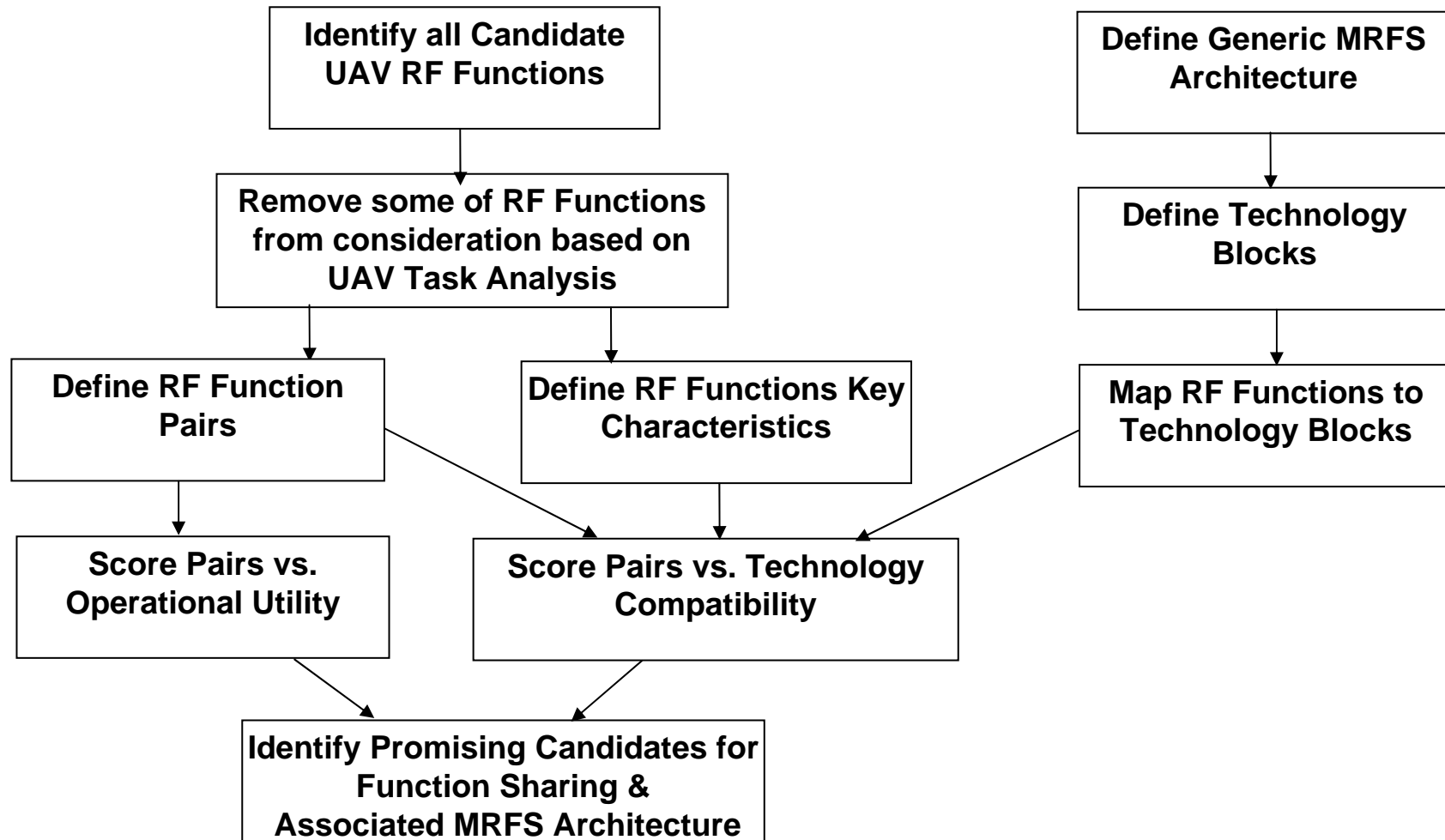
Cross-dipole array from BAE Systems

# Systems Concepts for Ultra-Compact Multi-Function RF Sensors



- **Study carried out by Selex Galileo (UK) and Thales (UK) under EMRS-DTC funding – recently completed**
  - Focus on Military Capability and Technical Feasibility
- **Examined MRFS concepts for Ultra-Compact (~7kg payload) and Tactical (~50kg payload) UAVs**
- **RF Functions considered were:**
  - Synthetic Aperture Radar (incl. GMTI), with centre frequencies from VHF up to W-band;
    - includes bistatic SAR (both co-operative & non-cooperative transmitters)
  - IFF interrogation (L-band) and BTID interrogation (Ka-band)
  - Comms ESM (30 MHz to 6 GHz), including requirements for geolocation
  - Radar ESM (UHF up to Ka-band), including requirements for geolocation
  - Comms ECM (30 MHz to 6 GHz)
  - Radar ECM (UHF up to Ka-band), including requirements for geolocation
  - Comms datalinks, including current and anticipated future standards
  - Navigation RF systems (GPS, Galileo), primarily focusing on operation in a jamming environment

# RF Function Sharing - Study down-selection process



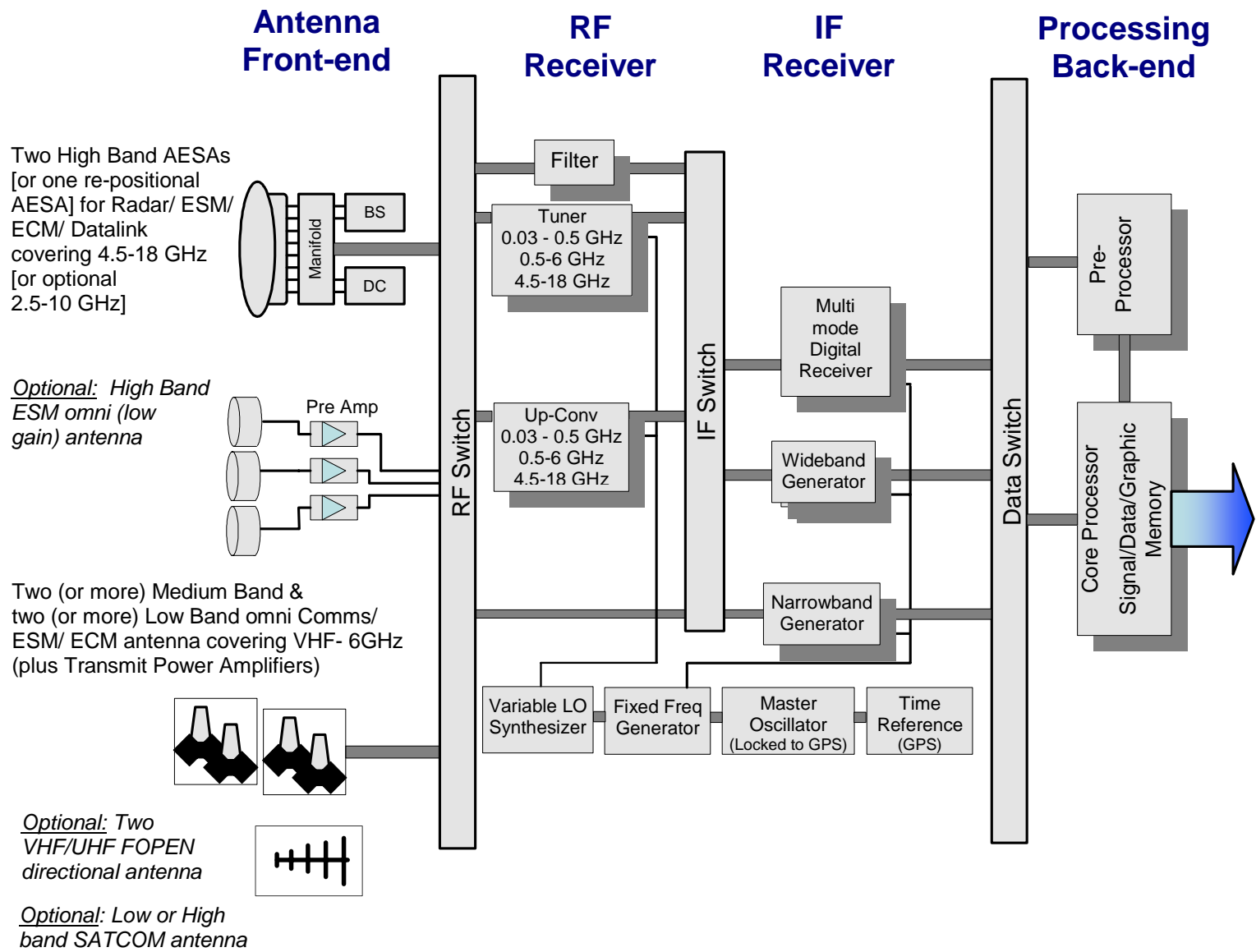
# Functions Considered for RF Sensor Payload Fit after Initial Down- Selection



TUAV	Mini UAV
• Tactical Radio	• Tactical Radio
• Narrowband Data Link	
• Wideband Data Link	• Wideband Data Link
• Command & Control Data Link	• Command & Control Data Link
• SATCOM	
• Radar CDL	• Radar CDL
• BTID/S	• BTID/S
• I Band Transponder Interrogator	
• V/UHF Beacon Locator System	
• AIS Receiver	
• Rad Alt System	
• Comms ESM	• Comms ESM
• Radar ESM	• Radar ESM
• Comms ECM	• Comms ECM
• Radar ECM	• Radar ECM
• FOPEN SAR/GMTI Radar	
• I-band SAR/GMTI Radar	• I-band SAR/GMTI Radar
• J band SAR/GMTI Radar	• J band SAR/GMTI Radar
	• K-band SAR/GMTI Radar
	• M-band SAR/GMTI Radar
	• Upper M-band SAR/GMTI Radar
• Obstacle Avoidance Radar	

'Platform fit' rather than 'Sensor payload fit'
• GPS (TUAV & Mini)
• IFF Transponder (TUAV)
• Prime C&C Data Link (TUAV)
• ATOL (TUAV)

# Recommended MRFS Architecture



# RF Functions Supported by Recommended MRFS Architecture



TUAV	Mini UAV
Tactical Radio	Tactical Radio
Narrowband Data Link	
Wideband Data Link	Wideband Data Link
Command & Control Data Link <i>(reversionary in event of failure of prime function)</i>	Command & Control Data Link <i>(primary link)</i>
SATCOM (optional fit)	
Radar Common Data Link (R-CDL, a w/band datalink)	Radar Common Data Link
I Band Transponder Interrogator (short range)	
V/UHF Beacon Airborne Locator System	<i>(not a likely Mini requirement but can be supported)</i>
Automatic Identification System (AIS) Receiver	<i>(not a likely Mini requirement but can be supported)</i>
Comms ESM	Comms ESM
Radar ESM	Radar ESM
Comms ECM	Comms ECM
Radar ECM	Radar ECM
FOPEN SAR/GMTI Radar (optional fit)	
I/Jband SAR/GMTI Radar	I/Jband SAR/GMTI Radar

# Study MRFS Conclusions (1)

- MRFS concepts offer great potential to enhance a UAV's overall operational capability. In particular:
  - Reduce the mass and volume of existing UAV RF sensor payloads, thereby increasing the UAV's endurance
  - Within a UAV's fixed RF payload constraints, increase the suite of RF sensor functions/capabilities that can be carried by the UAV thereby significantly increasing the UAV's military utility
- MRFS concepts are applicable to both UAVs with moderate payload mass limits (~50 kg) and small mass limits (~7 kg).
  - Offers the potential to operate Mini UAVs with operationally usefully RF sensor payloads such as SAR/GMTI without sacrificing other sensor capabilities
- However these significant benefits do not come without a 'price'
  - Compromises in RF sensor performance may have to be accepted

## Study MRFS Conclusions (2)

- There are varying degrees of implementing MRFS from simply sharing two or more RF functions to a fully integrated RF system.
  - Complex trade-off studies are needed to establish the optimum approach and the military utility of various solution concepts
- The non- recurring costs of implementing a MRFS are potentially very high, yet the target price for UAV sensors are relatively low, particularly for Mini UAVs where the benefits are potentially greatest.
  - The target prices can probably only be met by high volumes of MRFS procurement based on modular, scaleable architectures
- A list of proposed future research topics necessary to achieve the desired system level technology demonstration in around 5-7 years has been defined

## State-of-the-Art Lightweight MRFS

- **Multi-band transmit/receive module**
  - 850MHz to 2100MHz
- **Digital waveform generation**
- **Digital receiver**
- **Integrated GPS**
- **Integrated processing**
- **Cost < £200**
- **Battery powered- 17 day life**
- **110 grams**



**This class of technology needs to be exploited !**

# Proposed Areas for Future MRFS Research



- **Aperture /Antenna Level Research**
  - Wideband Array Face Design – exploiting current EMRS-DTC work
  - Conformal / Structural Array
- **Receiver (and Transmitter) Level Research**
  - Integrated RF Architecture Concepts/Trades
  - RF Sampling/Up-conversion (applicable to both EW & non EW functions)
  - Sampling Rate and Dynamic Range Trades in MRFS Systems
  - Dual Mode ADCs
  - Miniature Reconfigurable RF Filters
- **Processor Level Research**
  - Processing Architecture for Multi Function Systems
  - Exploitation of Emerging Low Power COTS Processors
  - Safety and Non-Safety Critical Software as Separate Threads in a Common Processor
- **Overall System Level Research**
  - Operational Trades
  - Cost benefit / COEIA Analysis
  - Optimisation of Datalink and SATCOM choices
  - EMC Issues
  - Waveform Commonality for Different Functions
  - Multi-platform Concepts and Requirements



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**QUESTIONS ?**