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Partners from RF to Light

Bringing Commercial Manufacturing Practices to Defence Electronics

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Rome, Italy | September 30th, 2014

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Agenda

- Motivation and Approach
- Examples at each level of assembly
  - MMICs
  - Power Devices
  - Power Modules
  - T/R Modules
  - Planar Arrays
- Conclusions and Questions

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Motivation and Approach

- Widespread deployment of critical defense systems – particularly phased array radar and communications – is hindered by high system cost
- Expansion of market into civil systems will not be realized without addressing cost
- Cost is driven by
  - System Architecture
  - Manufacturing Approaches – often low volume, proprietary, captive

Effectively Leverage the Global, > Trillion Dollar, Electronics Market Manufacturing Infrastructure for Defense Electronics

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Approach

- **Conventional Approach to T/R Modules and AESA's is not cost effective**
  - Limits the use and proliferation of this technology
  - Does not leverage scale of the commercial market
  - Focus is 110% on performance with little regard to cost
- **Need to emulate commercial practices**
  - Leverage manufacturing infrastructure
  - Accelerate Time To Market – Months NOT Years
  - Drive the cost to enable the market

Think iPhone *Not* JSF!

Conventional Approaches

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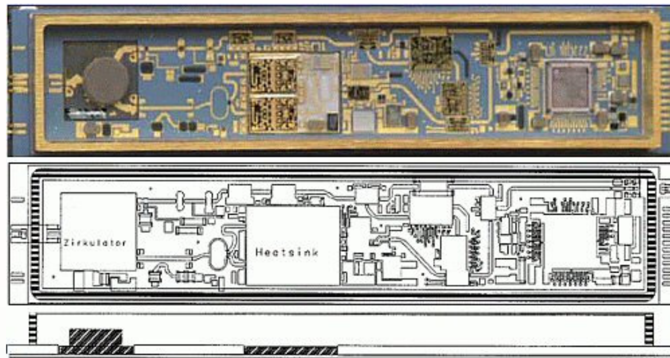
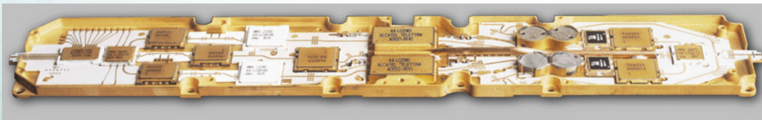
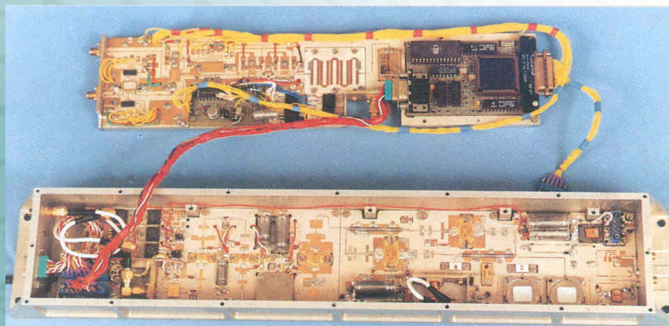
European



European Space



India DRDO



- **Conventional Approach:**
  - Ceramic/Metal Hermetic Housing
  - Both “Chip and Wire” and Packaged Components
  - Focus on Performance
  - Slow to develop and move to production
- **Approach Drives:**
  - Manual or Semi-Automated Assembly
  - “Custom” Mentality
  - Manual Test
  - Low Volume Production
  - High Cost
- **Commercial Approach:**
  - Plastic Packaged Parts
  - Printed Circuit Boards
  - Automated Assembly
  - Automated Test
  - Performance is king
  - Design and Build to Cost

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Low Cost Guidelines

Approach		Implementation
Simplest architecture to meet application requirement	✓	Reduces beam count/subarray complexity
Use standard manufacturing processes	✓	Standard Process Technologies, Packaging and Printed Circuit Board Approaches
Minimize number of parts	✓	Integration where is makes sense
Avoid large number of connectors	✓	Panel vs Brick
Integrate as much as it makes sense	✓	Smart Functional Partitioning of the System Block Diagram
Use COTS parts as much as possible	✓	Passives and backplane components – Careful Consideration of COTS / Custom Trade-off
Avoid exotic materials and technologies	✓	Standard Semi and Board materials
Avoid very high precision machining	✓	None
Test of components prior to higher level assembly	✓	At Chip, T/R, and LRU level
Maximize automatic testing	✓	Conform to High Speed Automated Testing at All LEvels
Reduce or eliminate touch labor	✓	Auto Assembly, Surface Mount Technologies

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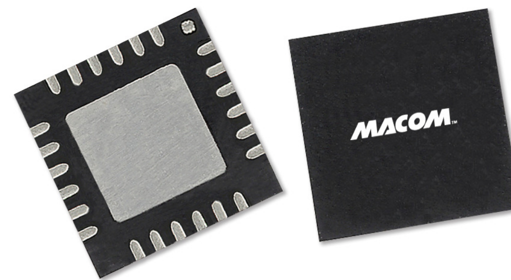
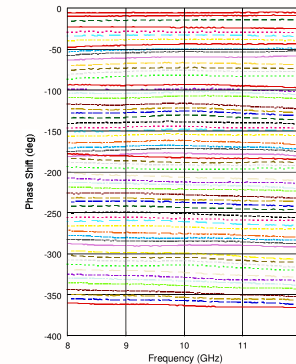
MMIC Components

- Exploit mainstream technologies and processes which support commercial scale production
- COTs versus Custom Decisions driven by OVERALL best value
- Packaging compatible with high speed automated test and surface mount assembly

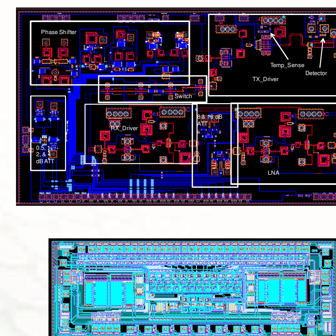
Discrete Functions

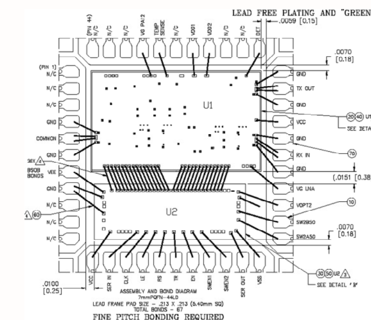




Phase shifter in QFN Package

Integrated Solutions





X-Band Single Chip T/R in QFN Package

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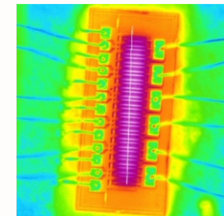
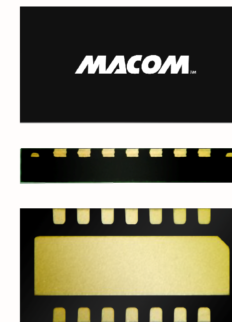
Power

GaN is Just The Start of The Solution

High Power In Plastic Packaging



- PQFN, DFN, SOT-89, TO-272
- Why A New Way ….
  - Lower Cost of Packaging
  - Lower Cost of Test
  - Lower Cost of Next Level Assembly
  - Lower Weigh
  - Smaller Size



- High Power in Plastic Enables Surface Mount Assembly and New Defense System Manufacturing Approaches

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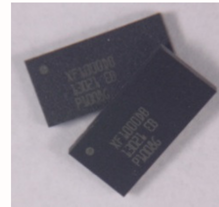
Multistage Surface Mount Power Modules

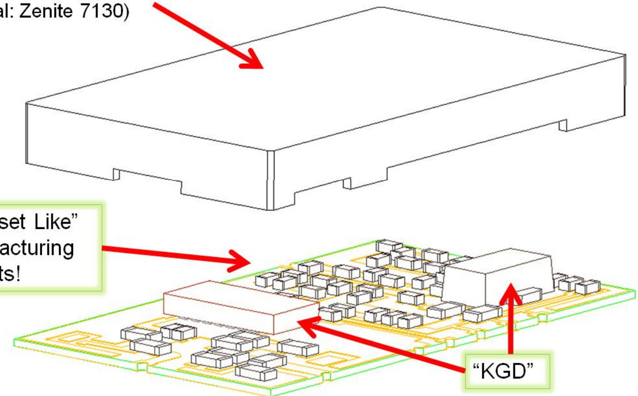
Leveraging Commercial Scale

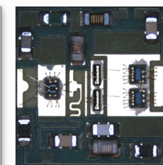
Exploiting Surface Mount Technologies

- Modules assembled with highly automated pick and place
- Enables surface mount assembly at next level of the system
- PCB Based manufacturing drives down system SWaPC

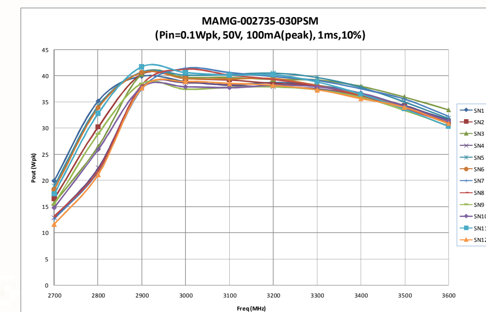


14x24 mm L-Band Surface Mount, 90W Two Stage Power Module





7x7mm QFN, 30W, S-Band Two Stage Power Module



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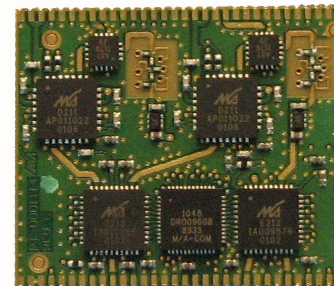
T/R Modules for Planar Phased Arrays

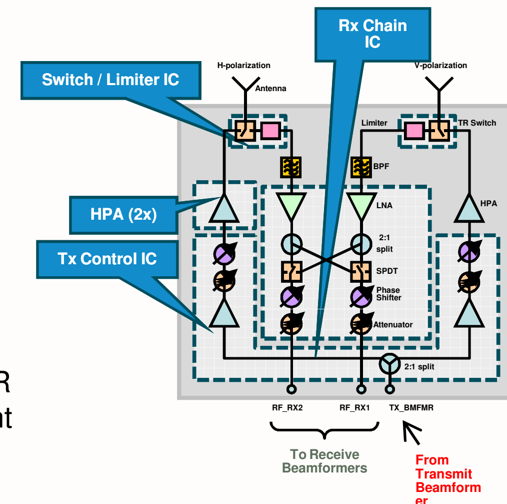
Non-Hermetic T/R Modules

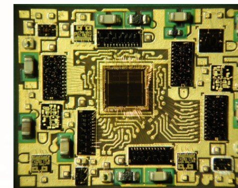
Surface Mount Assembly

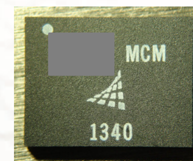
- Dual Polarization S-Band and C-Band Modules Demonstrated
- Fully Compatible with GaN Module Approach for High Power GaN Versions
- Enables Surface Mount Manufacturing at the Array Level



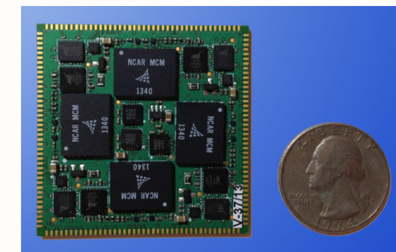
S-Band Dual Polarization T/R Module – LGA Surface Mount Format







C-Band Dual Polarization Quad-pack T/R Module – LGA Format



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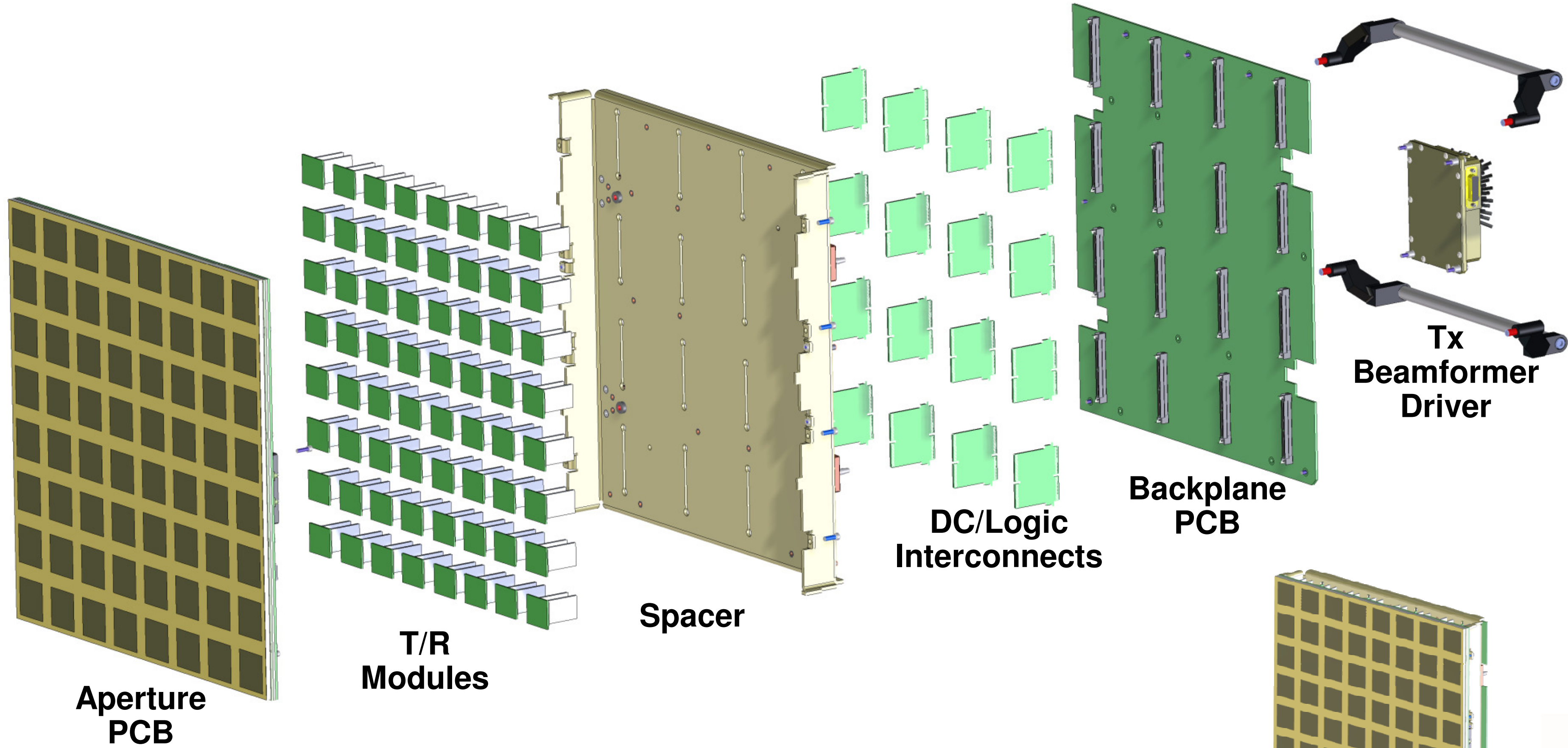
Surface Mount Manufactured AESA



Planar Phased Array Line Replaceable Unit

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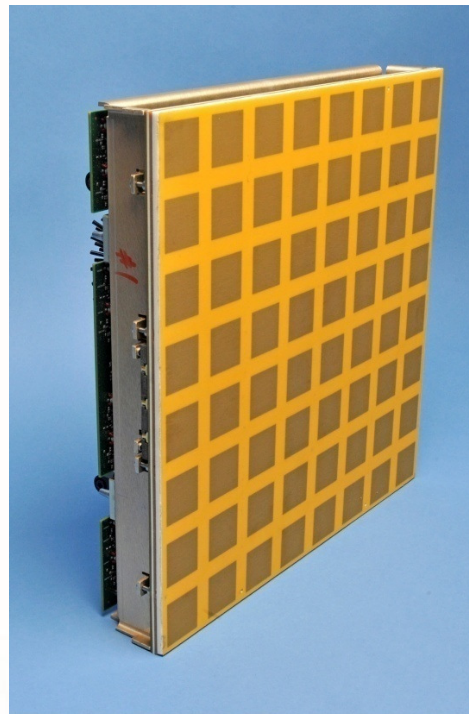
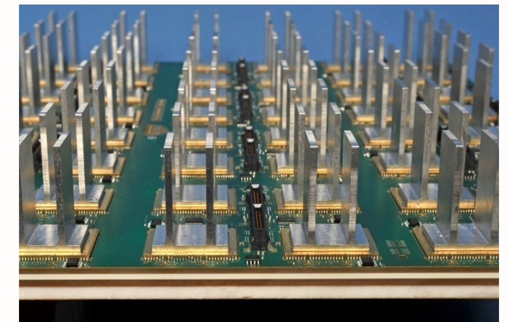
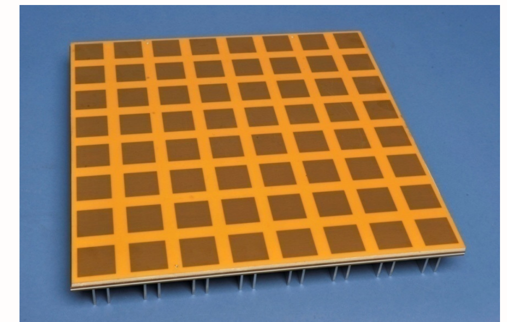
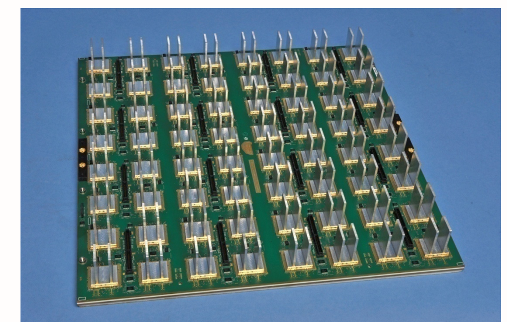
S-Band – Dual Polarization

- 64 Elements per LRU – 16 W per element
- Overlapping Sub-array digital beamforming
- Successfully demonstrated aircraft tracking over Logan Airport: Boston, MA
- Extending Technology
  - 100W per element at S-Band
  - 25 W per Element at C-Band









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Conclusions

- MACOM is pioneering the use of commercial manufacturing practices in demanding defense radar and communications applications
- Solutions based upon:
  - GaN, GaAs, Silicon semiconductor process
    - The right technology for each function
  - Plastic Packaging – Even for Power!
    - Enables surface mount assembly at next level of manufacture
  - Laminate Based T/R and Power Modules
    - In Surface Mount Formats
  - Planar Phased Arrays based on Printed Circuit Boards and Surface Mount Assembly of Line Replaceable Units

Driving Rapid Development, Affordability and Performance

A New Paradigm for Defense System Manufacturing