LOCKHEED MARTIN

# Latest Innovations In PAR: The Lockheed Martin Perspective

***Lockheed Martin MS2***

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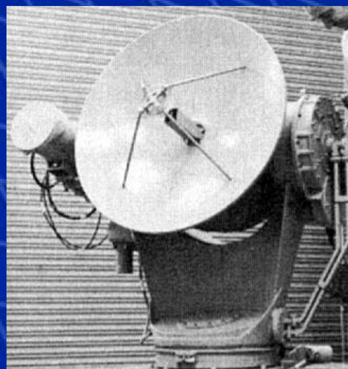
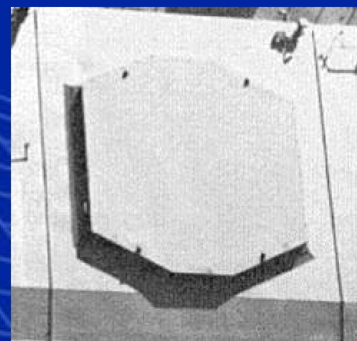
# Current State of Multifunction PAR Radar

*R76*
*(1960's)*



1970

*SPY-1A*
*(1970's)*



2000

*COBRA*
*(1980's)*

*SPY-4 VSR*
*(2008)*

*EQ-36*
*(2010)*

## *Reflector Radar*

- *Tube Transmitter*
- *Slow Search rates*
- *Low Tracking rates*
- *Few Targets*

## *Passive Phased Array Radar*

- *Tube Transmitter*
- *Fast Search rates*
- *Agile, Adaptive Scan*
- *Heavy*

## *Active Phased Array Radar*

- *Solid-State T/R Modules - no central Transmitter*
- *Very Fast Search rates*
- *High Reliability*
- *Lower Weight*
- *Increased Performance*

# Examples of Multifunction PAR for Weather and Air Surveillance

1995-1996
**MOTR**

1996-2006
**Tactical Environmental Processor**


1990-1995
**DTASS**

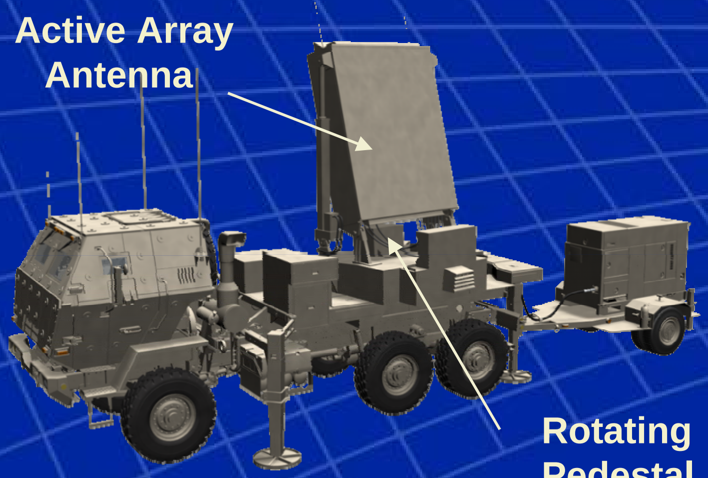
2000-2007
**National Weather Radar Testbed**

# Solid-State PAR Provides Performance and Reliability

## Legacy System (AN/TPQ-36/37) Shortcomings

- ***Range / Accuracy Limitations***
- ***Clutter Problems / False Detection Rates***
- ***Obsolescence: Availability issues (Ao) and Repair Challenges***
- ***Mobility and Transportability Restrictions***

**Legacy AN/TPQ-37**

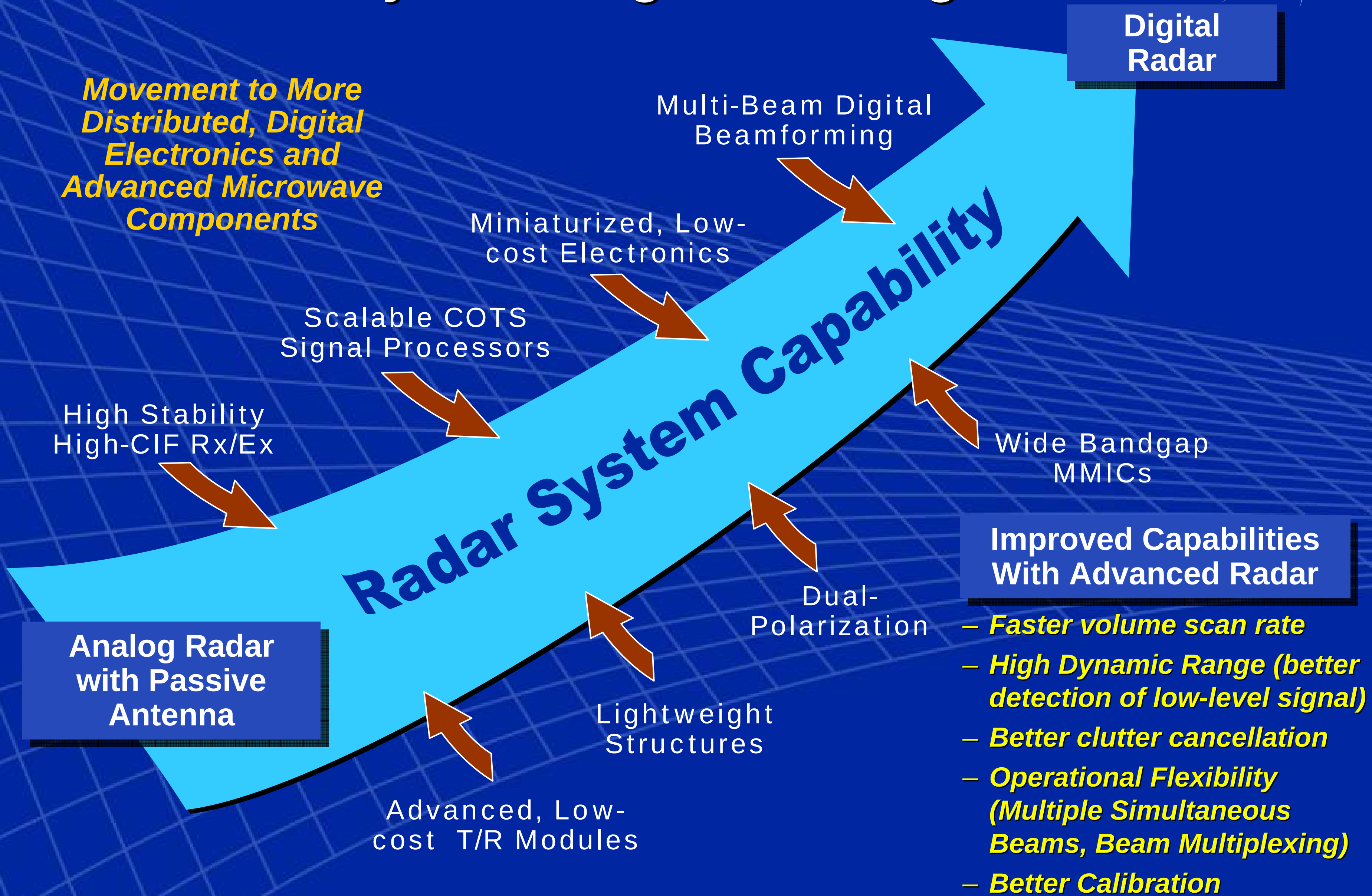



**EQ-36 Active Solid-State PAR**

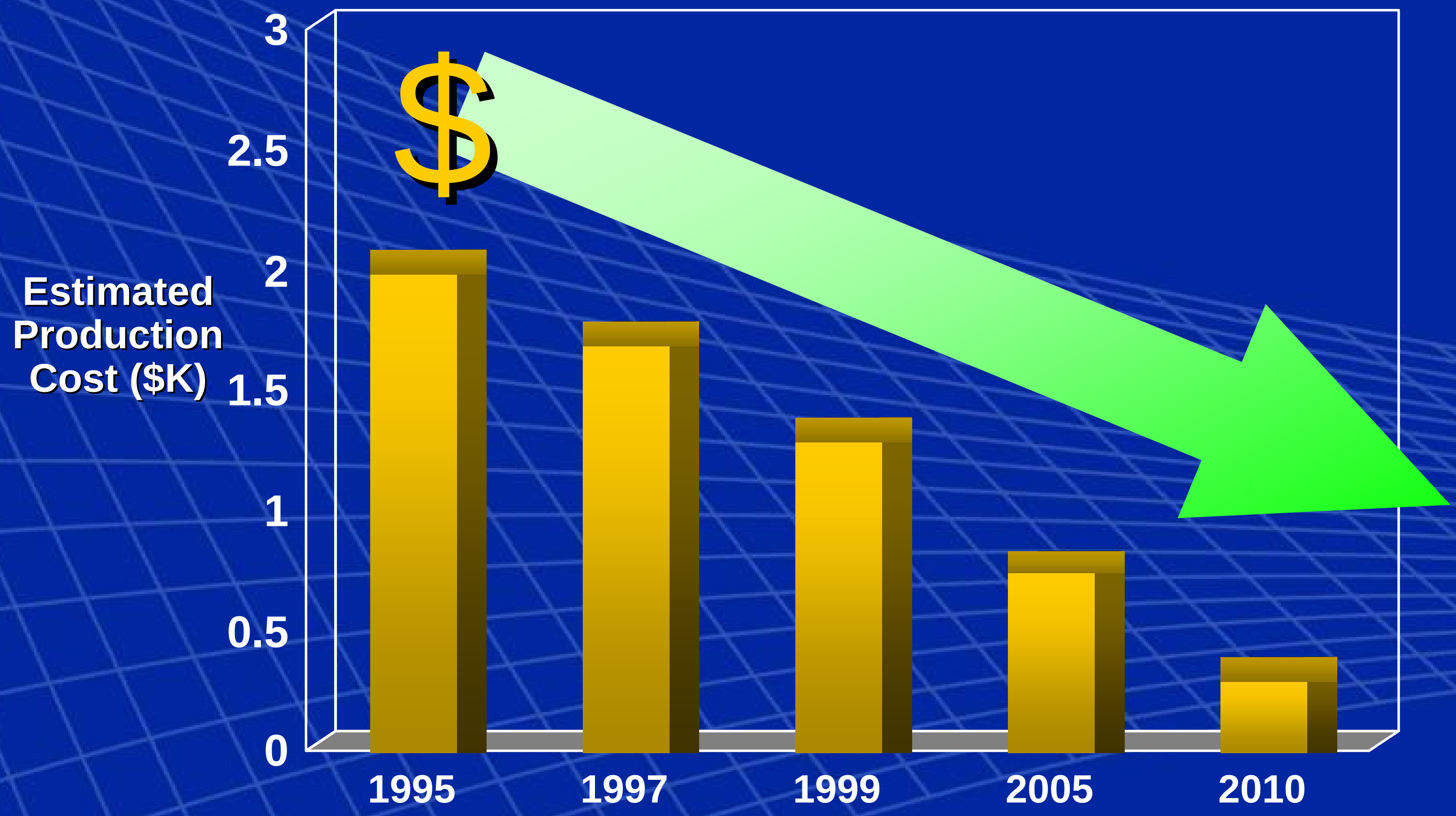
## EQ-36 Operations in Urban Environments

- ***High clutter environment***
- ***High Reliability (MTBF) and Availability (Ao)***
- ***Detect, Classify, Track incoming projectiles mortars, artillery (cannon), rockets***
- ***360˚ Capable***
- ***36 month design to delivery***

# Trends in Key Enabling Technologies



# The PAR Challenge:  Affordability




**Prices for Solid-State T/R Modules are Trending Downward Driven by Revolution in Wireless Devices**

# Advanced Solid State Materials

- *Evolving from Si and GaAs to SiC and GaN*
- *Trend toward materials with:*
  - *Wide bandgap*
  - *High efficiency*
  - *High breakdown voltage*
  - *Good thermal properties*
- *DoD Driving this Evolution (e.g. DARPA Wide Bandgap Program)*

| Semiconductor (commonly used compounds) | | | Gallium arsenide (AlGaAs/ InGaAs) | Indium phosphide (InAlAs/ InGaAs)[a] | | Gallium nitride (AlGaN/ GaN) |
|---|---|---|---|---|---|---|
| Characteristic | Unit | Silicon | | | Silicon carbide | |
| Bandgap | eV | 1.1 | 1.42 | 1.35 | 3.26 | 3.49 |
| Electron mobility at 300 K | cm2/Vs | 1500 | 8500 | 5400 | 700 | 1000-2000 |
| Saturated (peak) electron velocity | $X10^7$ cm/s | 1.0 (1.0) | 1.3 (2.1) | 1.0 (2.3) | 2.0 (2.0) | 1.3 (2.1) |
| Critical breakdown field | MV/cm | 0.3 | 0.4 | 0.5 | 3.0 | 3.0 |
| Thermal conductivity | W/cm•K | 1.5 | 0.5 | 0.7 | 4.5 | >1.5 |
| Relative dielectric constant | $\varepsilon_r$ | 11.8 | 12.8 | 12.5 | 10.0 | 9.0 |

[a] The compounds are loosely known as indium-based.

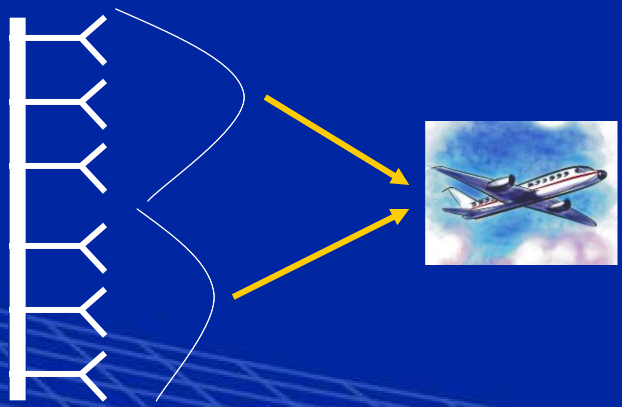
**"The toughest transistor yet [GaN transistors]"**, *Eastman, L.F.; Mishra, U.K.;* IEEE Spectrum, Volume: 39 , Issue: 5 , May 2002 Pages:28 – 33.

**Advanced Semiconductors Provide the Physics for Improved T/R Modules**

# Possible Areas of New Research

***MIMO for Phased Arrays***

**Explore application of MIMO techniques to subarray beamforming**



***Increases radar performance through use of multiple, independent transmit and receive chains***

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## *Leveraging of GaN Commercial Applications*

- **GaN solid-state lighting has tremendous economic benefits**
- **Strong commercial pull will drive GaN material affordability**
- **Use of affordable GaN microcircuits (MMICS) holds potential for radar efficiency and performance**

***LED Traffic Signal 12 Watts vs. 150 watts for incandescent bulb***
***More than 10x energy savings***

# Promoting Dual-Use PAR Research

*Utilizes Military Technology*
*.... to Benefit Non-Military Market*

- **High Performance Radar**
- **Device Development (MMICs)**

*Promotes Civilian Technology Development*
*... and Feeds Results Back to Military Products*

- **Affordability and Efficiency**
- **Electronic Manufacturing Technology**
- **Commercial Market Drives Down Component Cost**

# Way Forward

***Industry is investing in core technology enablers for other applications…***

***…for MPAR to become reality, the User Agencies need to do the same to apply these towards their applications***

***Time is NOW to fully fund R&D in order to meet 2015-2020 time frame for deployment.***

- ***Joint mission needs and requirements definition***
- ***Core enabling research, including testing and demos***
- ***Analysis of Alternatives and Cost-Benefits Case***

**MPAR is Achievable… but the program must transition from the "vision" to an engineering "concept"**

# Summary

- *Lockheed Martin is fully committed to the Joint Agency goals and visions for MPAR*
- *Significant DoD investments in S-Band PAR can be leveraged for MPAR*
- *The revolution in commercial wireless will drastically alter the radar paradigm and enable low-cost, highly capable digital PAR radars…*
- *… but the commercial wireless industry will not close the gap to radar applications!  Gov't R&D investment is needed.*
- *Significant savings for the gov't can be achieved through lower total cost of ownership.*