Far Infrared and Terahertz Technology
—at the turning point of change!

Presented by:
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Agenda

- Scientific Change Happens!
- Translation for Far Infrared and Terahertz
- Insertion into Applications
- Near Term Pathway Going Forward
“Anyone who has never made a mistake has never tried anything new”

“Great Spirits have always encountered violent opposition from mediocre minds”
Span of Eras -- Merging Components and Systems

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Terahertz and Far IR Era Change

First Half 20th Century

Analog

Moore’s Law

Metcalf’s Law

Terahertz & Far IR Sources /Detectors

YEAR

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The Three Horizons*

Building a healthy product Pipeline across all three horizons is the foundation for business growth.

Managing all three horizons is done concurrently.

Horizon 1 – The Core

Horizon 2 – Adjacent & Advanced Programs

Horizon 3 – Embryonic Business

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“Translation Point” for Far Infrared and Terahertz

• “Black Swan” Paradigm in Optical Science
  – Unique Imaging Characteristics
• Significant R&D advances since 1960
  – New Sources (QCL, nano, plasmonics)
  – New Detectors
• TRL and MRL Support Translation & Applications
  – Extended Applications
  – Translation (scaling)
• Validation of “Success Models” for Cost/Performance Attributes that are dominant for Translation
  – Seeking the “Killer Apps”
Strategy: Define the Customer Value Proposition for New Products at Every Stage of Development
Systems Engineering Trades Impact the Terahertz Gap

Photo Source: NASA and US Army NVEOSD
LM Interests in Far Infrared and Terahertz

- Space Systems NDE efforts with NASA-Langley
  - LM Michoud -- Shuttle External Tank foam inspection problem
  - Picometrix T-Ray 2000 sensor
  - Foam Void/Crack detection

- Aircraft NDE/NDI Manufacturing and Maintenance
  - F-35 manufacturing process control
  - C-130 Supplier Composite/Radom inspection

- Component Waveguide Development
  - LANCER Program for THz Waveguide with Rice University
  - Transponder Efficiency Improvement

- “Killer App” constructs for Terahertz Technology
  - Exo-atmospheric Communication
  - Homeland Security Screening System
  - Robotic Sensors for Short Range Vision through Obscurants
Terahertz NDE of Shuttle Tank Foam

Void and Cracks Found within Foams and Non-Conducting Laminates

Photos Source: NASA
Terahertz Imaging Through Obscurants

Vehicle Driving Aids
>1-20 meter ranges

Helicopter Landing Aids
>10-25 meter standoff ranges

Imaging Applications for < 10dB/m attenuation
Terahertz NDI Imaging

Advanced Cargo Composite Aircraft

C-130 J Aircraft

Advanced Aircraft Materials Provides NDI Applications for Terahertz Imaging
Raster Imaging System*

- Scan X & Y one point at a time
- Collect T-Ray scan for each point
- Allows one to examine different features of the T-Ray signal
- Raster scanning works, but its slow

* Data/Photos courtesy of Picometrix
Objects imaged between two ¾”-thick foam inserts:
• Two allen wrenches
• #0-80 Socket cap screw in a pill bottle
• Seam on Ziploc bag

* Data/Photos courtesy of Picometrix
Analyze Variations in Amplitude

Almonds

* Data/Photo courtesy of Picometrix
Terahertz Exo-Atmospheric Communications

- Evaluate the feasibility of a T-Com system for use in space
- Compare notional performance to RF and Optical systems

**Results:**
- THZ Comm is Feasible but low TRL
- TRX Beam Divergence
  - 200 X> Laser Comm
  - 200X< RF(10GHz) Comm
- RCX
  - Hot Electron Bolometers (2-3Thx)
  - Bandwidths up to 5GHz demo

**Conceptual Diagram/Picture**
- >5 Gb/sec transceiver at 2.5 THz
- Potentially less SWAP than optical or RF solutions
- Optimal pointing tolerances
Terahertz Transceiver

Monolithic THz transceiver with QCL transmitter/LO and coherent diode-mixer receiver.

Near Term Challenges

• Development of validated high-resolution terahertz atmospheric absorption band models
  • Key Atmospheric Windows for Active and Passive Transmission
  • Effects of Moisture & Dust on transmission path needed

• More studies of phenomenology, signatures and systems
  • Exo-atmospheric Communication
  • Security Screening
  • Chemical Sensing
  • Medical Diagnostics & Sensing
  • Non-Destructive Testing/Manufacturing

• Components costs and maturity limit systems use
  • Large Optics
  • Limited Reliability of Thz Components compared to EO and Radar
“Killer Apps” for Terahertz?
Terahertz is under-leveraged in applications
Exploitation new phenomenology – in areas not adequately addressed by EO and Radar

LM has interest and use of Terahertz Technology & Systems

Where are the near-term Terahertz limitations?
Lack of workforce training/education and awareness
Material metrics limitations are cost, performance and reliability of components
New Components are emerging -- QCL, detectors & processing – more feasibility studies

Emerging New Applications in 4+ years
Brown out Sensing for UAS platform applications
Resonant Absorption Chemical/Biological Material Standoff Detection
Frequency agile Imaging Sensors (multi-transmission band phenomenology)
Short Range Communications or Exo-Atmospheric Communications

Terahertz is at the Turning Point of Change
LM Terahertz Contact Information

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• Dr. Van Rudd  Louisville, CO  303/379-3251
  • Phenomenology, THz Systems, Components, Measurements

• Dr. Carey Cates  Palo Alto, CA  650/424-2801
  • Phenomenology, Detectors, Sources, Components