COMMUNICATIONS
The Mobile Internet – The Next Big Thing
Electrons & Photons: You need both!

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**Title:** The Mobile Internet The Next Big Thing

**Performing Organization:** DARPA

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**Supplementary Notes:** DARPA Microsystems Technology Symposium held in San Jose, California on March 5-7, 2007. Presentations, The original document contains color images.
Integrated Microsystem

Communications: Voice, Video & Data Information Transfer

Platform Centric Warfighting
Comms → Wired Interconnects & Data Links

20th Century

Network Centric Warfighting
Comms → Wired & Wireless Links

21st Century
The Military Comms Problem
Network Centric Operations

21st Century RF Technologies Will Change The Way We Engage Our Adversaries

See Anything...
From Anywhere...
At Anytime...

PERSISTANT, STANDOFF SURVEILLANCE

AND

Provide Real-Time Global Information Distribution

SENSOR TO SHOOTER INFORMATION GRID

Networked Manned and Unmanned Systems

Expanding ISR Demands

SIGINT  IMINT  MASINT

Multi-INT

Burgeoning Comms Demands

Sensor Grid

Information Grid

Shooter Grid
RF Front-End Technology Trajectory On Target To Satisfy The Military Comms Problem

DARPA’s Current Programs ↔ Tommorrow RF Front-End Solutions

- >20 DARPA/MTO RF Programs across the spectrum
  - RF & Mixed Signal Electronics
  - Analog & Digital Photonics

Enables Network Centric Warfare

5-10 yr. timeframe
Spectrally efficient adaptive multi-level frequency hopping coherent waveforms

- **Multi-level complex waveforms** for high-capacity (short-up emitter)
- **Waveform agility** for SNR utilization
- **Multi-dimensional diversity** for link availability, LPI/LPD, anti-jam & security (e.g. frequency, polarization, spatial, …)
- **Coherent detection** brings sensitivity and enables DSP channel compensation

**Software Defined Agile Modems**

**Unified JTRS-Like RF to Optical Transmission Architecture**

2 Polarization I,Q Synthesizer (Vector Modulator)

Coherent Band Translation

“**RF**” DC to Daylight

Coherent Band Translation

“**IF**” DC to Daylight

2 Polarization I,Q Analyzer (Coherent Receiver)

Overlaying Free-Space Optical Communications Brings Added Capacity & Security
**Big Optical Challenge/Opportunity:**

**Hyperfine Optical Filtering**

Ultra-Low Loss Photonic Waveguides & Resonators

**Problems:**
- Today’s PIC waveguides have losses closer to **Black Paint** than to **Optical Fibers**!
- Today’s resonator Q’s are well below the predicted limitations

**Opportunity:**
- Orders of magnitude (>10^2) improvement in optical waveguide & resonator loss enables agile RF processing & filtering on a chip (**high resolution I/Q optical processors**)

*“Radical Improvements in Chip-Scale Passive Optical Waveguides & Resonators Are Still To Come”* - Steve Pappert, 2007
What About Commercial Comms?
Driven by Capacity (bits/sec/Hz) & Affordability (Mbits/$)

Can we affordably bring the bandwidth of the core to the mobile user?
The Commercial Comms Vision
The Mobile Internet

Today’s Wired Capacity → Tomorrow Land's Wireless Capacity

Home/Business Impact

- 24/7 Productivity
- Home/Work Multi-Tasking
- Reduced Operating Costs
- Global Virtual Businesses

The Mobile Internet
Multi-Mbps Voice, Video, Data Services Available Per User On Demand
The Mobile Internet
How Do We Get There?

The Last-mile Solution
Novel technologies maximizing the utilization of time, frequency, and spatial domains

Technical Challenges

ADC/DAC  Forward Error Correction  Distortion Mitigation  Smart Antenna  Bandwidth Efficiency  LNA/HPA  Spectrum Availability

Bandwidth & Spectral Efficiency → Millions of Available Multi-Mbps Channels
Problems:
• Today’s ADCs/DACs have limited bandwidth-resolution product with high power consumption
• Today’s Front-End RF electronics have severe linearity limitations

Opportunity:
• Bandgap engineered materials & heterogeneous materials & device integration for optimum RF performance
• Capitalize on remarkable DSP advances to push RF performance beyond material limitations

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“InP Electronic Mixed Signal IC technologies”

“Dramatic Advances in RF & Mixed Signal Electronics Are Still To Come” - Steve Pappert, 2007
### Summary of Key Technology Enablers

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**IF we are successful, revolutionary increases in mobile communication data rates will be available for ...**

(1) **warfighters and commanders**, providing coordinated situational awareness for tactical and strategic superiority.

(2) **individuals and businesses**, providing coordinated situational awareness for tactical and strategic superiority.

At the end of the day, we are all after the same objective …

**See Anything, From Anywhere, At Anytime**; and the mobile internet will take us there using **Electrons & Photons**!