COMMUNICATIONS

The Mobile Internet – The Next Big Thing

Electrons & Photons: You need both!

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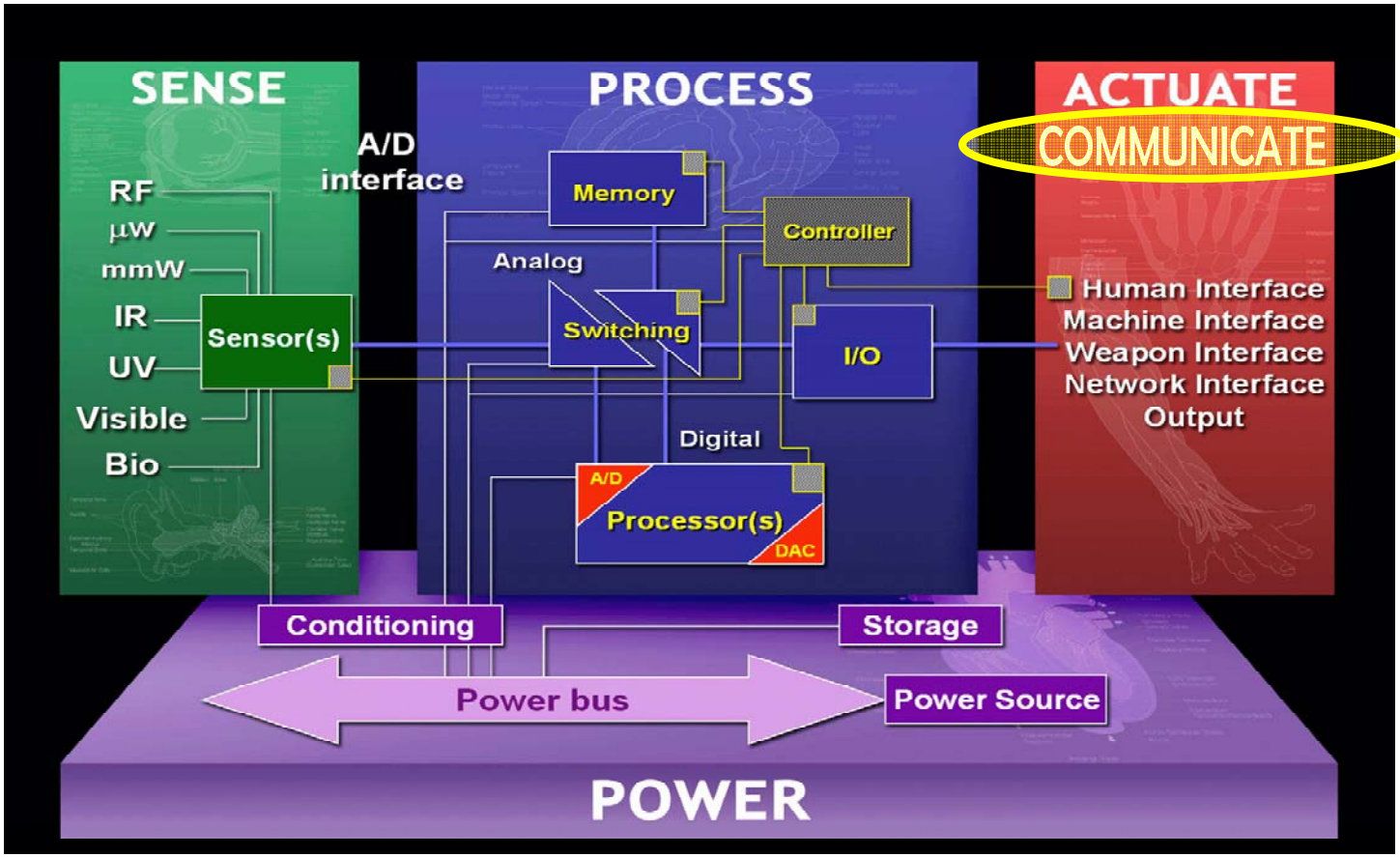
Integrated Microsystem



Communications: Voice, Video & Data Information Transfer

Platform Centric Warfighting
Comms → Wired Interconnects & Data Links

20th Century

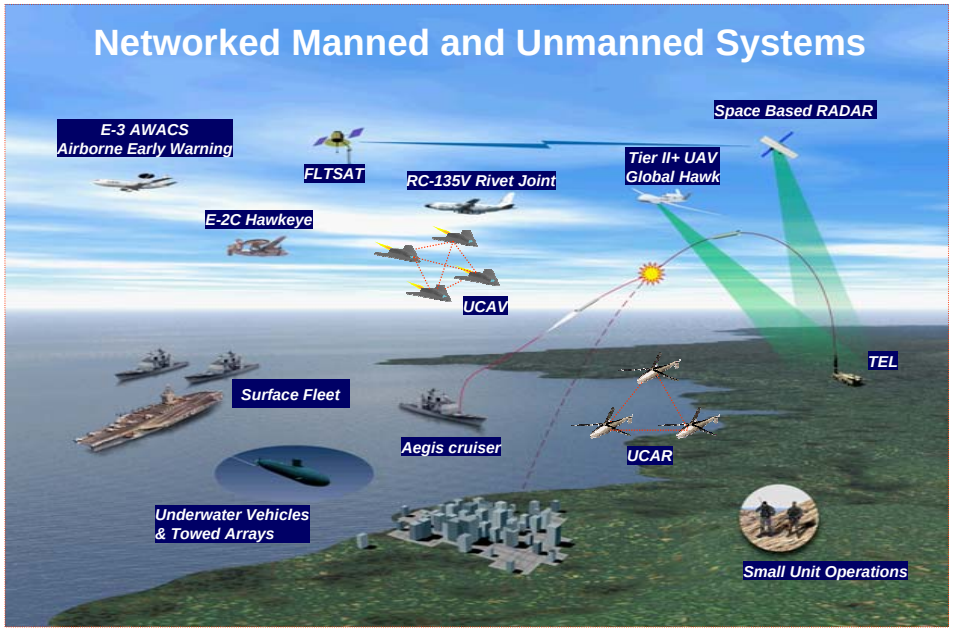
21th Century

Network Centric Warfighting
Comms → Wired & Wireless Links

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

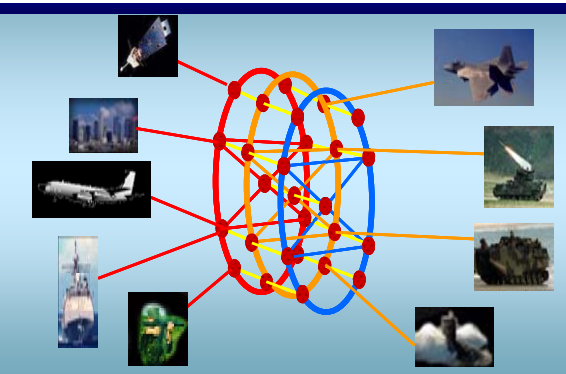
SENSOR TO SHOOTER INFORMATION GRID

Expanding ISR Demands

SIGINT ***IMINT*** ***MASINT***

Multi-INT

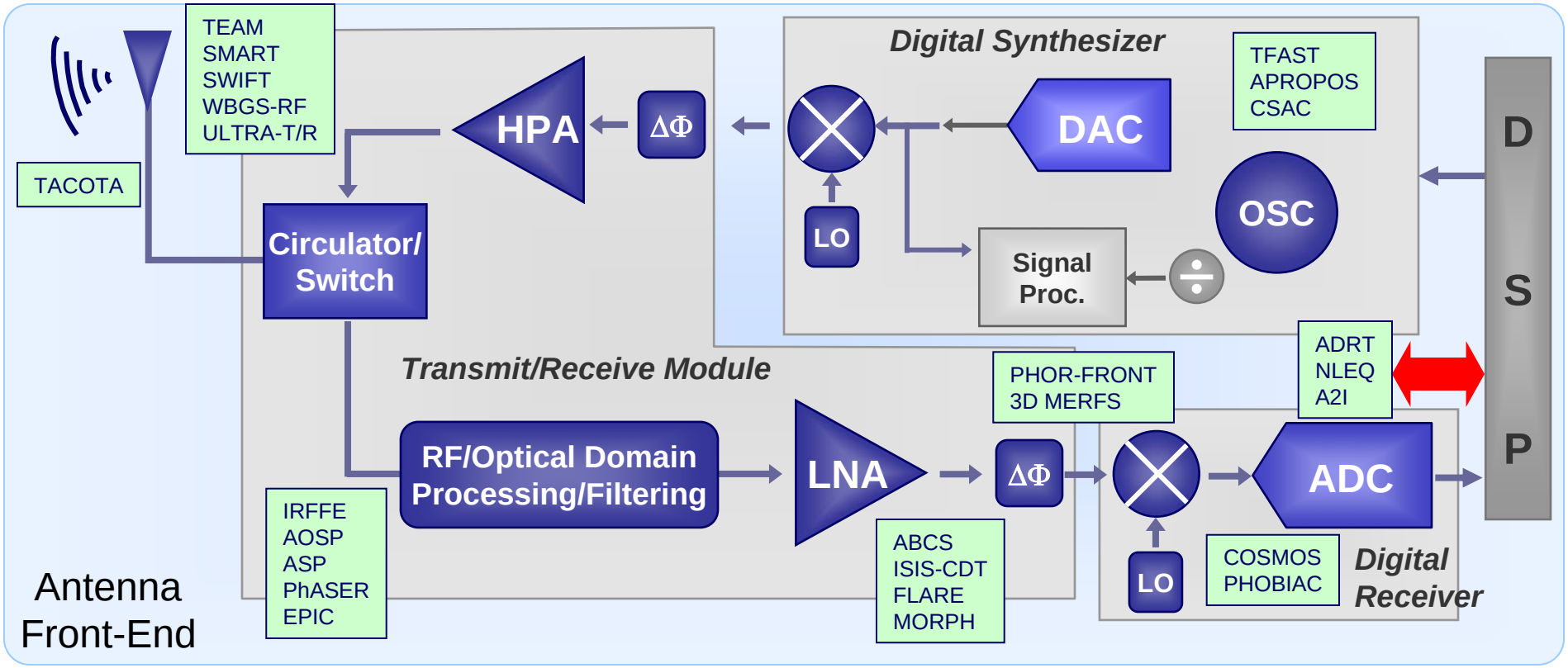
Burgeoning Comms Demands



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

Ultimate Military Comms Solution

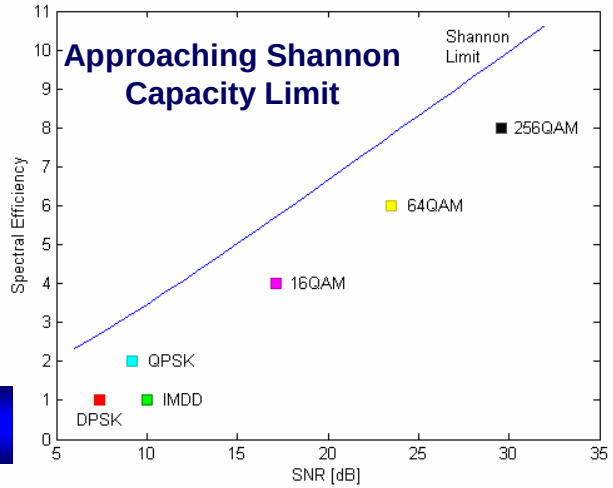
Driven by Capacity, Availability & Security

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

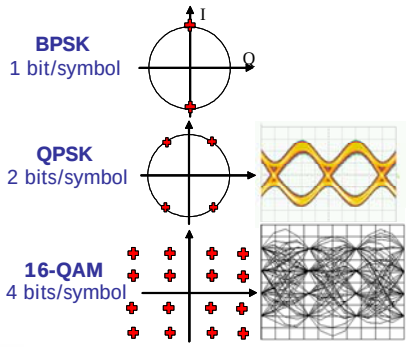
Link Capacity



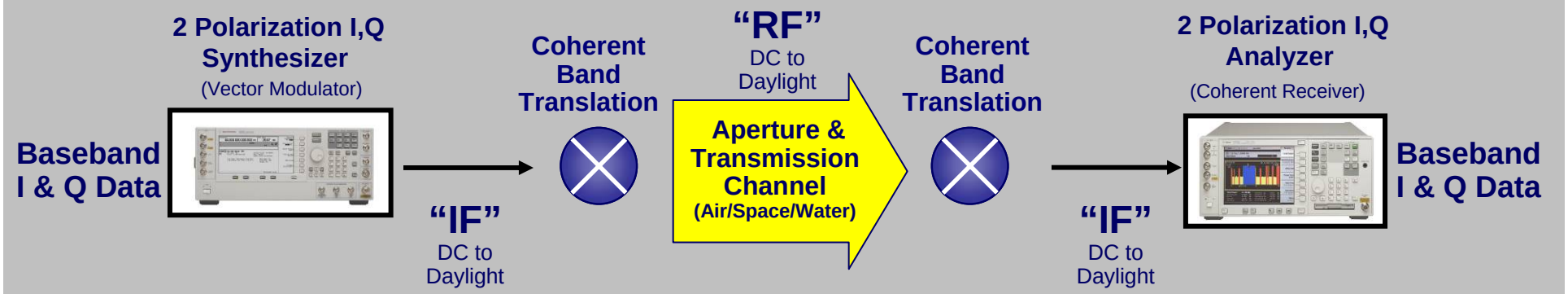
Waveform/Symbol Rate Agility

Modulation Agility

- Use modulation that is best suited for the target environment and link
- Enables variable bit rates and ultra high capacity per wavelength



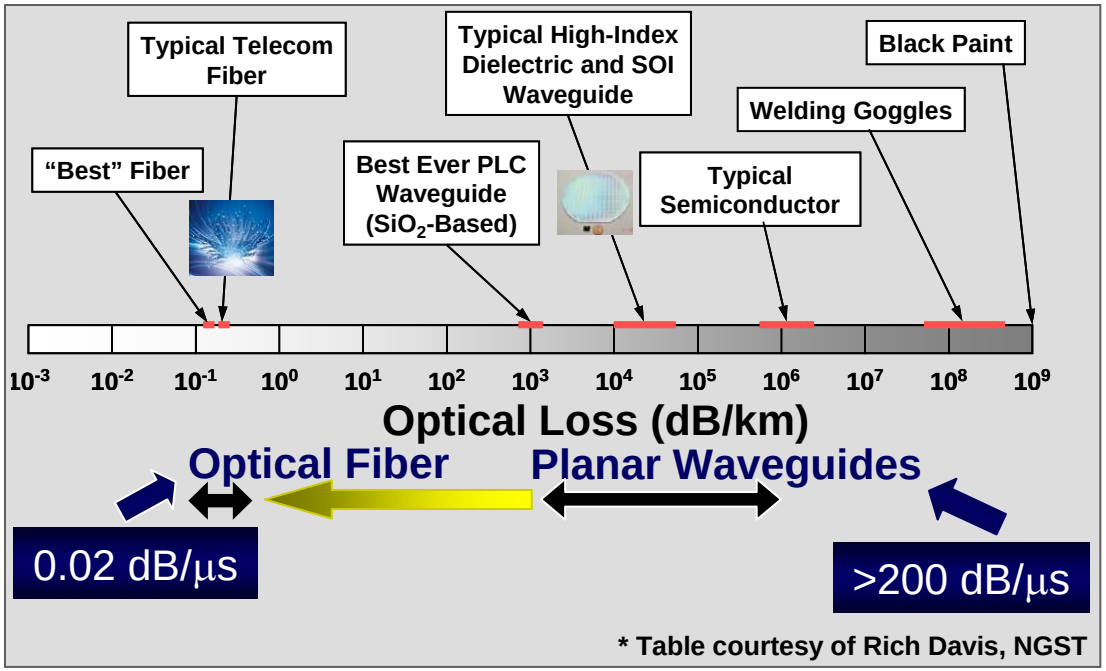
Unified JTRS-Like RF to Optical Transmission Architecture



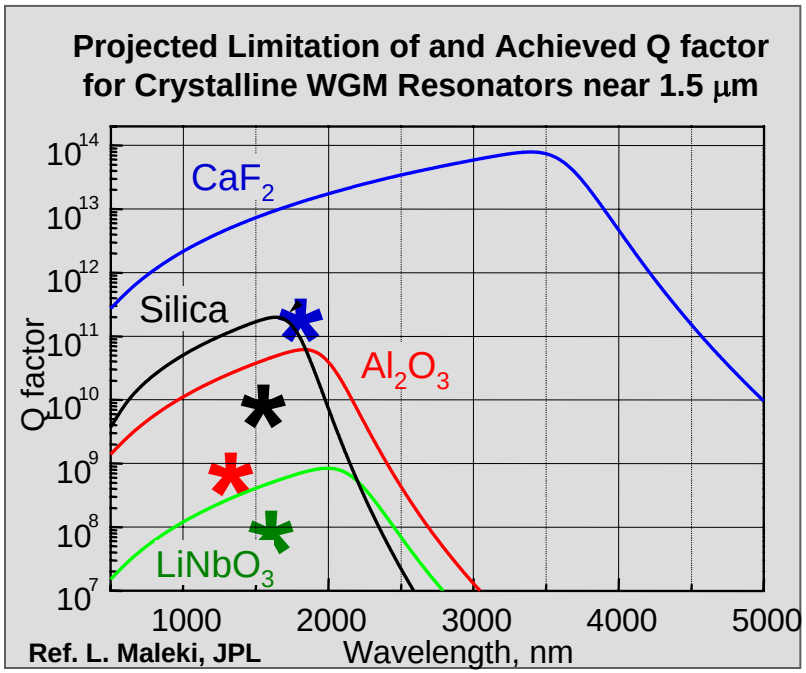
Overlaying Free-Space Optical Communications Brings Added Capacity & Security

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



* Table courtesy of Rich Davis, NGST



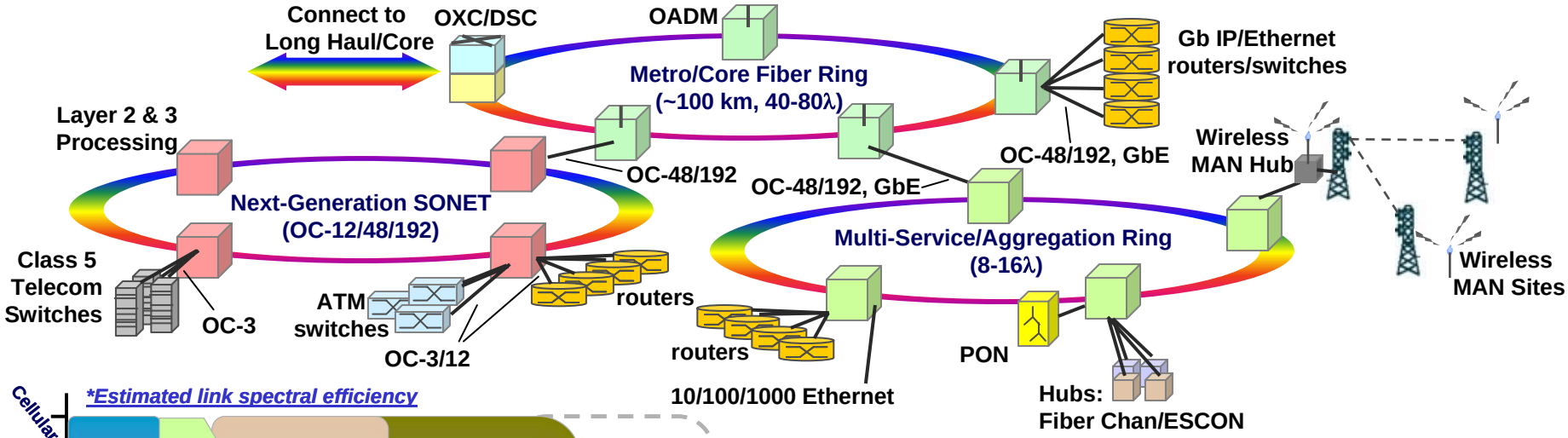
Opportunity:
- Orders of magnitude (>10^2) improvement in optical waveguide & resonator loss enables agile RF processing & filtering on a chip **(high resolution I /Q optical processors)**

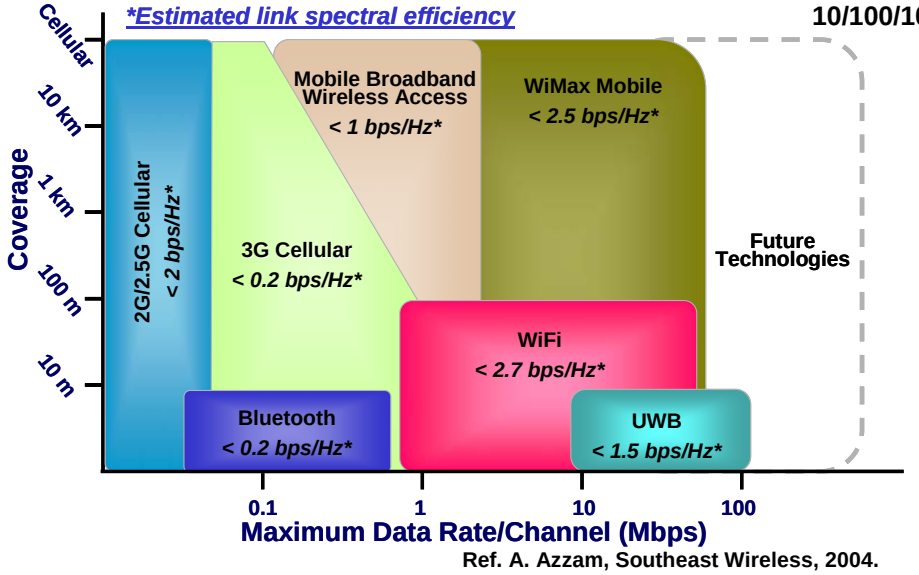
"Radical Improvements in Chip-Scale Passive Optical Waveguides & Resonators Are Still To Come" *-Steve Pappert, 2007*

What About Commercial Comms?

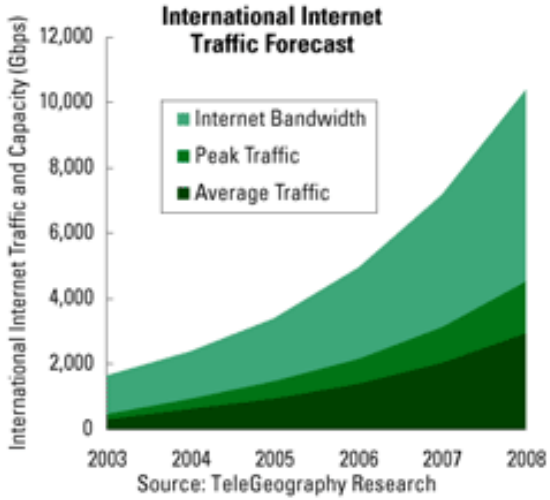
Driven by Capacity (bits/sec/Hz) & Affordability (Mbits/$)

Telecom/Datacom Network





Ref. A. Azzam, Southeast Wireless, 2004.

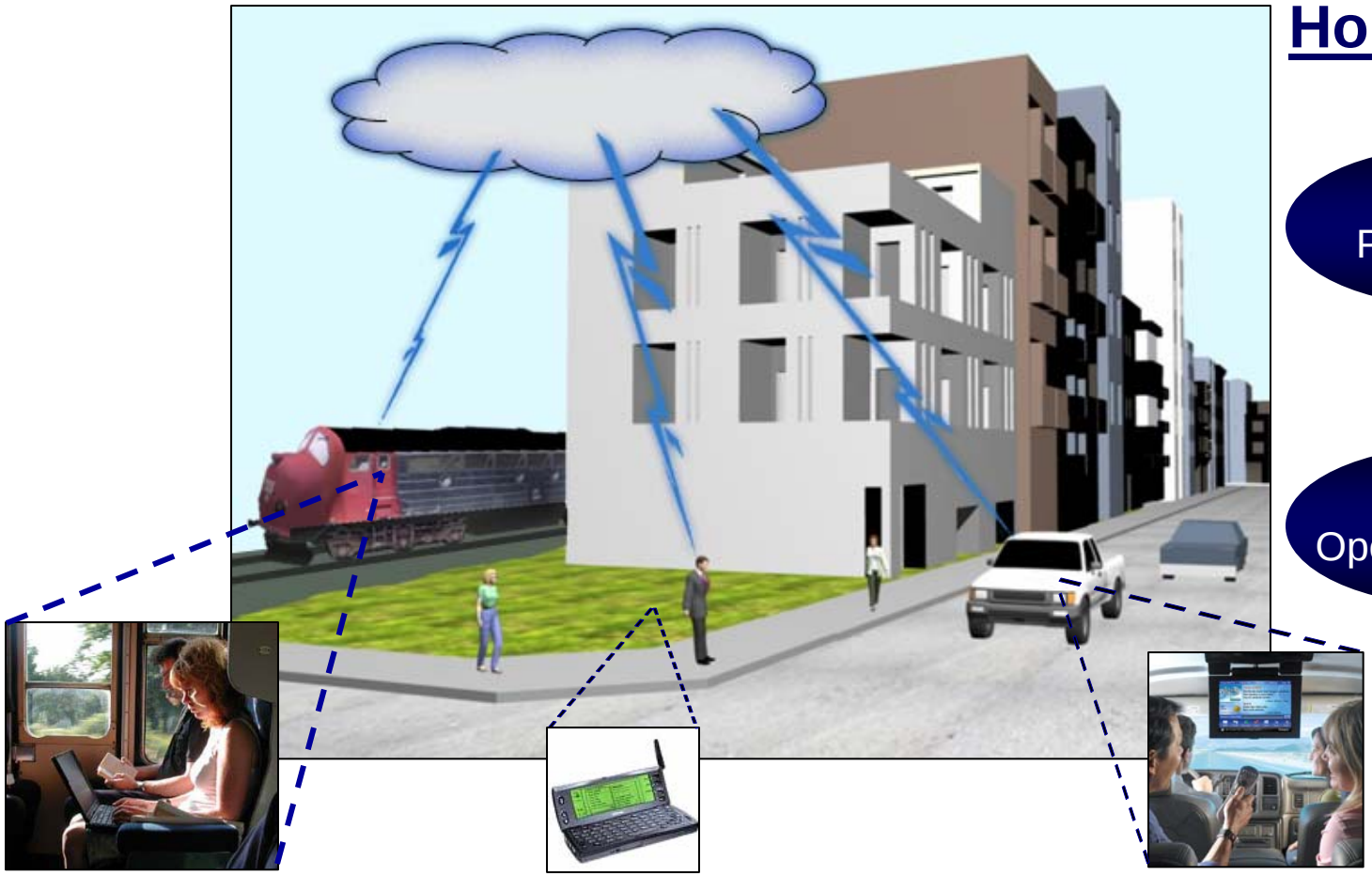


Can we affordably bring the bandwidth of the core to the mobile user?

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

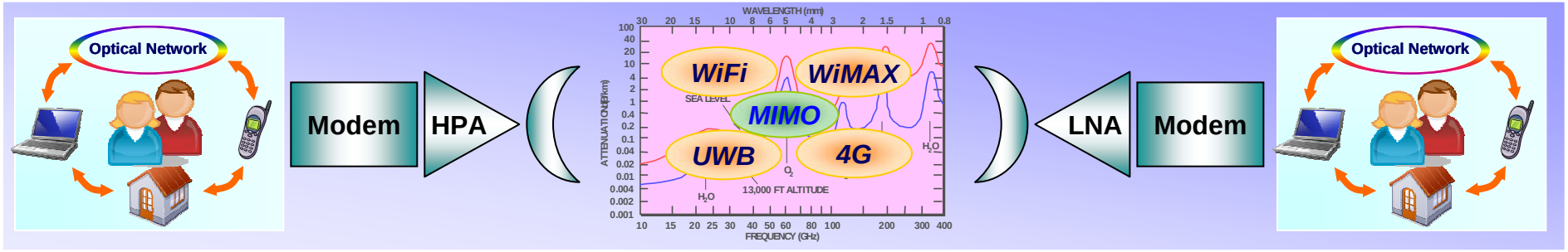
Multi-Mbps Voice, Video, Data Services Available Per User On Demand

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

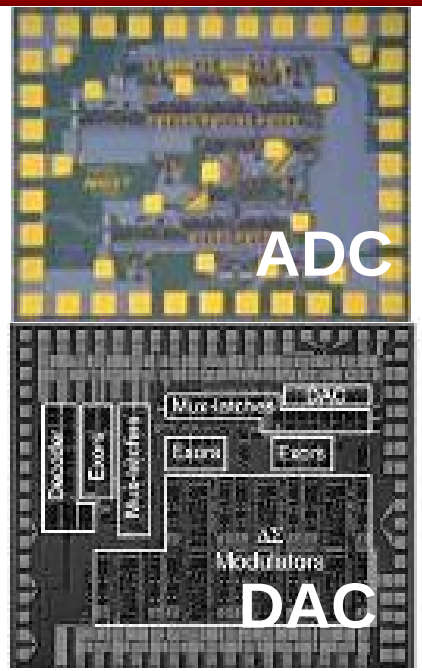
Bandwidth & Spectral Efficiency → Millions of Available Multi-Mbps Channels

Big Electronic Challenge/Opportunity:
Increased Bandwidth & Linearity
Power & Low Noise Amplifier, Mixer, ADC/DAC

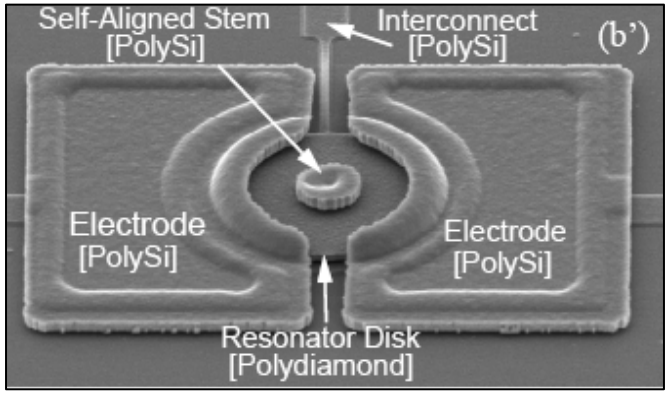
Problems:
- Today's ADCs/DACs have limited bandwidth-resolution product with high power consumption
- Today's Front-End RF electronics have severe linearity limitations

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

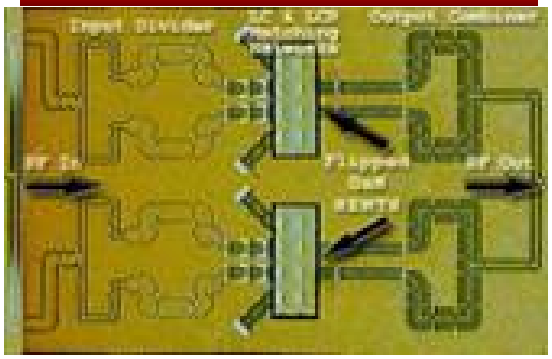
InP Electronic Mixed Signal IC technologies



Narrowband RF Resonators & Filters



GaN MMIC Technologies



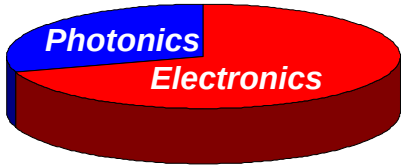
Towards THz Transistors

"Dramatic Advances in RF & Mixed Signal Electronics Are Still To Come" *-Steve Pappert, 2007*

Military & Commercial Mobile Communications

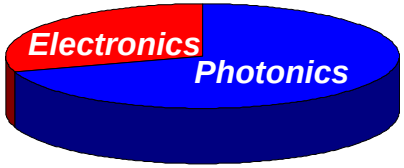
Summary of Key Technology Enablers

Commercial Comms Enabler Portfolio



- **Capacity**
- **Affordability**

Military Comms Enabler Portfolio



- **Security/Anti-Jam**
- **Link Availability**

Electronics

- Higher-speed, low power DSP
- Higher-speed mixed signal circuits
- Sub-MMW electronics
- Linear amplifiers & mixers
- Narrow-band fast-tunable RF filters

Photonics

- λ-stable low phase noise optical oscillators
- Optical Phased-Locked-Loops (OPLLs)
- Narrow-band fast-tunable optical filters
- Optical phased arrays
- Opto-Electronic Integration

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***!