THOR

Tera Hertz Operational Reachback

"Network-Enabled Free-Space Optical Communications"

DARPA Advanced Technology Office
G. Duchak
Program Manager

There is nothing more powerful than an idea whose time has come.

--- Victor Hugo

TERA HERTZ OPERATIONAL REACHBACK

THOR

October 22, 2002

DARPA Advanced Technology Office
G. Duchak
Program Manager

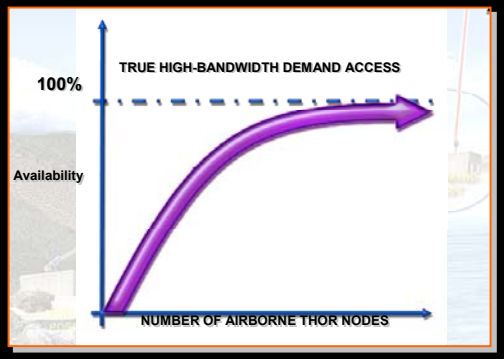
Purpose

- Provide Industry with the DARPA plan for THOR
- Introduce THOR Principal Investigators for Phase 1 and and update industry with some initial THOR Phase 1 discoveries
- Allow industry to present their independent discoveries
- <u>Facilitate teaming</u> for Phase 2 of THOR

THOR 101

- Leverage the extensive deployment of terrestrial fiber
  - Extend fiber to the theater via a mobile free space optical path
  - Provide broadband (fat pipe) communications into/and out of the theater

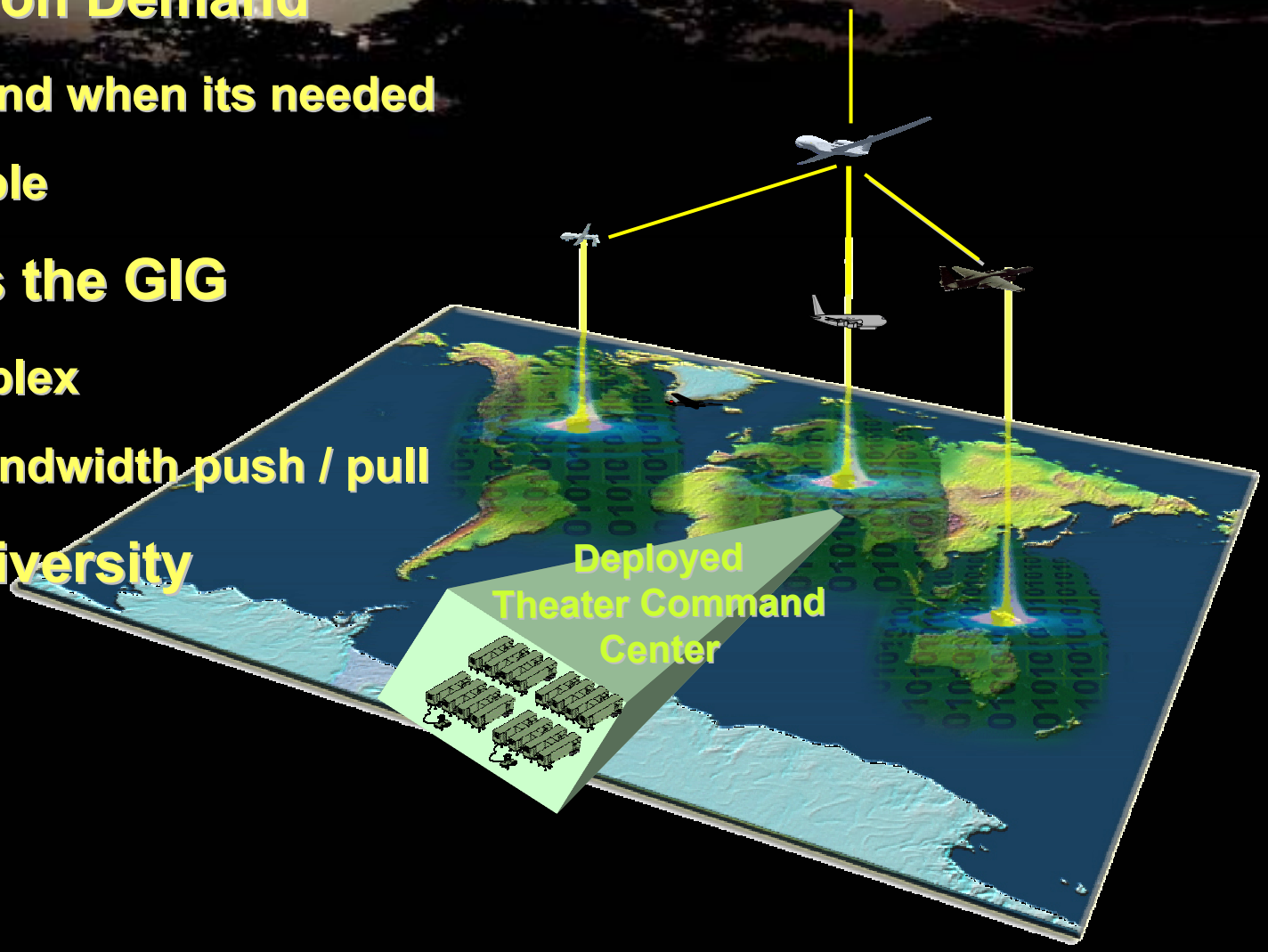
- Use improved technology within the context of a network to mitigate Mobile Free Space Optical limitations



- THOR strives to achieve, compared to the best current tactical RF link:
  - 40X improvement in data rate
  - 10X reduction in size, weight and power
  - at least a 10X reduction in cost

Moving 10 Gbps out of the ground

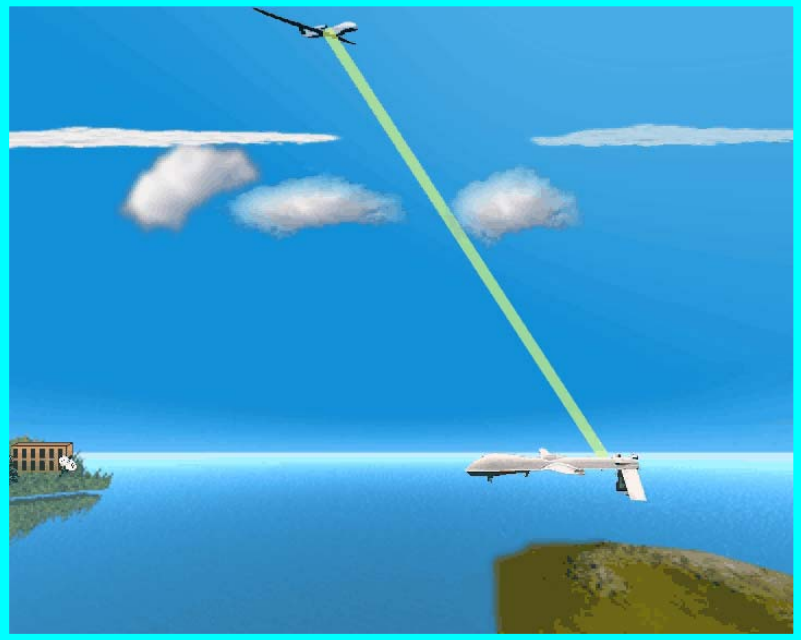
- Deployed on Demand
  - Where and when its needed
  - Extensible
- Augments the GIG
  - Full Duplex
  - High bandwidth push / pull
- Routing diversity
- Robust
- Ad Hoc



The Network Enables MFSOC

"THOR leverages the switching and correcting power of a network to overcome the traditional MFSOC pitfalls; no line-of-sight and poor atmospherics"
- Neil Fox

THOR Routing Assures Connectivity



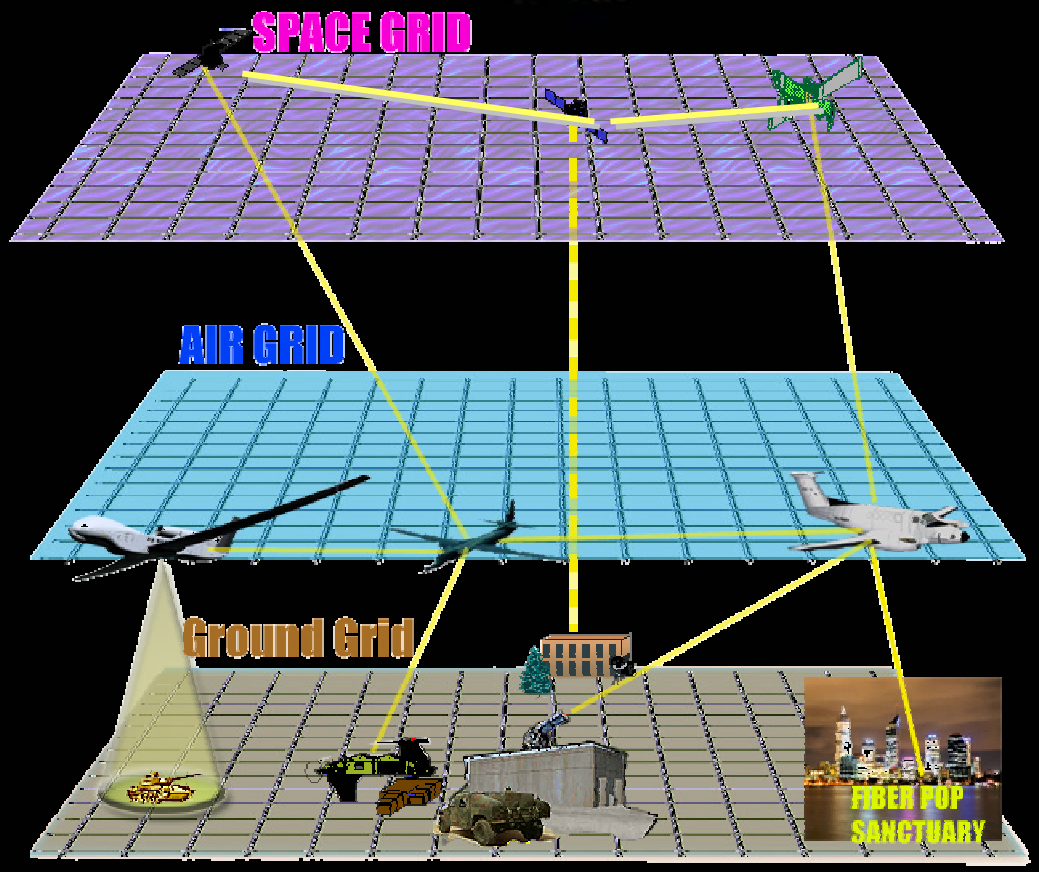
THOR Adapts to Changing Conditions

THOR Enables a 3D Global Grid

Emerging

THOR Nexus

Reality Today



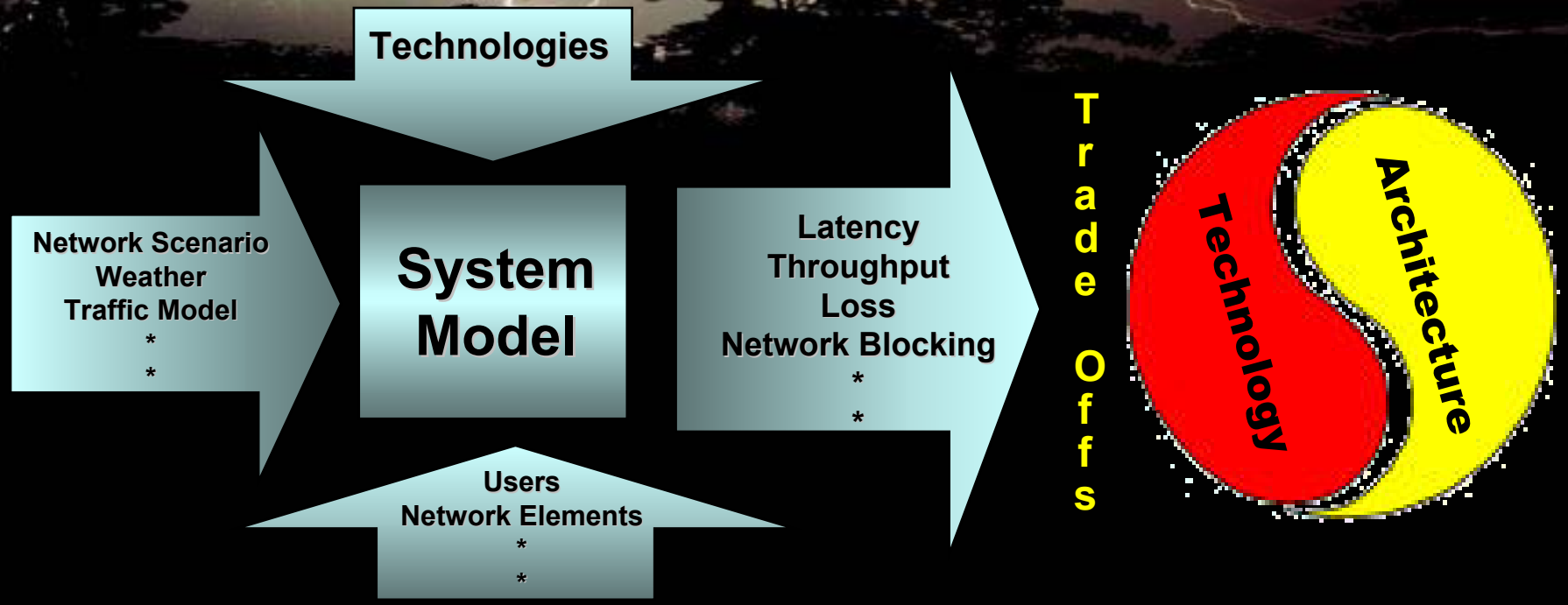
"Fiberless Fiber" will complete the Global Grid and provide secure, assured, high data rate and end-to-end communications to airborne, terrestrial, surface, and subsurface warfighters by developing, integrating and demonstrating innovative optical system concepts and technologies.

THOR Program Objective

Develop the key technology and demonstrate a laser communications system for end-to-end high data rate connectivity of air, surface and underwater assets

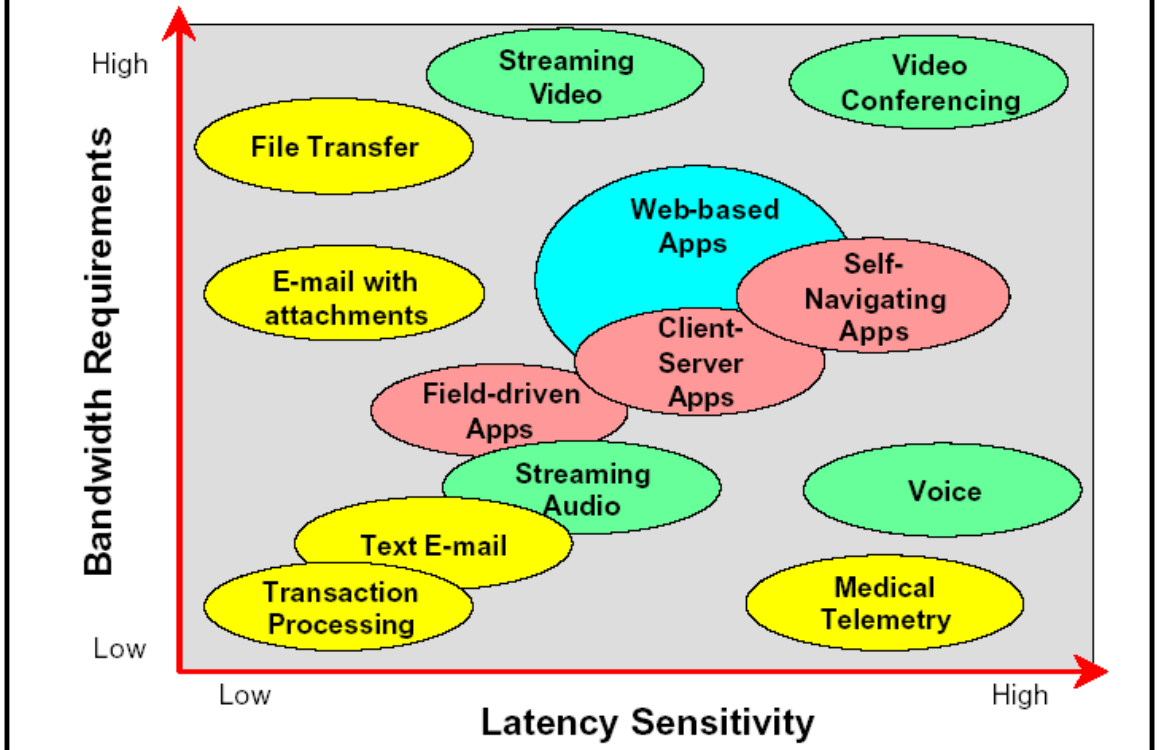
- Take an end-to-end network system approach
- Develop family of critical technologies applicable to all the operating environments
- Demonstrate optical links in variety of environments and channels
- Establish credibility for transition to acquisition

Architectural Trade-Offs



Overall system performance depends on the whole

Network Provisioning, Latency & Bandwidth



Reference: NetForcast Report 5052, Peter Sevcik & Rebecca Wetzel, May 2001,

A WIDE range of applications require different bandwidth and performance characteristics

A SINGLE network must support many diverse applications with differing and likely competing requirements

THOR Program Schedule

FY02	FY03	FY04	FY05	FY06

Technology Push

Acq

Phase I

Technology Lab Demos

PI Meetings

10 month PoP

Technology Innovation & Maturation

System Architecture, Concept, and CONOPS

Many Technology Investigators

Subsystem Development

Acq

Phase II

Refine System Architecture, Concept & CONOPS

Subsystem Lab Demos

Subsystem Demos

20 month PoP (10 month base/10 month option)

Subsystem Technology Development & Network Modeling

First 10 months ~ 5 teams

Next 10 months ~ 2 teams

Plan to fund novel ideas under DARPA ATO Office BAA

Tech Opportunities

Value

- TBA Base
- TBA Option
- $ Un-priced Phase III Option.

Technology Integration & End-to-End System Demonstration

Acq

Phase III

Final Demo

Refine System Architecture, Concept, & CONOPS

24 month PoP

Network Modeling, Flight System Prototype, & Flight Demonstration

Single System Integrator

Expected Value TBA

THOR Phase 1

Focus: Enabling Component Technology Push

- ✓ Mature the key enabling technologies
  - Beam Steering and Agility
  - High Power
  - Receiver Integration
  - Passive Terminal
- ✓ Meet Go/No-Go requirements for each THOR element
- ✓ Independent Verification and Validation of key requirements
- ✓ Perform network modeling to assess baseline performance
  - Establish baseline scenarios
  - Define and estimate network Quality of Service (QoS)

THOR Phase 2

Focus: Demonstrate sufficient maturity of system to take to flight demo

- ✓ Use the Lab test to demonstrate THOR efficacy
- ✓ Mature Subsystems
  - ✓ Resolve Interfaces
  - ✓ Robust Pointing, Acquisition, & Tracking
  - ✓ Field of Regard
  - ✓ Vibration
  - ✓ Environmental issues and packaging
  - ✓ Preliminary RMA & LCC
- ✓ Baseline CONOPS & Architecture
- ✓ Identify platforms for Phase 3 and for Post Phase 3
- ✓ Meet Go/No-Go requirements
- ✓ Independent Verification and Validation
- ✓ Perform network modeling to assess performance

Phase 2 is NOT a PDR

THOR Phase 3

Focus: Prototype and Flight Demonstrate Integrated THOR End-to-End System (Ground-Air; Air-Air, Air-Ground)

- ✓ Mature & Refine Phase 2 Architecture and CONOPS
- ✓ Design the Demonstration (a/c GFE TBD)
- ✓ Full Duplex, Multi-Media
- ✓ Meet Go/No-Go requirements for each THOR element
- ✓ Independent Verification and Validation
- ✓ Perform network modeling to assess baseline performance

Simply pushing harder within the old boundaries will not do.

-- Karl Weick

Professor of Psychology

University of Michigan

Successful Proposal Criteria for Phase 2

- Innovation
- Innovation
- Innovation
- Team Composition
- Modular, Open & Scaleable Design
  - Core framework for a family of terminals
  - Ability to incorporate legacy comms in the terminal design
- Cost & Producability Potential
- Transition Plan

THOR Mission Focus

THOR Phase II Focus

Satellite

Enables diverse routing of HDR traffic via emerging space grid. Multi-User Head Supports Transition Architecture. Theater FOV enables simple PAT of multiple vehicles

Aircraft

Nexus between space and terrestrial grids.

Enables deep reach to deployed command or ship at sea from terrestrial fiber PoP in sanctuary

Network

Dynamic Networking mitigates effects of weather and blockages

Terrestrial (Mobile & Fixed)

FSO launch point and connection to Grid

Enables Exploitation from Sanctuary

Ships

HDR Connection from above

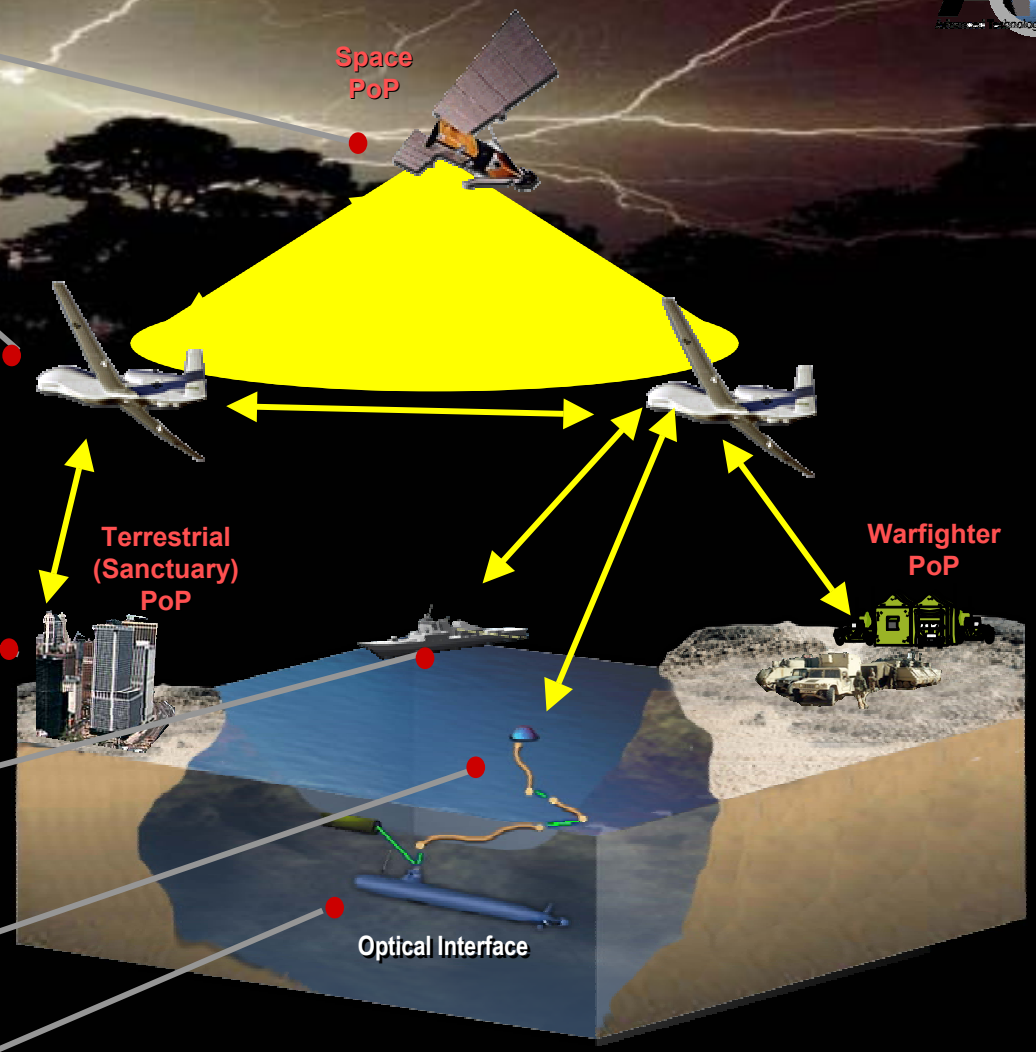
HDR link with submarine or UUV

Lasercomm Buoys

Hybrid fiber and free-water optical synapse to connect to to underwater vehicle

Submarines

Connect Subs & UUVs to Grid and enables new classes fo missions



The THOR approach is to view Free Space Optical within the construct of a network to provide the end-to-end QoS the warfigher demands

Phase 1

Enabling Technologies

- Mobile Free-Space optical networking
- High power inexpensive optical source
- Beam agility and steering (heritage from STAB)
- Improved optical receiver technology
- Passive optical terminal
- Demonstration: Proof it works

In the long run men hit only what they aim at. Therefore ....they had better aim at something high.

--- Henry David Thoreau