



Lasercomm AUGMENTATION of RF Comms

Lasercomm will <u>NOT</u> operate in all weather conditions although 90% availability in maritime environment has been measured

Lasercomm advanta	ges over	RF:
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•AJ, LPI, and LPD

No frequency allocation

No RF interference

High data rates (Mbps-Tbps)

Small size, weight, and power

Operate during EMCON and HERO

No multi-path interference issues

RF advantages over lasercomm:

Less susceptibility to weather & clouds

Less sensitive to atmospheric turbulence

Multi-access terminals straightforward

High precision pointing not required

Existing RF communication infrastructure

Non-LOS comms possible (at lower freq)

Established low risk investment

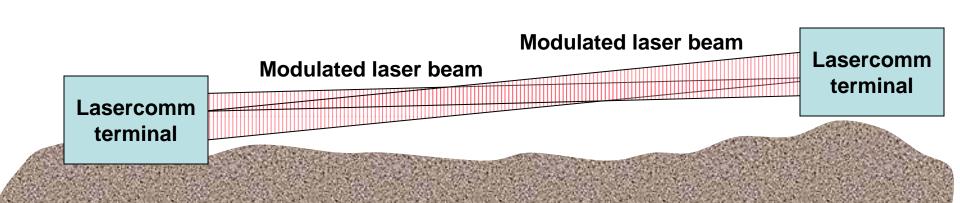
Lasercomm not a replacement for RF systems

Use of Lasercomm & RF systems will allow exploitation of both technologies advantages



Direct infrared lasercomm links

- Laser and pointing and tracking (PAT) required at both ends of the link
- Extremely high bandwidth: 200 THz carrier physical limit; practical modulation bandwidth limited to 10's of GHz due to electronics
- Link falls off as 1/R²
- Range typically limited by LOS (10's km ship-ship, 100's km air-air, etc.)
- "Equivalent" of fiber telecomm (with burst errors from atmosphere)





Modulating retro-reflector (MRR) links

- Laser and pointing and tracking (PAT) required at one end of the link
- Small and simple passive MRR (no laser & no PAT) at other end
- Very low power/weight at MRR end of the link (10's-100's of grams, 10's of mW)
- Appropriate for: unattended sensors; users who can't carry a lot of equipment; small platforms....low SWAP requirements in general
- Link falls off as 1/R⁴; Ranges of a few km to 10's of km depending on link
- Data rates of up to 10 Mbps (corner cube optics) or 100's Mbps (cat's eye optics)

Single retro (30° FOV)

5-element array (60° FOV)





Lasercomm terminal

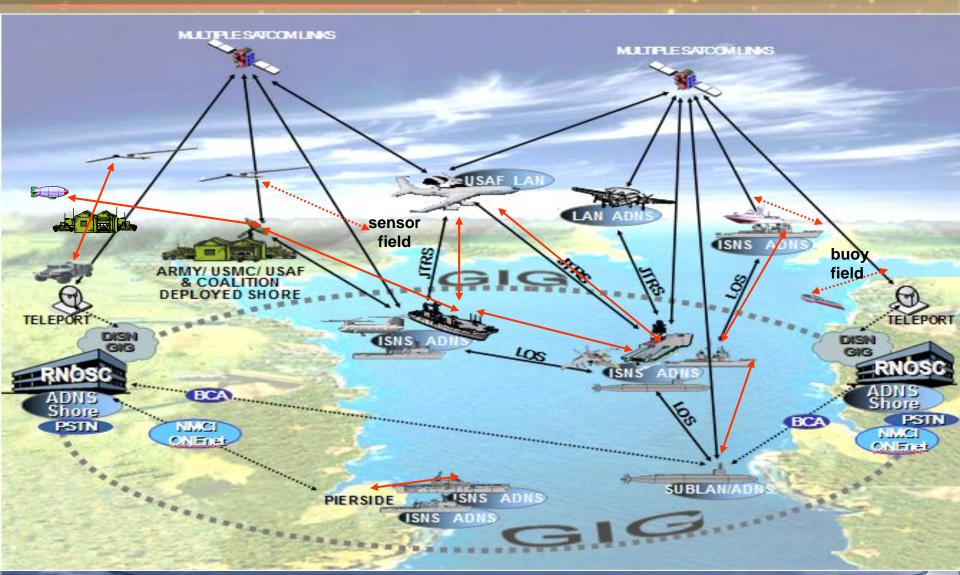
Modulated Retro-reflected return

△ MRR

Laser interrogating beam



LASERCOMM OV-1





Direct link example scenarios

Example scenarios where direct lasercomm links may be implemented are:

- Intra-strike group ship-to-ship communications
- Ship-to-shore communications during amphibious operations
- Line-of-sight (LOS) links between USMC Forward Operating Bases (FOBs)
- •Submarine-to-ship communications (with the optical link entirely through the air)
- •Air-to-surface communications for Intelligence, Surveillance and Reconnaissance (ISR), Situation Awareness (SA), & Command and Control (C2)
- •Surface-to-air-to-surface communications for beyond LOS communications relay
- •Pierside communications for ports where permanent install of a pierside lasercomm terminal is possible



MRR link example scenarios

Example scenarios where MRR lasercomm links may be implemented are:

- Maritime interdiction operations
- •SOF support and/or data exfiltration for submarine-to-shore communications (with the optical link entirely though the air)
- •Ship-to-pier communications in ports where permanent install of a pierside terminal is not practical
- •Air-to-surface communications for ISR, SA, & C2 on platforms incapable of supporting full size lasercomm terminals
- •MRR Submarine terminals where installation of full size terminal in submarine mast is impractical



Primary Goals

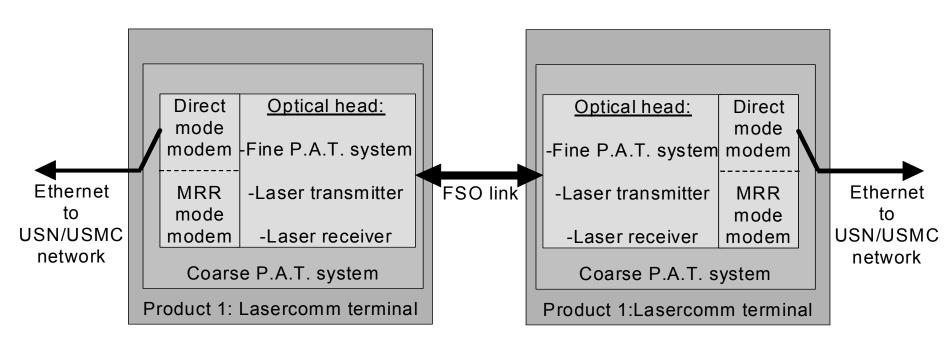
To ensure operational effectiveness and minimal impact to existing infrastructure, manpower requirements, and cost, a few primary operational goals for systems developed in this Enabling Capability (EC) are:

- •Lasercomm link appears to USN/USMC networks as "just another communication link" as seen by applications, routers, etc.
- •Automated operation of entire system (for example: acquisition, tracking, laser power, divergence, error handling, data rate, ...)
- •Single compact optical head design able to operate in a direct or MRR mode and able to be integrated into one model Commercial-Off-the-Shelf (COTS) gimbal for all surface operations and another model COTS gimbal for all airborne operations (speed ≤ 200 knots*)
- •Small size, weight, and power (SWAP) single man portable MRR terminal able to be rapidly setup and operated
- Low cost
- High system reliability
- •Navy Laser Safety Review Board approval for unattended operation in all applicable operational environments
- *Airborne terminal designs which allow for future upgrades to operate on higher speed platforms (up to 300 knots) are highly desirable.



Lasercomm System Overview

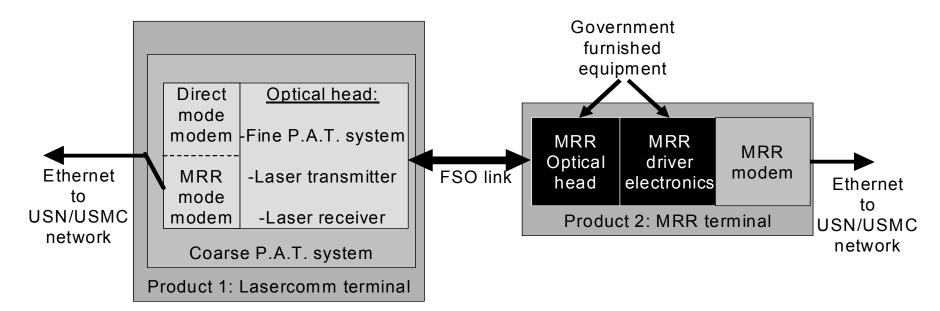
- •Develop lasercomm systems capable of connecting to a USN/USMC network and autonomously linking to another USN/USMC network via a lasercomm communication link.
- •Terminals should communicate both in a "direct mode" between two lasercomm terminals and in a "Modulating Retro-reflector (MRR) mode"



Example of direct mode configuration



Lasercomm System Overview (cont)



Example of MRR mode configuration

- Product 1 Lasercomm terminals capable of communicating both in direct mode to another lasercomm terminal and in MRR mode to an MRR terminal (product 2)
- •Product 2 Modulating retro-reflector (MRR) communications terminals



Product 1: The Lasercomm Terminal

The lasercomm terminal contains in very general terms:

- 1. an optical head with a laser transmitter, receiver, and fine pointing, acquisition, and tracking (PAT) system
- 2. coarse PAT system able to automatically establish and maintain lasercomm links between terminals when provided bearings between terminals from an external (government provided) source
- modem(s) for communication between the lasercomm link and USN/USMC network consisting of either two separate modems for direct mode and MRR mode communications or a combined modem capable of communicating in both modes



Clarification to BAA 09-018:

Item 1:

Change bullet item on pages 4 & 6 in BAA 09-018 from:

 Single compact optical head design able to operate in a direct or MRR mode and able to be integrated into one model Commercial-Off-the-Shelf (COTS) gimbal for all surface operations and another model COTS gimbal for all airborne operations (speed ≤ 200 knots)

to:

Single compact optical head design able to operate in a direct or MRR mode and able to be integrated into one model Commercial-Off-the-Shelf (COTS) gimbal for all surface operations and another model COTS gimbal for all airborne operations (speed ≤ 200 knots). Optical heads with input and output fiber ports for future upgrades are desirable.

Item 2:

Add following paragraph to BAA 09-018 on page 8 in section titled "Single compact optical head design able to operate in a direct or MRR mode and able to be integrated into a single COTS gimbal for all surface operations and possibly another for all airborne operations (speed \leq 200 knots)":

The wide range of applications, as well as potential improvements in technology make it desirable, but not required, for the optical head to include fiber input and output ports. For example, a single mode fiber input port would allow an external laser and transmit modem to be switched into the optical path before the amplifier. A single mode, or multimode, fiber output port would switch the raw received optical signal out from the internal receiver path to an external receiver and modem. If fiber input and output ports are included, proposers must still provide laser transmitters and receivers as part of their base design, and these parts may be internal to the optical head.



Submitted Q&A

- Q: What is ONR's intent for the contractor's responsibilities with regard to the gimbals for this BAA?
 - A: Gimbals are to be purchased by contractor. COTS gimbals already developed for maritime and/or airborne platforms are desired
- Q: Do the weight and volume targets include the gimbals or not?
 - A: The weight and volume metrics include the gimbal.
- Q: Does ONR have a target maximum aperture for the telescope mounted on the gimbals?
 - A: There is no target maximum aperture. SWAP limits maximum, laser safety and/or diffraction limits minimum aperture size
- Q: Please provide guidance on the platforms for the airborne nodes and any mobile ground based nodes. Will those be GFE? Are there specific platforms required?
 - A: Specific platforms TBD. All platforms GFE. EC goal to develop generic small SWAP terminals that are easy to integrate on wide variety of platforms. Government will integrate terminals with platforms and networks
- Q: Is there any need or requirement for mod-sim? If so, would you like it performed by the contractor, or would you like a government-side modeling effort to track contractor actual/expected performance?
 - A: Government-side M&S may be performed but will not be decided until awards made.
 Contractor-side M&S may be included with proposals as deemed appropriate by vendors.
- Q: Do you think there will be a need for atmospheric profiling to validate link performance?
 - A: Government-side characterization of atmosphere will be performed. Decisions on the exact characterizations needed will be determined after award decisions are made.



Notional Performance Metrics

The following are notional metrics for lasercomm system performance, they are not requirements:

	Direct Lasercom Terminal	MRR Link	
Data rate	≥100Mbps	2 – 45Mbps	
(Clear air ; vis.~20 miles)			
Range	Surf-to-Surf:50 yds to 20-30 Nmi 50 yds to 3-10 Nmi		
	Surf-to-Air*:100 yds to 20-40 Nmi		
	Air*-to-Air*: 500 yds to >40 Nmi		
SWAP	< 1ft ³ , < 50lbs, < 200W	< 10in ³ , < 1lb, < 10W	
Initial Acquisition Time	< 10sec		
Re-acquisition after breakage	< 1sec		
Modem	Capable of interfacing links with burst errors to standard Ethernet link		

^{*}Airborne nodes for this program are slow flying platforms (~200 knots or less) such as aerostats, balloons, helicopters, slow flying fixed wing aircraft, and small to medium class UAVs. However, designs which allow for future upgrades to operate on higher speed platforms (up to 300 knots) are highly desirable.



Summary of technical goals/challenges

Specific technical challenges that exist for extending current lasercomm system technology to useful USN/USMC lasercomm terminals are:

- •Modems that handle potentially high error rates over link and deliver standard Ethernet packets with an apparent low error rate
- Compact designs that ensure sufficient link margins for communications
- •Reliable systems able to endure military environmental effects: salt water spray, strong EMI, weather, vibrations, etc.
- •Automated operation of system:
 - •Automatic sensing of link degradation due to attenuation, scintillation, etc. and adaptation of data rate or other system parameters to maintain link and increase range/availability
 - •Automatic determination of optimal transmit laser power, divergence, etc. to maintain optimal receive power
 - Automatic PAT to acquire and maintain links between lasercomm terminals without user intervention



Phase 1 Demo – 18 months

Point-to-point demonstrations of automated PAT and high quality of service data transfer using compact terminals integrated into standard gimbals.

- •Demonstrate maritime direct link to the horizon and MRR link to maximum range with at least one end of the link on a boat. Operation on the move (OTM) required.
- •Demonstrate automated acquisition, pointing, and tracking of terminals and determine effectiveness of modems and terminals to transmit/receive data with a high quality of service.
- •Significant automation expected with only minimal operator control necessary for system operation.
- •Bearing information for acquisition will be provided by the government.

GOAL: Base demonstration of terminal capabilities and use of lessons learned to optimize system for demonstration at end of phase 2.

-System primarily operated by vendor



Phase 2 demo - 36 months (option)

Fully automated demonstration of a minimum of four networked terminals on three platforms ("nodes") integrated to simulated USN/USMC networks.

- •Demonstrate sea based three node network of maritime direct links to the horizon and MRR link to maximum range with a minimum of two nodes on boats.
- •Demonstrate land based three node network of direct and MRR links with a minimum of two ground nodes and one airborne node (operation above 10,000 feet desired but not required) capable of relaying network between the two ground nodes. Three main nodes should communicate through all direct links as base demonstration. Demonstration should also include air-to-ground and ground-to-air interrogation of MRR.

GOAL: Demonstrate fully automated system with high quality of service operation in simulated USN/USMC environments before demonstration in operational environments.

-System primarily operated by government



Phase 3 demo - 52 months (option)

Fully automated system installed on operational USN/USMC platforms and integrated to operational USN/USMC networks.

USN:

- •Operational underway demonstration of a minimum of three networked US Navy ships to horizon limited range (~20 Nmi)
- •Demonstrate underway MRR links to a simulated vessel of interest for Maritime interdiction operations and a supply ship for underway replenishment
- •Demonstrate addition of airborne node with capability to connect two Navy ships over-the-horizon with a minimum separation between ships of 40 Nmi.

USMC:

- •Demonstrate a ground-to-air-to-ground relay with ground terminals separated by >40 Nmi and ground terminals fully integrated to USMC network.
- •Demonstrate addition of MRR terminal to network interrogated from both ground nodes and airborne nodes (not simultaneously).

GOAL: Demonstrate high bandwidth laser communications terminals on operational platforms fully integrated with operational USN/USMC networks in realistic scenarios – USN: Intra-strike group communications; USMC: FOB-to-FOB communications.

-System primarily operated by government and users



Some Useful References:

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