Undersea Narrow-Beam Optical Communications

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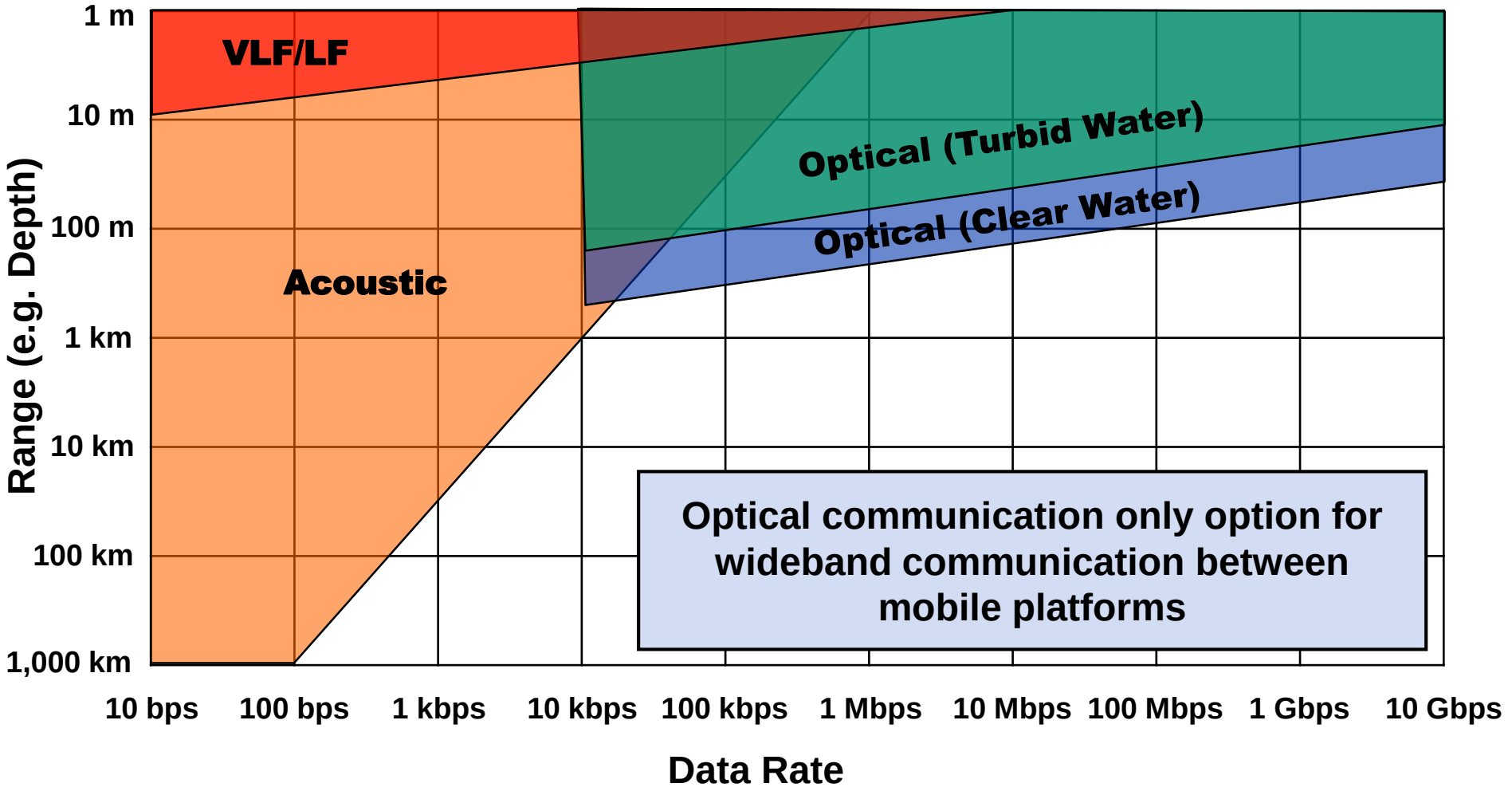
Undersea Communications Tradespace



Published Undersea Optical Communication Milestones

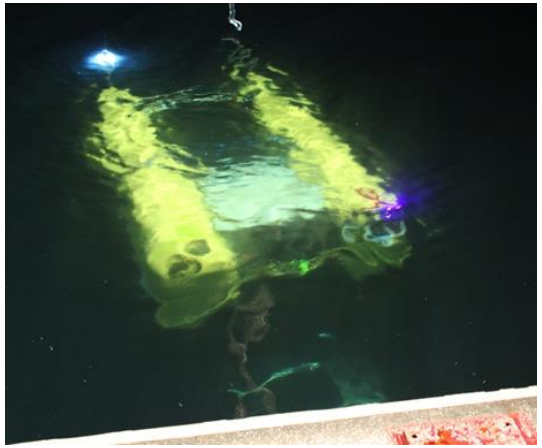
Published Demonstrations Milestones

- Laboratory test beds
  - Short ranges, max data rate of 3.2 Gbps
- In-water fixed to fixed terminals
  - Max demonstrated range of 200 m at 5 Mbps
- Mobile to fixed terminals
  - Max demonstrated range of 100 m at 1 Mbps

Mobile terminal demonstrations have used wide beams that are body pointed

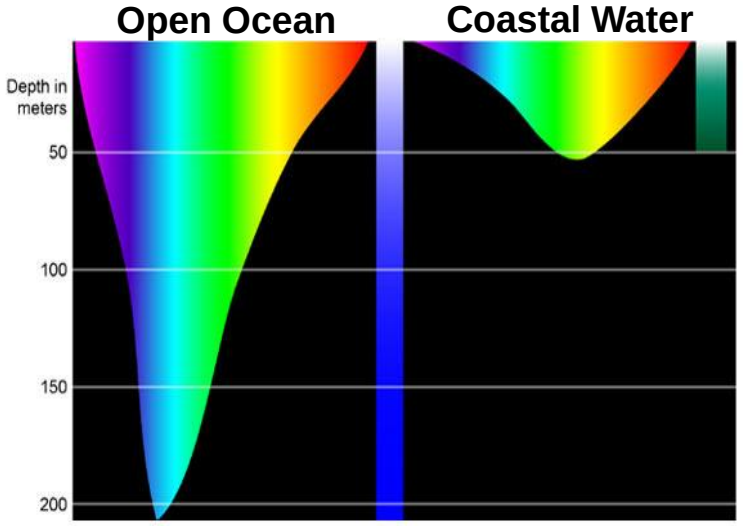
Woods Hole Oceanographic Institution (WHOI)

LED Modem



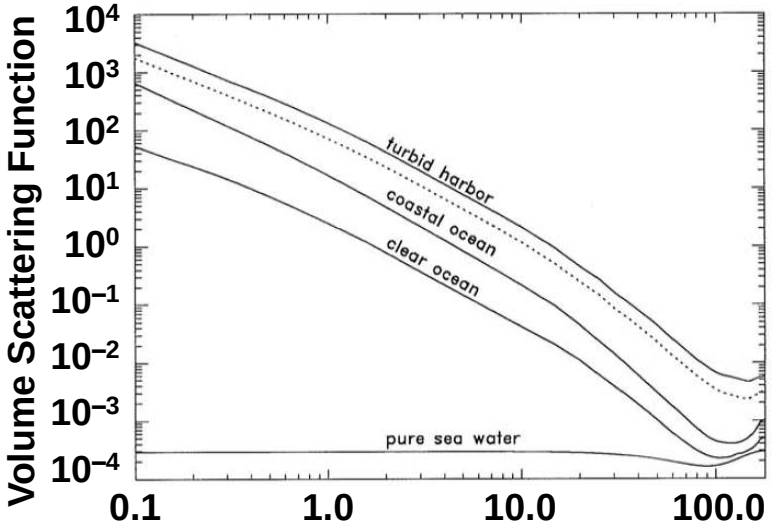
Undersea Propagation Model

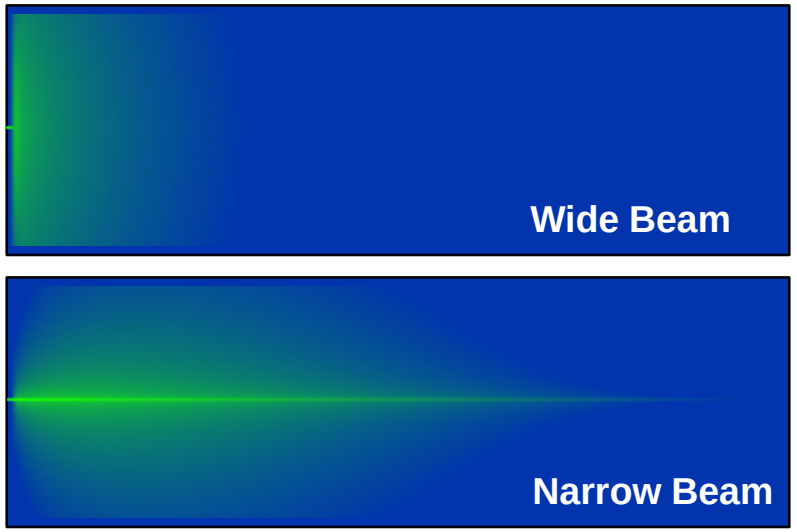
Transmissivity vs. Wavelength



Source: NOAA

Scattering Angular Deflection*





Water Types	λ	a [m^{-1}]	b [m^{-1}]	c [m^{-1}]	EL** [m]	Source
Turbid Harbor	514 nm (green)	0.37	1.8	2.2	0.45 m	Petzold (1972)
Clear Ocean	514 nm (green)	0.11	0.037	0.15	6.7 m	Petzold (1972)
	470 nm (blue)	0.038*	0.012*	0.05	20 m	Pontbriand (2008)

- Blue light transmits best in open ocean
- Green light transmits best in coastal and harbor water
- Scattering is highly peaked in forward direction

Enabling Technology for Low-Swap Undersea Narrow-Beam Lasercom

Key Technologies

Collimated Laser Transmitter

+ Geometric Gain
– Requires Pointing, Acquisition and Tracking (PAT)

Spectral Filtering

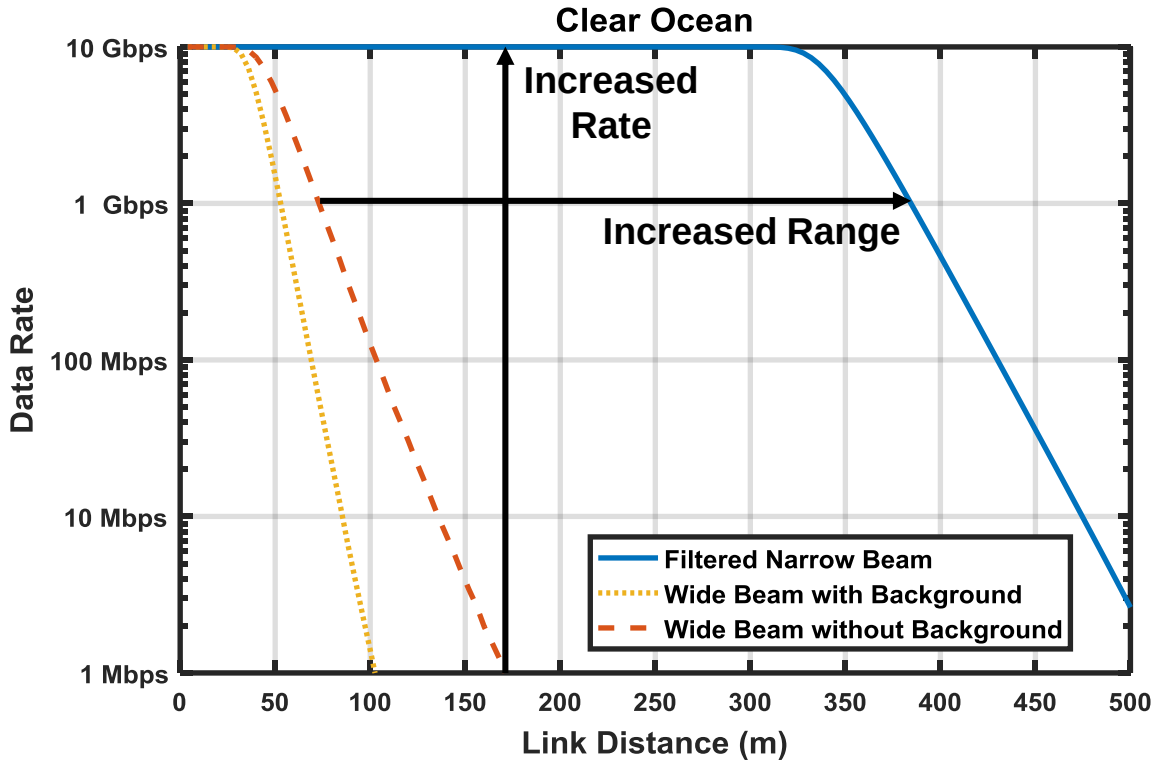
+ Remove out-of-band solar background
– Requires narrow field-of-view receiver

Spatial Filtering

+ Enables COTS spectral interference filters
+ Removes off-axis solar background
– Requires PAT system

Pointing, Acquisition, and Tracking (PAT)

+ Enables collimated laser, spatial filter, COTS spectral filter

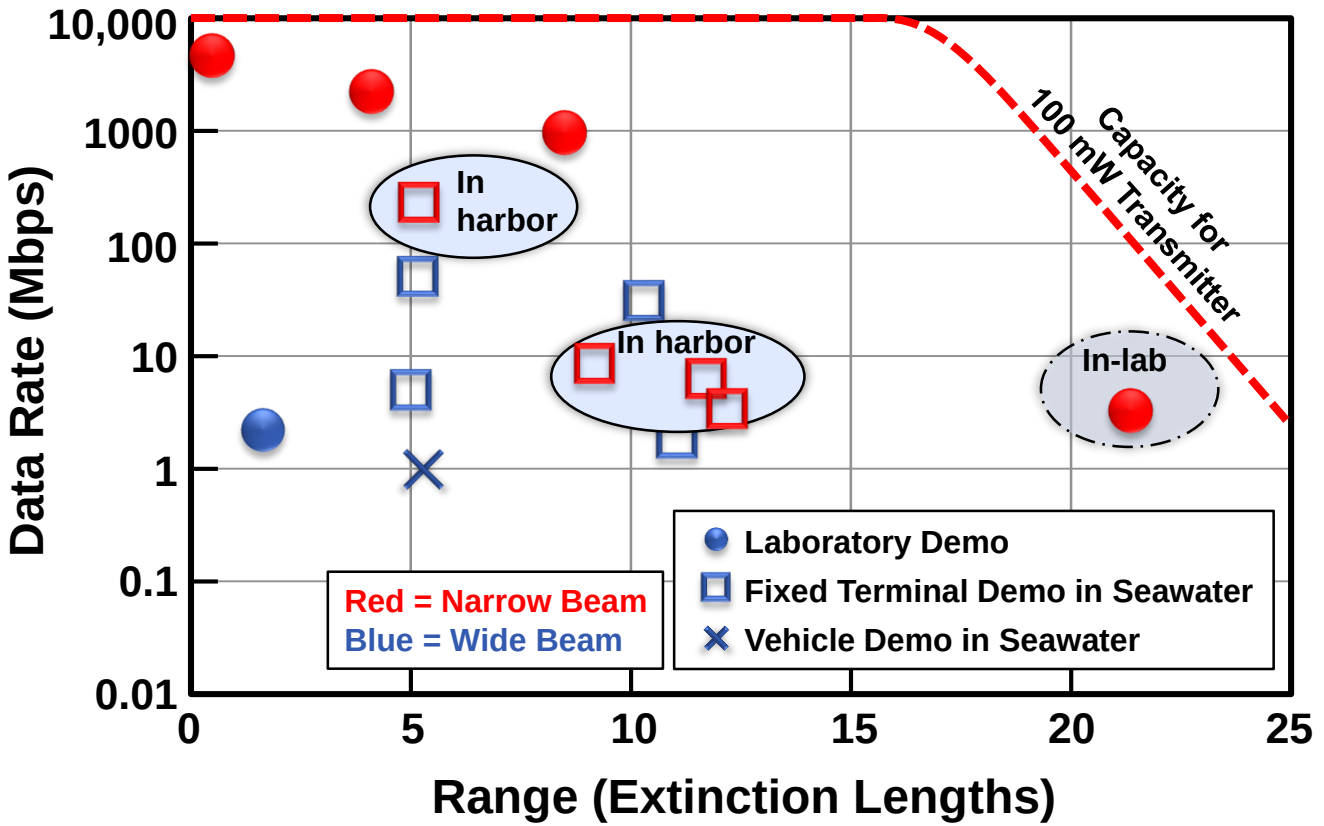


Narrow beam system can have significantly enhanced range and rate, but requires precise beam tracking

Narrow-Beam Communication Performance

Accomplishments

- **Laboratory test bed demonstrated modem can operate with 97 dB end-to-end channel loss**
  - **20 mW launch power, 21 extinction lengths**
  - **< 1 detected photon/bit sensitivity at 5 Mbps**
- **Capacity-approaching day/night operation in natural waters**
  - **0.25 mW launch power, 11.5 extinction lengths**
  - **1.2 detected photon/bit sensitivity at 8.7 Mbps**
- **High-rate communications in natural water**
  - **125-Mbps communication**



Natural water performance matched laboratory performance