Integration & validation networked and modular sensing and analyzing devices on an in situ biogeochemical payload for underwater ROV and observatories

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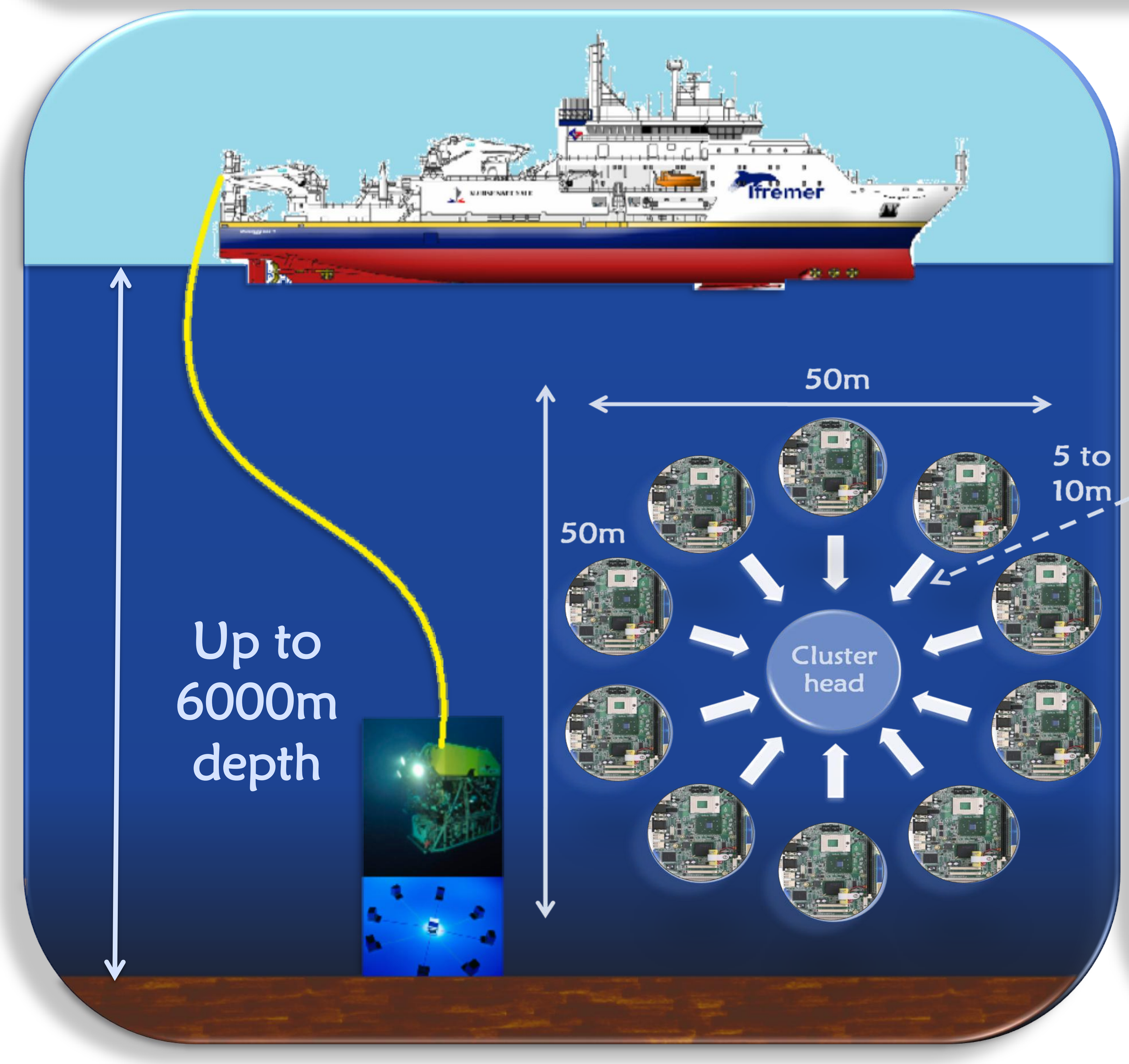
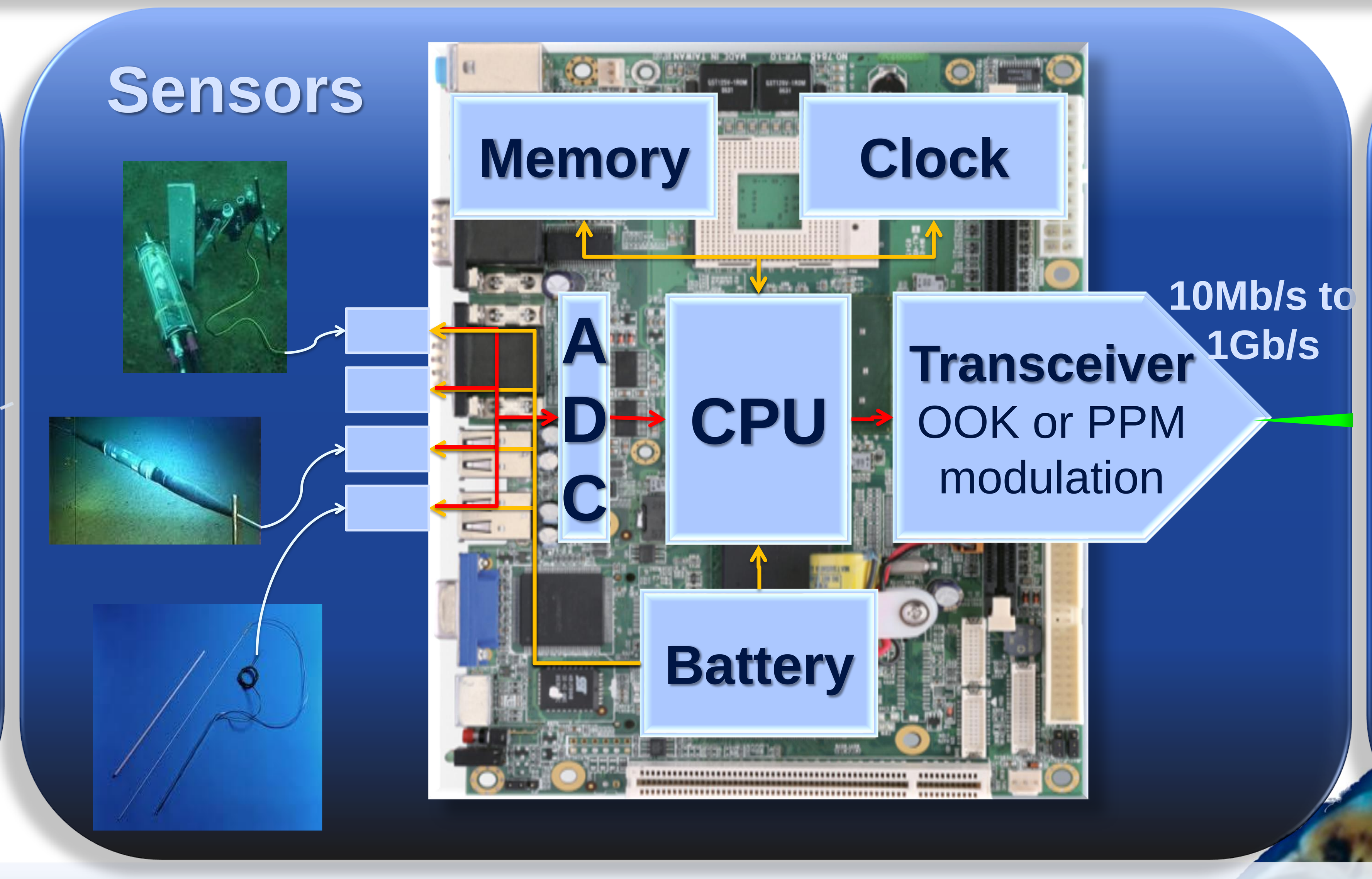
Definition

Wireless Sensor Networks (WSN) are self organized systems formed by multi-functioning devices called nodes to which multiple sensors and measuring instruments can be linked. Data are collected from the sensors, processed in a node and routed wirelessly to the other network nodes. Building a wireless sensor network adapted to aqueous environments (UWSN) must overcome a large number of problems related to the environment itself such as propagation delays, node mobility, limited link capacity, localization, synchronization, and energy consumption.

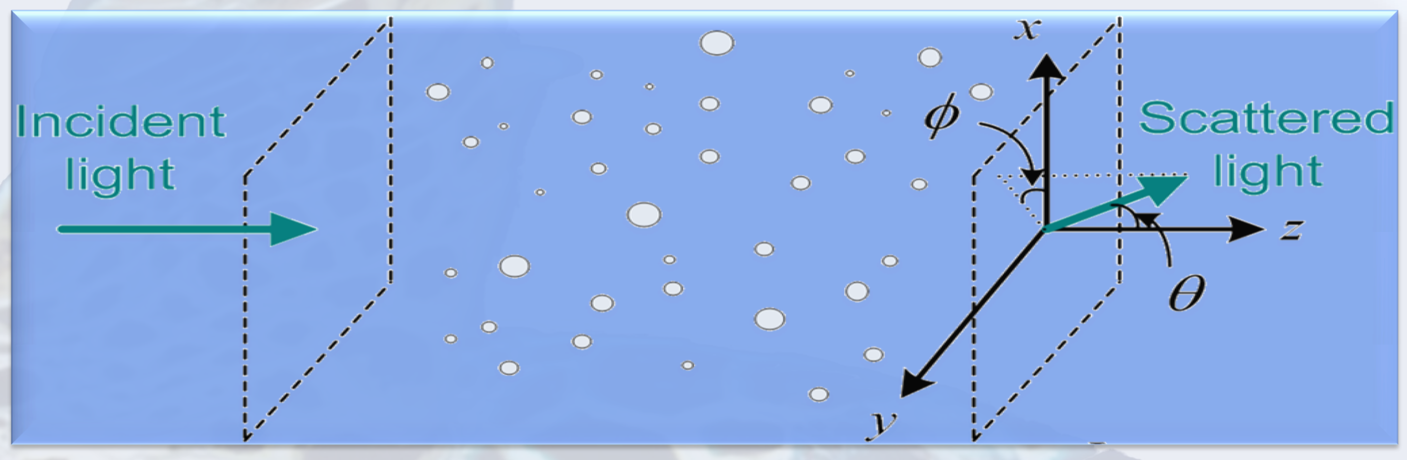




Transmitter/Receiver

Internodal communication	ROV-node communication
• 10Mbps • LED (532nm) • Photomultiplier/ PAD	• 1Gbps • Laser (532nm) • Photomultiplier/ PAD

Propagation



Absorption and scattering affects underwater optical signal propagation. They are described by:

- **a(λ) the spectral coefficient of absorption** (m^{-1})
- **β(θ) the volume scattering function (VSF)** $(m^{-1}sr^{-1})$

Integrating the VSF over all directions, gives the spectral scattering coefficients b(λ):

$b(\lambda) = 2\pi\int (\beta(\Psi, \lambda) \sin(\Psi) d\Psi)$ (m^{-1})

knowing β and b(λ), one can compute the spectral volume scattering phase function **$\beta'(\Psi, \lambda) = \beta(\Psi, \lambda)/b(\lambda)$** (sr^{-1})

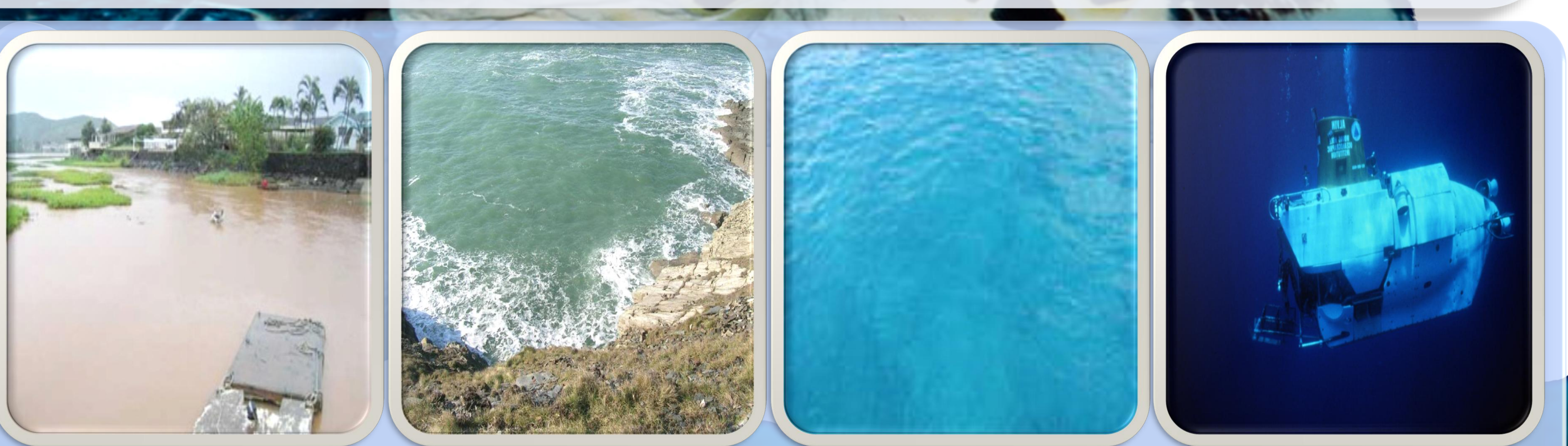
Adding a(λ) and b(λ) gives the spectral beam attenuation coefficient **$c(\lambda) = a(\lambda) + b(\lambda)$** (m^{-1})

Water types

"a" and "b" can be calculated by adding the contribution of pure water to that of the particles in suspension/solution:

-Colored Dissolved Organic Matters CDOM
-Salt
-Detritus and minerals
-Organic matters and planktons

Bio-optical statistical models , like the "Gordon and Morel" model, are based on the chlorophyll concentration C (mg.m-3) as the main parameter to compute "a" and "b".



Estuaries	Coastal waters	Clean waters	Deep sea waters
$c > 3m^{-1}$	$c \approx 0.5m^{-1}$	$c \approx 0.2m^{-1}$	$c \approx 0.08m^{-1}$

Radiative Transfer Function (RTF)

The received signal power $P_R(t)$ is:

$$P_R(t) = P_T(t) * G * L + n(t) \quad (W)$$

P_T is the transmitted power and G is the gain at the transmitter and at the receiver.
L is the radiance of the light emitted wave.

The RTF is the equation governing the behavior of radiance within natural water bodies.

$$dL/dr = \cos(\theta)\, dL/dz = -cL + L_{elastic} \quad (Wm^{-3}sr^{-1}nm^{-1})$$

Then,

$$L(z) = L(0)\exp(-cr) + L_{Elastic}(0)\exp(-Kr\cos\theta)/(c - K\cos\theta)\,[1-\exp(-r(c - K\cos\theta)]$$

K is the diffuse attenuation coefficient of radiance: $K(\theta,\phi) = -1/L(z, \theta, \phi, \lambda) dL/dz$

Objectives & Conclusion

- Solve the RTF using a Monte Carlo simulator.
- Evaluate Inter-Symbol-Interference (ISI)
- Determine the Bit-Error-Rates (BER) for the modulation technique used.
- Propose channel code.
- Test the studied communication system in-situ.
- Build the protocols for the upper network layers.
- Make a test-bed for the UWSN.