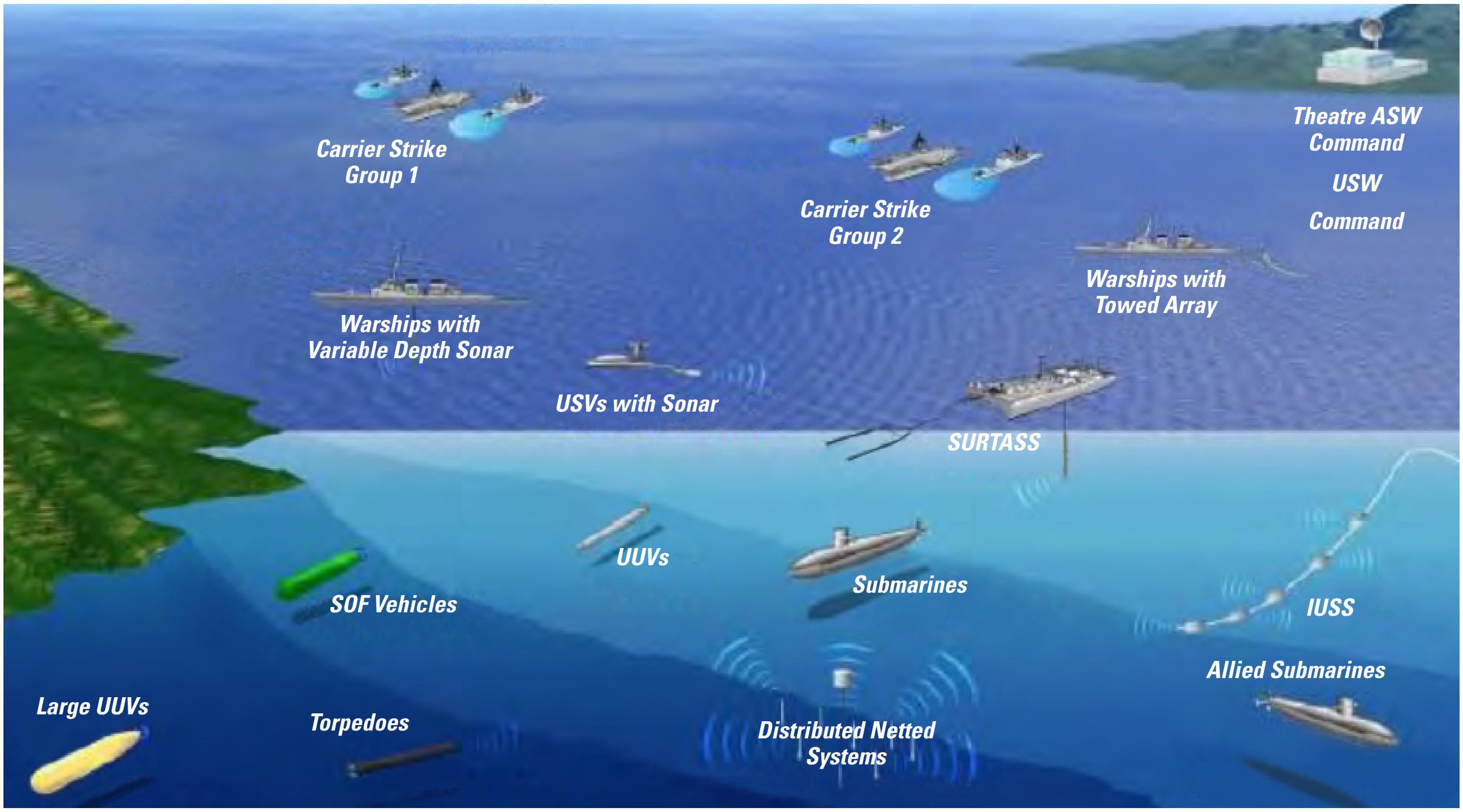
Underwater Communications Networks Model Library

The SCALABLE suite of model libraries provide a large number of reusable models for network devices, protocols from all layers of the protocol stack, applications, and the communication environment. These models make it possible to easily create scenarios which can be used in the design and analysis of a large variety of communication networks, and can be used with the QualNet and EXata simulation/emulation tools and with the Network Defense Trainer.

QualNet/EXata scenarios can also be used in a federated environment, using the High Level Architecture (HLA), Distributed Interactive Simulation (DIS), or IP sockets, to run co-operative simulations with other simulators to provide more realistic and meaningful results.

The Underwater Communications Networks (UCN) Model Library can be incorporated into QualNet, EXata and NDT, adding support for underwater acoustic and optical communications. The UCN Model Library provides high fidelity models of underwater acoustic and Free-Space Optical (FSO) communications, which can be used to analyze underwater network performance and visualize communications under a variety of operational and environmental conditions.



Propagation Models

BELLHOP Acoustic Propagation Model: BELLHOP is a beam tracing model for predicting acoustic pressure fields in ocean environments. The model takes into account the refraction of the beam away from the straight line path due to vertical variability of the water column and the reflection of the ray from the ocean surface or seabed. It also includes the effects of geometric spreading and uses the Thorp model to estimate the effects of absorption. The values obtained from beam tracing provide pathloss, arrival delay, and multi-path interference values to the simulation.

Thorp Acoustic Pathloss Model: This model calculates sound losses in the ocean due to both spreading and absorption. In deep water the spreading is spherical, whereas in shallow water the spreading can be considered to be cylindrical. In both cases the intensity of the received signal decreases as the distance between the source and the receiver increases. Absorption losses are frequency dependent because they are due to the effects of molecules dissolved in the water. The energy loss due to absorption is an exponential function of the distance. The absorption loss calculation is based on the Thorp model and is valid for frequencies between about 100 Hz and 50KHz.

Beer-Lambert Optical Pathloss Model: This model calculates the attenuation in light intensity when it travels through sea water due to both scattering and absorption. The coefficients of absorption and scattering are wavelength dependent, and are also a strong function of the minerals dissolved in the water and particulate matter floating in it. The Beer–Lambert model accounts for the effects of these losses on optical signals from lasers and LED sources.

Physical Layer Models

Acoustic PHY Model: A PHY model represents how the transmitted and received waveforms are converted to/from signals and distinguishes meaningful signals from noise, and passes the information to/from the MAC layer. Underwater communication devices use different modulation schemes depending on the range and environment. The Binary Frequency Shift Keying (BFSK) scheme is appropriate for poor quality channels, whereas the Orthogonal Frequency Division Multiplexing (OFDM) scheme provides higher throughput for better channels.

In an acoustic environment, the variability in arrival time of signals due to multiple paths can cause significant inter-symbol interference. To accurately model the inter-symbol interference, the Acoustic PHY model uses BFSK modulation with the BELLHOP propagation model. The OFDM and other modulation schemes are used in conjunction with the Thorp propagation model.

Acoustic Noise Model: When a signal is received at an underwater communications node, the receiver also picks up ambient noise. This noise, combined with signals from other transmitters, and the inter-symbol interference, reduces the receiver's ability to correctly discern the received signal. The Acoustic Noise model calculates the noise from wind and distant shipping, which are the dominant sources of noise in the frequency range used for acoustic communications.

Optical PHY Model: This model includes geometric factors of beam transmission and reception, an Optical Noise model, and a receiver model that supports Non Return to Zero On-Off Keyed (NRZ-OOK) encoding scheme. The Optical PHY model uses the Beer-Lambert pathloss model, an antenna pattern and a representation of the receiver's geometry to determine the strength of the received signal.

Optical Noise Model: This model calculates noise from scatted sunlight as well as internal receiver noise. It uses a single scattering model to estimate the amount of sunlight scattered into the receiver, based on the position of the sun, the pointing direction of the receiver, the depth, and the scattering and absorption coefficients.