

# Optical Signaling Tool for Training and Operations

Morse Code, Semaphore, Signal Flags, QR Codes

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light gray background

☐ horizontal ☒ vertical*click to continue*

# NAVAL RESEARCH PROGRAM

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## NAVAL POSTGRADUATE SCHOOL

medium

Morse code

volume

☐ append

zoom + -

enter

clear

log

MORSE  
orientation vertical  
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zoom 130



# Topics

## **Optical Signal Vocabularies**

- Morse Code
  - Semaphore
  - Signal Flags
  - QR Codes
- 
- Combined user interface

## **Goals for Future Work**

- Learning support tool
  - Tactical Decision Aid (TDA)
  - Proficiency practice, refresher
  - Software development in support of schoolhouse needs
- 
- Potential next steps

# Motivation for Optical Signal Vocabularies

- Restore significant Navy capability for past 2 ½ centuries
- Line of sight (LOS) reduces ship vulnerability to detection, intercept
- Gain new signal paths to unmanned systems
- Regain signaling competence with international partners

Especially

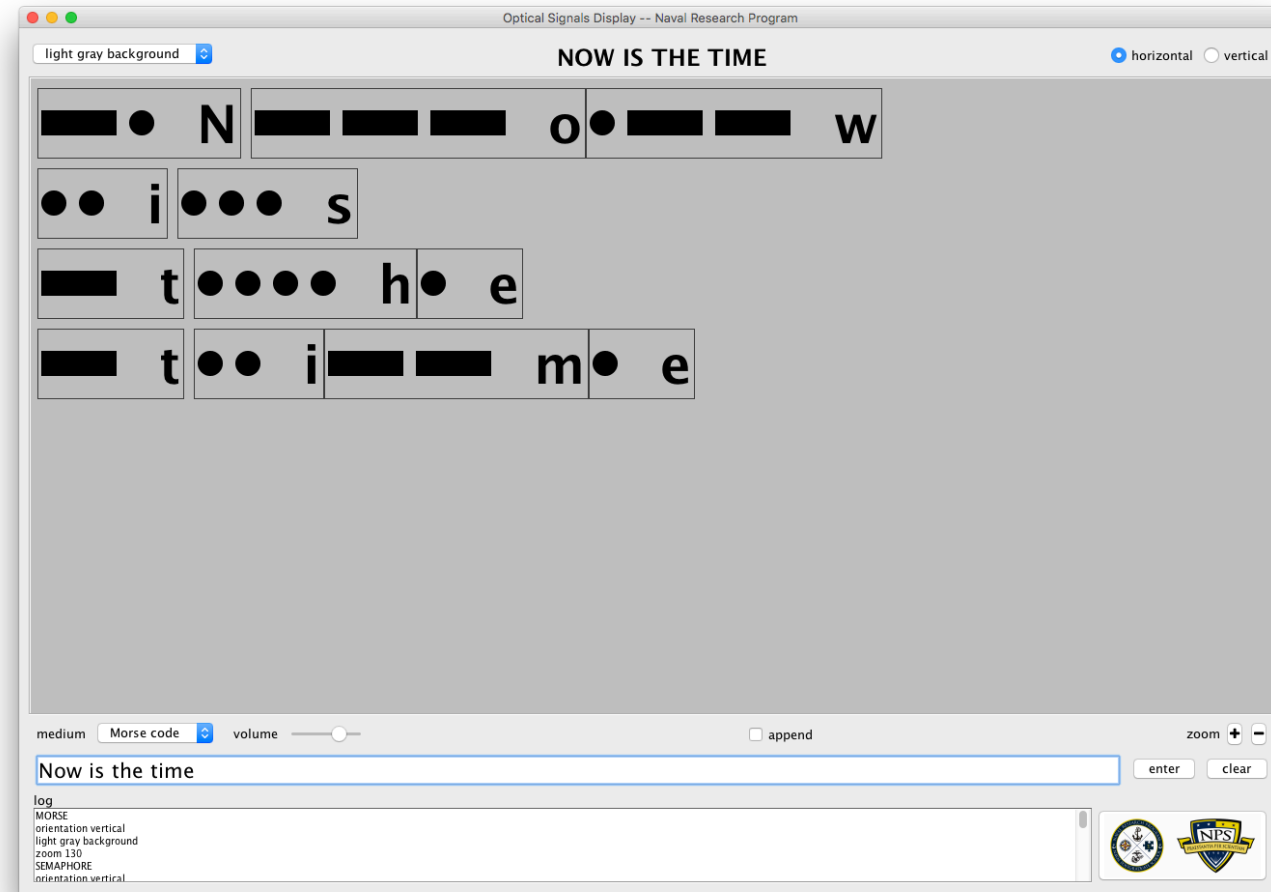
- Avoid steep “learning curve” help sailors be competent signallers

# Morse Code

- Teaching, learning, maintaining proficiency at morse code is challenging
- Convert text to morse
- Also provides audio

## TODO

- Add screen flashing on/off
- Add signal-key input device

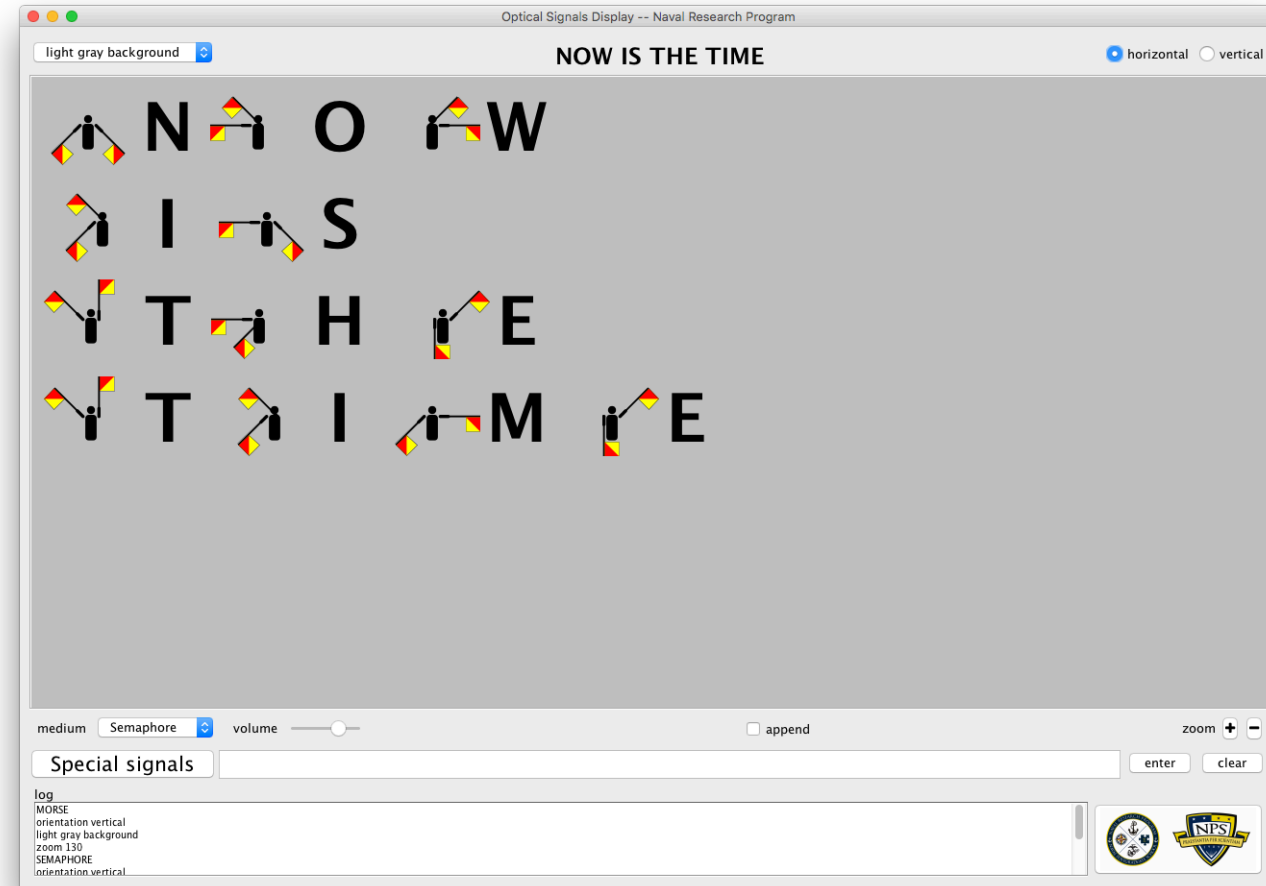


# Semaphore

- Not common but good capability
- Might need in unusual situations
- Might need for communication with international partners
- Can use next to high-power optics to read signals from other ships or forces ashore

## TODO

- Display of tablet photo or video capture, enabling user decode

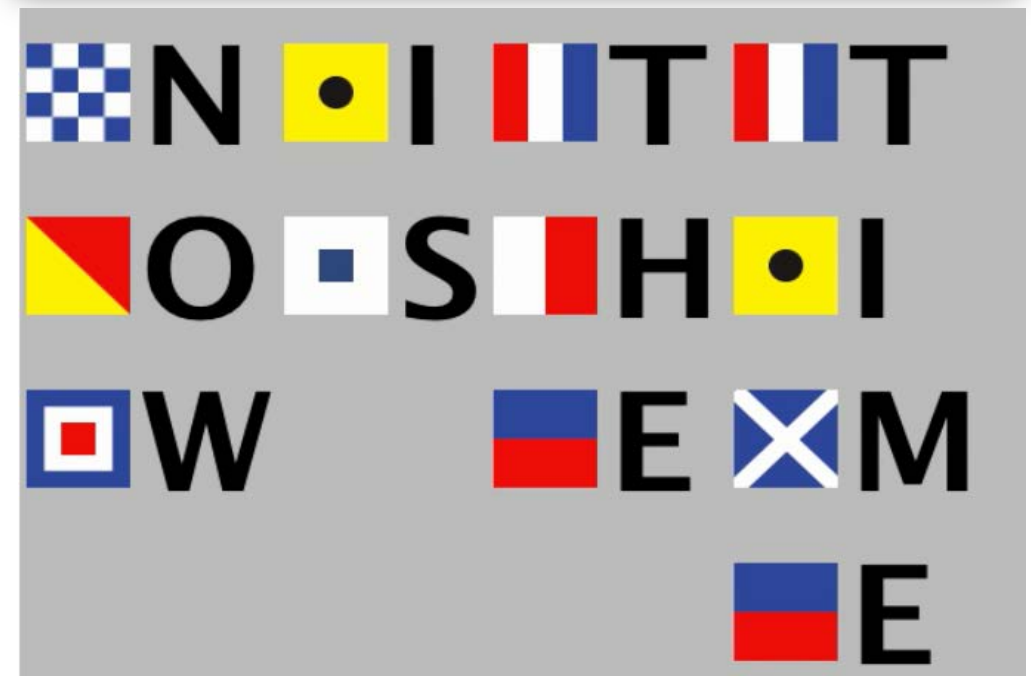
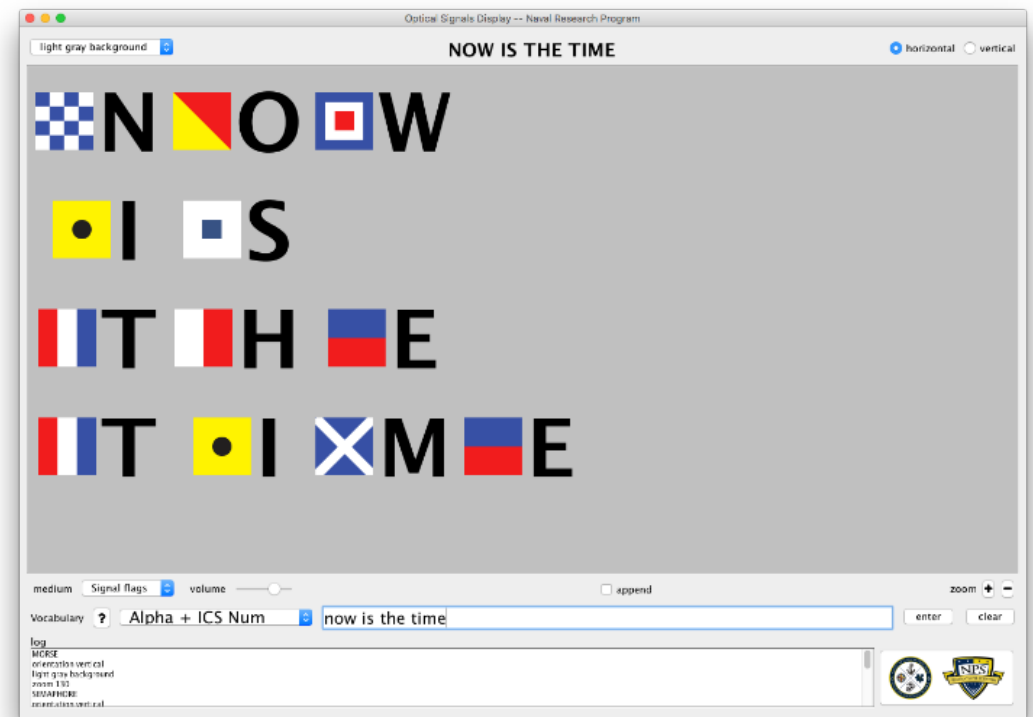


# Signal Flags






















- Horizontal or vertical layout
- Standard flag bag plus various alternate flag vocabularies
- Can use next to high-power optics to read signals from other ships

## TODO

- Improve horizontal, vertical swap
- Display of tablet photo or video capture, enabling user decode



# Special Signal Flags: choice of multiple vocabularies

	Distress signal (NC)
	I am abandoning my vessel (AC)
	I am abandoning my vessel which has suffered a nuclear accident and is a possible source of radiation danger (AD)
	I need a doctor (AN)
	I need a doctor; I have severe burns (AN1)
	I need a doctor; I have radiation casualties (AN2)
	Repeat the distress position (EL)
	What is the position of vessel in distress? (EL1)
	I cannot save my vessel (GM)
	You should take off persons (GN)
	I wish some persons taken off; Skeleton crew will remain on board (GN1)
	I will take off persons (GN2)
	Can you take off persons (GN3)
	I am on fire (IT)
	I request urgent medical advice (MAA)
	I request you to make rendezvous in position indicated (MAB)
	I request you to arrange hospital admission (MAC)
	I am # hours from the nearest port (MAD#)
	My vessel is a dangerous source of radiation; you may approach from my starboard side (MS1)
	The coverage of low cloud in octants (VG#)
	Nothing can be done until weather moderates (US4)

	Code/answer (ANS)
	Preparatory (PREP)
	Question (INT)
	Negation (NEGAT)
	Designation (DESIG)
	Course pennant (CORPEN)
	TURN
	SCREEN
	SPEED
	STATION

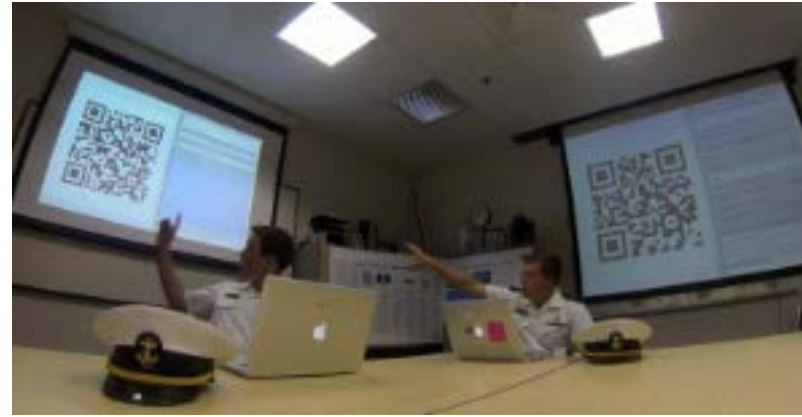
	PORT
	Starboard (STBD)
	Formation (FORM)
	Division (DIV)
	Squadron (SQUAD)
	Group (FLOT)
	Subdivision (SUBDIV)
	Emergency (EMERG)

	I have a diver down; keep well clear at slow speed
	I am taking in or discharging or carrying dangerous goods
	Affirmative
	Keep clear of me; I am maneuvering with difficulty
	I am altering my course to starboard
	I am disabled; communicate with me
	I require a pilot
	I have a pilot on board
	I am altering my course to port
	I am on fire and have dangerous cargo on board; keep well clear of me
	I wish to communicate with you
	You should stop your vessel instantly (in harbor: quarantined)
	My vessel is stopped and making no way through the water
	Negative
	Man overboard
	All persons should report on board; vessel is about to proceed to sea
	My vessel is healthy; I request free pratique
	I am operating astern propulsion
	Keep clear of me; I am engaged in pair trawling
	You are running into danger
	I require assistance
	I require medical assistance
	Stop carrying out your intentions and watch for my signals
	I am dragging my anchor
	I require a tug

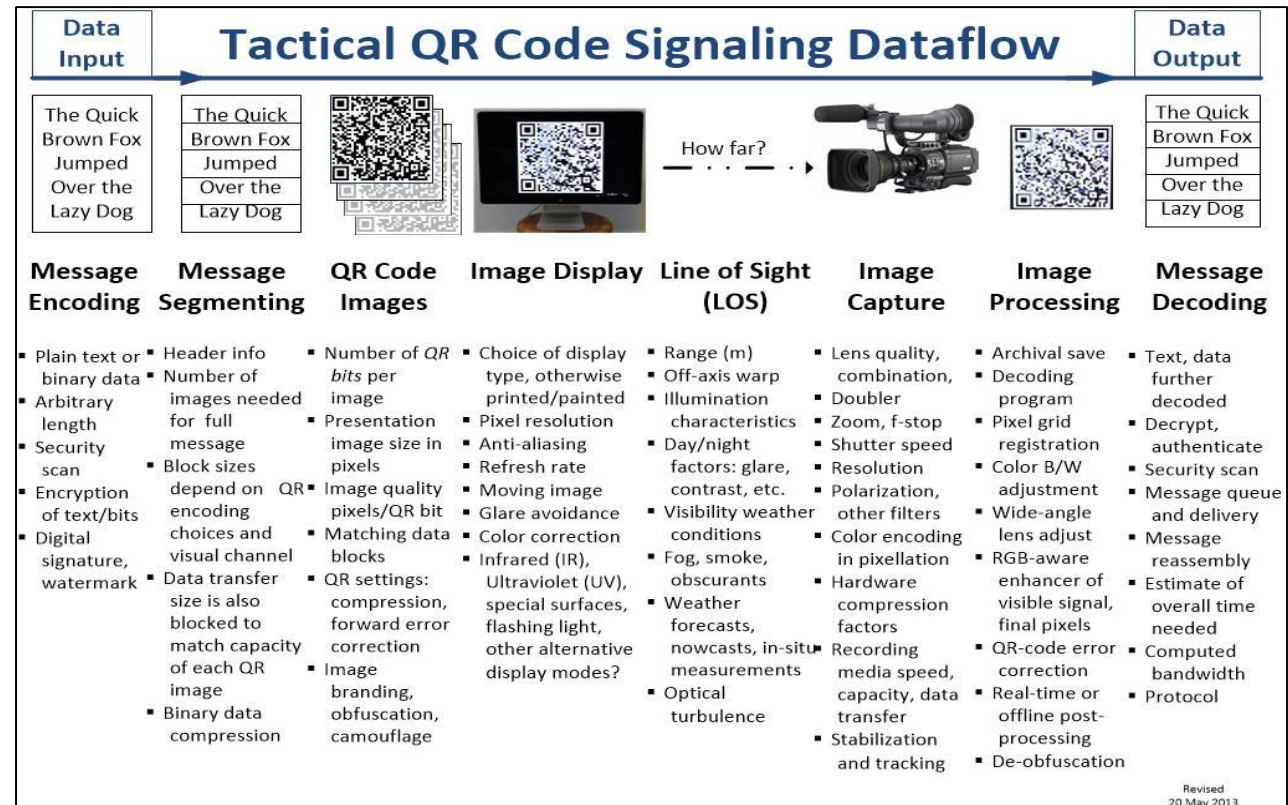


# QR Codes

- Optical data channel, situated
- Excellent experimental testing, multiple NPS theses, demo videos online at [qr.nps.edu](http://qr.nps.edu)
- Can send or read QR codes, one-by-one or streaming
- Robust data channel, QR pixels can be partially obscured
- “Hide in plain sight” security by controlling observability
- Cool!



<http://qr.nps.edu>



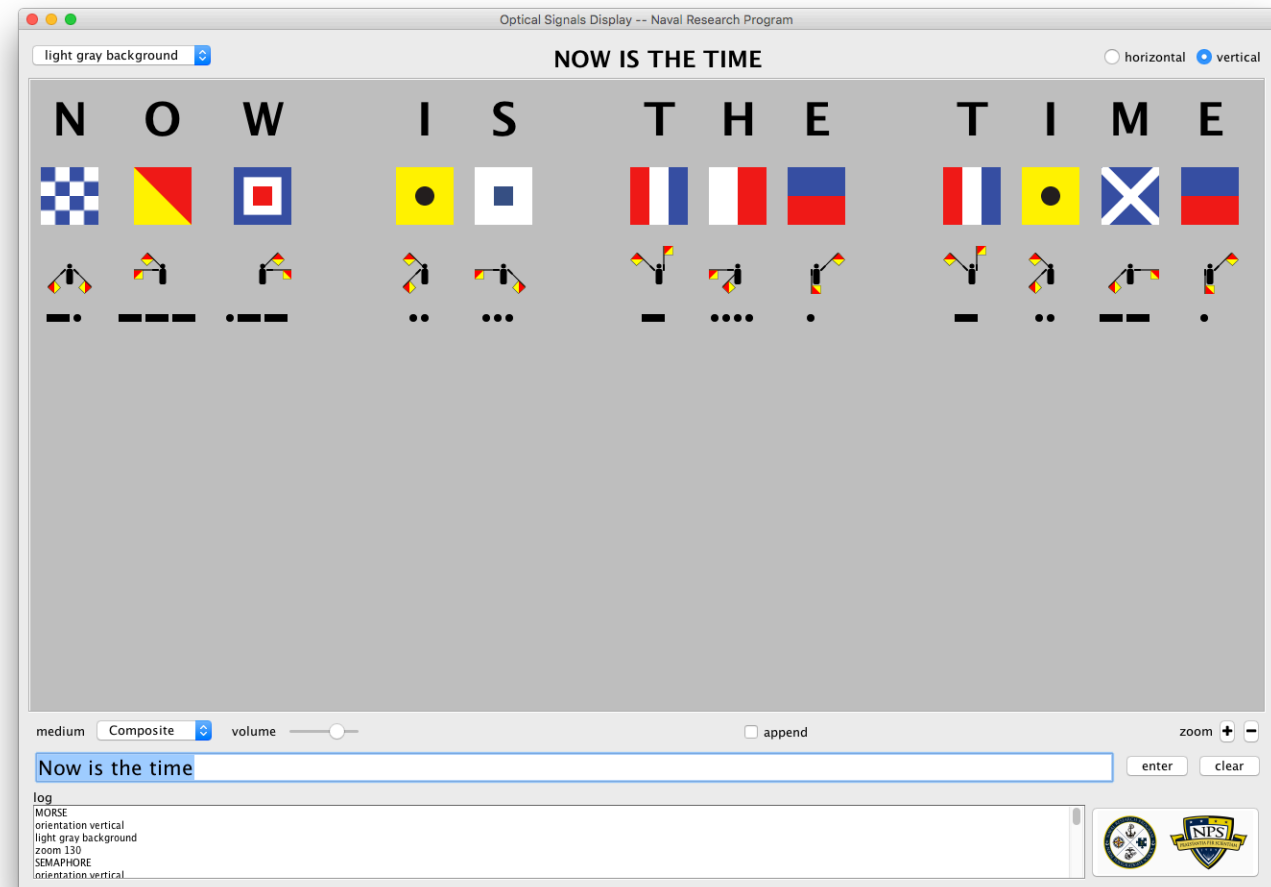
# Combined User Interface

## Single display together shows

- Plain text
- Signal flags
- Semaphore
- Morse Code
- Audio playback

## TODO

- Add full screen Flashing Light (on/off) and QR code display



# Goals for Future Work

## **Learning support tool**

- Tablet or desktop application, open-source Java application

## **Tactical Decision Aid (TDA)**

- Shipboard use: tablets with no network interface for data security
- Type message, then take tablet to signal bridge to show flags/light

## **Proficiency practice, refresher**

- Enable sailors to review or self-evaluate whenever needed

## **Software development in support of schoolhouse needs**

- Partnership can help guide our development efforts effectively

# Source code availability

Open source license protects government investment and usage

- Also allows compatible industry development
- Java programming language, package includes freely available images

Version control at NPS allows concurrent development, testing

- <https://gitlab.nps.edu/Savage/OpticalSignaling/tree/master/OpticalSignalingCommsToolbox>

Also available: [software demonstration video](#)

# Future work

- Cooperative development with schoolhouse to achieve best possible student learning and instructor effectiveness
  - Produce procedures and precautions for shipboard use
  - Establish feedback loop for end-user suggestions, software updates
  - Keep track of emerging fleet capabilities in optical signaling
- 
- Keen to learn how we can best support Navy partners and sponsors
  - Discussion always welcome, thanks for all interest!

# Backup slides

Optical signaling is part of Network Optional Warfare (NOW) operational concept

# Network Optional Warfare (NOW)

**Naval forces do not have to be engaged in constant centralized communication.** Deployed Navy vessels have demonstrated independence of action within coordinated operations for hundreds of years.

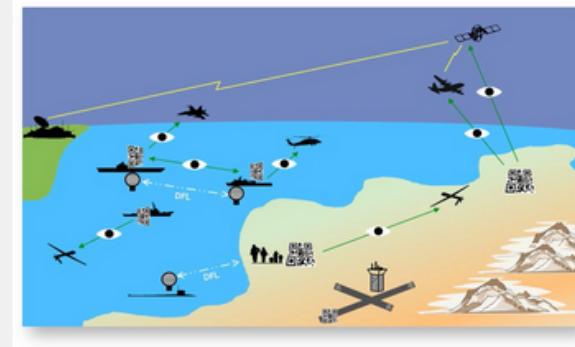
Littoral operations, unmanned systems, and single-purpose ships pose a growing set of naval challenges and opportunities. Network-optional warfare (NOW) can be achieved through efficient communications, signaling stealth, and deliberate tactical messaging.

## Network-Optional Warfare (NOW)

- Vulnerabilities arise for naval forces conducting constant communications due to lack of stealth and dependence on continuous data exchange.
- "Radio silence" emissions control (EMCON) and judicious use of low-probability of intercept (LPI) communications can restore naval covertness and tactical surprise.
- Data compression and a coherently defined signal book can enable fluid operations across NCW and NOW, aiding remote command initiative and operational freedom of action.

## Network-Centric Warfare (NCW)

- "Seeks to translate an information advantage, enabled in part by information technology, into a competitive advantage through the robust networking of well-informed geographically dispersed forces."
- "This networking—combined with changes in technology, organization, processes, and people—may allow new forms of organizational behavior."
- Source: [Network-Centric Warfare](#), Wikipedia



Operational View (OV-1) shows line-of-sight (LOS) optical signaling via Quick Reaction (QR) codes and Digital Flashing Light (DFL).

Only two EM-based lightning bolts!

Technology enablers of interest include [Efficient Messaging](#), [Optical Signaling](#), and [Semantic Coherence](#), three long-running areas of composable research work.

<https://wiki.nps.edu/display/NOW/Network+Optional+Warfare>

# Supporting technologies for NOW

- Efficient Messaging
  - Efficient XML Interchange (EXI), WAN optimization

- Optical Signaling
  - QR code streaming, Digital Flashing Light (DFL)

- Semantic Coherence
  - Structured vocabularies, Navy/allied “signal book”



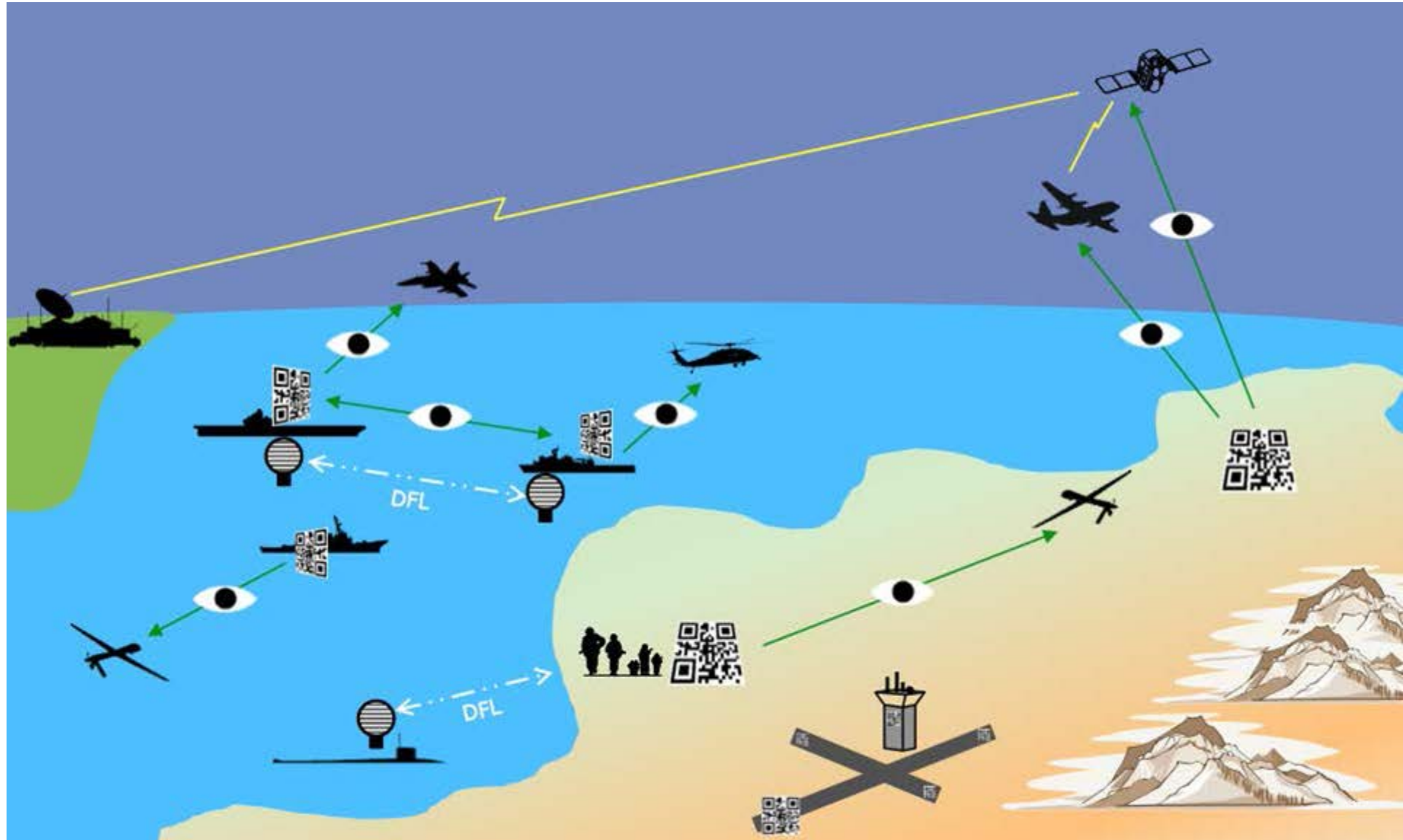


# Network Optional Warfare (NOW) precepts

- Vulnerabilities arise for naval forces conducting constant communications due to lack of stealth and dependence on continuous data exchange.
- Agile Emissions control (EMCON), judicious use of low-probability of intercept (LPI) channels to restore naval covertness and tactical surprise.
- Data compression and a well-defined signal book can enable fluid operations across NCW and NOW, aiding command autonomy and freedom of action.

<https://wiki.nps.edu/display/NOW/Network+Optional+Warfare>

# Optical communications operational concept



Brutzman, Donald (Don) (CIV) posted on Jun 24, 2015

## CC4913 Class Project report and briefing, April 2015

Point of Contact: Professor Dan Boger, [dboger@nps.edu](mailto:dboger@nps.edu), 831.656.3671

*CC4913 Policies and Problems in C2* is a capstone course for NPS Command and Control students. Study of the fundamental role C2 systems fulfill in operational military situations, including the full range of military operations. Topics include analysis of the changing role of organizational structures and processes, as well as technologies and impacts on C2 systems requirements and designs. Considerations include the complexities imposed on C2 systems as the force structure becomes more heterogeneous. Case study of selected incidents and systems provide a focus on current problems.

This year's class was divided into RF and non-RF groups and asked to explore C2 issues in a scenario where we were trying to prevent conflict by "holding at risk" aggressors in a complex political and geographic situation described above. In last year's scenario, high power jamming only originated from the mainland. Developments in the past few months caused a change in that assumption: all SATCOM uplinks are at risk within 300 miles of fixed bases and large surface ships. This was how our simple communications wargame transpired: Aggressive action by nation X; Send in UAV to support ROL (Predator-Global Hawk); Lose UAV SATCOM link; Send in missile boats; Missile Boats tracked via omni-MF and VHF; Send in UAV (Shadow-Scan Eagle); Lose UAV CDL; Patrol boats to visual range – all RF comm jammed; Patrol boats exfil to establish link; Picture gone. This led us to consider a combined RF/non-RF solution.

Network Optional Communications (NOW) is comprised of the following potential methods: lasers, flashing light in various bands, underwater/acoustic, QR codes, and data muling. What we rediscovered was this is not a question of RF vs non-RF. There is a spectrum of options, and we may decide to operate at some level of EMCON to avoid detection. Or the enemy and weather may conspire to reduce the availability of our network. We found situations where there did not appear to be a viable and elegant RF solution but a hybrid combination of techniques could meet user requirements. We refer to this as Mission Agile EMCON and is shown on slide 32 of the accompanying presentation. Slide 34 presents our recommendations.

**Attached.** [Class Project Report](#) and [Class Project Briefing](#).

This work was presented at the [Littoral Combat Ship \(LCS\) Wargame Planning and Innovation Workshop](#) hosted by the NPS [Littoral Operations Center \(LOC\)](#), 23-24 April 2015.



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