NSRP | National Shipbuilding Research Program

BCA for Resilient Optical Networks on Ships

Cost Model based Network Design

Ship Warfare Systems Integration (SWSI) Panel Project Status

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July 24, 2018
Washington DC

DISTRIBUTION STATEMENT A: Approved for public release.

Outline

- Participants
- Problem – Solution
- Technical Approach
- Statement of Work (adjustment)
- Status
- Accomplishments
- Near Term Plans
- Acknowledgements

Participants

PennState
Applied Research Laboratory

perspecta
LABS

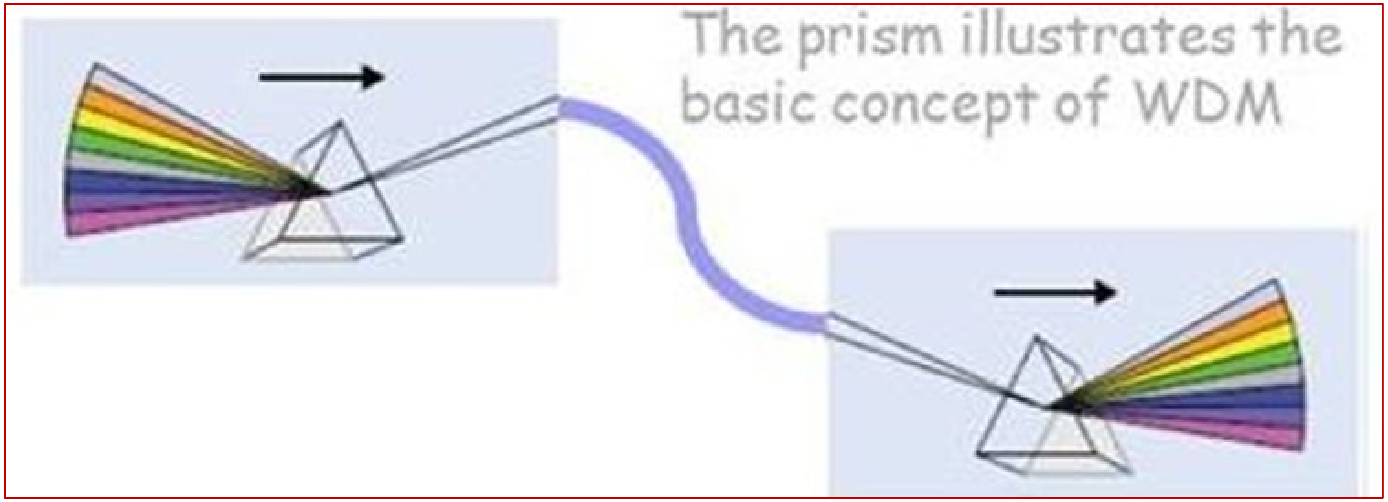
Ingalls
Shipbuilding

LOCKHEED MARTIN

NSRP

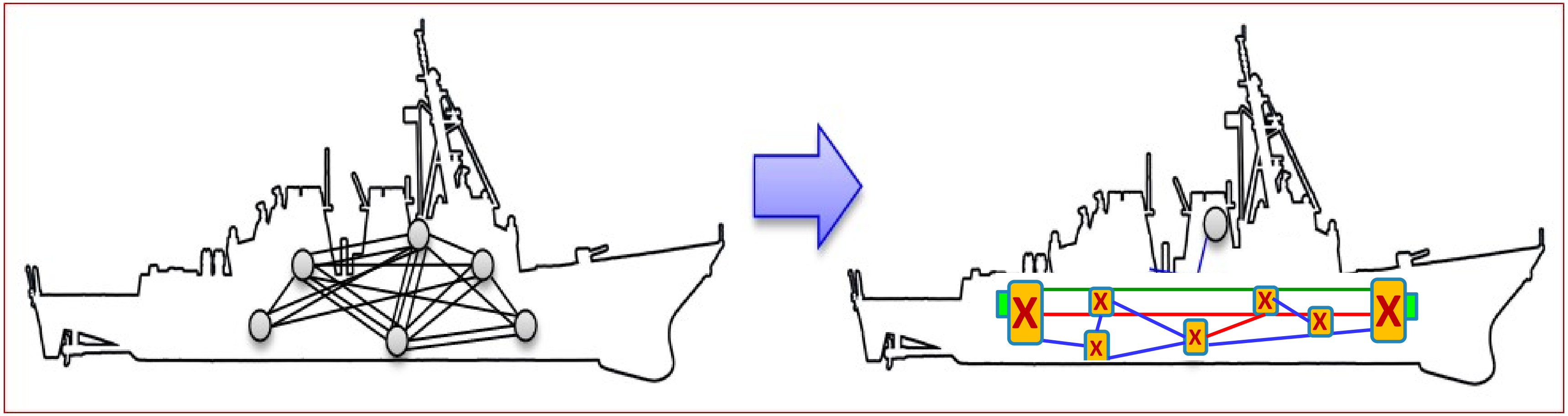
Problem - Solution

- PROBLEM- Weight, space, and complexity
- PROBLEM- EMI susceptibility
- PROBLEM- “Build-to-Print” cable infrastructure
- SOLUTION- Network infrastructure that is used over life of ship
- SOLUTION- Large capacity resilient physical layer handles all traffic
- SOLUTION- Necessary data available in every compartment



Overall Goals

- **SOLVE** the issue of cable weight and complexity, driven by shipyards installing custom build-to-print cabling
- **ASSESS** optical networks' ability (cost / performance) to achieve functional goals using subsystem examples
- **REDUCE COST** of shipboard cabling acquisition and ownership



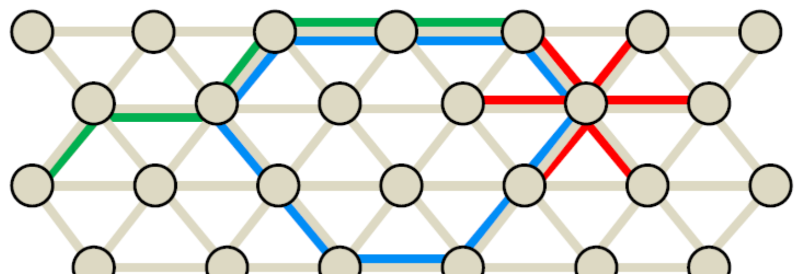
Courtesy: Lockheed-Martin

Assumptions

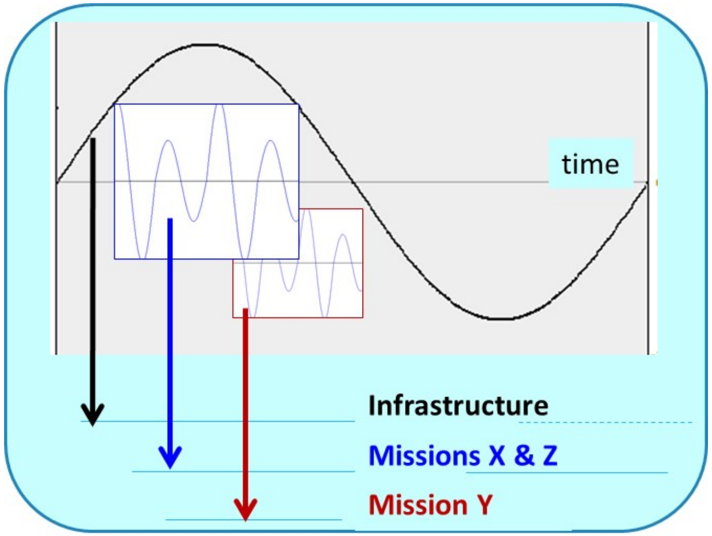
- DoD / rugged environment compliant
- Compatible with shipbuilding
- Compliant with recognized network standards
- Secure supply chain / ecosystem

Optical Networks Provide

- **CAPACITY:** Ability to keep pace with increasing need for bandwidth
- **ACCESSIBILITY:** Access to data and systems from any compartment
- **RESILIENCE:** Use mesh topology / control for quick damage recovery
- **LIFE CYCLE SUPPORT:** Shipyard installs optical backbone infrastructure that functions over the ship lifetime
- **ADAPTATION ELEMENTS** between the backbone and client equipment, used for mission changes and upgrades



RED = Star BLUE = Ring GREEN = Bus CLEAR = Mesh



Ecosystem

GOVT:
NAVSEA
NAVAIR

SHIPYARDS:
INGALLS NNS
AUSTAL GD-EB
GD-BIW BOLLINGER
GD-NASSCO
MM

UNIVERSITIES:
PENN ST GTRI
UCSB U VIRGINIA
U DELAWARE
MIT JHU

STANDARD ORG:
SAE
ARINC
TELCORDIA
IEEE ITU

NETWORKS:
CIENA CISCO
INFINERA ARISTA
IBM

PHOTONICS MFRS:
JDSU CORNING
OFS PRYSMIAN
IPITEK AFL FSI
DICON POLATIS
OPLINK ULTRA
FREEDOM LUXTERA
D-LIGHTSYS STM
GOOCH- HOUSEGO

SYSTEM MFRS:
L-M BAE
RAYTHEON L-3
GENERAL DYNAMICS
ROCKELL-COLLINS
HARRIS HONEYWELL
NORTHROP-GRUMMAN

NTDS SYSTEM MFRS:
IXI TECHNOLOGY
GET ENGINEERING
BIRD TECHNOLOGIES

Subsystems

- **NAVSSI-** Navigation Sensor System Interface
- **DiVDS-** Digital Video Distribution System
- **CANES-** Consolidated Afloat Networks and Enterprise Services
- **Shipboard Communications** (Telephones, etc.)
- **ALIS-** Autonomic Logistics Information System

These subsystems have been identified as compatible with optical networks.

Statement of Work (adjustment)

Task 1: Identify architectures, technology, applications, and associated interface protocols and required adaptation (Lockheed-Martin, Ingalls Shipbuilding, Penn State ARL, and Perspecta Labs).

Task 2: Construct cost model for selected variants (Penn State ARL and Perspecta Labs).

Task 3: Optimize interconnect methods considering single mode fiber and fusion splicing technologies for key interfaces (Lockheed-Martin, Ingalls Shipbuilding, Penn State ARL and Perspecta Labs).

Task 4: Develop a technology implementation roadmap identifying steps needed for future USN implementation, including outline of WDM testbed using existing facilities (Lockheed-Martin, Ingalls Shipbuilding, Penn State ARL and Perspecta Labs).

Project Status

Task 1: Identify architectures, technology, applications, and associated interface protocols and required adaptation.

STATUS: Subsystems identified; need to acquire subsystem information

Task 2: Construct cost model for selected variants.

STATUS: General cost model complete; must populate subsystems

Task 3: Optimize interconnect methods considering single mode fiber and fusion splicing technologies (for key interfaces).

STATUS: General business case complete; must consider subsystems

Task 4: Develop a technology implementation roadmap identifying steps needed for future USN implementation, including outline of WDM testbed using existing facilities.

STATUS: Have begun ship-specific ecosystem discussions

Accomplishments

ADMINISTRATIVE

- ✓ Informal kickoff, organization roles 4/12/2018.
- ✓ Formal kickoff 4/26/2018.
- ✓ Arrangement for Lockheed-Martin participation / data transfer.
- ✓ Work meeting at Lockheed-Martin Camden 6/1/2018.
- ✓ Work teleconference 6/12/2018.
- ✓ Project update teleconference 6/15/2018.
- ✓ First quarterly report 6/20/2018.
- ✓ Status teleconference 7/19/2018.

TECHNICAL

- ✓ Subsystems identified 6/1/2018.
- Ship specific ecosystem discussions (IXC, GET).
- Executive level brief development.

Near Term Plans

ADMINISTRATIVE

- Populate SharePoint site.

TECHNICAL

- Transfer subsystem information.
- Populate baseline subsystem cost model.
- Identify architecture / topology alternatives.
- Continue to refine ship-specific ecosystem.
- Continue to develop executive level brief.

Acknowledgements

The cost model was developed under the National Shipbuilding Research Program (NSRP) Panel Project Number 2016-426 “Paradigm for Optical Networks”

Connection methods (fusion splicing) were analyzed under the National Shipbuilding Research Program (NSRP) Panel Project Number 2015-442 ”Alternatives to Fiber Optic Connectors”

Back-up Slides

Overall Goals

Reduce shipboard cabling acquisition, ownership and deployment costs and increase commonality.

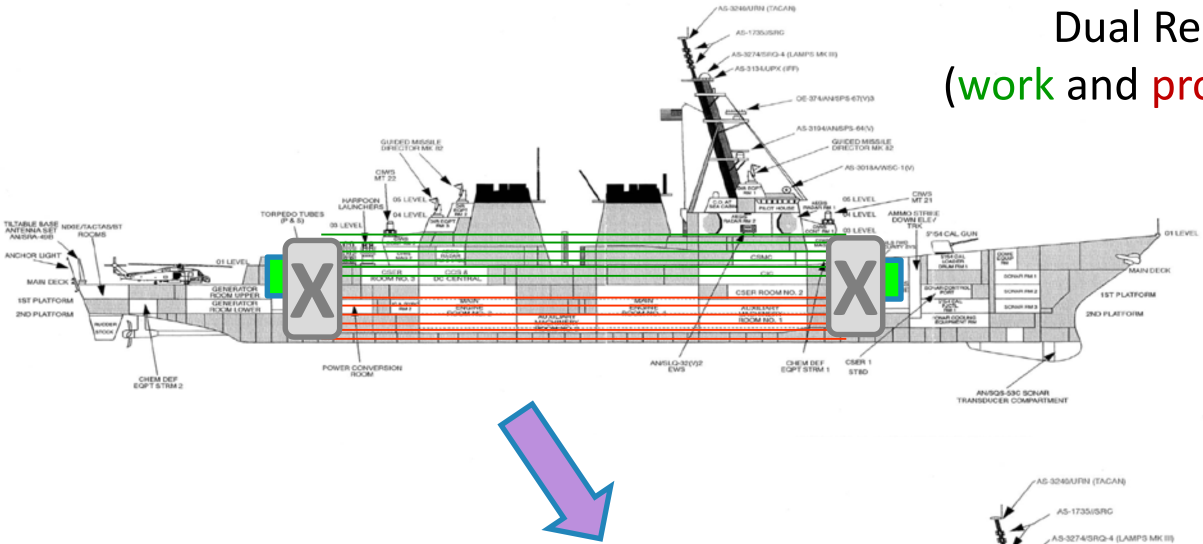
Solve the issue of cable weight and complexity driven by shipyards installing custom build-to-print cabling

Assess optical networks' ability (cost / performance) to achieve functional goals using the AEGIS Combat System as an example

Optical Networks Provide:

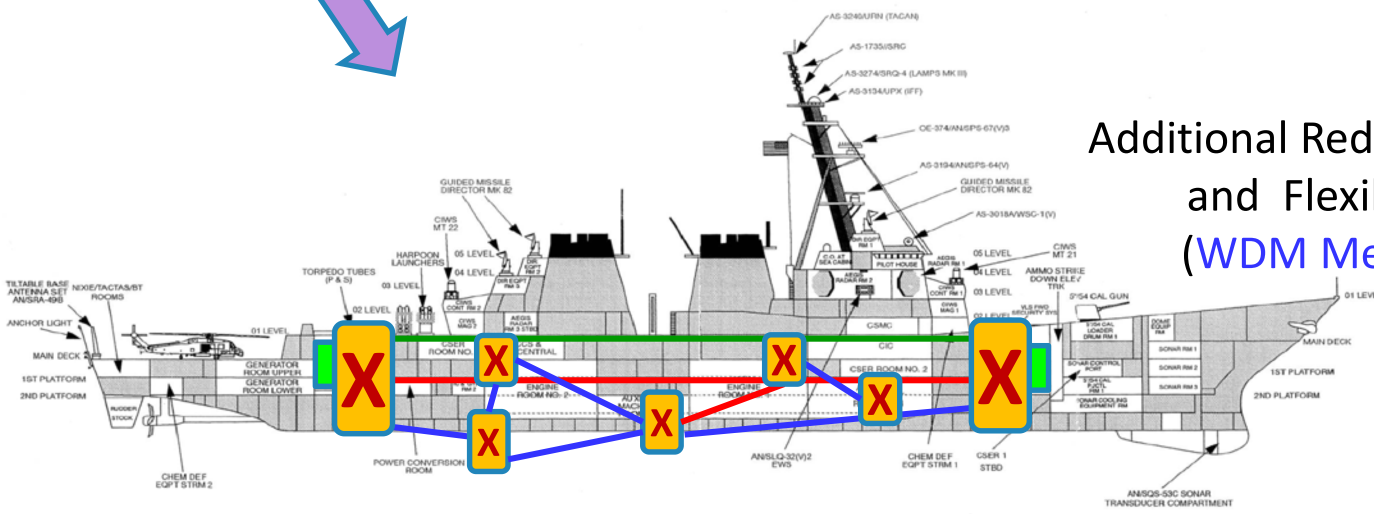
- **Capacity:** Ability to keep pace with increasing demand for network capacity.
- **Accessibility:** Access to relevant data and systems from any compartment.
- **Resilience:** Use mesh/equivalent topology, and controls, for quick damage recovery
- **Life Cycle support**: Shipyard installs optical backbone infrastructure that functions over the ship lifetime.
- **Adaptation elements,** installed between the backbone and client equipment, are used for mission changes and upgrades

WAS / IS (Evolve this diagram, during project)



Dual Redundant
(work and protection paths)

Next Steps
- Add Animation (below)
- 2D & “3D” versions
- change background ship



Additional Redundancy
and Flexibility
(WDM Mesh?)

Optical Technology Readiness

Technologies for Ecosystem – Security of Supply: Industry survey

– Risk/gaps – packaging for DoD applications , standards status

- Optical Fiber and Connectors
- WDM/DWDM technology
- DWDM routing systems (Passive Star, OXC, OADM, etc.)

Assessment of Secure Supply Chain / Ecosystem (work in progress)

- Traditional telecom supplier examples (many offer government network solutions)
  - ✓ ***Systems***: Ciena, Cisco, ARISTA, Fujitsu, etc.
  - ✓ ***Modules/devices***: Dicon, Polatis, Oplink, …, etc.)
- IXI, GET (NTDS Suppliers, WDM distributors/resellers) –
- SBIR suppliers (Examples only): Ultra Communications (now Murata?), Freedom Photonics, Dlightsys*, other companies affiliated/associated with USCB, Univ. of Delaware, GaTech, …

*D-Lightsys, a Radiall Company, designs and manufactures high performance optical interconnect products for severe environment applications. D-Lightsys products are based on optoelectronic components.

WORK IN PROGRESS
"Simplified Table/Slide" version

Summary of challenges / Goals / Value Proposition

CH	Challenge/Requirement	Goal	Optical Value Prop
1	Technology advances moving too quickly	Meet flexible system / mission demands; dynamic resource reconfiguration	WDM: single fiber has multi-channel utility. Keep pace with increasing demand for network capacity
2	Ship cable architecture redundancy (reduce cost)	Develop robust solution: connect sensors/weapons; with autonomous recovery	Quick damage recovery using mesh / equivalent topology and controls with minimal added weight (WDM)
3	Ship cabling improvements	Enable rapid ship-building / delivery / upgrades	Shipyard-installed optical backbone increases commonality, functions over ship's lifetime
4	Single infrastructure to support highly variable traffic	Enable flexible data bandwidth demand	Adaptation elements between optical backbone and client equipment used for mission changes and upgrades
5	Shipbuilding expensive / time consuming	Reduce shipbuilding cable cost by "X" % **Define X (range) during project**	"Infinite" upgrades with WDM optical backbone; access to relevant data/systems from any compartment

Extended GOAL: Project results also used to minimize risk for (other) Future Surface Combatant (FCS).

WORK IN PROGRESS
"Detailed Slides" version

Problem Statement (Part 1: Infrastructure Requirements)

Upgrading ships is a challenge – see desirable features/goals of an optical solution in following slides

Infrastructure Challenges/Requirements (CH1-3)

1) Today shipbuilding is expensive and time consuming (must pull new cable every time a system is introduced/upgraded) – CH1
2) Technology advances moving too quickly: Cannot sustain performing technology upgrades using a "rip-out-and-replace" approach. Current/initial point-to-point Fiber Optic approach is labor intensive – CH
3) Current ship cable architecture has redundancy but is not as robust as desired – attaining desired robustness today leads to building ships that are heavy/expensive, labor costs dominate. Hardware changes tend to drive cable changes (rip out every time you modernize) – CH3

Technology Challenges / Requirements (CH4-5)

4) Ship cabling improvements needed – reduce cable weight/complexity/acquisition & life cycle costs: CH4
5) Support highly variable traffic with a ***single infrastructure type*** – robust solution that allows connecting sensors to weapons on demand is needed – CH5

Other possible project Acronyms

<u>Suggested new project acronyms / variations</u>:

Still searching for Acronym, capturing "resilient, cost-efficient optical network architecture…"

- CIRON: Cable infrastructure for Resilient Optical Networks (pronounce siren)?
- CROWN: Cable infrastructure for Resilient Optical WDM Networks
- DARON: Design of Advanced Resilient Optical Networks for Ships
  - (variations: DARONS or DARON-Ships) → can also use as DARON-Air for aircraft, etc.)
  - (variations: ARONS or ARON-Ship) → can also use as ARON-Air)
- ORCIDS: Optical Resilient Cable Infrastructure Design for Ships
- ORCIS: Optical Resilient Cable Infrastructure for Ships
- NAOIS: Network for Advanced Optical Infrastructure for Ships
- NAOCI: Network for Advanced Optical Cable Infrastructure
- NAOFI: Network for Advanced Optical Fiber Infrastructure
- ADONIS: Advanced Design of Optical Network Infrastructure for Ships
- AOCIS: Advanced Optical Cable Infrastructure for Ships

→ Any feedback is appreciated…