



Trends, transitions, and challenges in modern penetrators for UUVs, Sea Floor Systems, Towed arrays, and Submarines

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Abstract

- The Undersea Business Climate is moving in a positive direction
 - Investment is returning, thus driving the desire for innovative new products.
- Users are demanding new capabilities and the connectivity solutions must evolve
- The evolution of new products are impacted by the associated Market, Technical, and Business Trends
 - impact the Connectivity / Penetrator Suppliers as they adapt to these strenuous new user requirements
 - Accommodating the demands for increasing bandwidth, power, a diversity of signal types, and the demand for lower size and weight



- Penetrator Overview
- Market Trends
- Technology Trends
- Business Trends



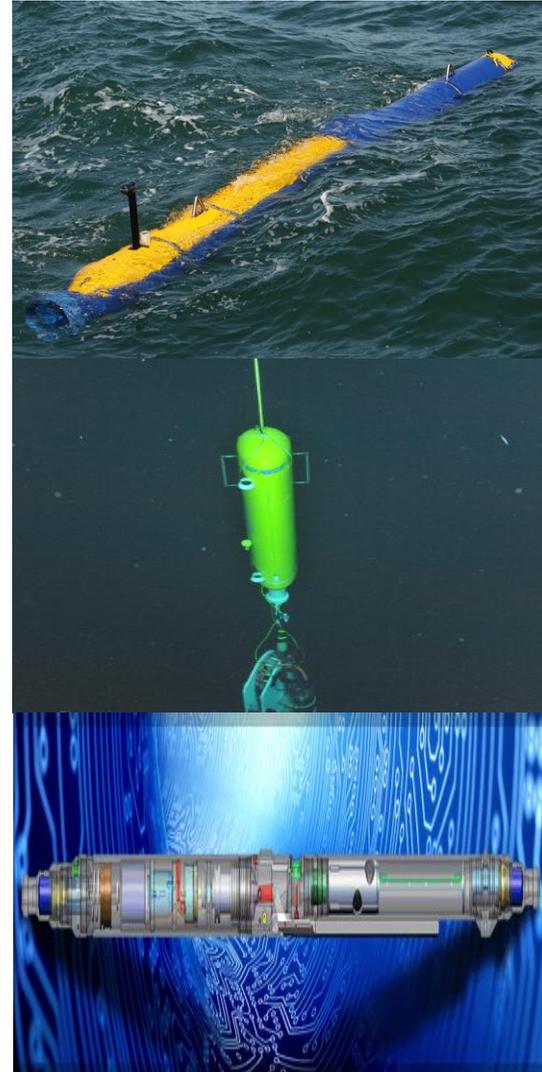
Penetrators Are The Gateway To The Outside World

- Sight – Cameras, Sonars, LIDARs
- Sound – Hydrophones / Acoustic Sensing
- Touch – Command / Control / Temperature / Strain / Stress / Health
- Smell / Taste – ChemBio / Salinity

Who Uses Penetrators



- Submarines / Submersibles
- UUV / AUV / ROV / USV
- Towed Arrays
- Environmental Data Collection
- Sea Floor Systems
- Energy / O&G Downhole



Pressure Hull Penetrator Functions

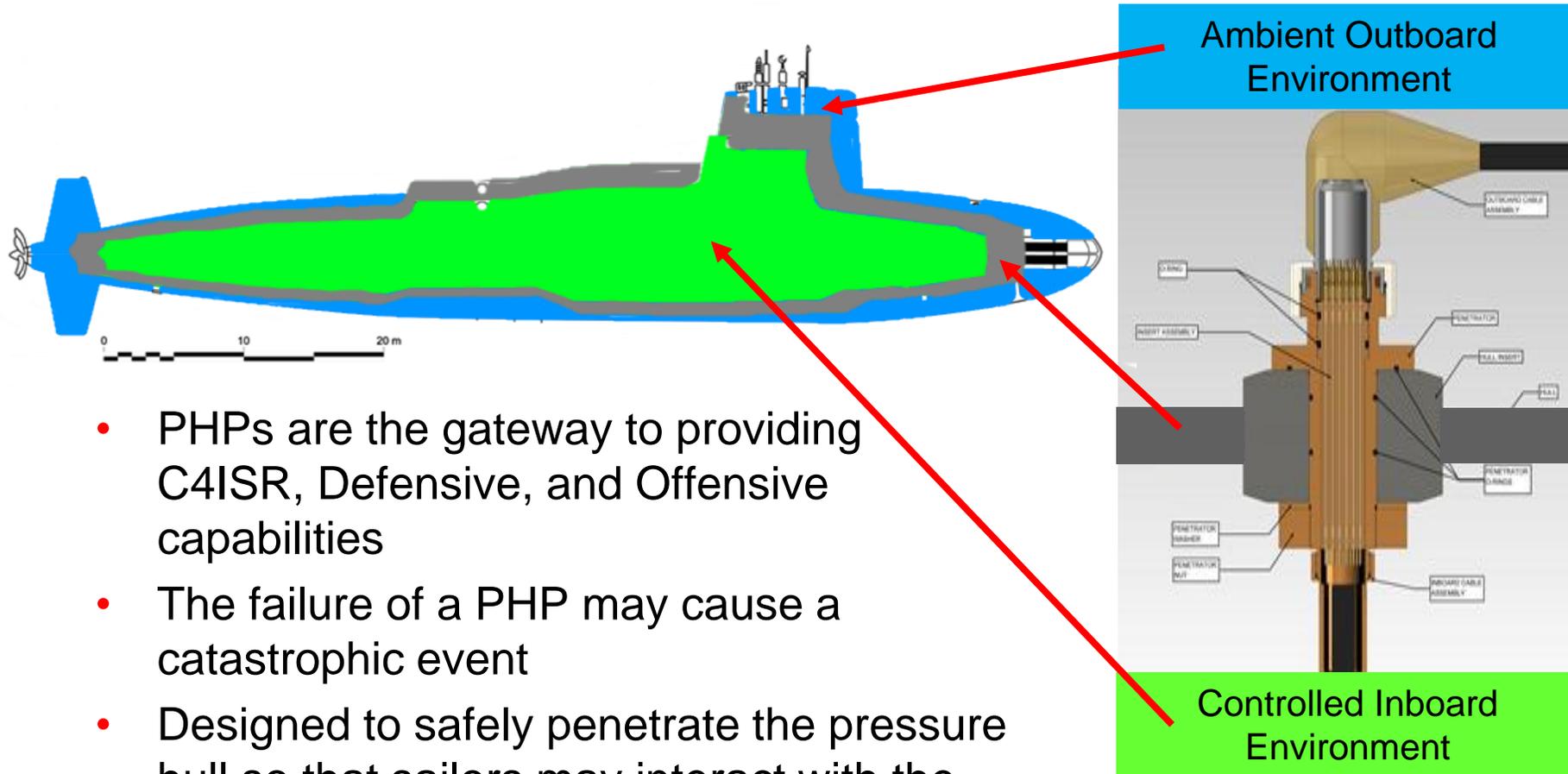
- Gateway Through The Pressure Boundary
 - Connect circuits from systems located outside the pressure hull to processing and power equipment located inside the pressure hull
 - Assuring connectivity under subsea operating conditions

- Maintain Water-tight Integrity
 - No Leak Path
 - Protect personnel & equipment inside pressure hull
 - If outboard cable breaks, water will not pass water to inside cable

- Multiple Types To Meet Many Requirements
 - Connect ethernet cables as well as coaxial, fiber optic, RF, microwave, and / or power connections.

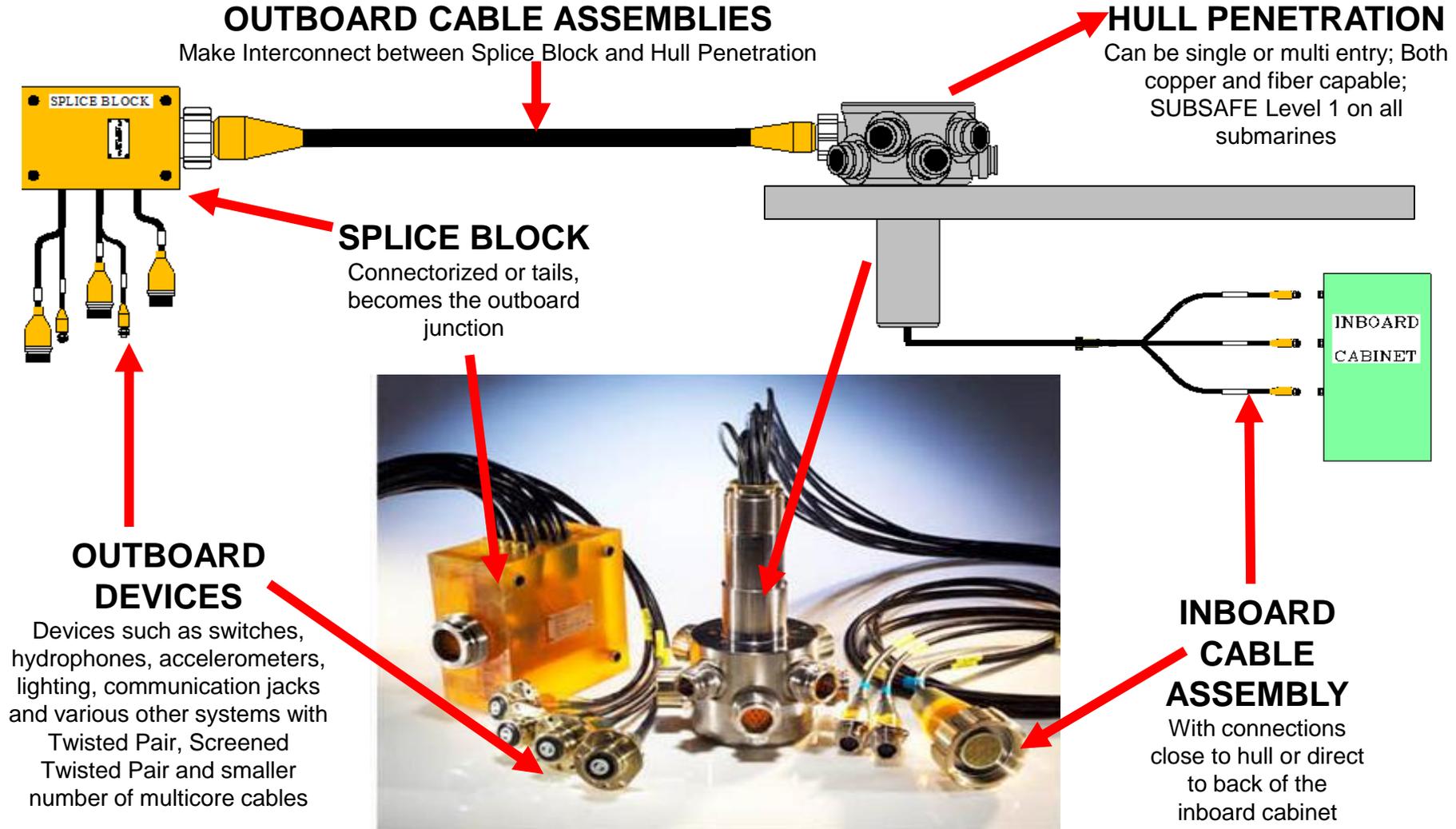


Pressure Hull Penetrators



- PHPs are the gateway to providing C4ISR, Defensive, and Offensive capabilities
- The failure of a PHP may cause a catastrophic event
- Designed to safely penetrate the pressure hull so that sailors may interact with the external systems

Installed Penetrator



Technologies Needed To Build Penetrators

Materials /
Machining / Welding



Mast Antenna



Optronics



**Fiber Optic
Multiport**

Glass-to-Metal /
Hermetic Seals



**Glass to Metal: Fiber,
RF, COAX, Ethernet**



Glass Seals



**Instrument and
High Density**

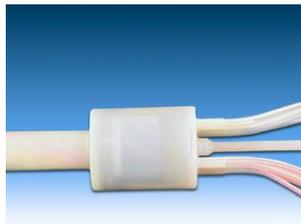
Overmoldings



Polyurethane



Neoprene



Polyethylene

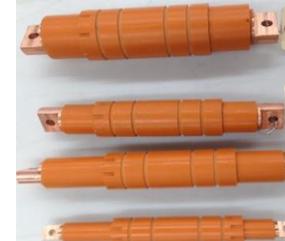
Electrical / EMC /
EMI



RF



Mixed Signal



Power

Fiber Optics



FO Feed Through

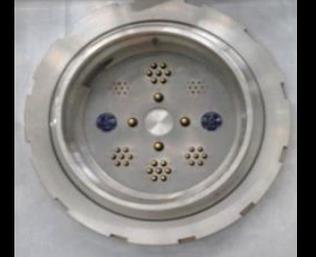


Fiber Dry Mate

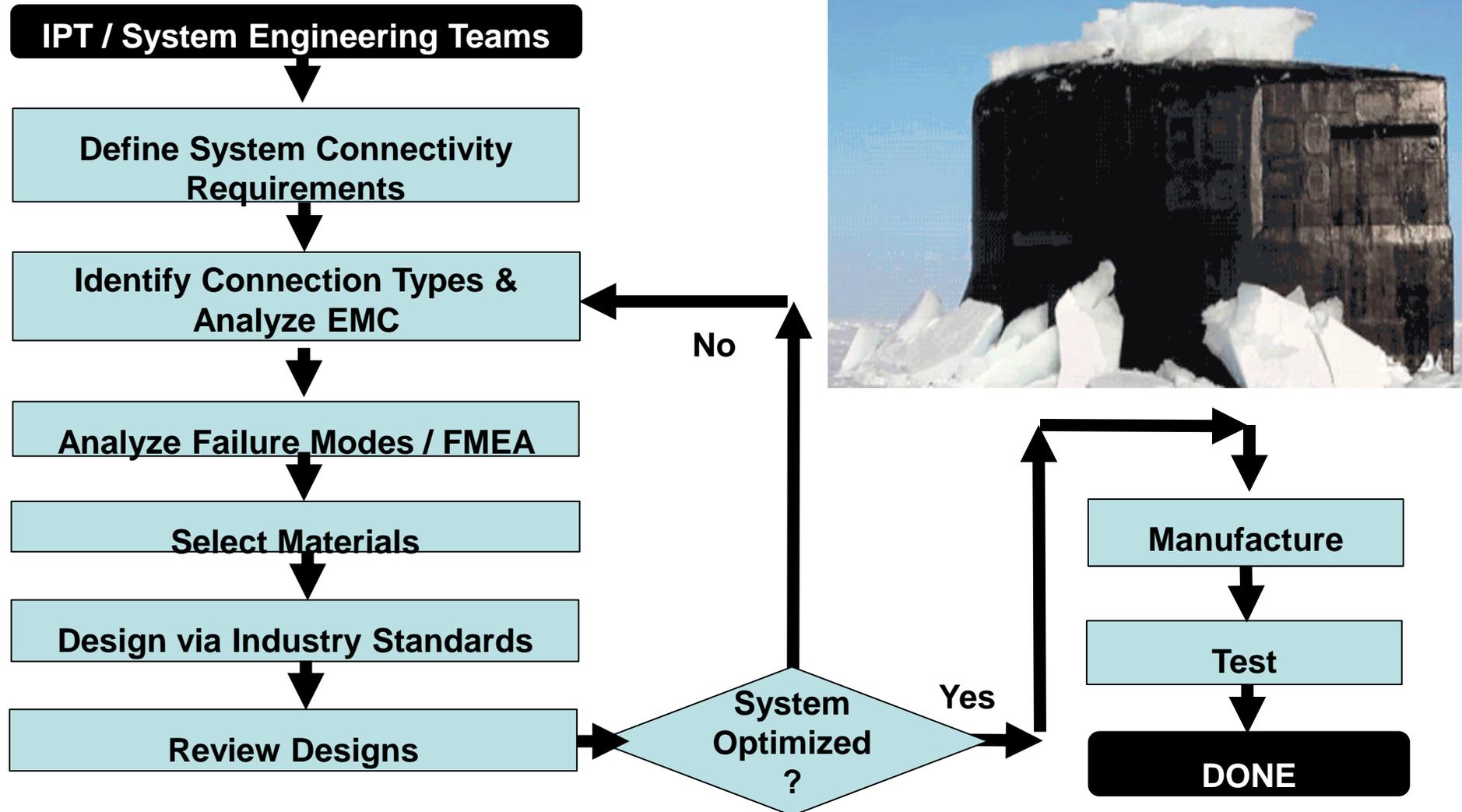


Fusion Splicing

Penetrator Types

				
Type	Fiber Optic Feed Through	Coax	Elite Dry Mate	High Pressure High Temperature
In. / cm	0.5 / 1	1 / 3	2 / 5	3 / 7
				
Type	RF and Mixed Signal	Submarine Hull	Bulkhead	Power
In. / cm	6 / 15	8 / 20	8 / 20	12 / 30

Penetrator Optimization via Collaborative System Engineering





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Market Trends



Market Trends - Market Stage Definition

Market Stage	Declining Or Stagnant Sales	Introductory Or Recovering Sales	Emerging Or Re-emerging Sales	Peak or Expanding Sales	Maintenance Sales
Characteristics	<ul style="list-style-type: none"> • Only legally required sales • Equipment may be allowed to deteriorate 	<ul style="list-style-type: none"> • Engineering prototype activity • Pre-Production 	<ul style="list-style-type: none"> • Low Rate Production • Field Testing • Proof of Concept 	<ul style="list-style-type: none"> • Full Rate Production • Engineering Change Orders • Repeat Orders 	<ul style="list-style-type: none"> • Equipment kept near 100% operating efficiency • No new capabilities introduced



Market Trends - Submarines

Submarket	2017	2018	2019	2020
USA	Blue	Blue	Blue	Blue
UK	Blue	Blue	Blue	Blue
Australia	Yellow	Yellow	Green	Green
Asia	Yellow	Green	Green	Blue
Non-UK Europe	Yellow	Yellow	Yellow	Green
South America	Yellow	Yellow	Yellow	Green



Declining Or Stagnant



Introductory Or Recovering



Emerging Or Re-Emerging



Peak Or Expanding



Maintenance





Market Trends - UUV / AUV / ROV

Submarket	2017	2018	2019	2020
Small	Yellow	Yellow	Yellow/Green	Green
Medium	Yellow	Yellow/Green	Green	Blue
Large – LDUUV	Yellow	Yellow	Yellow	Yellow/Green
X-Large – XLDUUV	Yellow	Yellow	Yellow	Yellow/Green

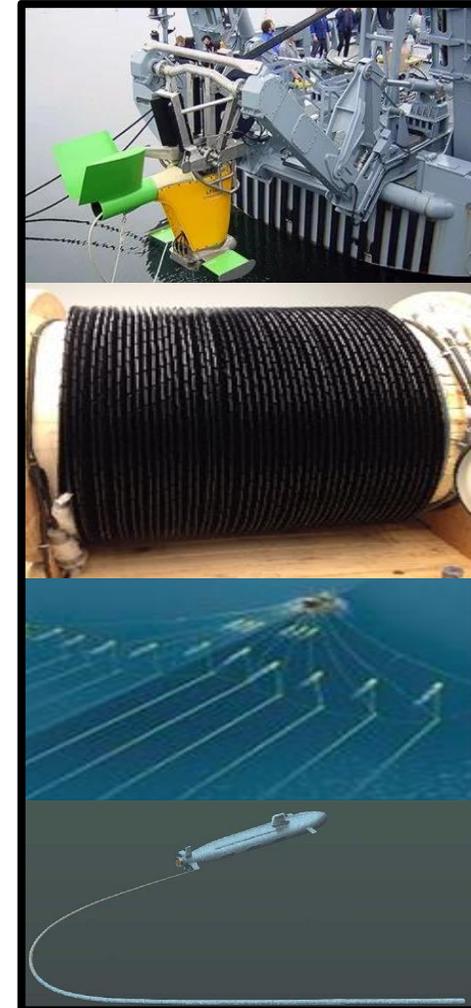


● Declining Or Stagnant
 ● Introductory Or Recovering
 ● Emerging Or Re-Emerging
 ● Peak Or Expanding
 ● Maintenance



Market Trends - Towed Arrays

Submarket	2017	2018	2019	2020
Ships	Blue	Blue	Blue	Blue
Subs	Blue	Blue	Blue	Blue
UUV	Yellow	Yellow	Yellow	Green
O&G /Energy	Red	Red	Yellow	Green

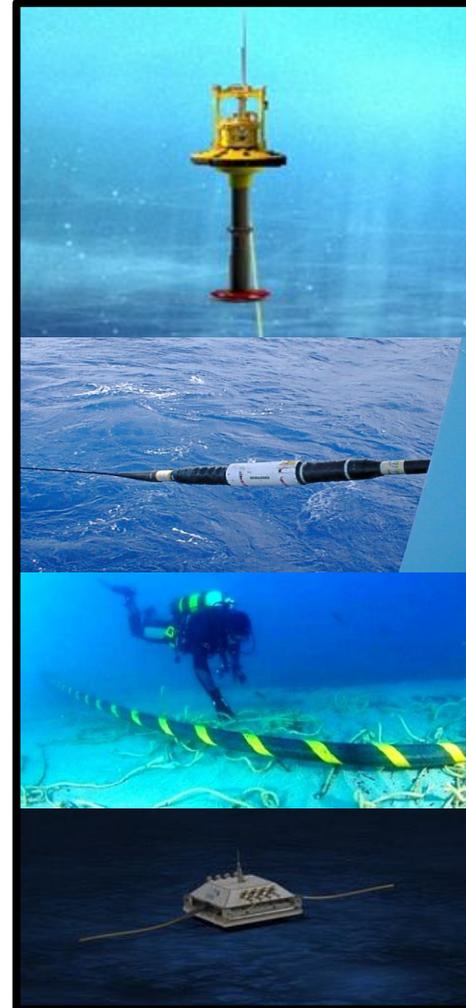


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Market Trends - Energy / Scientific / Sea Floor

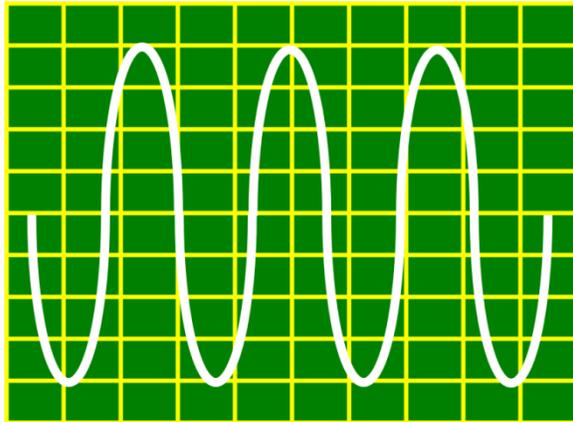
Submarket	2017	2018	2019	2020
Energy / O&G	Declining Or Stagnant	Declining Or Stagnant	Introductory Or Recovering	Emerging Or Re-Emerging
Energy / Green	Introductory Or Recovering	Introductory Or Recovering	Emerging Or Re-Emerging / Peak Or Expanding	Emerging Or Re-Emerging
Scientific / Environmental	Peak Or Expanding / Introductory Or Recovering			
Sea Floor - Commercial	Peak Or Expanding	Peak Or Expanding	Peak Or Expanding	Peak Or Expanding
Sea Floor - Defense	Maintenance	Maintenance	Introductory Or Recovering	Emerging Or Re-Emerging





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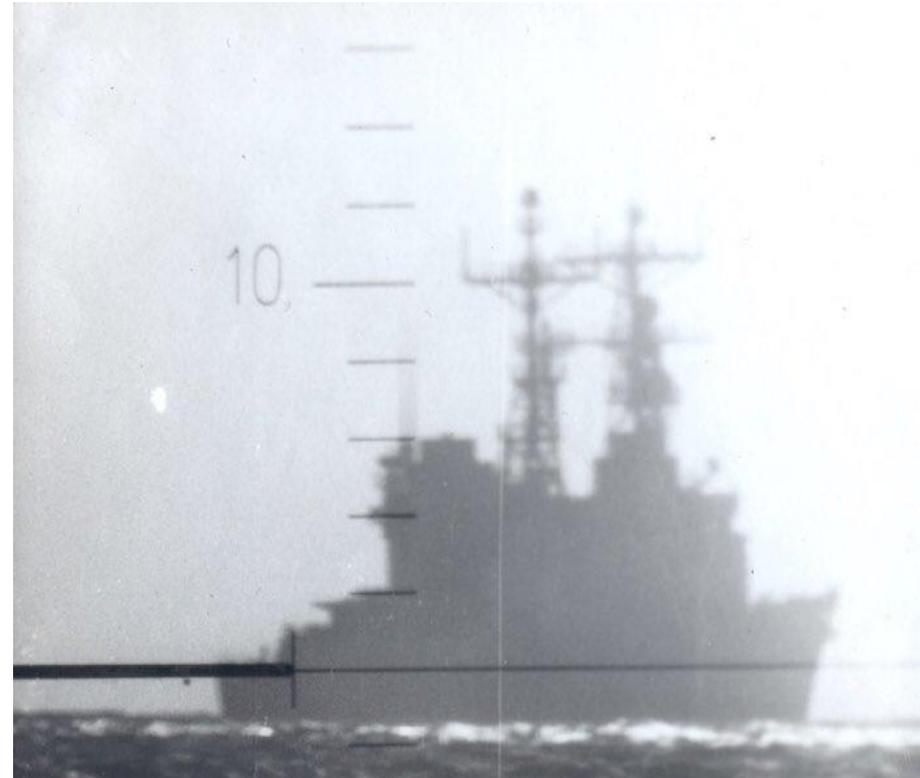


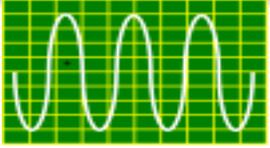
Technical Trends



Technical Trends – Higher Speeds And Feeds

- Driven by Video / Photonics
- Photonics, LIDAR, Side Scan SONAR and other Imaging and Video technologies are at the top of every User's wish list for technology.
- Great improvement has been made with these technologies, but at the cost of much higher bandwidth requirements.

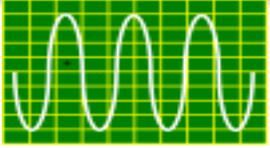




Technical Trends – Higher Density Connectors

- Pin counts are increasing without increasing the Outside Diameter (OD) or even decreasing the diameter
- Solution designers want to maximize the mission capability while minimizing or maintaining the number and size of hull penetrations.
- This results in the need to keep adding additional signals and pins in penetrators and connections.
- In addition to the mechanical challenge this presents, the design is now exposed to greater Electro-Magnetic interference (EMI) challenges (copper only).





Technical Trends - Higher Power Requirements

- Driven by higher speeds and High Power Performance Subsystems
- Higher bandwidth technologies and longer duration missions require increased power and energy.
- Higher power requirements result in thermodynamic issues that must be accommodated.

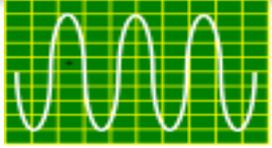




Technical Trends - Reliability

- 20+ years of service life
- Requirements needs to be fully understood
- Customer needs to have a total system view to maximize service life
- Materials must be carefully selected
- Manufacturers must have credible experience / expertise
- Shock, Vibration, O-Ring Failure, Leakage, Signal Continuity





Technical Trends – Fiber Optics

- Fiber Optics on Mobile Platforms is a growing trend
 - In motion, e.g., towed array
 - Bending, e.g., periscope
 - Rugged / Robust issues for connectors
- Training for design, manufacturing, handling, installation
- As a technology enabler, as a sensor
 - Lasers
 - Distributed Temperature Sensing





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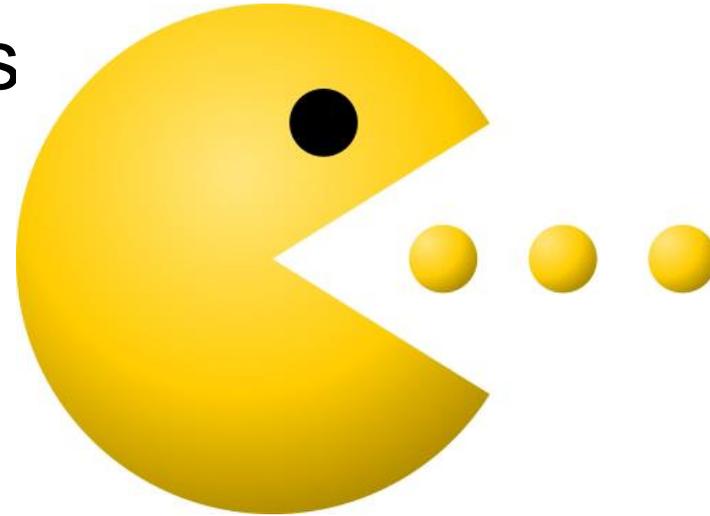


Business Trends



Business Trends - Market Consolidation

- Big companies continue buying smaller companies
- Since 2000, there have been approximately 500 acquisitions of smaller suppliers.
- Supplier culture / behaviour changes with new company





Business Trends - Supply Chain

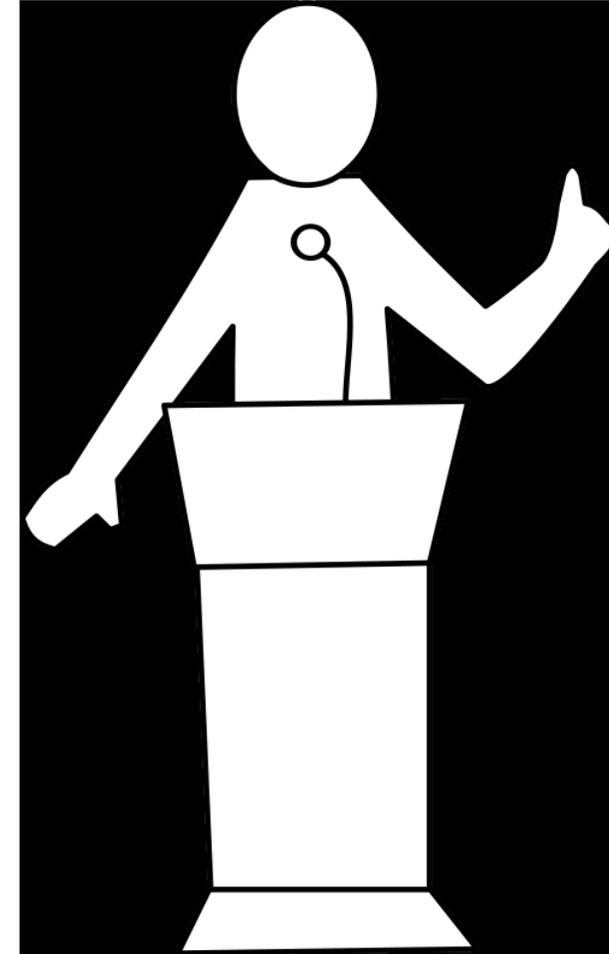
- Creating constant churn in the supplier base
- No long term partnerships / relationships
- Suppliers eventually leave the market, contracting the supplier base and thus reducing competition





Business Trends – Geo-Political / World Events

- BREXIT
- US Public Policy
 - Tariffs - Material Cost Increases
 - US DoD Budgets Increasing: Undersea Funding Very Good
 - 2020 Budget is proposing Three Virginia Class Subs per year
 - Columbia Class Lead Boat Long Lead items started
 - US / UK Cooperation on Submarine Fabrication
- World Events
 - Many Countries Desire Submarines due to growing threats
 - *Of the roughly 400 non-US submarines operating the world, 75 percent of them work in the Indo-Pacific region*
 - *Around 160 of those subs are being operated by China, Russia, and North Korea.*



Conclusions

- From a Penetrator Supplier Perspective, All Undersea Markets are moving in a positive direction
- Users are demanding new capabilities with higher bandwidth and higher power requirements
- The connectivity industry must adapt to support these evolutions
- *We live in interesting times*

