

Suggested Elements for a New Tow Cable & Handling System Design Standard for Littoral Towed Systems



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Inspiration for the topic

- Customer's desire to **qualify** a littoral, high speed, towed system for a new application
- Requirement to **validate** the design against existing tow cable & handling system standards

Notional Handling System & Towbody

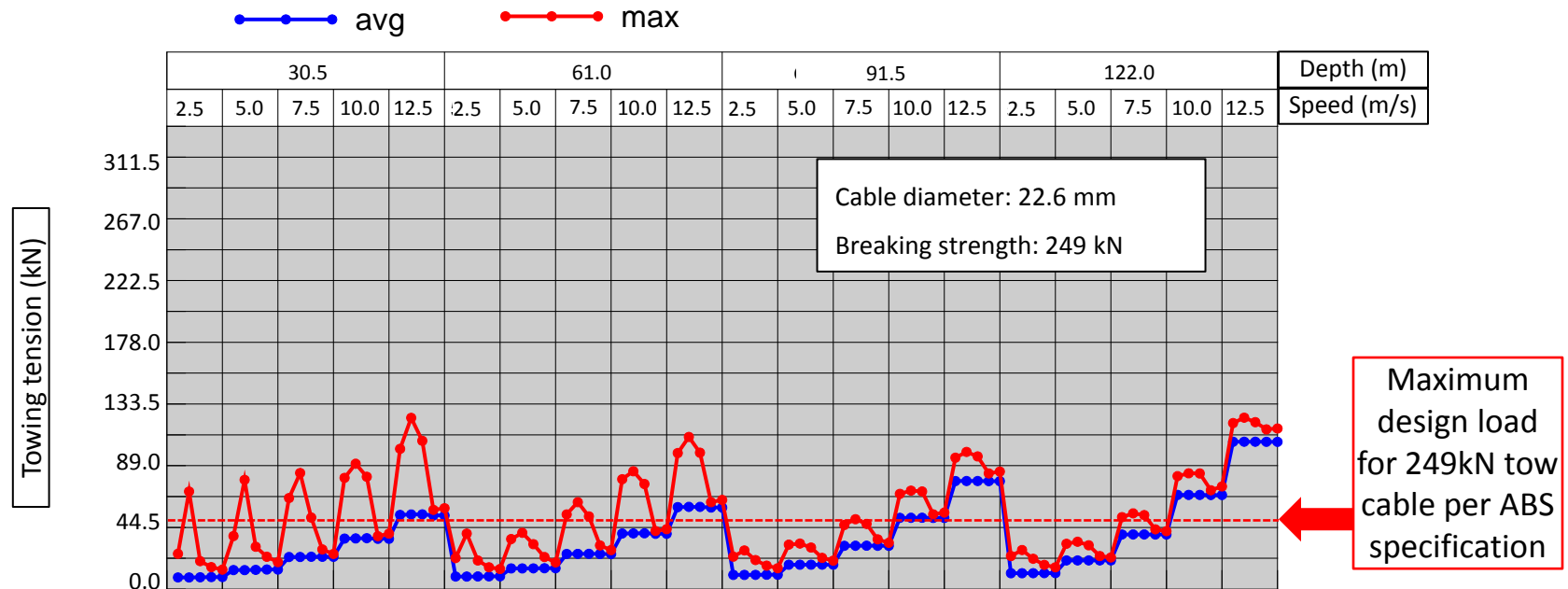


- Dedicated purpose handling system
- Towed array in littoral waters.
- Towing close to the bottom.
- Towing at high speeds.
- Impact of the towbody on the seafloor is possible.

Longstanding Issue for the Industry

- Expanded usage of high, specific strength tow cables & tension members
 - Requires larger, heavier handling systems or limitations on existing equipment.
- To increase the utility of existing or future equipment
 - Requires rethinking the handling system design standards & factor of safety.
- *Approach is to match the Factor of Safety (FoS) to the task being performed.*

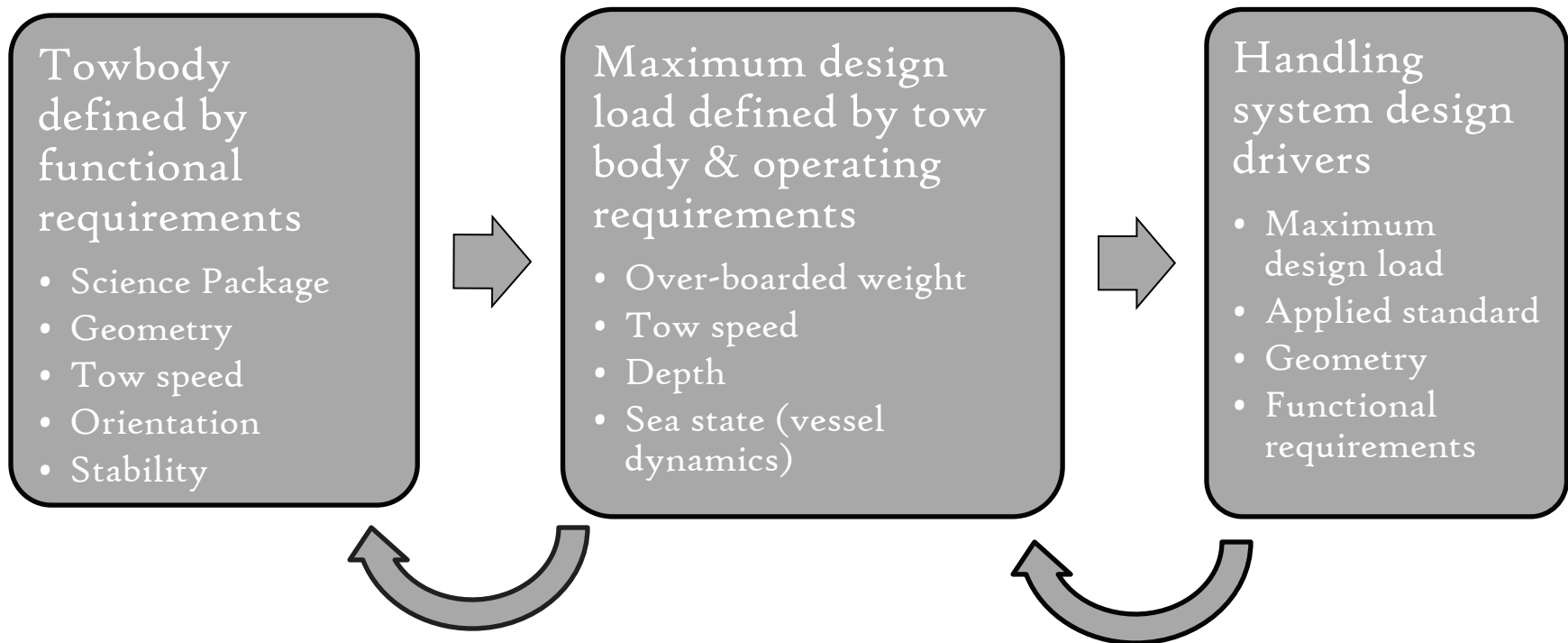
ABS applied to the Notional System





The Design Process & Approaches

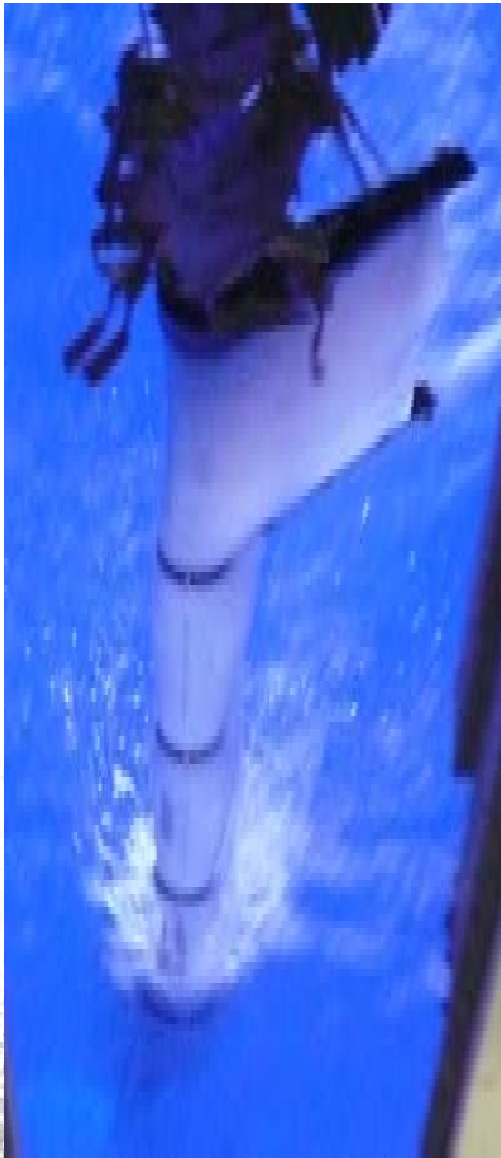
Typical Design Approach



Allowable Stresses based on Maximum Design Load

- Typical approach used by industry standards such as ABS, DNV, API, Lloyds...
- Handling system and tow cable sized by the calculated “Maximum Design Load” or the standard prescribed calculation.
 - Example ABS (UVSHF) : for non-manned systems the designer can assume a vertical dynamic load factor of 1.75
- Required tow cable safety factor set by type of rope and usage
 - Example ABS (UVSHF) : For a running rope an FoS of 5.0 is required (Maximum Design Load versus minimum breaking strength)

Allowable Stresses based on Tension Member Breaking Strength



- Approach used by USCG under Title 46, Code of Federal Regulations Part 189.35
- Considered the “Gold Standard”
- Allowable stresses based on loads generated at breaking strength of cable.
- Maximum component stress set to $\frac{2}{3}$ of material yield at cable breaking strength.
 - ❖ Factor of Safety for the tension member is NOT addressed by the CFR.

Problem in Applying ABS to Littoral/High Speed Towed Systems

What is the maximum design load if a bottom impact is likely?

“An important point to note in each of the overload failures, and indeed in some which will be described below, is that a larger and stronger cable would not necessarily have withstood the loads. Dynamic loads which quickly rise to over 70,000 pounds (300,000N) will, in all probability will also rise to 100,000 pounds (450,000N)...”

J.R. Hatthews and B.F. Peters, “Effective Service Life of Variable Depth Sonar Tow Cable”
Defence Research Establishment Atlantic, IEEE, 1987

Failure Mechanisms of Wire Rope Systems

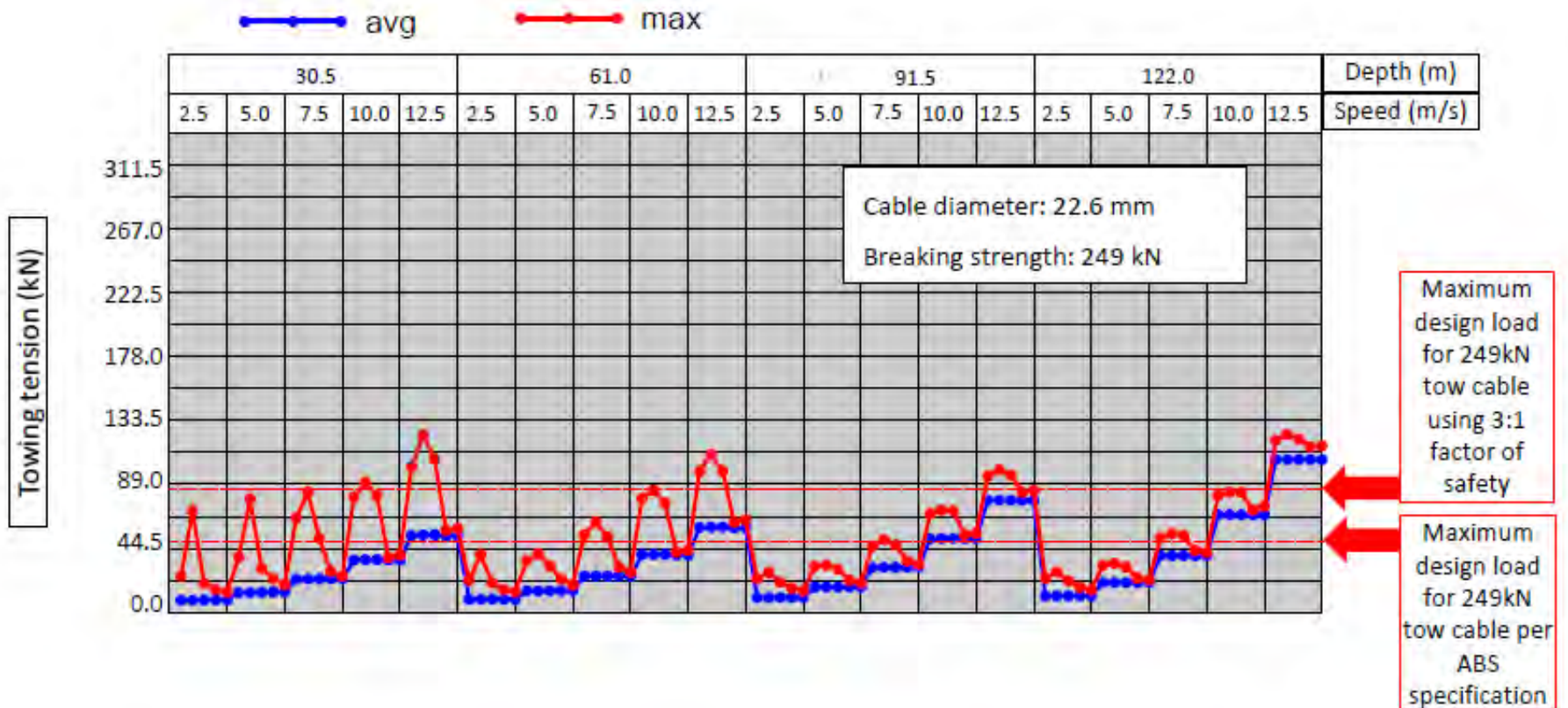
Rank	Cause	%
1	Unsuitable construction	28
2	Fatigue	20
3	Corrosion	14
4	Shock	12
5	Erosion, scuffing and local wear	8
6	Insufficient strength	4
7	Improper handling	4
8	Improper lubrication	4
9	Variable rope quality	2
10	Other	4

A. Vanderveldt, C. DeYoung: "A Survey of Publications on Mechanical Wire Rope and Wire Rope Systems", Naval Ship Eng. Center (NAVSEC) N) N00024-70-C-5439, August 1970.

Alternative Design Approach

- Bi-level Tow Cable Safety Factor (SF)
(SF = Cable breaking strength/Max design load)
 - SF Tied to specific phase & characteristics of operations
 - Towing versus Deployment/Recovery
 - Hands-On versus Hands-Off
 - Actual lower SF Based on quantifying tow cable through laboratory testing.
 - Assumes a tow cable parting even will occur.

Gain in Operational Window



Elements of a new Standard

- Handling System Design
 - Meets the CFR
 - Tested to the CFR
- Towbody Termination Design
 - Includes a weak link
 - Validated by testing
 - Streamlined to avoid fouling above the weak link



Elements of a new Standard (cont'd)

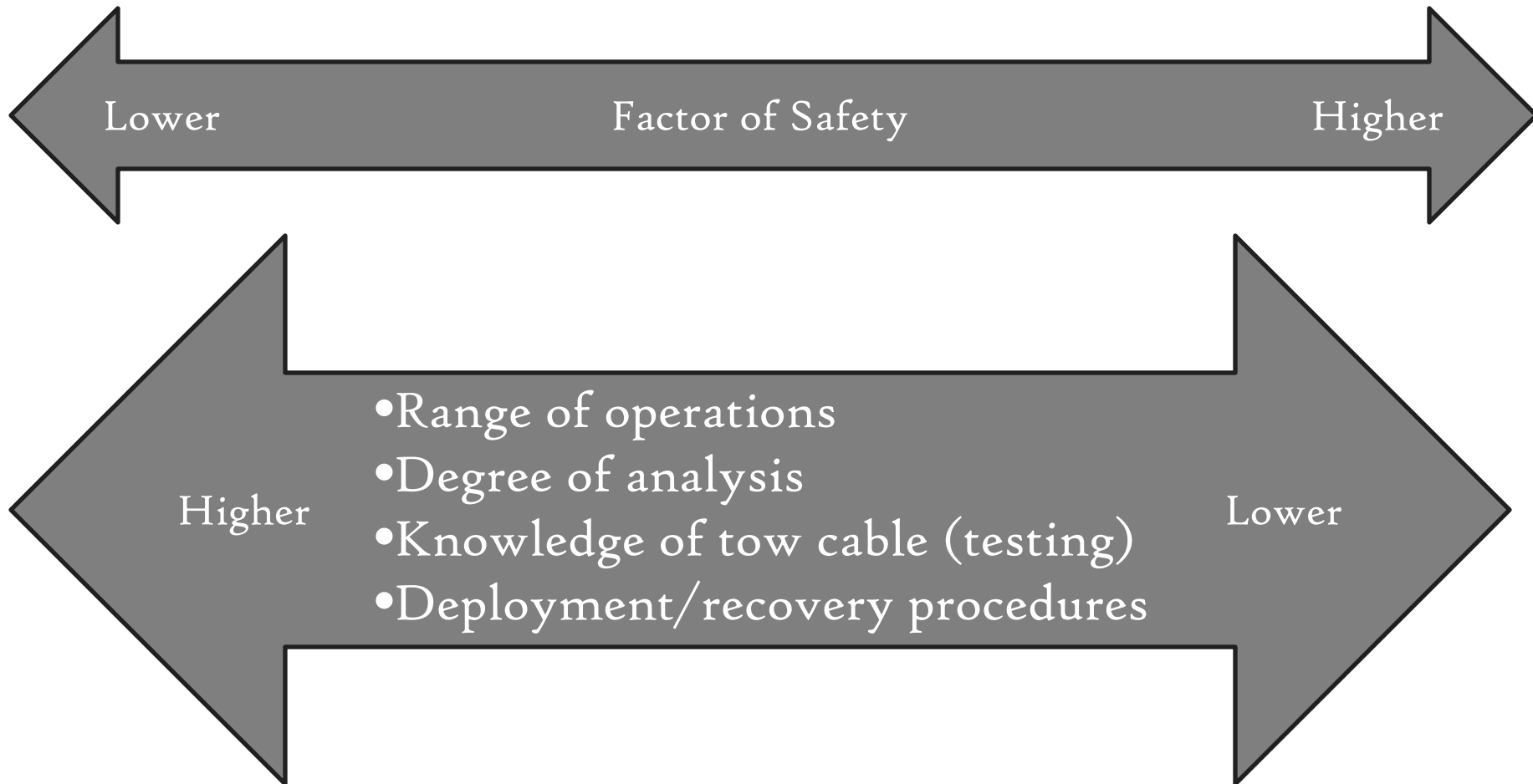
- Tow Cable Testing & Monitoring Protocol
 - Quantified through laboratory testing
 - Identify the point at which Z-kinking occurs
 - Determination of fatigue life through bend-over sheave cyclic testing.
 - High resolution load monitoring
 - Position monitoring to track areas of high fatigue
 - Specimen testing at end-for end events



Elements of a new Standard (cont'd)

- Tow Cable Failure Planning & Testing
 - Review to determine physical areas on/around handling system impacted by a towcable parting event.
 - Determination of the “Personnel Free Zone” (PFZ)
 - Conduct testing to simulate a towcable parting event
- Handling System Operations and Ship Handling Requirements
 - During all “hands-on” operations such as launch & recovery the higher SF of 5:1 is observed.
 - Procedures that ensure the PFZ is observed during lower SF operations.
 - Close coordination w/ bridge during lower SF operations

Trade Offs



Summary

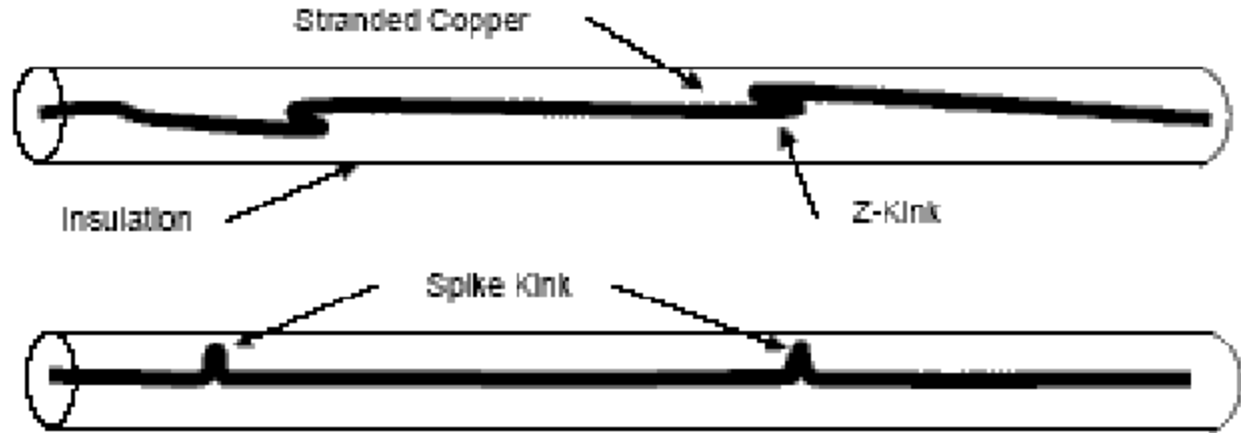
- For the littoral towed notional system a bi-level factor of safety was proposed to provide increased range of operations while maintaining operator & equipment safety.
- Factor of Safety during hands-on handling to be 5:1. FoS during hands-off operations to be set by test & evaluation.
- The operational gains come at the cost of increased level of effort in engineering, development and operation of the system.
- Expansion into more generic systems????



Backup Slides

Z-kinking

A cable overload event in which the copper conductors are loaded beyond yield while the strength member is not. Upon release of the load localized buckling of the conductors occurs.



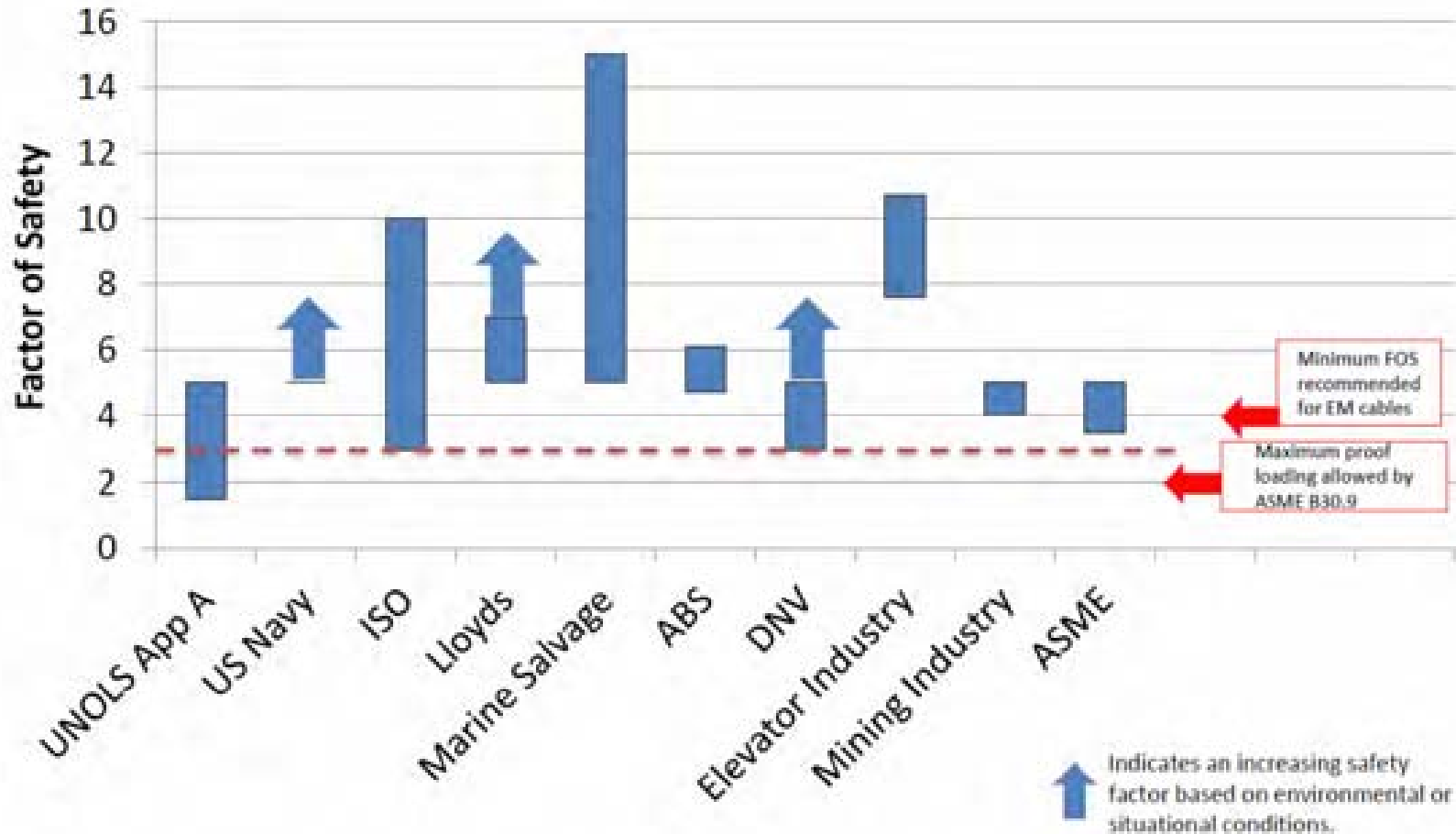
Drawing taken from CAMESA Online EM Cable Manual, Figure 1.



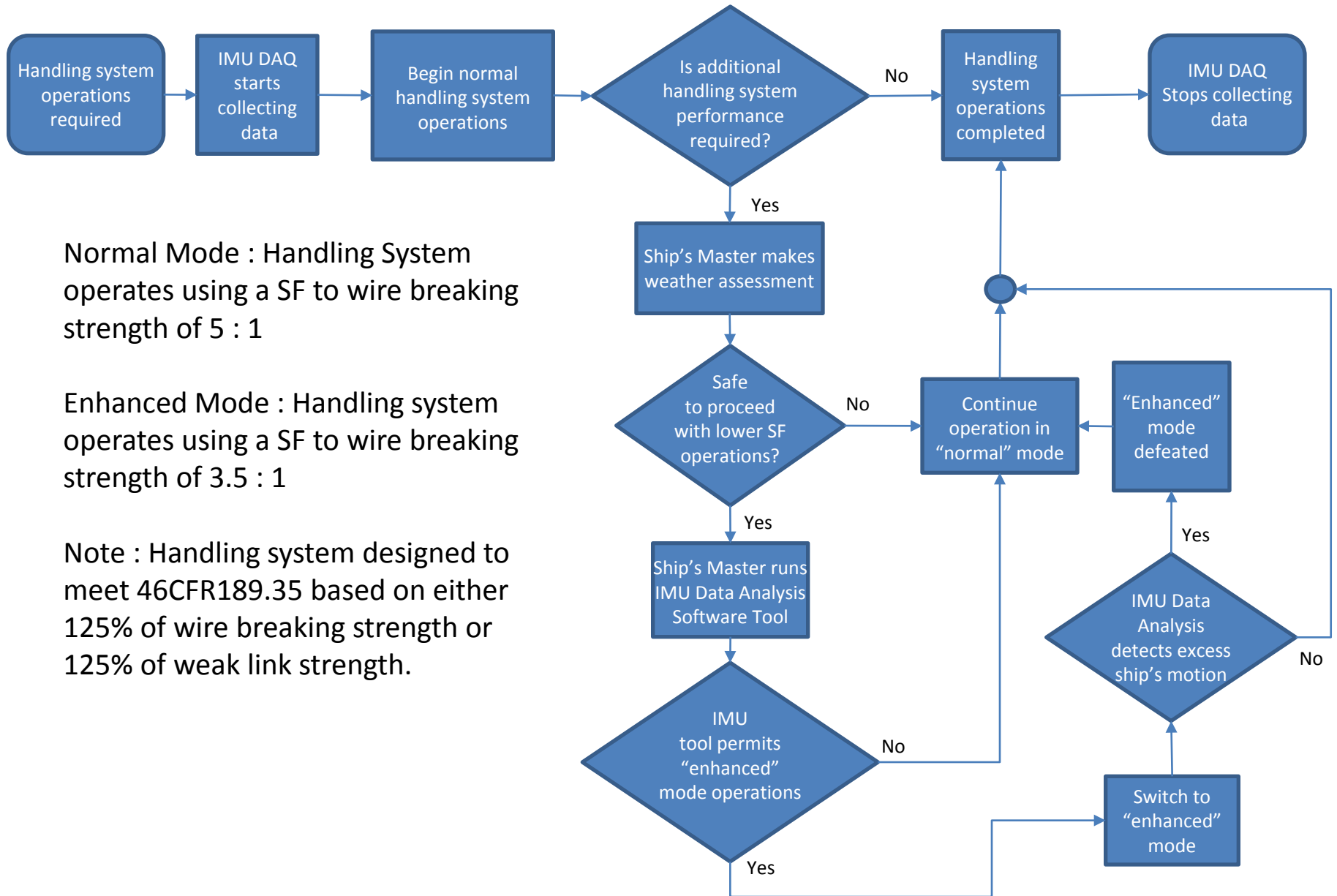
Some Applicable Standards

- **ABS**, “Underwater Vehicles, Systems and Hyperbaric Facilities”
- **Lloyds Register**, “Code for Lifting Appliances in a Marine Environment,”
- **API** , “Specification for Offshore Pedestal Mounted Cranes”
- **DNV**, “Standard for Certification of Lifting Appliances”

FoS Comparison across Standards & Industry



Handling System Operations Flow Chart – Normal & Enhanced Mode



Normal Mode : Handling System operates using a SF to wire breaking strength of 5 : 1

Enhanced Mode : Handling system operates using a SF to wire breaking strength of 3.5 : 1

Note : Handling system designed to meet 46CFR189.35 based on either 125% of wire breaking strength or 125% of weak link strength.