LIGHT STRUCTURES
Passion for Monitoring

Montreal, November 2018

Arnstein Stavnheim, EVP Sales

Hull Stress Monitoring (HSM)

LIGHT STRUCTURES

- ✓ The leading class societies recommend HSM systems on all large hulls
- ✓ Most new Boxships, Tankers, Bulkers, LNGC's and Navy/Coastguard vessels install HSM systems
- ✓ Well suited to be retro-fitted, even in service
- ✓ The leading class societies wants to make HSM systems compulsory on large hulls

Why Monitor your Hull/Structure

LIGHT STRUCTURES

Improved safety by quantification of uncertainties

Reduced operational cost **(OPEX)**

Reduced frequency of inspections

Prolonged remaining structure/field life

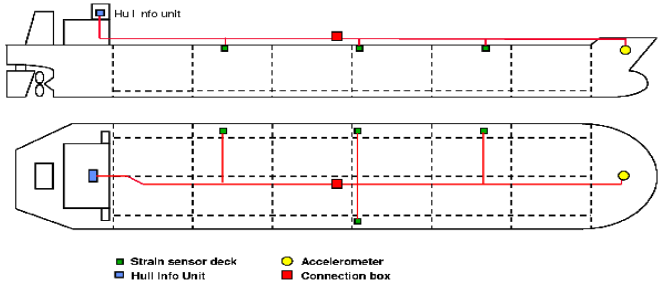
Light Structures AS

- World's leading supplier of fiber optic Hull Condition Monitoring Systems
- Founded in 2001 by scientists from the Norwegian Defense Research Establishment
- Head office and production based in Oslo. Acquired GME in Korea in 2017
- Represented by a network of agents in Korea, China, Japan, Taiwan, Russia, India, Singapore, USA, Canada, Australia, UAE and Greece
- More than 200 sold systems - to commercial ships, navy and offshore units

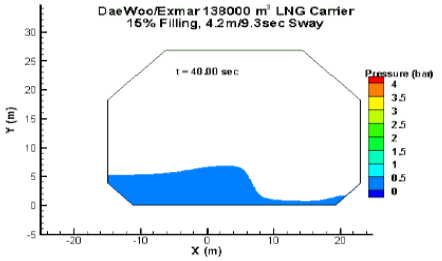
Light Structures AS

LIGHT STRUCTURES

Hull condition monitoring



Sloshing monitoring



Ice Load monitoring

Strategic Markets

LIGHT STRUCTURES

Shipping

Oil & Gas

Navy/Coast Guard

Shipping

LIGHT STRUCTURES

Tankers

Container vessels

Bulk carriers

LNG carriers

Ro-Ro vessels

Seismic vessels

- Hull condition monitoring
- Ice Load monitoring
- Sloshing monitoring

Oil & Gas

LIGHT STRUCTURES

FPSO's: Pazflor, Nexus I, Goliat, Knarr, Egina

Drillers: Sevan Brazil

FSO's: Heidrun, Mariner, Gina Krogh

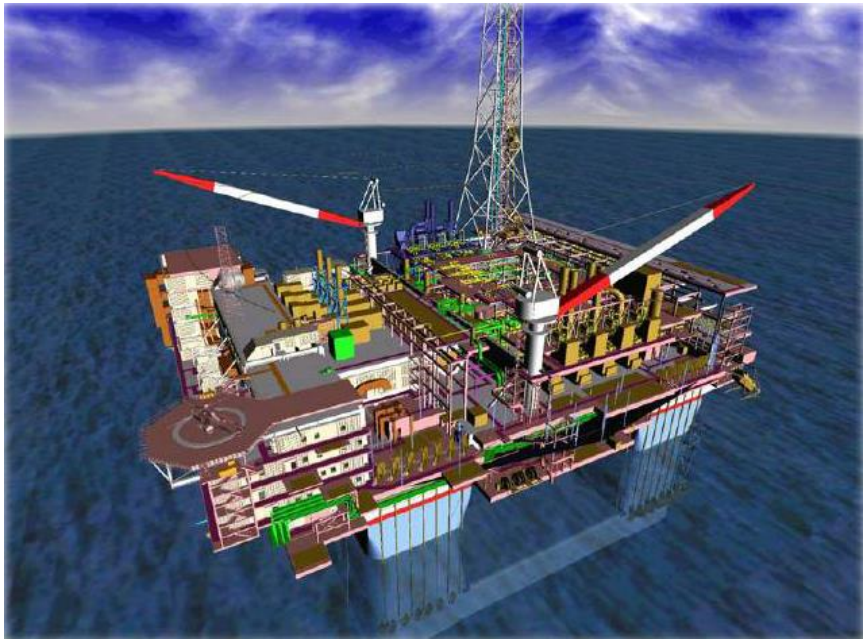
Semisub's: Ichthys CPF

- **Hull Stress Monitoring**
- **Integrated Marine Monitoring System (IMMS)**
- **Mooring Tension Monitoring**

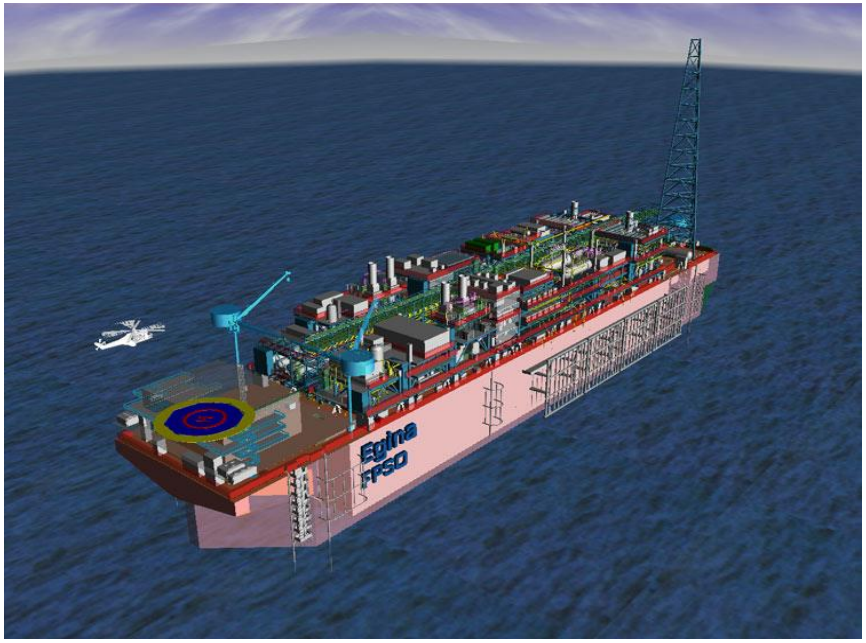
Offshore Structures

LIGHT STRUCTURES

Ichthys CPF



Egina FPSO



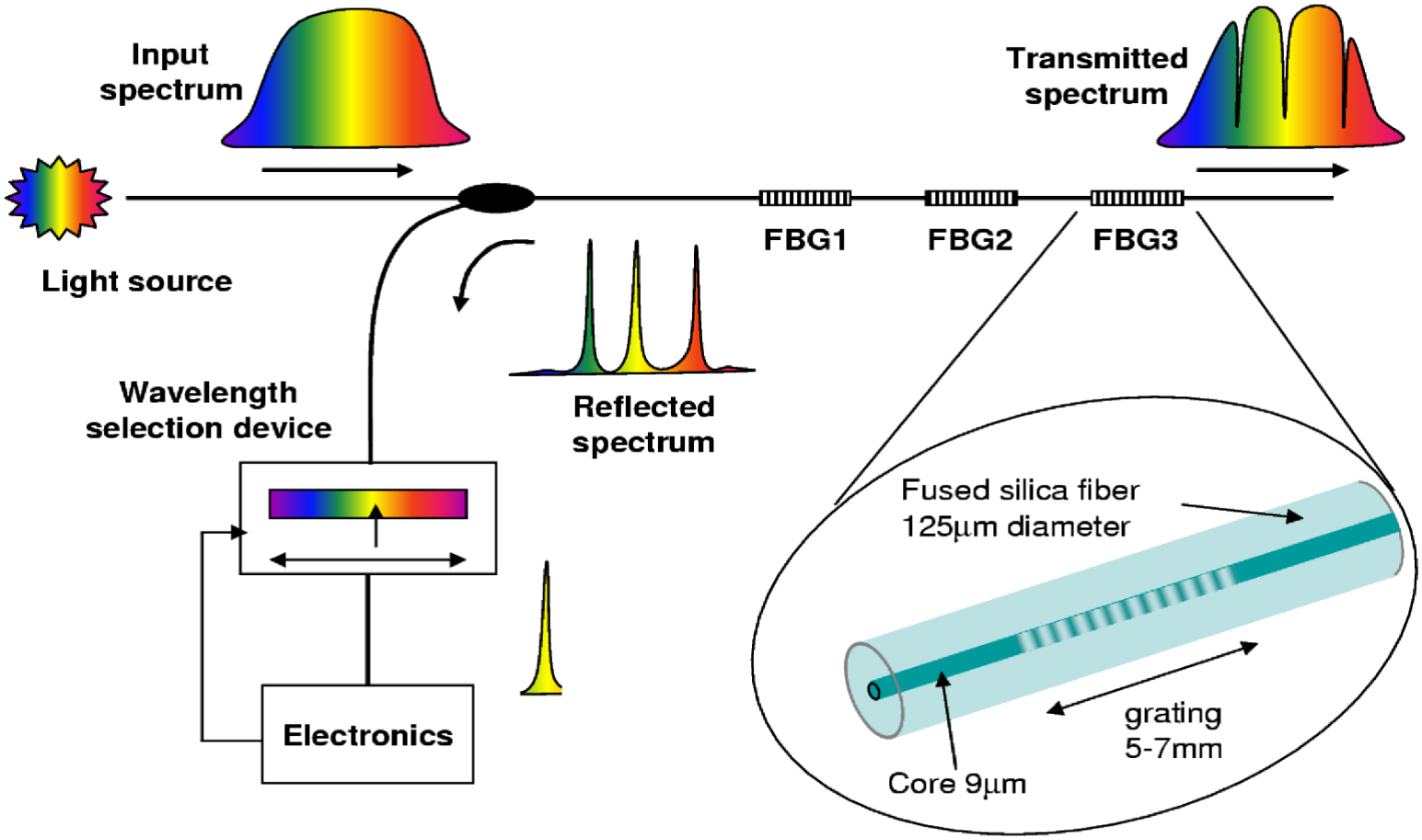
MIL /Navy

LIGHT STRUCTURES

- Hull condition monitoring
- Ice Load monitoring

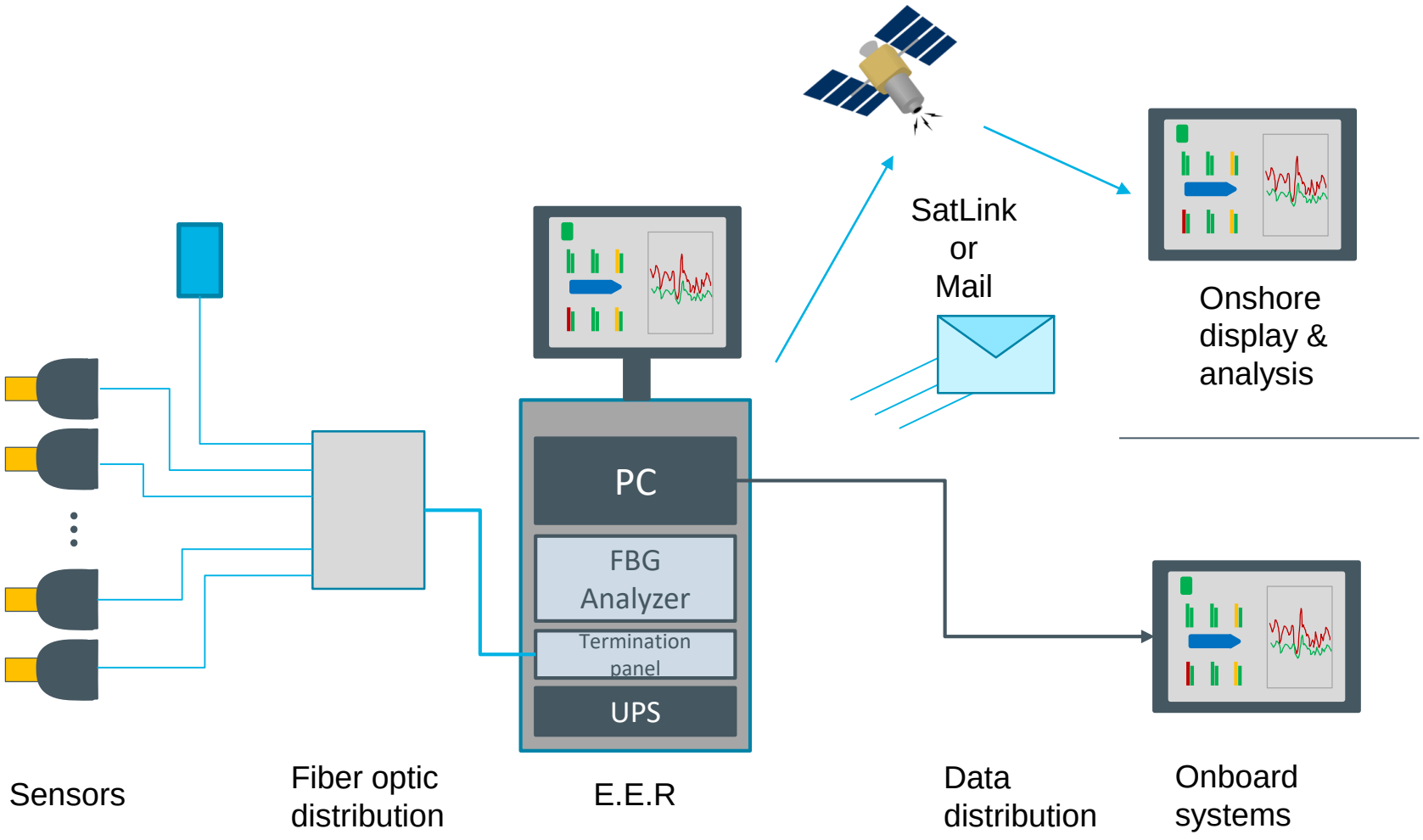
- **Patrol vessels**
- **FTB/Coast corvette**
- **MCMV**
- **Coast Guard**
- **Frigates**

Overview of measurement principle



Generic System Architecture

LIGHT STRUCTURES



Strain sensor installation (Retrofit)

LIGHT STRUCTURES

Recommended short-base sensors fixed directly on deck longitudinal or stiffener with epoxy glue
Watertight protection, integrated in anti-corrosion coating
Place in ballast tank, void space or on deck

Sensor installation (retrofit)

LIGHT STRUCTURES

YARD

- Prepare cable support
- Pull cable from sensor position to junction box (midships and forepeak, typically)
- At sensor positions remove anti-corrosion coating and sand metal surface
- After sensor gluing, recoat with anti-corrosion coating

MAKER's ENGINEER

- Fix sensor with epoxy glue and make watertight (short-base sensor)
- Terminate fiber optic cable in junction boxes and processing electronics

Fiber optic sensor types

LIGHT STRUCTURES

Our sensors were developed specifically for hull stress monitoring requirements

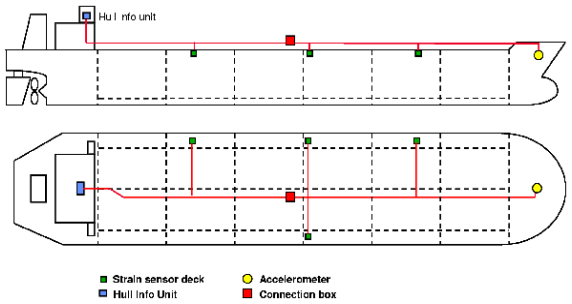
- Short-base fiber optic strain sensor
- Long-base fiber optic strain sensor
- Fiber optic accelerometer
- Fiber optic sloshing pressure sensor

All sensors use Fiber Bragg Gratings

Hull Stress Monitoring (HSM)

LIGHT STRUCTURES

- Developed in 1997 for the Norw. Navy
- Fiber optic technology, patented
- More than 180 installations
- All major Class notations DNV GL, ABS, BV, Lloyds, Rina, CCS, ICS



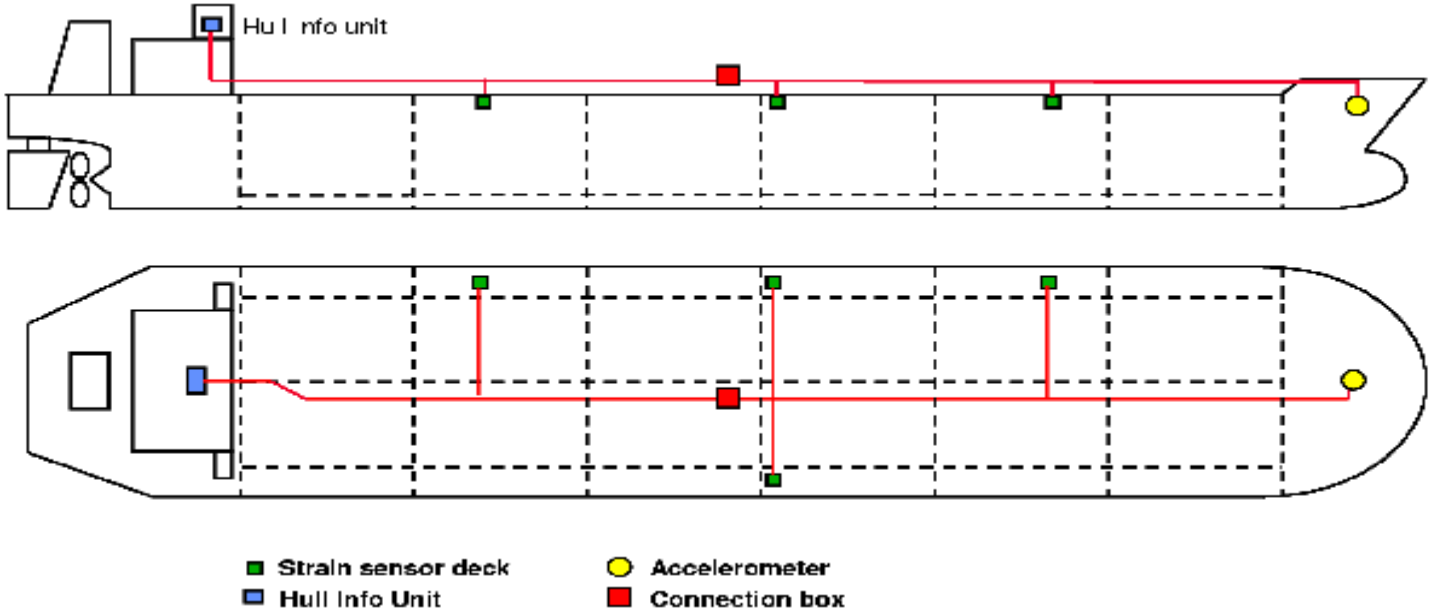
Basic system based on the minimum requirements for HMON notation: four sensors + accelerometer.

Possible to add sensors for more comprehensive measurements of global forces plus surveillance of "hotspots".

Active Fatigue Management – onshore database for maintenance planning for fleet and individual vessel.

Sugggested solution for ship design SENSFIB

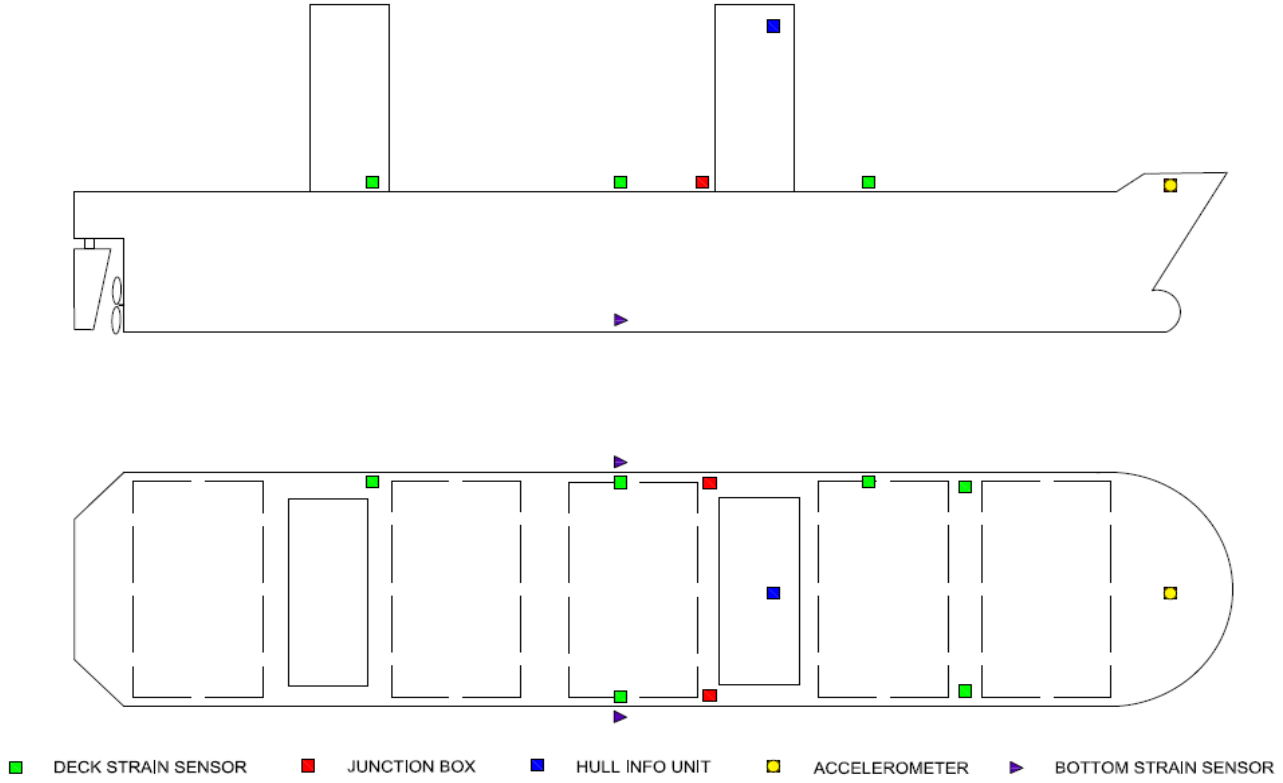
LIGHT STRUCTURES



DNV·GL Lloyd's Register BUREAU VERITAS ABS ClassNK CCS CHINA CLASSIFICATION SOCIETY

Intermediate Configuration (Container vessels)

LIGHT STRUCTURES



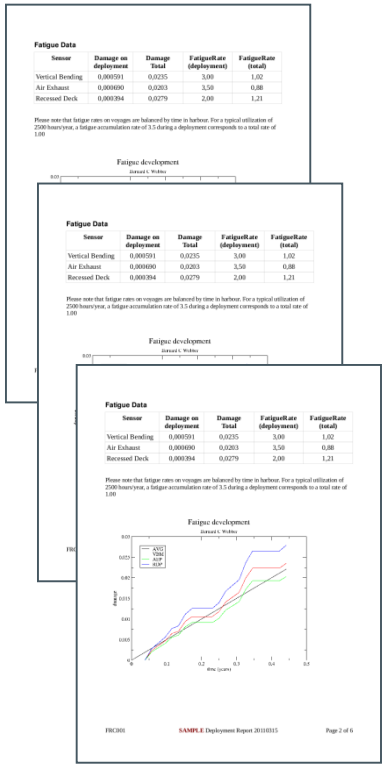
8	pc	Fiber optic strain sensor SS1T
1	pc	Fiber optic accelerometer, 0-100 Hz
1	pc	FBG Analyzer-3 signal receiver

Active Fatigue Management

LIGHT STRUCTURES

Vessels / units

Reports



Fatigue Data

Sensor	Damage on deployment	Damage Total	FatigueRate (deployment)	FatigueRate (total)
Vertical Bending	0,000591	0,0235	3,00	1,02
Air Exhaust	0,000690	0,0203	3,50	0,88
Recessed Deck	0,000394	0,0279	2,00	1,21

Please note that fatigue rates on voyages are balanced by time in harbour. For a typical utilization of 2500 hours/year, a fatigue accumulation rate of 3.5 during a deployment corresponds to a total rate of 1.00

Fatigue development

Bernard L. Wobbes

SAMPLE Deployment Report 20110315

Page 2 of 6

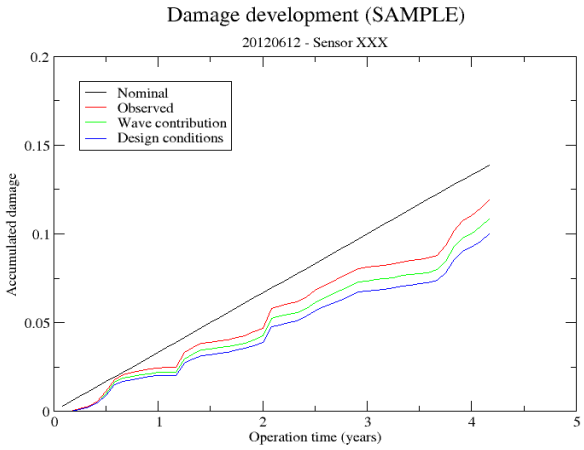
Benefits

- ✓ Improved maintenance planning
- ✓ Tool & reports accepted by leading class societies
- ✓ Reduced docking days
- ✓ Improved hull lifecycle
- ✓ Improved fleet scheduling/utilization
- ✓ Attractive ROI

AFM for fleet planning/optimization

LIGHT STRUCTURES

Database

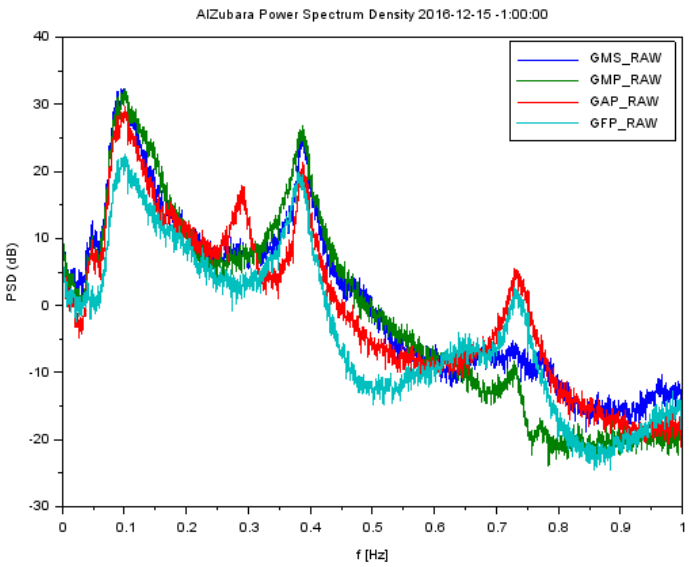


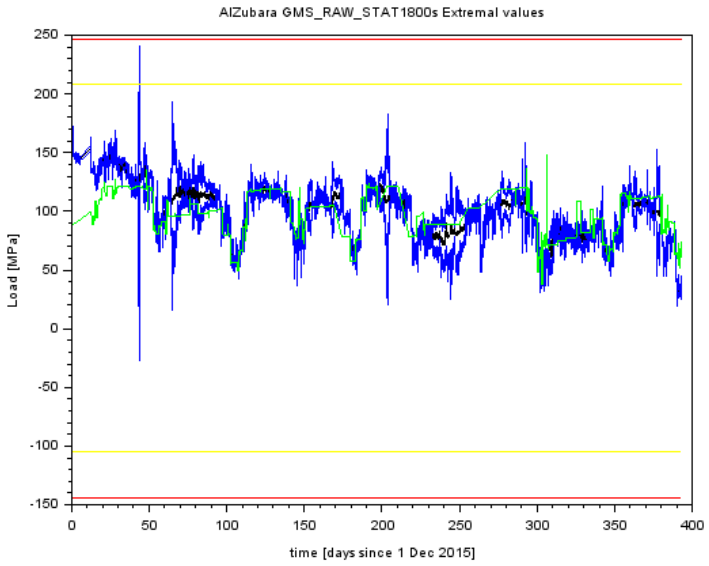
- ✓ **Improved maintenance planning**
- ✓ **Improved hull lifecycle**
- ✓ **Improved fleet scheduling/utilization**
- ✓ **Attractive ROI**

Example Targeted reports

LIGHT STRUCTURES

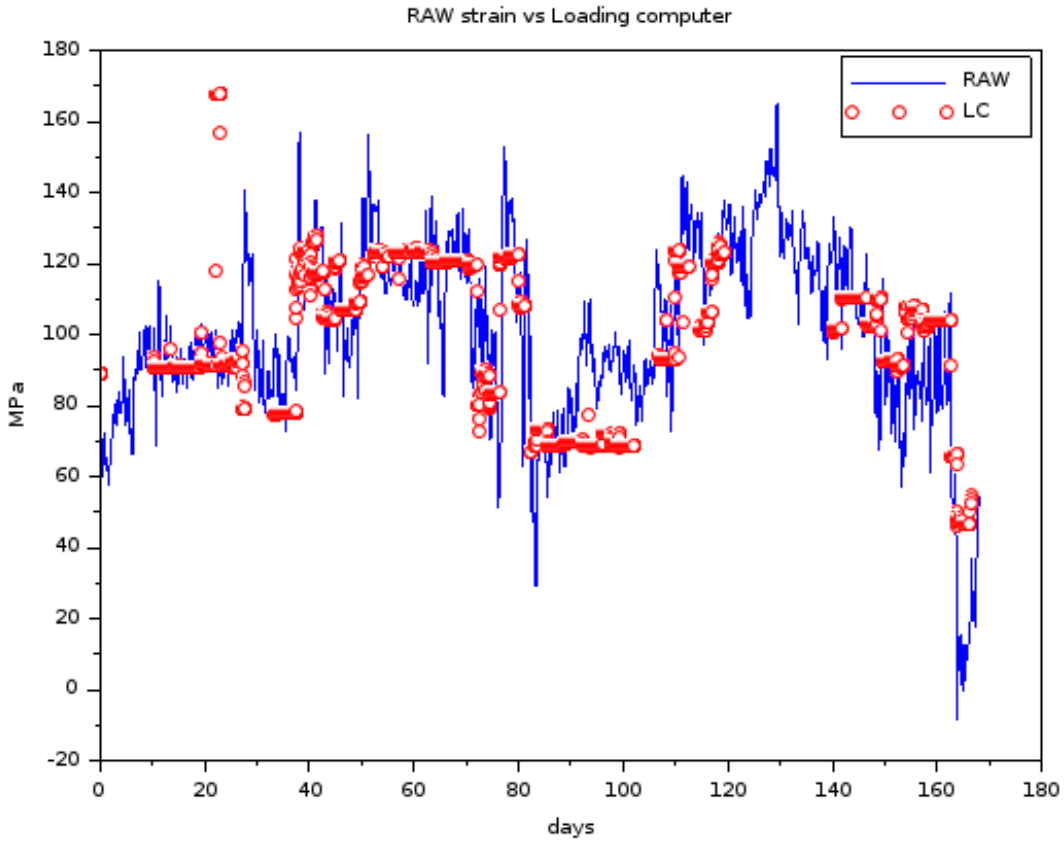
- Analysis of incidents and vessel status based on exported data
- Loading, frequency responses, fatigue status
- Data export by USB or satellite link





Monitoring vrs.loading computer

LIGHT STRUCTURES



18k TEU container vessel measured over 6 months period

Conditions to Trigger Alarms

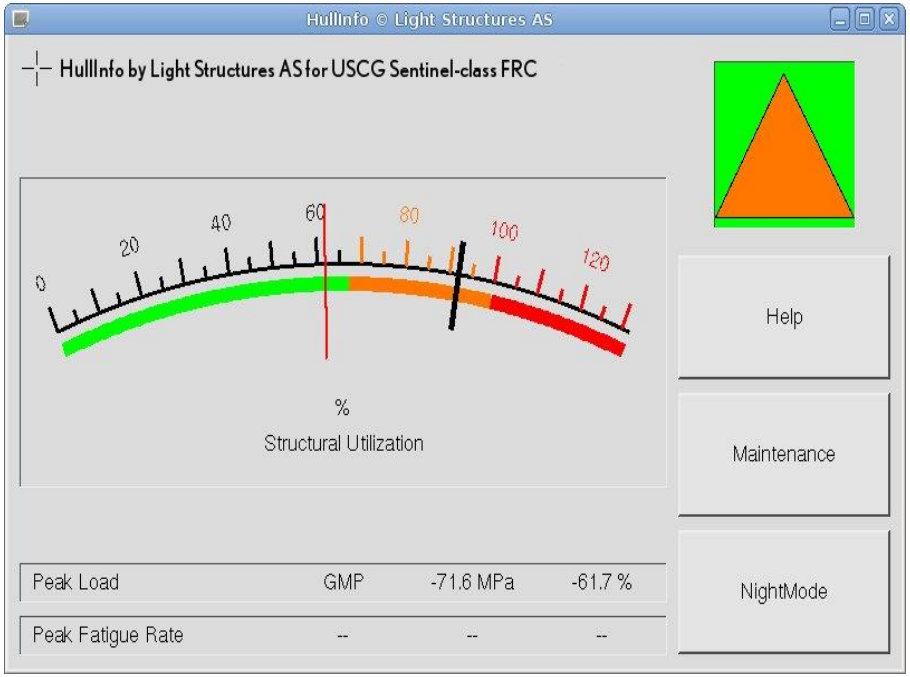
LIGHT STRUCTURES

- Based on measured stress (or bending moment) exceeding threshold level defined by classification society or hull designer (independent of loading computer interface)
- Based on deviation between HSM measurement and loading computer calculation, e.g. during loading (requires online link to LC)
- Possible also to have warning of high fatigue rates, i.e. material fatigue accumulating faster than desired. Allows the navigator to adjust speed or course to conserve hull operational life.

Risk-based operator guidance for high speed navy vessels

LIGHT STRUCTURES

Local response



Risk model

Go or No Go

Hull Info Graphical User Interface

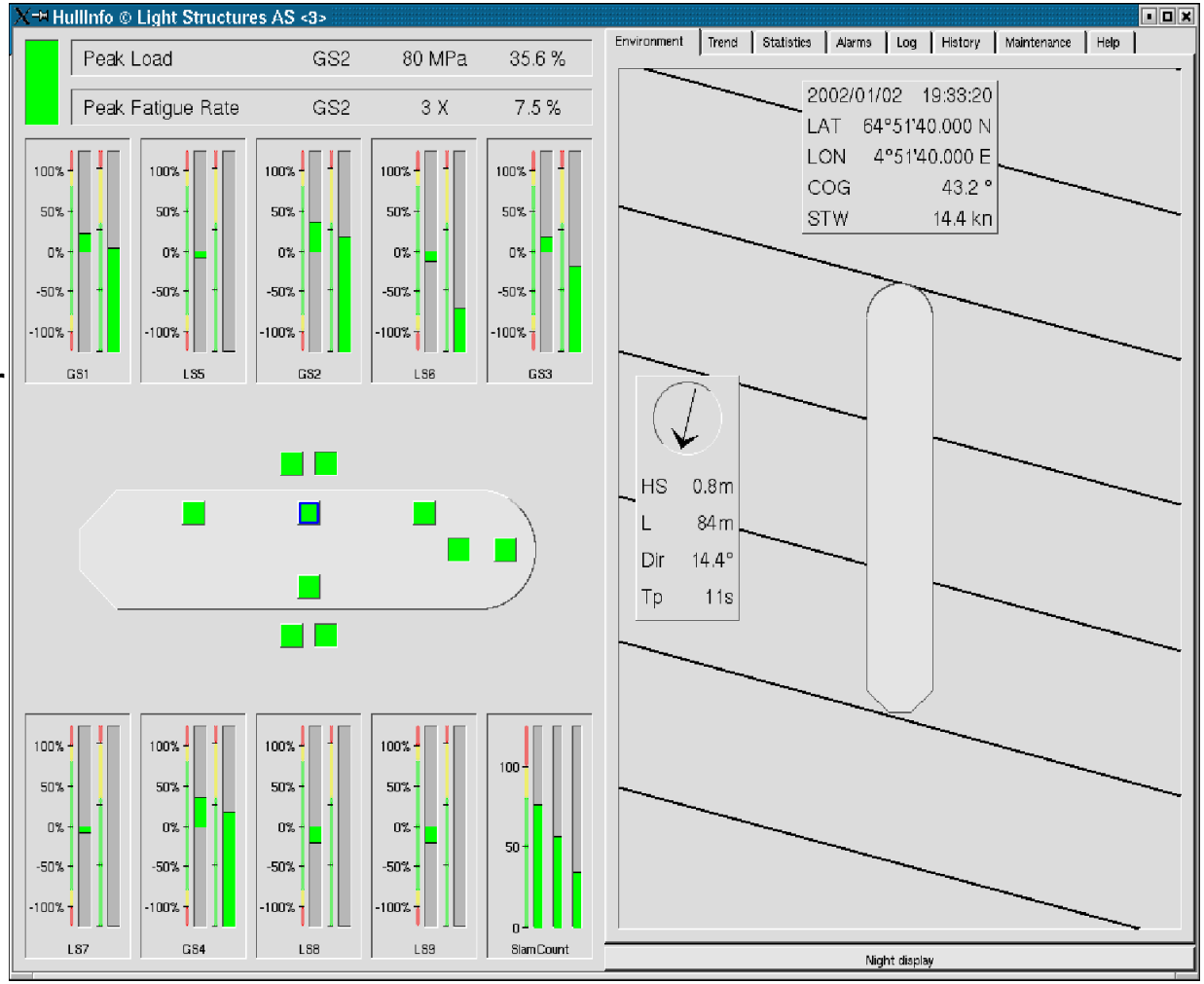
LIGHT STRUCTURES

Bar graphs for each sensor with current stress and fatigue rate

Ship outline with sensor status indicator

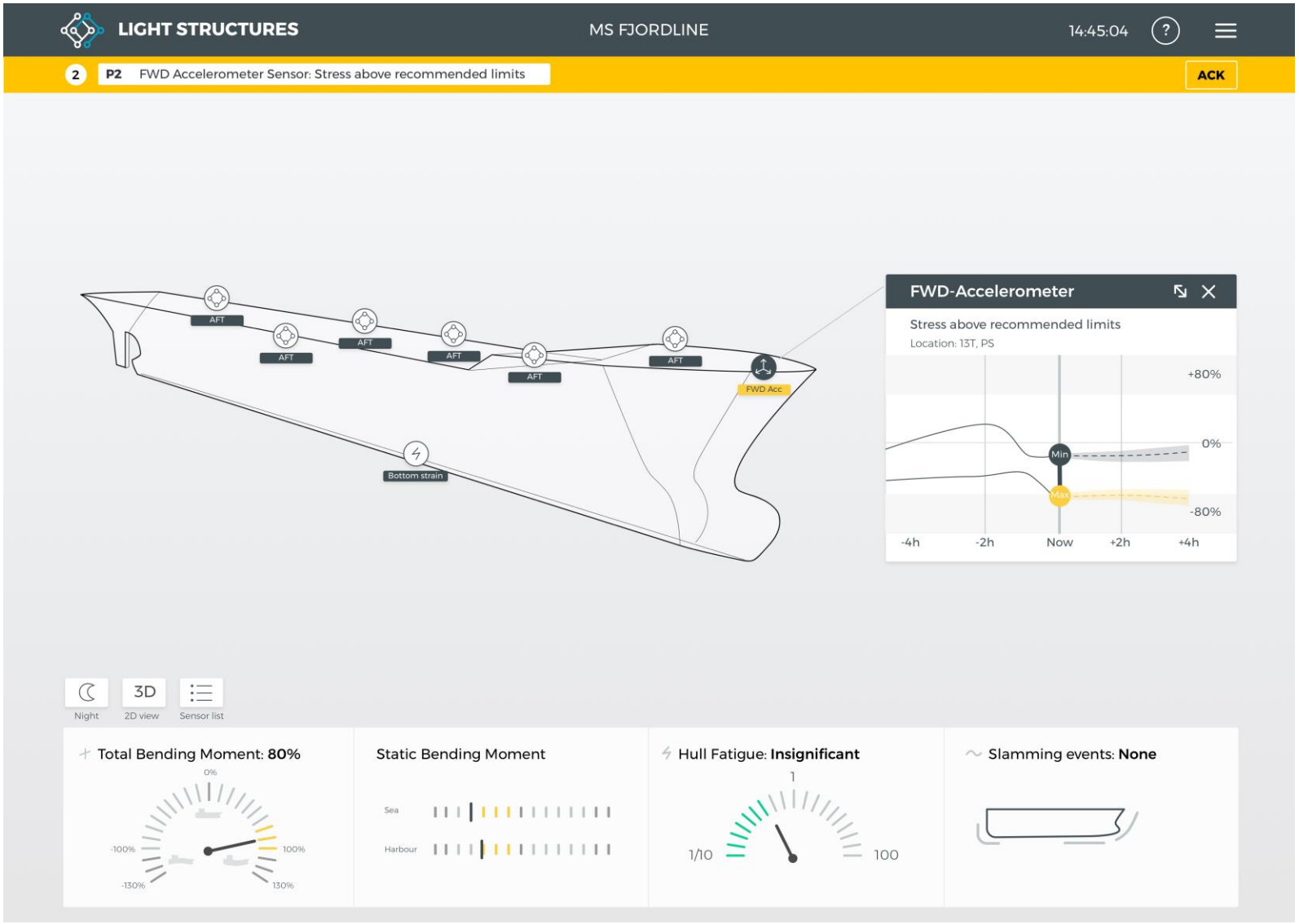
Operating conditions at a glance (data from external sources)

Color indicates level green for normal, yellow for warning, red for overload



Intermediate Configuration (Container vessels)

LIGHT STRUCTURES



Research and Development

LIGHT STRUCTURES

- Partner in the Nerves of Steel DNVGL extraordinary innovation project in 2017
- Data for key projects uploaded and analyzed

Previous research projects

- HMON systems (EU)
- Ice Load Monitoring (DNVGL)
- Container vessel monitoring (DNVGL)
- LNG tank sloshing (DNVGL, Lloyds, ABS)
- Advanced load prediction (Norwegian Navy)
- Infrastructure monitoring (EU)
- Windmills (Kongsberg Maritime, ++)
- Aircraft (EDA, Airbus, ++)

Comparison table

LIGHT STRUCTURES

No	Item	Fiber optic short-base	Conventional
1	System accuracy	Excellent	Good
2	System reliability	Excellent	Acceptable
3	System repeatability	Excellent	Acceptable
4	Location of sensors	On/under deck	On deck
5	Cable	Fiber optic	Electric twisted pair
6	Intrinsically safe	Yes	No
7	Calibration needed	No	Yearly
8	Maintenance	Mainly upgrades	Regular maintenance

Ice Load Monitoring (ILM)

LIGHT STRUCTURES

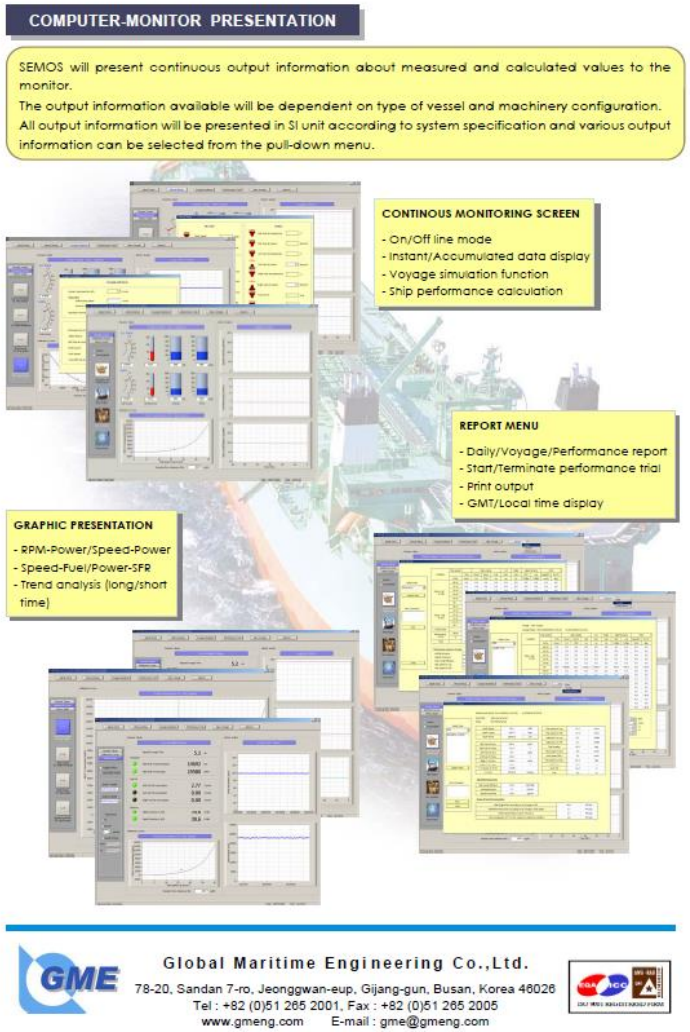
- **Developed in JIP with the Norwegian Navy (Coastguard) and DNV**
- **All fiber optic technology**
- **First commercial installation 2012**
- **Comply with recommendations of Major Class societies.**

- ❑ **Avoid damages**
- ❑ **Dynamic operator guidance**
- ❑ **Extended hull lifecycle**
- ❑ **Improved fleet utilization**
- ❑ **Attractive ROI**

Combines the traditional Hmon system with the need for measuring local ice loads.
Two and three directional sensors will cover all design hotspots and sensitive areas.
Alarms and operator friendly display.

Torque meter and Ship Performance Monitoring System (SPMS)

LIGHT STRUCTURES



6DOF Motion sensor MRU2000

LIGHT STRUCTURES

- The MRU-2000 unit is based on state-of-the art MEMS technology and is intended for use in mari

PERFORMANCE		
Parameter	**MRU-2000**	**Remark**
Outputs	Roll, pitch, yaw, surge, sway, heave, xyz accelerations	
Roll & pitch	± 0.10°	RMS (Dynamic)
Heave (Real-time)	5.0 cm or 5%	Whichever is greater
Rotation speed range	± 150 °/s	
Acceleration range	± 3 g	Measurement range
Output frequency	0 – 200 Hz	Adjustable setting
POWER AND SIGNAL		
Parameter	**MRU-2000**	**Remark**
Power consumption	6 W	
Supply voltage	12 – 36 VDC	24 VDC nominal
Ports	Ethernet, RS-232, RS485, 2 x Sync	Gigabit Ethernet
Protocols	NMEA, ASCII, binary, TSS, MDL, OCTANS, ATLAS	Wide range available on request
PHYSICAL CHARACTERISTICS		
Parameter	**MRU-2000**	**Remark**
Weight	1.2 kg	
Footprint (L x B)	154 x 86 mm	
Height	67 mm	
Depth rating	200 m	Marine Aluminium Housing

Some of our customers

LIGHT STRUCTURES

Advantages

LIGHT STRUCTURES

- ✓ Hull stress monitoring will reduce risk for structural damage and dangerous events
- ✓ Will have a positive impact on maintenance planning – and hence a cost benefit
- ✓ Will improve fleet scheduling & utilization
- ✓ Will most likely become compulsory

.....Why wait

Contact Details

LIGHT STRUCTURES

Thank you for your attention!

For more info please contact :

Arnstein Stavnheim
Executive Vice President Sales

Mob. Phone : +47 95835805
E-mail : ast@lightstructures.no

www.lightstructures.no