



GUIDANCE NOTES ON

SMART FUNCTION IMPLEMENTATION

NOVEMBER 2018

**American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862**

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Foreword

Smart Functions, which provide crew and support personnel with key information to aid in decision-making, are becoming increasingly common on board marine and offshore vessels. Common Smart Functions include structural and machinery health monitoring, asset efficiency monitoring, operational performance management, and crew assistance and augmentation to support vessel operations.

Smart Functions are enabled via a data infrastructure and supported by robust software integrity and cybersecurity that facilitates the use of aggregated data from sensors and other sources, data communications, data processing, data analytics, and data synthesis for reporting, decision making and actions.

These *ABS Guidance Notes on Smart Function Implementation* define the goals, functional requirements, and verification and validation principles for the implementation of Smart Functions on board marine and offshore vessels. The goals and subsequent functional requirements, together with the general implementation procedure, describe a framework for Smart Function implementation and are intended to provide clarity on the subject.

The aspects covered in this document include the definition of Smart Functions, their intended purpose and capabilities, a goal-based approach, and a set of risk-based verification and validation principles for implementing Smart Functions for condition, performance, and situational awareness and informed decision support, be it onboard or remote to the vessel itself.

These Guidance Notes become effective on the first day of the month of publication.

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SECTION 1 General

1 Objectives

Marine vessels and offshore units, equipped with digitally enabled functions that assist in providing various forms of decision-making support to an owner/operator, are becoming increasingly prevalent.

Classification societies acknowledge that data-driven monitoring techniques, data analytics applications, and streaming data for troubleshooting and operation assistance are changing vessel operations and management. By applying technical requirements established upon risk-based verification and validation principles, ABS can assist owners and operators to identify, assess and eventually incorporate data-enabled functions with onboard vessel equipment and systems and provide guidance on the use of supporting technologies with ABS class programs and services.

These Guidance Notes serve as a reference for marine and offshore vessel owners, operators, designers, shipyards, and equipment and system manufacturers, as well as Smart Function product and service providers, vendors, and equipment/system integrators.

The objectives of this document are:

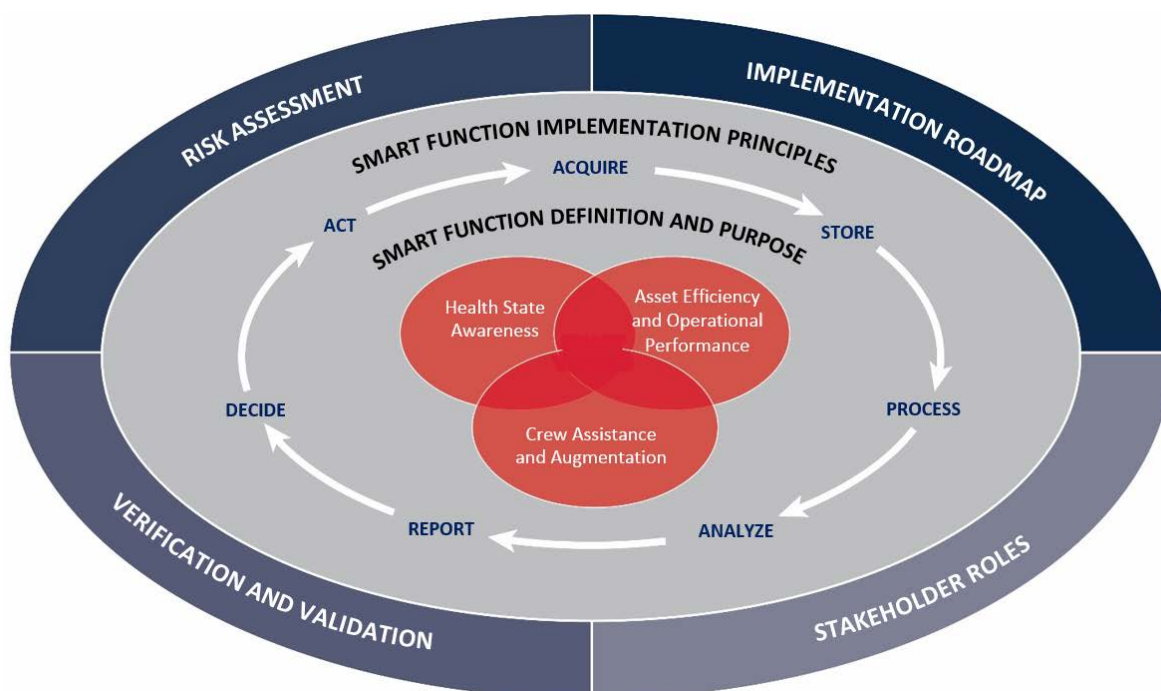
- i) Establish the concept of Smart Functions
 - Define a range of Smart Functions for marine and offshore vessels
 - Outline each Smart Function's capability applicable to marine and offshore vessels
- ii) Provide a goal-based approach for Smart Function implementation
 - Set the goals for Smart Function implementation
 - Define Smart Function scope associated with the goals
 - Outline a goal-based procedure for a Smart Function implementation
- iii) Lay out a set of risk-based verification and validation principles for Smart Function implementation

2 Scope of Application

This document applies to the implementation of Smart Functions for ships and offshore units, herein referred to as marine and offshore vessels. The document is organized into four Sections. It covers the definition, goals and functional requirements, verification and validation principles, and a roadmap covering stakeholder roles for the implementation of Smart Function, as shown in Section 1, Figure 1.

These Guidance Notes cover Smart Functions that are permanently installed, or intended to be permanently installed on marine or offshore vessels, either during construction or via retrofit. Temporarily installed equipment and systems are outside of this document's scope.

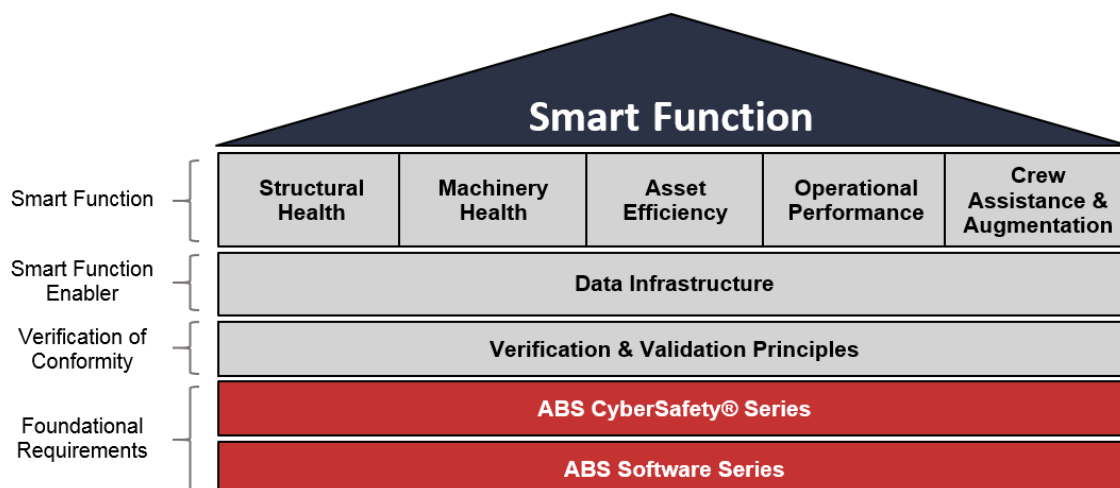
FIGURE 1
Smart Function Concept and Guidance Notes Outline



3 Smart Function Framework

The Smart Function framework is shown in Section 1, Figure 2. The functional requirements as well as the verification and validation processes performed by ABS are supported by foundational requirements covering the vessel data infrastructure that enables the Smart Functions, namely the hardware, software, data integrity, data analytics, and cyber security.

FIGURE 2
ABS Smart Function Framework



4 Definitions

4.1 Data Infrastructure

The data infrastructure enables data gathering, storage, management, and transmission from onboard and external data sources, both time-series and transactional in format, in a variety of real-time or periodic-to-continuous approaches.

The data infrastructure establishes the foundational elements for data applications and enables the Smart Functions implementation, and ensures reliable and efficient data flow, data sharing, data management, data quality, data integrity, and cyber safety.

4.2 Smart Function

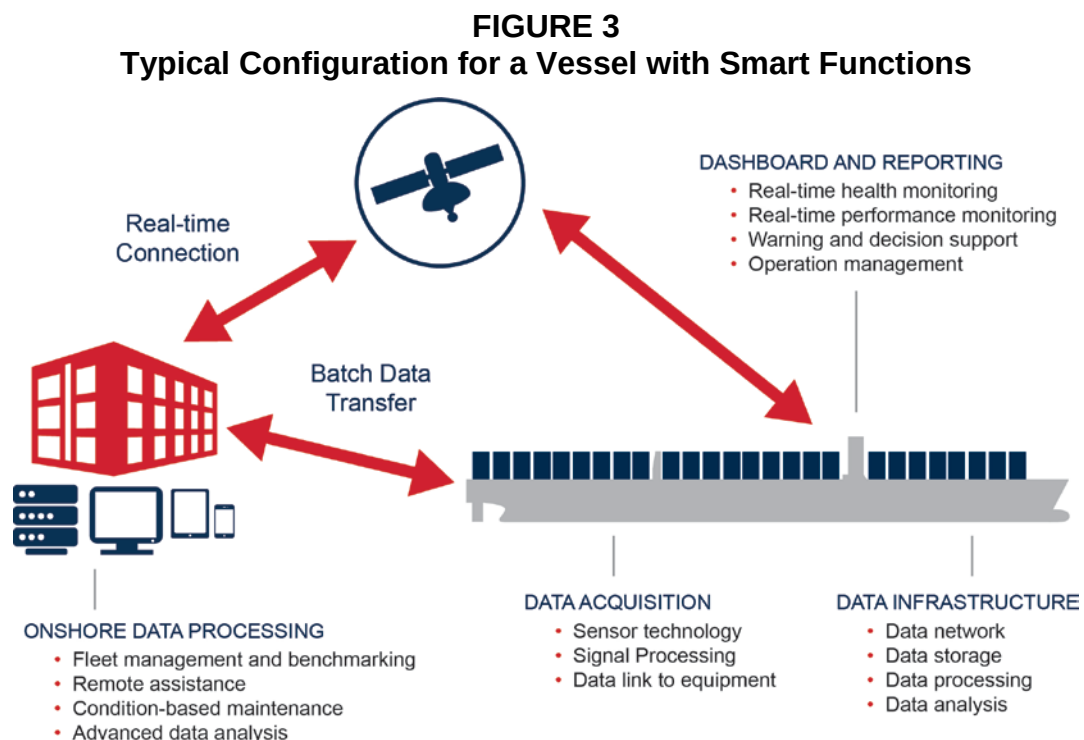
The Smart Functions described in this document refer to equipment, systems, services, or a combination thereof installed or implemented to continuously collect, transmit, manage, analyze, and report data for enhanced awareness, operational assistance and decision making support.

Smart Functions can be implemented for individual onboard equipment, across functional systems, or holistically across the entire vessel to provide enhanced insights on health state and/or performance and high frequency feedback to assist and augment crew.

Smart Functions can be implemented on top of the established and verified onboard data infrastructure as described in 1/4.1 or independently as standalone systems with their own hardware and software, isolated from other onboard systems.

A Smart Function commonly applies data analytics at various levels of sophistication and typically provides passive decision support for human-initiated operational decisions and actions. The passive role refers to the fact that Smart Functions typically do not initiate any action but merely provide information and/or recommendations for human decision-making.

A typical configuration for a vessel with Smart Functions includes onboard modules and onshore supporting facilities, which are interlinked for continuous or periodic data exchange capabilities, as shown in Section 1, Figure 3.



Depending on the technologies employed, a Smart Function may be capable of detecting condition and operational anomalies (diagnosis) with consideration of system and operational correlation, predicting asset health and performance trends (prognosis), and providing prioritized recommendations for corrective and preventive actions (decision making support). Data analysis approaches may combine the use of data-driven models, physics-based models, and also the use of well-established condition monitoring (CM) and performance monitoring techniques. Smart Functions can be realized through onboard systems with or without onshore data and domain support. Smart Functions can be capable of the following:

- *Sensing and Monitoring:* Measuring and collecting data on parameters directly reflecting the monitored environment, structure, equipment, and systems, for understanding various aspects of vessel operations, health, and/or performance through integrated or retrofitted sensors. A real-time onboard/onshore dashboard typically visualizes the data and alarms any threshold-based outliers. It can also identify and display trends. The outlier thresholds are often established using Original Equipment Manufacturer (OEM) recommendations, operator knowledge, relevant class rules, industry standards, and industry best practice.
- *Diagnostic and Prognostic Health and Efficiency Monitoring:* Traditional condition monitoring approaches as outlined in the *ABS Guidance Notes on Equipment Condition Monitoring Techniques*, such as vibration and oil analysis, operational parameter monitoring, or other similar techniques, are combined with diagnostic and potentially prognostic models using physics-based and/or historical data driven approaches. These functions are typically capable of detecting health and/or performance anomalies in the form of impending failure or performance degradation at an early stage. This provides valuable information for corrective and preventative actions including operational adjustment (usage and behavioral) as well as adjustments to inspection and maintenance planning to avoid unexpected down time and/or productivity loss in operations.
- *Performance Optimization:* Data analysis converts collected datasets into actionable insights on machinery and vessel performance and provide prediction capability using one or more performance models along with the forecasted operational environment. The performance and recommended operational parameters are derived by examination of possible parameter combinations and operational scenarios for the optimization goals, such as minimized energy consumption.
- *Crew Assistance and Augmentation:* Electronic data logging, and centralized data management and processing enable automatic reporting for use in regulatory compliance reporting and meeting stakeholder's needs with the aim of reduced crew workloads and decreased human errors. Advanced sensor and data analytics-based approaches can also assist and augment crew in situational awareness for vessel operations and navigation, such as image recognition using sensor arrays and pattern mapping approaches that can identify obstacles for collision avoidance.

5 The IMO Goal Based Approach

According to the IMO MSC.1/Circ.1394 “*GENERIC GUIDELINES FOR DEVELOPING IMO GOAL-BASED STANDARDS*”, a goal-based standards framework consists of goal-based standards and the associated detailed requirements of rules and regulations for vessels (see Section 1, Figure 4).

Goal Based Standards (GBS) as defined by the IMO:

High-level standards and procedures that are to be met through regulations, rules and standards for ships. GBS are comprised of at least one goal, functional requirement(s) associated with that goal, and verification of conformity that rules/regulations meet the functional requirements including goals.

The IMO goal based definitions form the foundation for the ABS Smart Function implementation.

5.1 Goal Based Definitions

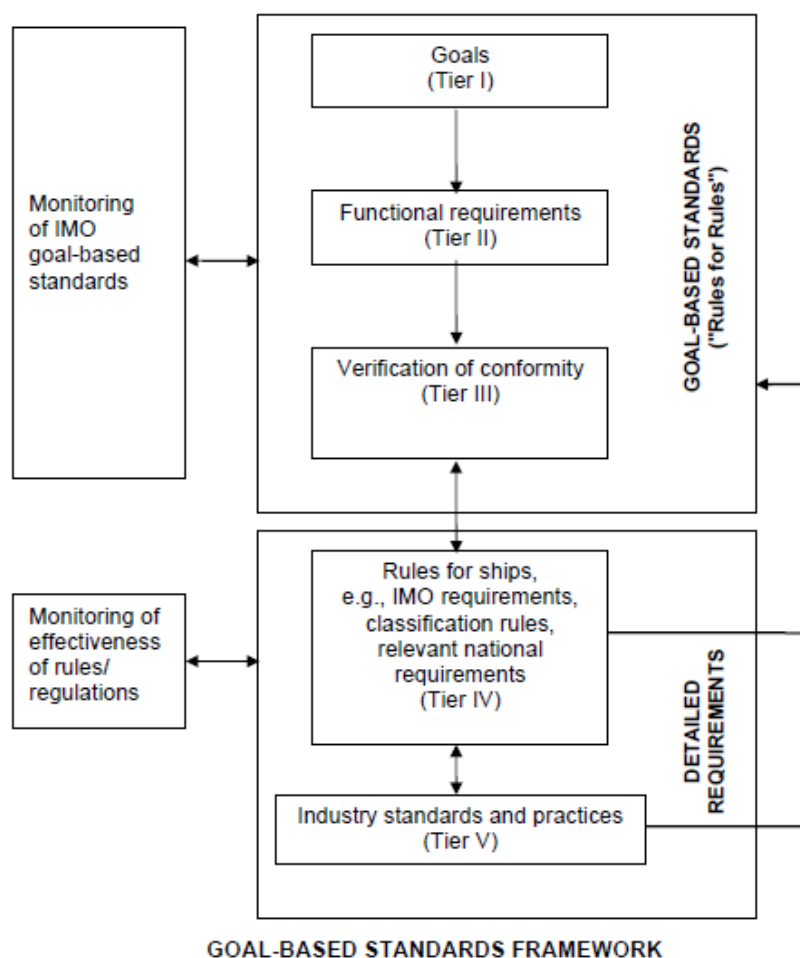
Goals: Goals are high-level objectives to be met. A goal should address the issue(s) of concern and reflect the required level of safety.

Functional Requirements: Functional requirements provide the criteria to be satisfied in order to meet the goals. Once a goal has been set, functional requirements are defined to cover all functions/areas necessary to meet the goal. The functional requirements are developed based on experience, an assessment of existing regulations, and/or systematic analysis of relevant hazards.

Verification of Conformity: Establishes the method and criteria to demonstrate and verify that the Smart Function specification and implementation conforms to the goals and functional requirements. A verification plan should be developed followed by subsequent initial and continued validation that the goals and functional requirements are met. The Smart Function's risk level, assigned due to its potential function failure or under-performance, forms the basis for setting the required criteria for the verification and validation process. A risk assessment of system activities will help map to requirements in existing standards and Rules or determine the need for additional requirements. Safety of the vessel and risk expand beyond just the crew or humans on board, but also to the maritime community that interacts with the vessels.

This document covers Tier I to Tier III as defined in the IMO Goal Based Standard Framework, as shown in Section 1, Figure 4, for Smart Function implementation.

FIGURE 4
IMO Goal Based Standard Framework





SECTION 2 Goal Based Approach for Smart Function Implementation

1 The Vision for Smart Function Implementation

The ABS vision for Smart Function implementation is the enablement of improved decision making by all stakeholders, including both crew and shore-based personnel, to better manage vessel operations in the fulfillment of the vessel's mission.

The vision for Smart Function implementation should support the primary purpose of vessel operations, which ABS considers to be:

Design, Construct and Maintain vessel for planned mission with safety and reliability. Safe vessel operations include the security of life, property, and preserving the natural environment.

Smart Functions, when incorporated on marine and offshore vessels, may support the pursuit of best-in-class results and the standards and regulations for design, construction, maintenance and survey.

2 Smart Function Implementation Goals

Based on the vision statement in Section 2/1 and the premise that Smart Functions, when applied as intended, address and further enhance data-driven optimization of onboard systems and operations, the following goals have been defined for Smart Function implementation:

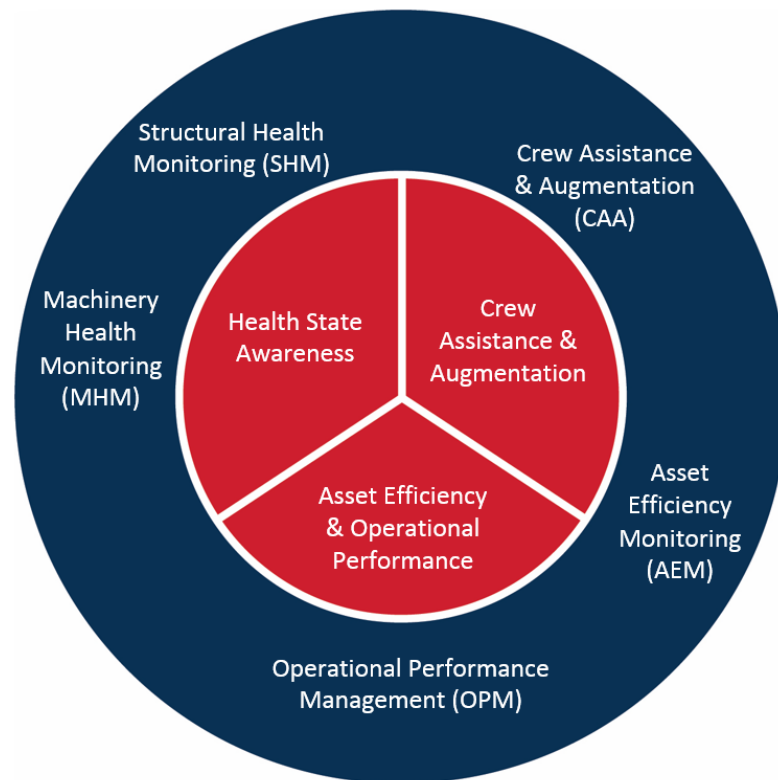
- i) Increase health state awareness in order to enhance safety and asset integrity and to minimize downtime associated with failures and maintenance, via a comprehensive data-driven approach.
- ii) Operate the vessel optimally to maximize asset efficiency and operational performance in order to reduce fuel consumption, emissions and Operational Expenses (OPEX).
- iii) Assist and augment crew with vessel operations related to navigation bridge management/practices and compliance reporting in order to:
 - Enhance vessel situational awareness and navigation safety
 - Reduce crew workload burden and reporting errors
 - Reduce potential for human error related incidents

Smart Functions should be implemented in a secure manner without decreasing the vessel's safety and operability. The implementation of Smart Functions in pursuit of the above goals should not adversely affect the vessel's primary functions and core system operations.

3 Functional Requirements for Smart Function Implementation

Section 2, Figure 1 shows the main and subordinate Smart Function categories and their association with the above defined goals, described in detail further below.

FIGURE 1
Smart Function Categories



3.1 Health State Awareness

The health state of structures and machinery is crucial in determining a marine and offshore vessel's safety, integrity, and operability. Health state awareness is improved via the following two Smart Function categories:

- *Structural Health Monitoring (SHM)*: Monitors structural loads, responses, and health conditions to assess the structural integrity, provide structural health awareness, and help minimize the potential of structural damage and failure.
- *Machinery Health Monitoring (MHM)*: Monitors the health state and operational conditions of onboard machinery and systems to detect operation and condition anomalies and predict the onset of any form of condition degradation and impending functional failure.

For detailed descriptions of SHM and MHM Smart Function categories including objectives, features, employed techniques and outcomes, refer to Appendix 2.

3.2 Asset Efficiency and Operational Performance

Two main factors contribute to the performance of an equipment, system, or vessel during its lifetime:

- The efficiency of equipment, systems, or vessels in performing its function based on inherent design and manufacture characteristics, and the current operational readiness status (presence of degradation and status with respect to prescribed maintenance).
- The operational efficiency of equipment, systems, or vessels to achieve optimum performance through adjustment of operational parameters within the design envelope, system and plant management (human-machine interaction, "behavioral" and operational planning aspects).