ANNEX

A SELECTION OF TERMS RELATED TO AUTONOMOUS SHIP SYSTEMS

The following paragraphs contains a selection of definitions from ISO/TS 23860. The headings group definitions into sections of related definitions. Each definition consists of the term in bold text and after that a paragraph with an explanation and in some cases a rationale for using the selected term.

Automatic or autonomous

Automatic

This is defined as processes or equipment that, under specified conditions, *can function* without human control

Autonomous

This is defined as processes or equipment in a ship system which, under certain conditions, *are designed and verified* to be controlled by automation, without human assistance

Rationale: In engineering, the term *autonomy* has been used to describe the ability of an engineering system to make its own decisions, without the need for the involvement of an exogenous system or operator. However, this is in practical terms indistinguishable from the above definition of automatic. Arguably, the most significant change from today's automation to autonomous operation is that autonomous processes must be *designed and verified* to be operated without human supervision or intervention. This can be exemplified by an autopilot that safely can steer the ship for hours or days, as long as there is a human present that can disable the autopilot to take evasive manoeuvres, when necessary. This, according to these definitions should be classified as automatic. If a new device, including facilities for object detection and evasion, was approved to operate the ship without supervision under certain conditions, it could be classified as autonomous.

MASS and autonomous ship system

Autonomous Ship System

These are the elements that interact to ensure effective functioning of the autonomous and non-autonomous processes and equipment that are necessary to perform the ship's operation or voyage.

Rationale: MASS is a set of interacting elements that can include systems external to the vessel, e.g. a remote control centre, digital communication, etc. It can be operated by a combination of automation systems and personnel that can reside on or off the ship. There may also be additional sensor systems or other equipment on land that are essential for operation of the system. Thus, it is more appropriate to talk about a "ship system" than a ship. Note that this also would allow the acronym MASS to be interpreted as Maritime Autonomous Ship System.

Terms related to control

Control

This is defined as a purposeful action on or in a process to meet specified objectives. *Control* does not preclude that the action is only to monitor the process, e.g. to raise an alarm or to request intervention. Control can be exercised by a human or by automation.

Rationale: The explicit inclusion of monitoring in control simplifies certain other definitions, such as remote control centre. It also captures the inherent responsibility of a human operator "on the loop" to act when it is detected that the automation system does not function properly.

Process

A set of interrelated or interacting activities that transforms inputs into outputs (from ISO 9000). Processes onboard a ship can correspond to functions as defined in the International Convention on Standards of Training, Certification and Watchkeeping (STCW): "Function means a group of tasks, duties and responsibilities, as specified in STCW, necessary for ship operation, safety of life at sea or protection of the marine environment."

Remote Control Centre

A site remote from the ship that can control some or all of the autonomous ship system processes. A remote control centre may consist of more than one control room or stations that may be located at different physical locations. See ISO 11064-3 for a more extensive set of terminology for control rooms and centres. Note that there may be a need for two different definitions to cover this general concept:

1. The control of the ship system processes that are covered by regulations or voluntary codes, and which were normally performed onboard conventional ships.
2. The more general remote operation of MASS, including other tasks as chartering, voyage orders, cargo operations from shore, etc.

Rationale: The term "control" covers both active control and monitoring, hence the preference for control centre. Also, a centre may consist of several control rooms and each room can consist of several control stations, hence the preference for centre. The abbreviation RCC is not included in the definitions to avoid unnecessary confusion with the abbreviation for rescue coordination centre. Defining the preferred abbreviation locally will help to avoid any confusion.

Uncrewed

A ship with no crew onboard. Crew does not include passengers, special personnel, etc.

Rationale: The term uncrewed was strongly supported as a gender-neutral term. Uncrewed is also logical if one considers MASS that may have other persons than crew onboard during the voyage. Thus, uncrewed is a *property* of a ship that can be operated without crew onboard, while unmanned is the *state* of an uncrewed ship when it has no persons at all on board.

Unmanned

A ship with no humans onboard.

Terms related to system capabilities

Operational envelope

This is defined as the conditions and related operator control modes under which an autonomous ship system is designed to operate, including all tolerable events. The operational envelope should cover at least all relevant voyage or operation phases as well as all relevant autonomous ship system processes. The conditions should include geographic or fairway

conditions, environmental conditions, own ship conditions, traffic conditions, division of responsibility between human and automatic control, as well as any other factors that have a significant impact on the operation of the autonomous ship system.

Tolerable event

This is a technical or operational event for which there is a designed response that keeps the system within its operational envelope. A tolerable event includes events that are part of routine operations as well as events that are not considered part of normal operation but occur in practice as a result of different operational contexts (e.g. heavy weather, damage, failures, reduced communications capabilities, operator errors, etc.).

Fallback

A fallback state is a designed state that can be entered through a fallback function when it is not possible for the autonomous ship system to stay within the operational envelope. Being in a fallback state should not result in an intolerable risk

Rationale: MASS will in most cases have both human personnel and automation cooperating in executing the different control functions. The operational envelope (OE) is inspired by the operational design domain (ODD) as defined in SAE J3016:2021. However, as the OE also includes operations under human control, and as the relationship between OE and fallbacks are somewhat different than for the ODD, it has been decided to not use the name ODD and rather call this operational envelope. The term fallback was chosen as the resulting state does not necessarily represent a "minimum risk condition" or an unconditionally "safe state". It is a state that does not represent an intolerable risk, and this can be both in the negligible or in the ALARP (As Low As Reasonably Practicable) risk level regions (see section 4 in appendix 5 of the Formal Safety Assessment Guidelines: MSC-MEPC.2/Circ. 12/Rev. 2). Note that the term "fallback" is also used by the car industry as specified in SAE J3016, and that they define the fallback state as a "minimal risk condition". As "minimal" can be given both a qualitative and a quantitative meaning, this is more similar to the proposed ISO definition, but the ISO group is still of the opinion that a fallback state defined as a state that does "not result in an intolerable risk" is more accurate.

Operator control modes

Operator control mode

This is a working mode, sometimes supported by technology or procedures, that represents the expected class of actions performed by the crew or remote-control centre operators. Modes can be changed during a voyage or operation and/or for specific functions. Four operator control modes have been defined as described in the following paragraphs.

Monitoring

An operator control mode with operations which monitor a situation but do not take any action to influence necessary processes. In monitoring mode, operators may adjust non-necessary processes or equipment to facilitate gathering of information. Monitoring can, for example, be to adjust a system for exclusively human use, such as external lights or cameras, or to inspect equipment or trends in performance parameters.

Strategic control

An operator control mode with operations to issue fleet-wide instructions that implement and, if appropriate, define specific functions to be used by the automatic decision-making units.

Tactical control

An operator control mode with operations to influence the conclusion made by the automatic decision-making units of the autonomous ship for a particular purpose. Tactical control includes, for example, changing the required minimum closest point of approach to other ships or the port of destination and letting the autonomous ship system afterwards construct the avoidance manoeuvre or route itself. It can also be adjustment of a technical alert level, based on prevailing conditions, for example, the time delay in actuation of the bilge alarm.

Direct control

An operator control mode with operations to control a specific function or parameter. Direct control means, for example, that the operator changes a waypoint that would otherwise be decided by the autonomous ship systems directly, or that the operator selects and overrides the machinery standby configuration, such as changing of generator or pump standby status.