Defining levels of autonomy for ships and inland vessels

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The idea of uncrewed ships has been around since the 1980s. With latter year's increasing interest in mobile robot autonomy, the common terms for these ships have become variants over "autonomous ship". One example is IMO's preliminary term: Maritime Autonomous Surface Ship (MASS). However, autonomy is not easy to define and IMO has a preliminary and fairly open definition that states "*[MASS] is defined as a ship which, to a varying degree, can operate independent of human interaction*". There are also problems in defining the difference between autonomy and automation. IEC 60050-351 defines automation as "*pertaining to a process or equipment that, under specified conditions functions without human intervention*". In the car industry, the Society of Automotive Engineers (SAE J3016:2021) does not use the term autonomous at all and refers to "driving automation".

However, the general term autonomous ship has become common in the maritime and inland waterways industry, and it is not necessarily useful to to depreciate it. As automation is already common on ships and inland vessels, e.g. as autopilots or engine automation, it may be more useful to look at the basic difference between today's automation and what is expected to define the new autonomous ship. The main points to consider are:

1. Ships needs many different processes to function, e.g. energy production, stability, fire safety and navigation. Not all of these will have the same level of autonomy.
2. Ships will normally have different levels of autonomy during different voyage phases, e.g. open sea versus port navigation.
3. Ships are expensive and potentially dangerous assets and will normally be supervised by humans, even when they are autonomous or uncrewed. This makes it possible that the remote control centre (RCC) can handle situations that the ship automation cannot handle.

The most significant change from today's automation to autonomous operation is that autonomous functions must be approved to be operated without human supervision or intervention. Today's automation can operate without human intervention, but a crew member is always required nearby to intervene when necessary.

	C2	C1	C0
A2	OA	AC	FA
A1	OA	AC	
A0	OE		

This has led us to propose the following definition for autonomy: "*In the context of ships, autonomy means that one or more of a ship system's processes or equipment, under certain conditions, is designed and verified to be controlled by automation, without human assistance*."

Dependent on the level of human attention, (C0 – none, C1 – periodic, C2 – continuous) and level of automation (A0 – always require human attention, A1 – may operate under certain conditions alone, A2 – can operate without human supervision), we can define a matrix of different combinations as shown to the left.

This allows us to define four levels of autonomy as follows:

- OE (Operator Exclusive) – No autonomy.

- OA (Operator and Automation) – Automation controls the process, but with continuous attention from crew.
- AC (Autonomous Control) – Automation can control the process for a specified period without human attention.
- FA (Full Autonomy) – Automation can control the process for as long as needed without human attention.

In addition, one may have to consider if the ship has crew onboard or if any crew is only in the RCC.

The paper will go into more detail on these issues and describe the basis for certain other definitions that have been proposed in the new ISO/TS 23860 technical specification for autonomous ship systems terminology.