Part III

Interface to enable teamwork between autonomous and manned ships

In the previous part a decision model is described which uses only criteria which do not require communication for an unimpeded voyage. There are however cases in which the decision model can't determine the right strategy. This is often the case due to missing information, or a lack of understanding about the intentions of other vessels. With manned ships verbal communication is used get the missing information, or discuss a strategy with other ships. To have unmanned vessel sail between manned vessel, an interface is needed.

Using the situated Cognitive Engineering (sCE) method, this interface can be developed using an iterative process where a requirement baseline is continuously refined by reviews and prototype evaluations. How to apply sCE is described by Neerincx and Linderberg [Neerincx and Linderberg(2012].

First step is to create a foundation. This discusses the problem to be solved, existing knowledge to solve the problem and the envisioned technology. This together forms the system design specification. Which describes the solution in the form of a system design. This design is finally evaluated.

12 | Foundation

The foundation segment in the sCE methodology describes the design rationale in terms of (a) operational demands, (b) relevant human factors knowledge, and (c) envisioned technologies. Together, these three constituents describe (1) the problem to be solved, (2) the existing knowledge on ways to solve the problem, and (3) the technology needed to implement that solution.

12.1 Operational demands

The operational demands describe the current practice as it is, i.e. without the envisioned technology. For the operational demands, the sCE method prescribes as main components the stakeholders and their characteristics, and the problem description and analysis thereof.

12.1.1 Problem scenario

Convention on the International Regulations for Preventing Collisions at Sea (COLREGs) have been developed long before bridge-to-bridge voice communications became available. They are supposed to be unambigious. It is the responsibility of all bridge watch keepers to know how to apply them instinctively, on the basis of observation primarily by sight and radar. They work effectively when ships in an interaction obey them; they also specifically address circumstances where one ship does not.

However, as shown in the previous parts, are COLREGs not always sufficient to decide on the strategy. For example due to missing information. In those cases the VHF radio can be used for verbal bridge-to-bridge communication. Leading here is the Standard of Maritime Communication Phrases (SMCP). The primary task of this protocol is to diminish misunderstanding in safety related verbal communications. Beside this verbal communication, non-verbal communication might be used, such as light signals, sound signals and semaphore signing.

These different ways for communication are not developed to be used by unmanned vessels. On the other hand, is it not feasible to require all manned vessel to install new systems for communication, before introducing unmanned vessels.

When using the current systems in a way they are not designed for. This might result in information overload of the crew and communication channels. Resulting in misunderstanding and problems with communication. As the VHF can only be used in one way. As it is a receiver or a transmitter, but can't be both at the same time.

12.1.2 Problem analysis

To avoid misunderstanding which could result in hazardous situations. It is important that manned and unmanned vessels are able to communicate. To solve this problem, a more extensive analysis is made. Describing the values of the stakeholders, other actors, and related problems.

Stakeholders

The focus of this research will be on bridge-to-bridge communication. This means the most important stakeholders are the bridges of the manned and unmanned vessels.

- *Officer of watch*. He is the responsible person. He might work together with a helmsman and a lookout. He has to ensure a proper functioning of all available systems. Thereby does he discuss with other crew members if there are any unusual activities. He is responsible to follow a proper navigation plan, while having his own safe passage plan, to avoid collisions. He will use sight, ARPA and ECDIS. Thereby is he aware of the ship's speed, turning circle and other handling characteristics to decide on the right strategy. He will monitor the VHF radio all the time while underway to assist in emergencies if necessary, to hear Coast Guard alerts for weather and hazards or restrictions to navigation, and to hear another vessel hailing you.

  He wants to avoid information overload, while being aware of the situation. This is only possible when he stays concentrated, to acquire this, the tasks must be challenging and he needs to have a form of autonomy.

- *Helmsman and lookout*. Both monitor the situation and execute commands from the officer of watch. They also want to avoid information overload.

- *Crew on nearby vessels*. They might want to know the intentions of other vessels to base their strategy on. However do not want to receive all discussions. As this will result in an information overload.

Other possible actors

- The agent controlling the unmanned vessel.
- Vessel traffic controllers.
- Pilots on nearby vessels.
- Crew on vessels which are not traveling.
- Crew on vessel which are in distress and require assistance.
- Shipowners of unmanned vessels, monitoring vessel from other location.

Information extraction from problem scenario

- Different actors are afraid of information overload.
- Officer of watch is afraid to lose situational awareness.
- Officer of watch is afraid to lose autonomy.
- Current systems not designed to be used by unmanned vessels.
- Manned ships want to ask for support or information.
- Unmanned ships want to ask for support or information.

Goals

The main goal is to ensure reliable sharing of information, without the risk for information overload or misunderstanding.

Problem breakdown

This means that manned vessels should be updated only when requested or in case of an unusual activity which could affect their strategy. And manned vessel should be aware when unmanned vessels desire more information to decide on the right strategy.

Possible situations when communication is needed

- No visual

- Bad weather

- Unreliable information from AIS

Problems that might also be adressed

Communication with traffic controllers. If it is also not feasible for them to have a new system to communicate and direct unmanned ships.

Infeasible solutions

The easiest solution for unmanned ships would be to just install a new system. However this is not feasible, as this would mean that all ships which could encounter an unmanned ship will have to install this too. It might be possible to make it obligatory via regulations, this will however cost a lot of time and money. Making the introduction of unmanned ships less likely. This is also the reason to use a Non-visual User Interaction (no-UI), as a GUI will require new screens or changes to the ECDIS which are only possible when regulations are changed.

12.2   Human factors

When designing technology, there are two driving questions that need to be well-thought out: (1) What tasks and/or values is the user trying to accomplish and how can the technology support the user in doing so?, and (2) How can the technology be designed such that the user is able to work with the technology?

The Human Factors segment of the sCE method describes the available relevant knowledge about, for instance, human cognition, performance, task support, learning, human-machine interaction, ergonomics, etc. Note that we emphasize that this knowledge should be relevant for the problem and its design solution: the knowledge described here should lead to a better understanding of either (1) or (2).

The three constituents important to the human factors analysis are: (a) the human factors knowledge, (b) measures, and (c) interaction design patterns.

Human factor knowledge

Human factors knowledge describes available knowledge coming from previous research about how to solve the problems that have been identified in the problem analysis.

- Which information is needed to have situational awareness? [Rothblum et al.(2002] [Breda and Passenier(1999] [Prison et al.(2013] [Hodgetts et al.(2015] [Porathe et al.(2014]

- When does information overload occur? [Arimura et al.(2001] [Neerincx(2008)] [Schutter(2016)] [Porathe et al.(2014]

- What is more effective to ensure a feeling of autonomy? [Feys et al.(2016]

- How is information perceived if it is being pushed or pulled? Thus listen to radio with continious information (repeating), or only send message when asked for

- What are the expectations of a human from an unmanned ship?

- Do people trust automated systems in emergency situations? [Neerincx(2008)] [Walliser(2011)]

- ...

link papers to questions and answer

Human factor measures

Measures describe how to operationalise the quality of the intended behaviour or performance, i.e. how well is a user working with the design able to reach his/her objectives and what is the quality of the collaboration between the human worker and the technology?

- Is the system used correctly?

- Does the interface give reliable information?

- Will it solve the problem of missing information?

- ...

Interaction design patterns

Interaction design patterns (IDPs) focus on the human-computer interaction, such as usable interface design and control options. IDPs offer generic solutions to recurring HCI design problems that have been proven to be effective. IDPs are often made available in repositories.

- Auditory alarms

- Distress, urgency and safety signals

- Usage of message markers

- Chatbot

- Natural language variations on SMCP

- Light signals

- Sound signals

- ...

12.3   Envisioned technology

The envisioned technology describes the available options of using existing technology and/or the need to develop novel technology in order to come to a system solution. The sCE method asks designers to specify what devices (hardware) and software could be used in the system design. In addition, for each type of technology, an argument should be provided as to why this technology might be of use and what the possible downsides might be of that particular type of technology.

Using only existing systems to develop a Non-visual User Interaction (no-UI). These existing systems are described in chapter 1.

- Visible signals

  - Positions

  - Change of heading

  - Light signals

  - Flags or symbols

- Availability on VHF

- Exchange of information via AIS

- Horn

Thereby is it easier to learn when its based on known protocols, such as Standard of Maritime Communication Phrases (SMCP) and COLREGs.