Intuitive operation
and pilot training
when using marine
azimuthing
control devices

AZIPILOT

Report Title:

Deliverable 3.4:

Review of Bridge Systems and the Human Interface

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Publishable Executive Summary

The objective of this task 3.4 was to complement the work performed in 2.4 by surveying the use, perceptions and satisfaction with bridge systems using ASD control devices. Once again, interviews with masters having experience using the ASD system proved invaluable. As such the methodology employed was a series of interviews supplemented with technical knowledge concerning human performance.

The work revealed the following:

- As identified in 2.4, different types of vessels have different type of pod systems and the larger vessels appear to have more information available to the user. This can be seen as a challenge to a pilot visiting the vessel.
- Instructions for ASD use vary and often the greater the explanation on how to use the system, the greater the difficulty in use, due to the cognitive workload.
- Direct drive pods appear to be easier to use
- Users often have a feeling of becoming disconnected from the operation. With conventional ship handling, mariners often experience a “feel” of how the ship responds with engine and helm configuration. This can be initially lost with the use of ASD system and immersion in the system use seems the only solution.
- The human element should be examined more closely. As an example, the concept and perception of workload can play a role in performance. The individual’s attitude towards automation (acceptance or rejection) and the assumption of “The vessel is doing what I want so the configuration must be OK”, may not be entirely accurate. When confronted with emergency situations, most automation can be switched back to a manual mode and the user can thereby stop the automation process. This presents a challenge when using ASD propulsion.

The conclusions reached centred around a number of factors. Firstly, a simplified standardized explanation of operation would be most useful, such as a pilot manoeuvring card. Secondly, individuals should be trained on human resource management to help integrate into the bridge team and thereby create an optimal working environment. In most, if not all cases, the marine pilot will be at a disadvantage when it comes to user knowledge of the ASD system. This is a clear opportunity for the bridge resource management skills (BRM) to be exercised, not only in normal operations but also in emergency situations. This should be seen as a necessity in order to minimize the inherent risks.

Task 3.4 Review of bridge systems and the human interface

Introduction

This task report according to the WP documentation involved three parties, BSM, FORC and STC. To date contributions have been received from two parties BSM and STC.

Responsibilities of each were as follows:

BSM
Through the use of a survey, compare the intended use and actual use of dedicated bridge systems.

FORC
Survey the perceptions regarding the advantages and disadvantages of automation for the steering control of azimuthing controlling devices.

STC
Discuss perceptions of the value of automation in emergency situations explore correlation.
Explore the correlation between perceived and real emergency situations specific to the automation of azimuthing control devices

The BSM contribution consisted of a series of questions posed to an experienced ACD operator. The questions revealed the following:

- The larger vessels appear to have instruction guides on the ACD use
- Direct drive pods appear to be easier to use
- Some pod designs are more difficult to service than others
- A challenge exists with the human interface and pod operation

The STC contribution involved an investigation into human perceptions of automation and identified various factors involved in apparent workload situations. Coupled with emergency situations this highlighted the challenge to the user cognitively and physically. In the conclusion, suggestions were made to help address this problem.

Item (1): "Through the use of a survey, compare the intended use and actual use of dedicated bridge systems."

Introduction

The observations in this section were a result of comments made by a Master familiar with the ACD system in association with colleagues and is submitted on behalf of BSM.

Observations

Intended use and actual use of the bridge systems / Here it depends a lot on what kind of ACD-system you have onboard. It seems that it is much less trouble with the systems that have ”direct drive”(shaft driven pods). Compared to the vessels with ”diesel electric” driven pods. Where there are much stronger forces involved, while manouvring.

The big passenger vessels which are equipped with PODS, they have much more detailed instructions / limitations, in how to operate the pods. Than the smaller vessels with PODS, where there seems to be hardly any written instructions / limitations.

Another issue here is the brand of the PODS. Some manufacturers have had more problems with the construction of their POD systems, than others. Which have consequenses for the ”end user”. Less problems means less detailed instructions / more problems means more detailed instructions. And at the same time more complicated to use.

Conclusion: The more instructions and detailed limitations in how to operate the POD:systems / The more difficulties with the ”human interface” between the operator and the system.

This also means that he or she needs to concentrate to much on the system and less on the most important thing, which is to manovre the vessel in the safest way possible.

The human interface need to be as intergrated as possible. So that the ”feeling” between the operator on the bridge and the vessel, is as if they were ”one” and not ”different parts” in the same body.

Item (2): “Survey the perceptions regarding the advantages and disadvantages of automation for the steering control of azimuthing controlling devices”

Introduction

The observations in this section were a result of comments made by a Master familiar with the ACD system in association with colleagues and is submitted on behalf of BSM.

Steering ASD tug

Steering is understood as handling on the ASD tug
To clarify the meaning of this question, “steering” is in the following text defined as being the same as “controlling” the azimuth propulsion systems controls and thereby *handling* the tug. In the maritime world the word “steering” is most often understood as maintaining a certain course or heading or changing/adjusting from one course or heading to another.

ASD (Azimuth Stern Drive) tugs, which Force have focused on in this project, are course unstable and therefore have to be “handled” constantly to get the tug moving in the desired direction. Therefore we find that it makes more sense to understand the word “steering” in this question as *handling*. Therefore the question can be rephrased to: *“Survey the perceptions regarding the advantages and disadvantages of automation of ASD tug handling”*

Perception of automation of ASD tug handling

In general the question of developing, installing and using any automation on an ASD tug is a complicated matter where many considerations need to be made. For a better overview of the complexity of choosing automation or not and choosing the correct level of automation to avoid pitfalls the reader is recommended to read chapter 2.4 and the contributions from STC in this task, 3.4.

As discussed in the reporting of task 3.3 in this project data from interviews, observations and questionnaires (please see chapter WP 3.3) there seems to be an agreement among expert captains, instructors, experienced and inexperienced navigators that automation on an ASD tug is only second best to proper manual handling of the controls when performed by an experienced navigator.

Only during transit voyages and “traditional” navigation (maintaining certain courses for a longer period of time on route) is automation seen as an advantage. Besides these examples automation is seen as something a captain or mate on an ASD tug would only use if he did not know how to handle the individual azimuths (individual controls) well enough manually.

In our facilities we have seen examples of this when crew from conventional tugs have been put on newly purchased ASD tugs without any preliminary training in a simulator or on board by an experienced training captain.

We do not have any experience of any existing automation for ASD tugs resulting in better or safer performance than an experienced captain or mate is capable of[1]. This has also been confirmed by navigators that have used automation systems on ASD tugs before training at our facilities. After having gone through just a small amount of personal training with our expert ASD tug master and instructor they definitely believe they will be able to handle the tug much better and safer manually than by using any automation system they know of.

We must however still refer to received comments from novice and expert users (captains and mates) which say that if automation of more difficult sub tasks of tug handling – for instance "side stepping" could be performed safely and totally reliably by an automated system they would find it useful in some situations.

Some captains have actually had positive experiences with joystick control but also clearly remember the difficulty of keeping these systems perfectly adjusted and calibrated. They say that services from systems experts from shore have often been needed for continuous adjustments and calibration in order to keep the system working properly.

The following part of the interview made with the expert ASD tug master gives a good impression of the perceived utility of any known automation and safety system among the professionals:

"B: I think that they mean joystick. Some systems have what you call a micro pilot as they call it from Aquamaster – installed. You can with this system control it in different modes; if you are sailing back or forth and turn or sidestep. But we have had mechanics coming to adjust it all the time everyday and several days! And my experience is that a captain with just one year of experience is a lot better at handling the vessel than the aqua pilot. As of yet anyway. I can also tell you that some come to us and say that they already have ASD experience because that is the propulsion system they have on their vessel. But as the ones we just had this week from Lisbon it turns out that they sail using the joystick and therefore they do not have the same control of their vessel at all.

I: What were the officers you just had on course this week?

B: Two of them were tug boat captains from Lisbon. They had been operating their azimuth tugs. But they do not have the individual control of each of the azimuths. They have a joystick and some kind of combined system which means that they can not set the azimuths to each side. The system automatically reduces the revolutions when the azimuths are turned. This means that the very efficient method we use in transverse arrest where we put the propellers to each side 90 degrees from the moving direction can not be used on a tug like that. This way of stopping means that with a tug like this with 60 tonnes of bollard pull static. But if we make a transverse arrest we can come above 100 tonnes of brake power.

I: So that is very efficient in some situations when tugging?'

B: Absolutely. I have done that a lot. "

(Interview, p. 17)

[1] Eexcept for autopilot. But the autopilot is generally not used in tug work.

…and:

I: When we talk about safety devices which could be some kind of combined use of the azimuths. If you think about something that could be of an advantage regarding safe operation of azimuths what do you think of?

B: Well I think training is the one thing that can do the most for the safety. That is the most important. The next is the quick release mechanism on the winch where we can let go the line. And the other is the release hook after if we have something made fast aft. These are the two most important things.

I: Is it possible to imagine some combination of an automatic mechanism regarding the manoeuvre of the tug or adjustment of the controls (some optimization)?

B: No – not really. What we must keep in mind is that we often have to give the maximum pull on the line that we possibly can. You can in fact say this is the criteria for success. Something that would release it at a certain force that would be completely opposite to what tug operation is all about. Much of the safety is build into the line you choose to fit on your tug. This line is calibrated to fit the effect of the tug and so on. If you are at the limit where the tug is in danger then the line must break. So the dimensions of the line is tailored to the limits of the tug. That may be from an economical perspective but it is some sort of a safety measure. It is generally very important in the tug business that you follow the procedures that exists. That you ensure watertightness and so on. So that the vessel actually can stand lying on its side – as it is supposed to be able to withstand and come back up again. Building in of any automatic measures is hard to imagine because the kind of work you have to do with the tug is about operating on the "crazy" side of what many would consider right. But that is what tugs are for.

(Interview, p. 18)

Conclusion

Ending up where this text started, at the definition of the question, the conclusion from the data Force has collected throughout this part of the Azipilot project is that the most widespread - and at the same time reliable - automation feature on the ASD tugs, that has anything to do with the control of the azimuths, is actually the autopilot. But the autopilot is only a very simple automated system that can not "handle" the tug. It can adjust the azimuth propeller angle (or azimuth) in order to maintain a by the navigator preset course (sailing direction). It can therefore be used for "steering" the tug but not *handling* the tug. It is an important and widely used feature for the long "legs" on a voyage and in navigation and situations where the tug is just another "normal" vessel. But it is never used during any tug work, especially not if the tug is connected to (or in physical contact with) the vessels it assists. Further more automation of certain sub task of ASD tug handling is welcomed by the professionals but it most prove safer and more reliable than the known systems already available.

References

Questionnaire
Interview with expert ASD tug master
(Please see these documents in their full length in the annex to chapter 3.3.5 & 3.3.6)

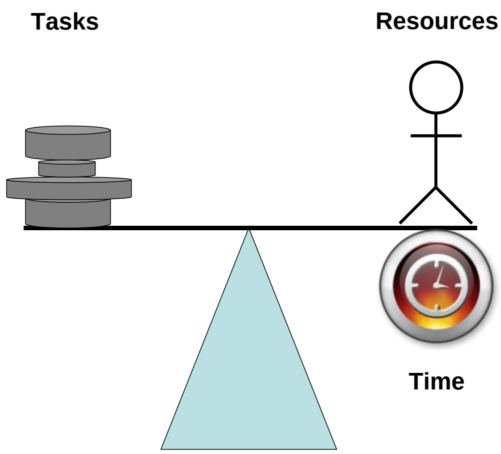
Item (3) – "Discuss perceptions of the value of the automation in emergency operations"

Approach

To address this WP task we must consider a few elements. To begin we should discuss perception as a stand alone topic, likewise the value of automation and finally these elements during emergency operations.

Perceptions

Our perception of events and situations has an impact on our performance and how we approach a situation. One's perception or how we feel about something will affect our attitude towards it and thus our behaviour. Our perception of a situation can be greatly affected by our workload at that time. When we discuss workload we need to differentiate between actual workload and perceived work load. Our workload is a balance between the task and our resources within the perceived amount of time available. Deficiency in resources or time, or too high a task (demand) will be reflected in our workload or our perceived workload.

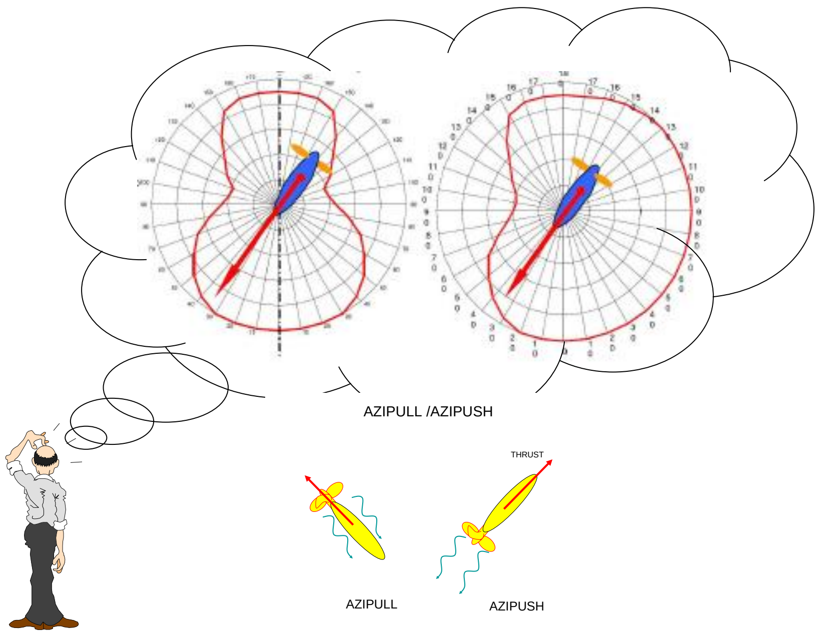


For our discussion we can consider the difference between actual and perceived value of an appliance such as the propulsion ACD system. If in the start situation or in a period where there does not exist an emergency, a negative perception of the automation exists, this will be amplified during the period of an emergency when the stress level can be expected as higher than previous. For this reason it is important that the navigator initially perceives the automation item in a positive light.

Automation

In order for automation to be experienced as positive, it must bring added value to the team unit or the individual's task. This so-called value is only realized providing it does not increase the workload on the individual or team during not only normal operations but also emergency situations. The individual must always be able to manage the amount of automation and be in control of the level of automation employed.

A consideration with respect to human interaction with automation is that humans tend to make decisions based on experience. Aside from understanding the workings of the individual unit and the input – output relationship, humans rely on an experience factor which can only be gained with prolonged use under a variety of situations. This puts the new user or in this case the harbour pilot at a disadvantage.



An extra challenge when using an ACD system is it is easy for the new user to mentally revert back to the older more familiar understanding of the conventional arrangement. Finally, there is extra cognitive requirement on the user. Though he/she will know how they want the vessel to react, they have to understand how to apply this new arrangement, employ it, observe the response, correct if necessary, then link their action to the perceived propulsion arrangement. This is not the easiest of tasks even in a normal situation.

Finally, we should reflect upon a challenge and response environment when dealing with automation. Many can easily see that a challenge of learning new equipment exist here. What may not be so apparent is that during the operation of a new system, the response of a given command introduces challenges to the user. For example if the user gives a specific command and the vessel responds in the correct way the user may not always challenge him/herself with the understanding of the configuration. A common human challenge error, "I'm not sure what I did but it seems to be working" can be experienced. This can be linked to a workload situation and the amount of time available to explore the propulsion arrangement and his/her understanding of the system.

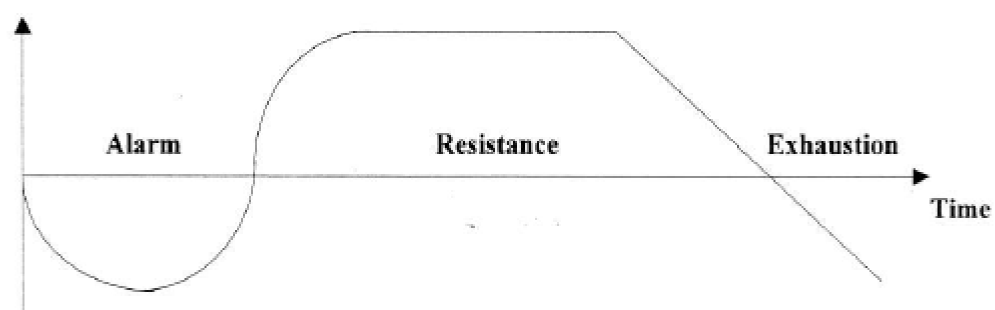
Emergency operations

Up to this point we have considered purely perceptions and automation under normal situations and the impact, use of a new propulsion system has upon the individual and his/her response. To enter into discussion about ACD in emergency situations we must first investigate the definition of an emergency situation and the effect upon the individual. Only then can we integrate the impact the ACD will have on the event.

An emergency situation is an event which happens out of the ordinary. Without going into great detail of psychological impact on the user it can be appreciated that there are a host of possible effects upon the individual ranging from "IQ dump" where the individual is momentarily paralysed to a response at the other end of the spectrum where he/she reacts quickly and efficiently.

Some persons' reactions to stress can be reflected in the schematic below. The first phase "alarm" can in some cases be met with low activity or no activity and what can be referred to as an "IQ dump". As the individual adjusts to the situation, activity increases as they enter into the resistance phase, coping successfully or unsuccessfully for a period of time. Prolong exposure to this phase will result in exhaustion of the individual where he/she will no longer be able to function properly.

Three stages in adjusting to stress :



When we consider an optimal reaction to an emergency situation (for which we have no established procedure) we can refer to a model for guidance. One such model refers to development of a short term strategy (STS) and is typically used when an event out of the ordinary occurs. This is applicable in emergency and non emergency situations. A STS employs a number of steps with no specific time limit for each. Development of an STS can either take a minute or much longer depending upon the time and resources available. There are several steps when producing and executing a complete STS but for our discussion we only need to investigate the first two important steps.

1. Identify the problem

Though this must seem academic in nature, the real problem at hand may not always be readily apparent. The developers of the STS must be able to detach emotion or perceptions from the event. As an example: loss of steering and subsequent drifting towards a shoal may be viewed as a steering challenge. However it may be that the first priority is to halt the movement towards the shoal. In this situation the priority is to stop the vessel rather than focus on regaining steering. This could be accomplished by engine manoeuvres or even dropping the anchor if this option exits.

2**. Build plans to deal with the problem**

Once the problem is identified, plans must be developed with all team members available. Development of a plan relies on a shared mental model of the situation. With dealing with persons of varying experience, this can present problems. For our study we can appreciate that the master of the vessel will have a better and greater understanding of the ASD system arrangement. So, rather than add to this shared mental model of problem and solution the pilot may find him/herself at a disadvantage.

Discussion

We can combine the elements previously discussed to appreciate the challenge which is presented to the pilot upon an encounter with the ACD. It bears mentioning at this point that we have not discussed in detail the possible permutations of such a system. As examined in other work packages the ACD system can be in a push or pull arrangement, allowing full rotation of the drive. What also must also considered is that the blades themselves can be of variable pitch design such that a pull arrangement become a push and rotation of the drive can reverses the situation once again. Connected to this consideration of what might be the optimum arrangement not simply whether push or pull is utilized but also of the given pitch of the blades.

Our perception of the value of such an appliance will depend on the factors discussed above. Perception aside, the value of such an appliance during an emergency will depend upon its ease of use, a general understanding of the unit operation by the team members and its value towards a solution.

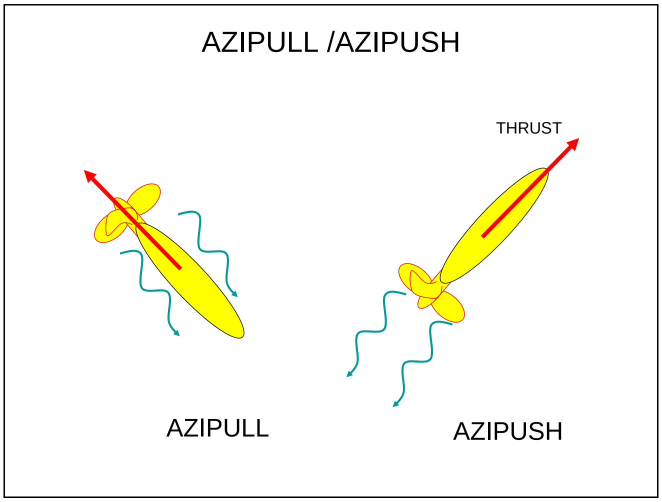
Item (4) – "Explore the correlation between perceived and real emergency situations specific to automation of azimuthing control devices"

Approach

Item 3 discussed earlier investigated the topic of perception and of perception and reaction of individuals and team units in emergency situations. To complete the task for this work package we will focus on automation of the azimuth control devices in emergency situations. A number of combinations on arrangement are offered to assist the reader in understanding the complexity of arrangements possible.

Automation of azimuth control devices

As identified in earlier work packages, standard arrangements exist for ACD propulsion. ACD systems are either of push or pull design as illustrated below.



The system itself has full rotation thus the direction of resultant thrust is understood properly only if direction and arrangement can be processed by the user. This can at times be challenging, in the best of situations. Some arrangements have an added component in that the blades can be of variable pitch arrangement. As can be imagined what was once a pull arrangement can now become a push. With variable pitch we have until now assumed the pitch is the same for both, but this may not necessarily exits. The user can also have on ASD on a forward pitch and the other on an aft pitch.

What may have been anticipated as an element of added value becomes a challenge for the user to maintain a visual picture of expected results as a result of a specific action. Inability of the user to correctly apply an understanding of the configuration, command and response can place the operation in a position of unacceptable risk. The combinations of possible arrangements, tasks the user with an excessive workload, at least in the early learning phases. Education and training will be necessary to minimize the inherent risks.