Explorative study
towards supporting dredgers' control work

By HoloLens

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Appendix

TABLE OF CONTENT
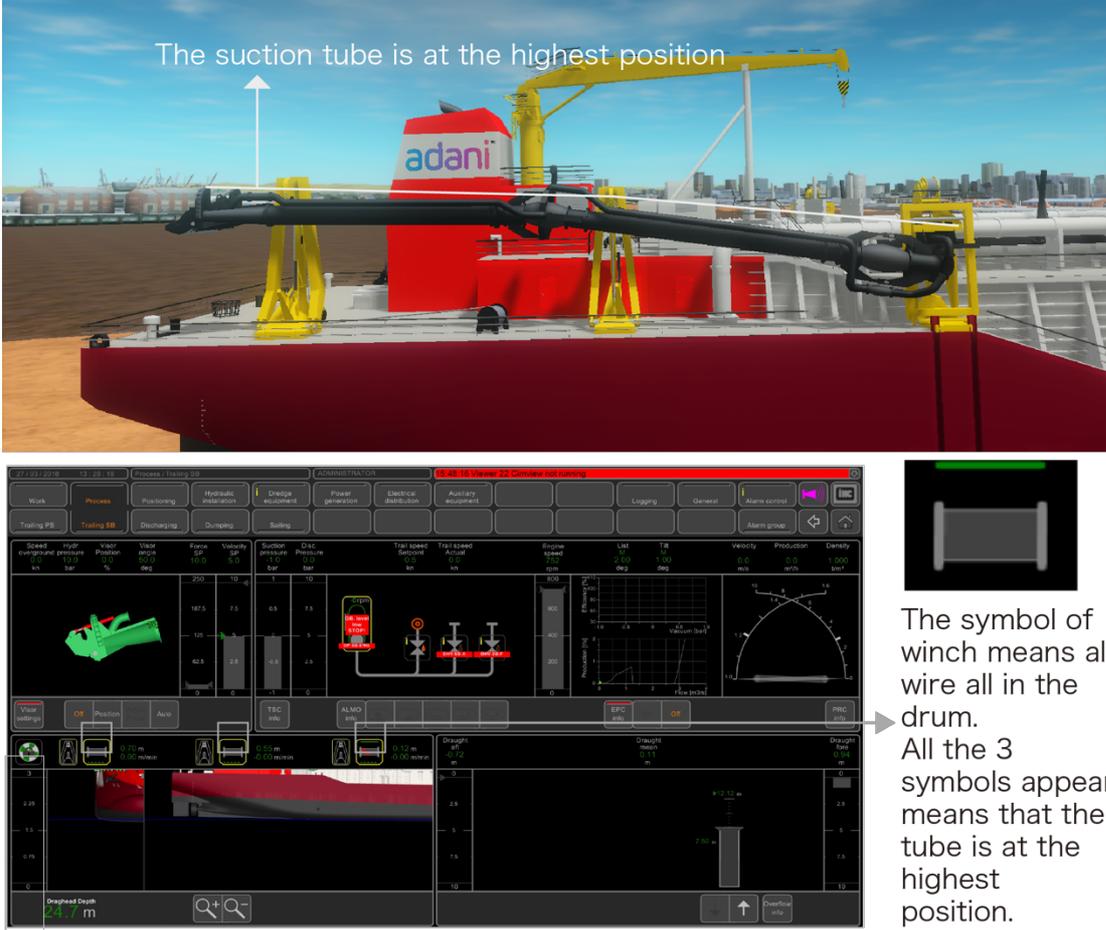
Appendix 2. Task analysis

Task. 1.1

Figure 1: The real situation and system interface illustration of Task 1.1

The figure 1 shows what the suction tube are at the highest position. It means there is no wire left of each winch drum. To complete the task, the operator has to lower the suction tube by controlling winches. The drag head winch and intermediate winch are controlled by joysticks. The trunnion winch is controlled by buttons. The operator controls the winches and observe the symbol of winches on screens. The figure 1 also shows the symbol that indicates the tube is at highest position. Meanwhile, the operator also looks outside to see the real suction tubes moving.

Task 1.2

The figure 2 shows what the gantry is and what means moving gantries outboard. For doing this task, the operator should press the "out" button for gantries on control chair. Then the operator should observe the symbol of gantries on screen in front. The operator should stop pressing the button when symbol changed to the right one. The figure 26 shows how the symbol looks like and the changing process of the symbol. Meanwhile, the operator also look outside
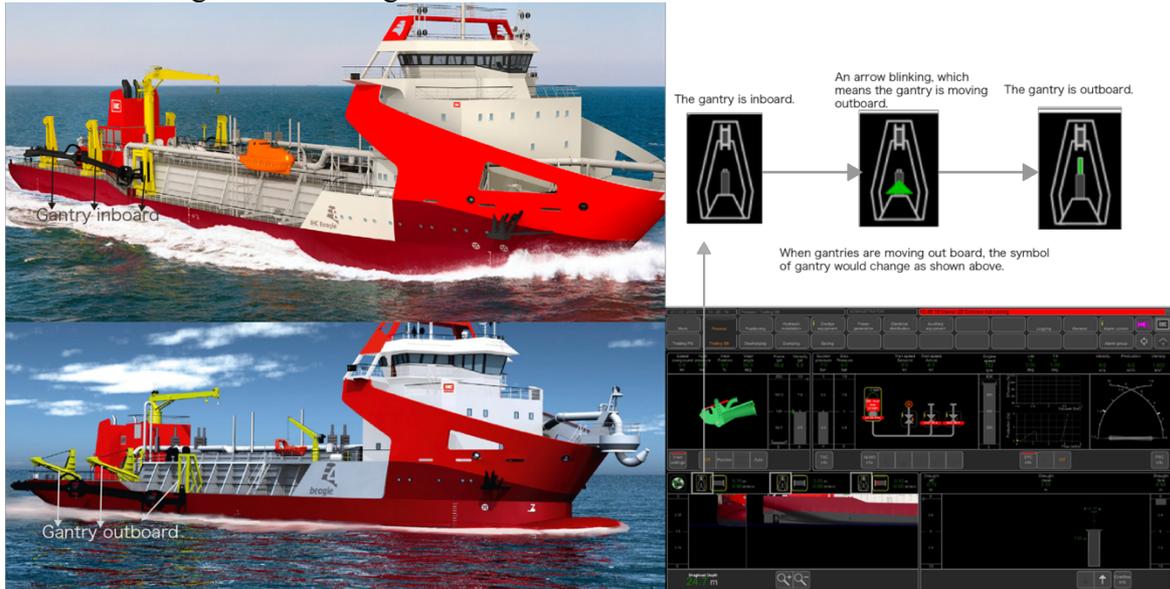
to see the real gantries moving.

Figure 2: The real situation and system interface of Task 1.2
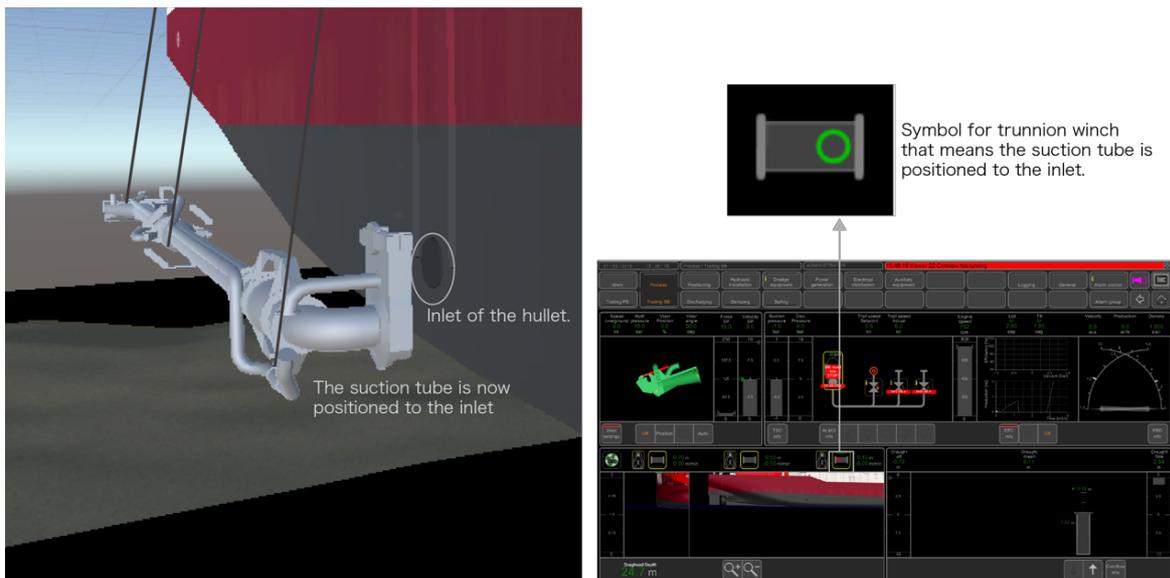
Task 1.3

Figure 3: The real situation and system interface illustration of Task 1.3

The figure 3 shows what suction tube is positioned to the inlet. To complete the task, the operator has to lower the suction tube by controlling winches. At the same time, the operator should observe the symbol of trunnion winch as well as the spatial shape of the suction tubes. The figure 27 also shows the symbol which means the suction tube is positioned to the inlet.

Task 1.4

Symbol for trunnion winch that means the suction tube is attached to the inlet.

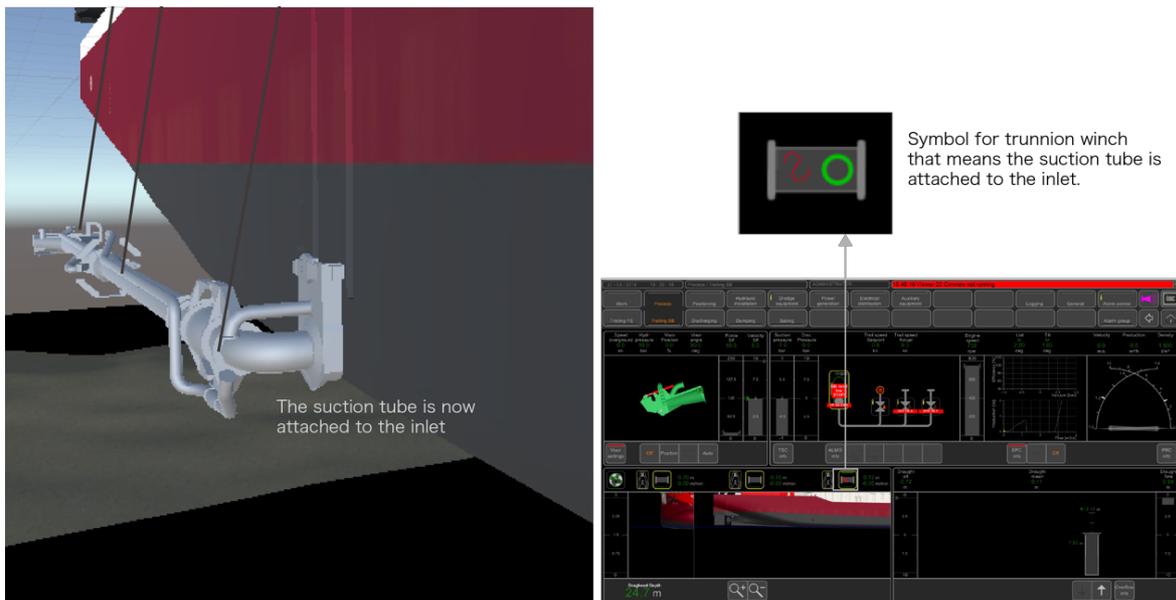The suction tube is now attached to the inlet

Figure 4: The real situation and system interface illustration of Task 1.4

The figure 4 shows what means the suction tube is attached to the inlet. To complete the task, the operator just has to wait until he observes the right symbol of trunnion winch appear. The figure 4 also shows the symbol which means the suction tube is attached to the inlet.

Task 1.5

The operator observe the spatial shape of suction tube and the distance between drag head and seabed via system.

The symbol of intermediate winch means that there is no more wire on the drum.
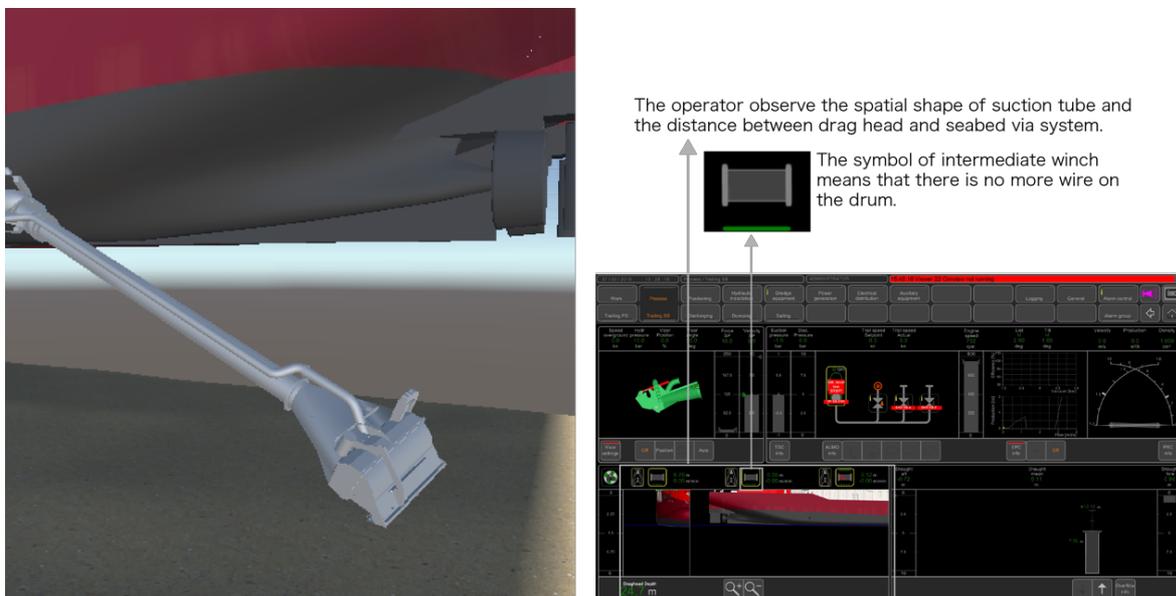
Figure 5: The real situation and system interface illustration of Task 1.5

The left of the figure 5 shows what means the drag head is placed on the ground. To complete the task, the operator has to lower the drag head by controlling drag head winch and intermediate winch. At the same time, the operator should observe the spatial shape of the tube, the drag head depth and the symbol of intermediate winch on screens. If the symbol in the right of the figure 5 appears, there is no more wire of intermediate winch drum. The angle between the upper part of the tube and the lower part of the tube should not be too small. Otherwise, the

tube would be broken. The tube should not be placed under the vessel itself. This would ruin the tube as well.
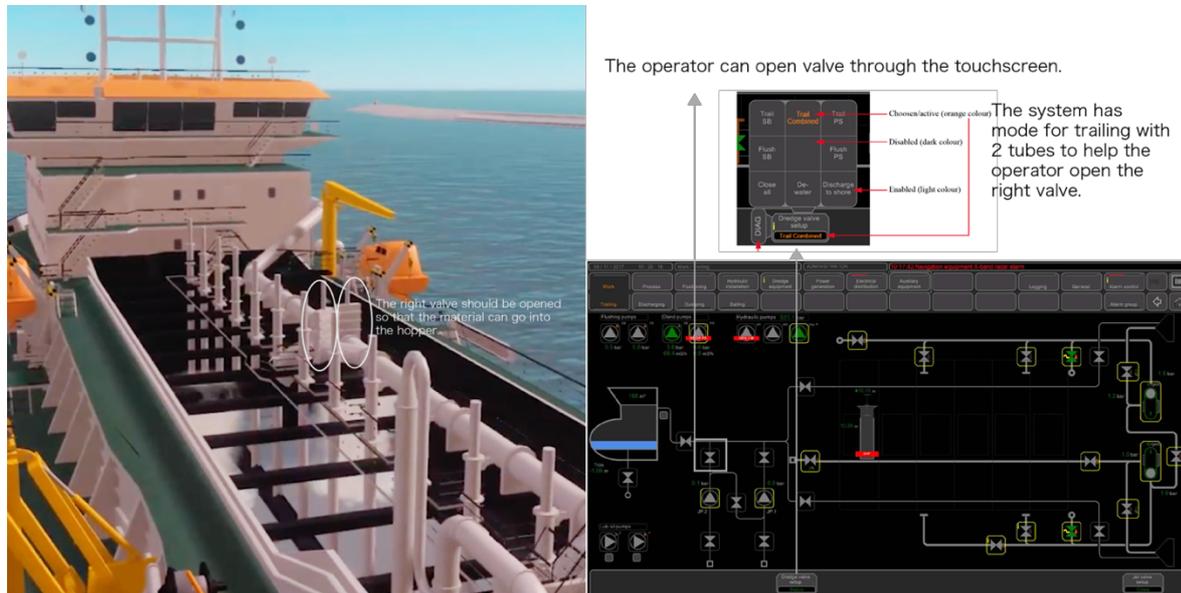
Task 2.1

Figure 6: The real situation and system interface illustration of Task 2.1

The operator should open the right valves that the soil sucked up through suction tube can be transported into hopper (Figure 6). The operator control valves via the touchscreen (Figure 6). The software has dredge valve setting for different condition.

Task 2.2

The operator should open the dredge pump via touchscreen.

Task 2.3

The operator should monitor the spatial shape of suction tubes and its productivity. The operator needs to adjust the suction tubes and other dredge equipment for high productivity and safety. The suction tube should suck up the soil and water together. The productivity is affected by velocity and density of this mixture. High velocity and density would create high productivity. The operator should adjust velocity and density to have high productivity by adjusting the drag head depth and parameters of other equipment to affect velocity and density. The operator should also monitor the spatial shape of the suction tubes. Especially when the suction tube is intended to come under the vessel, the suction tube might be damaged. (For detailed analysis of all the parallel tasks, see in Appendix A.)

Task 2.3.1

Figure 7: Cross needle indicator

Visor

Visor is one of the component of drag head. The visor can control the mixture of water and soil. The position of visor can be chagned to change the velocity and density of mixture.
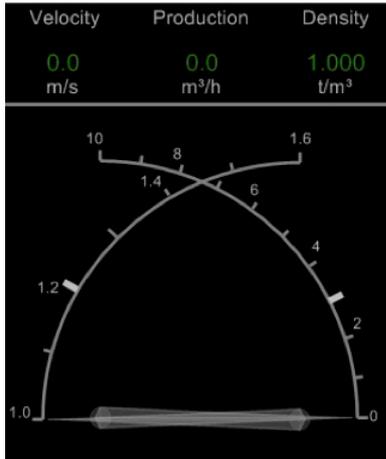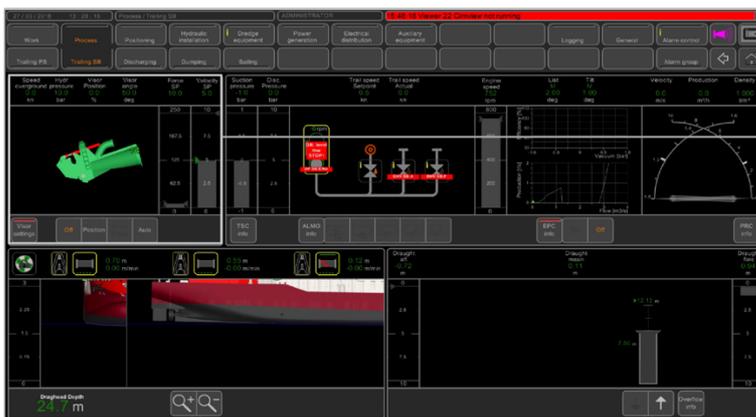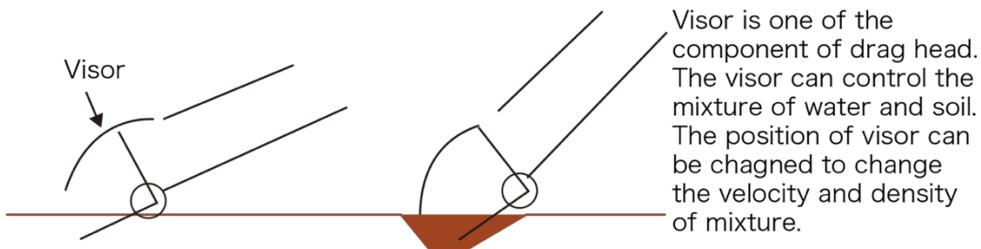

There are automation function that automatically control the position of visor to get high productivity.

Figure 8: The function and control of visor

Swell compensator
The swell compensator is used to control the contact between the drag head and seabed when dredging in waves. The swell compensator also help maintain a certain dredge wire tension on the winch drum.

The operator see the pressure level of the swell compensator from a bar. The swell compensator can be locked by the button on the drag head winch joystick. Then the swell compensator would not work.
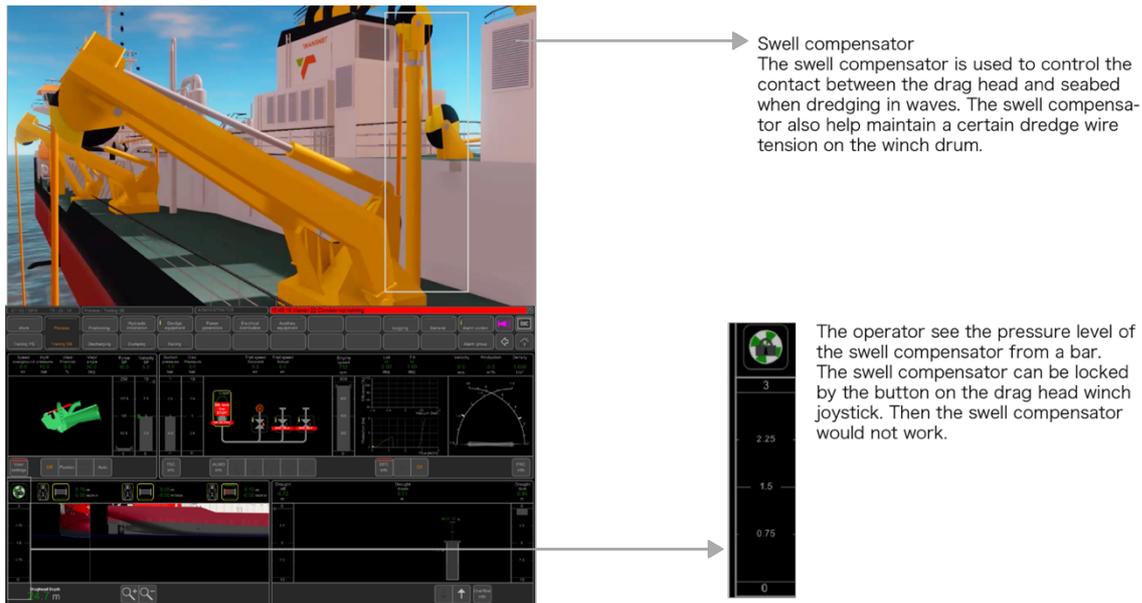
Figure 9: The function and control of swell compensator

The operator should adjust velocity and density to have high productivity. The suction tube should suck up the soil and water together. The productivity is affected by velocity and density of the mixture. According to Royal IHC, the dredge operator prefers to present the value of velocity and density on a cross needle indicator (Figure 7). It has become customary to use this cross needle indicator for years (Royal IHC, 2018). When velocity is high while density is low, the drag head must be stiffer on the ground or visors (see explanation of visor in the figure 8) need to dig deeper or swell compensator pressure (see explanation of swell compensator in the figure 9) should be lower. When velocity is low while the density is high, the visor should be higher or the drag head could be lift up. There is automatic visor control function on Beagle. The function would control visor in order to achieve the highest productivity. The spatial shape of the suction tube also affects the density as well.

Task 2.3.2

The operator should also control drag head winch according to the swell compensator. The operator sees the bar on the screen shows the pressure level of swell compensator of each tube. During dredging, ideally the operator wants to have the stroke of the swell compensator cylinder 50% out so that when the vessel is moving up and down in sea swell the drag head maintains on the sea bed in order to continue the production process. Once the swell compensator stroke reaches let say 80%, the operator needs to hoist the winch and when the stroke reaches 20% the operator needs to pay out more wire length. Once the swell compensator is still far out, the operator needs to pull in timely through a button on the winch joystick.

Task 2.3.3

The operator should monitor the spatial shape of the tube. when the suction tube intends to come under the ships keel, the suction tube might be damaged. In that case the operator needs to hoist the winches to clear the suction tube. The operator also need to pay attention to the

spatial angle between the upper tube and lower tube. The angle should not be too small otherwise the suction tube would be broken.

Task 2.3.4

The operator could also change other parameters to increase the productivity such as the sailing speed.

Task 2.3.5
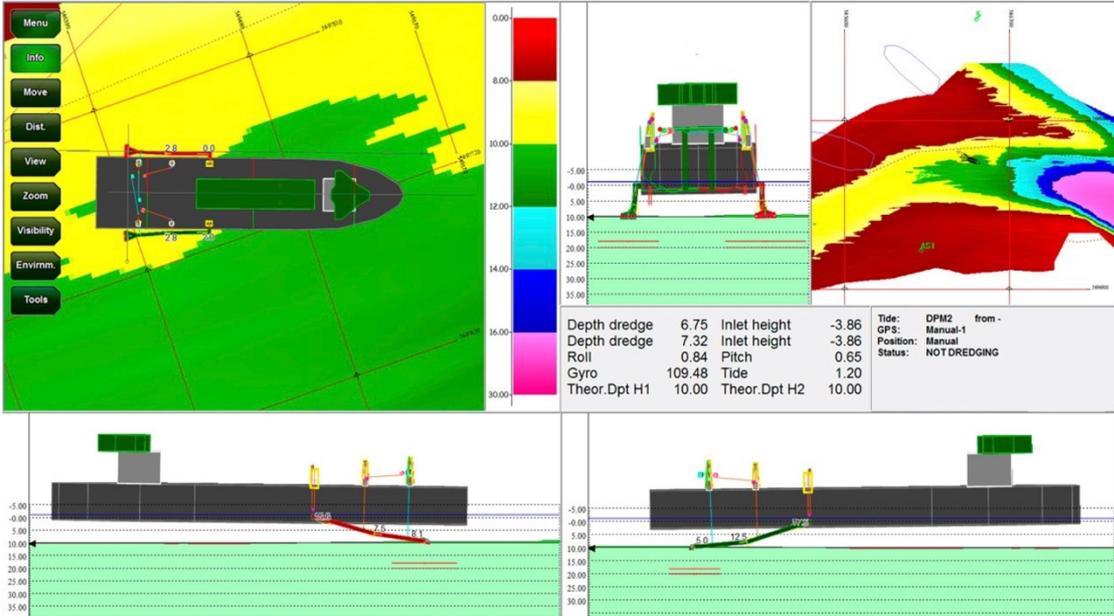
Figure 10: The interface of DTPS

The operator should check the overall state of the vessel in the water through DTPS(Figure). The interface is shown on the upper left screen (Figure 10) in dredge operator cockpit. The bottom side of the figure 36 shows that the vessel is unbalance in the water. If the vessel is unbalance, the operator should change valves to balance the vessel.

Task 2.4

The operator should be informed by navigational officer to stop dredging and close dredge installations.

Task 2.5

The overflow is positioned in the cargo. The soil of mixture sucked up would sink down. The operator can drain excess water on top by lowering the overflow.

The operator can easily adjust overflow via touchscreen.

Figure 11: The function and control of overflow

The function and control of overflow is explained in the figure 11. The operator should control overflow to get rid of the extra water. The operator would usually look at the cargo and adjust the overflow at the same time.

Task 3.1

The operator should hoist up the suction tubes by controlling winches until the suction tubes are at the highest position. It is almost the same situation in Task 1.1. The requirement is almost like task1.1. The operator should stop hoisting up suction tubes until he observes the right symbols appear. The operator would look at the suction tube hoisting up as well.

Task 3.2

The operator should move gantries inboard which is the opposite direction when moving gantries outboard.

Appendix 3. Current icons

Symbol	Colour indication	Winch state
	Vertical lines: steady grey Lower direction lines: steady green	**Veering/Lowering**
	Upper direction lines: steady green Vertical lines: steady grey	**Hauling/Hoisting**
	Red S-line	**Slack wire**
	Circle in winch drum	**Winch pipe positioned for inlet (trunnion winch only)**
	Horizontal lines: Lower steady green	**Lowest position/End of wire**
	Horizontal lines: Lower striped green	**Almost lowest position/Pre end of wire**
	Horizontal lines: Upper steady green	**Highest position/Anchor reached**
	Horizontal lines: Upper striped green	**Almost lowest position/Pre end of wire**
	Red S-line Circle in winch drum	Winch pipe attached to the inlet (trunnion winch only)
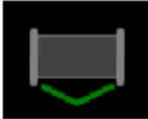
Symbol	Colour animation	Gantry State
	Only grey	**Gantry positioned inboard**
	Green cylinder	**Gantry positioned outboard**
	Blinking arrow	**Gantry moving to outboard**

Symbol	Colour animation	Gantry State
	Blinking arrow	**Gantry moving to inboard**

Appendix 4. DigiSys toolkit
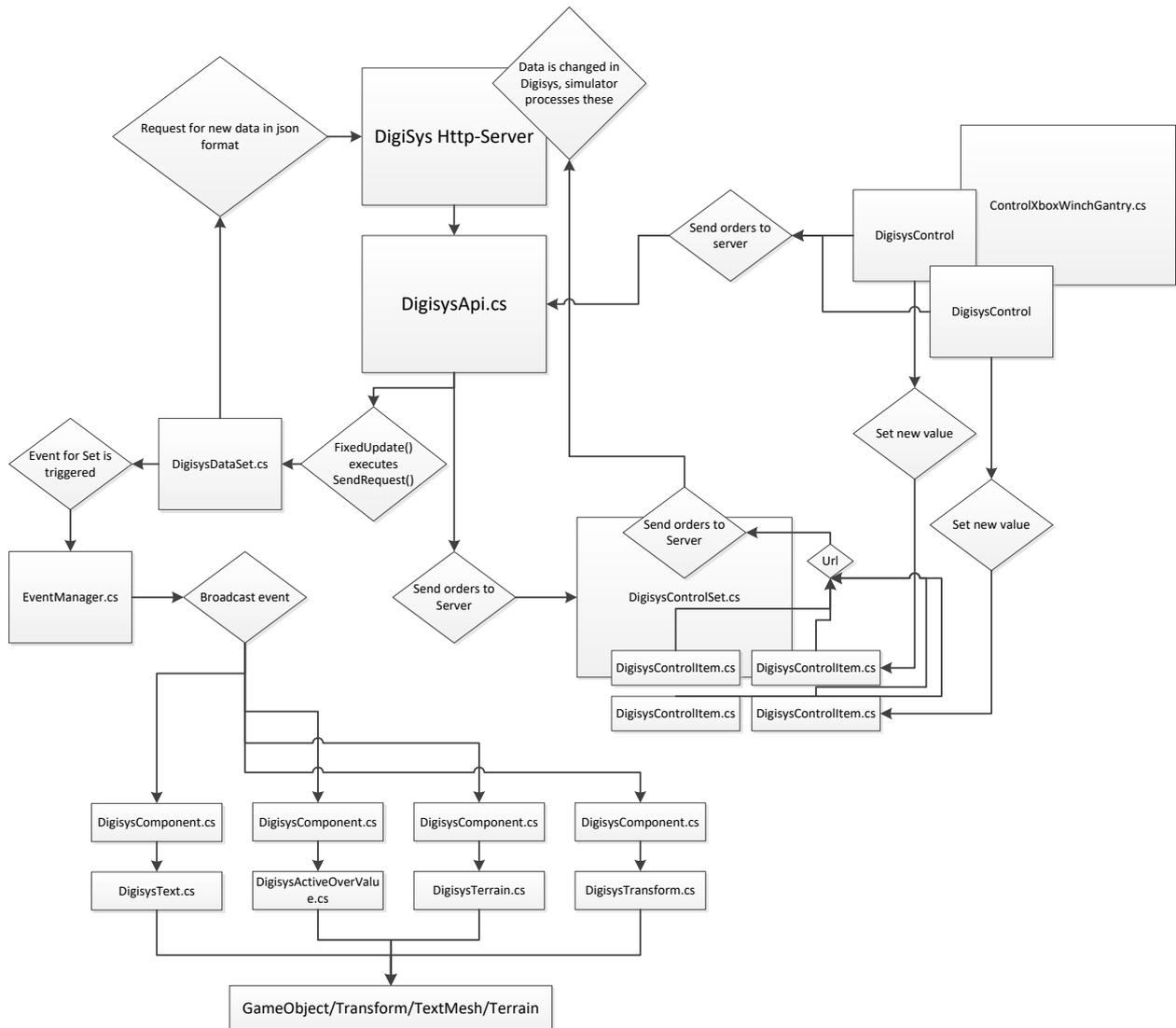
Figure 13: Work flow of Digisys Toolkit

DigisysComponent.cs

- Finds the first DigiSysApi component in the scene.
- Listens for the event relating to its configured dataset.
- Fetches the data from the component when the event is triggered.
- Searches the json-output from DigisysApi for the object referred to in the URI entered into string PathToContent.
- Makes the value availalable for other objects to inherit in float ReadValueFromHere.
- If bool UseDigisys is unchecked, DigisysApi will not be consulted and ReadValueFromHere is filled in by another script.

DigisysText.cs (extends DigisysComponent)

- Find a TextMesh or Text component if none is configured.
- Formats ReadValueFromHere.
- Puts ReadValueFromHere in an a configured or found TextMesh.text and Text.text .

DigisysTransform.cs (extends DigisysComponent)

- Disregards inherited PathToContent.
- Iterates through DigisysTransformItem and applies values.
- Puts each referenced value from DigisysTransformItem.PathToValue into localPosition, eulerangles, or localScale and in its respective x, y, or z for enum array AxisChoice. It does this by iterating trough a list of DigisysTransformItems.
- If set, substracts a transform, usually a parent, in order to be able to process worldspace coordinates from digisys.

DigisysTransformItem.cs

It has values to be applied to transforms, and to decide which transforms go where.

DigisysActiveOverValue.cs(extends DigisysComponent)

- Deactivates an array of objects if ReadValueFromHere falls below a DeactivateBelowThisValue.
- Activates instead of deactivates if checkbox Inverse is set to true.

DigisysActiveWhileIncreasing.cs(extends DigisysComponent)

- Activates an array of objects while ReadValueFromHere has been increasing for at least int ContinuousFrameToAct.
- If bool InverseActivated is checked it deactivates the objects instead.
- If bool InverseIncreased is checked it activates the objects if a value is decreasing.

DigisysTerrain.cs (extends DigisysComponent)

- Updates a terrain component with a 2d matrix originating from digisys.
- Passes the minimum and maximum heights multiplied by the range to the "_HeightMax" and "_HeightMin" fields of a material if terrainMat is set, excludes values over .99 and below .01.

MultiplyAndSetResult.cs

- Multiplies ReadValueFromHere from an array of DigisysComponents and sets the ReadValueFromHere on another to the product. Remember to uncheck UseDigisys in the target DigisysComponent.

DigisysApi.cs

- Uses FixedUpdate() to trigger SendRequest on its configured datasets.
- Triggers SendRequestNow() for the configured Controlsets.

DigisysDataset.cs

- Generates the datasetspecific part of the url.
- If GetValue() is used, it remembers a previously looked up value is case another object requests it from the dataset before it is renewed. Remembers the query in a dictionary.
- Send the request to Digisys using the generated parts of the url, then sends out an event that new data is available.

DigisysControlset.cs

- GenerateUrl() Iterate through all the DigisysControoItems and adds their fieldnames and values to the url. This ensures the url always has the necessary fields even if no interface is there to change or address them.
- Send the request to Digisys using the generated parts of the url.

DigisysMatrixConfig.cs

A class that makes config files for the digisysmatrix. It puts the configs in textfields which look messed up and give errors, but that's just because there's too much text in them. It's fine, you can still copy and paste them into a texteditor for review and digisys.−

TransformFiller.cs

Copies old transform configurations into the new format; the one using DigisysTransformItem.

ControlXboxWinchGantry.cs (extends MonoBehaviour)

Links the values of buttons on an XboxController to DigisysController scripts. It allows you to send values to DigisysControllers. Basically a hardcoded control-setup specifically for Beagle 8.

Appendix 5. Questionnaires

Consent for participation in the evaluation experiment of 'Mixed Reality User Test'

1. I volunteer to participate in a product evaluation experiment conducted by University of Technology Delft, Faculty of Industrial Design Engineering.

2. I understand that the product evaluation experiment is designed to gather information about the appropriateness of the MIXED REALITY PRODUCT in a specific context and that I will be one of 30 participating in this research.

3. My participation in this product evaluation experiment is voluntary. I understand that I will not be paid for my participation, except for the free gift. I may withdraw and discontinue participation at any time without penalty.

4. Participation involves answering personal background questions, participating in a virtual play environment, using the MIXED REALITY PRODUCT for the purpose of interacting with virtual objects. This process will take around 40 minutes.

5. I understand that the experiment will be video & audio taped (please mark the item which applies)

I agree for the use within project presentation, including but not limited to: conferences, journal publications, and/or other commercial use.

I agree ONLY for the purpose of measuring my responses. The audio & video content will be destroyed before the end date of the project.

If I don't want to be taped, I will not be able to participate in the study.

6. I understand that the experiment doesn't want to measure my performance, but the performance of the MIXED REALITY PRODUCT. No specific participant related performance measurement is transferred to any external source.

7. I have read and understand the explanation provided to me. I have had all my questions answered to my satisfaction, and I voluntarily agree to participate in this study.

8. I have been given a copy of this consent form.

My Name, Signature and Date

_____

_____

_____

For further information, please contact:

Mengyin Dai

Personal Data

Please fill out this preliminary questionnaire; it helps us to classify the experiment data.

Age 20-25   25-30   30-35   35-40

40-45   45-50   over 50

Gender male   female

Background

1.) Which nationality do you have?

2.) What is your education level?

Prior experience

Which of the following have you already used before (multiple answers possible)?

Tablet / Ipad Touchscreen VR goggles

Questionnaire: QUESI – Questionnaire for Intuitive Use

		Fully disagree	Mainly disagree	Neutral	Mainly agree	Fully agree
1	I could use the system without thinking about it.	○	○	○	○	○
2	I achieved what I wanted to achieve with the system.	○	○	○	○	○
3	The way the system worked was immediately clear to me.	○	○	○	○	○
4	I could interact with the system in a way that seemed familiar to me.	○	○	○	○	○
5	No problems occurred when I used the system.	○	○	○	○	○
6	The system was not complicated to use.	○	○	○	○	○
7	I was able to achieve my goals in the way I had imagined to.	○	○	○	○	○
8	The system was easy to use from the start.	○	○	○	○	○
9	It was always clear to me what I had to do to use the system.	○	○	○	○	○
10	The process of using the system went smoothly.	○	○	○	○	○
11	I barely had to concentrate on using the system.	○	○	○	○	○
12	The system helped me to completely achieve my goals.	○	○	○	○	○
13	How the system is used was clear to me straight away.	○	○	○	○	○
14	I automatically did the right thing to achieve my goals.	○	○	○	○	○

Questionnaire : NASA TLX – Task Load Index

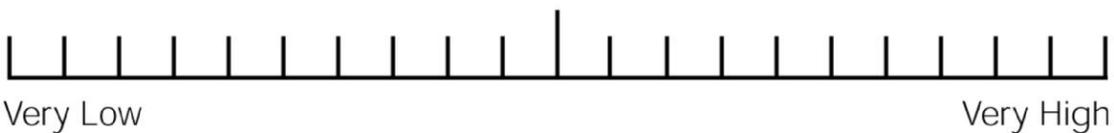**Mental Demand**   How mentally demanding was the task?

Very Low   Very High
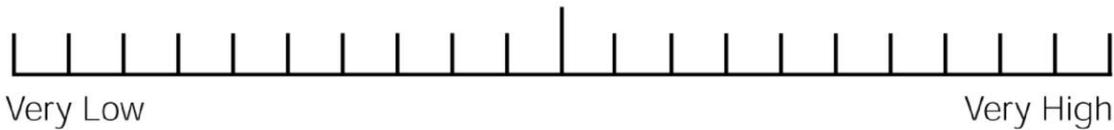
Physical Demand   How physically demanding was the task?

Very Low   Very High

Temporal Demand   How hurried or rushed was the pace of the task?

Very Low   Very High
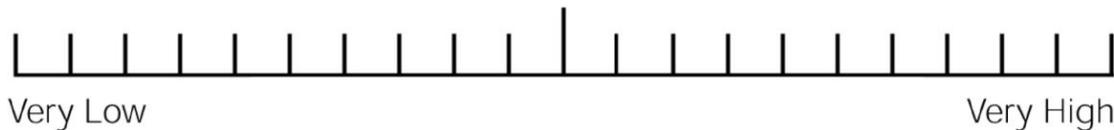
Performance   How successful were you in accomplishing what you were asked to do?

Perfect   Failure

Effort   How hard did you have to work to accomplish your level of performance?

Very Low   Very High

Frustration   How insecure, discouraged, irritated, stressed, and annoyed wereyou?

Very Low   Very High

Questionnaire : Situation Awareness Test (Post- test)

Instability of Situation

How changeable is the situation? Is the situation highly unstable and likely to change suddenly (High) or is it very stable and straightforward (Low)?

1	2	3	4	5	6	7

Complexity of Situation

How complicated is the situation? Is it complex with many interrelated components (High) or is it simple and straightforward (Low)?

1	2	3	4	5	6	7

Variability of Situation

How many variables are changing within the situation? Are there a large number of factors varying (High) or are there very few variables changing (Low)?
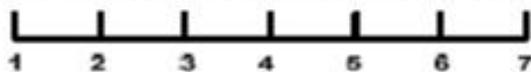
1	2	3	4	5	6	7

Arousal

How aroused are you in the situation? Are you alert and ready for activity (High) or do you have a low degree of alertness (Low)?

1	2	3	4	5	6	7

Concentration of Attention

How much are you concentrating on the situation? Are you concentrating on many aspects of the situation (High) or focussed on only one (Low)?

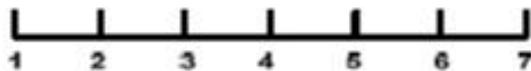|						
1	2	3	4	5	6	7

Division of Attention

How much is your attention divided in the situation? Are you concentrating on many aspects of the situation (High) or focussed on only one (Low)?

1	2	3	4	5	6	7

Spare Mental Capacity

How much mental capacity do you have to spare in the situation? Do you have sufficient to attend to many variables (High) or nothing to spare at all (Low)?

1	2	3	4	5	6	7

Information Quantity

How much information have you gained about the situation? Have you received and understood a great deal of knowledge (High) or very little (Low)?

1	2	3	4	5	6	7

Familiarity with Situation

How familiar are you with the situation? Do you have a great deal of relevant experience (High) or is it a new situation (Low)?

1	2	3	4	5	6	7