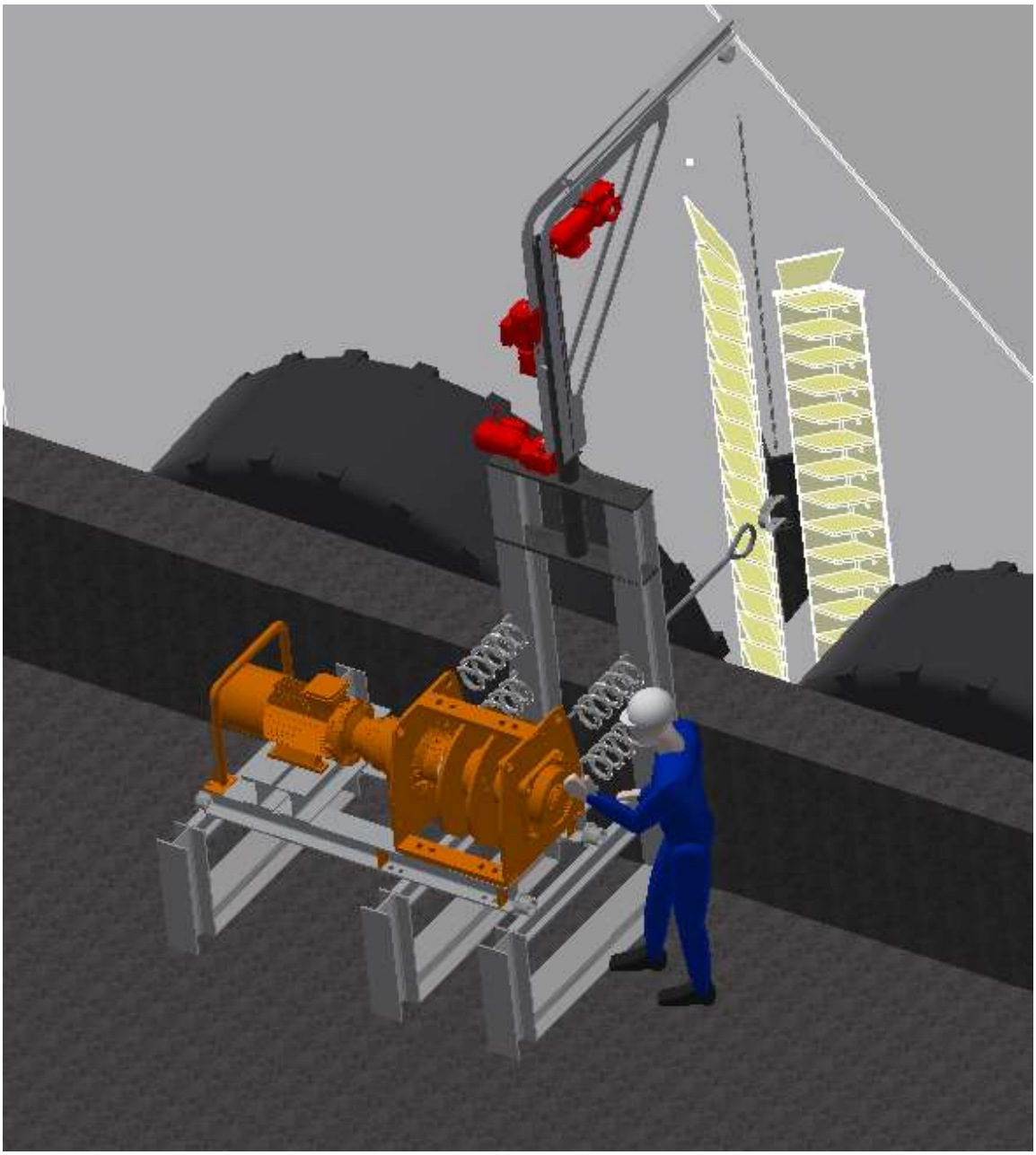
SMART
Self Mooring And Release Technology

Some technical facts on the SMART technology



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1 Introduction

Addressing the general concerns about climate change and public health around ports and terminals, relevant authorities are pushing more and more the shipping industry to reduce its emissions, especially in ports.

This is true, in particular, for short sea ferry's projects, where Diesel propulsion is now challenged by pure electric or hybrid propulsion solutions, in particular for Norway Fjord crossing ferry's, where grid power is coming mostly from hydroelectric dams and, is hence, affordable and nearly emissions free…

This move towards electric propulsion, has resulted in a drastic review by ship designers of all the on board power consumers in order to reduce the sizing of the corresponding batteries, which are a leading driver. Among these, one of the one is the use of the propulsion power to maintain the vessel's position, once docked at the terminal, by continuously pushing it against the quay and ramp. To suppress this power consumption, an alternative mooring solution is required. As the number of calls of Fjord crossing ferry's is very high (typically several tens per day), their duration of calls are very short (typically down to a few minutes, just enough to unload/unload vehicles) and crew work load is very high, one mandatory requirement, for this solution, is to be fully automatic.

For this purpose, NG3 is proposing, its SMART (acronym for **S**elf-**M**ooring **A**nd **R**elease **T**echnology).

The purpose of this document is to present in more details this solution, having in view the particular case of electric fjord Norwegian ferry's.

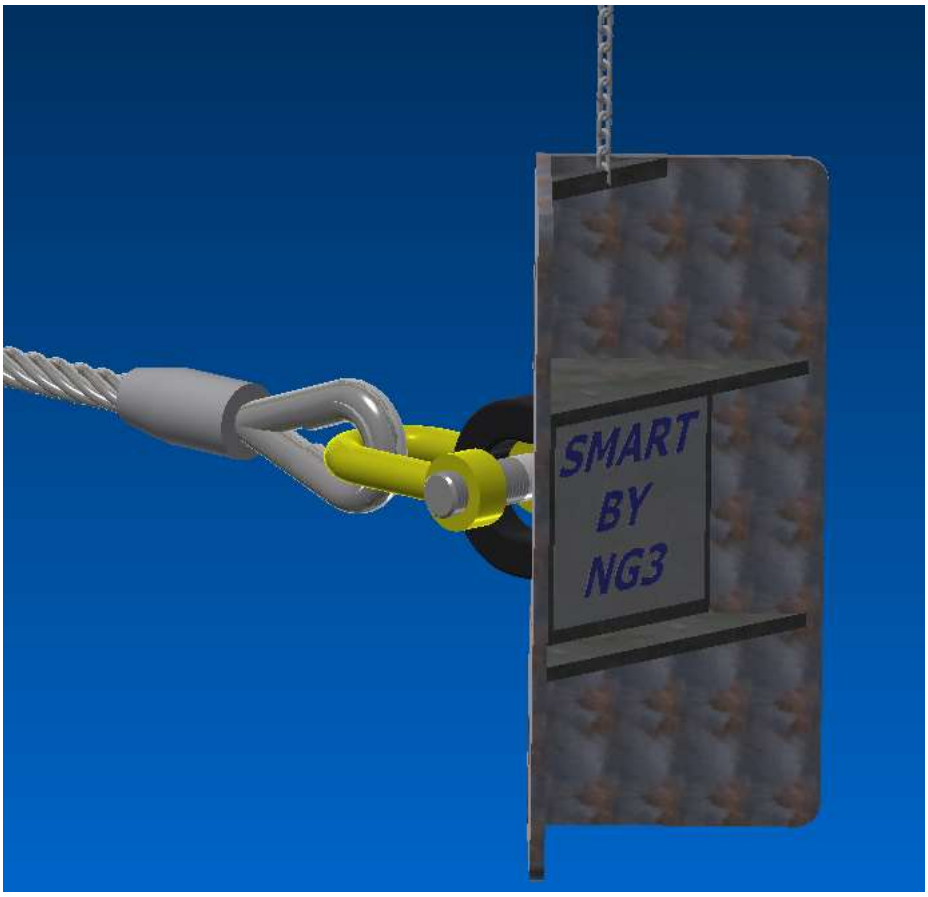
2 Understanding of the requirements

The main requirements for this SMART solution are understood to be:

- Fully automated operations with remote back up control from the bridge;
- Local back up control command capability with smart phone;
- 20 000 daN maximum pulling force;
- Mooring / release within 10 seconds after lowering/raising of the ferry bow loading ramp , up to 50 times a day;
- Cost of ownership and maintenance to be minimized;
- High reliability and maintainability and safety shall be considered as a key design driver to guaranty the safety and operational efficiency of the vessel
- Simplicity is appreciated;
- Footprint and mass to be minimized on the vessel and the quay side;
- The system shall be compatible with tide variation of +/- 2 meter and heave motion of +/- 0,2 m
- The solution shall be compatible with a docking accuracy, once the ship ramp is lowered on the terminal ramp +/- 0,20 meters longitudinally
- The system shall meet Marine Authorities or Class safety requirements.

3 Main design features

SMART operations are performed automatically. It is based on a mooring line linked on one side to an electric winch and, on the other end, to a specific "blade" hook.



SMART blade hook

This hook is similar to the shuttle bar we use for our automated shore connection PLUG solutions, which is suspended to a chain and is attached to a hoisting system suspended to a crane so that it can be driven, with a set of video tracking cameras, above the ship side funnel shaped mooring slide and lowered into it to establish the mechanical connection between the ship and the mooring line. Once this is done, the electric winch can be activated to pull the line and drive and maintain the ship in position against the fenders.

No direct handling of the mooring cable or the hook is required.

Thanks to SMART unique guiding and locking system, these automated sequences will be performed mostly by simple, reliable, mechanical effects.

One of the key issue is to have a very fast automated capture, alignment and locking of the hook into the shipside mooring slide.

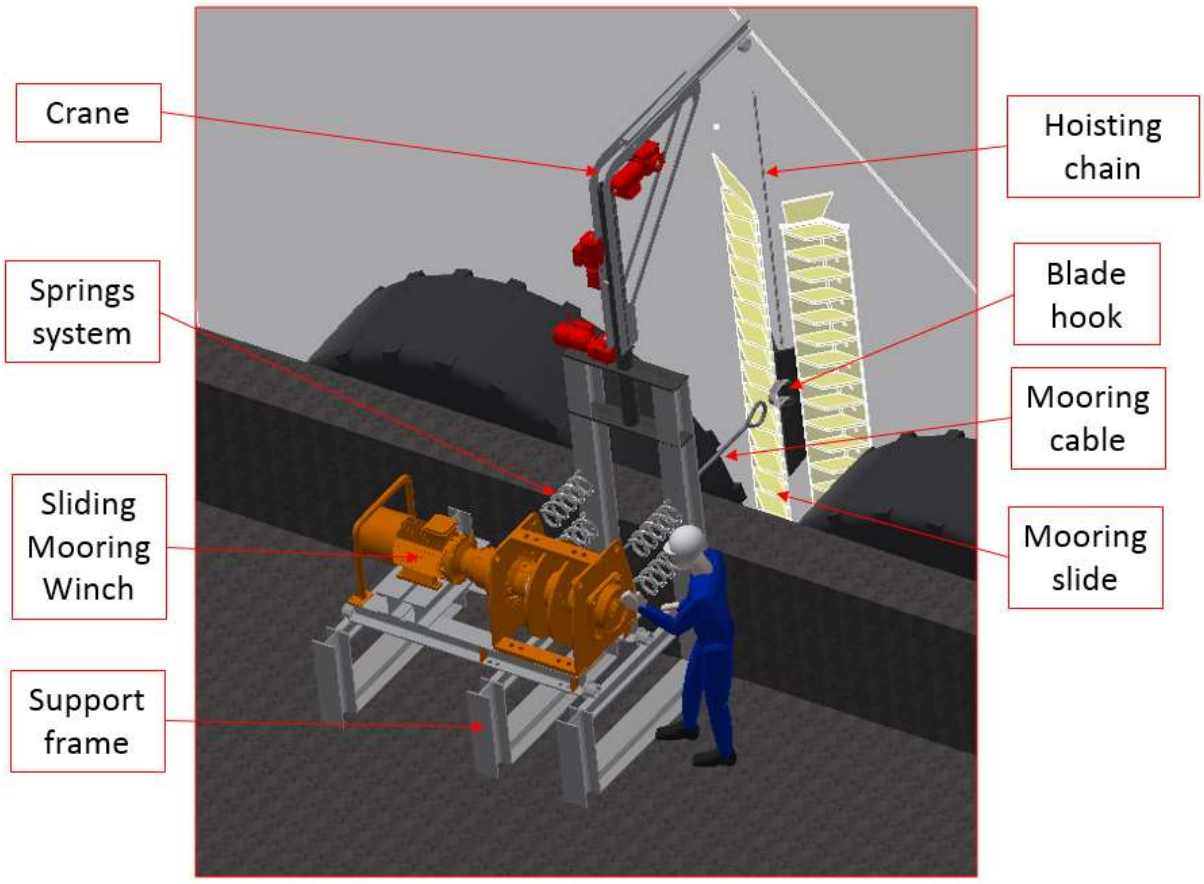
The hook lower end is designed to self-center itself into the ship side mooring point as soon as it gets into it, within, typically, a 10 cm diameter alignment uncertainty.

To get within this alignment area the following approach is proposed:

- to follow the ship (longitudinal) X axis and side (lateral) Y ship axis movements the quay side hook hoisting system is attached on rotating crane with a sliding beam;
- to “fish” the ship and release the hook , the hook is attached to a chain motorized by a windlass (Z axis), which compensates as well, tide and draft variations .

The combination of these X, Y, Z movements allows to track with the hook the shipside mooring point in all directions, in order to lower it within the 10 cm insertion target area. This tracking and hooking operations will be automatically performed as soon as:

- the video tracking system detect and identify the vessel;
- a request for mooring request has been received from the captain, by wifi



SMART system main components

To perform an automated tracking and operations of the system, a set of video cameras and sensors are used to monitor the different components absolute and relative position, in order to lower, and lock into the shipside mooring slide, the blade hook.

Once this is done, the ship can be pulled towards the quay side fenders and once this is done, a permanent pulling force is applied to keep it in position.

The winch is mounted on a rail system and a spring system

To compensate minor ship movements during docking, without activating the electric winch, the winch is sliding on rails, a set of spring absorbing minor movements.

The cameras monitor the ship / quay relative position during mooring operations, to adjust the pulling force, if needed, for example due to tide variations during long stops, the cameras will detect the need to adjust the hook vertical position within the ship side mooring slides. To do this, the pulling force is released during a few seconds and

the hoisting system is used to raise or lower the hook at the proper height. The pulling force is then be re-established.

As the vessel is expected to be “hooked” longitudinally by the terminal ramp, a single SMART system is proposed, located at mid ship, on one or both sides of the vessel (depending on the terminals configurations) .

A full size demonstrator has been design and manufactured and on display at the SMM Hamburg 2016 exhibition demonstrating the capability of the system. Typically, the mooring line is attached to the vessel in less than 20 seconds…well before the vessel bow flap will be lowered on the terminal ramp, and release will take even less time!

Blade hook, shackle and mooring cable

Full size prototype test

Example of camera image processing

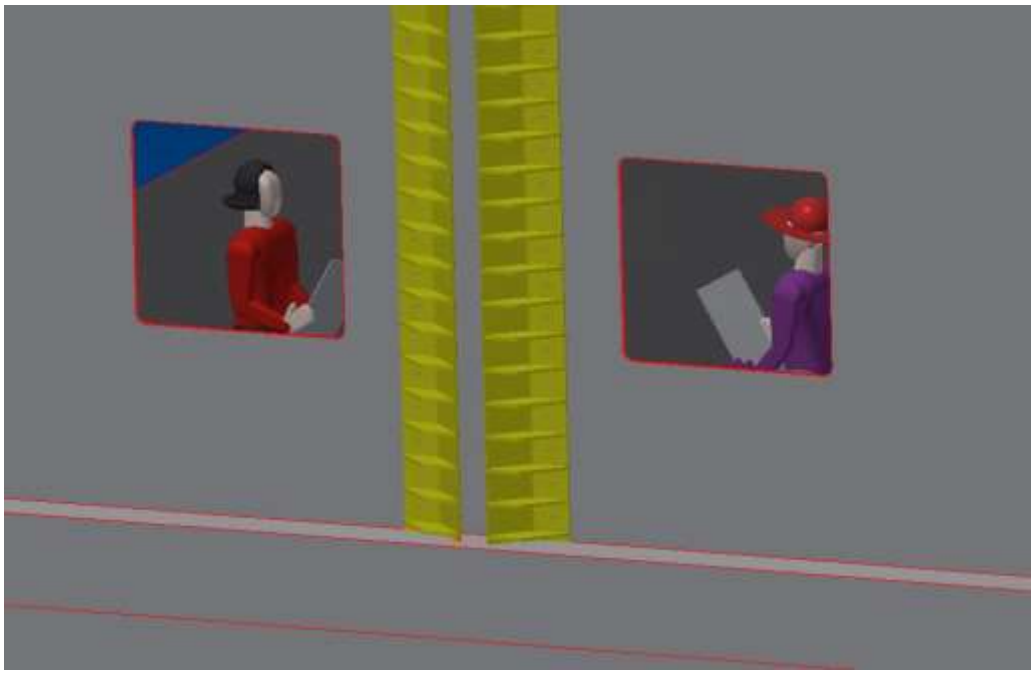
The quay side Interface will be implemented on the quay concrete structure, typically just behind the existing concrete fender wall, by a bolted interface. This steel structure will support, at the level of the fender wall, the winch, the hook crane and the video tracking cameras. These quay side equipment's will be covered by a shelter for weather protection and public access restriction.

The goal is to track and "fish" the shipside mooring point before the vessel is actually docked to the loading ramp, in the last meter/minute of the docking maneuver, so that the final mooring position can be performed as early as possible, typically just after the bow flap has been lowered, maximizing the power consumption savings.

To release the vessel, the captain will have to send a command through wifi to request the mooring release.

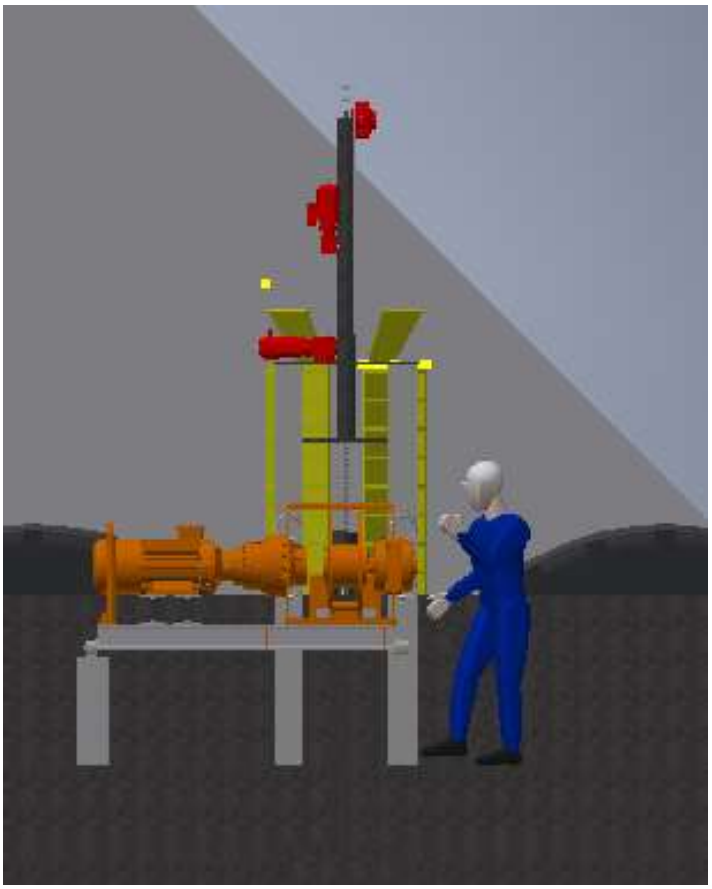
Once received, the winch will release the mooring line and the crane will hoist up the hook out of the ship side mooring point. Once this is done, the system will park the crane and the hook to avoid any risk of collision, for example if another ship use the quay.

One of SMART's benefit is that if does not impact the mid ship passenger's area.

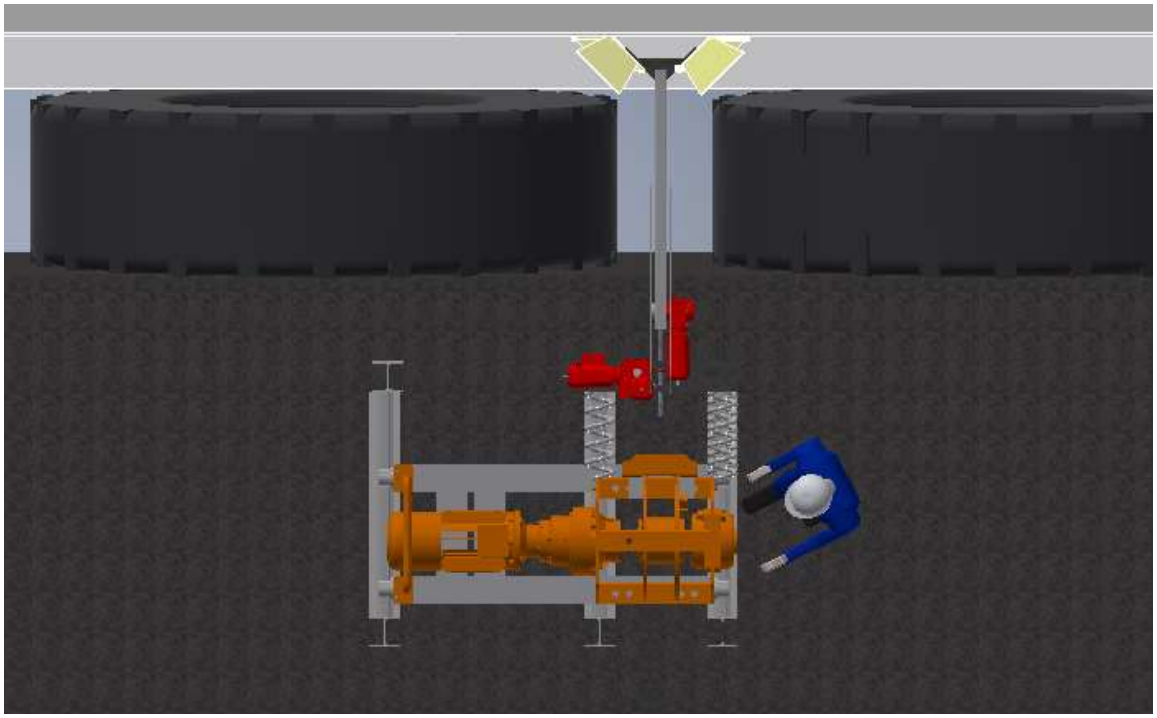


Midship View

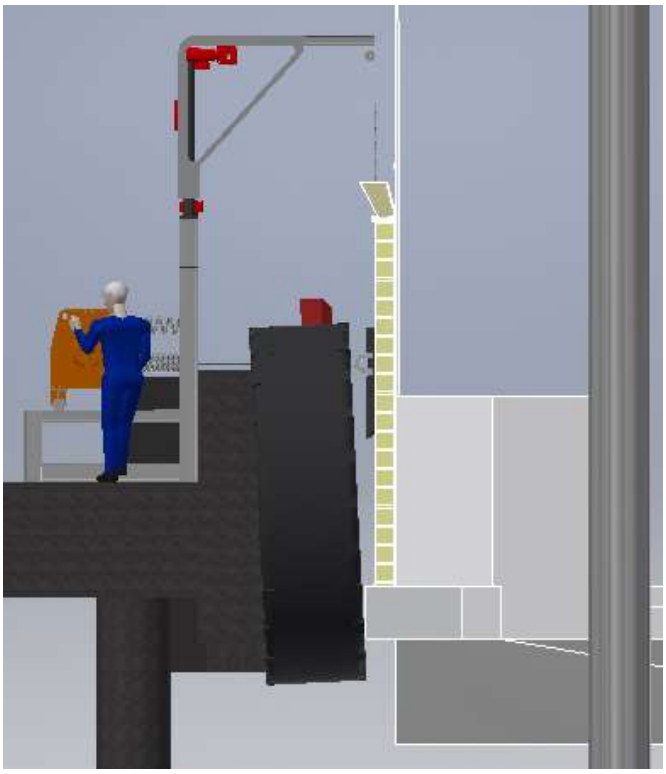
The following drawings give an overview of the proposed solution.



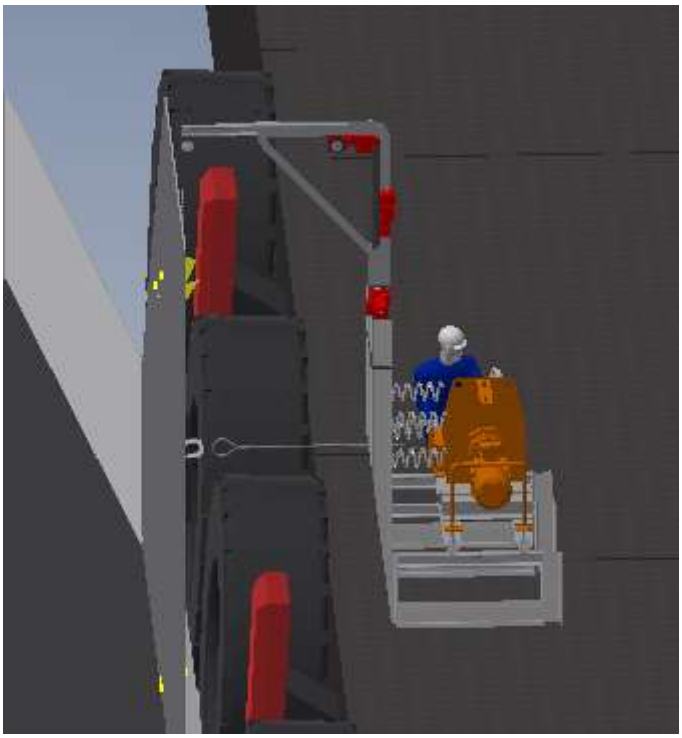
Side view



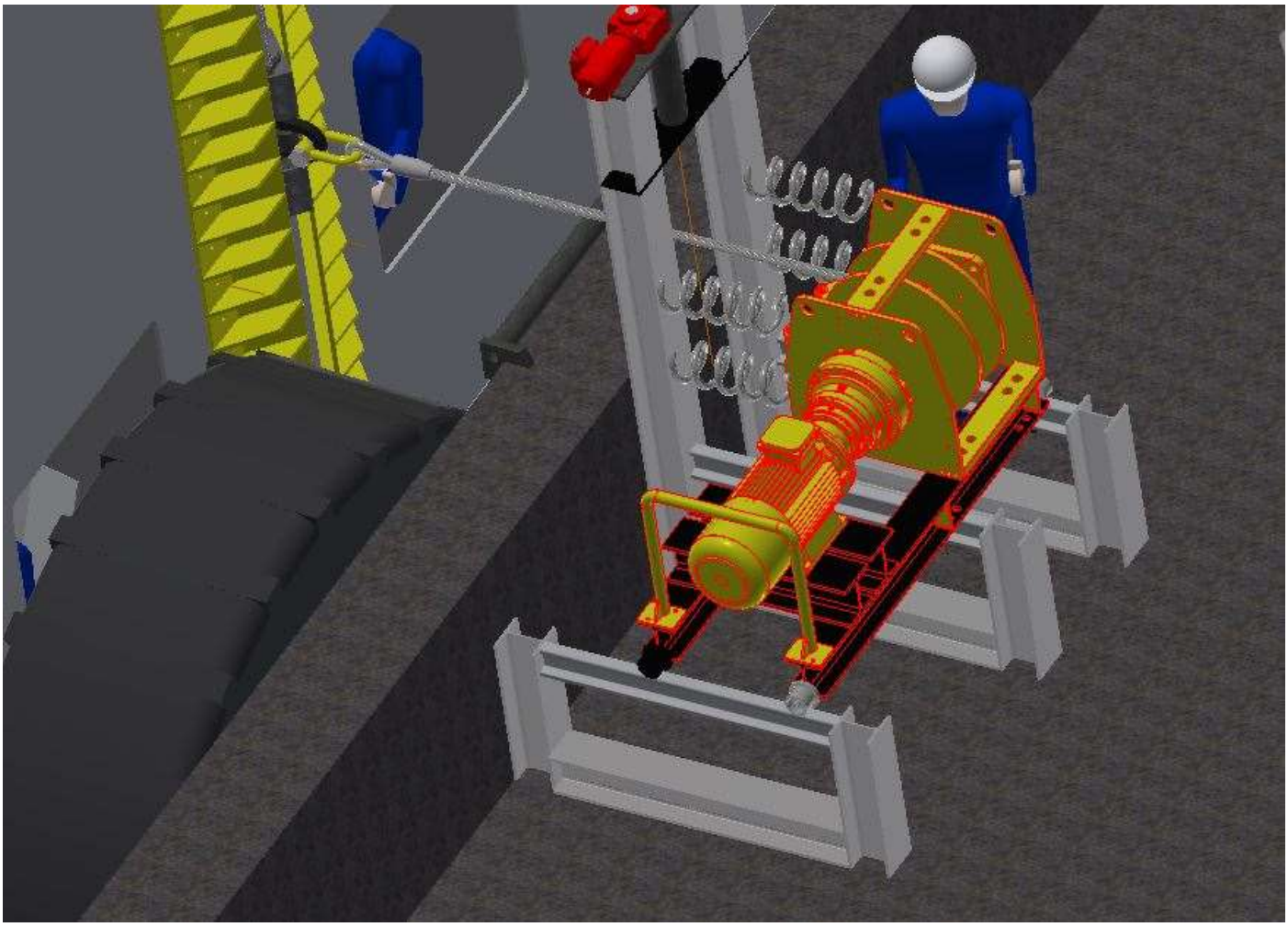
Top view



Front view



Captain's View



Hook and sliding mooring point view

Operations

3.1.1 Automated operations

On the bridge, the touch screen will display a view of the system and status /error messages so that crew will be informed of the status of the sequence. In nominal case, the messages will be the following:

- *"Safely parked"* : informing crew that the crane is in its parking position, with no risk of collision;
- *"wifi OK"* : informing crew that the wi fi link between the ship and quay interfaces is established;
- *"Searching"* : informing crew that the video tracking system is trying to detect the ship mooring slidet;
- *"Tracking"* : informing crew that the video tracking system is initiating combination of X, Y axis movement to align the crane with the shipside mooring point on the same vertical axis , ready to insert the hook into it
- *"Fishing "* : informing crew that the Z axis motor is activated to insert the hook into the shipside mooring point and then when this is done, to lower it further until the hook is in front of the winch
- *"pulling "* : informing crew that the winch is pulling the line and keeping the tension to the required level and that the video tracking system monitors the ship vertical and hook vertical position to compensate, if needed, vertical position of the hook to compensate tide or draft variations.
- *"Releasing"* : informing crew that the winch is releasing the mooring line and that the hook is hoist up by the crane to release it out of the ship side mooring slide;
- *"Parking"* : informing crew that the crane beam is being retracted and rotated in a safe position;

- *"Safely parked"*: informing crew that the crane and hook are in their parking position, with no risk of collision, ready for next cycle…

If an error is detected or if an alarm is triggered, a message will inform the crew and suggest corrective actions for example:

- "*tracking failure – clean camera lens* "
- "*parking failure – check system position*"…

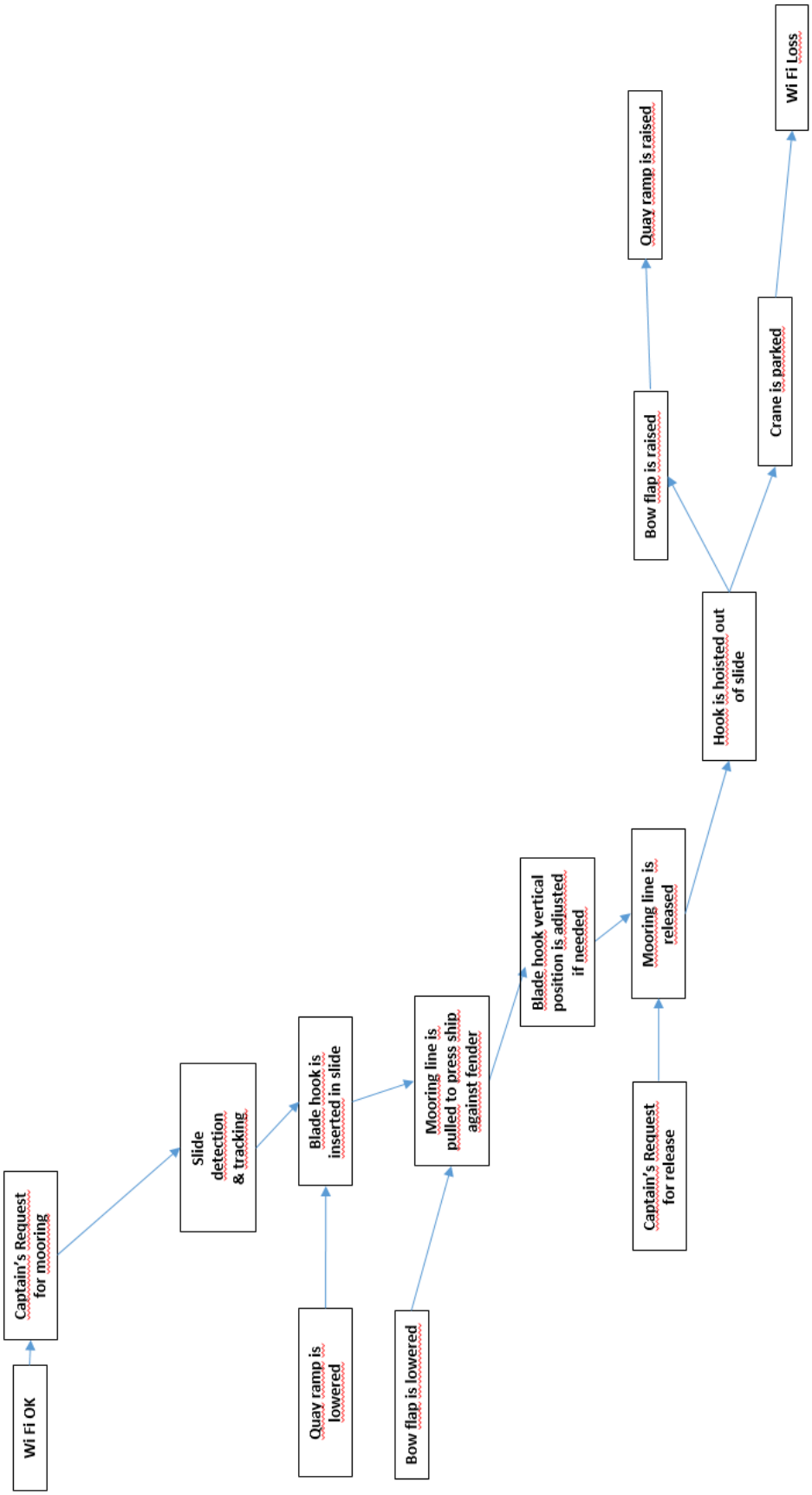
3.1.2 Bridge remote operations

As a backup solution, if the automated mode is not possible, a manual mode is available, where the captain can operate the system the system through the bridge touch screen interface, in a similar way as Color Line crew is doing on its Color Magic/fantasy and Superspeed 1 PLUG installations, sending direct commands to the motors, bypassing the Videotracking system.

3.1.3 Maintenance smart phone operations

For maintenance purpose, the system can be operated in maintenance mode through a smart phone user interface, as demonstrated on PLUG 2015.

PLUG 2015 smart phone interface



SMART automated operation logic (typical)

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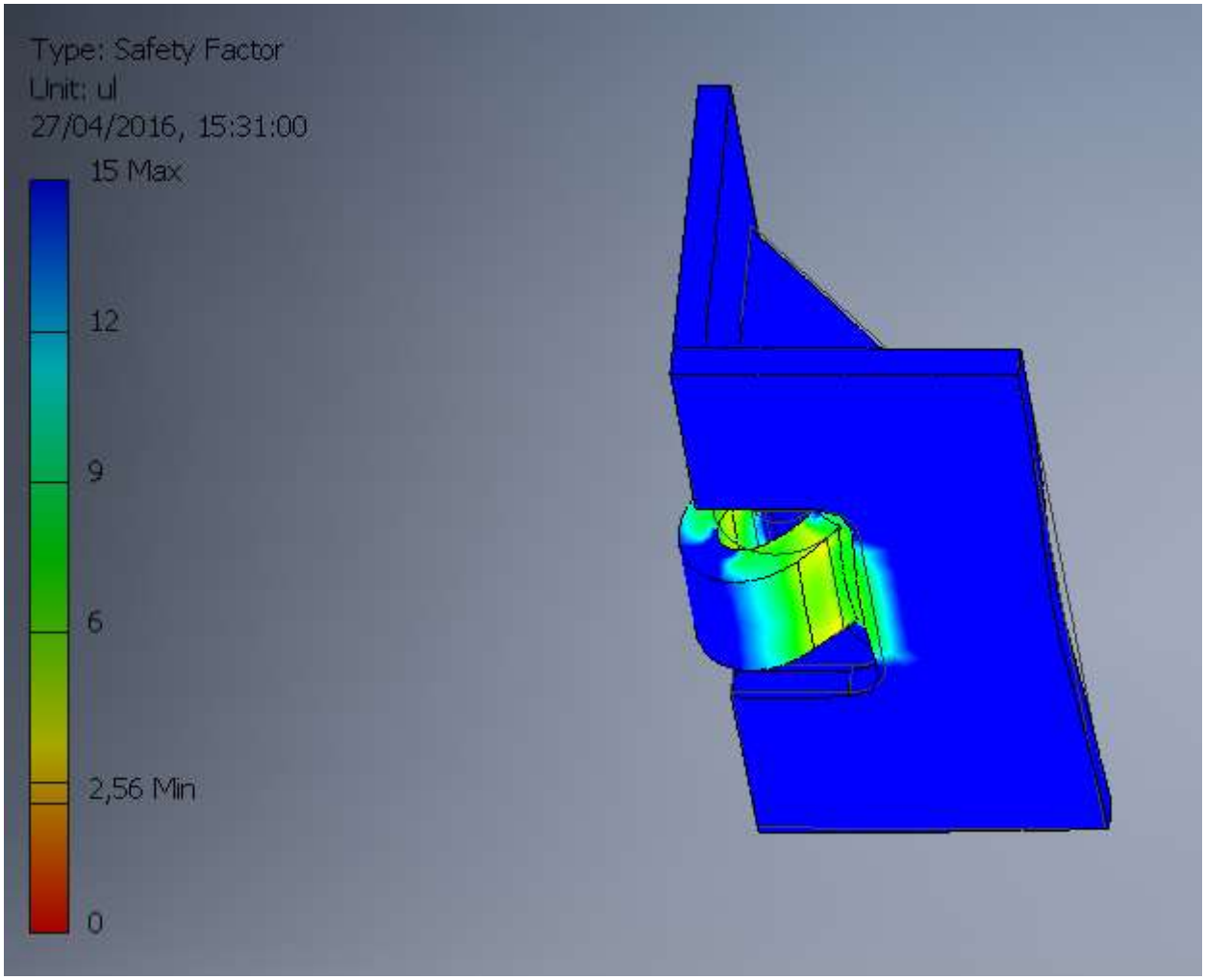

Hook safety factors mechanical analysis (typical)

4 SMART project status

Basic design has been completed and a full size demonstrator has been manufactured and tested during the summer 2016, and displayed at the SMM 2016 exhibition.

SMART is officially released during the SMM exhibition in Hamburg in September.

SMART prototype)

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