How to Increase the Safety During Anchor Handling Operations?

Thor Hukkelas

*Kongsberg, Norway*
How to increase the safety during anchor handling operations?
KM’s new Design Thinking for DP & Offshore Marine Operations
Outline

1. Offshore Marine Operations
2. Challenges & How to meet them
3. SITUMAR R&D project
4. Situation Awareness & Decision Support
5. KM’s new Anchor Handling Concept
6. Summing Up
Pushing the limits

• Demanding and critical offshore marine operations all push people, vessels and systems to their limits.

• Deeper waters, colder waters, heavier loads, larger forces, tougher environment and more demanding weather and climate conditions.

• Control systems, organizations and tasks are becoming increasingly more complex and complicated.

The consequences of making wrong decisions during failure or stress situations can be disastrous and may have catastrophic implications.
What’s wrong with the current situation?

- “Users are flooded with too much information, and lose mastery of the situation.”

- “Users need to criss-cross the bridge consulting screens to create a cohesive picture of the situation.”

- “In alarm situations, many buttons and indicators start flashing. Heartbeats race, without a sense of what can be done.”
What’s wrong with the current situation?

- **Alarms:**
  - “Audio alarms are distracting and tiring. Loud noise leads to irritated and angry operators.”
  - “When the screen is filled up with alarms, the operator just has to pick out some using gut instinct”.

- **Human-Machine-Interface (HMI):**
  - “Today there are too many buttons and too much text.”
  - “I have trouble with reading text in stressful situations. It must be self-explanatory. Use pictures instead.”

- **General**
  - “We think with our spine.”
  - “We don’t read manuals”
  - “Technology is built around what is possible, not around what users want or need.”
The big question

How to maintain “Human in the loop”?

“Dynamic Positioning is said to be 99% boredom and 1% panic”
Meeting the challenges

The SITUMAR R&D Project.
Situation Awareness and Decision Support Tools for demanding marine operations

Sponsored by the Norwegian Research Council
SITUMAR – is about regaining control

• How to maintain «**Human-in-the-loop**»?
• How to support **good human decision** making?
• How to reduce complexity and “**feature creep**” and enhance **simplification**?
• How to close the “**information gap**”?
• How to provide for proper **training**?
• How to design for optimal **Situational Awareness and Decision Support**?
A 3 year R&D project – User Centered Design

Phase 1
- Literature Studies
- General information collection and research with special emphases on Human Factors, Decision Making and the importance of Situation Awareness.

01/02/12

Phase 2
- Case studies of selected marine operations
- We go on board and perform Task Analysis (what is actually done during Planning, Execution, Evaluation etc.)
- System Design

01/01/13

Phase 3
- Building prototypes in simulator environment
- User-evaluation of prototype in a realistic, simulated environment
- Reporting and requirement validation

01/01/14
31/12/14
User Centred Design?

“If I had asked people what they wanted, they would have said faster horses.”

Henry Ford

“Do not ask users what they want, ask them what they do”
Technology should adapt to humans, not the other way around!

- Organize technology around the user’s goals, tasks and abilities.
- Organize technology around the way users process information and make decisions.
- Technology must keep the user in control and aware of the state of the system.
What is Situation Awareness (SA)?

- Basically, SA is being aware of what is happening around you and understanding what that information means to you now and in the future.

- The formal definition of SA breaks down into three separate levels:
  - Level 1 – perception of the elements in the environment
  - Level 2 – comprehension of the current situation, and
  - Level 3 – projection of future status

Situation Awareness in dynamic decision making

Task and Environmental Factors
- Workload
- Stressors
- System design
- Complexity

State of the environment/system

Situation Awareness
- Perception of data and the elements of the environment (Level 1)
- Comprehension of the meaning and significance of the situation (Level 2)
- Projection of future states and events (Level 3)

Individual Factors
- Goals
- Preconceptions
- Knowledge

Decision

Performance of Action
Applying the new Design Thinking: KM’s new Anchor Handling Concept
Anchor Handling Concept

- Winch control, deck equipment ctrl, CCTV in #2
- On-line stability analysis & monitoring
- Dual K-Master on aft bridge
- Ship Handling in #1
- AH Situational Awareness Displays
- Improved DP capability
- Unified Communication Solution (SIMOPS, MBR, AIS)
- System for estimation of vertical- and horizontal anchor chain forces
- System for estimation of distance AHV – Rig (SIMOPS)
- Deck Equipment control from K-Master
Basic AH Configuration - Twin K-Masters

A unified HMI for many subsystems via K-Master
Anchor Handling Challenges.

• Q1 : How to calculate and visualise the stability margin in real-time?

• Q2 : How to improve DP and manoeuvre ctrl capabilities (heading & sway ctrl)?

Solution to both problems:
• Develop a system that gives a sufficiently accurate estimate or measurement of the horizontal and vertical forces acting on the vessel from the anchor line in addition to the attack point for these forces.
Line tension estimation / calculation

- A mix of measurements for sensors and estimates from mathematical models resembling the structure of a Kalman filter.
- Measurements from the winch & load cells in shark yaws.
- Math model = f(ancestor line, geometry of the operation, i.e. vessel position, rig position and arrangement, line length, catenary calculation).

(sensor filtering & fusion)

(MRU)

(roll, pitch, heave)

(location of sensors)

(Tension, t)

(line/chain parameters)

(force measurements)

(predicted force measurements)

(sensor)

(sensor)

(catenary calculation)

(AH & Rig position, speed & heading)

(init conditions)

(DP system)

(stability calculation)

(force vector estimates to consumers)

(depth & offset)

(cosh & sinh inside)
Online stability calculation & monitoring

- Including line tension in stability calculation and present current and maximum tension for selected line angles.
Dynamic Positioning and the Force balance:

- Thruster forces
- External forces
- Wind
- Waves
- Current
- Other external forces
- Yaw
- Sway
- Surge
- Azimuth Thruster
- Main Propulsion and Rudder
- Tunnel Thruster
Dynamic Positioning and the Force balance:

Thruster forces

External forces

Wind

Waves

Current

Other external forces
Adaptations of DP system for AHTS

- **New estimator and controller**
  - Line tension feed forward
  - More precise and robust heading estimation

- **AH track line mode**
  - Setpoint coordinated with winch speed and line corridor
  - Heading control with wave filtering

- **Thruster control – AH split mode**

- **Online AHTS sway capability plot**
AH Situation Awareness Displays

**Consumed Power**

- Bus 1
- Bus 2

**AH Winch Starboard**
- Range: 367 m
- Speed: 31 m/min
- Load: 45 t

**AH Winch Port**
- Range: 10 m
- Speed: 0 m/min
- Load: 16 t

**Range thru...**

- 025°/630 m
Summing Up:

How can the presented concept increase the safety level?
Thank you for your attention.