

A SWATH Mothership Concept for the Far Shore Wind Farms Informed by Environmental Psychology Model

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Abstract

The Toyota Production System (TPS) is a continuous improvement philosophy. It became the basis for the LEAN and Six Sigma manufacturing philosophies. A significant element of TPS is autonomation, or "automation with a human touch". In the same way that lean techniques have been applied to automotive manufacturing, the principles of autonomation can be applied to offshore wind farm maintenance practices to improve turbine availability. This paper presents a mothership concept design to support an autonomation approach to offshore wind farm maintenance practices, developed through an implementation of the 'NetWork' model of Environmental Psychology and Biophilic design.

The NetWork model encompasses both how and where work is done and how workers, processes and places are supported. It differs from previous models by focusing on the work that is to be done and how to enable it to be done most effectively. This knowledge informs the specification of furnishings, technologies, equipment and infrastructure that enable workers to make the best of wherever they work, to develop effective work practices, and to continue to adapt. This contrasts with the more traditional focus, which addresses only the places of work, and their efficient delivery and maintenance. The evolutionary basis for Biophilia, is that contact with nature is a basic human need: not a cultural amenity, not an individual preference, but a universal primary need. The Biophilia hypothesis and supporting research tells us that, as a species, we are still powerfully responsive to nature's forms, processes, and patterns. The design process presented is a Transfer of Innovation from interior architecture where it is a well establish approach to produce highly productive and low stress working environments. The potential of this Human Factors focused approach to reduce risk and hence operational costs such as insurance is significant.

Exterior Design and Biophilia

European Boat Design Innovation Group – Wind Farm Support Vessels

The stylised exterior form has a structural glass roof feature, enclosing a large interior garden space. Inspired by superyachts and architectural forms the exterior has an imposing presence of architecture upon the water. The flowing sculptural features on the upper decks and the use of a colour break help to give the simplistic geometric form a sense of motion and elegance, as shown in Figure 3.



The communal lounge facilitates formal and informal communication and team building through providing a range of spaces for together, alone etc. Adaptability of space is critical, drop down project screens and large meeting tables are used that can be transformed into smaller tables. The implementation of individual pod areas facilitates work in isolation, with tables providing small group work and meeting spaces. The lounge areas have views of either the sea or the interior garden engaging in Biophilia. All of these facilities are optimised through the development of communication and planning software to allow individuals to know where people are, what they do and what events or activities are happening. The individual tablet is the conduit for such information. This requires a significant amount of interaction designer and app development, which is outside the scope of this initial proposal. Natural light and sea views are critical to engage in Biophilic design.

While the primary function of the dining room is eating, the actual daily usage of the space for this activity is low. Adaptability of the space is therefore critical to support the objectives of the design brief. The tables have window views, shown in Figures 9 and 10, and allow staff to meet both formally and informally supported through integrated IT systems such as retractable large screens for communication and team work.



TPM and Environmental Psychology

Total Productive Maintenance is based around having zero breakdowns and production losses, and is one of the foundation principles of the lean production system. TPM evolved from suppliers to Toyota in Japan to enable them to meet the demands of the TPS [1].TPM is a philosophy that does not just focus on the 'Maintenance Department' although maintenance does have a significant part to play. TPM addresses all the reasons for equipment losses.. Consistent standards including Overall Equipment Effectiveness are the basis of the structure, shown in Figure 1, and the pillars that support TPM are:

- 1. Autonomous Maintenance: This means that everyone owns maintenance and that everyone has a role related to maintaining equipment.
- 2. Effective Training: The TPM training is to be focussed on plant operators so they can detect abnormalities in equipment before a breakdown occurs.
- 3. The maintenance function must have a multi-functional workforce, effective and appropriate PM's, well-defined KPI's and an in built continuous improvement loop.
- 4. Early Equipment Management: Ensuring equipment is fit for purpose before implementation. This includes effective and informed decision making during the design process, ensuring the machine is operator friendly and understanding the preventative maintenance requirements for the life of the equipment.

The TPM philosophy promotes training to understand potential breakdown causes, and the development of effective and efficient maintenance strategies that are continuously improved.[2]



Figure 3: Render of final exterior form proposal



Figure 4: Plan view sketch of interior garden with CAD render of plan view

The second stage of the NetWork platform of support involves creating new work settings and their infrastructure, including those tools and protocols needed by workers outside of the places controlled by their employer. The following provisioning specification for interior areas was developed from an analysis of the identified activities, considering the y generation approach to developing social networks, with a focus on informal collaboration communication.

Engaging in the principles of Biophilia, the central focal point of the design is a large interior garden space with a light canopy, shown in Figures 4, 5 and 6, to enable previously land based technicians to experience well-being through a connection with nature. Due to the specific nature of the user group the mothership platform is a SWATH to ensure minimal motion of the vessel in the challenging weather conditions of the North Sea. The garden space has a range of seating configurations and seating locations designed to offer a sense of privacy between them. To facilitate a range of activities from individual to group socialising and informal meetings. Connectivity is provided by tablets. The inboard cabins connect with the garden area for natural light, giving them the design meaning of a small apartment on land.

Figure 9: View of dining room from seating area



Figure 10: View of dining room from serving area

Living and working in the same space requires a formal demarcation between activities, even though people continue to work in fourth spaces. This is achieved by locating the briefing room and changing room in the lower decks. This means that the lower stairwell has to communicate the design meaning of a transition between the formal work areas and the accommodation areas of the vessel. The briefing room is essential for face-to-face communication before a 12 hour maintenance shift and afterwards for communication as a TPM activity. The changing area shown in Figures 11, 12 and 13, is designed as a personal space with storage of work ware and storage for personal items, to help the user develop an affinity with the space. The use of simulated environment views engages in Biophilia. Given the loading time of WFSV the changing provision is for half the total crew, using domotic technology to identify crew members enables the changing room as a space to be shared by two crew members at different times with security control on the lockers, to make it a personalised space. The inclusion of VOIP technology to allow technicians to make a brief connection with friends or family before starting work will keep them connected.



Fig.1: The Five Pillar model of TPM [2]

The majority of continuous improvement philosophies and tools are derived from the Toyota Production System [1]. The application of a continuous improvement philosophy to the wind farm maintenance function can only have a positive effect if all stakeholders are involved in the deployment and effective Work Flow processes are maintained. Therefore the mothership must be designed as a work environment that can support and nurture a culture based on a continuous improvement philosophy.

To implement the TPM within the offshore wind farm, there should be a move to on-line condition based maintenance wherever possible. This should be supported by autonomation inspection system approach which is efficient and effective for new and developing technologies. Given that both wind turbine and condition monitoring technology are constantly evolving. The mothership and WFSV become the office and plant space respectively for the technicians, with the mothership also providing an accommodation role. Both spaces must effectively support the culture and work activities. These work activities being a combination of knowledge work and maintenance activity. A clearly documented work flow need to be developed based on the principles of Lean, Kaizen, TQM and TPM. This being implemented through rigorous staff training before deployment and CPD activities when in post. The design of the mothership platform as an offshore workplace and accommodation has to facilitate the key technician activities identified in the paper and nurture the identified cultural aspects:

"NetWork" is an environmental psychology model proposed by Heerwagen et al[3] for the analysis, strategy, design and provisioning of workplaces, shown in Figure 2. It represents a change in focus from "place" to "work," through a thorough understanding of work as the basis for workplace design. The model emphasizes the importance of understanding knowledge work now and as it evolves, and the settings in which it takes place. Whereby organizations need to provide settings beyond those traditionally provided by "the office" and to develop a robust capability to continuously adapt settings and provisions as work evolves over time.





Figure 5: View of interior garden from seating area

Figure 6: View of interior garden from roof

Interior Design



Figure 7: View of technician apartment from entrance

Figure 11: View of changing room from shower



Figure 12: :Perspective view of room

Figure 13: View from sink area

To help the technicians maintain fitness a gym is implemented as a 4th space, fully equipped for technicians to engage in knowledge work while exercising on a treadmill or other exercise machine. These activities include report writing through voice recognition software and CPD training material.

Conclusions

The proposed exterior form needs to be evaluated in terms of the emotional response of stakeholders. Given the significant 'knowledge work' nature of the technicians role in the O&M activities in the offshore wind sector, Environmental Psychology offers a significant opportunity for Transfer of Innovation from the built environment to the commercial marine sector. The 'NetWork' model [3] offers a more complete approach to the support for work based on: thoroughly understanding what work is and how it is carried out; provisioning individuals, teams and the places over which the organization has control or influence. The critical activity for Marine Designers is to engage in thoughtful analysis of the behaviours and processes that are most important and then to design the work settings to support them. To support the full range of behaviours the implementation of new technologies and applications is critical, requiring an effective engagement in Environmental Psychology to address the challenges they pose, such as the loss of face-to-face interaction in virtual collaboration.



Fig. 2 :NetWork, the Workplace of the Future [3]

The activities of wind farm O&M within the framework of TPM combine maintenance work activities with Knowledge work. The 'Network' model suggest that mobility, collaboration and sustainable practices must be considered holistically, as part of a larger workplace strategy, in order to effectively support individuals and teams. This approach to environmental psychology facilitates a better definition of knowledge work and effectively and efficiently translates that understanding to the design, provisioning and ongoing management of workplaces.



Figure 8: View of technician apartment from bed

The technician apartment Shown in Figures 7 and 8, has natural light to promote well being applying the principles of Biophipilia. A minimalist interior design approach I sused with adjustable mood lighting to promote a positive space. It has a computer, tablet terminal and large screen to connect with family and friends. This also facilitates CPD informal work communication for improvements and report development. The ensuite bathroom is designed to give the feel of a small apartment rather than a commercial vessel. In board apartments have a view of the interior garden and those at the perimeter have a view of the sea.

References

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EWEA Offshore 2015 – Copenhagen – 10-12 March 2015

