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ENGAGEMENT IN THE ARCTIC – THE 'MODULAR ARCTIC HUB (MODARC)' FACILITATES THE 'KICK-OFF'

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ABSTRACT

It seems to be certain that a huge variety of activities will be established in the Arctic in turn of global warming in the coming decades. These activities comprise fishery, tourism, cargo shipping and resource extraction mainly taking place in Arctic waters, at coastal areas and at shore. As history shows, these activities often suffer from a complicate supply of skilled personnel, insufficient infrastructure and not suitable tools for use in harsh environment, which are significant obstacles towards a cost efficient setup of required hubs supporting the 'conquering of the Arctic'.

IMPaC has taken the chance of participating in the European funded joint research project ACCESS (Ref. [3]) to develop a concept for the modular establishment of stations in the Arctic: MODARC (MODular ARCtic Hub). The basic module of MODARC shall act as initial hub providing fundamentals like accommodation, energy, communication in a safe and secure way. The hubs shall be self-sufficient for an extended kick-off period and operable conforming to a zero-emission policy, which IMPaC has already met during projects for the Caspian Sea (Ref. [2]).

The basic modules are operable right after installation allowing supporting the establishment of further specialized activities serving the various means of activities mentioned above. Thus, the character of each settlement will be case (project) dependent but comparable in its basic concept. Paramount advantage of the MODARC concept is the idea of producing the floating modules in worldwide benign conditions like harbors or wharfs allowing testing and certifying each module prior to send out and installation at location. Even personnel can be trained before or during the shipment to the operation location – just like it is usual e.g. in Aerospace technology.

INTRODUCTION

A paper published by IMPaC at OMAE 2014 (23085) introduced the results from an assessment of EER means (Escape, Evacuation and Rescue) suitable to work in Arctic conditions. The work has been prepared in turn of the funded EU project ACCESS. As one of the results a gap has been identified arising with the required land based 'backbone' of any of the existing techniques.

This paper describes the risk based development of an efficient way to close this gap by providing a modular 'backbone' for any kind of activity in the Arctic, the MODARC. MODARC consists of a floating Basic Module, which can be added by land based specialized extensions supporting special needs of fishery, tourism, cargo shipping and resource extraction in Arctic conditions. Special emphasis is laid on the EER capacity, which is essential to be functional in this area of the world.

Reference to Paper OMAE2014-23085

It is not economic to repeat all information mentioned in paper 23085 published with the OMAE2014 conference. Nevertheless, a few basic statements shall be refreshed:

- The Arctic is a challenging environment characterized by harsh climate, very few infrastructure and enormous distances between settlements
- Nevertheless, the Arctic experiences a significant change as global warming results in e.g. permafrost decline at shore and melting sea ice coming with reduced extent and thickness on one hand but with increased wave heights and sea ice drift speed on the other hand
- A lot of activities tend to take advantage from these changes as there are fishery, tourism, cargo shipping (e.g. Northern Sea Route and Northwest Passage) and resource extraction (e.g. oil, gas and minerals) (Figure 1)

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- These activities put one focus on adequate support and Search and Rescue (SAR) infrastructure in the Arctic which is not yet everywhere available as assessments show (e.g. Ref. [2])
- It is mandatory and wise to consider existing structures and involve as much as possible local communities in any major development
- IMPaC proposes to follow a modular approach to cope with these challenges in a case dependent way

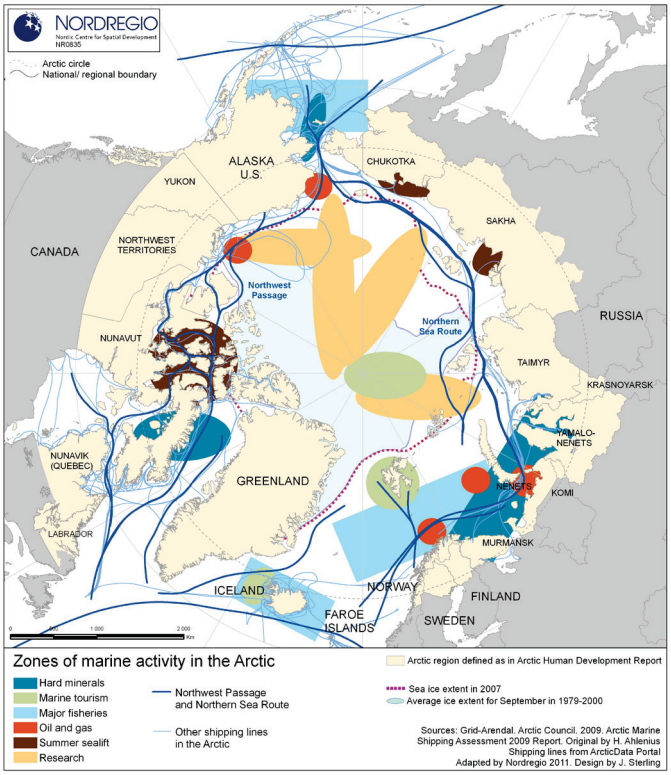

Figure 1: Zones of marine activity in the Arctic (Ref. [5])

Since OMAE 2014 this modular approach for service stations for the Arctic has been further developed by IMPaC as presented in this paper.

STRATEGIC LOCATION(S)

As exemplary approach the Northern Sea Route shall be considered in more detail and formulate the following questions: What happens if there is an accident on a platform or on a ship along the Northern Sea Route? From where does any help arrive? Where do the people escape to, if they have to leave the ship?

One answer would be: According to standard helicopter ranges we propose to build several new stations onshore and offshore. Individual station locations should be determined by proximity to highly active areas ideally covering the whole area depending on air and sea rescue ranges.

If risk assessments confirm existing settlements on islands and on the main land can be re-used and upgraded. Nevertheless, most of these existing settlements are military relicts of the cold war and are thus often ruins today.

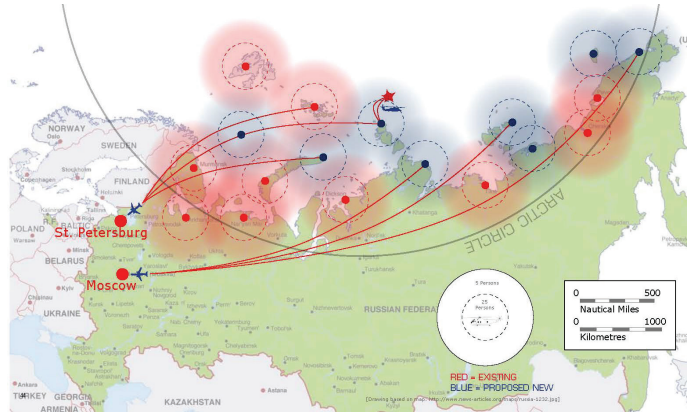

Figure 2: Strategic locations for regional Hubs along NSR (source: IMPaC)

The location map (Figure 1) represents a first approach via a gap analysis based on helicopter radii. The map also highlights the gaps in the arctic region, i.e. it is not possible to cover all areas from onshore facilities. This could lead to a demand for potential offshore rescue facilities.
More detailed studies and local surveys need to determine future settlement locations in the arctic region.

GATEWAY TO THE ARCTIC

A modern arctic settlement – only rarely does an opportunity like this arise. The rescue facility for multiple industries combined in a single settlement will become the gateway to the arctic. This gateway to the arctic should include the key elements airport, harbour and accommodation / healthcare.

The vision is to create a gateway beyond the industrial settlement providing necessary rescue infrastructure and to develop it into an arctic settlement attracting people, i.e. operating staff and families alike – at least for a defined scope of work and time.

ASSESSMENT OF FLOATING STRUCTURES

The idea of using floating structures for extending initially land based infrastructure to near shore or even offshore locations is not new. It has been successfully employed since decades and with several specific adaptations for various purposes, which shall be briefly introduced by the following examples.

Floating Hotels

In 2006 the company FLOATEL started business by providing accommodation and construction support vessels, the so called *Floatels* (Ref. [9]). These vessels are dedicated to support

offshore activities of the oil and gas and the construction industry in times when standard capacities at drilling or construction vessels are overloaded. These peak shaving capabilities are of major importance as many offshore activities are increasingly complicate and require many more specialized personnel as in former times, which cannot be accommodated in a traditional way on board the operation platform.

One of the most advanced designs developed for harsh environments is the so called Floatel *Superior*, which has the following characteristics: 94x91x64.5m (L, B, H) with a draft of 23m (operation conditions, with thrusters) with a displacement of abt. 29.000t. It can accommodate up to 440 persons in single bed cabins and offers 50 work stations for clients. It is equipped with all relevant facilities to support daily work like Hospital, Helideck, Gangway, and Cranes (up to 50t at 30m).

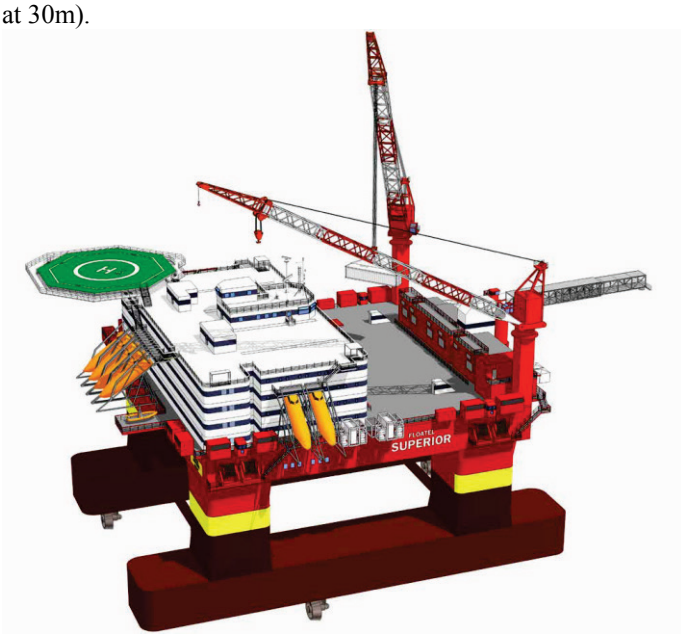

Figure 2: Floatel *Superior* (Ref. [5])

Megafloater Airports

Megafloating airports are offshore structures that accommodate complete airports including runway and support facilities. Their characteristics are features like being unaffected from earthquakes, having few environmental impacts on ocean currents and marine eco-systems, being able to be constructed at low cost and in a short period of time independent of ocean depth and ground condition, and also making possible use of the immense ocean space.

Megafloating airports are a focus of constant attention, particularly for metropolitan cities that typically require large airports, but only have limited construction space.

In 2000, the Japanese Ministry of Land, Infrastructure, and Transport sponsored the construction of Mega-Float, a 1000 metre floating runway in Tokyo Bay. After conducting several real aircraft landings, the Ministry concluded that floating runways' hydro-elastic response would not affect aircraft operations, including precision instrument approaches in a protected waterway such as a large bay. The structure has been dismantled and is no longer in use.

In March of 2001, the "Mega-float Airport Investigation Committee" put together a detailed evaluation of the verification tests on the 1000m Mega-Float airport and the 4000m-class test design, and announced in their final report that a Mega-Float airport with a scale of up to 4000m as being more than feasible.

Figure 3: 1000m Mega-Float floating airport during installation and ready for operation in Tokyo Bay (Ref. [7])

Floating Liquefaction Plant

The core of the Snøhvit gas liquefaction plant is the cold box technology supplied by Linde, Germany. This part of the overall LNG plant has been assembled on top of a floating pontoon at a wharf in Cadiz (Spain) before it was shipped via a heavy load dock ship to the operating site in the Arctic (Melkoya Island close to Hammerfest, North Norway, Ref. [10]). Dimensions of the pontoon: 154m x 54m, weight of the pontoon: 10.000t, weight of the process facility: 25.000t (Figure 4). Thus, assembling, testing and certification of the plant has been drastically facilitated compared to an at location operation.

IMPaC has been involved in the design of the electrical substation of the plant as sub-contractor to Linde.

Figure 4: Float over of the Snøhvit process facility pontoon to the dockship prior shipment to the Arctic (source: Linde)

Beside these applications a lot of other facilities and functions have been mounted on floating platforms as it is well known from the oil and gas industry.

THE MODULAR ARCTIC HUB - MODARC

Aim of the development called MODARC is the improvement of the so called kick-off phase of any activity in the Arctic. Thus, the modular approach allows for a stepwise installation and establishment under harsh conditions. At the beginning stands the risk based site selection considering the 'clients' needs on one hand, which differs for fishery, tourism, cargo transport and resource extraction scenarios. On the other hand the challenging Arctic environmental conditions have to be taken into account, as well as the significant distance to other hubs along the coastline. Consequently, as one characteristic of the MODARC concept the modules shall be built in benign areas around the globe (wharfs, harbors) in order to reduce construction costs while increasing quality and reliability of scheduling. In addition the flexible modular concept allows considering of specific requirements of each client industry. All applications in common is the need for a basic support structure providing initial infrastructure to start the work.
Aim is to provide infrastructure for third-party support services to passing ships, which include very basic repairs/spare parts and maintenance, traffic control, communications, SAR, and weather forecasts, particularly for predicting the hazardous polar lows.

Risk Based Approach

The idea of introducing the concept of a floating MODARC is the awareness that bundling all essential and secondary infrastructure of a high technical content on a barge like structure will reduce the risks associated with an incomplete or malfunctioning infrastructure. This barge can be fabricated and tested in an industrial and environmentally less challenging location. Once finalized, the MODARC-barge can be transferred to its target location along the arctic coastline. The modular approach ensures that all essential infrastructures will be available and ready for the development of an initial settlement along the arctic coastline in an efficient and environmental friendly manner.
Common and core parameter for the development of settlements in arctic regions regardless their final purpose is the availability of a functional prime /essential infrastructure providing:

- Housing
- Fuel
- Electricity
- Warmth (HVAC/ steam)
- Fresh water
- Safety equipment / vehicles
- Ambulance and medication
- Construction equipment and consumables

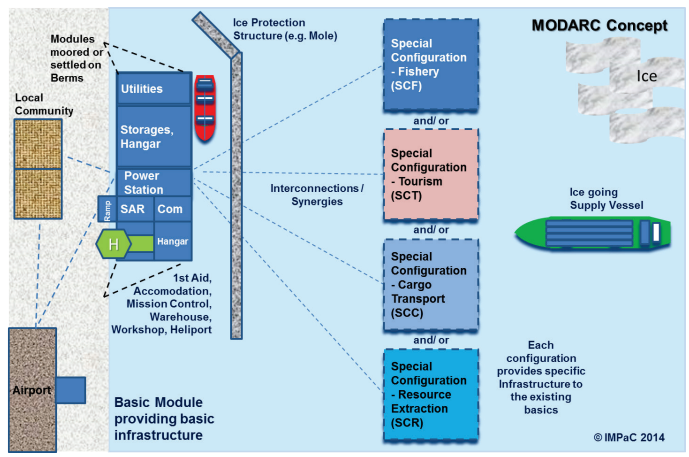

Figure 5: MODARC provides basic infrastructure which can be easily configured to suit specific needs

These main infrastructural components of the MODARC-barge such as fuel-, freshwater tank capacity power generator and steam generator sizing will be adopted as required for the individual needs and sizes of the settlements planned (Figure 5). For example do the requirements of a settlement, which mainly is intended to suit the needs for the fishing industry, differ to the requirements of a settlement especially developed for tourism in terms of:

- Housing requirements for fishermen or tourists
- Fuel storage for a fisher fleet or for Cruise Liners and vehicles for onshore tourism
- Electricity consumption for fish processing and cooling or the requirements for touristic needs
- Freshwater supply for fish processing or the requirements for touristic needs
- Safety equipment / vehicles for the fishing fleet or for rescue from up to 5.000 tourists Cruise Liners

- Ambulance and medication for a fishing settlement or for the event that individual tourists have to be urgently brought onshore treated and the event that all passengers of a Cruise Liner needed to be evacuated, housed and treated until they can proceed their trip or are flown out.

Likewise the setup of the MODARC-barge can be adopted and optimized for settlements for various purposes such as:

- Fishery:
  A settlement with a suitable harbor protected by breakwaters, a fish processing industrial part, suitable housing for fishermen and workers in the fish processing industry and a small airfield for crew and worker transfer.
- Tourism:
  A settlement providing hotels, touristic facilities, a park of onshore vehicles for tours into the mainland a medium sized airfield to enable suitable accessibility to the area for tourists' arrival and departure as well as for evacuation of the entire number of Cruise Liner passengers after being rescued and brought to the tourism settlement
- Cargo Shipping:
  An industrial estate providing berthing and refueling capacities for cargo ships and ice breakers, as well as small airfield for crew and worker transfer.
- Resource extraction:
  A settlement with a suitable harbor protected by breakwaters, a helicopter base and a small airfield for crew and worker transfer.

The final adaptation of the MODARC-barge will also be determined by its final target location along the arctic coastline. The coastline could be rocky, which would result into a solution of berthing the MODARC-barge within an artificial harbor being generated by rock blasting. The extracted rock volume would serve well for construction of harbor and jetty structures.
Should the final location of the MODARC-barge and development of adjacent settlement be along swampy, sandy or pebbly coastlines, the approach will be different. In this case the MODARC-barge will need to be equipped with respective construction machinery and earth-moving equipment.
For all final purposes of a settlement the centralization of key infrastructure will reduce the risks by:

- Providing essential equipment in the first phase of the development
- Providing adequate storage and repair facilities
- Being able to assure that suitable safety equipment / vehicles as well as ambulance and medication will always be available during the development
- Providing adequate means of communication
- Providing suitable housing for the work force of skilled worker and technicians required
- Being able to ensure the hygienic standard for canteen and sanitary areas
- Assuring that equipment and tanks on site are certified and tested
- Preventing polluting the environment due to providing emission protection means (noise, liquids) as well as an operational effluent treatment and or incinerator facilities
- Efficient generation of e.g. electricity and steam due to preassembled and optimized equipment

An exemplary implementation

The assessments made for the different markets, the requirements in term of environmental constraints and differing existing local and regional infrastructure, and cost structure for constructions made in Arctic conditions compared to those made in benign areas worldwide led to the development of a basic MODARC concept, compare Figure 5. This concept has been translated into a first CAD model showing a possible implementation, see Figure 6 and Figure 7.

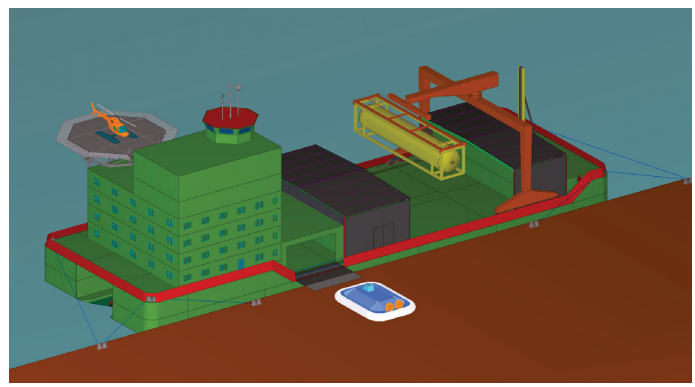

Figure 6: MODARC with launched Hovercraft and crane operation

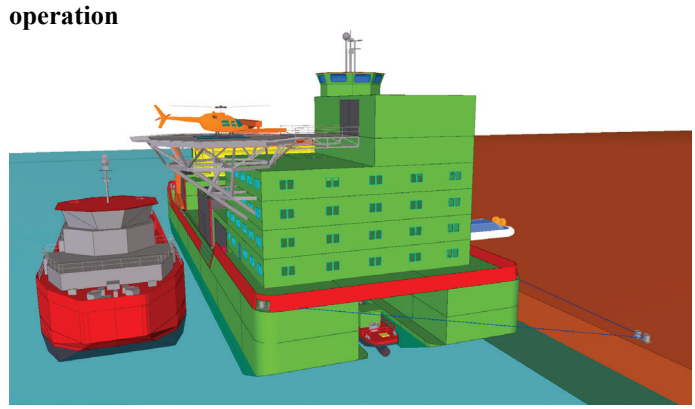

Figure 7: View from aft on MODARC with supply vessel and optional garage for the rescue boat

The MODARC kernel module is based on a barge type floating vessel with a wave flattening and ice breaking bow and aft to reduce sea born loads. Main dimensions of the barge are 90m/ 30m/ 38m (L/B/H). The barge has no self-propulsion and must thus be towed by tugs or transported via dockship to location. Nevertheless, the barge is fully self-contained for a defined time of e.g. one year when moored at location or settled on a berm.

To reduce the influence of bad weather conditions the MODARC can be placed in a sheltered position e.g. behind an island or behind an artificial mole or in a harbour.

Based on a suitable and redundant power generation with sufficient fuel bunker capacity as well as sufficient fresh water capacity a welcoming accommodation and working atmosphere shall be provided to the permanent staff of abt. 50 persons and temporary guests of up to another 50 persons. Tanks for grey and black water shall be dimensioned according the number of persons accommodated. In addition a sewage treatment facility shall be available enabling to follow a zero-emission policy; residuals shall be off taken by the scheduled supply boats.

To reduce icing of relevant structures and components everything is housed and protected for winterisation or can be heated, like external stairways or gangways.

Access to MODARC is possible via helicopter, which can be sheltered in a hangar on top of the accommodation structure when not in use. It is assumed that the wind speed limit for the helicopters to operate on the helicopter deck is about 55 to 60 knots, but normal flying operations may be performed at wind speeds with gusts up to 60 knots. The helideck shall be dimensioned to meet requirements of smaller helicopters like Airbus Helicopter BK 117 C-2 or comparable. Larger rescue helicopters like the Sikorsky S-92 might land onshore nearby the MODARC. Other means of transportation is provided by two hovercrafts, which can be launched via ramps on both sides of MODARC, port side or starboard, allowing reacting if one way is blocked by ice etc. In addition a small rescue boat with light ice breaking capacity shall be sheltered in a garage at the aft end of the barge while a number of jet skis and one or two smaller trucks (5t) shall be available to provide land based transportation and interaction with local communities (Figure 7).

Lifting of material or consumables e.g. stored in containers is possible by means of a bridge crane which can travel alongside and transversal the cargo storage area making it possible to provide lifting from both, onshore and offshore (supply vessels) with a crane lifting capacity assumed to be 25t.
The storage area provides space up to 875m² and height up to 6m. Access is realized by two large doors which slide aside to open the space.

Every operation is supervised from a control room located in the top of the accommodation building with a tower like upper structure for optimal overview. For communication the control room is equipped with all required means e.g. for broadband VSAT satellite communication. MODARC shall act as hub for land / sea bound communication for domestic and international ship traffic and as hub for Arctic shipping pilots.

CONCLUSIONS

The following basic ideas shall be taken home as conclusion:

- Various developments will be required to serve increasing activities in the Arctic in turn of global warming, facilitating access to Arctic waters and shorelines
- The challenging environment in these regions demands special technology and methodology providing safe and reliable workspace, storage, transfer, accommodation, and EER means for personnel, tools and material
- The risk based MODARC concept provides the case dependent essential equipment in an effective way as the self-floating structures can be built, tested and certified in benign areas of the world; personnel can be trained prior to shipment on the new systems in controllable conditions; transport and installation at location is an easy task compared to built-up of onshore facilities in this region of the world
- MODARC is especially dedicated to enable and facilitate the first phase of each development for harsh or even Arctic environments in a cost effective way

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The authors want to acknowledge the contribution of all project involved colleagues at IMPaC.

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