USER FEEDBACK IN SHIP DESIGN

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SUMMARY

In the design, construction and management of ships, there appear to be few opportunities for communication between the designers, and the users. Ships are often large, complex single entities, including hundreds of technical sub-systems and components from a variety of sources. The designers and providers of large ships do not usually have the advantages of volume production industries where considerable resources can be devoted to prototyping and testing the completed assembly before commitment is made to final production.

In the absence of this, however, the experience of ships' users – those who build, manage, operate, maintain, own, and travel on ships – can provide large amounts of valuable information for the design of new ships. This feedback from users informs designers of the good features to be continued and developed, the failures and weaknesses, and even some ideas about how to improve them.

Techniques which are used to successfully capture user feedback for the design of land-based buildings and facilities are described in this paper. Experience from marine design shows that these techniques have considerable potential for the ship design and construction industries, as well as for the owners and operators of ships.

NOMENCLATURE

POE = post occupancy evaluation, a participatory evaluation method whereby those who have an interest in a facility evaluate that facility, in the facility.

1. INTRODUCTION

User feedback provides important information about how ships, their components and services, are used, and can assist with improving ship design, safety and operation. Ship design based on systematically derived information about how ships are used, and about users' perceptions of the strengths and weaknesses of ships in service, is likely to improve safety and operation as well as comfort and quality.

User feedback about ships in service is important because the designers and builders of ships do not usually have the advantages of volume production industries where considerable resources can be devoted to prototyping and testing the completed assembly before commitment is made for final production. There are seldom opportunities for users of ships to communicate with designers and builders, and unlike consumer products, ships are not subject to the mediation of the market place.

There are many people involved with a ship throughout its lifetime, with a large variety of roles and reasons for their involvement. They will have a wide variety of expectations relating to the ship, and so we need user feedback which can reconcile these.

In ship design, as in all design fields, regulation and ergonomic measurement form much of the basis for achieving safety and convenience of use. Often these are based on experimentation, assumptions, traditions, and accepted practices, and do not necessarily account for the behaviours of individuals using the ships. It is difficult to foresee all of the physical and social conditions under which a ship or its components will be used. When designing for safety and operation, we need to know more about what people do and how they do it, and about what they expected. The best people to tell us this are the users.

In ship design, as in all design fields, there are also problems about getting information into design. Designers have to hold a lot of things in their heads at once while they are developing a concept, and usually design development is undertaken by a number of people, not always in contact with each other. In developing user feedback, we have to be mindful of the way information is categorised, stored and transmitted to designers – so that it can and will be used effectively.

Designs for both ships and buildings have to meet a range of health and safety regulations, users' workplace agreements, the provisions of employment contracts, and the like. In addition, ships often have to comply with the regulations of more than one jurisdiction, and they have to perform in a range of climate and weather zones. However, many similarities between the design, construction, and operating processes for ships and for land-based structures have been identified [1] and user feedback techniques developed for building design are likely to be suitable also for ship design. Most effective among these is post occupancy evaluation (POE). It enables systematically derived information about users' experience of ships in use, to be integrated with the processes of design and operation, and has potential to improve ship design, safety and operation.

2. IMPORTANCE OF USER FEEDBACK

People who use ships for their livelihood or as passengers probably know them best. However, designers and providers of ships are seldom able to talk to the users of the ships they make.

Ships are designed, built, owned, and used by different groups of people, who have different and sometimes conflicting expectations about what should be provided. It is important to have feedback from representatives of all those groups of people in a way which enables reconciliation of differences in expectations, and which enables optimisation of the design for each group.

In all design fields, understanding differences in expectations enables designers to achieve improved levels of user satisfaction, as well as improved safety in operation and use. It also enables more adventurous design approaches, and can often result in cost savings.

Ships are built to order to designs and specifications. They are built by a main contractor, but also include thousands of components and systems supplied by others. They take months or years to make, and once finished, users and owners have to accept them as they are. Furthermore, from the day of hand over, they require ongoing maintenance which in itself establishes particular patterns of commitment and use.

Ships may be used for several years before they are modified. Unlike the processes of design and manufacture of mass produced products, there are few opportunities to prototype and test a complete ship before finally committing to production. Knowledge about what works, what customers, users, operators, and crews like, and what is perhaps not so successful, has to be accumulated and passed on from one project to another. Because of the size, structure and complexity of ship design, construction and operation industries, this probably does not always happen very well.

Figure 1: Ships have many users over many years

3. FEEDBACK INFORMING DESIGN

What is needed is a systematic way of obtaining user feedback which is structured in a way which makes it useable in design and operation.

Similar challenges are faced in the architecture and building industries. In the preface to his book on Architectural Knowledge, Duffy [2] describes how user research and user feedback enables the benefits of design invention to be demonstrated to clients and users. With better knowledge about how buildings are used and what users expect from them, their design can be advanced and enhanced. Duffy identifies two special characteristics of architectural knowledge.

The first is that it is usually *combinatory and complex* – linking understanding of user requirements to the capacity of buildings to accommodate those requirements. Linking what has been done in the past with predictions of what ought to be done better in the future. Linking practicality with artistic judgement. Linking many disparate elements, because buildings are such large, complex, and value-laden objects.

The second characteristic is that architectural knowledge is usually concerned with the deontic rather than the descriptive – with *things as they ought to be* rather than things as they are.

3.1 PUTTING KNOWELDGE IN CONTEXT

User feedback has been used to enhance both the *linking* and the *deontic* characteristics of design knowledge, by bringing them into the context of things as they are.

It seems likely that knowledge about designing and operating ships also has these two special characteristics. However, because of conventions and the nature of the ship building industry, many of the opportunities for developing linking information in ship design are lost at the outset. We would expect that in the ordering and commissioning of new vessels, the owner's and possibly the operator's expectations would be conveyed to the designers. But it is unlikely, except perhaps in the case of super yachts and sporting vessels, that the designers will have contact with those who crew a ship, maintain its equipment, manage passenger services, or indeed ride on it as passengers. There are different cultures of providers and users.

In relation to building, Kernohan et al [3] describe these different and distinct cultures of providers and users. Providers of ships include makers, naval architects, designers, engineers, and ship building companies. They also include traders, the agencies that buy and sell or lease vessels, and the maritime finance companies. Providers also include maintainers, for example, ship yards which carry out maintenance work, or contract cleaning services for ferries.

Kernohan et al [3] concluded that the two cultures of providers and users are divided by supply and demand. These two cultures hold different values, they rarely make contact with each other, and their values often conflict. The expectations of passengers and crew – the

users – are likely to be quite different from those of the providers – the ship builders and owners. Users and providers are alike in that they derive some advantage from their connection with the ship, but the nature of that advantage for each group is different. Owners, as providers, for example, will want to maximise profit and efficiency and return on investment in the vessel. Crew, as users, will regard the vessel as their place of work, and will have expectations relating to their personal and collective safety, comfort, and support for effectively carrying out their professional duties. Passengers as users, will be expecting the best qualities of space, comfort and service in relation to the fares they have paid and their reasons for being on the vessel. A freight forwarding and logistics company will be expecting high standards of care and handling of goods along with punctual deliveries and low charges.

Fundamental aspects of crew and passenger safety and well-being are the subject of international regulations and agreements. However many of the characteristics of a vessel which affect its comfortable, safe, and efficient operation to meet expectations of both users and providers, will be a qualitative and subtle nature over and above the regulatory requirements for health and safety, and will probably have little to do with cost. There is a complex relationship between physical and organisational factors which can be clarified through user feedback.

Safety in operation might be improved, for example, by changes in the sleeping accommodation for ships officers. These could be modifications to environmental qualities such as noise and vibration, or they might be issues to do with the length and frequency of watches. Recent studies undertaken for airlines relating to the sleeping regimes of flight crews have highlighted these complexities and the need for further intensive studies across a range of physical and social factors [4]. There is probably no systematically collected information about the effects of restricted sleeping and working accommodation for ships crews on their abilities to operate ships safely.

3.2 FEEDBACK FROM DIVERSE USERS

In a general sense, the concepts of user needs in ships is simple. However, most are used by more than one group of users – even the family powerboat has more than one user, and if visitors and friends are taken into account, the list of users becomes quite large and diverse. On ships there are passengers and crew. There may be several classes of passengers relating to fares and accommodation standards, and there will almost certainly be classes of crew – officers, seamen, cooks, stewards, engineers, etc. All of these have social and cultural groupings that are distinctive, and expectations that are probably not aligned.

It is unlikely that ships will satisfy the differing interests of the various users and providers. Kernohan et al point out that in the architectural context, buildings usually satisfy one or the other group preferentially, and often the supply side dominates, because people on the supply side are accustomed to making decisions about what is built in their day-to-day work. They know how they want things to be, and they have to hand the resources and expertise to bring that about. Users do not usually have that advantage, and so are destined to accept things as they are. The same will apply to ships. Other than to avoid using it, passengers have no say in how the accommodation is configured. Similarly, crew will have to accept things as they find them, unless they have strong support and feedback opportunities through their employers to their ship owners and providers. Without such user feedback opportunities, it is hard for people who design accommodation, cargo handling, or the layout of navigational equipment on ships, to know whether what they design is as good as it could be, or any good at all from the point of view of the users.

3.3 ACCOUNTING FOR TRADITION

In ship design, construction and operation, there is an engineering dominance which further weights the supply side. This is also the case with other transport vehicles, where power plant, machinery, and drive trains for example (which are of course fundamental to the vehicle's purpose) dominate the layout, configuration, and shape of the vehicle. Perhaps extreme examples of this can be seen in the compromises to crew accommodation in submarines and space craft.

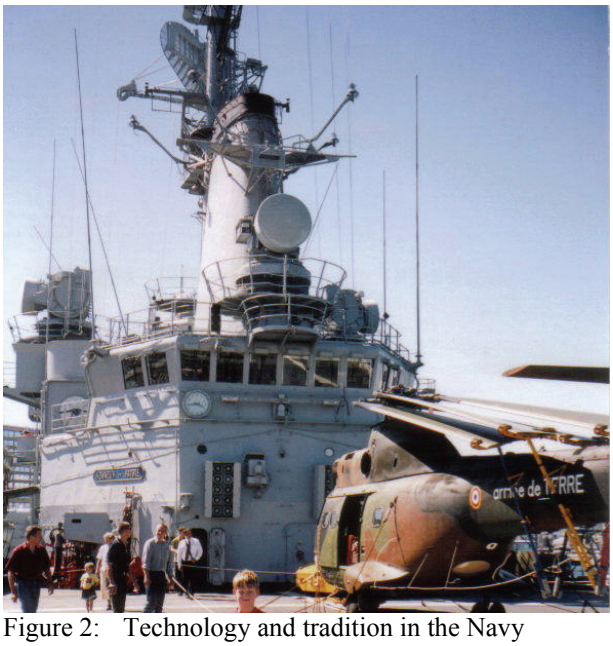

Figure 2: Technology and tradition in the Navy

The connections between ships and the people who operate them are complex and steeped in traditions relating to behaviour and design. There are of course long traditions in the navy and merchant navy, and indeed extensive and ancient cultures to do with seafaring and ships, to which many of the exigencies and spatial deprivations of shipboard life are totally

acceptable. There is a close relationship in the navy between accommodation, rank and status, and pride in seamanship and weaponry, which can render these issues unquestionable.

The design and operational layout of ships also largely follow tradition in such things as provisions for berthing and docking (which in principle have not change in thousands of years) separation of command and navigation from control of the power plant, sea keeping and weathering. For those who make and operate ships, it seems, expectations about what could be, are dulled by tradition.

It is also probably true, that many passengers are attracted to spending time on boats and ships, partly because of the particular kinds of accommodation they provide, and the evidence of seafaring traditions. For some passengers there is the romance and excitement associated with travelling in ships and experiencing the special kinds of accommodation and spatial arrangements which they perceive as being a necessary and important aspect of being at sea.

Maritime safety regulations, employment unions, and operator company agreements, will also have an influence on the design of ships. But if they are like their land-based equivalents in building and architecture, they too will follow traditions. Much of what they recommend will no doubt be short on knowledge about what people think and do in their work or recreational time. Extreme examples of this were demonstrated in Jonathan Sime's studies of people's behaviour in emergency situations [5]. He found that despite adequate provisions in terms of regulations, people died in building fires because of social and behavioural factors. They were slow or reluctant to respond to alarms, and tried to leave buildings by the way they had come in rather than by the fire escapes. No matter what is provided, if it is not perceived as relevant or safe by the users, it will not be used.

Standards and regulations do not guarantee comfort and safety, let alone user satisfaction. There is a need for more systematically derived information from users about the ways and conditions in which they use the spaces and equipment provided for them.

4. FEEDBACK ON BEHAVIOUR

User feedback can provide good information about people's behaviour on ships, and insights into how equipment and spaces could be improved to enable safer operation and well-being.

There are many codes of practice, standards and regulations relating to human accommodation in buildings, ships, aircraft, and all kinds of vehicles and conveyances. Some of these are applicable internationally, and some apply within specific jurisdictions or countries. The intentions of most are clearly to minimise the risk of injury to users of the facility to which they apply – to make it safer to use, more convenient to use, or more comfortable.

4.1 SOCIAL AND CULTURAL INFLUENCES

A lot of science and technology has been applied to improving safety, comfort and convenience of all manner of transport vehicles, equipment and buildings we use. Many improvements have been driven by social influences (trade unions, political lobbies). They include air quality, hygiene, waste disposal, lighting, access, fire protection, emergency evacuation, crash testing, seat belts, air bags, and so on.

However, most technical improvements will only improve safety and comfort for users if they are used or applied as the designers and legislators intended. This is frequently not the case, so they don't work. Handrails on companionways only prevent falling if people hold onto them. Seatbelts in cars only reduce crash injuries if people wear them. Sophisticated satellite navigation systems are only effective when ships' crews know how to use them and pay attention to them. Each physical refinement is only made effective through corresponding social and cultural action. User feedback can inform designers and operators about those social and cultural connections with physical space and equipment.

Figure 3: Safety on ships is a social and cultural issue

Elton Mayo's Hawthorne studies [6] were among the first to show, in a systematic way, that there is not a direct relationship of a stimulus-response kind between people's behaviour and the physical spaces and equipment they use. They showed that the relationship is more complex and has a strong social component. His studies compared productivity levels of factory workers with changes in lighting levels. Increases in productivity were seen to be related more closely to people's perceived attention from senior management than to improvements in physical working conditions. In other words, factory workers were responding to a perceived

social situation rather than to changes in their physical environment as such.

The studies by Rapoport and Watson in the early 1970s [7] have drawn attention to the cultural variability in environmental standards most of which bear little relationship to what people do, or how they are able to perform. There are many examples of people being able to work in physical conditions which would be intolerable to others, and much of these differences can be explained by socially and culturally based expectations. For example, some people would find it difficult to think clearly, reason, and calculate among the distractions and clatter of a ship's engine room, but marine engineers expect to do this all the time.

4.2 THE INFLUENCE OF EXPECTATIONS

From the work of Terence Lee [8] and others, we know that people have mental schemata of their environments which are based on their social experiences and expectations. Our activities can be seen to be more closely related to these schemata than to the physical things. Our expectations about the spaces and equipment we use, our activities and our behaviours are socially and culturally defined. Boat drills on passenger ships are an example of attempts to re-programme passengers' schemata in order to prevent, in ships emergencies, the kinds of fatal behaviours reported by Sime [5] in relation to building fires.

In this regard, it is important to recognise that accommodation and equipment do not cause behaviour, but are passive, and either permit or prevent us from carrying out the activities we want to undertake for socially and culturally defined reasons. The mechanic doesn't top up the oil cups on the bearings because they are there. The naval rating doesn't stand at the ship's wheel because it is there. They do those things because they have socially and culturally defined roles relating to getting the ship from one place to another, and those pieces of equipment enable them to carry out those roles. Aspects of the design and location of the equipment will make those roles easier, safer, or more pleasurable however, and may provide opportunities for new things to be done. Constance Perin [9] has said that behaviour originates with the person, who endows the environment with various kinds of stimulus properties. Meaning taken from the environment depends on the person's intentions towards it.

To demonstrate this for designers, we have been able to propose a model of environment-behaviour relationships which have been used in design education and practice [10]. The key feature of he model is that it shows how people are involved in a continuous process of negotiation between the things they want to do, and the opportunities provided by their physical equipment and surroundings.

4.3 FEEDBACK AND SOCIAL NEGOTIATION

Ellis and Joiner [11] have described the complex relationship between what we do, the socially and culturally based expectations we have, and the constraints and opportunities provided by physical resources and equipment. Our ability to negotiate within these relationships will affect how well we are able to perform and how we feel about what we do.

For designers and providers to have a better understanding of how to make better ships, it will be important for them to have access to the negotiation process which is experienced by the people who use ships. Appropriately structured user feedback can provide that access and open up the insights about what might be possible that go with it.

5. STRUCTURING FEEDBACK

There are many ways of getting feedback from users of facilities, including questionnaire, surveys, interviews, formal maintenance reports, observations and inspections.

Asking people questions about how they operate a piece of ship's equipment, or the suitability of a space they use, requires them to think in retrospect about a large number of factors at once, which means that sometimes critical ones can be missed or ignored, especially as most people do not think about or appraise the spaces and facilities they use in a critical sense on a regular basis.

Another challenge with feedback, is structuring the information in a form that is useful for designers and operators of facilities. Statistically presented information for example, is often not particularly informative from this point of view. The results of surveys and questionnaires are usually presented in statistical form which excludes anomalies and presents the norm. The trouble is that normal people in normal operating conditions seldom exist. Anomalies are often the most important thing, because they set the conditions to which we have to design.

Post occupancy evaluation overcomes these issues. Daish and Joiner [12] have described an approach to architectural design practice based on the shared experience of owners, users, and designers, and it is this concept of sharing experiences that participatory post occupancy evaluation methods build upon.

Post occupancy evaluation is participatory and structured approach to user feedback, and is proposed here as a way of developing knowledge for improving existing vessels as well as informing the design of new ones. To do this, the process does not only enable us to examine existing ships, but also to enter directly into the negotiations which users, owners and regulators have with each other vis a vis the designs. A really positive outcome of this

approach is that it can open up new ways of thinking about the design of ships, their components and methods of operation.

6. POST OCCUPANCY EVALUATION

In post occupancy evaluation, the facility sets the agenda, and how it is used remains the constant focus of attention and discussion. Important aspects and anecdotes are less likely to be missed. Users of the facility have the opportunity to negotiate their experiences with each other and with people who have other interests in the facility. The result is substantiated information with considerable depth, and accompanying insights.

Post occupancy evaluation brings together people who have an interest in a particular facility, and a key feature is the touring interview or facility 'walk-through'. This is a systematic and structured way of getting user feedback about buildings, facilities and equipment. In light of the commonality between building design, delivery and operational characteristics and those of ships, post occupancy evaluation is regarded as a suitable and indeed essential activity in ship design and operation.

The participants are the evaluators. Stated simply, the process involves walking through the facility with interest groups, noting how they describe it, how they talk about how they use it, the good and the bad points, and how they think it could be better. In the walk through, the evaluators are negotiating their ideas and perceptions with what they see, and with each other. Following the walk-through, the interest groups further negotiate their findings and recommendations with each other in an evaluation meeting.

Participant groups represent the different interests in the accommodation. For instance, an interest group evaluating crew accommodation on a navy patrol boat, would be the naval ratings and NCOs. Another interest group might be the Master and officers, who also have accommodation on the ship, and who have responsibility for the ratings and for maintaining the social structure and protocols under which they all work. Other interest groups for this patrol boat would include maintenance staff, navy purchasing and policy staff, and possibly designers and builders of the ship.

The post occupancy evaluation is facilitated by facilitators who do not evaluate. Managers are normally not concerned with the evaluation, although they may be represented in a participant group. Their role is administrative and supportive. They may initiate, approve and authorise an evaluation, and they have responsibility for ensuring there is action on the outcomes, and for the ongoing management of the action [13].

Another important thing is that the focus on the facility makes it easy for post occupancy evaluation to become an integral part of the design, construction and operational processes. This is indeed what has happened in the practises of land-based architecture, where post occupancy evaluation is now a widely recognised and scheduled service offered by practitioners and used regularly by facilities managers, building owners and tenants.

6.1 POE METHODS

There are several well-documented post occupancy evaluation methods which are used by a variety of government, commercial and private organizations in the design and management of their buildings [14] [15]. These are also applicable to the design and operation of ships. The common attributes of the effective methods are that they are participatory, in that they provide a forum for providers and users to directly negotiate their ideas; they take place within the facility being evaluated, and have a walk through component; and they require the participants in their various interest groups to be the evaluators. The generic post occupancy evaluation process as described by Kernohan et al [13] includes three core events.

- An introductory meeting of the facilitators and the participant groups to explain the evaluation process, and the procedures of the touring interview and review meeting.
- Touring interviews, when each participant group walks through the building with the facilitators. They visit places relevant to their interests and to topics raised at the introductory meeting. The touring interview is primarily for the members of a group to discuss and reflect on their views of the facility.
- A review meeting where the essential negotiation event of the process takes place. Topics raised from the touring interview are discussed, and formed by consensus into participant group recommendations for action.

Figure 4: A touring interview. The facility being evaluated sets the agenda.

6.2 POE APPLICATIONS

The generic post occupancy evaluation method has been used in a wide variety of applications of various size and complexity. For ships, post occupancy evaluation is suited to eliciting user feed-back on the design of passenger accommodation on a cruise liner, or a harbour ferry, the design and layout of engine rooms, the layouts of bridge and navigational equipment, and so on. It can also be used for focus studies on equipment design, for example cargo handling equipment, birthing and docking facilities, communications, or weaponry.

Design and construction companies, and the operators of fleets can use post occupancy evaluation to provide an accumulating database to inform their provision of new ships, as well as to inform maintenance, operations and upgrading programmes for existing vessels. The benefits – both physical and organisational provided by such an accumulating database of user feedback information for land-based building designers and managers are far reaching [16] and it is reasonable to conclude that similar benefits would accrue to for the designers and operators of ships, shipping fleet operators and shipyards.

Post occupancy evaluation is also used for focus studies of particular aspects of accommodation. Way finding in large buildings with public access, such as museums, airports, and hospitals, is a particular problem to which imaginative design approaches have been applied [17]. Post occupancy evaluation has been used successfully to discover the kinds of physical and mental cues people rely upon to locate themselves in large buildings.

Other examples of focus studies include the layouts of machine rooms and workshops, and detailed studies of various kinds of workstations. The detailed design of plant, services, and equipment on ships could also benefit from focus study approaches such as these.

Figure 5: User feedback on machinery and navigation can improve design for operational safety.

Post occupancy evaluation methods have also been adapted for use in participatory design projects of the kind developed by Sanoff [18] where prospective users are involved in the design of new facilities. Evaluation and design using a range of interest groups could conceivably support new and inspirational approaches to the design of ships of all kinds.

A number of people who have facilitated post occupancy evaluations have remarked that people are willing to give time and commitment to discussing the physical environments they use. The benefits from post occupancy evaluations are usually both physical and social, and many participants describe the immediate benefits they feel from having had an opportunity to share their views and experiences with others and to reach a better understanding of the accommodation they use. Physical benefits usually include changes to existing facilities and/or to the designs of new facilities. Social benefits include organisational and operational changes resulting from evaluations, and in some instances, these were all that was necessary to bring about improvements.

7. CONCLUSIONS

In the provision and management of ships, there appear to be few opportunities for communication between providers and users. Ships are often large complex single entities, including hundreds of sub-systems and technologies from a variety of sources. They may take months or years to build, and are subject to large amounts of legislation, tradition, and established practice. Except perhaps in the case of small mass produced craft, ships are not subject to the mediation of the marketplace and individual customer choice which bridges the gap between providers of consumer products and their users.

Feedback from users of existing vessels is therefore important for informing design and operation of ships. Because feedback is about ships in service, in a wide range of physical and organisational contexts, it can be very valuable.

Feedback can occur in a variety of ways, including survey methods, observations and formal reports. Most of these are of limited use because people providing the information are divorced from the facility they are reporting on, they seldom capture important anomalies and insights, and the resulting data are hard to assimilate in design.

Post occupancy evaluation is recommended as a feedback method because of its focus on the facility being evaluated, and its inclusion of providers and users in the one process. It is also able to be integrated into design and operational processes.

When post occupancy evaluation is used routinely and regularly by providers, it enables them to quickly establish a comprehensive and valuable database about the aspects of designs that are appreciated by users, and those that are less than satisfactory. It also provides them with large amounts of anecdotal information which can

help them to better understand the preferences of the various social and cultural groups who use the facilities [19]. Just as important, post occupancy evaluation provides interest groups with a good understanding of the opportunities and constraints in a particular design or project. It has been found to open up opportunities which did not previously exist, and which enhance safety, usability and enjoyment of facilities and save money and resources.

Figure 6: Ship designers and operators will benefit from a database of systematically collected information.

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