# TECHNICAL NOTE

## SMART TECHNOLOGY APPLIED IN THE MANAGEMENT OF YACHTING MARINAS

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**SUMMARY**

The aim of this paper is to analyse smart technologies implemented in marinas and their impact on safety, service quality, sustainability, environmental protection, energy consumption and optimization of operations. Key performance indicators and the definition of the smart marina concept have been derived from the concept of smart ports. The analysis was performed to establish the advantages and disadvantages of introducing smart technologies in marina management. The results indicate that marinas are undergoing a revolution in terms of booking management, safety and service quality, while there is still need for improvement in the field of monitoring and control of the environmental impact of nautical tourism.

**KEYWORDS**

Marina; smart technologies; marina management; nautical tourism.

**NOMENCLATURE**

| | |
|---|---|
| ACI | Adriatic Croatia International Club |
| AI | Artificial Intelligence |
| CPS | Cyber Physical Systems |
| EASME | Executive Agency for Small and Medium-sized Enterprises |
| ECMAR | European Council for Maritime Applied R&D Association |
| EMFF | European Maritime and Fisheries Fund |
| ESPO | European Sea Ports Organisation |
| EU | European Union |
| FIWARE | an open cloud-based platform for cost-effective creation and delivery of innovative applications and services |
| H2020 | Horizon 2020 |
| ICOMIA | International Council of Marine Industry Associations |
| ICT | Information and communications technology |
| IoT | Internet of Things |
| KPI | Key performance indicators |
| NGO | Non-governmental organization |
| RIS3 | Research & Innovation Smart Specialisation Strategy |
| SMARTEES | European project funded by the European Union's Horizon 2020 Research and Innovation programme |
| SWOT | Strengths, Weaknesses, Opportunities, and Threats |

### 1. INTRODUCTION

Marinas are the starting point and most significant part of the development of nautical tourism. The emergence of new technologies and trends has led to a need to make the existing systems and solutions “smart”. Marinas are faced with increasing pressure to optimize their performance, while tackling economic and functional challenges that impact their sustainability (Baker, 2018). This gives rise to other related issues, which concern operations, the environment, energy, safety, and security (Baker, 2019a).

As demand for marine tourism increases, so does congestion, due to the growing number of vessels (especially in high season), causing delays in the arrival/departure of vessels at/from berths. If there is a lack of information sharing in the system, the marina management has to deal with operating errors. Further, the higher number of vessels in marinas creates more pollution (air, noise, waste, water) and requires more resources (electricity and water), resulting in higher costs for both the marina management and vessel owners (Baker, 2019b). To enhance the efficiency of marina operations and organization, a comprehensive overview of marina activities should be performed, with an emphasis on the safety of vessels and marina users. As regards security, control and supervision, activities in the marina are the key elements (Ernst & Young, 2020).

As the number of moorings grows exponentially, marinas need to be able to cope with dynamic changes. By finding an appropriate method of management, an opportunity can be seized to gain higher profits, which

 

also means lower costs. This directly leads to the factor that encourages the implementation of smart technology in marinas – the demand for better service. The satisfaction of boaters is a key indicator of service quality in the marina. Since boaters are free to choose their own destinations, marinas must ensure their competitiveness and continuously provide a high level of service.

For a very long time, it was thought that merely building a marina was enough to attract boaters. Today, a marina without a defined forward-looking strategy cannot endure the intensity of international competition. Making a marina smart can help in this, as it streamlines numerous operations previously performed manually, which drained valuable time. This can be achieved by supplementing physical operations with smart digital processes, which produces better results.

Adopting such a dual approach yields substantial benefits both for optimising the physical infrastructure, and for management processes. For example, expanding marina capacity by increasing the number of berths and facilities could be very costly without the aid of digital technologies and predictive analysis. Intelligent technologies offer a clear insight into the impacts those investments could have in reality. As a result, a considerable amount of money and time saved through digitalisation could be invested in maintenance and infrastructure projects, with a focus on improving service efficiency.

In the context of marina management, "smart" solutions are becoming increasingly attractive and competitive. They help minimise the loss of time, money, space, and resources by optimising processes, which maximises the use of the available resources and reduces effort (Łapko, Wagner, 2019). These factors correspond to the current challenges in the nautical market such as spatial limitations, financial constraints, and impact on productivity, environmental awareness, and sustainability (Holden, 2018).

The development of smart marinas requires the integration of infrastructure, work processes, and employees into a unique and complex system, so information can be collected from all sources (Hofmann, Strewe, Bosia, 2018). To optimise marina management, introducing a cloud-based information and communications platform is necessary (Tan, 2018). An internal cloud is a platform that gathers all data concerning marina-related activities. Key innovative technologies have been used for this purpose, such as the Internet of Things (IoT), Big Data, Artificial Intelligence (AI) and similar. Monitoring, data capture and anticipation are used for improving decision making and processes.

By embracing new technologies, marinas increase the level of process automation, which improves the utilisation of capacities and directly affects business efficiency, thus enhancing overall performance.

What exactly IoT provides to marinas is a clear return on investment that takes the user experience to a new level. The IoT technology in a marina can reduce emissions, noise, and waste, and optimise resource management, maintenance, and the plan of infrastructure and superstructure.

Artificial Intelligence makes operations in the marina safer, more reliable, and less vulnerable to human error. The ability to effectively share data benefits both the marinas and their users. Intelligent solutions optimise information flow in marinas, directly boosting effectiveness. In other words, this drives an increase in revenues and allows for a higher number of vessels on a permanent berth or in transit (Hofmann, Strewe, Bosia, 2018).

Proactive planning of operations and keeping the entire marina area under control is possible only by interlinking the information and communications systems. It is up to each marina to decide whether to apply smart practices or to implement smart technologies together with the physical infrastructure, and to what extent – the goal always being the same – to improve efficiency, productivity, and safety, as well as to enhance performance, economic competitiveness, and environmental sustainability.

## 2. SMART MARINA CONCEPT: DEFINITION AND KEY PERFORMANCE INDICATORS

The introduction of smart technologies in ports has led to the need to adopt smart solutions in marinas as well. To adequately handle existing problems, marinas are starting to implement new approaches and technologies in solutions for operations planning and management. This is the concept of the Smart Marina, which has evolved from the concept of the Smart Port. Smart port solutions can to some extent be applied to marinas, but they have to be adapted to the needs of nautical tourism.

The Smart Port concept was itself based on the Smart City concept, which contains three main areas with easily measurable key performance indicators, as follows: Operations, Energy Consumption, and the Environment (shipowner.io, 2018). Accordingly, the European Sea Ports Organisation (ESPO) and ports participating in the EcoPorts network regularly monitor the environmental priorities of European port authorities (Figure 1) to identify high priority environmental issues and define the framework for guidance and initiatives to be taken by the ESPO (Nightingale, 2018).

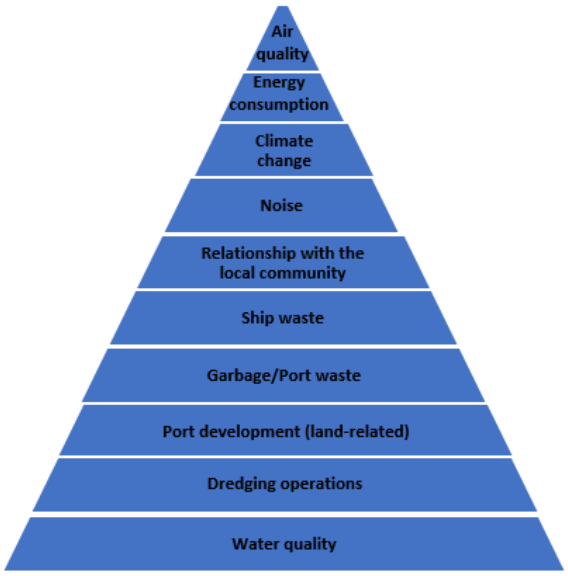


Figure 1: Environmental priorities of European ports (Nightingale, 2018)

Environmental priorities of European ports have remained unchanged over the last three years, as shown in Figure 1, but some of their relative positions have varied. For instance, climate change has risen from the tenth (2017) to third position in 2019, while air quality and energy consumption have occupied the first and second positions since 2013 and 2016, respectively (Nightingale, 2018). The growing importance attached to climate change shows that complying with climate regulations, reducing carbon emissions, and making the infrastructure climate-proof are high priorities for European ports.

Although noise has dropped by one place compared to the previous three years, it remains an important issue, especially for citizens living very close to port areas. Furthermore, the relationship with the local community is becoming increasingly significant for ports in terms of environmental quality, standard of living, and port development.

Ship waste and garbage/port waste have been the most closely monitored indicators for over five years, which clearly shows ports are ready to contribute to addressing marine litter, which is becoming a great concern for local communities and civil society (Holden, 2018). In comparison to previous years, the priority of port development (land-related) and water quality has decreased, while dredging operations have remained in the same position (Nightingale, 2018).

The Smart Port concept can be transformed into the Smart Marina concept by retaining the aforementioned main areas of the Smart City concept, and by altering the Operations and Energy Consumption KPIs. Since marinas can receive various types of vessels, the main problem is appropriate handling and organisation of the process of arrival and departure of vessels, as well as their maintenance. Smart marinas increase productivity by implementing smart technologies and adopting innovative management strategies.

As the number of vessels in a marina grows from one year to the next, marina management has to optimise capacity utilisation to increase effectiveness and minimise associated costs. Replacement of human workers with automated machinery leads to a decline in human error, safety issues and congestion, thus increasing the quality of service, safety, and security in marinas.

Marinas are large consumers of energy. Accounting for limited global energy resources, smart marinas endeavour to decrease energy consumption by promoting the use of renewables. Also, upgrading processes and equipment to require less energy and avoid energy loss raises the efficiency of energy consumption and reduces costs (Digitalship, 2018). Proper energy management in marinas generates continuous improvements in energy performance through continuous monitoring and controlling of energy consumption.

Environmental management systems offer a framework for evaluating, monitoring, and reducing environmental impact. Use of alternative fuels and zero emission technologies for vessels and land transportation in marinas significantly decreases harmful air emissions. Noise pollution can also negatively affect the natural ecosystem if effective actions are not designed and taken in a marina. Since marinas are mostly located near residential areas, one of the main environmental concerns is wastewater. Therefore, effective waste and water management are needed to reduce the amount of pollutants in marinas. Fast information exchange about the traffic flow of vessels facilitates decision making for marina managers and users. For successful implementation of the Smart Marina concept in practice, it is necessary to use innovative technologies that provide greater efficiency and sustainability through real time collection, processing, and sharing of data (Łapko and Wagner, 2019).

## 3. APPLICATION OF SMART TECHNOLOGIES IN MARINA MANAGEMENT

In recent years, state-of-the-art cloud technology has been used to create reliable business models for efficient marina management. Innovative technologies increase the productivity of marinas and optimize their operational processes. Managing the rising number of vessels and berths can be very challenging and sometimes causes operational problems, testing the managers' ability to keep the system stable. Many formal activities have to be coordinated and performed in a short time, such as concluding contracts, billing, accounting, reporting, and maintenance, while at the same time meeting the various requirements of clients. Therefore, the application of smart technologies in marina management is needed for

 

connecting all departments into a single functional unit, which improves communication by accelerating information flow, and gives a clearer overview of processes in the marina (Baker, 2018).

Process automation enables marinas to optimize their operations by making better use of time and their capacities. By examining the database, relevant statistics can be extracted and detailed analyses for a specific period can be done. This allows for faster decision making with much greater certainty, as the decisions are based on verified facts and conclusions. Better business decisions mean better service and, consequently, higher profits, which directly affects the competitiveness and overall effectiveness of marinas.

In addition, major advantages of smart systems in marina management are flexibility and mobility, as these systems can be installed on various interfaces and devices. Such systems are easily adaptable to the dynamic changes constantly present in the marina environment. In such a way, managers have an insight into the business 24 hours a day, which means they can promptly react in emergencies, even when they are not physically near the marina. The use of smart technologies means that less effort and time is needed to perform formal tasks, such as written communication with customers. This entire process is automated, since the system uses various templates and monitors all correspondence with ease.

One of the most important criteria for both customers and managers is safety: safety at sea, safety of the vessel, and environmental safety. To ensure maximum safety, prevent environmental pollution, and achieve sustainable development, the following smart sensors have seen increased application in marinas (Baker, 2019b):

- Smart battery sensor,
- Smart bilge sensor,
- Smart smoke sensor,
- Smart heat sensor,
- Smart water sensor,
- Berth occupancy sensor,
- Weather conditions sensor.

Smart sensors enable monitoring and controlling of vessels' condition 24/7 (Krpetic, 2012). Whenever a safety issue is detected, staff is immediately informed via email, voice call, and notification. Generating alerts allows for quick reactions of marina staff, helping prevent accidents that can jeopardise the safety of customers, the environment, and the marina infrastructure.

Marina staff regularly perform "dock walks" to check the status of vessels and berths in the marina. It takes a considerable time to put together the information about each vessel and berth without using smart systems. With the Dock Walk feature, every activity performed on the vessel is automatically logged straight into the system, with a description and photo of the vessel. This provides a simple and transparent overview of the performed operations, such as repairs and maintenance on a particular vessel and berth, both for marina staff and customers. This greatly facilitates the work of managers when planning and organising individual operations in the marina, and tracking performance. The system also keeps a list of employees who have checked a particular vessel and carried out the required operations on it, giving managers an insight into the performance of each employee, which may affect their future progress and career development.

Additionally, some marina management software offers docking assistance, automation of the check-in and check-out procedures, as well as the connection with power pedestals for controlling water and electricity consumption. These possibilities make it easier for boaters to access the marina and to plan their activities there. Time saved can instead be spent using the marina facilities, which increases customer satisfaction, as well as the quality of service and the marina's revenues.

Monitoring of available and occupied berths is still performed manually in most marinas. Using berth occupancy sensors, the marina staff can easily keep track of the marina via an on-screen map displaying the status of each berth, which optimises the process of finding available berths for incoming vessels. In addition, booking platforms enable clients to manage their reservations, and guide them to the booked berth.

Various sensors with an emphasis on environmental sustainability have been developed so far. Seawater level and seawater quality sensors help detect prohibited waste, fuel leaks, and other pollution factors in the marina environment, while some of them also monitor energy consumption. Usually, boaters struggle with finding available berths in high season due to congestion and changeable weather conditions. Consequently, fluctuations in demand occur, since boaters sometimes have to change their routes on account of bad weather. Based on the location and characteristics of the boat, the software shows a real time map of available berths in nearby marinas. Sensors for observing weather conditions can help boaters to plan their course and managers to adapt in terms of organisation and optimal capacity utilisation in such situations (Tan, 2018).

Some smart solutions allow for simple and comprehensive marina management through various modules, covering different departments such as reception, movement control, booking, customer relationship management, repair and maintenance, accounting, retail, charter, accommodation, etc. Smart technology enables marina managers to track the movement of vessels and condition of berths, to monitor arrivals and departures of vessels, with a graphic display of the vessels' movement history. It also provides data about concluded contracts, berth

location, sailing permit, open payments, with the option to create reports and extract relevant statistics for following and evaluating business performance.

Using Radio Frequency Identification technology (berth occupancy sensors), managers can easily monitor berth occupancy status and organise vessel arrivals and departures in the marina. This solution can be upgraded with additional sensors, such as engine sensors to increase the level of vessel safety. By selecting a particular vessel, marina staff can easily obtain the data required to quickly and efficiently serve the customer. The system shows a preview of all the activities a customer has performed regarding their vessel in the marina, such as recent bookings, contact details, invoices, performed and outstanding payments, due dates, and similar. Managers also have access to work orders, planned and performed operations, stock status, from which statistics can be derived so as to improve work processes.

In addition to marina managers, customers can also use these solutions, which allow them to manage bookings, contracts, payments, online check-in/check-out, and provide data concerning maintenance and repairs. Another advantage is that the system provides a calculation of total costs, which ensures business transparency. All financial transactions are automatically recorded upon execution. In this way, the system keeps track of both customers' and suppliers' account balances, making it easier for managers to create financial reports (Lowry, 2018).

The software collects all data about the vessel and its owner, thus facilitating database search and enabling marina staff to provide fast and efficient service. Smart software can be easily used by all management levels, offering comprehensive monitoring of activities related to the marina. All data can be filtered by various criteria (vessel flag, length, etc.), across different periods, and then exported if necessary.

In terms of sustainability, smart software automatically collects data about water and electricity consumption at each berth. Such systems, which are constantly being updated to provide the latest features for optimisation of business processes, have already been implemented in nine marinas. Smart technologies continuously collect, analyse, and use data to provide an ever higher level of service, and to improve marina business performance. SWOT analysis in marinas has been carried out, outlining strengths, weaknesses, opportunities, and threats of the implementation of smart technologies in marina management.

Smart technologies are easy to use, transparent, and can be installed on different devices, providing flexibility and functionality for both customers and managers. Since smart solutions save time and offer better capacity utilisation, workflow is optimised, resulting in higher revenues and lower costs, simultaneously making a marina more competitive and productive.

Smart technologies are beneficial to the marina environment since they reduce emissions (Baker, 2019a). For example, e-bicycles and scooters used in Marina Veruda, as well as charging stations for electric vehicles set up at ACI marinas reduce fuel consumption and the negative impact on natural resources. By comparison, the world's leading ports use smart lighting connected to motion sensors to reduce electricity consumption.

Artificial Intelligence helps in automating and standardising the processes, making them safer and less dependent on human error, however it creates the issue of reduced need for employment.

Since smart marinas have to deal with big data, privacy and security are potential areas of concern. The greatest weakness of any smart technology is lack of security coupled with a vulnerability to hacking, which is impossible to avoid. Since smart technologies rely on data collection to improve services, a massive amount of data has to be stored and analysed, causing major data-related issues due to infrastructure weaknesses.

While smart technology has many advantages, it is very costly to both introduce and maintain. However, using smart technologies in marina management improves the quality of service, which directly affects customer satisfaction. In turn, greater customer satisfaction raises demand, which opens marinas up to new markets.

Table 1: SWOT analysis of Smart technologies in marina management.

| Strengths | Weaknesses | Opportunities | Threats |
|---|---|---|---|
| Functionality | Lower employment | Increase in demand | Expensive introduction |
| Flexibility | Complexity | Improvement in quality | Expensive maintenance |
| Cost optimization | Data privacy and security | Opening new markets | Hacking vulnerability |
| Sustainability | Heavy data use | | |
| Efficiency | Power failure | | |
| Effectiveness | Internet failure | | |
| Productivity | | | |
| Emissions reduction | | | |
| Personal safety | | | |
| Navigational safety | | | |
| Business transparency | | | |
| Ease of use | | | |

## 4. STRATEGY FOR ENHANCING SMART MARINA DEVELOPMENT IN GUANGDONG

The construction of smart marinas in Guangdong achieved excellent results and provided experience for the development of smart marinas in China. However, in

order to progress further in this domain, the current weak spots and inefficiencies should be resolved. An examination of the construction of smart marinas in developed economies has been used to prepare a list of proposals and suggestions aimed at strategically enhancing the development of smart marinas in China, which can also apply to other marinas around the world (Dobrovnik *et al.*, 2018). These are presented below.

### 4.1 MANAGING/DEFINING THE CONSTRUCTION OF SMART MARINAS IN THE MAIN DESIGN AND OVERALL/STRATEGIC PLANNING

Promoting the construction of smart marinas at state level. Establishing a government body for the construction of smart marinas, which should be responsible for the main design, strategic planning, coordination and actual construction of smart marinas. This body should revamp the current administrative structure to enhance communication and coordination across the sector. The fundamentals of the new organisation should also take into consideration the management mechanisms, organizational structure, financing, the legal system, basic support and human resources (Kharchenko, Kondratenko, Kacprzyk, 2018)

#### 4.1 (a) Defining the organisational structure and management mechanisms

An independent maritime administration body with general governance functions is needed for the aspect of the organizational structure and management mechanism in marinas. This body should be tasked with the following objectives: a) independent evaluation of maritime legal terms, safety regulations, industry demands, and development advisories; b) coordinating public and private sectors in the maritime domain, developing a friendly environment for including NGOs and private organizations in public maritime administration, promoting cooperation between the government, enterprises, and universities; c) assisting the government to develop a progressive strategy and implementing maritime and port industry policies; d) promoting maritime services that add value, including ship administration, maritime financing, maritime insurance, maritime law and maritime arbitration.

#### 4.1 (b) Appointing chief information managers to enhance communication capabilities

From the aspect of human resources, emphasis should be placed on multidisciplinary personnel versed in emerging technologies. A chief information officer should be assigned to each division of the maritime administration body. The chief information officers should be responsible for the development of the information system to be used across sectors and regions, and for the coordination of data sharing among the divisions. The responsibility, core competence and position/role of the chief information officers should be specified in explicit legal terms.

The position of the chief information officer should be defined as an executive manager at each administrative level. Expanding the authority of the chief information officer improves information management and the redesign of the execution process, increases the efficiency of information technologies, and ensures ICT development within the government. NGOs should also be encouraged to assign chief information managers, establishing modern business procedures with information technologies, participating in decision making and standard data exchange in the maritime public sector.

#### 4.1 (c) Adopting an information/data administration law

The legislation for information/data administration should be adopted at the national level. This legislation should be adopted in line with the current context in the country. Supportive regulations should be adopted in the fields of digital governance, digital information publication, digital signatures, data security, data protection, privacy protection, etc. in order to build a high-efficiency secure administrative mechanism. Data ownership, collection, storage, processing and protection should be regulated as well. The responsibilities of the user, owner and administrator of data should be clear. The boundaries of freedom of data assessment and privacy protection should be clear.

#### 4.1 (d) Adapting infrastructure development to maritime administration

Overall infrastructure development in the maritime industry should be promoted. A comprehensive analysis of optical fibre connections, satellite connections, and the mobile network in maritime industry should be correlated with the elements in maritime data administration, transmission reliability, and data exchange security.

The results of the study should support the practical planning for accelerating the development of the maritime information infrastructure. Based on the demands of the maritime industry, the development of cloud technology should be promoted in both public and private sectors, guaranteeing collection of data on marina activities.

### 4.2 IDENTIFYING THE ROLE AND RELATIONSHIP AMONG THE ADMINISTRATIVE ELEMENTS OF MARINAS

The concept of governance should be adapted to suit the demands of an increasingly digital society. The view of stakeholders in the field of marinas should change. The previous hierarchical, top-down structure with closed administrative operations should be changed. It is necessary to emphasize cooperation between the

government, enterprises and individuals, develop common goals of the participants in the marina system, and transform the leader-follower relationship into an equal and cooperative relationship.

4.2 (a) Enhance cross-sector cooperation between industries

The government should enhance cooperation with external stakeholders in the marina industry, e.g. organizations in the shipping, commerce, and finance sectors. In addition, these organizations should be included in the construction of smart marinas.

The new administrative model should study and redesign maritime activities, pay attention to the demands of the industry, respect the idiosyncrasies of business operations, follow the demand of enterprises, facilitate trading activities, revamp the administrative procedure, and develop a social interface for both wired/wireless internet, social media, and all kinds of terminals, support enterprises and promote their competitiveness in the international market.

4.2 (b) Rational investment of public funds

Evaluating the effectiveness of government administration. Eliminating the authority of the government in its specialized administrative field. Redefining the government's role from a public service provider to a coordinator of public funds and beneficiaries. Investing limited funds more efficiently, improving the efficacy of governance.

4.2 (c) Promoting services provided by the private sector

Creating an environment that supports the development of industrial organizations, professional associations, and private enterprises, and transfers specialized service providers from the government sector to the non-governmental or private sectors. Facilitating the participation of NGOs in maritime administration. Taking advantage of the specialties of NGOs, the private sector and individuals, and replacing government inspections with industry regulations, gradually substituting government administration with professional services from the non-governmental sector.

4.3 IMPLEMENTING THE ENVIRONMENT OF SMART MARINAS THROUGH A STANDARDISATION STRATEGY

Promoting the implementation of a standardisation strategy, and cross-analysing the current maritime legislation and existing information system. Developing a unified industry data standard. Promoting standardisation of the maritime industry, enhancing research of smart ships, and an environment for the construction of smart marinas.

4.3 (a) Data standardization for the marina industry

Promoting the design and implementation of standardised maritime categorization, data collection, data transmission, data publication, data quality, statistical scales, exchange interface, access ports, data trading, technical products, information security, etc. Driving the entire sector towards developing products and acting according to a unified standard, and digitalizing maritime information.

4.3 (b) Supporting the standardisation of the maritime industry

Enhancing maritime technology research. Applying advanced technologies, especially IoT, automatic control and microchips to maritime products. Promoting maritime products to be smart, systematic, and integrated, making the applications user friendly and decreasing human intervention. Stepping up research in maritime technology standards and relevant regulations. Standardising the complex and disorganised maritime products.

4.3 (c) Accelerating research on smart ship standardization

Applying advanced technologies in ship design, such as IoT, Big Data, cloud, digital modelling, remote control, virtual reality, etc. Installing a variety of intelligent sensors and communication equipment, allowing for automatic identification, real time monitoring, effective association, and accurate prediction of the external environment with the use of this equipment.

Organising big data on ships, developing an essential database for each individual ship, processing and transferring single ship data to a maritime cloud centre by internet or satellite connection. The cloud system may simulate real time ship operation based on 'ship big data', and then process the information from feeding back to broadcasting.

Based on smart sensors, judging and analysing the situation, making decisions and controlling, so as to ensure ship security and efficiency, and reduce human-caused accidents.

4.4 DEVELOPING A GENERAL PLATFORM ACROSS MARITIME SECTORS

Establishing an integrated maritime service platform that connects the relevant maritime affairs sectors, unifies a maritime database, develops a distributed cloud system, and implements a unique identification mechanism with a single ID pass for the entire platform, by tasking the administration to lead the industry development.

 

4.4 (a) Establishing a general service platform

Establishing a general platform as a single window for maritime public services. Gathering stakeholders from different regions, different administrative levels and different sectors in one place. Authorising a specific government department to be responsible for the development of the single window. Providing enough political support, legal authority, funds and human resources to this specific department, allowing it to coordinate and control relevant organizations.

Legally defining a technical department or bringing in an NGO to work on the development and daily operation of the single-window system, with government authorisation. Establishing an administrative mechanism to coordinate the demand of each stakeholder, creating a win-win situation. Establishing a cooperative mechanism. Promoting deep participation and communication equality. Establishing a mechanism for information sharing and exchange. Moving all maritime affairs to automated and smart processes.

4.4 (b) Establishing a centralized maritime database

Reorganising and integrating the current data and information system located in each individual organization and independent system. Categorizing the data based on the demands of the business procedure, data ownership, co-relationship, and establishing a new database on organisation, infrastructure, ship, crew, goods, geographical, meteorological and ocean conditions, maritime security, legislation, and technical regulations.

Extracting specific information from maritime affairs, establishing a maritime database on ship trading, ship operations, transfer of goods, transfer of passengers, etc. Re-evaluating the maritime activity information chain, optimising controlling methods, and establishing a maritime inspection and service database based on ship report, goods declarations, ship inspections, crew certificates, and on-site inspections.

Developing a distributed maritime cloud data centre according to the pattern of maritime activities, shipping demand, information generation, information application, and infrastructure situations. Allocating storage of maritime big data to different servers, increasing the efficiency of data transmission with guaranteed data sharing.

4.4 (c) Creating a unique digital pass with a single ID system

Implementing the current legislation on personal identification and organization number, joining the personal identification and organization numbers into a single identity code for individuals and organizations. Assigning a unique identification number to each ship. The identification code would be used as a common pass for all organizations, individuals and ship administration authorities; the unique identification number can be used for individuals, organizations and ships in the entire maritime environment.

Developing a biological information identity verification and digital identity verification system as an advanced identity administration system. The unique identification number can be registered after logging into the general service platform; the platform can provide identity verification, authorization, and secured access support. The platform can also manage the users' basic information, position, and permissions in all situations. The platform would provide all functions with a single identification code.

4.4 (d) Promoting self-discipline by introducing a credibility management system

Comprehensive collection of credibility information on users of the platform to encourage the industry to develop self-discipline. Issuing a national unique digital certificate as a single identification for users of the maritime service platform. Creating an organization credibility report. Intensively collecting the participating organizations' credibility information and legal status regarding social activities. Implementing the participating organizations' credibility record to be used as a credibility reference for the permission to use the platform. Meanwhile, a distinct inspection instrument and procedure can be applied to organizations with different credibility levels.

Collection of personal information, implementing a database of information on personal characteristics. Collecting unique personal biological information (fingerprint, iris information). Applying encryption operations to verify the personal ID for participating in activities on the platform. Intensively collecting the participating individuals' credibility information and legal status regarding social activities. Implementing the participating individuals' credibility record to be used as a credibility reference for the permission to use the platform.

4.5 REDESIGNING THE MARITIME MANAGEMENT PROCEDURE BASED ON AN ELECTRONIC CERTIFICATION SYSTEM

According to the demands of an information society, taking advantage of digital information, which can be verified efficiently and broadly transmitted. Promoting an electronic certification system. Implementing the electronic certification publication and inspection mechanism. Redesigning the maritime affairs procedure. Revamping the organization structure based on the electronic certification system.

4.5 (a) Promoting the electronic certification system

Formulating a national electronic certificate. Regulating the requirements of the general index, the encryption key technology, the authorities' certification, and the application interface of electronic certification. Legalizing the procedure for issuing, changing, inspecting and invalidating the certificate. Digitalizing the issuance of documents, licenses, certificates, permissions, and identification reports according to national regulations. Enhancing information entry in certificate use. Changing the current situation with fake documents, and difficulties in document verification.

4.5 (b) Implementation of the electronic certificate publication and inspection system

Regulating the publication of electronic certificates, identifying the electronic certificate publication index and information range, opening the inquiry function of the platform, developing the electronic certificate verification terminal, and facilitating public inquiries and legal inspections. Identifying the interface for electronic certificate data exchange and inquiry. Identifying the conditions of access. Providing the electronic certificate publication and inspection system to the relevant authorities, third parties or enterprises. Facilitating each of the government departments in developing the software application for accessing the complicated information in the electronic certificates, and creating a verification function for the applications.

4.5 (c) Revamping the maritime service procedure

Radically reengineering the current maritime service procedure to shorten the inspection procedure and processing time. Integrating correlated data on maritime administration activities by using a maritime cloud system. Placing the variables for inspection and the rules for verification at the beginning of system design. Reducing human intervention through the use of data mining and analysis, automatic exchange, and automatic verification of live data. Adopting the procedure for changing, validating or extending electronic certificates; automatically extending qualified certificates using automatic data exchange and verification. Implementing the 'pre-verification, non-pending' maritime service.

4.5 (d) Organisational reform to reduce the number of intermediaries

Reforming the internal organization structure; transforming the hierarchical structure to a flat management structure. Reducing the administrative hierarchy in order to minimize delays and loss of information caused by having excessive layers of communication. Managing the public opinion and demand at the maritime administration bureau, and rapidly reacting to public demand.

Defining the role of each administrative section by operational block, establishing a research department. Increasing administrative capabilities by enhancing advanced maritime technology research, merging operational departments, applying comprehensive legal enforcement and inspection, and establishing a legal enforcement agency by geographical division.

4.6 IMPLEMENTING PRECISE AND INDIVIDUALIZED MANAGEMENT/ SERVICE USING DATA MINING (BIG DATA)

Enhancing the development of analysis techniques, and their application to the current accumulated data. Identifying the relationship between maritime activities using data mining, and based on this, further developing relevant regulations, and integrating crisis management plans by developing a comprehensive system for tracking the cases from the network, implementing individualized administration in each case.

4.6 (a) Implementing smart tracking of legal compliance of ship operations

Examining the relevant maritime administrative legislation and regulations, summarizing the legal terms from the regulations, inputting the maritime legal terms concerning navigation rules, priority rules, docking rules, fairway rules, ship reports, goods declarations, crew responsibilities, and fee charges to the general platform in the early stage of development. Smart tracking and establishing the legal compliance of enterprises, ships, and crews using big data analysis technology. Issuing alert messages upon detection of illegal activities.

## 5. CONCLUSIONS

In general, marinas follow the latest technological developments and solutions, but their practical application is still at an unsatisfactory level.

The software applications in use mainly focus on simplifying the entire administration process, with emphasis on safety, maintenance, and meeting the requirements of vessels and boaters. The existing solutions are mainly aimed at facilitating the process of finding and booking a berth, thus saving the marina staff valuable time that can be spent more productively, dedicating more attention to the clients.

Based on the analysis of the existing smart technologies mostly applied at marinas, these above all include e-booking, e-payment, and video surveillance, followed by smart battery, bilge, smoke, and heat sensors. Smart technologies that have rarely been implemented so far are the weather conditions sensor, Dock Walk, Smart Card, Tesla Destination Charging, and Eco-islands.

 

However, insufficient attention is still being paid to sensors that should monitor changes and the overall state in the marine environment, as well as the problems concerning pollution.

In conclusion, the main disadvantage of the currently implemented systems in marinas is the insufficient control of factors affecting pollution, such as emissions, energy consumption, waste, and noise management, which is subject to further analysis. According to the SWOT analysis, digitalizing marinas can result in multiple benefits, including an increase in demand, improvement in the quality of service, and opening of new markets.

With the introduction of smart technologies in marinas, the quality of service can be greatly increased, which can attract new customers and help retain existing ones, increasing the competitiveness of the marina, and provide opportunities for further sustainable growth and development in line with the new technologies.

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