International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.4004

(11/2021)

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Internet of things and smart cities and communities – General

Overview of smart oceans and seas, and requirements for their information and communication technology implementation

Recommendation ITU-T Y.4004

ITU-T Y-SERIES RECOMMENDATIONS

GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

GLOBAL INFORMATION INFRASTRUCTURE	
General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
IPTV over NGN	Y.1900–Y.1999
NEXT GENERATION NETWORKS	
Frameworks and functional architecture models	Y.2000–Y.2099
Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Enhancements to NGN	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Computing power networks	Y.2500–Y.2599
Packet-based Networks	Y.2600–Y.2699
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899
Carrier grade open environment	Y.2900–Y.2999
FUTURE NETWORKS	Y.3000–Y.3499
CLOUD COMPUTING	Y.3500–Y.3599
BIG DATA	Y.3600–Y.3799
QUANTUM KEY DISTRIBUTION NETWORKS	Y.3800–Y.3999
INTERNET OF THINGS AND SMART CITIES AND COMMUNITIES	
General	**Y.4000–Y.4049**
Definitions and terminologies	Y.4050–Y.4099
Requirements and use cases	Y.4100–Y.4249
Infrastructure, connectivity and networks	Y.4250–Y.4399
Frameworks, architectures and protocols	Y.4400–Y.4549
Services, applications, computation and data processing	Y.4550–Y.4699
Management, control and performance	Y.4700–Y.4799
Identification and security	Y.4800–Y.4899
Evaluation and assessment	Y.4900–Y.4999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T Y.4004

Overview of smart oceans and seas, and requirements for their information and communication technology implementation

Summary

Smart oceans and seas (SO&S) permit the use of telecommunications or information and communication technologies to conserve and sustainably use the oceans, seas and marine resources. Recommendation ITU-T Y.4004 provides an overview of SO&S and specifies high-level requirements for their implementation. SO&S use cases are also provided in an appendix.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.4004	2021-11-29	20	11.1002/1000/14812

Keywords

Implementation, overview, smart oceans and seas.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents/software copyrights, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the appropriate ITU-T databases available via the ITU-T website at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Recommendation ITU-T Y.4004

Overview of smart oceans and seas, and requirements for their information and communication technology implementation

1 Scope

This Recommendation provides an overview of smart oceans and seas (SO&S), including their goals, conceptual model and common characteristics, and specifies high-level requirements for their information and communication technology (ICT) implementation. Some SO&S use cases are also provided in an appendix.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

None.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 device [b-ITU-T Y.4000]: With regard to the Internet of things, this is a piece of equipment with the mandatory capabilities of communication and the optional capabilities of sensing, actuation, data capture, data storage and data processing.

3.1.2 high altitude platform station (HAPS) [b-ITU-R F.592-4]: A station located on an object at an altitude of 20 to 50 km and at a specified, nominal, fixed point relative to the Earth.

3.1.3 personal terminal [b-ITU-R M.1224-1]: A light-weight, small, portable terminal providing the capability for the user to be either stationary or in motion while accessing and using telecommunication services.

3.1.4 service [b-ITU-T Y.2091]: A set of functions and facilities offered to a user by a provider.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 smart oceans and seas (SO&S): Use of telecommunications or information and communication technology in the oceans and seas, to enable advanced services in different areas such as marine economy, marine public management and marine environment protection, so as to conserve and sustainably use the oceans, seas and marine resources.

3.2.2 smart oceans and seas platform (SO&S platform): A telecommunications or computer system or integration of these systems, equipped on carriers such as ships, oil and gas platforms, buoys and planes that use information and communication technology to access data sources and process them to offer SO&S services in a marine environment.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

HAPS High Altitude Platform Station

ICT Information and Communication Technology

SO&S Smart Oceans and Seas

5 Conventions

In this Recommendation:

The phrase "**is required to**" indicates a requirement that must be strictly followed and from which no deviation is permitted if conformity to this document is to be claimed.

The phrase "**is recommended**" indicates a requirement that is recommended but which is not absolutely required. Thus this requirement need not be present to claim conformity.

The phrases "**can optionally**" and "**may**" indicate an optional requirement that is permissible, without implying any sense of being recommended. These terms are not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator or service provider. Rather, it means the vendor may optionally provide the feature and still claim conformity to the specification.

6 Introduction to smart oceans and seas

6.1 Goals of smart oceans and seas

Human livelihoods and economic activities are closely related to the oceans and seas, such as shipping and fisheries. Marine information, such as that relating to meteorology, hydrology and pollution, is important for human activities in and on oceans and seas. However, it is more difficult to collect information about oceans and seas than the land. ICTs, such as marine sensor technology, satellite communications, navigation technology, remote sensing, unmanned technology, big data and artificial intelligence, make it easier for humans to get information about oceans and seas, so as to provide better services, such as more economical and safer shipping, sustainable fisheries and predictions of marine hazard weather.

The goals of SO&S are to use telecommunications or ICTs to enable advanced services in different marine areas such as economy, public management and environmental protection, so as to conserve and sustainably use the resources.

6.2 Conceptual model of smart oceans and seas

Figure 1 shows that SO&S has two parts: marine and onshore. The marine part contains SO&S platforms and devices thereon. There are two types of SO&S platform: manned and unmanned. The marine and the onshore parts are connected by a marine communication network.

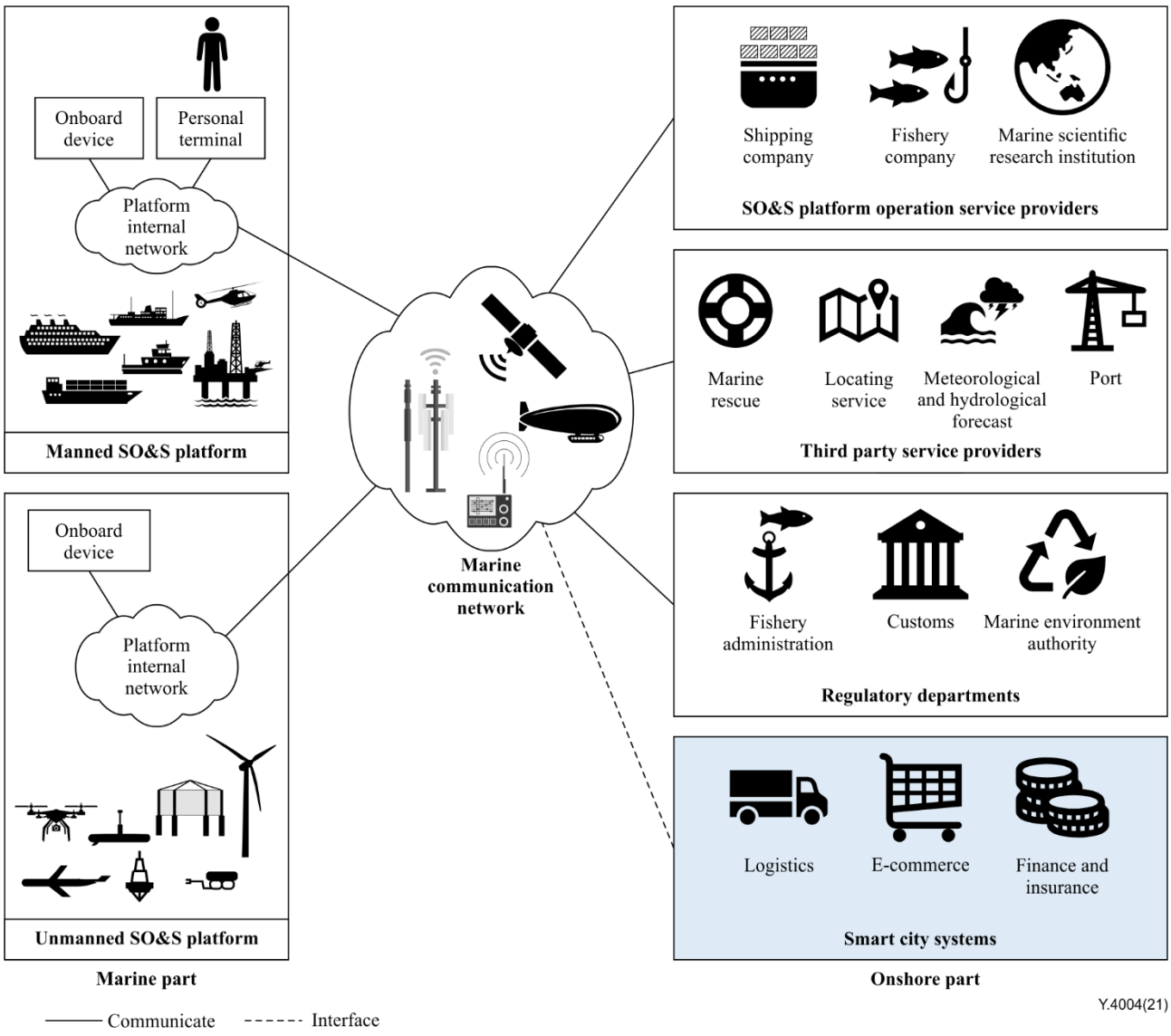

Figure 1 – Conceptual model of smart oceans and seas

Manned SO&S platforms operate with humans, such as operators, crews and passengers, on board. Examples of manned SO&S platforms are the computer systems on various kinds of ships, oil platforms and helicopters.

Unmanned SO&S platforms are usually designed to operate autonomously or controlled remotely by humans. Examples of unmanned SO&S platforms are computer systems on unmanned surface vehicles, unmanned underwater vehicles, buoys, drones, fish farms and wind power generators.

The devices on SO&S platforms are connected through platform internal networks that can be those used to connect devices, such as wireless fidelity and industrial field bus, usually connect to the marine network through gateways.

A marine communication network connects various kinds of SO&S platform, devices and humans at sea with service providers and onshore service users. A marine communication network is usually hybrid multi-method in nature, involving communication by methods such as satellite, short-wave radio, shore-based cellular, HAPS and underwater acoustic.

Personal terminals, such as cell phones, laptops and wearable electronics, usually connect to a SO&S platform through a platform internal network.

The onshore part of SO&S consists of service providers and onshore service users. There are three types of service providers and users.

– SO&S platform operation service providers are usually the owners of SO&S platforms, such as shipping companies, fishery companies and marine scientific research institutions. They acquire data from SO&S platforms, devices or human at sea, and send data to onshore data centres for processing, so as to provide services for their SO&S platforms or personnel at sea and other users. They are not only data providers, but also data consumers.
– Third-party information service providers usually provide marine infrastructure and marine services to other users, such as maritime rescue, meteorological and hydrological forecasts, as well as port and location services.
– Regulatory authorities, such as fishery administration, customs and marine environment authorities.

SO&S also have interfaces with smart city systems, such as logistics, e-commerce, finance and insurance, to enable more smart services for users.

6.3 Common characteristics of smart oceans and seas

The ICT implementations of SO&S are different from those on land in many aspects, such as the technologies used and deployment sites. Special considerations are required for SO&S ICT implementation.

– Spatial complexity of the oceans and seas. Mobile SO&S platforms and devices may travel across different zones of oceans and sea, which are probably under different regulatory requirements according to regulation and laws, such as the *United Nations convention on the law of the sea* [b-UNCLOS].
– Limited communication conditions. The main means of marine communication are achieved by satellite, radio, shore-based wireless and underwater acoustic methods, so usually bandwidth and communication range are limited and the costs high.
– Unstable energy supply of devices. The energy for offshore sensors and other devices is usually supplied by batteries, as well as renewable sources such as solar, wind nd ocean energy, that are limited in power and low in stability.
– Human operation and maintenance are limited. Human activities at sea rely on special carriers, such as ships, submersibles and aircraft, so operation and maintenance of platforms or devices are not easy. As a consequence, various kinds of unmanned ship, as well as underwater and unmanned aerial vehicles have been widely used to replace human intervention.
– Marine environmental protection requirements. The marine environment is more vulnerable than that on land to hazards from various devices, such as harmful chemical substances in batteries and electromagnetic signals that may impact marine life.

7 General requirements for smart oceans and seas

The following are general requirements for SO&S related to its common characteristics. It is required

– to provide precise and reliable locating capability and location-based services, in order to comply with international regulation and laws;
– to specify the quality of services according to different application scenarios, e.g., real-time control and emergency communication;
– to consider the energy efficiency of ICT equipment and means to reduce the hazards caused by power loss;

– to reduce manpower and to improve reliability by use of remote monitoring, diagnosis and self-maintenance;
– for the unmanned SO&S platforms, to have positioning and communication capabilities for navigation, tracking and rescue;
– to monitor and trace the SO&S platforms and the devices if they have harmful impacts on the marine environment.

8 Requirements for information and communication technology implementation of smart oceans and seas

8.1 Service support requirements

– Location-based services. Service providers are recommended to obtain SO&S platform location information based on authorization and provide location-based services.
– Traceability. It is recommended to provide traceability services at sea, e.g., tracing goods, seafood or marine pollutants.
– Time synchronization. For time-sensitive services, time synchronization support capabilities are required, including time synchronization of device times within an SO&S platform internal network and between the SO&S platform internal and a marine communication networks.
– Service prioritization. Service prioritization is required to be specified, so that service users can rank services according to their importance and optimize the use of limited resources on SO&S platforms.

NOTE – Due to the limitation of maritime communication bandwidth and processing capacity, it is required to give high priority to important services, such as disaster alerts, and then deal with less important services, such as entertainment and news information.

8.2 Communication requirements

– Regional temporary networking requirements. The ability rapidly to form regional broadband access is required for marine activities, such as maritime rescue.
– Heterogeneous communication support. Support for integration of heterogeneous communication networks, such as satellite, short wave radio, and shore-based cellular communication, is required.
– Communication control. Ability to control communication of an SO&S platforms is required to select the appropiate communication path and timing according to network conditions and the data for transmission, so as to improve communication efficiency and reduce cost.

NOTE – For example, a large amount of oil consumption data would be transmitted to an onshore data centre until a ship approaches port, when it communicates through an onshore cellular network instead of satellite communication at much higher cost.

– Communication prioritization. Networked SO&S platforms are required to prioritize communication tasks according to their importance and network conditions.
– Device communication backup. Networked SO&S platforms are recommended to have backup means of communication.

8.3 Platform requirements for smart oceans and seas

– Locating ability. Locating ability is required for SO&S platforms.
– Heterogeneous locating ability: It is required to support more than one means of location and to provide coherent location information.

NOTE – Location information is very important for SO&S platforms in many scenarios, such as marine rescue. There are many locating means, such as the automatic identification system [b-ITU-R M.585-8] and global navigation satellite system, with different coverages and precisions, and more than one means are usually used. When there are conflicts in location results, data fusion methods are required to generate a uniform location.

– Uniform time reference: An SO&S platform is required to provide a uniform time reference for all its devices.
– Uniform location reference. An SO&S platform is required to provide a uniform location reference for all its devices.
– Gateway ability. An SO&S platform is required to provide a gateway to connect its internal network and marine communication network.
– Status monitoring. An SO&S platform is required to monitor the status of its devices, networking status and the status of other important equipment, such as power supply.
– Reporting ability. An SO&S platform is required to report its status information to its onshore operation service providers.

8.4 Device requirements

– Status monitoring. An SO&S device is required to monitor its status.
– Reporting ability. An SO&S device is required to report its status to the SO&S platform.
– Locating ability. An SO&S device is required to obtain location information through its own location module or from an SO&S platform.
– Remote maintenance. Remote maintenance capabilities, such as remote diagnostics, configurations and software updates, are required for SO&S devices.
– Energy consumption management. An SO&S device is required to control its applications so as to manage its power consumption.
– Environmentally friendly. It is required to take appropriate measures in the processes of device design, manufacture, installation and maintenance, to prevent and mitigate the harmful impacts of a device on the marine environment and the living world.

8.5 Data management requirements

– Device data compression. It is recommended for an SO&S platform or its devices to compress data before transmission to reduce bandwidth usage, when the communication condition is limited.

NOTE 1 – Limited communication condition refers to situations where the communication bandwidth is low and the communication cost is high.

NOTE 2 – Data processing for extracting features is one data compression method.

– Common data format. Common data format is required to transmit data between SO&S platforms, service providers and other data users.
– Crucial data recording. SO&S platforms are required to record crucial data in real time and hold data after power loss.
– Crucial data transmission recovery. If crucial data transmission is interrupted due to power loss or network interruption, SO&S platforms are required to recover the data transmission after power and network recovery.
– Data encryption. Sensitive data is required to be encrypted when stored on SO&S platforms or transmitted over marine communication networks.

Appendix I

Use cases of SO&S

(This appendix does not form an integral part of this Recommendation.)

I.1 Shipping

– Ship transport management. For ships, reducing the operating cost and ensuring safe passage are important concerns in transport management. ICTs can provide integrated information services and auxiliary decision-making support for maritime shipping vessels, and realize the detailed management of vessels and optimize transport routes. With the help of ICTs, intelligent and unmanned ships can be used in maritime transport to reduce labour costs.

– Marine trade. The use of ICTs enables maritime transport to seamlessly connect to urban logistics and e-trade systems, optimizes the entire logistics management process by acquiring the status of goods at sea and supports financial services such as insurance.

– Smart ports. ICT improves port operation efficiency and cost-effectiveness.

– Maritime supervision. Because oceans and seas may span different administrative areas, there are many difficulties in maritime supervision. ICTs provide governments and intergovernmental organizations with maritime regulatory means, such as ship identification, ship behaviour monitoring and ship sewage monitoring.

I.2 Marine fisheries

– Marine fishery services. Provide services for marine environment and marine life activity monitoring, data analysis, early warning and other services for marine fisheries.

– Marine fishing services. To provide meteorological, hydrological, environmental and other information services for fishing vessels and fleets, as well as value-added services including fishing detection services, remote monitoring, positioning and navigation, fleet management and emergency rescue information.

– Aquatic product traceability. Support the identification and tracing of aquatic products.

– Fisheries resource conservation. Monitor global fishery resources, evaluate maximum fishing capacity that can be adapted, monitor fishing vessel behaviour, identify violations and improve traceability of fish from fishing to transport so as to support governments to develop policies for restoration of marine fish resources, management of fisheries organizations and support of international action plans to prevent and eliminate illegal, unreported and unregulated fishing.

I.3 Resource exploitation

– Marine resource exploration. Marine oil, gas and seabed deposits can be explored using various sensors and data analysis techniques.

– Offshore operations services. ICTs can provide services including equipment health management, personnel safety and health management, and operation environment monitoring for offshore operations such as offshore oil and gas production.

I.4 Marine tourism

– Public tourism services. ICTs can provide public services, such as for weather, tour guide, transportation, immigration and marine rescue information, for coastal, island and cruise ship tourism.

I.5 Disaster warning

– Marine disaster warning services. ICTs can provide monitoring and early warning services for marine disasters such as tsunamis, typhoons, storm surges, sea ice and red tides, and enable different countries or institutions to share information and to cooperate.

I.6 Maritime safety

Challenges to maritime security include maritime rescue, disaster relief, combating piracy, transnational crime at sea, drug trafficking, human trafficking and armed attacks. ICTs can provide the following support.

– Monitoring and identification of maritime target information, such as vessel and personnel status and location information.

– Rapidly deploying regional broadband networks and computing power to support offshore data, video, voice communications and information sharing.

I.7 Environmental protection and tackling climate change

Marine environmental issues include marine environmental pollution and environmental degradation caused by climate change, including emissions of industrial, life, port pollutants, eutrophication caused by marine aquaculture, oil spills caused by offshore oil platform and tanker accidents, radioactive material discharge from nuclear power plant, ocean temperature rise due to climate change, ocean and coastal acidification, sea level rise, shrinking polar ice cover, coastal erosion and extreme weather events. The ICTs provide more effective means of monitoring the marine environment.

– Various types of networked devices, such as distributed sensors, radar and remote sensing devices, reduce manual sampling, analysis and recording, and provide real-time environmental monitoring and accurate early warning.

– Improve traceability of monitoring data.

Bibliography

[b-ITU-T Y.2091] Recommendation ITU-T Y.2091 (2011), *Terms and definitions for next generation networks.*

[b-ITU-T Y.4000] Recommendation ITU-T Y.4000/Y.2060 (2012), *Overview of the Internet of things.*

[b-ITU-R F.592-4] Recommendation ITU-R F.592-4 (2007), *Vocabulary of terms for the fixed service.*

[b-ITU-R M.585-8] Recommendation ITU-R M.585-8 (2019), *Assignment and use of identities in the maritime mobile service*.

[b-ITU-R M.1224-1] Recommendation ITU-R M.1224-1 (2012), *Vocabulary of terms for international mobile telecommunications (IMT).*

[b-UNCLOS] United Nations (1982). *United Nations convention on the law of the sea*. Geneva:United Nations. 202 pp. Available [viewed 2021-12-17] at: https://www.un.org/Depts/los/convention_agreements/texts/unclos/unclos_e.pdf

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	Tariff and accounting principles and international telecommunication/ICT economic and policy issues
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling, and associated measurements and tests
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	**Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities**
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2022