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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 – Services, applications, computation and data processing

Requirements and functional architecture of base station inspection services using unmanned aerial vehicles

Recommendation ITU-T Y.4559

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Recommendation ITU-T Y.4559

Requirements and functional architecture of base station inspection services using unmanned aerial vehicles

Summary

The changes being experienced in weather conditions and the aging of materials may cause damage to base stations, which will affect network service quality and even cause safety incidents. Network operators need to carry out timely and periodic inspection and maintenance operations. Due to the long-term, high-intensity and high-altitude nature of these operations, the base station inspection (BSI) services conducted manually are dangerous, inefficient and costly.

Unmanned aerial vehicles (UAVs) with mature flight control and sensing capabilities can be used not only in the normal working environment but also in some extreme working environments. Therefore, BSI using UAVs can replace most manual inspections through a network connection and reduce the risk of inspection and ensure the safety of personnel.

To achieve automation functions, the UAV needs to bear corresponding flight control, sensing and capturing, and communication capabilities, and it is necessary to develop a BSI supporting platform with corresponding functions to fulfil the automation and safety requirements of BSI services using UAVs.

Recommendation ITU-T Y.4559 describes requirements and functional architecture of BSI services using UAVs. It focuses on how to effectively provide inspection services for the base station using BSI-dedicated UAVs (BSI-UAVs).

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.4559	2020-12-16	20	11.1002/1000/14424

Keywords

Base station inspection, Internet of things, unmanned aerial vehicles.

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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.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, 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 TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Requirements and functional architecture of base station inspection services using unmanned aerial vehicles

1 Scope

This Recommendation specifies requirements and functional architecture of base station inspection (BSI) services using unmanned aerial vehicles (UAVs). The scope of this Recommendation includes:

– Introduction of BSI services using UAVs, including the issues of manual BSI operation and advantages of BSI-dedicated UAV (BSI-UAV) usage;

– Capability requirements for BSI-UAVs and the BSI services supporting platform;

– Functional architecture of BSI services using UAVs.

NOTE 1 – The regulations and supervision of civilian unmanned aerial vehicle flight such as for example the functionality defined for registration, identification and traffic management addressed by the International Civil Aviation Organization (ICAO) are out of the scope of this Recommendation.

NOTE 2 – The generic capabilities and functionalities of existing communication networks, including 4G/5G mobile networks, are out of the scope of this Recommendation. No modification is required to these networks.

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 application [b-ITU-T Y.2091]: A structured set of capabilities, which provide value-added functionality supported by one or more services, which may be supported by an API interface.

3.1.2 capability [b-ITU-R M.1224-1]: The ability of an item to meet a service demand of given quantitative characteristics under given internal conditions.

3.1.3 functional entity [b-ITU-T Y.2012]: An entity that comprises an indivisible set of specific functions. Functional entities are logical concepts, while groupings of functional entities are used to describe practical, physical implementations.

3.1.4 Internet of things [b-ITU-T Y.4000]: A global infrastructure for the information society enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving, interoperable information and communication technologies.

NOTE 1 – Through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of things to offer services to all kinds of applications, whilst ensuring that security and privacy requirements are fulfilled.

NOTE 2 – In a broad perspective, the IoT can be perceived as a vision with technological and societal implications.

3.1.5 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

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BSI Base Station Inspection

BSI-UAV BSI-dedicated UAV

FE Functional Entity

GNSS Global Navigation Satellite System

IoT Internet of Things

UAS Unmanned Aircraft System

UAV Unmanned Aerial Vehicle

5 Conventions

The following conventions are used in this Recommendation:

– The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted, if conformance to this Recommendation is to be claimed.

– The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

6 Introduction of BSI services using UAVs

The changes being experienced in weather conditions and the aging of materials may cause damage to the base station including toppling of the tower body or antenna, cable breakage, structural corrosion, etc. Timely and periodic inspections are necessary for the network operators.

The typical base station inspection (BSI) services include:

– Facade observation: tower foundation, tower body, environment, antenna feeder, antenna stand, bolts and nuts, signboards, corrosion and obstacles, etc.

– Working parameters collection: latitude and longitude, hanging height, azimuth, mechanical inclination and electromagnetic inclination of the antenna, etc.

– Signal measurement: strength test, coverage test and interference test, etc.

However, the BSI services conducted manually cause two significant issues:

– Dangerous to the life safety of the base station inspection personnel. The personnel climb the base station tower to perform close-range inspection on the tower body, antenna, feeder, bracket and other components, which is a long-term, high-intensity and high-altitude operation.

– Low efficiency and high cost. On average, one member of personnel can complete inspections of up to 3 to 5 base stations per day when weather and geographic conditions permit. This may not be possible if disasters such as floods, earthquakes and landslides occur. The details and accuracy of an inspection rely on manual observation.

BSI services using UAVs (i.e., BSI-UAVs) employ dedicated UAVs to conduct the above-mentioned BSI services. With more mature flight control and sensing capabilities, the UAV can replace most of the manual inspections through a network connection, which reduces the risks of inspection and ensures the safety of personnel. The BSI-UAV has other advantages such as capability in reaching scenes that are difficult for personnel to enter, and conducting real time inspections on base stations and components objectively and efficiently without blind spots.

BSI services using UAVs can be conducted as follows:

– With awareness of the capabilities of BSI-UAV, the supporting platform can schedule and instruct specific operations for the BSI-UAV according to the BSI services and plans.

– The BSI-UAV then collects data and transmits the data to the supporting platform as instructed, the supporting platform can develop BSI reports accordingly.

This Recommendation describes capability requirements and defines necessary functional entities (FEs) for BSI-UAV and the BSI supporting platform, in order to effectively provide BSI services using UAVs.

7 Capability requirements of BSI services for BSI-UAV and BSI supporting platform

7.1 BSI-UAV capability requirements

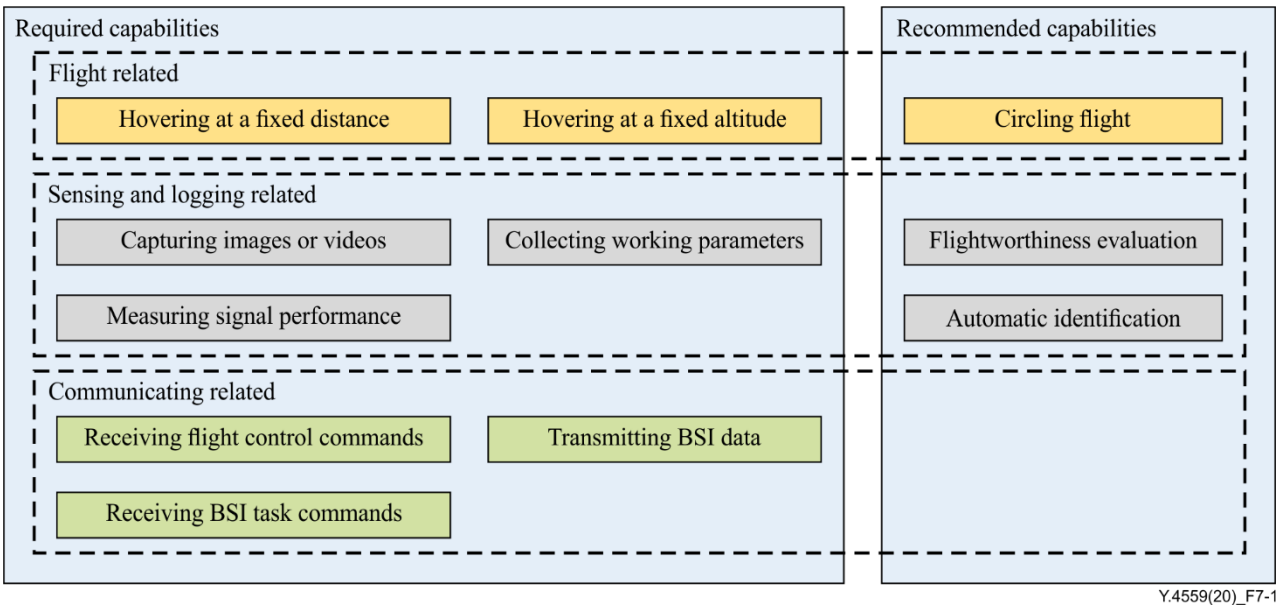

Figure 7-1 – BSI-UAV capability requirements

As shown in Figure 7-1, the BSI-UAV capability requirements consist of three main parts: flight adjustment capabilities, sensing and logging parameter capabilities and communicating with the BSI supporting platform capabilities. In each part, the capabilities are divided into two categories: required capability and recommended capability.

The capabilities of flight adjustment referring to a base station and its components necessary for the BSI-UAV include:

– It is required to have the capability of hovering at a fixed distance to a base station or its components;
– It is required to have the capability of hovering at a fixed altitude to a base station or its components;
– It is recommended to have the capability of circling flight around a base station or its components.

The capabilities of sensing and logging parameters necessary for the BSI-UAV, include:

– It is required to have the capability of capturing images or videos for a base station or its components;
– It is recommended to have the capability of automatic identification for a base station or its components via captured images or videos;
– It is required to have the capability of collecting temperature, air pressure or wind speed parameters around a base station or its components;
– It is recommended to have the capability of evaluating flightworthiness according to the measured results;
– It is required to have the capability of, or of bearing a load which is capable of, measuring signal strength, coverage or interference strength.

The capabilities of communicating with the BSI supporting platform necessary for the BSI-UAV, include:

– It is required to have the capability of receiving flight control commands for BSI (e.g., hovering or circling at a fixed distance or altitude to a base station or its components, taking-off, landing) from the BSI supporting platform via a specific communication network;
– It is required to have the capability of receiving BSI task commands (e.g., executing images or videos capturing, temperature, air pressure or wind speed parameters collection, and signal performance measurement) from the BSI supporting platform via a specific communication network;
– It is required to have the capability of transmitting captured or measured BSI data (e.g., images or videos of a base station or its components, observed mechanical inclination of antenna, signal or interference strength, measured electromagnetic inclination of antenna) to the BSI supporting platform via a specific communication network.

7.2 BSI supporting platform capability requirements

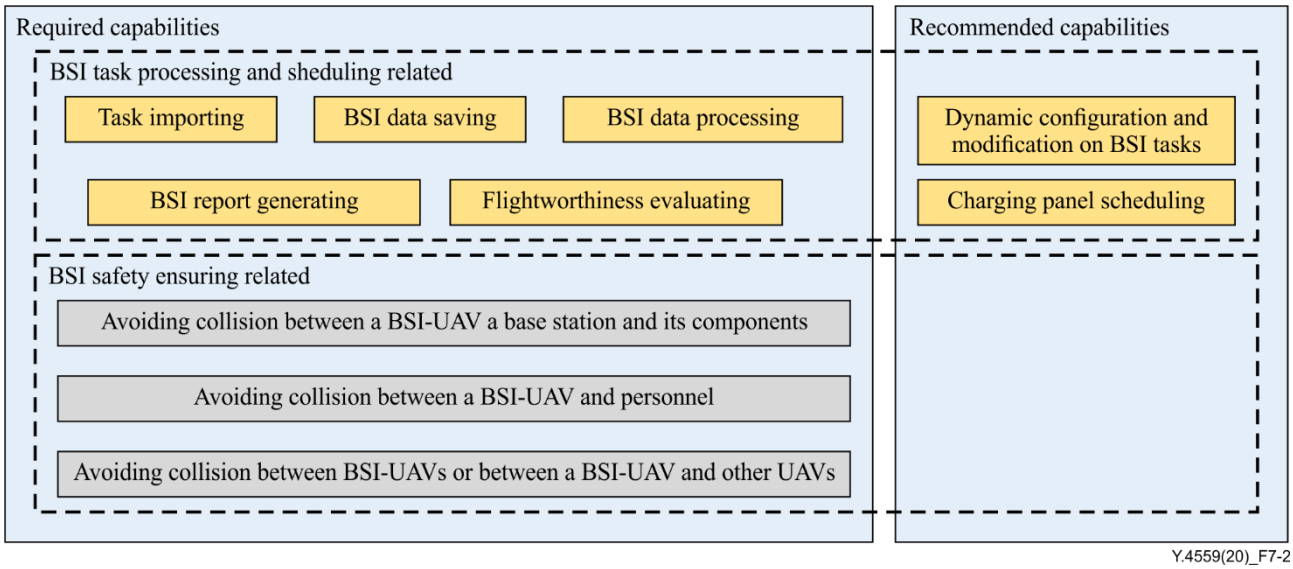

Figure 7-2 – BSI supporting platform capability requirements

As shown in Figure 7-2, the BSI supporting platform capability requirements consist of two main parts: BSI tasks processing and scheduling, and ensuring BSI safety. In each part, the capabilities are divided into two categories: required capability and recommended capability.

The capabilities of automatically processing and scheduling for BSI tasks necessary for the BSI supporting platform, include:

– It is required to have the capability of importing tasks to a BSI-UAV from a periodic or emergency BSI plan, which may include flightworthiness, taking-off and landing conditions, flight route and waypoints, action points and triggering conditions;

– It is recommended to have the capability of dynamic configuration and modification on BSI tasks;

– It is required to have the capability of automatically saving BSI data captured or measured by BSI-UAVs;

– It is required to have the capability of automatically processing the saved BSI data, e.g., analysing the status of integrity or deriving working parameters of a base station and its components by captured images or videos and plotting the distribution diagram of signal or interference by integrating the measured data;

– It is required to have the capability of automatically generating BSI reports according to the processed data.

– It is required to have the capability of evaluating the flightworthiness for BSI-UAV, including wind strength, weather conditions, battery, global navigation satellite system (GNSS) positioning availability, human activity and qualification of BSI-UAV pilot.

– It is recommended to have the capability of scheduling a charging panel for a BSI-UAV and guiding the BSI-UAV to land on the charging panel.

The capabilities of ensuring BSI safety that are necessary for the BSI supporting platform, include:

– It is required to have the capability of avoiding collision between BSI-UAVs or between a BSI-UAV and other UAVs;

– It is required to have the capability of avoiding collision between a BSI-UAV and a base station as well as its components;

– It is required to have the capability of avoiding collision between a BSI-UAV and personnel.

8 Functional architecture of UAV base station inspection services

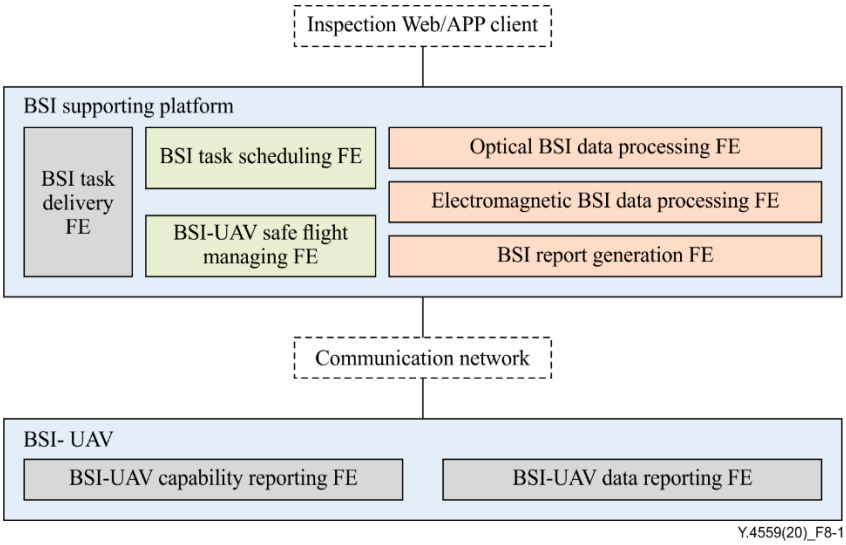

Figure 8-1 – Functional architecture of BSI services using UAVs

As shown in Figure 8-1, the functional architecture of BSI services using UAVs consists of two main parts. One is the BSI supporting platform, the other is the BSI-UAV. The communication network and Web/APP client are out of the scope of this Recommendation.

8.1 BSI-UAV FEs

8.1.1 BSI-UAV capability reporting FE

This FE reports on the available capabilities of a BSI-UAV to the BSI supporting platform via a specific communication network(s). Via this FE the BSI supporting platform is able to know the capabilities supported by a BSI-UAV as defined in clause 7.1 and these available capabilities can be used to schedule BSI tasks accordingly.

This FE enables the BSI-UAV with at least the ability to report to the BSI supporting platform whether it fulfils the essential capabilities for base station inspection services, e.g., hovering at a fixed distance, hovering at a fixed altitude, capturing images or videos, collecting working parameters, measuring signal performance, receiving flight control commands, receiving BSI task commands and transmitting BSI data, as required in clause 7.1. The required capabilities can be reported individually or together as a basic capability cluster with specific certifications issued by administration departments.

This FE may also enable the BSI-UAV with the ability to report to the BSI supporting platform whether it fulfils the optional capabilities for base station inspection services, e.g., circling flight, flightworthiness evaluation and automatic identification as recommended in clause 7.1. The recommended capabilities can be reported individually or together as a basic capability cluster with specific certifications issued by administration departments or manufacturers.

8.1.2 BSI-UAV data reporting FE

This FE reports captured or measured data from the BSI-UAV to the BSI supporting platform via a specific communication network(s). Via this FE the BSI supporting platform is able to acquire the BSI data for further processing, and therefore fulfils the capability requirement of communicating with corresponding FEs in the BSI supporting platform defined in clause 7.1.

This FE enables the BSI-UAV with at least the ability to report captured images or videos of a base station or its components, collected environment parameters around a base station or its components, or measured signal strength, coverage or interference strength to the BSI supporting platform.

This FE may also enable the BSI-UAV with the ability to report on an identified base station or its components, or flightworthiness evaluation to the BSI supporting platform.

8.2 BSI supporting platform FEs

8.2.1 BSI task delivery FE

This FE delivers task information from the BSI supporting platform to the BSI-UAV via a specific communication network(s). Via this FE the supporting platform is able to deliver specific operation commands to the BSI-UAV according to the BSI plan, especially to deploy the safe flight strategies and measures generated by the BSI-UAV safe flight managing FE defined in clause 8.2.3, and therefore fulfils the capability requirement of automatically processing and scheduling for BSI tasks defined in clause 7.2.

This FE enables the BSI supporting platform with at least the ability to deliver tasks to a BSI-UAV scheduled by the BSI task scheduling FE defined in clause 8.2.2. It may also enable the BSI supporting platform with the ability to modify, pause or abort a task. Multiple tasks can be delivered, modified, paused or aborted individually or together as a task cluster.

8.2.2 BSI task scheduling FE

This FE schedules BSI tasks depending on a periodic or emergency BSI plan or other inputs. Via this FE the BSI supporting platform is able to map BSI services into specific operations of BSI-UAVs, and therefore fulfils the capability requirement of automatically processing and scheduling for BSI tasks defined in clause 7.2.

This FE enables the BSI supporting platform with at least the ability to evaluate flightworthiness, set taking-off and landing conditions, and schedule flight route, waypoints, action points and triggering conditions for BSI-UAVs. It may also enable the BSI supporting platform with the ability to schedule charging panels for BSI-UAVs. Multiple scheduled operations can be clustered as a task to be delivered by the BSI task delivery FE in clause 8.2.1. The safe flight strategies and measures generated by the BSI-UAV safe flight managing FE defined in clause 8.2.3 should be followed in all task scheduling.

8.2.3 BSI-UAV safe flight managing FE

This FE generates and deploys strategies and measures to avoid collision between a BSI-UAV and another BSI-UAV, other UAVs, base station components or personnel. This FE can set a no-fly zone near a base station (e.g., BSI-UAVs cannot approach within a distance of less than 5 metres of any base station or its components). Via this FE the BSI supporting platform is able to at least guarantee flight safety around a base station or its components, and therefore fulfils the capability requirement of ensuring BSI safety as defined in clause 7.2.

This FE enables the BSI supporting platform with at least the ability to generate strategies and measures based on the analysis of positions and routes of BSI-UAVs, the presence and positions of other UAVs, positions of base stations and their components, human activity and other environment conditions.

8.2.4 Optical BSI data processing FE

This FE processes optical data measured and collected by the BSI and converts it to a BSI-related parameter or judgement.

This FE enables the BSI supporting platform with at least the ability to analyse the integrity status (tower foundation, tower body, environment, antenna feeder, antenna stand, bolts and nuts, signboard, corrosion and obstacles) or derive working parameters (height, azimuth and inclination) of a base station and its components by captured optical BSI data including images or videos. It may also enable the BSI supporting platform with the ability to confirm the identification results of a base station or its components from the BSI-UAV if supported.

8.2.5 Electromagnetic BSI data processing FE

This FE processes electromagnetic data measured and collected by BSI and converts it to a BSI-related parameter or judgement.

This FE enables the BSI supporting platform with at least the ability to plot the distribution diagram of signals or interference, discover coverage holes and trace interference sources by integrating and calculating measured electromagnetic BSI data including signal strength, coverage and interference.

8.2.6 BSI report generation FE

This FE generates the final BSI report according to the processed data and results.

This FE enables the BSI supporting platform with at least the ability to generate the BSI report including the status of integrity (tower foundation, tower body, environment, antenna feeder, antenna stand, bolts and nuts, signboard, corrosion and obstacles) or derived working parameters (height, azimuth and inclination) of a base station and its components, as well as the distribution diagram of signals or interference, coverage holes or interference sources discovered. It may also enable the BSI supporting platform with the ability to generate the BSI report including the flight log, task commandeering or safety management.

9 Security considerations

The security capabilities of the communication networks used between the BSI-UAV and the BSI supporting platform, including encryption and integrity protection for user data transmission, can be reused.

The BSI-UAV safe flight managing FE defined in this Recommendation ensures collision avoidance between a BSI-UAV and another BSI-UAV, other UAVs, base station components or personnel. Other flight safety elements that are related to the administrative regulations and supervisions are addressed and guaranteed by ICAO recommendations (see in Appendix I) and therefore are out of the scope of this Recommendation.

Appendix I

ICAO recommendations regarding UAV/UAS

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

This appendix provides a brief introduction to the International Civil Aviation Organization (ICAO) and ICAO recommendations regarding UAV/ UAS (unmanned aircraft system).

ICAO works with Member States and industry groups to reach consensus on international civil aviation standards and recommended practices and policies in support of a safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector. Regarding UAV/UAS, ICAO reviewed the existing UAS regulations of many States to identify commonalities and best practices that would be consistent with the ICAO aviation framework and that could be implemented by a broad range of States. The outcomes of this activity are Model UAS Regulations entitled Parts 101, 102 and 149.

Parts 101/102 model regulations are limited to the certification and safe operations of UAS. Part 101 describes the regulations about UAV registration, operating conditions, airspace limitations, approval of operating areas and other safe operating rules. Part 102 focuses on certification and authorization with regard to the eligibility, application, conditions, suspension and cancellation. Part 149 model regulations are intended for organizations operating in the UAS environment. It prescribes rules governing the certification and operation of approved aviation organizations.

ICAO recommendations regarding UAV/ UAS are meant to offer a model language for States to facilitate the establishment of UAS regulations for the administrative regulations and supervisions about flight safety. Thus, the administrative regulations and supervisions about flight safety are addressed in ICAO recommendations which are out of the scope of this Recommendation.

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[b-ITU-T Y.4113] Recommendation ITU-T Y.4113 (2016), *Requirements of the network for the Internet of things.*

[b-ITU-R M.1224-1] Recommendation ITU-R M.1224-1 (2012), *Vocabulary of terms for International Mobile Telecommunications (IMT)*.

[b-ICAO] ICAO Model UAS Regulations, *Part 101, Part 102 and Part 149*.

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