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SERIES F: NON-TELEPHONE TELECOMMUNICATION SERVICES

Multimedia services

Framework for communication application of civilian unmanned aerial vehicle

Recommendation ITU-T F.749.12

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Recommendation ITU-T F.749.12

Framework for communication application of civilian unmanned aerial vehicle

Summary

The civilian unmanned aerial vehicles are widely used in industry and consumer areas such as agriculture and plant protection, power line and petroleum pipeline inspection, police and traffic security surveillance, disaster monitoring, aerial photography and videography, express delivery, forestry and forest fire monitoring, meteorological, resource and scientific research, etc.

Recommendation ITU-T F.749.12 presents the general framework for communication application of civilian unmanned aerial vehicle (CUAV) and its functional entities, reference points, etc.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T F.749.12	2020-08-13	16	11.1002/1000/14331

Keywords

Civilian unmanned aerial vehicle, communication application, framework.

* 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.

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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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Framework for communication application of civilian unmanned aerial vehicle

1 Scope

This Recommendation defines the general framework for communication application of civilian unmanned aerial vehicle (CUAV) and its functional entities, reference points, etc. The communication applications include flight control, flight data transportation, mission payload data services and video/images services, etc. The regulations and supervision of civilian unmanned aerial vehicle flight are out scope of this Recommendation.

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.

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

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 civilian unmanned aerial vehicle [b-ITU-T F.749.10]: An unmanned flying device controlled by a ground control station or telecontroller via various wireless communication means. It usually consists of an aeroplane body, a power device, aviation electrical and electronic equipment and mission payload equipment, etc., and is used in non-military application areas such as industrial and consumer areas to complete the specific operation and transportation of data including audio, video and image.

3.1.2 flight control system [b-ITU-T F.749.10]: This is the sum of all components and driving devices of instruction transferring, rudder motion. It is mainly composed of airborne and ground control terminals. The one that is airborne includes three parts: airborne sensors, steering engine and flight control units.

3.1.3 ground control station [b-ITU-T F.749.10]: A ground control station is a device which is used to realize the functions of mission planning, flight control, payload control, flight path display, parameter display, image and video display and mission information displaying, recording and distributing.

3.1.4 ISM bands [b-ITU-T F.749.10]: The industrial, scientific and medical radio bands are radio bands (portions of the radio spectrum) reserved internationally for industrial, scientific and medical purposes other than telecommunications.

3.1.5 mission payload equipment [b-ITU-T F.749.10]: The mission payload equipment consists of an audio / video / image acquisition device, signal relay device, remote electronic detection / sense device and other auxiliary devices.

3.1.6 telecontroller [b-ITU-T F.749.10]: A piece of equipment used by human beings to control an unmanned aerial vehicle. It is usually composed of an operating device, coding device, transmitting device, receiving device, decoding device and executing mechanism.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CUAV Civilian Unmanned Aerial Vehicle

eSIM Embedded Subscriber Identification Module

GCS Ground Control Station

IoT Internet of Things

IMSI International Mobile Subscriber Identification

ISM Industrial Scientific Medical

M2M Machine-to-Machine

USIM Universal Subscriber Identification Module

VR Virtual reality

4G Fourth Generation

5G Fifth Generation

5 Conventions

In this Recommendation:

– The keywords "shall" 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 "should" indicate an optional requirement which is permissible. This term is not intended to imply that the vendor's implementation must provide the option, and the feature can be optionally enabled by the vendor. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

6 Introduction

Civilian unmanned aerial vehicles are widely used in industry, personal and consumer and other third party application fields. These applications have some common service and application features (such as flight service and control, application service and control) and management functions (such as CUAV management and flight database management), etc. This application framework is summarized and described from application layer, service support and application support layer, network layer and device layer.

7 High-level communication application frameworks

Figure 1 shows the overview of a CUAV communication application framework based on the Internet of things (IoT) reference model [ITU-T Y.4000]. It is composed of four layers as well as management, as illustrated in Figure 1.

The four layers are as follows:

– Application layer,
– Service support and application support layer,
– Network layer,
– Device layer.

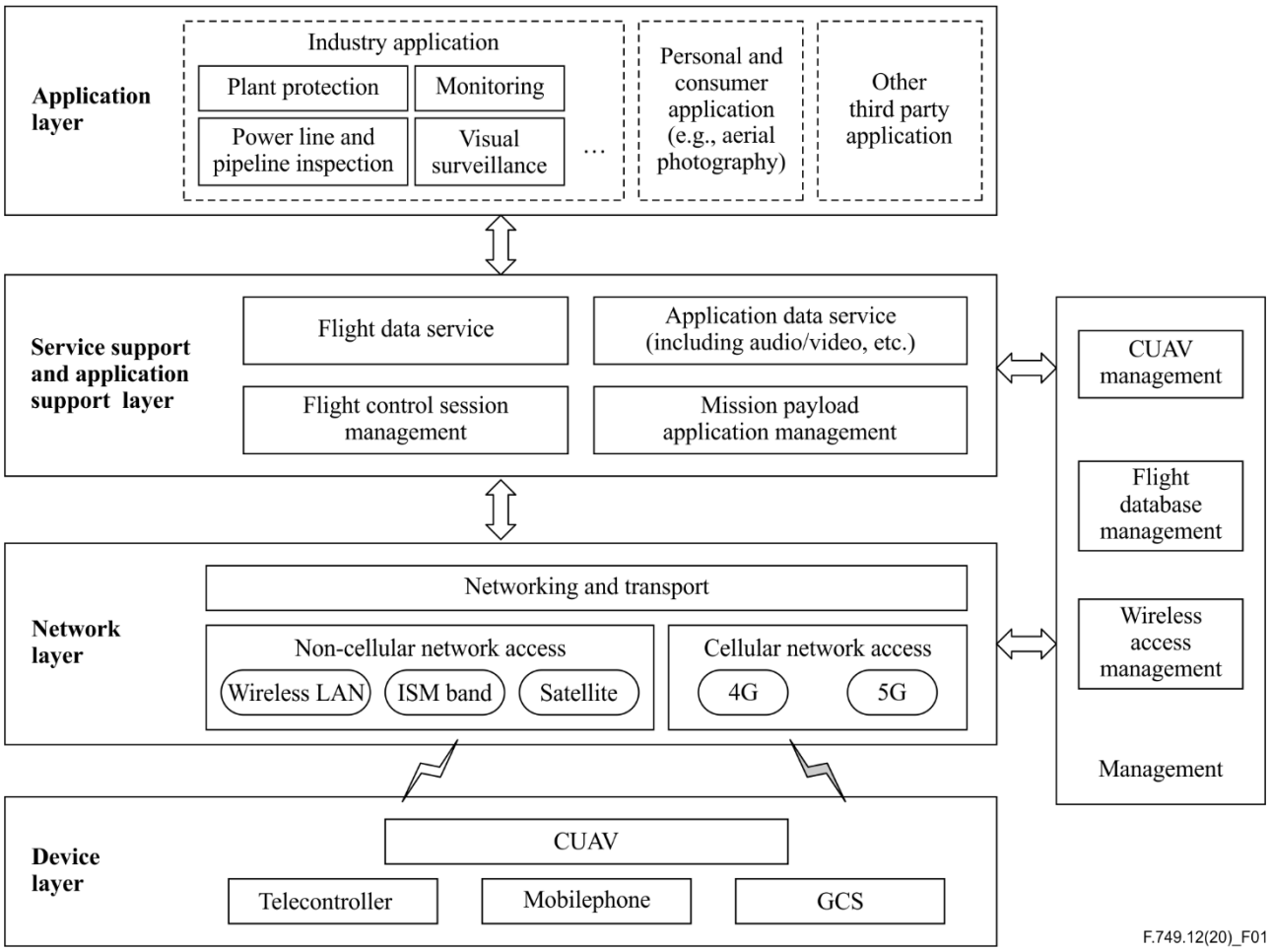

Figure 1 – Overview of CUAV communication application high level framework

7.1 Application layer

The application layer comprises three kinds of CUAV applications. They are industry application (e.g., plant protection, monitoring, power line and pipeline inspection, visual surveillance, etc.), personal and consumer application (e.g., aerial photography) as well as other third-party application.

7.2 Service support and application support layer

The service support and application support layer consists of the following functionality groupings:

– Flight control and flight data support functionalities: These support functionalities fulfil the CUAV real-time flight control, collecting the flight data of CUAV (including position, altitude and speed) to realize the real-time monitoring of CUAV flight and keeping away from flight-prohibition zone,

– Application support functionality, such as audio/video (including pictures) service and application data service can be provided to fulfil service as well as the related service management.

7.3 Network layer

The network layer consists of the following capabilities:

– Networking and transport capabilities: provide relevant control functions of network connectivity and transport resource control and connectivity for the transport of CUAV service and application specific data information, as well as the transport of CUAV-related control and management information.

– Network access capabilities: provide relevant control functions of network access, mobility managements or authentication, authorization, etc.

– Satellite communication is an optional communication method when Internet protocol networking is not available.

7.4 Device layer

The device layer includes the following four kinds of devices:

– CUAV

– Mobile phone

– Telecontroller

– GCS (ground control station)

The mobile phone, telecontroller and GCS, as controlling devices, control CUAVs to fulfil the payload mission.

7.5 Management

The management capabilities can be categorized into CUAV management and flight database management.

– CUAV management is based on the requirements of civil aviation management department. CUAV management completes the registration and management of CUAV users and CUAVs.

– Flight database management entails receiving real-time notification and release of flight-prohibition zone data from civil aviation management department. The flight database can be used by flight control and application.

8 Functional entity of communication application

8.1 Functional entity framework and reference points

The functional entity framework of the CUAV communication application is shown in Figure 2. All independent functional blocks are connected to each other through the reference points. There are three types of reference points in the CUAV communication application functional framework: flight control and flight data reference points, application and service reference points and management reference points.

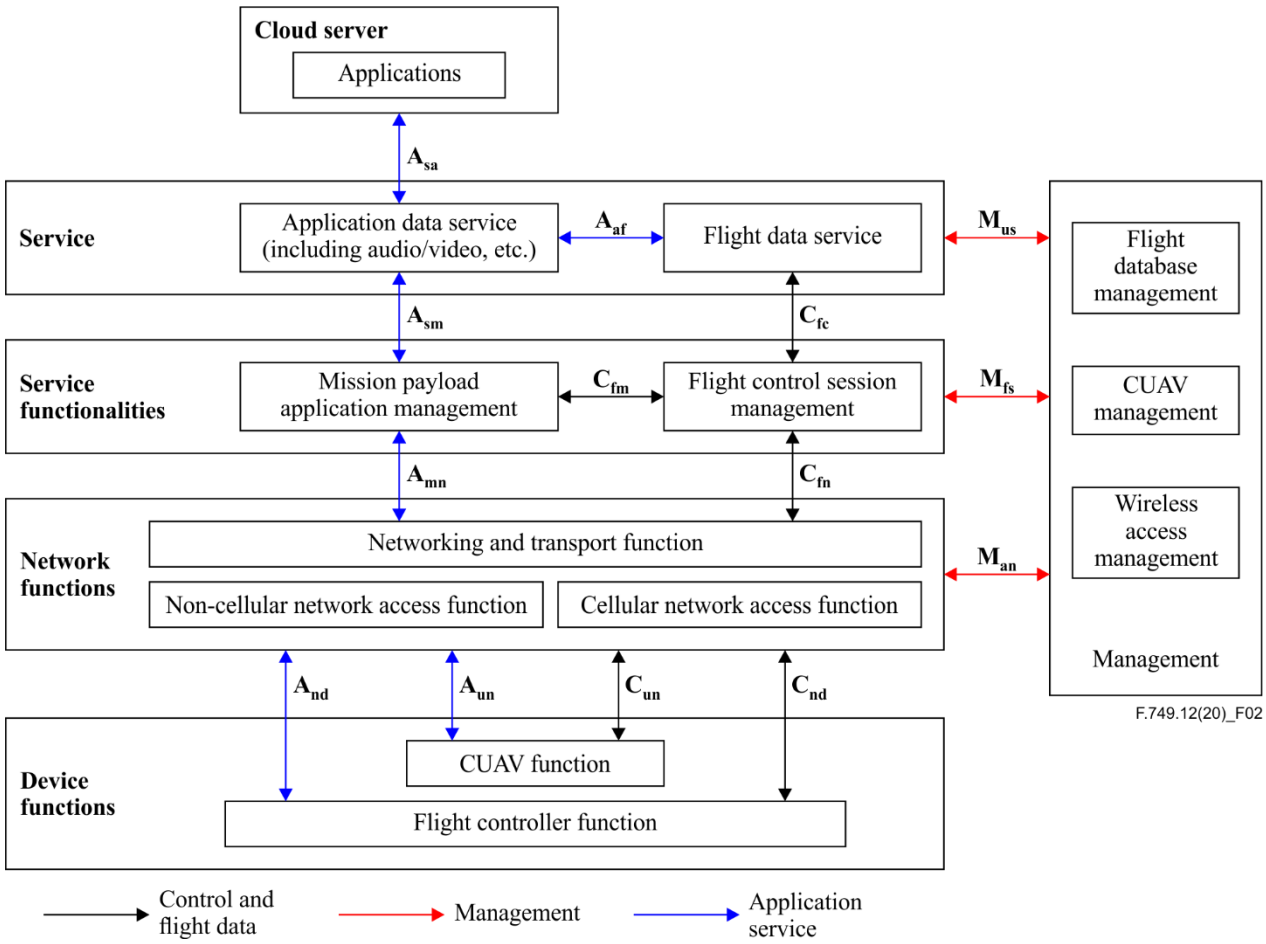

Figure 2 – Functional entity framework and the reference points

8.1.1 Control and flight data interface reference points

– C_{nd}. The reference point C_{nd} is located between the device functions and network functions. It is used for the interaction and transport of flight control command and flight data between the networks and flight controllers.

– C_{un}. The reference point C_{un} is located between the CUAV device functions and network functions. It is used for the interaction and transport of flight control command and flight data between the networks and CUAVs.

– C_{fn}. The reference point C_{fn} is located between the flight control session management functionality and network functions. It is used for the management of flight control session and access control.

– C_{fc}. The reference point C_{fc} is located between the flight data service and flight control session management functionality. It is used for the transport and processing of flight data.

– C_{fm}. The reference point C_{fm} is located between the flight control session management functionality and mission payload application management functionality. It is used for the transport of the specific flight control (including tracking, or along a regular direction or specific area) based on the specific application requirements.

8.1.2 Application and service interface reference points

– A_{un}. The reference point A_{un} is located between the CUAV device functions and network functions. It is used for the interaction and transport of application control command and application (including audio and video) data between the networks and CUAVs.

– A_{nd}. The reference point A_{nd} is located between the flight controller function and network functions. It is used for the interaction and transport of application control command and application data between the networks and flight controllers.

– A_{mn}. The reference point A_{mn} is located between the mission payload application management functionality and network functions. It is used for the management of application control session and application data transport.

– A_{sm}. The reference point A_{sm} is located between the application data service and mission payload application management functionality. It is used for the transport and processing of application data.

– A_{af}. The reference point A_{af} is located between the application data service and flight data service. It is used for the transport of flight data to some application to be used when necessary.

– A_{sa}. The reference point A_{sa} is located between the applications and application data service. It is used for the application data presentation, application instruction processing and application logic execution.

8.1.3 Management interface reference points

– M_{us}. The reference point M_{us} is located between the management and service. It is used for the transport and management of CUAV devices and flight data.

– M_{fs}. The reference point M_{fs} is located between the management and service functionalities. It is used for the management of CUAV flight controlling and mission payload application controlling.

– M_{an}. The reference point M_{an} is located between the management and network functions. It is used for the management of CUAVs' access controlling, authentication and authorization.

8.2 Application

The main function of the application is to provide interfaces and send requests for communication application procedure and data transport. Application realizes interface operations and display, such as CUAV flight status and location display, flight path, mission payload high-definition video and images presentation through virtual reality (VR) helmet, high-definition display screen for users to watch and use.

8.3 Services

Services includes flight data service and application data service.

8.3.1 Flight data service

Flight data service is a functional module to support the function of interacting with flight control session management and flight database management. Flight data service should complete the following functions:

– Flight data service shall provide flight-prohibition zone data query for flight control session management, such as electronic fence maps of flight-prohibition zone, densely populated areas, and airports as well as its viewing functions.

– Flight data service shall receive the latest real-time flight notification and the flight-prohibition zone data from the CUAV flight database management server and save the current flight data to the database management server.

– Flight data service shall provide flight data query and application capabilities for application data service, such as analysing user's behaviour, reasonable flight speed, flight altitude and route through "big data" method, so as to provide users and regulatory departments with more safe, feasible and efficient flight mode and supervision reference.

8.3.2 Application data service

Application data service supports the function of interacting with applications from application cloud server, and can be used by different applications (e.g., video monitoring, inspection and surveillance, etc.) based on the instructions from mission payload application management.

Application data service should provide the following functions:

– Application data service shall support the collection and storage of mission payload data. Cloud server can be used to manage, classify, store, and read application data.

– Application data service should support media processing, such as decomposition and synthesis of standard definition, high-definition videos and images to form a 3D or VR video for application display and playback, and support the storage and distribution of these images and videos.

8.4 Service functionalities

Service functionalities include flight control session management and mission payload application management.

8.4.1 Flight control session management

Flight control session management is a functional module to support the function of interacting with flight data service and CUAV management. Flight control session management shall complete CUAV flight process monitoring and flight control session management.

– Flight control session management shall review and record the flight plan (e.g., CUAV information, flight time schedule, flight mission, flight area, take-off place, maximum flight altitude, etc.) submitted by the user before each flight, and evaluate the user's flight credit grade to determine whether the flight is permitted (Appendix I gives an example use case of CUAV security flight monitoring based on cellular network).

– Flight control session management shall support real-time monitoring each CUAV and its owner's information, flight position, altitude and speed, flight mission, flight time, etc., and it shall display this information properly, as well as upload them to the flight database management server.

– Flight control session management shall support real-time flight warning in flight-prohibition zone and densely populated area (which can be made into electronic fence map). If CUAVs fly close to or enter electronic fence areas, then the immediate warning information shall be sent to users (for example, notifying or sending messages to users to inform illegal flights with time and locations).

– Flight control session management shall support control of the CUAV flying along specific routes/boundaries at specific speeds and altitudes according to the specific requirements of the application.

– Flight control session management shall support the CUAV login. After registration, the CUAV needs to initiate login request to the flight control session management system before interacting with it. Flight control session management system authenticates the information and login password of the CUAV, then establishes session data link with the CUAV. If there is no data interaction with the management system for a long time, the CUAV needs to send heartbeat information to the management system to maintain the login status.

– Flight control session management shall support the CUAV exit. When the CUAV ends the session with the management system, an exit request needs to be initiated by the CUAV, and the management system updates the CUAV status as an exit.

8.4.2 Mission payload application management

Mission payload application management is a functional module to support the function of interacting with applications data service and flight control session management.

Mission payload application management should fulfil the following functions:

– Mission payload application management shall fulfil session management and data synchronization functions for different types of applications, and provide unified query functions for users (including CUAV owners, users and supervisors) and their applications, such as query user information, flight weather, etc.

– Mission payload application management should support the control of mission payload task mode and operation mode according to application requirements.

– Mission payload application management should support the application of network resources with different bandwidth and service levels according to the application requirements.

– If the application needs to fly along the specific route and flight mode, mission payload application management shall support sending specific flight requirements to the flight control session management and obtain timely flight data.

– Mission payload application management should support the ability to dynamically adjust encoding speed and have error tolerance and error correcting coding ability to meet the requirements of transmission of pictures/video.

8.5 Network functions

Network functions include networking and transport function as well as the network access function. These functions provide relevant control functions of network connectivity, such as access and transport resource control functions, mobility management or authentication, authorization, and accounting. Transport capabilities focus on providing connectivity for the transport of IoT service and application specific data, as well as the transport of IoT-related control and management information.

8.5.1 Networking and transport function

Networking and transport function shall support flight related data and application related data transport. It can be divided into real-time transport and non-real-time transport.

– Networking and transport function shall support transporting real-time reliable flight control command and flight data.

– Networking and transport function shall support different transport mode when it has different mission targets, including to transport real-time high definition video/images and non-real-time application data.

– Transport function should support the transport of application data and video/images through satellite.

8.5.2 Network access function

The network access includes cellular 4G/5G and non-cellular access networks, such as industrial scientific medical (ISM) band and WLAN. They shall operate and conform to the regulatory limits and parameters defined in regional and national regulations.

8.6 Device functions

CUAV can be controlled by GCS, telecontroller and mobile phones. Correspondingly, the device functions include CUAV function and CUAV flight controller function. These functions should control CUAV to complete the mission payload tasks according to the application requirements.

8.6.1 CUAV function

The following are application requirements of the CUAV function:

– CUAV functions shall include identification and authentication function (e.g., international mobile subscriber identification (IMSI) number, or other machine-to-machine (M2M) device identifiers).

– Before flight, CUAV function shall support to be activated (based on the location and user information) online to ensure the CUAV operators use "correct geospatial information and flight capabilities". If not, then the flight distance and function of the CUAV will be limited.

– CUAV functions should support to act as the relay sources of cellular network to provide flexible and specific time interval public network access service for remote areas and mountain areas (e.g., when signals are cut off by high mountains).

– When the cellular network base stations or other IoT network base stations are damaged or broken-down, CUAV functions shall support to be used as the operator's temporary base stations for the residents of the affected region and devices to provide emergency network access services.

– When a CUAV is used as an operators' temporary base stations to provide emergency network access services, it shall obtain the location information of the IoT devices/terminals to be served, then inquire whether the devices/terminals are the pre-set service objects before the event, establish a wireless connection with the devices/terminals and provide services after confirmation.

– CUAV functions should support to be acted as a signal transmitter and data receiver for IoT devices (such as geological monitoring devices, farmland and infrastructure monitoring equipment etc.) in remote areas and mountainous areas to send control information (such as status control, start up and shut down) and periodically collect data from these monitoring devices.

8.6.2 Flight controller function

This function includes the following:

– Flight controllers include telecontroller, mobile phone and GCS. Flight controller functions shall provide support to operate and control the CUAV in the process of cruise flight (for example, flying along the contour line under specific application, etc.), mission execution and landing (return), and to coordinate various related equipment with a unified system clock, as well as to fulfil flight state monitoring, operation mode switch and fault diagnosis and treatment, etc.

– Flight controller functions shall support that multiple flight control modes should be realized for different environmental operations. When a CUAV loses its remote control signals, flight controller functions shall support to hover automatically, and calculate the best back route returning after exceeding a given time. Flight controller functions shall support pressing "one key" returning command.

– Flight controller functions shall support various technologies to realize intelligent flight control, e.g., using artificial intelligence to fulfil the flight control and multi-CUAVs coordinated flight control.

8.7 Management

8.7.1 CUAV management

CUAV management is a functional module to support the function of interacting with flight control session management and flight database management to realize the management of user and CUAV

access, including registration, login, exit and cancellation. CUAV management system shall complete the following functions:

– CUAV management shall provide a function to support user registration. CUAV management system shall provide function to authenticate users and enterprise information (including personal identity, business license, address, contact information, etc.) when they login management system.

– CUAV management shall provide function to support the CUAV registration. CUAV management system shall also provide function to register with the CUAV information (including the number of a CUAV, universal subscriber identification module (USIM) card number, communication module ID, CUAV model, flight control equipment number, category and related technical parameters, etc.) before the first flight. The national registration number is unique and traceable. After the management system checks the relevant information correctly, the CUAV status is recorded as registered. At the same time, the management system generates login password for the CUAV and sends it to the CUAV. Appendix I gives an example of the registration authentication process.

8.7.2 Flight database management

Flight database management is a functional module of CUAV flight management system. It interacts with CUAV management module and flight data service module. Flight database management module shall provide the following functions:

– The flight database management module shall receive the electronic map data of flight-prohibition zone, densely populated area and airports from the management department, and send the updated notice and data to CUAV flight control system (telecontroller, mobile phone or GCS).

– The flight database management module shall receive and store flight data from the flight data service module.

8.7.3 Wireless access management

The following are functions of the wireless access management:

– The wireless access management should support management of multiple wireless access network and keep uninterrupted real-time reliable communication of flight control between a CUAV and a GCS or telecontroller with low latency.

– The wireless access management should support management single-hop communication link between a CUAV and a telecontroller or a GCS and multi-hop communication mode among multiple CUAVs using cellular communication mode.

Appendix I

Example use case of CUAV security flight monitoring based on cellular networks (4G/5G)

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

Based on the authorized spectrum, the 4G/5G cellular network can provide large bandwidth, low delay, and high reliability communication services, and support the efficient and orderly air traffic management of CUAV in the future. Each CUAV have a unique digital identifier and a serial number which is composed of country code, industry domain code, enterprise name code and enterprise's own definition code. A CUAV shall be registered to the civil aviation management department before flight. Each CUAV may have one or more communication modules associated with the digital identifier. The communication module can optionally use the universal subscriber identification module (USIM) / embedded subscriber identification module (eSIM) card with an IMSI number.

Figure I.1 illustrates a use case of CUAV security flight monitoring based on cellular network (4G/5G).

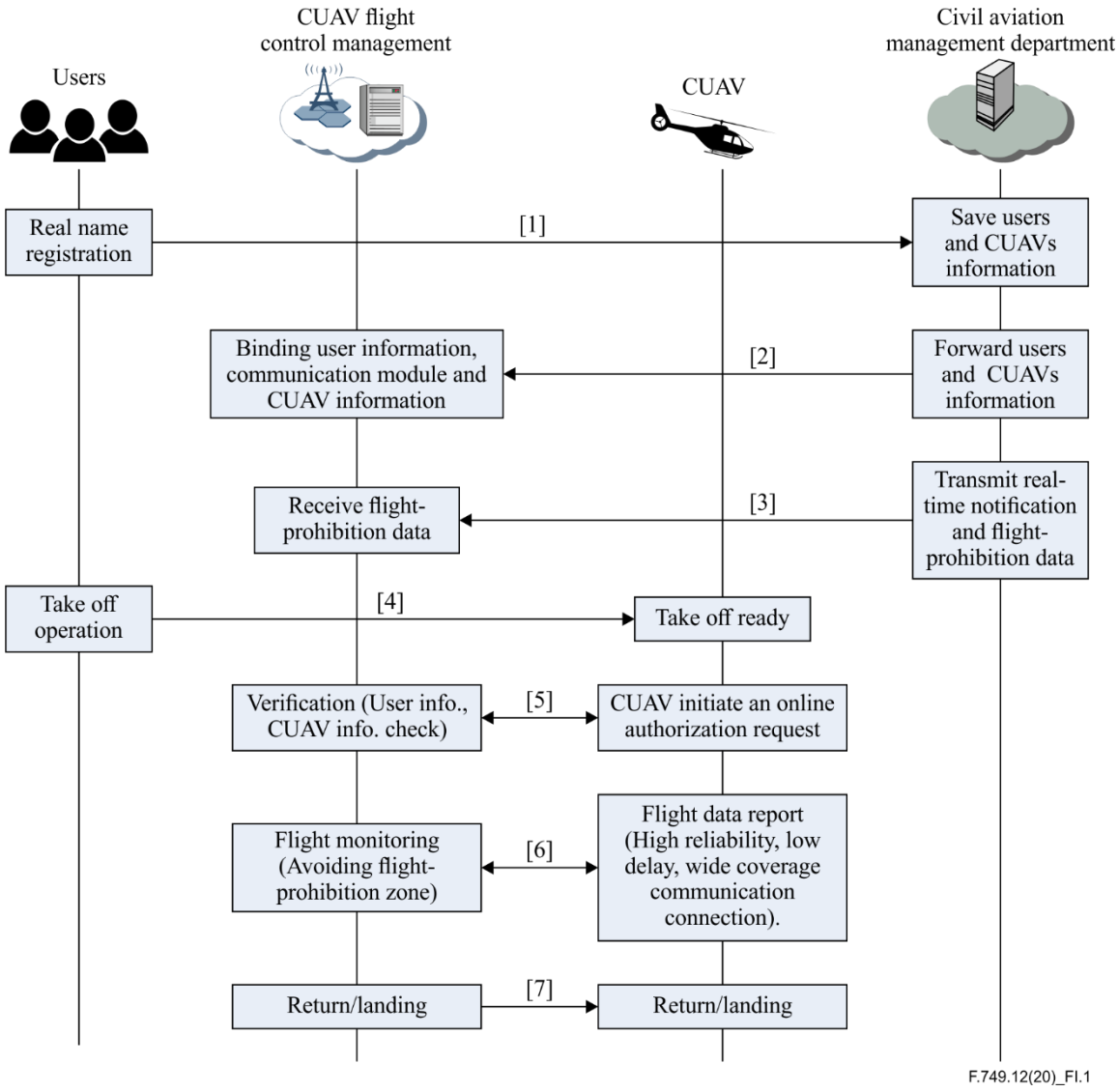

Figure I.1 – CUAV security flight monitoring based on cellular network (4G/5G)

1) Users register to the civil aviation management department and send the information of user ID and CUAVs to the civil aviation management department.

2) Civil aviation management department save users and CUAVs information and send down this information to the CUAV flight control management. The CUAV flight control management binds user information, communication module IMSI and CUAV information.

3) Civil aviation management department transmits real-time flight control notification and flight-prohibition data to the CUAV flight control management.

4) Users initiate taking off operation, the CUAVs are ready to communicate with the CUAV flight control management before take-off.

5) Before take-off, CUAV initiates online authorization request to the CUAV flight control management. The CUAV flight control management verifies users and CUAVs information to determine whether to take off and sends the verification result to the CUAV.

6) If permitted, the CUAV takes off and online reports flight data to the CUAV flight control management via 4G/5G network. The CUAV flight control management continuously monitors the flight of CUAV. If the CUAV approaches the flight-prohibition zone, it will alert the CUAV or the operator.

7) If the CUAV enters the flight-prohibition zone, it will force the CUAV to leave or return/landing.

Bibliography

[b-ITU-T F.749.10] Recommendation ITU-T F.749.10 (2019), *Requirements for communication services of civilian unmanned aerial vehicles*.

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