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SERIES F: NON-TELEPHONE TELECOMMUNICATION SERVICES

Multimedia services

Requirements for communication services of civilian unmanned aerial vehicles

Recommendation ITU-T F.749.10

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Recommendation ITU-T F.749.10

Requirements for communication services of civilian unmanned aerial vehicles

Summary

Recommendation ITU-T F.749.10 provides the requirements for communication services of civilian unmanned aerial vehicles (CUAVs), as well as the use cases of CUAV in industry and consumer application areas. This Recommendation includes a general communication service framework, communication system requirements, requirements for flight control communication and flight data transport and requirements for mission payload communication service (such as audio / video / images transport, sensor data transport and communication signal relay).

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T F.749.10	2019-05-14	16	11.1002/1000/13900

Keywords

Civilian unmanned aerial vehicle, communication service requirements, ground control station.

* 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

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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 for communication services of civilian unmanned aerial vehicles

1 Scope

This Recommendation specifies the requirements for communication services of civilian unmanned aerial vehicles (CUAVs), including communication system requirements, flight control communication requirements, flight data transport requirements and mission payload communication service requirements. The regulations and supervision of CUAV flights are out the scope of this Recommendation.

The scope of this Recommendation includes:

– overview of communication service framework;

– communication service requirements.

2 References

None.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following term 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.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 civilian unmanned aerial vehicle: 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.

3.2.2 flight control system: 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.

3.2.3 ground control station: 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.

3.2.4 ISM bands: 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.

3.2.5 mission payload equipment: The mission payload equipment consists of an audio / video / image acquisition device, signal relay device, remote electronic detection /sense device and other auxiliary devices.

3.2.6 telecontroller: 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.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

4G Fourth Generation

5G Fifth Generation

AP Access Point

CUAV Civilian Unmanned Aerial Vehicle

GCS Ground Control Station

GNSS Global Navigation Satellite System

IoT Internet of Things

ISM Industrial Scientific Medical

M2M Machine-to-Machine

SIM Subscriber Identity Module

UAV Unmanned Aerial Vehicle

5 Conventions

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 document is to be claimed.

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

The keywords "can optionally" and "may" indicate an optional requirement which 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/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

6 Introduction

Unmanned aerial vehicles were originally developed and used in a military context. However, as the industry and consumer UAV market grows, industry and consumer UAV technologies have developed rapidly and matured enough to support a wide range of industry and civilian consumer areas. As civilian applications of UAVs are expected to grow rapidly, requirements for the communication service of civilian UAVs need to be addressed.

7 Communication system framework of CUAV

7.1 Overview of communication system

The communication system of civilian unmanned aerial vehicles includes airborne wireless communication modules and a positioning device, a telecontroller, a ground control station (GCS), communication networks as well as a civil aviation flight management server. For different

application areas, a telecontroller or ground control station can be used to provide flight control and communication services. In order to acquire the position information and the flight data of CUAVs for regulatory monitoring and check-ups, cellular networks (such as 4G/5G) can be used to transport the CUAV identification, position, altitude, speed, flight status to the civil aviation flight management server which will be used by the relevant departments. Also, the CUAV flight management server can receive other flight-prohibition zone data and send this data to the GCS or telecontroller to control the CUAV flight. In addition, if there are multiple CUAVs in a cooperative flight, it is required to realize communication between CUAVs. Figure 7-1 gives a communication reference framework of CUAVs.

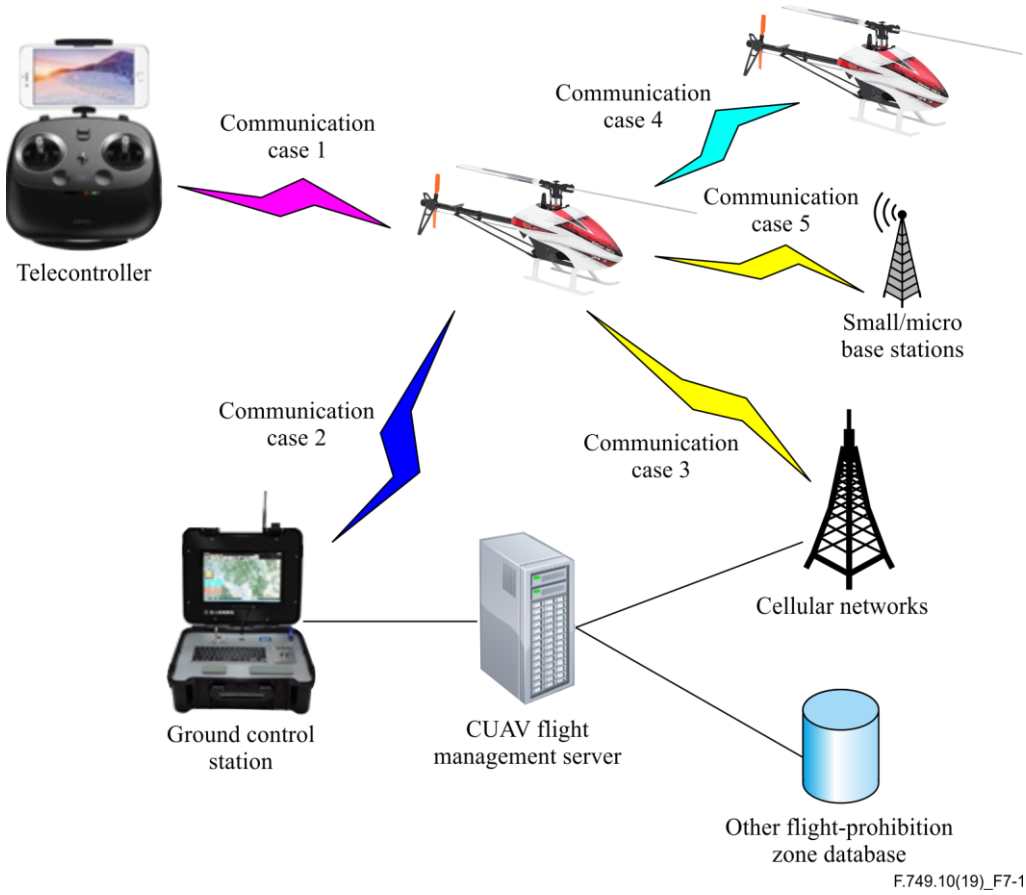

Figure 7-1 – Communication reference framework of civilian unmanned aerial vehicles

Figure 7-1 illustrates five cases of communication service requirements.

Case 1: communication requirements between a CUAV and a telecontroller

Two ways of communication are recommended to realize the communication between a CUAV and a telecontroller. One way is based on the ISM bands to realize the communication between the CUAV and a telecontroller. The other is based on the 4G/5G communication network to realize communication between the telecontroller and CUAV under the cellular base station controlling the wireless resource allocation.

Case 2: communication requirements between a CUAV and ground control station

The 4G/5G communication networks and ISM bands are recommended. One way is based on the ISM bands to realize the communication between the ground control station and CUAV. It is a very promising way to use 5G communication networks to real-time control the CUAV flight.

Case 3: communication requirements between CUAVs and cellular networks

Cellular networks (e.g., 4G/5G networks) are recommended to transport the CUAV flight data and mission payload data (such as application data, video and image, etc.).

Case 4: communication requirements between CUAVs

The 4G/5G communication mode or the Wi-Fi communication mode is recommended. E.g., a wireless AP (access point) can be set up on one CUAV, through which to command or to coordinate other nearby CUAVs flight.

Case 5: communication requirements between a CUAV and small / micro-base stations

With the aid of CUAVs, the communication signal of the public communication network can be transported to a place (via small / micro-base stations) where the public communication network cannot cover areas. Also, when the public communication network is damaged or failed, CUAVs act as the relay sources to transport data from one small / micro-base station (or IoT equipment with access point) to another small / micro-base station (or IoT equipment with access point). In addition, CUAVs can be used as a temporary collector to collect data from small / micro-base stations (or IoT equipment) in a certain area only when the public communication network is damaged or invalid.

7.2 General requirements for communication system

The communication system shall have a communication module, telecontroller, ground control system, communication networks and management devices to finish functions such as numbering for CUAVs, identification authentication for CUAV, etc. Furthermore, there are communication interfaces between the CUAV and other devices.

7.2.1 Numbering requirement for CUAV

– A CUAV is required to have a unique number. The number is optionally to include the country code, industry domain code, sustained flight time code, energy-used mode code, enterprise name code and CUAV type code. It is required to paste the code slice (e.g., two-dimensional code) to the CUAV body.

7.2.2 Identification authentication requirements for CUAV

– A CUAV and the CUAV owner are required to have a real name registration and send the registration information to the CUAV flight management server controlled by the civil aviation management department.

– A CUAV is required to have a unique digital identifier or device identification code. The assigned unique identifier or device identification code is the identity of the CUAV used for the CUAV identification, authentication. This unique digital identifier or device identification code can optionally be an International Mobile Subscriber Identification Number (IMSI), or other M2M device identifiers.

– A CUAV is required to have one or more communication modules associated with the unique digital identifier. The communication module with the unique digital identifier shall support functions that prevent non-authorized access from the external and internal networks, complying with one or several authentication methods along with authorization management, and should support one or several encryption modes.

7.2.3 The functional requirements for telecontroller

The telecontroller shall have functions such as display function, control function and communication function.

– The telecontroller is recommended to have the display function to show its remaining energy, as well as other information.

– The telecontroller is recommended to have the control function to control the flight direction, flight speed, take-off and landing, etc.

– The telecontroller is recommended to have the communication function to communicate with the CUAV. The communication module shall realize the encoding and decoding functions of the sending and receiving signals to the CUAV.

7.2.4 The functional requirements for ground control system

The ground control system refers to the ground control station which fulfils CUAV flight control and management, integrated data display, map and flight path display, mission planning, etc. The specific configuration can be determined by the mission.

7.2.4.1 Flight control and management

Flight control and management is required to fulfil the CUAV functions' check-ups before take-off (launch), and to operate and control the CUAV in the process of cruise flight, mission execution and landing (return). Also, it is required 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.

7.2.4.2 Integrated display system

The integrated display system is required to display the flight parameter and mission parameter, which will be used as the analysis and judgement basis for the operator to monitor the state of the CUAV flight and the mission payload equipment. The information displayed in the integrated display system includes, but is not limited to, the following:

– The flight parameter is recommended to include the height, speed, course, flight path coordinates, flight attitude, residual power, flight time, satellite navigation parameter, etc.

– The mission planning is recommended to generate CUAV flight routes, automatically or manually. The mission payload parameter can optionally display the working status information of the mission payload equipment.

– It can optionally require the integrated display system to be a graphical and digital display. For flight failure status and / or a mission payload equipment fault state, it is recommended to note with sound, light or red colour to attract operator attention.

7.2.5 Interface requirements with external devices

There are six communication interfaces between the CUAV and external devices.

– A CUAV is recommended to have a communication interface between the CUAV and telecontroller to control the CUAV flight.

– A CUAV is recommended to have a communication interface between the CUAV and ground control station. CUAV flight control and data can be transported through this interface.

– A CUAV is recommended to have a communication interface between the CUAV and cellular communication networks. The CUAV flight data and the mission payload information (such as data, video and image, etc.) can be transported through this interface.

– A CUAV is recommended to have a communication interface between a CUAV and another CUAV. Controlling and / or coordinating data between CUAVs is transported through this interface.

– A CUAV is recommended to have a communication interface between a CUAV and small / micro-base stations. Signal relay and data collection and exchange can be transported through this interface.

– A GCS is recommended to have a communication interface between the GCS and CUAV flight management server. The CUAV flight data can be uploaded to a CUAV flight management server and flight-prohibition data can be downloaded through this interface.

8 Requirements for flight control and flight data transport

To complete the mission of the CUAV, it is required to control the CUAV and adjust the flight status of a CUAV according to the flight data of the CUAV. Therefore, the transport of flight control and flight data is required.

8.1 Requirements for communication of flight control

A communication link between a CUAV and a telecontroller or a GCS is required to guarantee flight control of the CUAV. A communication link for flight control is required and optionally based on cellular communication networks (4G/5G networks) to support direct and indirect connection environments. Flight control with a direct connection is recommended to support a single-hop communication mode over cellular communication networks or ISM bands. Flight control with an indirect connection is recommended to support the multi-hop communication mode among multiple CUAVs using cellular communication modes. In addition, a CUAV is required to receive a flight control signal under a handover process among multiple base stations in order to guarantee a robust connectivity.

– It is required to keep uninterrupted real-time reliable communication of flight control between a CUAV and a GCS or telecontroller with a low latency.
– It is required that a GCS or telecontroller remotely controls the direction of flight, speed, height, etc. of a CUAV, and the CUAV sends its status information to a GCS through the established communication link.
– A CUAV is recommended to combine the global navigation satellite system (GNSS) with sensor units (e.g., optionally supporting 6 freedom degree inertial measurement units, magnetic field gauge, barometric altimeter) in order to provide high stability and reliability of the flight control means.
– It is recommended that multiple flight control modes should be realized for different environmental operations.
– A CUAV is required to hover automatically when it loses its remote control signals. After exceeding a given time, the CUAV flight control system shall calculate the best back route and return it safely. Otherwise, the GCS or telecontroller may send an automatic returning order or pressing "one key" returning command.
– It is recommended that the communication of flight control between a CUAV and GCS or telecontroller can optionally choose cellular networks (e.g., 4G/5G), ISM bands.
– Before flight, a CUAV is required 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.
– A CUAV is recommended to support various technologies to realize intelligent flight control, e.g., using artificial intelligence to fulfil the flight control and multi-CUAVs coordinated flight control.

8.2 Requirements for CUAV flight data transport

– It is required to have different flight data transport modes when it has different mission targets. It can be divided into real-time transport and non-real-time transport.
– A CUAV is required to receive real-time flight notifications and the flight-prohibition zone data from the CUAV flight management server.
– A CUAV is required to transport the flight data (e.g., height, speed, etc.) to the GCS or CUAV flight management server. The following table lists some type of flight data.

Table 1 – Flight data of a CUAV and the related components or meaning

	The type of flight data	Including components (not limited)
1	Speed data	Maximum flat speed, cruise speed, minimum speed, etc.
2	Height data	Height ceiling, the maximum usage height and minimum flight altitude
3	Continuation time and maximum continuation time of flight	
4	Flight radius	The flight radius refers to the distance from taking off to the far most point (returning point)
5	Manoeuvre flight performance	Minimum turning radius, the maximum climbing rate and the maximum descent rate
6	Weight data	Maximum take-off weight; maximum mission payload equipment weight
7	Flight posture stability	Pitch and tilt angle stationarity, the tilt angle stationary degree and the yaw angle stationary degree
8	Positioning accuracy	Positioning precision and the target location precision

– It is recommended that data communication between the CUAV and CUAV flight management server can optionally choose cellular networks (e.g., 4G/5G), ISM bands and satellite communication.

9 Requirements for mission payload service communication

Mission payload equipment includes audio / video / image acquisition equipment, remote electronic detection /sense equipment, signal relay equipment and other auxiliary equipment etc. mounted on the CUAV or integrated in the CUAV.

9.1 Requirements for mission payload data –transport related

Mission payload data may come from remote electronic sense equipment (such as temperature sensor/ humidity sensor) in the CUAV.

– A CUAV is recommended to support the collection and storage of mission payload data. This kind of data services have lower requirements for the delay and bandwidth and higher data integrity and reliability, and all the collected data is temporarily stored in the CUAV to be processed after coming back, e.g., data from micro-stations, sensors or IoT devices can be collected by a CUAV and exported to the third-party application server.

– A CUAV is optionally to support to transport real-time mission payload data (e.g., industrial disaster data and territorial resources and science research data, etc.) to the GCS or mobile terminal.

– It is required a secure data transmission channel be established before the beginning of the communication and that two-way authentication is performed between the CUAV and the GCS or CUAV flight management server. Networks that can be applied to data transmission services include cellular networks (e.g., 4G/5G), ISM bands and satellite.

9.2 Requirements for mission payload video / images – transport related

Mission payload video / images can be acquired by high-resolution cameras, infrared cameras, low light reconnaissance cameras, etc.

– It is required that secure and high bandwidth video / images transmission channels shall be established before the beginning of the communication and that two-way authentication is

performed between the CUAV and the GCS or CUAV flight management server. Networks that can be applied to video / pictures transmission services include cellular networks (e.g., 4G/5G), ISM bands and satellite.

– It is recommended that the delay is less than 100 milliseconds when using 4G/5G networks or ISM bands to control the CUAV.

– It is recommended that a communication system is capable to adjust transmission power, based on the environmental conditions and requirements, as well as the wireless transmission distance.

– It is required that the communication system supports the transmission of standard definition (SD) and high-definition (HD) video and images. As to HD, video and pictures shall at least reach 2 Mbit/s above with the delay less than 500 milliseconds. The system has the ability to dynamically adjust encoding speed and have an error tolerance and error correcting coding ability to meet the requirements of the transmission of pictures / video.

– A CUAV is optionally to support to transport real-time video / images to the GCS or mobile terminal (e.g., video / images related with power line and petroleum pipeline inspection, police and traffic security surveillance, disaster monitoring and aerial photography and video, etc.)

9.3 Requirements for mission payload communication signal relay

Mission payload communication signal relay is a process to amplify and retransmit / relay the signal from one place to other place(s).

– A CUAV is recommended to act as the relay sources of cellular networks to provide flexible and specific time interval public network access services for remote areas and mountain areas (e.g., when signals are cut off by high mountains). It is required that the signals sent by the CUAV are stable and do not interfere with other radio signals.

– When the cellular network base stations or other IoT network base stations are damaged or broken down, CUAVs can optionally be used as temporary base stations for the residents of the affected region and devices to provide emergency network access services (such as audio and video services, distance education, remote electronic medical as well as specific IoT devices access service).

– A CUAV can optionally act 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.

Appendix I

Use cases of civilian unmanned aerial vehicle communication services

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

I.1 Agriculture and plant protection related services

– **Service requirements**

It is required that CUAVs fulfil agricultural insecticide spraying, agricultural fertilizer dispensing, crop monitoring, etc.

– **Communication requirements**

A CUAV can be controlled by a telecontroller within the range of human vision or a GCS. The GCS monitors and sets up flight control modes for the CUAV. Sometimes, it is required to transport high-definition images and video to a GCS.

I.2 Power line and petroleum pipeline inspection related services

– **Service requirements**

It is required that CUAVs fulfil power line inspection, oil and gas pipeline monitoring, survey of drilling sites for the oil and gas industry, oil spill and oil slick detection and monitoring, etc.

– **Communication requirements**

A CUAV can be controlled by the GCS to monitor and cruise along the power line or oil pipeline to find whether there are any hazards or faults. If any, the location of hazards and fault information will be transported back to the GCS. A CUAV may save locally high-definition images or video or transport them in real-time to a GCS depending on the application requirements.

I.3 Police and traffic security surveillance related services

– **Service requirements**

It is required that CUAVs fulfil information gathering, aerial crime scene inspection, special and anti-terrorist operations, perimeter surveillance, surveillance of large public gatherings, road traffic surveillance, smuggling surveillance, etc.

– **Communication requirements**

A CUAV can be controlled by the GCS or a telecontroller and high-definition images or video are transported to a GCS or mobile terminal.

I.4 Natural disaster monitoring related services

– **Service requirements**

It is required that CUAVs fulfil natural disaster analysis, avalanche survivor search, forest fire prevention, the monitoring and investigation of disasters such as drought, fire, flood, landslide, earthquake and volcano eruption, etc.

– **Communication requirements**

A CUAV can be controlled by the GCS or a telecontroller and high-definition images and video and data are transported to a GCS or mobile terminal. Sometimes a CUAV can use satellites to transport images or video.

I.5 Aerial photography and video related services

– **Service requirements**

It is required that CUAVs fulfil news / disaster reporting, photography / film (capture the beautiful picture and shooting angle) for tourism, city publicity and extreme sports (taken from every angle tracking shots, downhill skiing athletes etc.), etc.

– **Communication requirements**

A CUAV can be controlled by the GCS or a telecontroller and high-definition images or video are transported to the GCS or a mobile terminal.

I.6 Logistics express delivery related services

– **Service requirements**

It is required that CUAVs fulfil transporting cargoes to remote areas or emergency medical / food supplies, or point-to-point transportation of small items, etc.

– **Communication requirements**

A CUAV can be controlled by the GCS or a telecontroller to reach a given spot or a place.

I.7 Meteorological, territorial resources and scientific research related services

– **Service requirements**

It is required that CUAVs fulfil weather assessments and measurements, atmospheric measurements, cloud seeding, typhoon tracking and measurement, land resource planning and geological exploration, marine mammal monitoring, iceberg surveillance and tracking, national and regional pollution monitoring, fishery monitoring, wildlife monitoring and protection, wildlife researching such as inventory, migration, conservation, etc.

– **Communication requirements**

A CUAV can be controlled by the GCS or a telecontroller and high-definition images and video and data are transported to a GCS or a mobile terminal. Sometimes, a CUAV can use satellites to transport images or video.

I.8 Network communication relay related services

– **Service requirements**

It is required that CUAVs provide flexible, low cost Wi-Fi network access, or act as an emergency communications network base station and provide network access services to residents in remote and mountain areas, etc.

– **Communication requirements**

A CUAV can be controlled by the GCS and acts as a temporary base station to relay communication signals for the residents of the affected region and devices when the cellular network base stations are damaged or have broken down, or acts as a signal transmitter and data receiver for IoT devices in remote areas and mountainous areas.

I.9 Bridge monitoring related services

– **Service requirements**

It is required for CUAVs to fulfil water level monitoring, crack detection of bridge structure such as decks, piers, abutments, etc.

– **Communication requirements**

A CUAV can be controlled by the GCS or a telecontroller and high-definition images and video and data are transported to a GCS or mobile terminal. Sometimes, a CUAV can use satellites to transport images or video.

I.10 Industrial disaster monitoring related services

– **Service requirements**

It is required for CUAVs to fulfil fire detection, fall accident detection, explosion accident detection of facilities such as factories, thermal power plants, nuclear power plants, construction sites, etc.

– **Communication requirements**

A CUAV can be controlled by the GCS or a telecontroller and high-definition images and video and data are transported to a GCS or servers or mobile terminal. Sometimes, a CUAV can use satellites to transport images or video.

Bibliography

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

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