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SERIES F: NON-TELEPHONE TELECOMMUNICATION SERVICES

Multimedia services

# Requirements of coordination for civilian unmanned aerial vehicles

Recommendation ITU-T F.749.14

ITU-T F-SERIES RECOMMENDATIONS

**NON-TELEPHONE TELECOMMUNICATION SERVICES**



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# Recommendation ITU-T F.749.14

## Requirements of coordination for civilian unmanned aerial vehicles


### Summary

Civilian unmanned aerial vehicle (CUAV) coordination refers to utilizing the coordination of multiple CUAVs to accomplish specific tasks through network communication. To enable CUAVs to cooperate well and accomplish tasks successfully, three important parts need to be fulfilled. First, a stable and reliable network connection is required to be established among CUAVs to ensure that every CUAV can connect to the others; second, efficient and reliable data transmission among CUAVs is required so as to ensure that the perception information, control information, coordination information and other required information is exchanged among CUAVs; finally, a CUAV collaborative task execution strategy is required to be reasonably worked out during the coordination process in order to improve the efficiency and quality of collaborative task execution. Recommendation ITU-T F.749.14 specifies the requirements of CUAV coordination, including the requirements of network connection among CUAVs, the requirements of data transmission among CUAVs, and the requirements of CUAV collaborative task execution.



### History

| Edition | Recommendation | Approval | Study Group | Unique ID* |
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| 1.0 | ITU-T F.749.14 | 2021-06-13 | 16 | 11.1002/1000/14685 |

Keywords

Civilian unmanned aerial vehicle, coordination, CUAV.


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# Recommendation ITU-T F.749.14

## Requirements of coordination for civilian unmanned aerial vehicles

## 1 Scope

This Recommendation specifies requirements of coordination for civilian unmanned aerial vehicles, including the framework, network connection, data transmission and task processing requirements during the coordination stage. The regulations and supervision of civilian unmanned aerial vehicle flight are out scope of this Recommendation.

The scope of this Recommendation includes:

– Requirements of the network connection among civilian unmanned aerial vehicles (CUAVs)
– Requirements of data transmission among CUAVs
– Requirement of CUAV collaborative task execution

## 2 References

None.

## 3 Definitions

### 3.1 Terms defined elsewhere

This Recommendation uses the following term 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.

### 3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

**3.2.1 civilian unmanned aerial vehicle (CUAV) coordination**: CUAV coordination refers to utilizing the ability of multiple unmanned aerial vehicles (UAVs) to accomplish specific tasks through network communication.

**3.2.2 position-based routing**: A routing method that does not need to know the topology of the network but makes each forwarder transmit data to its neighbour closest to the destination, according to the position of its neighbours. It is applicable for the scenario where the nodes have high mobility, and the network topology changes drastically.

**3.2.3 rateless codes**: Channel codes that continuously encode and transmit data at a high rate regardless of the link states. When the receiver accumulates adequate data packets, it can decode the original data successfully.

**3.2.4 topology-based routing**: A routing method that detects the topology information of the network and selects the optimal routing path from the source to the destination according to this topology information. It is applicable for the scenario where nodes have low mobility and the network topology does not change drastically.

## 4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CUAV Civilian Unmanned Aerial Vehicle

GPS Global Positioning System

QoS Quality of Service

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.

## 6 Overview of the framework of CUAV coordination

The framework of CUAV coordination includes three parts of requirements: requirements of network connection, requirements of data transmission and requirements of collaborative task execution. First of all, the reliable network connection among CUAVs is required. This is the basis of CUAV coordination that ensures that every CUAV can connect with each other. In this part, a topology control mechanism and a channel resource management mechanism are required. Second, efficient data transmission is required. This ensures that all kinds of information (control information, coordination information, perception information and other required information) can be exchanged efficiently. In this part, channel-coding data and a routing data are required. Finally, the collaborative task execution is required. This ensures that collaborative tasks can be completed efficiently. In this part, data sensing, information fusion, task assignment and cloud-end collaborative computing are required. The overall framework of CUAV coordination is shown in Figure 6-1.

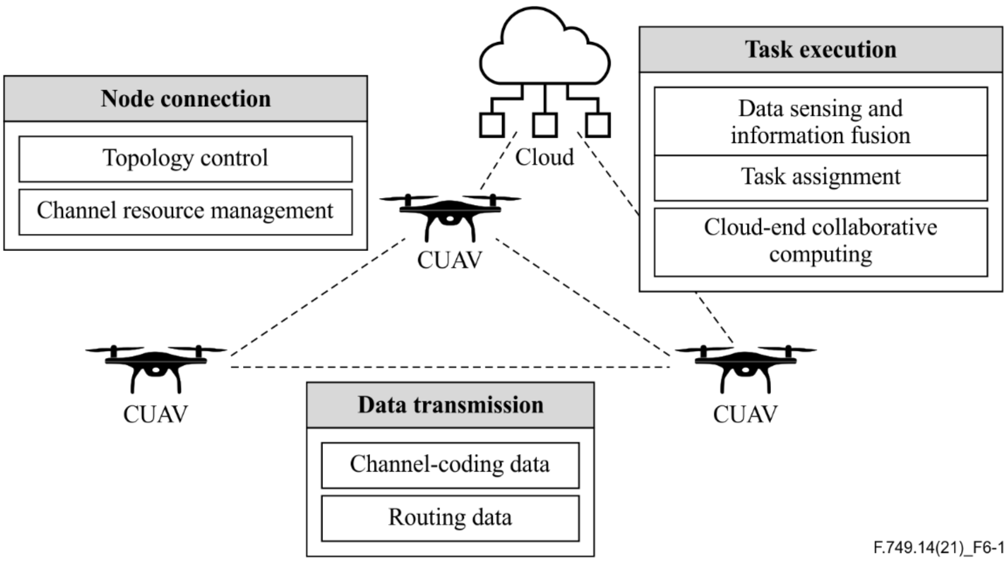


**Figure 6-1 – The overall framework of CUAV coordination**

## 7 Requirements of the network connection

### 7.1 Requirements of topology control

TC-01: CUAVs are required to know their own information such as residual energy, moving speed, maximum movable distance, maximum load, etc.

TC-02: CUAVs are required to be aware of the surrounding environment and obtain external environmental conditions such as terrain, wind direction, hydrology, obstacle distribution, etc.

TC-03: CUAVs are required to use their own information (such as residual energy, moving speed, maximum movable distance, maximum load, etc.) and surrounding environment information (such as terrain, wind direction, hydrology, obstacle distribution, etc.) to actively control topology, and actively optimize the performance of network connection.

### 7.2 Requirements of channel resource management

CRM-01: A channel resource management mechanism is required, which supports channel resources (such as spectrum resources) management, and collision avoidance when multiple CUAVs communicate with each other using 4G/5G, wireless LAN or other wireless communication technologies.

CRM-02: The channel resource management mechanism is recommended to be distributed, which has low delay and low overhead.

CRM-03: It is recommended that the control channel only transmits control information and the data channel only transmits data information. This can ensure the efficiency and reliability of the control information.

CRM-04: It is recommended to group multiple CUAVs according to their types, locations, coverage, and wireless access methods. Different groups of CUAVs are required to use different control channels to reduce mutual interference and improve collaboration efficiency and security.

## 8 Requirements of data transmission among CUAVs

### 8.1 Requirements of channel-coding data

CCD-01: In a one-to-one transmission scenario, it is recommended to use rateless codes as channel codes. This is because rateless codes can adapt the dynamic change of link qualities with time, guarantee the reliability of data transmission and maximize the efficiency of data transmission.

CCD-02: In a one-to-many transmission scenario, it is recommended to use rateless codes as channel codes. This is because rateless codes can adapt different qualities of multiple links and make a single CUAV transmitter meet different data receiving requirements of multiple CUAV receivers without changing rateless coding parameters.

CCD-03: In a one-to-many transmission scenario, it is recommended to set different rateless codes parameters for different CUAV receivers with different communication capacity or computing capacity, which can meet different QoS requirements (throughput, reliability, delay time, etc.) of different CUAV receivers and different application services.

### 8.2 Requirements of routing data

RD-01: In some application scenarios (such as disaster search and rescue, target tracking, etc.), CUAVs usually have high mobility, and as a result, the topology of the CUAV network may change drastically. So, it is recommended to use position-based routing in these application scenarios as position-based routing does not need to detect and maintain the topology of the network, but makes each forwarder transmit data to its neighbour closest to the destination according to the position (acquired by GPS services) of its neighbours.

RD-02: In some application scenarios (such as environmental monitoring, network coverage, etc.), CUAVs have low mobility and the topology of the CUAV network in these application scenarios does not change drastically. So, it is recommended to use topology-based routing. The topology-based routing selects the optimal routing path from the source to the destination according to the network topology information.

RD-03: It is recommended to introduce multiple parameters (such as position change, energy surplus, computing capacity, communication capacity, etc.) of CUAV as evaluation indicators for selecting the path from the source to the destination.

# 9 Requirements of CUAV collaborative task execution

## 9.1 Requirements of data sensing and information fusion

DSIF-01: To eliminate various defects in a single type of sensor, it is recommended that CUAVs use multiple kinds of sensors (including vision sensors, lidar, ultrasonic radar, infrared radar, millimetre-wave radar, etc.) to sense the various types of information of the environment and tasks.

DSIF-02: To enable CUAVs to analyse and recognize various changes in the dynamic environment and task requirements accurately, it is recommended to perform unified and efficient information fusion of various types of heterogeneous information sensed by multiple sensors on multiple CUAVs.

DSIF-03: It is recommended to adopt a variety of dynamic and adjustable information fusion methods according to the dynamic external environment, various task types, different dynamic task requirements, and heterogeneous node resources.

## 9.2 Requirements of task assignment

TA-01: Task assignment requires considering the dynamicity and the uncertainty of the external environment, task requirement change, the heterogeneity of CUAV resources, task assignment efficiency, task assignment delay and other constraints.

TA-02: Before tasks start, it is recommended to perform offline task assignments for each CUAV according to the known task requirements and CUAV resources.

TA-03: During the execution of tasks, it is recommended to perform the real-time online evaluation of the external environment, task requirements and the CUAV status.

TA-04: According to the evaluation results, it is recommended to perform real-time online task adjustments for each CUAV.

TA-05: For simple task scenarios, it is recommended to use a centralized task assignment method to obtain global optimal solutions.

TA-06: For complex task scenarios with high uncertainty, it is recommended to use a distributed task assignment method to improve the efficiency of the task assignment.

## 9.3 Requirements of cloud-end collaborative computing

CECC-01: For simple computing tasks, it is recommended that computation be done locally on the CUAV to reduce the computing delay.

CECC-02: For complex computing tasks, it is recommended that computation be done on the cloud platform to reduce the computing and storage overhead of CUAVs.

CECC-03: The computing task offloading from CUAV to the cloud platform will introduce communication overhead and corresponding delays. "Cloud-end" collaborative computing requires balancing the calculation cost, communication cost, communication delay and other performance indicators.

# Appendix I

## Typical scenarios of CUAV coordination

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

With the tremendous progress in the research of civilian unmanned aerial vehicles (CUAVs) technology, CUAVs are not only widely used in military, but also widely used in civilian and commercial fields. In commercial or civilian applications, CUAVs can be used for disaster search and rescue, environment monitoring, target tracking, network coverage, etc. As the workload and complexity of tasks in these scenarios continue to increase, using a single CUAV to perform tasks will increase the burden of this single CUAV in terms of load, communication, computing, storage, and endurance. In contrast, using multiple CUAVs in a cooperative way to accomplish tasks can not only improve coverage and range, but also reduce the risk of mission failure. In addition, CUAV coordination can effectively improve the system stability and the task execution efficiency. This clause describes various scenarios for CUAV coordination.

### I.1 Disaster search and rescue

In this scenario, multiple unmanned aerial vehicles are used to search and detect single or multiple targets (stationary or mobile) and keep track of the state of the target(s) to facilitate rescue victims in efficient time. See Figure I.1 and Figure I.2. Due to the time critical nature and the mobility of targets, mission response time is the most important. Thus, searching for different targets in different areas using multiple CUAVs in a collaborative manner is required, and can greatly shorten the search time. In this process, multiple CUAVs require network communication to exchange information with each other. Therefore, a long range communication and multi-hop connectivity are required in such scenarios.

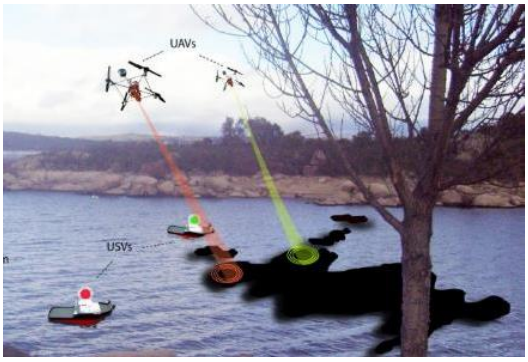


**Figure I.1 – CUAVs are used to search and detect targets in disasters**

**Figure I.2 – CUAVs keep track of the target(s) until victims are rescued**

## I.2 Environment monitoring

In this scenario, multiple CUAVs sense and collect environmental information (such as temperature information and humidity information). CUAVs should carry these data directly to the sink node or transmit these data to the sink node through multiple hops. If the detected area is large, communication range may be limited. Thus, multiple CUAVs are required to work in a cooperative way, and multi-hop communication is required to enable continuous connectivity between these CUAVs. See Figure I.3.

**Figure I.3 – CUAVs monitor the environment**

## I.3 Network coverage

In this scenario, CUAVs are used as air base stations to provide network coverage to users in disasters where ground network infrastructures are seriously destroyed, or in big events with a large number of audiences (such as a football match or an outdoor concert). These CUAVs connect the base station to the users' device in a multi-hop manner. See Figure I.4.

**Figure I.4 – CUAVs provide network coverage**

# Bibliography

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

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