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Abstract: This TD contains the output text for draft Recommendation ITU-T Y.UAV.arch “Functional architecture for unmanned aerial vehicles and unmanned aerial vehicle controllers using IMT-2020 networks” based on the discussion of contribution Doc004 and Doc005 (Virtual, 2-5 November 2020).

Please see below.

No.	Source	Title	Comments and Modifications
Doc004	China Mobile	Updated Draft Recommendation Y.UAV.arch	<p>The following proposed contents are added or modified:</p> <ul style="list-style-type: none"> - The summary and keywords are added in the beginning of the document. - English proof reading has been done and editorial improvements have been performed. <p>The following modifications are applied according to online comments:</p> <ul style="list-style-type: none"> - For the question about the classification and definition of UAVs: Editors studied UAV-related Recommendations from ITU, ICAO and other SDOs and have learnt that the category of the UAV may be related to size, weight as mentioned in online comments and even other specific characteristics raised by specific country. However, the category specification and the corresponding operation for the specific category are solved by regulations and supervision. This draft Recommendation just provides a reference architecture of functionalities and the functionalities for civilian UAVs. Regulations and supervision are out of the scope of this Recommendation. <p>To be more precise, the definition of CUAV in 3.1.4 is added in sub-Clause 3.1. “UAV is special kind of IoT devices” is deleted. “category specification is out of the scope” is added in the NOTE 2 of Clause 1. “civilian” is added in the Scope.</p> <ul style="list-style-type: none"> - For the question about UAV security including the data security and fight security mentioned by the online comments: As stated in the Clause 6 and Clause 9, the security capability of the IMT-2020 network can be reused. Further enhancements about data security for UAVs are out of the scope of this Recommendation and may be studied in a new WI under a security-related group like SG17. <p>For flight safety, e.g. no-fly zone and other flight restrictions mentioned in the online comments, the note in Clause 9 has explained that flight safety is out of the scope of this Recommendation.</p>
Doc005	UK, US, Canada	Request to apply TAP to Y.UAV.arch	It was agreed to submit this request to WP1/20 for further decision.

Draft new Recommendation ITU-T Y.UAV.arch

Functional architecture for unmanned aerial vehicles and unmanned aerial vehicle controllers using IMT-2020 networks

Summary

The widely used civilian UAVs generate increasing requirements for communication and network capability, including seamless coverage, low latency, Gbps-level rate and high-accuracy positioning. The existing commercial products of civilian UAVs utilize direct radio link, which is limited by service distance and quality. Therefore IMT-2020 can be employed for UAV communication. The UAV requires simultaneous services with different characters, which is a brand-new type of user terminal to IMT-2020. Likewise, IMT-2020 is a novel communication network to the UAVs since it is originally designed for ground coverage. With the purpose of implementing the support of civilian UAV operations in IMT-2020 networks and improving quality of UAV application service, a set of functionalities is needed to bridge the gap for interoperation between UAVs and IMT-2020 networks. This draft Recommendation provides a functional architecture for UAVs and UAV controllers using IMT-2020 networks and functionalities defined in application layer, service and application support layer, and security capabilities. The motivation of this Recommendation is to solve the issues of civilian UAVs accessing and communicating in IMT-2020 networks using its transmission capabilities.

Keywords

Functional architecture, unmanned aerial vehicles, IMT-2020

Contents

	Page
Contents	
1 Scope	5
2 References	5
3 Definitions	6
3.1 Terms defined elsewhere	6
3.2 Terms defined in this Recommendation	7
4 Abbreviations and acronyms	7
5 Conventions	7
6 Overview	7
7 Functional requirements	9
7.1 Application layer requirements	9
7.2 Service and application support layer requirements	10
7.3 Security capability requirements	11
8 Functional architecture	11
8.1 Flying Status Demonstration	13
8.2 Service Quality Demonstration	13
8.3 Public Information Distribution	14
8.4 UAV and Controller Service and Congestion Management	14
8.5 UAV Task Management	14
8.6 UAV and Controller Identity Storage	15
8.7 UAV and Controller Status Monitoring	15
8.8 UAV and Controller Matching	15
8.9 UAV and Controller Authorization and Authentication	15
8.10 User Authorization and Authentication	16
9 Security considerations	16
Appendix I	16

Draft new Recommendation ITU-T Y.UAV.arch

Functional architecture for unmanned aerial vehicles and unmanned aerial vehicle controllers using IMT-2020 networks

1 Scope

The scope of this Recommendation includes:

- **Functional architecture:** a reference architecture of functionalities for civilian UAVs and UAV controllers using IMT-2020 networks as user terminals.
- **Functionalities:** functionalities defined in the functional architecture, including application layer, service and application support layer, security capabilities.

Additionally, relevant requirements, procedures, security considerations and deployment use cases for using the functional architecture defined in this draft Recommendation.

NOTE 1 – The existing IMT-2020 generic functionalities and capabilities, as well as the powering and monitoring modules already integrated in the UAVs for flight are out of the scope of this work item.

NOTE 2 – The regulations and supervision of civilian unmanned aerial vehicle flight (e.g. category specification and functionality defined for registration, identification, traffic management addressed by ICAO) are out of the scope of this work item.

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 F.749.10] | Recommendation ITU-T F.749.10 (2019), Requirements for communication services of civilian unmanned aerial vehicles |
| [ITU-R M.1224-1] | Recommendation ITU-R M.1224-1 (2012), Vocabulary of terms for International Mobile Telecommunications (IMT) |
| [ITU-T Y.4000] | Recommendation ITU-T Y.4000 (2012), <i>Overview of Internet of thing</i> |
| [ITU-T Y.4100] | Recommendation ITU-T Y.4100 (2014), <i>Common requirements of the Internet of things.</i> |
| [ITU-T Y.4113] | Recommendation ITU-T Y.4113 (2016), <i>Requirements of the network for the Internet of Things.</i> |
| [ITU-T Y.3100] | Recommendation ITU-T Y.3100 (2017), <i>Terms and definitions for IMT-2020 network</i> |
| [ITU-T Y.3101] | Recommendation ITU-T Y.3101 (2018), <i>Requirements of the IMT-2020 network</i> |

[ITU-T Y.3110]	Recommendation ITU-T Y.3110 (2017), <i>IMT-2020 network management and orchestration requirements</i>
[ITU-T Y.3111]	Recommendation ITU-T Y.3111 (2017), <i>IMT-2020 network management and orchestration framework</i>
[ITU-T Y.3150]	Recommendation ITU-T Y.3150 (2018), <i>High level technical characteristics of network softwarization for IMT-2020</i>
[ITU-T Y.2091]	Recommendation ITU-T Y.2091 (2011), Terms and definitions for next generation networks
[ITU-T Y.2012]	Recommendation ITU-T Y.2012 (2010), Functional requirements and architecture of the NGN

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 Internet of Things [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.

3.1.2 application [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.

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

3.1.4 civilian unmanned aerial vehicle [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.

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

3.1.6 reference point [ITU-T Y.2012]: A conceptual point at the conjunction of two non-overlapping functional entities that can be used to identify the type of information passing between these functional entities.

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

3.1.8 thing [ITU-T Y.4000]: In the Internet of Things, object of the physical world (physical things) or of the information world (virtual things), which is capable of being identified and integrated into the communication networks.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

4G	Fourth Generation
eMBB	Enhanced Mobile Broadband Services
IMEI	International Mobile Equipment Identity
IMSI	International Mobile Subscriber Identification Number
IoT	Internet of Things
MTC	Machine Type Communication
mMTC	Massive Machine Type Communication-based Services
NFV	Network Functions Virtualization
SON	Self Organizing Network
SDN	Software-defined Networking
UAV	Unmanned Aerial Vehicle
uRLLC	Ultra-reliable and Low-latency Communication-based Services

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 Overview

According to [ITU-R M.2083-0], IMT-2020 can be seen as "systems, system components, and related aspects that provide far more enhanced capabilities than those described in [b ITU R M.1645]". Note that [b-ITU-R M.1645] defines the framework and overall objectives of the future development of IMT-2000, and systems beyond IMT-2000, for the radio access network.

The IMT-2020 network will differentiate itself from fourth generation (4G) networks [b ITU R M.2012] for not only further evolution in terms of radio performance, but also greatly increased end-to-end flexibility. This end-to-end flexibility will come in large part from the introduction of the network softwarization approach in IMT-2020 network components. Technologies such as software-defined networking (SDN) [b-ITU-T Y.3300], network functions virtualization (NFV) [b-ETSI NFV-WP1] [b-ETSI NFV-WP5G] and cloud computing [b ITU-T Y.3501] will together allow unprecedented flexibility in the IMT-2020 network. Such flexibility will enable a lot of new capabilities in the IMT-2020 network, including network slicing [b-ITU-T Y-Sup.44].

The services expected to be supported by the IMT-2020 network can be classified into three categories [ITU-R M.2083-0]: enhanced mobile broadband services (eMBB); ultra-reliable and low-latency communication-based services (uRLLC); and massive machine type communication (MTC) - based services (mMTC).

- eMBB allow users to experience high-speed and high-quality multimedia services, e.g., virtual reality, augmented reality, 4K or 8K ultra-high-definition videos and even hologram services, at any time and place.
- uRLLC enable delay-sensitive and mission-critical services that require very low end-to-end delay, e.g., tactile Internet, remote control of medical or industrial robots, driverless cars and real-time traffic control.
- mMTC involving massive numbers of MTC devices.

With its improved capabilities compared to IMT-advanced and other mobile communication networks in data rate, latency, coverage, positioning, security and energy efficiency, the IMT-2020 network will better help in UAV applications and cope with their requirements. In addition, by introducing new technologies such as Network Slicing, large-scale antennas, and Self Organizing Network (SON), it will further guarantee aerial network coverage, end-to-end service quality, and efficient identification and control for connected UAVs.

High-definition video feedback from UAV to the service centre or the controller is required in most UAV applications and services. For example, UAV-aided pipeline and base station inspection, search and rescue, and entertainment require uplink transmission data rate up to 30 Mbit/s, which can be provided in the typical urban and rural coverage scenario of IMT-2020. Some specialized application such as panoramic video, virtual reality, agriculture and forestry surveillance may require data rate higher than 100 Mbit/s, which can be supported in IMT-2020 networks with its coordinated coverage of high and low frequencies.

To achieve UAV attitude stabilization and adjustment, mission equipment management and emergency countermeasure, remote control is another typical demand in UAV applications and services. The end-to-end latency requirement may vary depending on application scenarios and service characteristics, e.g. entertainment, pipeline and base station inspection require remote control latency up to 500 ms, while search, rescue and surveillance require remote control latency less than 100 ms. This can be guaranteed by IMT-2020 networks thanks to its quality of service mechanism and flexible frame and scheduling designs.

The demand for positioning of UAVs has gradually increased with the diversification of applications. While ordinary surveillance and entertainment only require positioning accuracy within 50m, pipeline and base station inspection, search and rescue, and automatic returning and landing require higher positioning accuracy of 1m or even 0.1m. Through its hybrid positioning technology of cellular network and differential GNSS, IMT-2020 networks can achieve such positioning accuracy and thus meet the demand of UAV applications and services.

In addition to the breadth, the connected UAVs also impose in height of communication network coverage. The coverage height requirement for entertainment, search and rescue, surveillance is about 100m, while pipeline and base station inspection, surveying and mapping may require 300m to 1000m. Through large-scale antennas and interference cancellation technologies, IMT-2020 networks can greatly enhance aerial coverage performance for UAV applications and services.

From this perspective, the IMT-2020 networks (which is currently under early commercial deployment) will be able to meet above-mentioned requirements and play a key role in providing ubiquitous coverage and sustainable services for UAVs. This functional architecture is for civilian UAVs and UAV controllers to access and communicate in IMT-2020 networks using its transport

and transmission capabilities, and to bridge the gap for interoperation between UAVs and IMT-2020 networks. The user information of UAVs and controllers including application data, control command, flying status and identity information is transparent to the IMT-2020 networks.

7 Functional requirements

This clause describes the functional requirements, including application layer, service and application support layer and security capabilities.

Editor's Note: The description text in this clause for each functionality should be checked and recognized to avoid any impact on UAV regulations, supervision, registration, identification, traffic management or any other purpose that should be addressed by ICAO.

7.1 Application layer requirements

This subclause describes the functional requirements in application layer. The application layer provides applications that emerge functionalities by using capabilities from the service and application support layer to the UAVs, the UAV controllers and other authorized users.

Flying Status Demonstration: provides the function of demonstrating flying status of a UAV/UAVs for controllers and other authorized users for this application.

- It is required to demonstrate the altitude (above ground level) of the UAV;
- It is required to demonstrate the velocity (horizontal and/or vertical) and direction of the UAV;
- It is recommended to demonstrate the propeller speed of the UAV;
- It is recommended to demonstrate the remaining battery and duration of flight of the UAV;
- It is recommended to demonstrate the flight attitude (e.g. fuselage level) of the UAV;
- It is recommended to demonstrate the current flight procedure (e.g. taking-off, cruising and landing) of the UAV;
- It is recommended to demonstrate waypoints (e.g. three-dimensional coordinate) of the UAV.

Service Quality Demonstration: provides the function of demonstrating service quality for UAVs, controllers and other authorized users for this application.

- It is required to demonstrate end-to-end latency between the UAV and the UAV controller or the UAV control centre;
- It is required to demonstrate transmission rate between the UAV and the UAV controller or the UAV control centre;
- It is required to demonstrate loss ratio of data packet between the UAV and the UAV controller or the UAV control centre.

Public Information Distribution: provides the function of distributing public information to UAVs, controllers and other authorized users for this application.

- It is required to distribute air traffic control information to the UAV and the UAV controller;
- It is required to distribute restricted and warning area information for UAV flying to the UAV and the UAV controller;
- It is recommended to distribute weather information to the UAV and the UAV controller;
- It is recommended to distribute disaster information to the UAV and the UAV controller;

- It is recommended to distribute commercial information (e.g. network quality information) to the UAV and the UAV controller.

UAV and Controller Service and Congestion Management: provides the function of application level scheduling and priority handling based on the service type and importance. The UAV and controller service and congestion management function ensure QoS above network layer. It works as part of end-to-end QoS including IMT-2020 QoS mechanisms and can invoke network slices as defined in IMT-2020 for different applications.

- It is required to support static (in absolute orders) scheduling and priority handling for the UAV and UAV controller services.
- It is recommended to support dynamic (in relative orders) scheduling and priority handling for the UAV and UAV controller services.

UAV Task Management: provides the function of managing task-related and/or flight-related applications for the UAVs.

- It is required to support control command executing for the UAV and the UAV controller;
- It is required to support flight logging for the UAV;
- It is recommended to support route planning for the UAV;
- It is recommended to support navigating for the UAV;
- It is recommended to support task scheduling for the UAV and the UAV controller;
- It is recommended to support UAV grouping for the UAVs;
- It is recommended to support audio/video/monitor data processing for the UAV and the UAV controller.

7.2 Service and application support layer requirements

This subclause describes the functional requirements in service and application support layer. The service and application support layer consist of capabilities which can provide application interfaces to or collect data for different applications in the application layer.

UAV and Controller Identity Storage: stores the UAV and controller identity information for authorization and authentication to access IMT-2020 network. The stored identity information can be used for emerging identity-related functionalities defined in application layer and security capabilities.

- It is required to support storage of permanent identity for the UAV and the UAV controller;
- It is recommended to support storage of temporary identity for the UAV and the UAV controller.

UAV and Controller Status Monitoring: monitors the flying status and service quality information for demonstration. Information required by the application layer can be obtained by monitoring relevant parameters and systems, e.g. UAV powering system and engine system. The monitoring operation can be triggered by the UAV itself, or by the request from the controllers or other authorized users.

- It is required to support UAV triggered monitoring operation;
- It is required to support UAV controller triggered monitoring operation;
- It is recommended to support other authorized users triggered monitoring operation.

UAV and Controller Matching: stores the matching relation of the authorized UAV and controller. The matching relation can be used for emerging peer-to-peer (e.g. a UAV to its matched UAV controller) functionalities defined in application layer and security capabilities.

- It is required to support adding, removing and modifying matching relation between the UAV and the UAV controller.

7.3 Security capability requirements

This subclause describes the functional requirements in security capability. IMT-2020 security capabilities including encryption and integrity protection for user data transmission can be reused for the network layer and below.

UAV and Controller Authorization and Authentication: provides the function of authorizing and authenticating a UAV or a UAV controller to access IMT-2020 networks. IMT-2020 user authorization and authentication rules and procedures can be adopted as baselines. Additional and specific authorizing and authenticating rules and procedures can be developed in application level based on UAV and UAV controller identities.

- It is required to support adding, removing and modifying the association of certification or license of a UAV or a UAV controller for IMT-2020 network access, to its identity or subscription information used in IMT-2020.

User Authorization and Authentication: provides the function of authorizing and authenticating a user other than a UAV or a UAV controller to use functionalities defined in clauses 7.1 and 7.2. IMT-2020 user authorization and authentication rules and procedures can be adopted as baselines. Additional and specific authorizing and authenticating rules and procedures can be developed in application level.

- It is required to support adding, removing and modifying the association of certification or license of a user other than a UAV or a UAV controller for accessing all or part of the functionalities, to its identity or subscription information used in IMT-2020.

8 Functional architecture

Editor's Note: The followed figure should be checked and recognized to avoid any impact on UAV regulations, supervision, registration, identification, traffic management or any other purpose that should be addressed by ICAO.

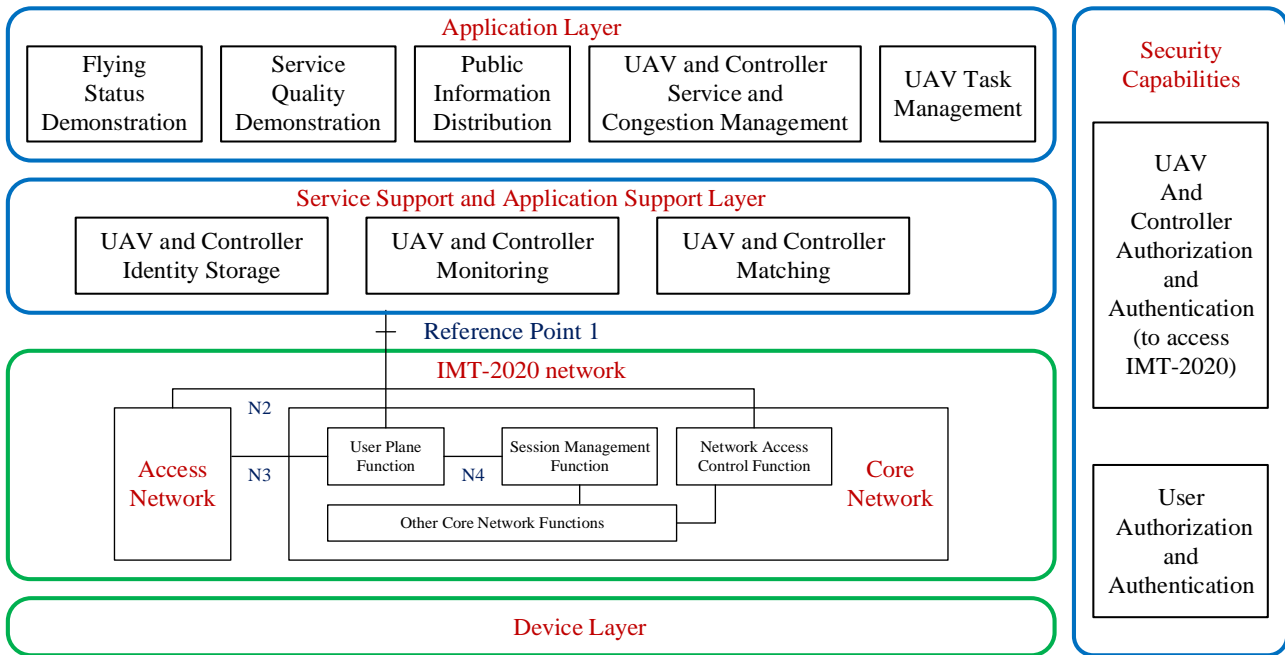


Figure 8-1 - Functional architecture of UAVs and UAV controllers using IMT-2020 networks

Reference Point 1 is between the Support Layer and the User Plane Function in Core Network of IMT-2020. For reference the position is between the “User Plane Function” and the “Data Network” in Figure 8-1 of Clause 8 in the ITU-T Recommendation Y.3102. It is also defined as N6 in 3GPP TS23.501. For example, weather information, disaster information and commercial information can be distributed from network operators to UAVs, UAV controllers and other authorized users via Reference point 1. Based on IMT-2020 rules, authorization and authentication for the UAVs, UAV controllers and users can be performed by the interaction between IMT-2020 networks and UAVs. Specifically, the digital identifier can be embedded in the message reported to networks via Reference point 1. Certification or license can be associated with the UAVs, UAV controllers and users by the above information.

Reference Point 1 is in the scope of IMT-2020 and 3GPP. No more definition or modification to Reference Point 1 is required in this Recommendation.

Despite that the defined functional architecture is of universality for various communication networks (e.g. IMT-2000), the technical reasons for using functions of IMT-2020 by this Recommendation include (but not limited to):

User Plane Function

It is the key to implement the new QoS mechanism developed for IMT-2020 network. Different from other communication networks (e.g. IMT-2000), the IMT-2020 network employs a 2-level QoS mechanism: the core network maps data flows into QoS flows according to their QoS requirements, while the access network further maps the QoS flows into data radio bearers according to the current wireless channel condition and load. The mechanism delegates part of the QoS guaranteeing rights to the access network and therefore achieves more flexible adaptation between the service demand and transmission capability. With this QoS mechanism the access network is able to ensure critical UAV services such as remote control at maximum effort and apply preliminary adjustment of data bearer to reduce latency or avoid interruption.

Session Management Function

In addition to the new QoS mechanism implemented by the User Plan Function, the Session Management Function further guarantees appropriate scheduling of services to different destinations by priority handling of sessions. This is vital for the UAV services especially ensuring the efficiency of remote control while the continuity of other services like video feedback can be maintained. Besides, this function also allows suspension and resume of sessions, which allows UAV service pending on demand for energy-saving and quick recovery if needed.

Network Access Control Function

With Network Access Control Function, the IMT-2020 network leverages relevant security technologies while implementing new security protocols to address previously unresolved threats. Instead of authenticating users through sim cards, which is hard to meet the various services and requirements of UAVs, the IMT-2020 network solves this problem by assigning a unique identity to each device. Moreover, it also provides better encryption (256-bit instead of 128-bit) especially for the procedure of the first-step verification to avoid UAV identity and location information leakage.

Other Core Network Functions

The IMT-2020 core network is designed based on Service Based Architecture. Instead of integrating functions into physical network elements, this architecture allows IMT-2020 core network to invoke functions based on logical interfaces. It realizes dynamic network load sharing, disaster recovery, simpler capacity expansion and openness of network functions that better supports massive volume of UAVs and UAV services.

Another important feature for UAV services is network slices. The IMT-2020 network defines a set of slice-related functions including Network Slice Selection Function, Network Repository Function and Network Data Analytics Function. With Network Slice Selection Function, the UAVs in the IMT-2020 network can form one or more types of tenants based on their own attributes, application industries or business requirements. By assigning (or permitting to use) a dedicated slice set for the UAVs, it is possible to logically distinguish the service policies of the UAVs from other users. By refining the dedicated slice identification of the UAVs, it is possible to distinguish the UAVs in different application industries, as well as control data and multi-type application data services, which can be guaranteed using different slices.

8.1 Flying Status Demonstration

This function enables the capability of demonstrating flying status of the UAVs. The demonstrating flying status can be used for information sharing or applications/services. The demonstrated flying status comprises one or more parameters described in 7.1 of this draft Recommendation.

This function gathers flying status information from the functions of UAV Task Management defined in 8.5 of this draft Recommendation and UAV and Controller Status Monitoring defined in 8.7 of this draft Recommendation. It translates the gathered information into parameters which can be demonstrated and shared to the UAV controllers or other authorized users. The matching relations between the UAVs and the UAV controllers or other authorized users can be determined by the matching relations provided by the function of UAV and Controller Matching defined in 8.8 of this draft Recommendation, or by the authority of using this function provided by the function of User Authorization and Authentication defined in 8.10 of this draft Recommendation.

8.2 Service Quality Demonstration

This function enables the capability of demonstrating service quality of the UAVs from/to the UAV controllers or the control centres. The demonstrating service quality can be used for information

sharing or applications/services. The demonstrated service quality comprises one or more parameters described in 7.1 of this draft Recommendation.

This function gathers service quality information from the function of UAV and Controller Status Monitoring defined in 8.7 of this draft Recommendation. It translates the gathered information into parameters which can be demonstrated and shared to the UAV controllers or other authorized users. The matching relations between the UAVs and the UAV controllers or other authorized users can be determined by the matching relations provided by the function of UAV and Controller Matching defined in 8.8 of this draft Recommendation, or by the authority of using this function provided by the function of User Authorization and Authentication defined in 8.10 of this draft Recommendation.

8.3 Public Information Distribution

This function enables the capability of distributing public information to the UAV controllers or other authorized users. The distributing public information can be used for information sharing or applications/services. The distributed public information comprises one or more parameters described in 7.1 of this draft Recommendation.

This function gathers public information from administrative departments e.g. civil aviation management, public safety or disaster warning, or commercial information from enterprises (e.g. network operators). It translates the gathered information into parameters which can be distributed to the UAV controllers or other authorized users. The matching relations between the UAVs and the UAV controllers or other authorized users can be determined by the matching relations provided by the function of UAV and Controller Matching defined in 8.8 of this draft Recommendation, or by the authority of using this function provided by the function of User Authorization and Authentication defined in 8.10 of this draft Recommendation, or by the location or route information provided by the function of UAV Task Management defined in 8.5 of this draft Recommendation.

8.4 UAV and Controller Service and Congestion Management

This function enables the capability of service scheduling and priority handling at application level. Services can be statically or dynamically scheduled as described in 7.1 of this draft Recommendation.

This function gathers service information from the function of UAV Task Management defined in 8.5. It then sorts the services in an absolute or relative order based on the service type and importance, aiming to guarantee service quality of prioritized tasks and avoid possible congestions of transmission.

8.5 UAV Task Management

This function enables the capability of task or flight management for the UAVs. It supports one or more applications described in 7.1 of this draft Recommendation.

This function gathers task-related or flight-related information or flying command from the UAV controllers, the control centres, or the administrative departments (e.g. civil aviation management). It can provide functions including forwarding control commands, logging flight, planning route or scheduling task accordingly for the corresponding UAV, etc.

This function is also able to obtain network quality information (e.g. service load, signal strength, interference or coverage holes in a certain area) from IMT-2020 networks via open interfaces if supported. It can plan flight route or waypoint accordingly for the UAVs based on network quality information from IMT-2020 networks to guarantee service quality.

This function also provides necessary information including flying status and service type and importance to the functions of Flying Status Demonstration and UAV defined in 8.1 of this draft Recommendation and Controller Service and Congestion Management defined in 8.4 of this draft Recommendation, respectively.

8.6 UAV and Controller Identity Storage

This function enables the capability of storing identities of the UAVs and the UAV controllers which are defined for applications and service support functions, or other identity-related functionalities defined in this functional architecture.

This function gathers device identity information from the UAV and controller or certification or license information from their manufactures or administration departments. It generates identities of the UAVs and the UAV controllers that to be used within this functional architecture from the gathered information via certain algorithms. Each generated identity of a UAV or controller will be stored and served as dedicated identifiers for matching as defined in 8.8 and associating with the identity or subscription information used in IMT-2020 as defined in 8.9.

8.7 UAV and Controller Status Monitoring

This function enables the capability of monitoring the flying status and service quality information triggered by the UAVs or the UAV controllers. It can be triggered by other authorized users (e.g. in the command centre) as well.

This function gathers status information (mostly measured parameters) from the sensors or software installed in the UAVs or the UAV controllers. It translates the gathered information into monitored parameters as requested by other functions (e.g. velocity for Flying Status Demonstration or transmission latency for Service Quality Demonstration) and delivers the results.

This function is also able to provide gathered information or monitored items to the IMT-2020 network via open interfaces if supported. With the information from this function, IMT-2020 can configure cell relations, measurement report and cell reselection rules according to altitude or velocity information of the UAVs.

8.8 UAV and Controller Matching

This function enables the capability of matching relation management for the UAVs and the UAV controllers. The matching relations can be used to ensure the communicating source and destination via IMT-2020 network, or to emerge pairing-related functionalities defined in the application layer.

This function gathers matching information from the UAVs and the UAV controllers or from their manufactures or administration departments. It generates a matching table including the identities of matched UAVs and UAV controllers, which are generated by the function of UAV and Controller Identity Storage defined in 8.6 of this draft Recommendation. The matching table can be further used to determine the destination of delivering status information or distributing public information as described in 8.1, 8.2 and 8.3 of this draft Recommendation.

8.9 UAV and Controller Authorization and Authentication

This function enables the capability of authorizing and authenticating the UAVs or the UAV controllers to access IMT-2020 networks by using the existing IMT-2020 user authorization and authentication rules and procedures.

This function gathers certification or license information of the UAVs and the UAV controllers from their manufactures or administration departments. It derives permission settings based on the gathered information to authorize the UAVs and the UAV controllers to access IMT-2020 network.

It is also responsible for authentication by verifying the permission when the UAVs or the UAV controllers require access.

This function may further provide certification or license information to the IMT-2020 network to assist dedicated network deployment, scheduling or QoS guaranteeing for the UAVs and the UAV controllers.

8.10 User Authorization and Authentication

This function enables the capability of authorizing and authenticating users other than the UAVs or the UAV controllers to use functionalities defined in Section 8 of this draft Recommendation at application level.

This function gathers certification or license information of users other than the UAVs or the UAV controllers from their manufactures or administration departments. It derives permission settings based on the gathered information to authorize the users to access certain functionalities. It is also responsible for authentication by verifying the permission when the users require access to any functionality.

9 Security considerations

IMT-2020 security capabilities including encryption and integrity protection for user data transmission can be used for supporting security requirements of the application layer, service and application support layer, security capabilities defined in this draft Recommendation.

Note: The flight safety related to the regulations and supervision are addressed and guaranteed by ICAO recommendations and therefore out of the scope of this draft Recommendation.

Appendix I

Use cases of UAV registration and security flight controlling / monitoring based on IMT-2020 networks

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

I.1 use case of a UAV and the user registration based on IMT-2020 networks

Based on the authorized spectrum, the IMT-2020 network can provide large bandwidth, low delay and high reliability communication services, and support the efficient and orderly air traffic management of UAV in the future. Each UAV 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 UAV shall be registered to the civil aviation management department before flight. Each UAV shall have at least one IMT-2020 communication module associated with the digital identifier (e.g. IMEI, International Mobile Equipment Identity). The communication module can optionally use the SIM card with an IMSI (International Mobile Subscriber Identification Number).

The following diagram presents a use case of a UAV and the user registration based on IMT-2020 networks.

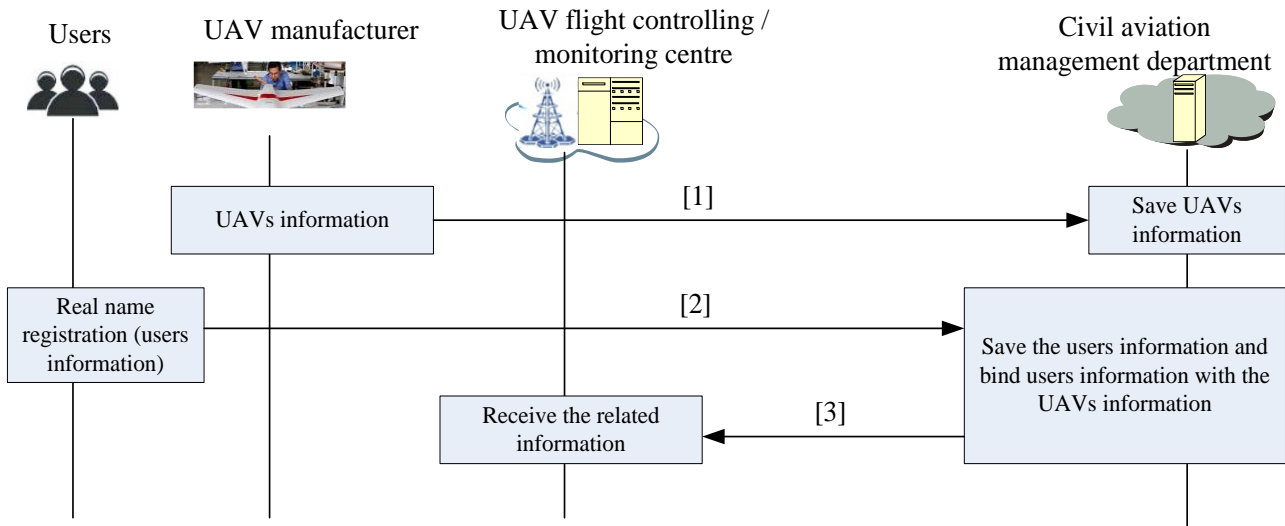


Figure I.1 The UAV and the user be registered based on IMT-2020 networks

1. UAVs information, such as the UAV Number, UAV digital identifier and SIM card / communication module, are sent to the civil aviation management department.
2. Users information, such as users ID, name and mobile number, are sent to the civil aviation management department. The civil aviation management department binds users' information with the UAVs information after verification and checkout.
3. Civil aviation management department send both the user information and UAVs information to the UAV flight controlling / monitoring centre, and the UAV flight controlling / monitoring centre save these information.

I.2 use case of a UAV security flight controlling / monitoring process based on IMT-2020 networks

The above registration process is ready for the follow-up safety flight and monitoring, but the civil aviation management department is a management department, not a flight controlling / monitoring department. Therefore, a flight controlling / monitoring centre / entity (the entity can optional be telecom operators), relying on the high reliability, low delay and wide coverage communication network, is required to control / monitor real-time UAVs safety flight and collect flight data for the civil aviation management department.

The following diagram presents a use case of UAV security flight controlling / monitoring process based on IMT-2020 networks.

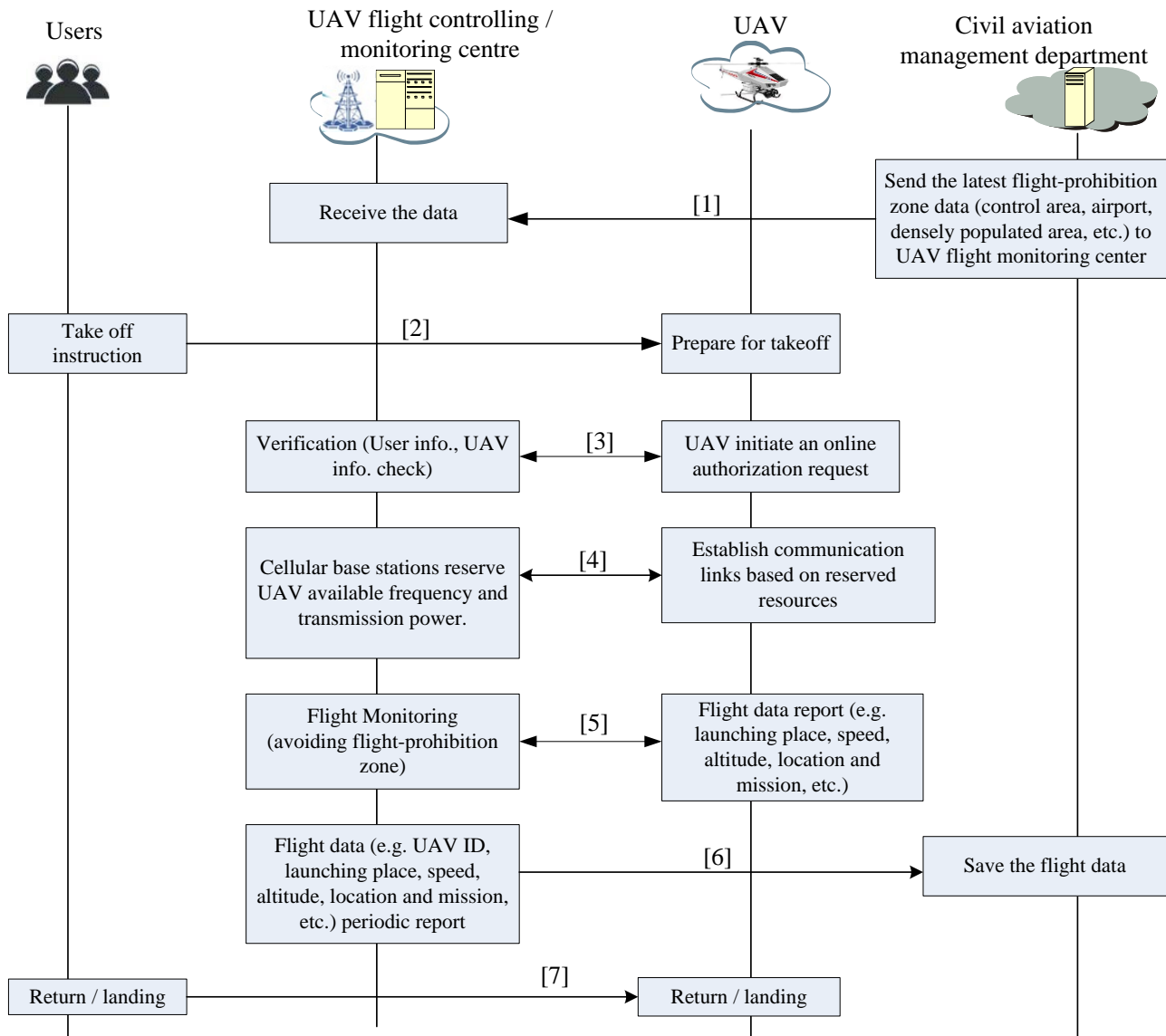


Figure I.2 The UAV security flight monitoring process based on IMT-2020 networks

1. Before flight, the civil aviation management department shall send the latest flight-prohibition zone data (control area, airport, densely populated area, etc.) to UAV flight controlling / monitoring centre. These data will be used to monitor the UAVs' flight.
2. User sends out take-off instruction, and the UAV prepares for take-off.
3. The UAV initiates an online authorization request to the UAV flight controlling / monitoring centre by device check (serial number, digital identifier and the IMEI) with users' telephone number and trusted location. The UAV flight controlling / monitoring centre verifies and tests the UAV information with the user information.
4. If the authorization and authentication passed, then cellular base stations reserve available frequency and transmission power for the UAV, and notice the UAV to establish communication links based on reserved resources. If not, then the UAV be locked until the right UAV information with the user information, or the flight is prohibited, and waiting for the next take off instruction.
5. After launching, the UAV reports real-time flight data (e.g. speed, altitude, location and mission, etc.) to the UAV flight controlling / monitoring centre. The UAV flight controlling /

monitoring centre monitors the UAV flight process to avoid flight-prohibition zone by the high reliability, low delay and wide coverage communication network.

6. The UAV flight controlling / monitoring centre periodically reports flight data (e.g. UAV ID, speed, altitude, location and mission, etc.) to the civil aviation management department.

When mission done, the user instructs the UAV return / landing.

I.3 use case of a UAV route planning based on IMT-2020 networks

A flight controlling / monitoring centre which can be telecom operators can plan flight route accordingly for the UAVs based on network quality information from IMT-2020 networks to guarantee service quality.

The following diagram presents a use case of UAV route planning based on IMT-2020 networks.

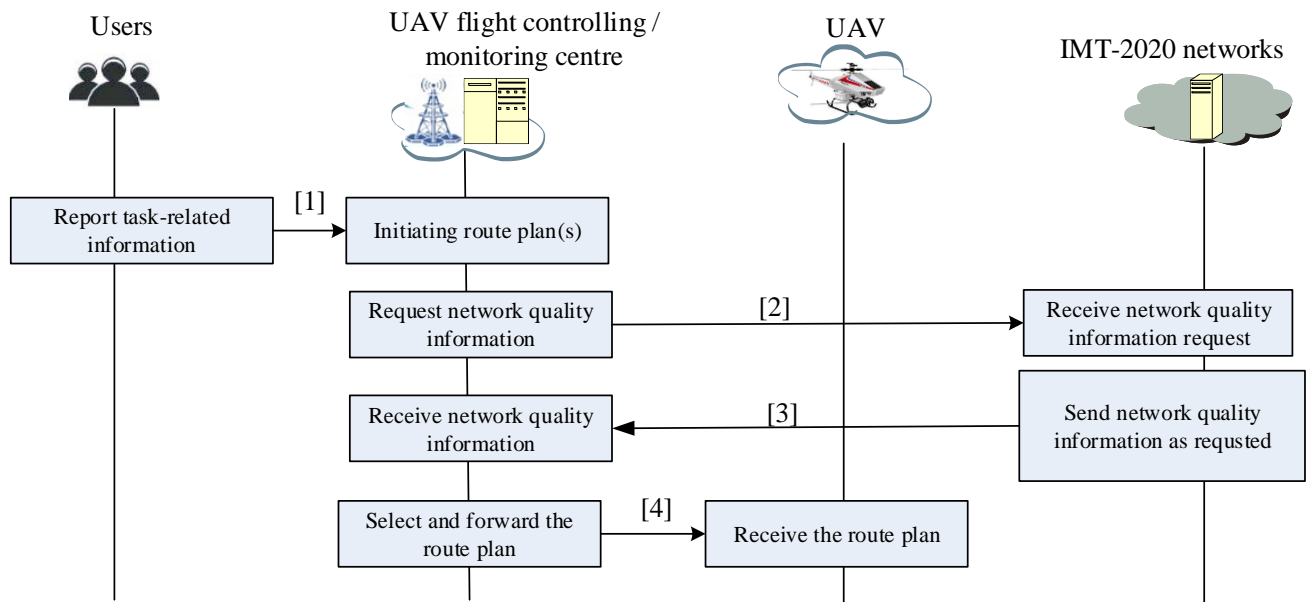


Figure I.3 The UAV route planning based on IMT-2020 networks

1. Before flight, the users (as UAV controller) sends the task-related information to UAV flight controlling / monitoring centre. And the centre initially generates one or multiple route plans.
2. The UAV flight controlling / monitoring centre requests network quality information along the initially planned routes from IMT-2020 networks.
3. IMT-2020 networks will send the network quality information (e.g. signal strength, average latency, transmission rate, service load, etc.) as request. These data will be used to adjust the UAVs' initial route plans or ranking the routes.
4. The UAV flight controlling / monitoring centre may adjust the initial route plans based on the network quality information. The optimal route plan selected from initial route plans or adjusted route plans is forwarded to the UAV. The UAV executes the task based on the received route plan.