Global UTM Association

UAS Traffic Management Architecture

April 2017

Version History

Version	Description	Date
1.0	High-Level Architecture Document	April 29 2017

References

Description	Source	Location
Unmanned Aircraft System Traffic Management (UTM) Concept of Operations	NASA Ames Research Center	https://utm.arc.nasa.gov/docs/Kopardekar_2016-3292_ATIO.pdf
Roadmap for Application and Technology Development of UAVs in Japan	METI	http://www.meti.go.jp/english/policy/mono_info_service/robot_industry/downloadfiles/uasroadmap.pdf
Demonstrating RPAS Integration in the European Aviation System	SESAR-JU	http://www.sesarju.eu/sites/default/files/documents/reports/RPAS-demo-final.pdf
ICAO – Circulaire 328 – Unmanned Aircraft Systems	ICAO	http://www.icao.int/Meetings/UAS/Documents/Circular 328_en.pdf
Notice of Proposed Amendment 2014-09	EASA	https://www.easa.europa.eu/system/files/dfu/NPA 2014-09.pdf

List of abbreviations and glossary

ATM	Air traffic management
BVLOS	Beyond visual line of sight
EVLOS	Extended visual line of sight
IFR	Instrument flight rules
RPAS	Remotely piloted aircraft system
SoS	System of systems
UAV	Unmanned aerial vehicle
UAS	Unmanned aerial system
U-Space	Urban space
UTM	UAS traffic management
VFR	Visual flight rules
VLOS	Visual line of sight

List of definitions

Aircraft	Any machine that can derive support in the atmosphere from reactions of the air other than the reactions of the air against the earth's surface
Autonomous operation	An operation during which a remotely piloted aircraft is operating without pilot intervention in the management of the flight
Beyond VLOS	An operation where neither the drone pilot nor the observer maintains direct unaided visual contact with the RPA
Detect and avoid	The capability to see, sense or detect conflicting traffic or other hazards, and take the appropriate action to comply with the applicable rules of flight
Extended VLOS	An operation in which the drone pilot is supported by one or more observers, and in which the remote crew maintains direct unaided visual contact with the RPA
(UAS) operator	A person, organization or enterprise engaged in, or offering to engage in, an aircraft operation
Drone pilot	The person who manipulates the flight controls of a remotely piloted aircraft during flight time
Remotely piloted aircraft system	A set of configurable elements consisting of a remotely piloted aircraft, its associated remote pilot station(s), the required command and control links, and any other system elements as may be required at any point during flight operation
RPA observer	A person who, by visual observation of the remotely piloted aircraft, assists the drone pilot in the safe conduct of the flight
Segregated airspace	Airspace of specified dimensions allocated for exclusive use to a specific user(s)
Unmanned aircraft	An aircraft that is intended to operate with no pilot on board
Unmanned aircraft system	An aircraft that is operated with no pilot on board and its associated elements. A synonym for UAS is drone, or UAV.
Very low level	A vertical reference designated below the minimum heights prescribed for normal IFR or VFR operations; for instance, below 500ft above ground level
Visual line-of-sight operation	An operation in which the drone pilot or RPA observer maintains direct unaided visual contact with the remotely piloted aircraft

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1 Introduction

Unmanned aircraft are a growing market that promises economic value and jobs in the near future.

Today, unmanned aircraft are commercially used for inspections and monitoring, surveying and mapping, filming and photography, precision agriculture, search and rescue, disaster relief, and public safety. Unmanned aircraft are a useful addition to range of services provided.

Smaller aircraft especially require significantly less infrastructure. They are much easier to deploy, and some can fly where conventional aircraft cannot: indoors or underground. Rescue or relief operations, or reconnaissance or supply operations, might require flying in severe weather or in geographically challenging locations. These can be conducted with expendable unmanned aircraft without putting personnel in danger.

In a nutshell, unmanned aircraft can be operated more economically in many cases; they provide additional, otherwise unfeasible, options; and they can go where no other aircraft could go previously.

In 2013, Amazon revealed plans to develop its own delivery drone. In December 2016 the first Amazon Prime Air delivery was conducted in Great Britain. Logistics service providers around the world are working on concepts for deliveries by unmanned aircraft. The passenger drone manufacturers EHANG and Airbus are working on flying taxis. Such developments adumbrate what kind of applications can be expected in the future.

Different kinds of operations entail different levels of requirements of infrastructure or equipment. There are operations where the drone is at all times in sight of the pilot; those where it is out of sight of the pilot but in sight of somebody else; and those where it is out of sight. There are also operations where the drone provides its own sight, and – the holy grail of the industry – autonomous operations where the drone provides its own control. And all of these kinds of operations will possibly take place in the same airspace.

Increasing demand for services, fascination with the technology, and great business potential drive the unmanned aircraft systems industry to develop more technologies more rapidly – at a much faster pace than the conventional aviation industry.

The development of the drone industry is outpacing all predictions. In the United States, the National Airspace System currently handles about 7,000 flights at any given moment. In July 2016, the Teal Group provided the Federal Aviation Administration with a forecast that assumes that the commercial unmanned aircraft market will take time to develop, and forecasts the fleet to grow to approximately 542,500 over a 5-year period. According to the Federal Aviation Administration's registration database in December 2016, there were already 616,000 registered users of unmanned aircraft systems, most of whom were hobbyists, as at the time there were no rules enabling commercial use without exemptions. It is therefore very likely that the number of unmanned aircraft will continue to increase in the coming years.

2 Problem Statement

Most regular unmanned aircraft operations are presumably going to take place at very low level – a part of the airspace currently used by general aviation (military, police, and search and rescue aircraft), but also by cars, ships, people, animals, and infrastructure. In order to share their space, unmanned aircraft must comply with the safety standards that have already been established. Additional standards may have to be developed.

Various national regulations have been put in place in reaction to market developments, but no international harmonization has been achieved yet.

The absence of a pilot on board the aircraft raises the question of how to detect and avoid other traffic, or objects, and how to handle dangerous situations. Airborne collision avoidance systems can protect unmanned aircraft from damage, but they are not designed to deal with denser traffic. This is comparable to the situation with road traffic: As long as there are just a few vehicles on the road, the driver is able to control the situation and avoid other vehicles or obstacles; but the denser traffic becomes, the more traffic control in the form of, for example, traffic lights is needed.

At present there is no system to manage unmanned air traffic.

Conventional air traffic management cannot be applied to unmanned aircraft. It relies on voice communication between air traffic controllers and pilots, and on radar detection. Larger drones may be equipped with voice recognition/speech synthesis radio, and have a significantly larger radar cross-section. However, many drones are too small, and operate too close to the ground, for radar to be of any use. Current airspace management and air traffic flow management systems are not predicted to have the capabilities to handle the type of operations relevant to drones. In addition, the anticipated traffic density of drones is far beyond the capabilities of current air traffic management systems, which were never designed to handle large amounts of dense heterogeneous traffic with widely varying performance characteristics.

Assuming increasing demand for drone operations at very low altitudes, where space is limited and shared with many other users, a reasonable choice would be to take an organized and systematic approach, and design UAS traffic management (UTM) systems to enable the safe, orderly, and expeditious flow of traffic.

The following are the guiding principles:

- UAS traffic management shall be designed to accommodate diversity of traffic, and to anticipate increasing traffic density.

- Where drones share space with others, UTM shall live up to existing safety standards, or improve on them.
- All communications shall be secure.
- The privacy of others shall be respected.
- Innovation is to be encouraged.

3 Current Activities in UTM

Building on its legacy of work in Air Traffic Management (ATM) for manned aircraft, NASA began researching prototype technologies for a UTM system that could develop airspace integration requirements for enabling safe, efficient low-altitude operations.

The European Commission introduced an initiative called “U-Space”. The U-Space is described as an efficient framework for all individuals and businesses to operate UAS at lower levels. The U-Space will make denser traffic of automated UAS operations over longer distances possible, including over cities, and so open the door to a UAS service market.

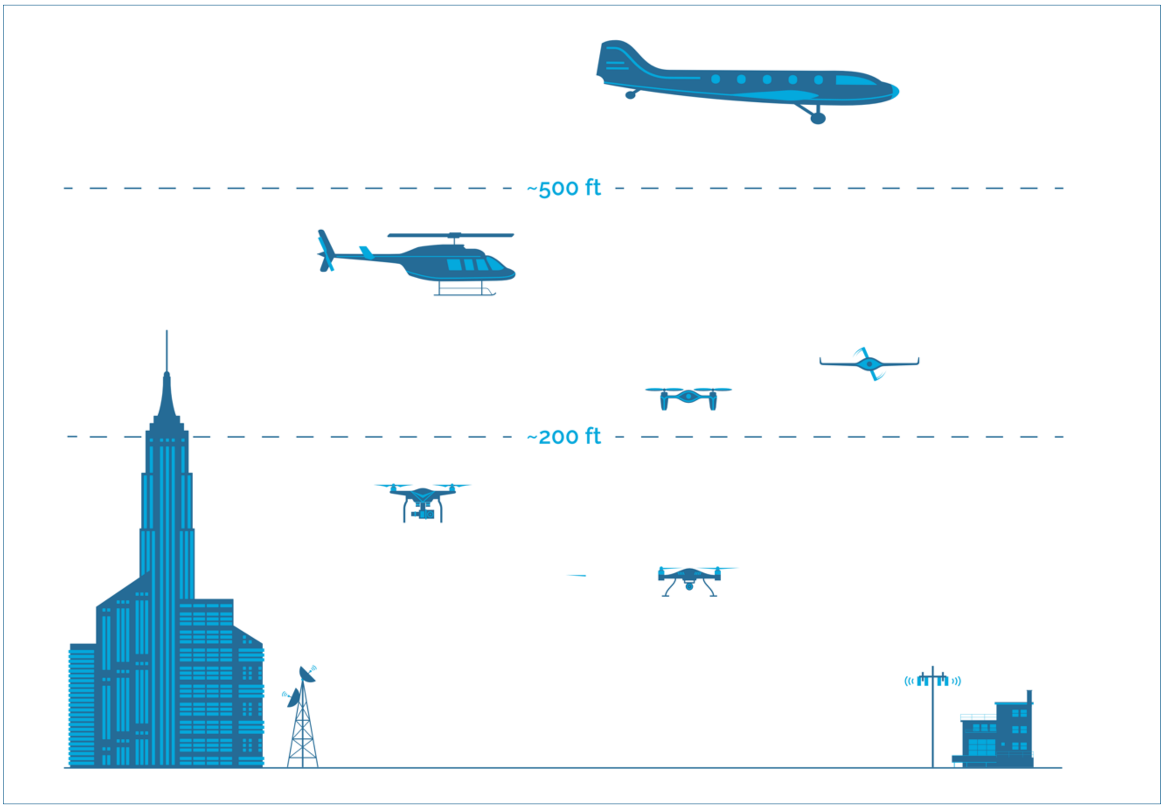

Illustration 1. Operations by altitudes

4 Scope of the Document

This document describes the overall high-level UTM architecture. It considers all types of UAS operations (VLOS, EVLOS and BVLOS), and covers the needs of both RPAS (piloted) and autonomous unmanned aircraft.

The scope of the UTM described in this document will focus on a UTM solution for UAS operations in very-low-level airspace.

The document will address the requirements for all phases of the flight.

5 Purpose of the Document

Representatives of industry and conventional aviation from all over the world have joined forces to develop a UTM architecture. This architecture represents a technological proposal for safe integration of unmanned aircraft into traffic. The aim is to use available expertise and make it available to regulatory bodies.

This document is identified as a common architecture with interfaces with external systems. This will serve as a baseline to define the standard interfaces.

As analyses, studies, and tests are conducted, this document will be updated with newer versions of the architecture.

This document answers the following questions:

- What is a UTM?
- Who are the stakeholders?
- What are the stakeholders' interests and interactions with the system?
- How can users interact with the system?
- What are the functions of a UTM?

6 UAS Traffic Management

Before going into more detail about what UAS Traffic Management is, the difference between the UTM Concept and the UTM System should be clarified.

The **UTM Concept** is a complex system in which several stakeholders contribute to ensure the required safety level of UAS operations. For this reason, UTM is defined as a system of stakeholders and technical systems collaborating in certain interactions, and according to certain regulations, to maintain safe separation of unmanned aircraft, between themselves and from ATM users, at very low level, and to provide an efficient and orderly flow of traffic.

On the other hand, a **UTM System** is a concrete technical implementation comprising software, the necessary infrastructure for running the software, and the drones themselves, all contributing to the achievement of UTM. The system provides distinct services through public or restricted standard interfaces. Individual services are provided at distinct levels of quality depending on the situation or regulation (from best effort to high-integrity, low-latency). Different systems providing similar/equivalent/interdependent/interfering services within the same area of effect are required to collaborate.

The UTM concept covers all type of UAS operations in very-low-level airspace, in all categories, ranging from simple remotely piloted aircraft systems to complex autonomous operations and beyond.

7 System of Systems

In the literature, the term System of Systems (SoS) is used whenever the overall system, composed of many sub-systems, provides capabilities not achieved by the individual systems.

It is pertinent to talk about SoS for systems with the following characteristics:

- Operational and managerial independence of different portions identified in the system, and several stakeholders organizations;
- Geographical distribution of stakeholder organizations and their physical assets;
- Impossibility of achieving targets/goals if single portions work in isolation – emerging behaviors and capability are obtained if portions work together;
- Evolutionary development; overall system capabilities will be developed incrementally.

The UTM concept can be represented as a system of individual UTM systems, standardized by operational procedures, in which UASs are operating more autonomously, and in which information is shared and exchanged, with a high degree of decision-autonomy, allowing more efficient adaptations, to achieve a common objective: the safe, orderly and efficient use of the available, limited and shared airspace.

8 Stakeholders

A UTM stakeholder is defined as an individual, team, or organization with an interest in unmanned aircraft traffic management, being affected by unmanned aircraft traffic management, or perceiving itself or themselves to be affected by unmanned aircraft traffic management.

These stakeholders and relevant organizations can be interested in customized solutions to their businesses (*e.g.* different models of UAS for pilots, or different systems for UAS operations management), even when maintaining the possibility of interoperation. An example is given by UAS Pilot and their active role in detecting and avoiding obstacles and other traffic. Several solutions and UAS models are already available off the shelf.

UAS Traffic Management is achieved by close cooperation of the involved stakeholders, each of them playing a significant role as described in the reference Concept of Operation. Operating methods and technical systems to guide them during the different phases of flight are as follows:

- Strategic phase, well before the time of operation, which addresses the airspace design, definition of strategic no-fly zones, regulations, *etc*.;
- Pre-flight phase, before the time of operation but focused on the specific flight, mainly to address the operations planning;
- In-flight phase, which is the time of operation when the flight is performing its operations;
- Post-flight phase, which addresses the analysis of recordings aspects and other relevant post-flight business and obligations.

All details and techniques are described in specific operation concept documents, and elaborated on by the relevant authorities.

The interoperability of systems will ensure proper management of UAS traffic. The focus of the UTM R&D and standardization activities is on all the segments of the UTM SoS, considering the peculiarity of this context and the dependencies of the enablers.

The stakeholders are classified according to their rationale, interest in UTM, and foreseeable interactions with the UTM system.

8.1 National Aviation Authority (NAA)

Rationale

According to the Chicago Convention (ICAO Doc 7300/9), “[...] every State has complete and exclusive sovereignty over the airspace above its territory.” In consequence, this makes a national aviation authority the primary stakeholder with regard to any aircraft traffic management operation.

Primary interests in UTM

A national aviation authority would regulate all aspects of drone traffic (which may include registration of drones), and their integration into the airspace. Implementations may differ from state to state.

Foreseeable interactions with UTMS

Certification of development and operation of the system (components);

Maintenance of restrictions, granting of permissions, and analysis of data.

8.2 Supranational Institutions

Rationale

Associating airspace sovereignty with national aviation authorities leads immediately to the question of how to handle unmanned aircraft traffic management where two or more authorities are concerned. Unlike conventional long-haul aircraft operations that can span several national airspaces, drones operate in much more confined regions. However, cross-border drone operations are entirely likely to occur. For a few states this is not an issue: Australia, for example, has no immediate neighbours. Most states, however, have multiple immediate neighbors.

To regulate cross-border operations, adjacent national aviation authorities would have to enter into bilateral or multilateral agreements, or sign international conventions. If any such agreements or conventions are institutionalized, then such an institution becomes a stakeholder. (A prominent example is the ICAO.)

Primary interests in UTM

Harmonization

Foreseeable interactions with UTMS

None

8.3 Drone Pilots

Rationale

Drone pilots can be categorized in different ways. The most obvious is by those using it for leisure purposes or those using it for commercial purposes. Another way to categorize drone pilots is by the type of operation, or by the license needed to operate a drone. Some drone pilots, depending on the applicable drone regulations, need to register themselves, and get a type of license and/or undertake training, notify their activity, or even provide some type of identification.

Primary interests in UTM

The drone pilot is the person who is the user of the drone. As such the drone pilot is responsible for the safe execution of the drone flight.

Foreseeable interactions with UTMS

May use strategic UTM services;

May use pre-flight UTM services;

May use in-flight UTM services;

May use post-flight UTM services.

8.4 Operator

Rationale

The “operator” is to the “drone pilot” what the “airline” is to a “pilot”.

Primary interests in UTM

The operator is accountable for all the commercial drone operations. The operator is not a person, but a commercial entity.

Foreseeable interactions with UTMS

Uses fleet-oriented strategic UTM services;

Uses fleet-oriented pre-flight UTM services;

Uses fleet-oriented in-flight UTM services;

Uses fleet-oriented post-flight UTM services.

8.5 Drone Owner

Rationale

The person or entity who owns the drone.

Primary interests in UTM

If required by the applicable legislation, the drone owner registers the drone in the drone registry.

Foreseeable interactions with UTMS

Uses strategic UTM services, more specifically a registration service.

8.6 Conventional Aviation Pilot (flights according to IFR in controlled airspace)

Rationale

Current airspace user

Primary interests in UTM

Relies on Air Traffic Control for separation from unmanned aircraft traffic.

Foreseeable interactions with UTMS

None

8.7 Conventional Aviation Pilot (flights in uncontrolled airspace)

Rationale

Current airspace user

Primary interests in UTM

Relies on drones being detectable;

Relies on drones implementing collision avoidance.

Foreseeable interactions with UTMS

Provide position and flight plan information;

Receive drone traffic information.

8.8 Conventional Ground, Rail or Sea Traffic (not aware of any airborne traffic)

Rationale

Current airspace user

Primary interests in UTM

Relies on drones being detectable;

Relies on drones implementing collision avoidance.

Foreseeable interactions with UTMS

None

8.9 Conventional Ground, Rail or Sea Traffic (aware of airborne traffic)

Rationale

Current airspace user

Primary interests in UTM

Relies on drones being detectable;

Relies on drones implementing collision avoidance.

Foreseeable interactions with UTMS

Provides information on position, route and intentions;

Receives drone traffic information.

8.10 Law Enforcement

Rationale

No regulation without enforcement

Primary interests in UTM

Traffic control and prosecution of traffic violations

Foreseeable interactions with UTMS

Receives drone traffic information;

Imposes fines automatically;

Provides intercept advisories.

8.11 Emergency Services

Rationale

Current airspace user

Primary interests in UTM

Relies on drones being detectable;

Relies on drones implementing collision avoidance.

Foreseeable interactions with UTMS

Creates drone-free corridors/zones (a.k.a. virtual bow wave) for emergency procedures.

8.12 Drone Manufacturer

Rationale

The builder of drones that are able to operate in a UTM environment

Primary interests in UTM

Specification of interfaces

Foreseeable interactions with UTMS

Data analysis, and provision of the drone characteristics to the UTM. (Which contingency features do the drones have, *etc*.?)

8.13 UTM Service Provider

Rationale

Encompasses any provider of any collection of UTM services. Includes data providers. May be purely informational or may be traffic control (*e.g.*, priorities, authorizations or clearances).

Primary interests in UTM

Provides UTM service(s).

Foreseeable interactions with UTMS

UTMS–UTMS information exchange

UTMS–ATMS information exchange

9 UTM System of Systems Breakdown

Having highlighted the active stakeholders of the system, it is evident that the UTM domain will have to deal with different and heterogeneous organizations, geographically distributed. Each of them in isolation is not in the position to provide traffic management with required level of safety. In synthesis:

- UTM groups a variety of stakeholders; some of these may contain other sub-varieties: *e.g*. considering their size, which may result in different requirements on the system (*E.g.*, small UAS operators *vs* major ones).
- UTM stakeholders and relevant organizations are distributed.
- UTM shall be designed to accommodate diversity and scalability of solutions (*e.g*. for future densities/business).
- The whole UTM system can be broken down into two major interacting systems types:
    - The systems that contains all technical infrastructures supporting the functioning of the UTM;
    - The systems that include all human interface components of the whole system (*e.g*. UTM operators, UAS pilots/operators and public authorities).

The following is a proposed possible list of technical infrastructure systems:

- Communication infrastructure;
- Navigation infrastructure;
- Surveillance sensors/infrastructure;
- Spatial data infrastructure;
- Meteo sensors/infrastructure.

A proposed possible list of systems that includes all human interface components is as follows:

- UAS (through human interaction by the UAS pilot/operator, be it manual, automated or autonomous).
- UAS Registration System (Note that in other deployment options, the registration system may be an integral part of the UAS Traffic Management System.)
- UAS Traffic Management System (Note that in other deployment options you can have more systems providing services. For example, in the United States, in the NASA architecture the UAS service supplier will be responsible for some services.)

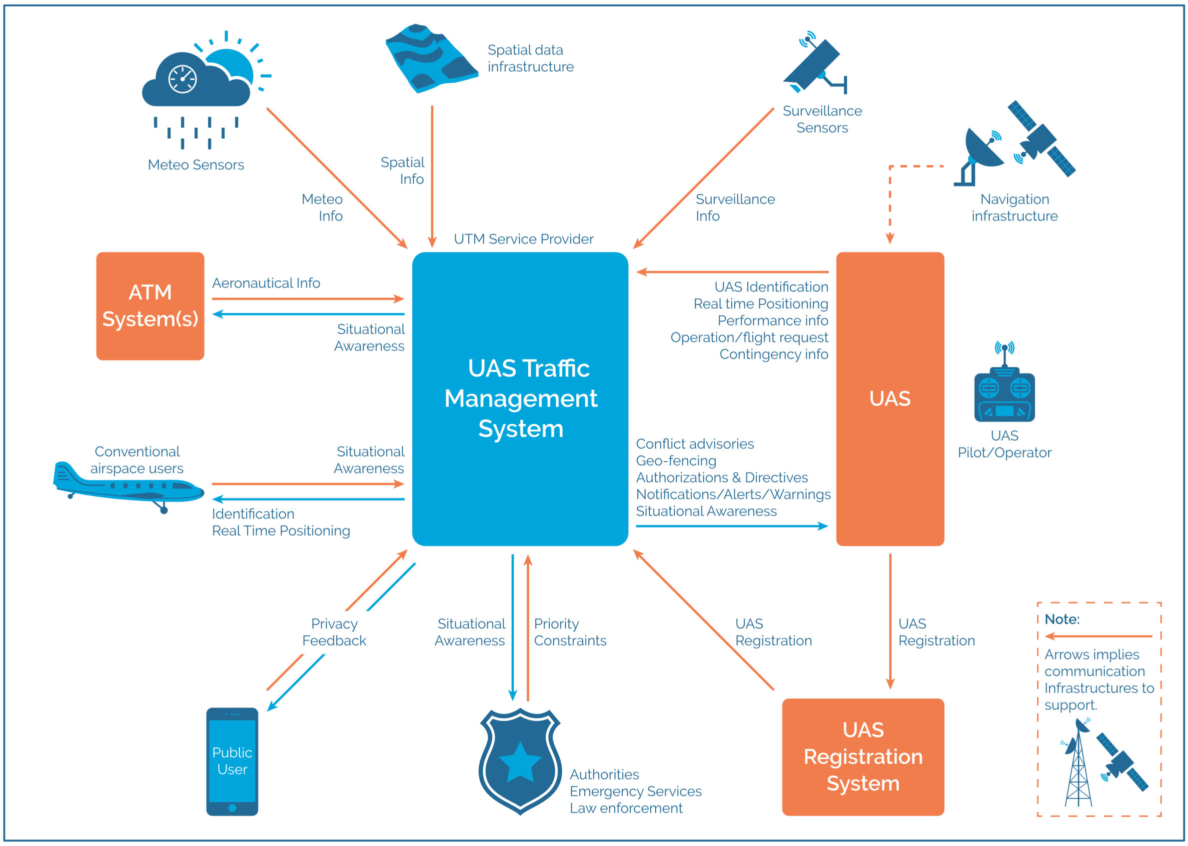

Illustration 2. A view of an UTM system

Each UTM system can be modelled as a set of functional blocks in mutual interaction in order to accomplish the system mission. This proposal is a logical breakdown not aimed at constraining possible deployments, which may vary in the physical architecture according to the specific deployment case. The breakdown is rather aimed at highlighting important information exchanges, inputs for service, and data protocol definitions.

Another possible breakdown is the one proposed by NASA, which shows how a UTM system will be deployed in the United States.

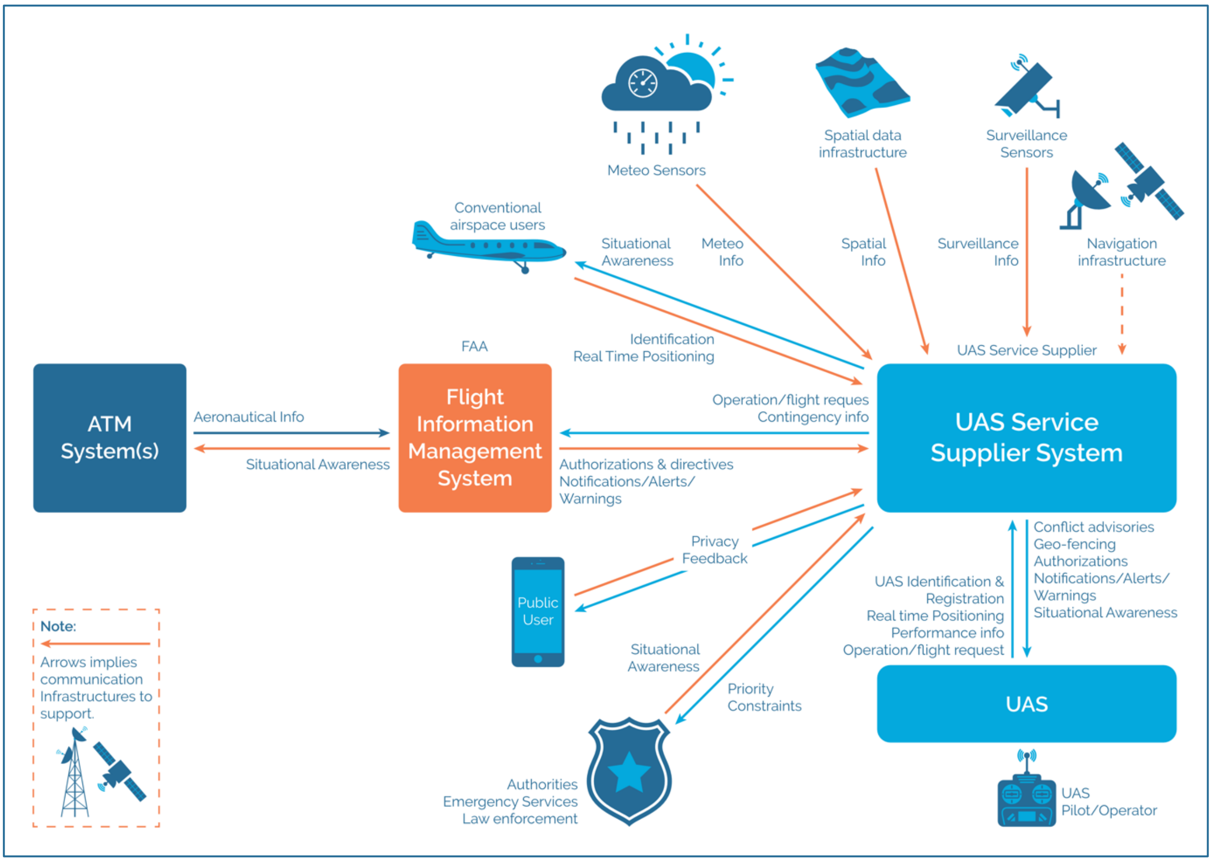

Illustration 3. NASA UTM system

9.1 Technical infrastructure systems

9.1.1 Communication infrastructure

This provides a UTM supporting service for ensuring the exchange of data among systems, and within each system itself.

9.1.2 Navigation infrastructure

Navigation infrastructure provides the required performance in UAS navigation and piloting. Examples are satellites, ground/satellite based augmentation systems, cellular mobile networks, *etc*.

9.1.3 Surveillance infrastructure

Surveillance infrastructure provides, for cooperative and non-cooperative traffic with different technology solutions, surveillance reports and tracking information about UAS to build a complete situational awareness of UAS positioning. Besides radars, WAM, MLAT, ADS-B, other surveillance sources can also be mentioned: *e.g.* mobile telecom networks, IoT, NFC, LoRa.

9.1.4 Spatial data infrastructure

Spatial data infrastructure provides geographic data with the required level of detail to be used as support to the UTM.

9.1.5 Meteo infrastructure

Meteo infrastructure provideseather data with the required level of detail to be used as support to the UTM.

9.2 Systems (including human interface components)

9.2.1 UAS

The UAS is composed of ground and air portions related by a command and control link, operated by the UAS pilot or autonomously, where the drone operator is accountable for the safe execution of these drone flights. The ground portion of the system also supports the UAS pilot or UAS operator in the operations activities. It encompasses the following functions and capabilities:

- Navigation and piloting capabilities, which are essential to the conduct of safe operations;
- Geo-fencing (or geo-limitation) capability support, to respect constraints imposed (stay-in and stay-out volumes);
- Identification capability, to ensure a cooperative surveillance;
- Detect and avoid capabilities for obstacles;
- Termination and return-home capabilities for reducing the risk in case of contingencies;
- Operation planning, to support the UAS pilot or UAS operator in defining the operation;
- Monitoring and control support, to follow in-flight UAS operations.

9.2.2 UAS registration system

The UAS registration system manages UAS registrations. It encompasses the UAS registration capabilities, to enable sharing of UAS, operators' and pilots' registration information.

9.2.3 UAS traffic management system

Airspace management, UAS traffic flow management, and control systems represent the core part of the UTM, collecting intentions, managing the balance of demand and capacity, and providing required authorization, directives and advice (implementing ground based traffic management services). It encompasses the following as a minimum:

- **Identification**: UAS and operator/UAS pilot identification capabilities, to be able to identify UAS pilots/operators and UAS flown in a UTM-monitored airspace;
- **Flight plan (operation) management**: Operation/flight plan data management and authorization capabilities, to collect (providing common human machine interface for UAS pilot or operator or by interfacing/interoperating with the UAS Service Supplier System), analyse and validate UAS operations.
- **Flight permissions and directives**: Flight permissions and directives, issued or denied manually or automatically based on data such as airspace restrictions, weather conditions, obstacles, other aircraft, and registration data;
- **Airspace management**: Airspace management capability, to act as the single point for adding or removing any permanent or temporary airspace restrictions (referred to as geo-fencing at the UAS level);
- UAS surveillance and tracking capabilities: to provide situational awareness;
- **Conformance monitoring**: Conformance monitoring capability, to check the compliance of flight progress in respect of the declared plans;
- **Meteo information**: to inform on local weather information regarding the operation;
- **Obstacle information**: to inform on obstacle information related to the operation;
- **Conflict detection and advisory capability**: to anticipate the risk of collision between UAS and manned aircraft, and entering of restricted airspace;
- **Contingency management:** To inform in the event of emergency situations;
- **Recording and playback capabilities**: to provide evidence during post-flight phases (*e.g*. incident investigation, statistics).

10 System Interactions

10.1 Categories of Interfaces

Knowledge of the external environment of the system is a key point for the system analysis. The target should be as exhaustive as possible regarding the ***identification*** of the external interface. The interface notion is taken as a general concept; it means:

- stakeholders: every person or organisation that has an interaction with the system;
- systems: a system that has a relationship with the UTM system, whatever this relationship may be.

Based on the external environment and functional breakdown, the dynamic analysis describes the functional relationships between the systems and their environment.

10.2 Methodology

The purpose is not to provide a detailed description of the system interactions, which would require defining a CONOPS beforehand. However, it is possible to provide some high-level description of those interactions and explain the methodology to be applied in order to achieve detailed descriptions of the interactions. The methodology is mainly based on the generic use cases. A generic use case is a thematic sequence of functionalities. The list of generic use cases has to cover all end-user functionalities. The methodology will consist of making a dynamic analysis with the following phases:

- Identification of the functional use cases
- For each use case:
    - **Static view**: The static view represents the systems and external components that are involved in the use case, with the relationships between them.
    - **Dynamic view**: The dynamic view represents the functional relations of the static view, in a sequential way, with the functions that implies.
    - **Flows**: According to the dynamic view, it is possible to identify the flows of data for each functional relationship between systems and components.

10.3 List of Functional Use Cases

The list of functional uses cases with the stakeholders and systems involved are listed in the following table:

Functional use case	Description	Systems / stakeholder involved
UAS registration	UAS, pilots and operators should be registered in order to be able to be identified in the UTM system.	- UAS pilot/operator - UAS registration system - UAS - UTM service provider - UTM system - National aviation authorities
UAS identification	UAS, pilots and operators should be identified in order to be able to provide dedicated UTM services.	- UAS pilot/operator - UAS - UTM system - UTM service provider
Operation/flight request	Drone flight plans should be created, changed and deleted to provide the intent to the UTM system.	- UAS pilot/operator - UAS - UTM system - UTM service provider

Authorizations and directives	Flight permission should be created, changed or rejected either manually or automatically to provide airspace access information to UAS.	- UAS pilot/operator - UAS - UTM system - UTM service provider
Geo-fencing info	Permanent or temporary airspace restrictions should be shared to provide correct geo-fence information to UAS.	- UAS pilot/operator - UAS - UTM system - UTM service provider
Notifications/alerts/ warnings	Notifications, alerts and warnings such as NOTAM, weather alerts, *etc*. should be shared to improve the awareness of the UAS pilot.	- UAS pilot/operator - UAS - UTM system - UTM service provider
Situational awareness	Information on UAS positioning and contingency information should be shared to improve situational awareness, warn all other airspace users, and enable certain authorities to act if required.	- UAS pilot/operator - UAS - UTM system - UTM service provider - Authorities - Law enforcement - Emergency services - Conventional airspace users - ATM System(s)
Contingency information	Information on unplanned flight executions, deviations, and emergencies should be shared to warn all other airspace users.	- UAS pilot/operator - UAS - UTM system - UTM service provider
Real-time positioning	Real-time positioning information should be shared in order to have an actual overview to improve situational awareness and/or to provide conflict advisories.	- UAS pilot/operator - UAS - UTM system - UTM service provider - Conventional airspace users
Performance information	Performance information of UAS should be shared in order to have accurate information on the UAS, which is needed for optimizing route management.	- UAS pilot/operator - UAS - UTM system - UTM service provider
Conflict advisories	When conflicts (could be other UAS, obstacles, manned aircraft, emergencies, incidents, *etc.*) are detected by the UTM system, the UTM should share the advisories to resolve the conflict.	- UAS pilot/operator - UAS - UTM system - UTM service provider

Priority constraints	A priority constraint should be created if, for example, an incident occurs, and it is needed to create a temporary restricted area.	- Law enforcement - Emergency services - Authorities - UTM system - UTM service provider
Identification	Aircraft should be identified in order to receive correct information, which can be communicated to UAS pilots/operators to improve situational awareness.	- UTM system - UTM service provider - Conventional airspace users
Aeronautical information	Aeronautical information should be shared to be used in the UTM system to provide UTM services for the UAS pilots/operators.	- UTM system - UTM service provider - ATM system(s)
Meteo information	Meteo information should be shared to be used in the UTM system to provide UTM services for the UAS pilots/operators.	- UTM system - UTM service provider - Meteo sensors
Spatial information	Spatial information should be shared to be used in the UTM system to provide UTM services for the UAS pilots/operators.	- UTM system - UTM service provider - Spatial data infrastructure
Surveillance information	Surveillance information of cooperative and non-cooperative traffic should be provided, in order to build a complete situational awareness of UAS positioning.	- UTM system - UTM service provider - Surveillance sensors
Privacy feedback	Information to protect privacy of people shall be shared by, and with, the UTM system.	- UTM system - UTM service provider - Public user

The system interaction is described using a dynamic view. As an example, the dynamic view of the registration of UAS is illustrated below:

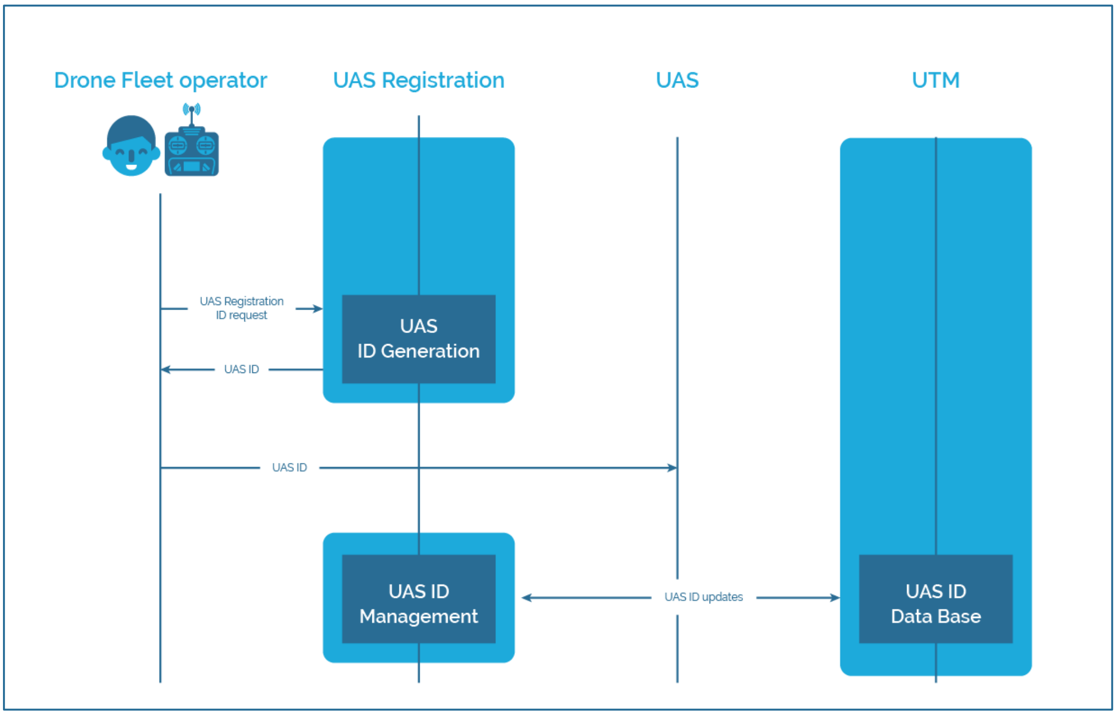

Illustration 4. UTM system interaction