The elements that make up a UTM system

There are many different views as to the exact composition of a UAS traffic management (UTM) system – and even more diverse views as to who should be responsible for what. But there is at least a general understanding of the high-level functions of such a network.

The Global UTM Association (GUTMA) defines UTM "*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*."

It has produced a key reference document for all UTM architectures [1], defining UTM services in a more detailed way.

Another important publications to bring most of these issues together is *Unmanned Aerial System (UAS) Traffic Management (UTM): Enabling Low-Altitude Airspace and UAS Operations* written by Parmial Kopardekar, Ames Research Center[2]. According to this paper:

"The inputs to UTM will include: UAV mission/business flight plan or trajectory, real-time weather and wind, predicted wind and weather, airspace constraints (dynamically adjusted), community needs about sensitive areas (dynamically adjusted), three-dimensional maps that include man-made structures as well as natural terrain. The UTM will need persistent communication, navigation, and surveillance (CNS) coverage to ensure and monitoring conformance to the constraints. This could be provided by a combination of low-altitude radar, cell, satellite, and other means. The important aspect of this coverage is continuous robust, reliable, and redundant coverage to ensure monitoring and support needed for safe operations. The UTM will provide authentication, airspace design, airspace corridors, and dynamic geo-fencing, weather integration, constraint management (congestion prediction), sequencing and spacing as needed, trajectory changes to ensure safety, contingency management, separation management, transition locations and locations with NAS, and geo-fencing design and dynamic adjustments. The contingency management services will include but are not limited to emergency landing site guidance for UAS and geo-fencing segments of airspace due to wind to ensure safe operations, which may be unable to continue the mission."

A major difference between an air traffic management system for manned aircraft and a UTM system for UAS is the degree of automation and autonomy which the safe separation of drones will require. In all the enabling technologies (see below) there is an implicit understanding that the interactions, local and strategic, will be essentially machine-to-machine, with human involvement kept to a minimum.

A simplified view of core UTM functions and enabling technologies

Enabling technology	**Functions**
UAS identification and registration	Airspace managers need to identify each UAS operating in the airspace for which they are responsible and the pilot/organisation responsible for the flight. They need to communicate directly with the flight manager/pilot in case airspace is suddenly closed to UAS operations. They will also

[1] https://www.gutma.org/docs/Global_UTM_Architecture_V1.pdf

[2] https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20140013436.pdf

	need to develop a non-cooperative surveillance capability to identify rogue UAS in a timely manner
Pre-flight planning – airspace management – flight management tool	An airspace management tool is needed which gives UAS operators and managers an accurate and up-to-date picture of the airspace in which the UAS will operate, including data on obstacles, other UAS, no-go areas, weather and any other phenomenon and events to impact the flight. This needs to be dynamically organised so the operator can receive instantaneous flight approval before starting the operation, and be made immediately aware during the flight of any changes in airspace status to impact the flight plan. This will incorporate geo-fencing as well as geo-caging, and automated approval by the UTM of any possible in-flight rerouting that the pilot (or flight manager or auto-pilot) might suggest in reaction to the changes in airspace status.
Collision avoidance – obstacles and other drones	A sense-and-avoid system is needed for UAS to detect and avoid dynamic and static obstacles
Communications	The UAS needs to be able to communicate its position to its operator and the airspace manager. The pilot/flight manager needs to be able to dynamically alter the UAS' trajectory in case of emergencies. The airspace manager needs to be able to communicate airspace status information to the pilot/flight manager and receive confirmation that messages have been received and understood
Navigation	The UAS needs to be able to navigate itself with precision in all conditions. In the event of a failure it needs to be able to return to base or to a safe landing space; complying with UTM and airworthiness standards

Roadmaps

It is no coincidence that the driving bodies behind the world's three most strategically significant next generation ATM research programmes – the USA's NextGen, the European Union's SESAR joint undertaking (SJU) and Japan's Collaborative Action for Renovation of Air Transport Systems (CARATS) projects – have developed the most advanced top-down concepts and roadmaps for UTM technology, procedures and standards development. UTM in these countries is any many ways seen as a subset of ATM research.

The USA and Europe have drawn up detailed roadmaps for the implementation of their UTM systems

FAA/NASA UAS research transition team (RTT) UTM roadmap

The FAA and NASA formed a UAS research transition team (RTT) in 2015 to jointly identify, quantify, conduct, and effectively transfer UTM capabilities and technologies from the NASA research centres to the FAA as the implementing agency and to provide guidance and information to UTM stakeholders to facilitate an efficient implementation of UTM operations. It produced a plan in January 2017[3]. Results of research in the form of airspace integration requirements are expected to be transferred from NASA to the FAA in 2019 for their further testing.

UTM sub-domain	**Description of sub-domain elements**	**Planned date**
UTM Concept of Operations	Overarching concept for UTM operations that serves as a foundational construct for UTM scenarios and use cases. Updated as needed to reflect the outcome of research, demonstrations, and increasing information from across the subgroups and TCL demonstrations	March 2018 – Updated Annually
Data Exchange & Information Architecture Technology Transfer Package 1	UTM Interface Control Document (ICD), UTM API, UTM data model gap analysis, information exchange schemas and data dictionaries, and other technical documentation supporting technology transfer of TCL1/2 capabilities: Including with multiple operations under constraints, BVLOS and other scenarios	February 2018
Data Exchange & Information Architecture Technology Transfer Package 2	Updates to technical documentation including UTM ICD, UTM API, UTM data model gap analysis, information exchange schemas and data dictionaries supporting technology transfer of TCL3/4 capabilities: Including operations over people, mixed environments, urban operations, large scale contingencies and other scenarios	December 2019
UTM Prototype Interface	Flight information management system prototype demonstrating capabilities of the ANSP interface for UTM and prototype capabilities for UTM stakeholder coordination	December 2018
Sense-and-avoid Technical Documentation Package – Heterogeneous Traffic	Guidance to industry for assuring collision avoidance in dense UA environments, determining minimum separation standards for various technology solutions, and overall SAA system performance in avoiding manned aircraft. Report based on the evaluation of Scenarios & Use Cases Packages to include: - Conflict scenarios between UA and UA - Conflict scenarios between UA and manned aircraft - Analysis of minimum separation - Data sharing requirements - Analysis of SAA system-level performance	June 2018
Sense-and-avoid Technical Documentation Package – Large-scale contingencies mitigation	Guidance to industry for assuring collision avoidance in dense UA environments, determining minimum separation standards for various technology solutions, and overall SAA system performance in avoiding manned aircraft. Report based on the evaluation of Scenarios & Use Cases Packages to include: - Conflict scenarios between UA and UA - Conflict scenarios between UA and manned aircraft - Analysis of minimum separation - Data sharing requirements - Analysis of SAA system-level performance.	August 2019
Communications and navigation Technical Documentation Package –	Report based on the evaluation of Scenarios & Use Cases - Packages to include: - Communication and Navigation (C&N) guidance to industry for Use Case Packages – test & performance methodologies for maintaining operational control and remaining in designated areas or on designated routes	June 2018

[3] https://www.faa.gov/uas/research/utm/media/FAA_NASA_UAS_Traffic_Management_Research_Plan.pdf

Heterogeneous Traffic	- C&N best practices for performance data collection and aggregation of communication and navigation performance data	
Communications and navigation Technical Documentation Package – Large-scale contingencies mitigation	Report based on the evaluation of Scenarios & Use Cases - Packages to include: - C&N guidance to industry for Use Case Packages – test & performance methodologies for maintaining operational control and remaining in designated areas or on designated routes - C&N best practices for performance data collection and aggregation of communication and navigation performance data	August 2019

Following a request by the European Commission, the Single European Sky Air Traffic management Research Joint Undertaking (SJU) – whose role is to develop the new technologies and procedures for a next-generation European air traffic management system – has unveiled its blueprint to make drone use in low-level airspace safe, secure and environmentally friendly. This "U-Space" covers altitudes of up to 150 metres[4]. Registration of drones and drone operators, their e-identification and geo-fencing should be in place by 2019.

The high level European UTM roadmap

Timescale	UTM services	RPAS integration
2019 plus	U1 UTM Foundation services • e-registration • e-identification • geo-fencing	RPAS 1 – IFR in classes A-C
2022 plus	U2 UTM Initial services • flight planning • flight approval • tracking • airspace dynamic information • procedural interface with ATC	RPAS 2 – IFR in classes A-G
2027 plus	U3 UTM Advanced/enhanced services • capacity management • assistance for conflict detection	
2030 plus		RPAS 3 – IFR and VFR in classes A-G
2035 plus	U4 UTM Full services • additional new services and integrated interfaces with manned aviation	

Given these roadmaps and information on UTM development plans from other parts of the world the table below is a possible, perhaps even likely, scenario for a world-wide UTM development programme for the next two years.

[4] http://europa.eu/rapid/press-release_IP-17-1605_en.htm
and http://www.sesarju.eu/sites/default//files/documents/reports/U-space%20Blueprint.pdf

Forecast timeline for global UTM deployment 2018-2019

Timeline
2018
Q1 Poland DroneRadar implements nationwide airspace authorisation programme with civil and military ANSPs
Q1 USA FAA LAANC trials end in the USA
Q1 USA Start of NASA UTM TCL3 trials testing technologies that maintain safe spacing between cooperative (responsive) and non-cooperative (non-responsive) UAS over moderately populated areas
Q1 USA FAA/NASA UAS research transition team (RTT) publishes first UTM concept of operations document
Q1 USA FAA/NASA UAS research transition team (RTT) publishes UTM Interface Control Document (ICD), UTM API, UTM data model gap analysis, information exchange schemas and data dictionaries, and other technical documentation supporting technology transfer of TCL1/2 capabilities: Including with multiple operations under constraints, BVLOS, and other scenarios
Q1 Singapore Government announces industry partners for urban UTM development programme
Q1 Europe Work starts on the SESAR Horizon 2020 PODIUM project to test VLOS, BVLOS very low-level drone operations in rural and urban areas, in the vicinity of airports, in uncontrolled and controlled airspace, and in mixed environments with manned aviation, with regulatory proposals to be issued later 2019.
Q1 Europe First meeting of Horizon 2020 CORUS consortium, developing a concept of operations for U-Space, the system for control of drones in European VLL airspace
Q2 Singapore Industry team start work on detailed urban UTM development for Singapore
Q2 USA FAA/NASA UAS research transition team (RTT) produce guidance to industry for assuring collision avoidance in dense UA environments, determining minimum separation standards for various technology solutions, and overall SAA system performance in avoiding manned aircraft. Report based on the evaluation of Scenarios & Use Cases Packages to include: 2016 UTM RTT Plan Version 1.0 20 - Conflict scenarios between UA and UA - Conflict scenarios between UA and manned aircraft - Analysis of minimum separation - Data sharing requirements - Analysis of SAA system-level performance
Q2 USA FAA/NASA UAS research transition team (RTT) produces report based on the evaluation of Scenarios & Use Cases - Packages to include: - Communication and Navigation (C&N) guidance to industry for Use Case Packages – test & performance methodologies for maintaining operational control and remaining in designated areas or on designated routes - C&N best practices for performance data collection and aggregation of communication and navigation performance data
Q2 USA FAA due to release recommendations on communications methods for UTM
Q3 Europe EUROCAE team to develop standards for detect and avoid (DAA) tactical mitigation, against conflicting traffic for RPAS operating under VFR and IFR conditions
Q4 USA FAA/NASA UAS research transition team (RTT) develop concept for flight information system prototype demonstrating capabilities of the ANSP interface for UTM and prototype capabilities for UTM stakeholder coordination
Q4 Europe EUROCAE team to develop standards for UAS to recover from data link loss
Q4 Global ICAO sets up pilot programme for global drone operator/platform/pilot registration system
2019
Q1 USA Start of NASA UTM TCL 4 trials, focusing on UAS operations in higher-density urban areas for tasks such as news gathering and package delivery. It will also test technologies that could be used to manage large-scale contingencies
Q3 USA FAA/NASA UAS research transition team (RTT) produce guidance to industry for assuring collision avoidance in dense UA environments, determining minimum separation standards for various technology solutions, and overall SAA system performance in avoiding manned aircraft. Report based on the evaluation of Scenarios & Use Cases Packages to include: - Conflict scenarios between UA and UA

- Conflict scenarios between UA and manned aircraft - Analysis of minimum separation - Data sharing requirements Analysis of SAA system-level performance
Q3 USA FAA/NASA UAS research transition team (RTT) produce report based on the evaluation of Scenarios & Use Cases. Packages to include: - C&N guidance to industry for Use Case Packages –Test & performance methodologies for maintaining operational control and remaining in designated areas or on designated routes - C&N best practices for performance data collection and aggregation of communication and navigation performance data
Q4 FAA/NASA UAS research transition team (RTT) publishes updates to technical documentation including UTM ICD, UTM API, UTM data model gap analysis, information exchange schemas and data dictionaries supporting technology transfer of TCL3/4 capabilities, including operations over people, mixed environments, urban operations, large- scale contingencies, and other scenarios
Q4 Europe SESAR PODIUM regulatory proposals (see above) announced

February 2018