FEATURE ARTICLE

The VUSIL Project

Validation of UAS Integration into the Airspace

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Validation of Unmanned Aircraft Systems (UAS) Integration into the Airspace (VUSIL) is a research project conducted by the German Air Navigation Service Provider (DFS Deutsche Flugsicherung GmbH, DFS) on behalf of the German Ministry of Transport, Building and Urban Affairs. The UAS manufacturer EMT and the German Military (Bundesamt für Wehrtechnik und Beschaffung, BWB) are project partners. Also involved are the German Ministry of Defence and the German Aerospace Center (DLR). The project was kicked-off in November 2007 and will be accomplished in February 2009.

While UAS are currently being used in restricted and military airspace, there are no operational concepts for the integration into regular airspace. It is the objective of VUSIL to provide empirical evidence about integration possibilities. This will be achieved by a combination of simulation and field flight studies.

UAS Definition

UAS were developed during the last decades primarily for military use. Especially the US Army uses different UAS for reconnaissance purposes. The German Army also makes ncreasingly use of UAS in this area.

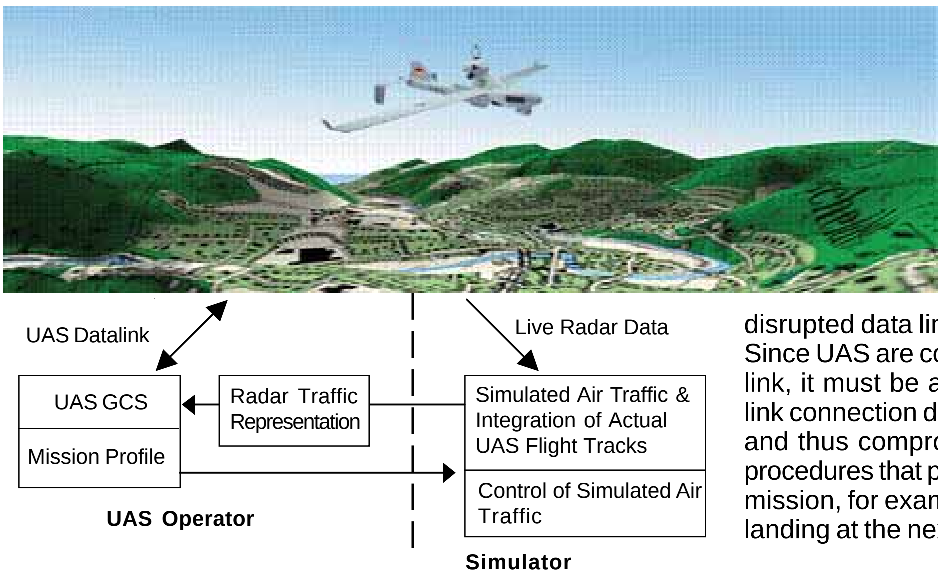
A UAS mainly consists of three major components:

- The flying component or Unmanned Aircraft (UA). This contains all parts necessary for flying, for example, the hull, the engine, flight management and navigation systems. The UA carries the occupancy loading, for example, reconnaissance sensory systems, like cameras.
- The communication component. Depending on the UAS size and the airspace it is operating in, communication systems with the Ground Control Station (GCS) must be installed. Technically, this is a data link connection, which must be stable and interference proof. Moreover, the UAS needs radio transmission systems for the communication with Air Traffic Control (ATC). Depending on the distances between UAV, GCS, and ATC unit in charge, relay-stations are necessary to maintain constant communication. Relay-stations might be satellites, aircraft, or a chain of ground stations.
- The GCS: Here the UAS operator exerts control the entire system. The size of the GCS can vary from a be a laptop computer to a stationary control centre. The most frequent form of a GCS is a mobile container. Usually, the data generated by the occupancy loading is also analysed here.

UAS Integration Problems

Currently, UAS flights are only permitted in restricted airspace, i.e. segregated from civil air traffic. There are two main integration problems:

- See and Avoid
  The basic safety regulation of the International Civil Aviation Organisation (ICAO) is the „see and avoid» principle. Since a UAS is unmanned by definition, the „see and avoid» principle requires an alternative to the human pilot.
  One alternative could be the development of sensory systems that together with electronic flight management systems replace the „see and avoid» of human pilots by «sense and avoid» by means of technology. Currently available approaches suggest integrating the sensory system and corresponding electronics into the actually flying part of the UAS, the Unmanned Aircraft, making it able to «sense and avoid». An Equivalent Level of Safety (ELOS) is required which is at least as reliable as human „see and avoid». However, there is no defined „see and avoid» safety level, which could be used as a benchmark yet . Therefore, our approach is to make the traffic information available to the UAS operator at the Ground Control Station (GCS) by means of radar Mode S technology (Figure 1). If the UAS operator on the ground receives sufficient radar information about the surrounding traffic, he/she can resume the „see and avoid» of the pilot in ordinary aircraft. Thus, the complex additional sensory and electronic systems onboard can be avoided.
- Emergency procedures for disrupted data link between UAV and GCS:
  Since UAS are controlled by distant operators via data link, it must be assured that a disruption of the data link connection does not result in an uncontrolled UAS and thus compromise safety. Internationally binding procedures that prescribe the safe termination of a UAV mission, for example, UA self-distruction or automatic landing at the next airfield must be developed.



[1] The acronym refers to the original German title Validierung von UAS (Unmanned Aircraft System) zur Integration in den Luftraum

Table 1: VUSIL Research Objectives		
Nr	**Objective**	**Operational Definition**
Function		
1	The developed integration concept will be accepted by the responsible German authority	The German Ministry of Transport, Building and Urban Affairs will approve the developed integration concept.
2	The necessary technical and operational infrastructure for flight simulations and real flights will be made available	Simulations and real flights are successful, i.e. conducted without technical and without safety problems; the UAS operator has all relevant traffic information available for a safe conduct of the UAS flight
3	The safety standards in Air Traffic Management are not violated by the UAS	- Number of separation infringements = 0 - Safety assessment by the involved air traffic controllers on a scale ranging from 1 safe to 7 unsafe in no trial > 3 - Safety assessment by the UAS operator on a scale ranging from 1 (safe) to 7 (unsafe) in no trial > 3 - No safety doubts in the debriefings of UAS operator and air traffic controllers
4	The integration concept will be assessed feasible	- safety standards in Air Traffic Management are not violated - Workload of the UAV operator not more than 50% in the NASA TLX (Hart & Staveland, 1988) scales mental and temporal demands - No negative assessment of the concept in the debriefings of UAS operator and air traffic controllers
Time		
5	The flight trials will be completed in time	The flight trials will be completed until July 2008
6	The project will be completed in time	The project will be completed in February 2009
Work Integrity		
7	The UAS operator will be straining at an acceptable level	- Number of separation infringements = 0 - Workload of the UAV operator not more than 50% in the NASA TLX (Hart & Staveland, 1983) scales mental and temporal demands - No report of unacceptable stress and strain in the debriefings of the UAS operator

Research Objectives

Table 1 shows the objectives of the project and their detailed operational definition.

Method

As described in chapter 1.3 the VUSIL project is a combination of real flights and simulated flights. A Mode S transponder will be integrated into the UAS „LUNA» build by the German manufacture EMT. EMT is sponsored by BWB to conduct the real flight trials.

The UAS will be launched near by the airfield of Manching, Bavaria, Germany. Under the control of the Manching Tower the «LUNA» will fly to the ED-R 138. In the ED-R 138 the «LUNA» will conduct a search pattern. After finishing the search pattern the «LUNA» will fly back to its starting position and land near by the airfield of Maching.

To prepare the flight trials there will be test trials at the DFS Research and Development Centre in Langen in February 2008. During these test trials the different traffic scenarios according to Table 2 shall be developed and tested.

For the flight trials in Manching in June 2008 the DFS Advanced Function Simulator will be installed next to the UAS GCS. The AFS will feed simulated radar data into the DFS developed ATC System «Phönix». The radar data from the real flying «LUNA» will be transmitted via UMTS from Langen to Manching and will also be fed into the ATC System. The ATC System «Phönix» will process the radar data and display the complete traffic situation to the UAS operator and to an ATC controller.

The study design will incorporate 8 trials which are combinations of traffic load and traffic modes, as displayed in Table 2. The responsibility of the collision avoidance is varying between the different scenarios.

Traffic Load	Primary Radar Display	VFR Traffic	VFR/IFR Traffic	IFR Traffic
Low	1	2	3	4
High	5	6	7	8
Separation Responsibility	UAS Operator	UAS Operator	UAS Operator/ ATCO	ATCO

Table 2: VUSIL Study Design

Current Project Status and Outlook

The VUSIL Project has been kicked-off in November 2007. Since then the operational concept of integrating UAS in unrestricted airspace has been developed. Currently, the test trials at DFS R&D Centre in Langen are being prepared. After successful testing of the technical infrastructure, the real flight trials with fed-in simulated and live radar data will be conducted in June 2008.

An analysis with a focus on safety assessment is planned for November 2008. The final project report is due in February 2009. The project will be considered successful if the operational targets as described in Table 1 will be fully achieved.