

# VUSIL Project: Results & Further Development

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Validation of Unmanned Aircraft Systems' (UAS') Integration into the Airspace (VUSIL) was a research project conducted by the German Air Navigation Service Provider (DFS Deutsche Flugsicherung GmbH) on behalf of the German Federal Ministry of Transport, Building and Urban Affairs. The UAV manufacturer EMT and the German Military (Bundesamt für Wehrtechnik und Beschaffung BWB) were project partners. The project was kicked off in November 2007 and was accomplished in February 2009.

This paper explains the results of an investigation of the paradigm shift from «see and avoid» of pilots to «sense and avoid» in UAS. This paradigm shift was realised by a UAS pilot monitoring the surrounding traffic on a radar data display. The radar data were provided by DFS's ground radar infrastructure. This approach of integrating UAS into the airspace was investigated in the VUSIL project. The methodology and the results to validate this integration approach by a combination of a real flying UAS and simulated surrounding traffic is presented here.

### Aim of the Project

The German Ministry of Transport Building and Urban Affairs has defined the following aims for the study:

- Development of a UAS integration concept based on the DFS ground radar infrastructure;
- First Validation of the integration concept by flight trials (procedures, separation between UAS and surrounding aircraft);
- Preparation of the necessary infrastructure (radar data, simulated surrounding traffic, traffic display, sense and avoid assistant);
- Production of a first safety analysis based on the results of the flight trials.

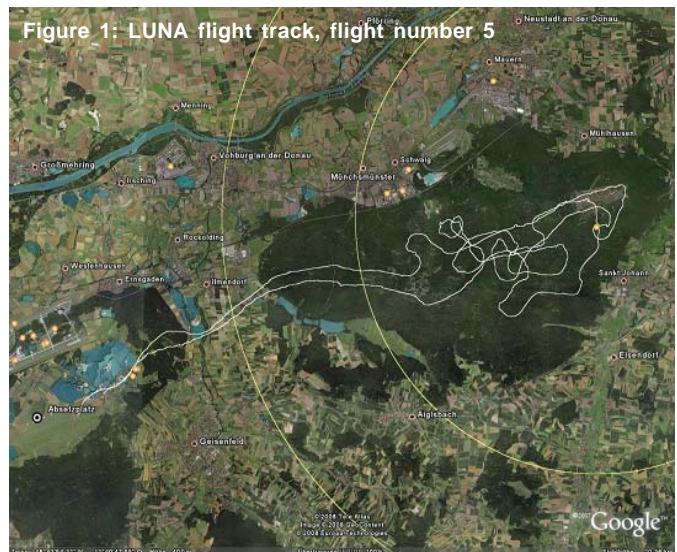
### Realisation of the Project

Four work packages were defined to realise the project:

- Preparation of the flight trials  
In this work package the integration concept was developed. The core elements were defined: Separation between the UAS and the surrounding traffic shall be as minimum 500ft vertically and/or 0.5NM horizontally. All traffic in the area must be transponder equipped. The radar coverage in the area must be 100%.  
The necessary infrastructure was defined. As test area the restricted area 138 (ED-R 138) near the military airfield Manching (Bavaria) was selected. The radar data from the DFS radar net were sent via UMTS to the UAS ground control station. As experimental vehicle the UAS «LUNA» from EMT was provided by the BWB. The LUNA was transponder equipped. The infrastructure was built up in Manching. For the data collection questionnaires, interviews and a structured debriefing were prepared. Furthermore the radar data and the simulated traffic were recorded and analysed after the flight trials were finished. For a detailed description

of the infrastructure and methodology see UVS Yearbook 2007.

- Performance of the flight trials  
In June and July 2008 the flight trials were conducted as planned in the ED-R 138. 13 flights were performed during this time. The radar data and the data from the interviews and discussions were collected. Figure 1 shows the flight track of the LUNA from the flight number 5.



- Safety analysis  
Based on the results of the flight trials a safety workshop was conducted with the participants of the flight trials. UAS pilots, UAS technicians, engineers, involved personal from ATC and safety specialists participated in the workshop. The workshop was conducted in September 2009.
- Analysis of the integration concept  
The last work package contained the analysis of the integration concept. Based on the results of the flight trials and the results of the safety workshop the integration concept was evaluated.

### Results

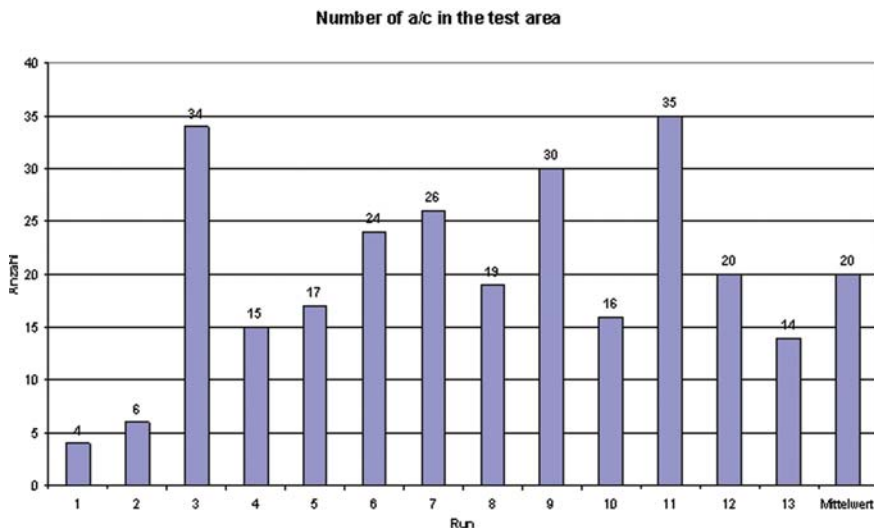
It is not possible to present all results from the flight trials and from the safety workshop in detail in this paper, so only the highlights are presented here. The analysis of the radar data shows a shortfall in the separation between UAS and surrounding traffic in six cases (see Table 1).

**Table 1: Separation shortfall between UAS & surrounding traffic**

Flight Trial	3	6	9	9	13
LUNA	DBFSZ	DBFSZ	DBFSZ	DBFSZ	DBFSZ
Call sign	DECBO	DIFFR	HBLEV	GAF002	DIATO
Time of closest distance	13:03:41	07:57:10	12:55:13	13:21:34	07:23:34
Vertical distance (ft)	275	250	350	0	75
Horizontal distance (NM)	0.27	0.43	0.36	0.47	0.24

In most of the cases the traffic density was very high (see figure 2). During flight number 3, 34 simulated aircraft and

<sup>1</sup> The acronym refers to the original German title Validierung von UAS (Unmanned Aircraft System) zur Integration in den Luftraum



**Figure 2: Number of simulated a/c during the flight trials**

during flight number 9, 30 simulated aircraft were in the test area. In flight number 6 the traffic density with 24 aircraft was high as well. During flight 13 technical problems were the reason for the shortfall of the separation. Therefore the flight was aborted.

The discussions with the UAS pilots and the participants in the flight trials show some interesting results:

- The traffic display with the surrounding traffic was rated as very helpful for the situational awareness. But it was not easy for the pilots to interpret the information on the display. To full fill this task more training time is needed.
- The sense and avoid assistant was also rated as helpful. Especially for the avoidance manoeuvre the assistance was very supportive. Possible solutions to avoid the conflict are displayed to the UAS pilot. But the software could be enhanced by integrating vertical avoidance manoeuvres. More training could also enhance the performance of this assistant.
- The combination of both support tools was rated as very helpful. A better integration into the UAS ground equipment could further enhance the performance of the integration concept.
- The necessary instruction and training of the UAS pilot based on such an integration concept was discussed. The participants agreed in a combination of a pilot licensing and elements of air traffic controller training.
- All in all the tested integration concept was rated positive. The participants agreed that the tested concept could be a way to integrate UAS into airspace outside restricted areas. But the training of the pilots must be taken into account and the technical integration must be enhanced.

The results of the safety workshop supported the results of the interviews and discussions. Furthermore some relevant issues were discussed:

- The detection of a UAS by a pilot of the surrounding traffic was rated negative by the participants. The UAS is normally very small and therefore its visibility is very poor. This could generate problems if the pilot of the surrounding traffic is responsible for the conflict avoidance (Rules of the air). Special lights or a special colour could increase the visibility of the UAS.
- The performance and steering of the UAS was also rated negative. The performance of the LUNA is slow and especially during strong wind conditions the reaction of the LUNA is inert. This could create problems in the collision avoidance.

- The detection of the surrounding traffic was judged positive by the participants. The sense and avoid assistant and the traffic display was very helpful to «see» and avoid the surrounding traffic. Especially the range of the radar display was rated positive. The pilot could see the traffic in advance and can react before the situation becomes critical.

- The instruction and training of the UAS pilot was not clear for the participant. So a detailed analysis of the requirements on the UAS pilot was proposed. Based on this requirements a concept for the instruction and training could be developed.

The results of the flight trials show that the proposed integration concept could be a possible way to integrate UAS into the air traffic outside restricted airspace. Some

questions are still open and shall be investigated in a succeeding project.

### Outlook

Together with the German Ministry of Internal Affairs the VUSIL II project will be conducted in 2009 and 2010. As in VUSIL, flight trials will be conducted to test the integration concept and to find answers for the open questions. The following topics shall be investigated during the VUSIL II project:

- Based on the results of VUSIL the integration concept will be improved. The technical solutions (traffic display and sense and avoid assistant) will also be enhanced.
- Instead of simulated surrounding traffic real aircraft will participate in the flight trials. So the visibility of the UAS can be tested and the reaction of the real pilots can be observed.
- The requirements on the UAS pilot will be investigated during the flight trials. Based on these requirements possible instruction and trainings will be developed.
- The legal aspects of operations outside restricted areas based on the integration concept will be discussed.
- The licensing of the UAS shall be discussed with the relevant authorities. At the end of the project the basis for a licensing will be developed.
- Based on the flight trials a safety analysis will be conducted. So the integration of UAS into the airspace outside restricted areas can be evaluated.

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