REMOTE SENSING AND IN-SITU-MEASUREMENTS WITH A MOTORGLIDER-BASED NEW CONCEPT AIRCRAFT

by F. J. Ossing, Stemme Aircraft, Berlin, Germany; Dr. B. Neininger, MetAir, Illnau, Switzerland; Dr. M. Krauss, InfraTec, Dresden, Germany

Presented at the XXIII OSTIV Congress, Borlänge, Sweden, (1993)

The use of motorgliders in environmental tasks is well known. In particular, the flight characteristics and the low operational costs of these aircraft make them an indispensable tool, especially in atmospheric research (DFVLR 1985, Jochum et.al. 1984). On the other hand, evolution in glider construction has come to a standard where it should be expected that the next generation of motor-gliders technically incorporates a major step forward in flight performance, in particular with respect to speed, range, and payload (Brinkmann/Zacher 1992).

The Stemme S10 can be seen as a representative of the new generation of motorgliders. Due to a completely new propulsion concept and a very high aspect ratio of L = 28.3, it has the full-scale advantages of a motor aircraft while on the other hand it offers the useful characteristics of a high-performance glider. Based on this design concept, an aircraft for remote sensing and in-situmeasurements, the S10-VC, was developed (Figure 1). Major changes as compared to the motorglider S10 are:

- 350 kg useful load in total
- hardpoints for underwing loads
- 2 underwing pods of 60 kg capacity payload each for mission specific equipment

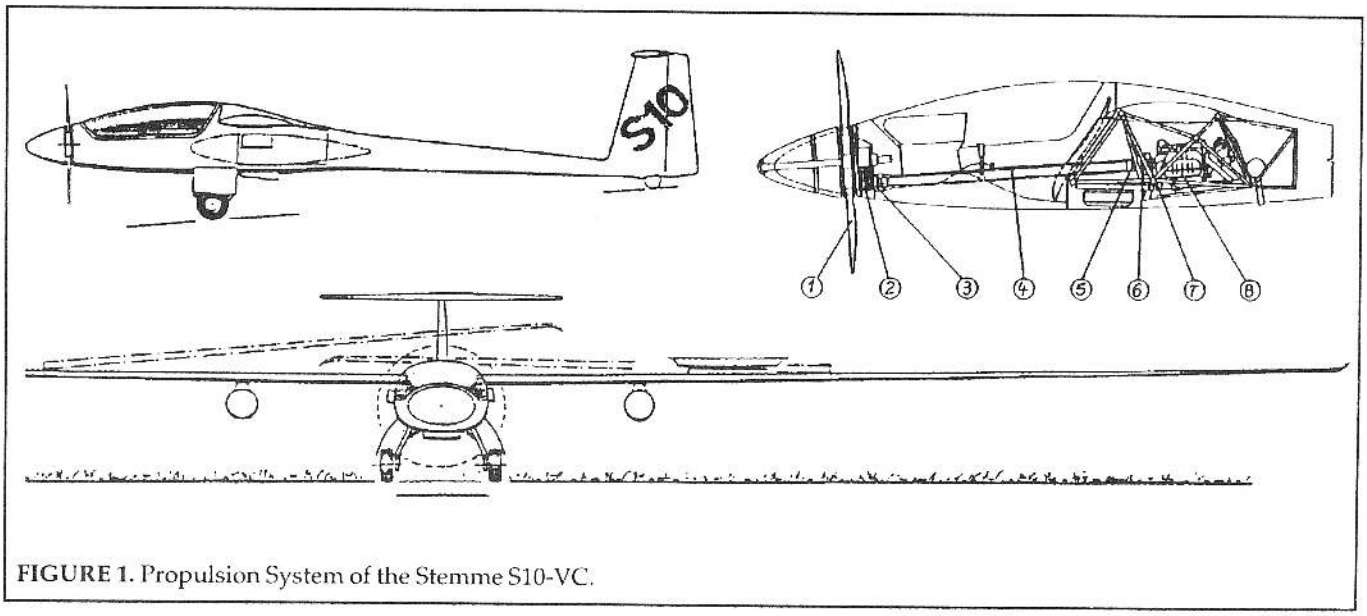

FIGURE 1. Propulsion System of the Stemme S10-VC.

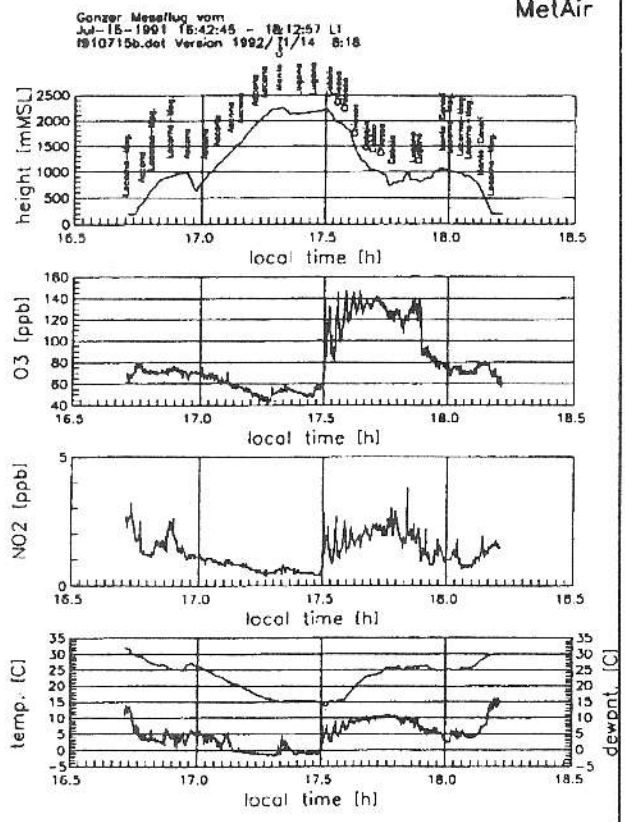

FIGURE 2. Stemme S10-VC surveillance and measurement aircraft.

- 1201 internal fuel capacity
- increased strength of wing structure
- preparation for power supply for sensors incl. cable channels in the wing between fuselage and wing hardpoints
- reinforced undercarriage for operation in rough terrain

Because of these changes, and in particular due to exceeding the 850 kg weight-limit of JAR 22, the S10-VC will be certificated as a special aircraft of the 350 kg useful load class in FAR 23 Special specifications. Currently, the aircraft is undergoing advanced tests including remote sensing and measurements of atmospheric pollution of which in the following typical examples of measurements of photochemical air pollutants and infrared (IR) remote sensing will be presented.

Measurements of Photochemical Air Pollution

Research of meteorological parameters and air pollution is the classical field for motorgliders (Lindemann 1973, Hacker/Schwerdtfeger 1988). During the POLLUMET measurement campaign in Switzerland in the summers 1990/91, a S10-VC of MetAir, Illnau was instrumented with sensors for different meteorological parameters (T, p, Q, v) and air pollutants (O_3, NO_2, H_2O_2). The aim of the campaign was the three-dimensional analysis of photochemical processes leading to the formation of ozone as the typical trace gas. The airborne measurements provided the possibility to detect local ozone production on the background screen of long range transport of ozone (MetAir 1992). A remarkable example is given in Figure 2 and 3. On the afternoon of July 15, 1991 an exploratory flight showed high concentrations of ozone (O_3) and nitrogene dioxide (NO_2) in a sharp "front". These measurements were well correlated to a variation in the dew point temperatures. O_3 maximum values of more than 150 ppb were measured, related to NO_2 maxima of more than 3 ppb. This compares to values of ozone not exceeding 80 ppb in the air mass before this ozone front.

As in the course of the measurements the mixing height decreased from 800 m to 500 m (mMSL), it is assured that these concentration values had been observed within the so-called residual layer. This is the layer in which air pollutants had been transported by turbulent mixing. Typically, with the decrease of turbulence due to convective processes in the late afternoon and evening vertical mixing processes cease; the pollut-

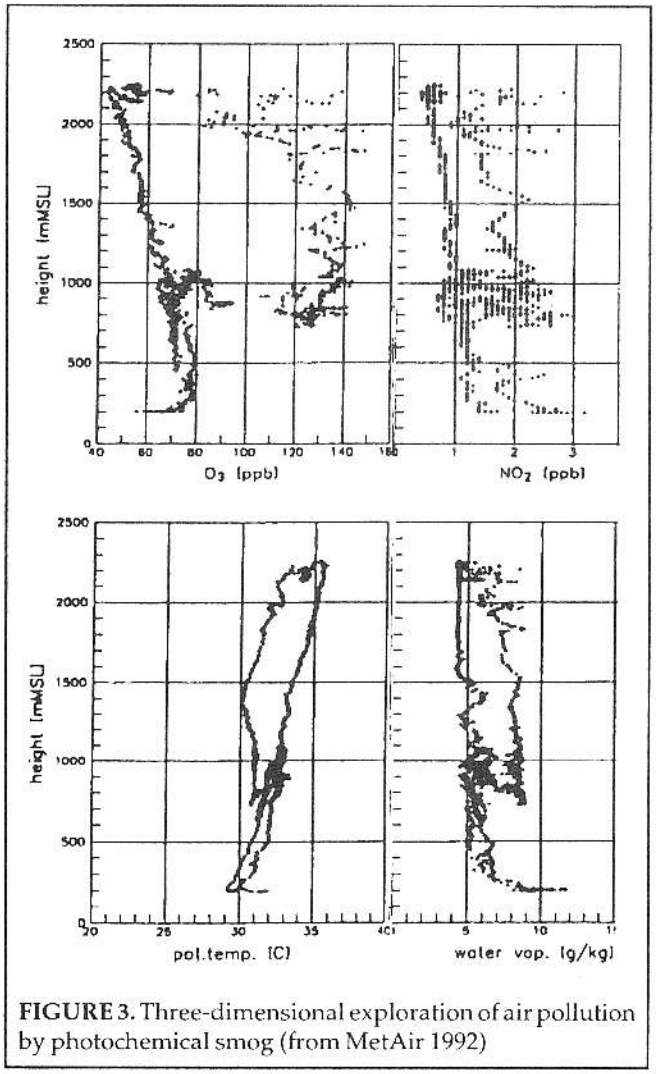

FIGURE 3. Three-dimensional exploration of air pollution by photochemical smog (from MetAir 1992)

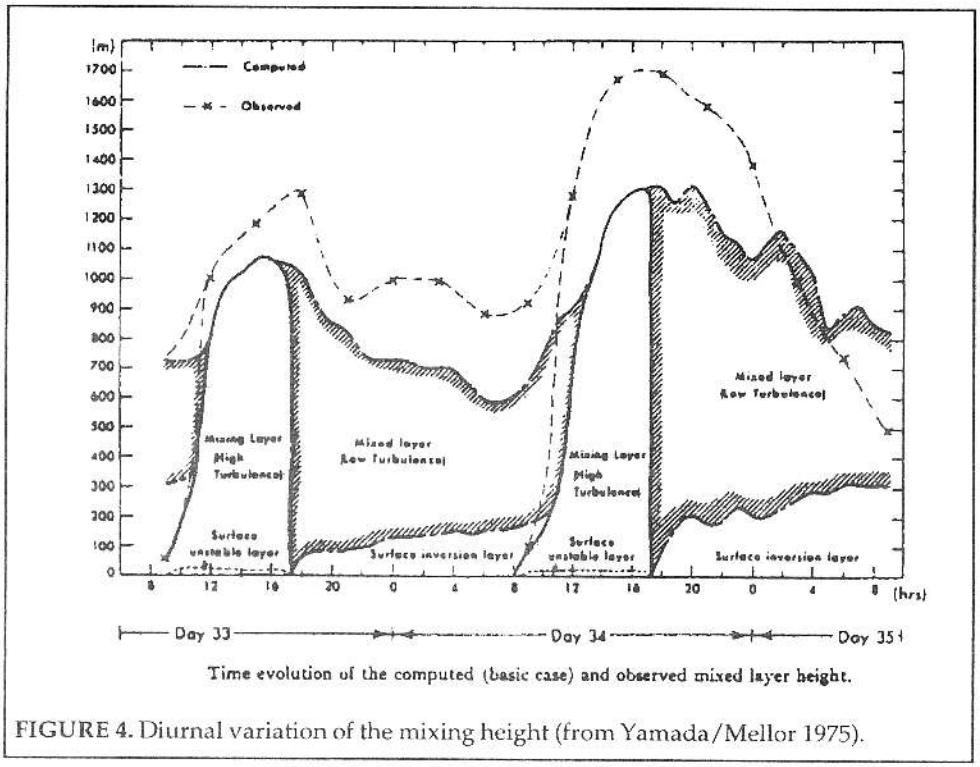

FIGURE 4. Diurnal variation of the mixing height (from Yamada/Mellor 1975).

ants, however, remain aloft while a temperature inversion near the surface marks the top of the mixing height. An example of the diurnal variation of the mixing heights is given in Figure 4. The pollutants in the residual layer can be transported with the main wind direction over longer distances.

The pollution of the air mass characterized by the MetAir-measurements of Figure 2 and 3 could not have been detected by ground stations alone. This air mass approached the area of research from the south and seems to have had its origin in the Po river area or in the pollution plume of Milan.

Infrared Remote Sensing

For investigations into forestal degradation in the Harz area and in the foreland of the Alps a video camera system was developed which consisted of two monitors, a recording unit, and two cameras (VIS and IR, Video-8-quality) looking down on parallel axes at an angle of 90° vertically. Experts from the Technical University of Berlin analyzed the tapes for Greenpeace Germany. Though the cameras had not been placed on a stabilized platform, results prooved to be fair enough for inventory and analyis scopes.

To detect thermal leaks of buildings, unallowed water release, and other items that can be recognized in the infrared spectrum, an InfraMetrics Model 760 infrared scanner was applied for thermal mapping of the urban agglomeration of Berlin. These data can provide the basis for urban energy saving concepts and other environmental purposes. The scanner was accommodated by Infratec Dresden in the right underwing pod together with a video recorder and the scanner recording unit, and was remotely controlled from the cockpit (Figure 5). Infrared mapping of cities or industrial plants generally is carried out at night. Since motorglider operation under Night VFR conditions usually is not allowed, a special permit from the German Civil Aviation Authorities (LBA) in accordance with the regional air traffic control was requested. As the S10-VC's noise emissions are very low, additionally the noise problem of night flights could be avoided.

This mission is, to our knowledge, the first in which a motorglider-like aircraft was used at night for thermography.

Results of these missions can be found in Figure 6. The

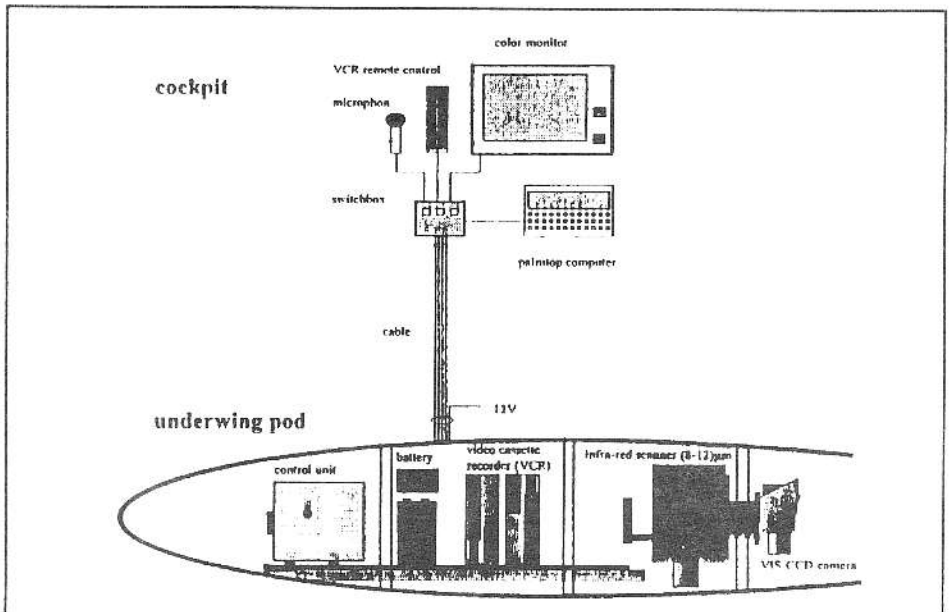

FIGURE 5. Arrangement of InfraTec IR Scanner System.

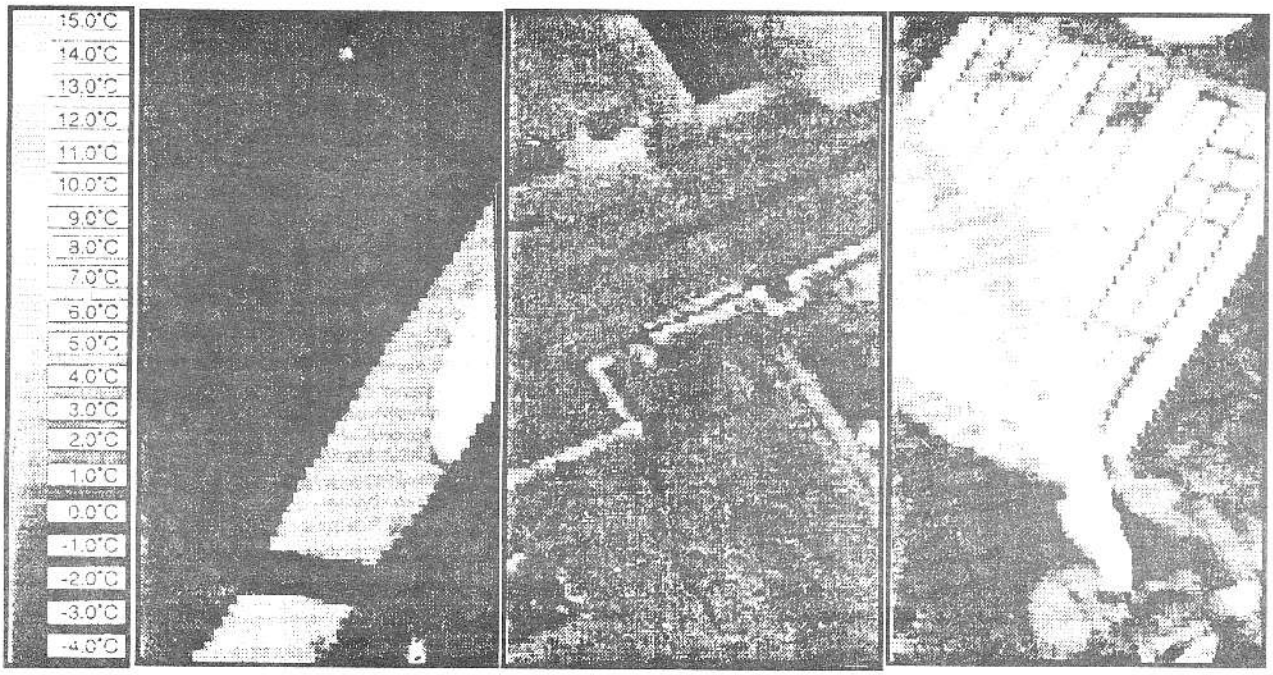

FIGURE 6.
Left – detection of waste water release.
Center – scanning of municipal heat distribution pipelines.
Right – IR scanning of sewage plant.

left part shows the release of waste water from a facility into the Teltow channel. The plume of the injected warm waste water with a temperature of 12 - 14° C clearly stands out against the channel water with temperatures of 4 - 5° C. Due to cooling and mixing processes this difference diminishes slowly. Temperatures of soils and buildings show values of well below zero with minimum values of less than - 5° C.

The center part shows the pipelines of a municipal heat distribution system of the type that is frequently found in East Germany. Energy wasting due to loss of heat is indicated by the marked spots which refer to leaks with temperatures of up to 15° C as compared to 5° C of the pipeline itself and surface and building temperatures around the freezing point and below. This indicates the energy effectiveness of such systems and give insights into necessary repair/overhaul work.

The right part shows temperatures of the water clarification basins of a sewage plant in a range of 12 - 14° C while the surroundings again display temperatures between 0° C and - 5° C. This points out the biochemical processes taking place in the clarifiers and can serve as an indication of the effectiveness of the clarifying process. At the left bottom of the picture, a smoke plume rises from a small facility, showing an initial temperature of more than 15° C (which was the upper value of the scanner temperature range in this case) and cooling down to values of 5 - 4° C as is seen in the upper left corner of the figure.

Summary

The next generation of motorgliders or motorglider-like aircraft will be able to be applied in a variety of missions which are carried out today by bigger motor aircraft. Combining the characteristics of sailplanes and motor aircraft at full scale, these aircraft will not be intended to replace helicopters and other, fixed wing aircraft completely, but can substitute them in a variety of missions offering low cost, low noise and low detection characteristics.

In the particular case of the S10-VC, further projects include an observation version for coastal surveillance of oil spill and fishery patrol, and for wildlife inspection in large territories.

References:

Brinkmann, G., Zacher, H., 1992: "Die Evolution der Segelflugzeuge", Bonn.

DFVLR (ed.), 1985: "Beiträge zum Workshop MEMO 84 (Meteorologischer Motorsegler) vom 1.- 5. Oktober 1984 am Institut für Physik der Atmosphäre der DFVLR in Oberpfaffenhofen", DFVLR-Mitt 85-04, Oberpfaffenhofen.

Hacker, J.M., Schwerdtfeger, P., 1988: "The FIAMS Research Aircraft System Description", Flinders Institute for Atmospheric and Marine Sciences, Techn.

Rep. No. 8, Flinders.

Jochum, A., Reinhardt, M.E., Willeke, H., 1984: "Die drei Motorsegler der DFVLR - ein meteorologisches Mess-System zur Untersuchung der atmosphärischen Grenzschicht", DFVLR-FB 84-50, Oberpfaffenhofen.

Lindemann, C., 1973: "Mesometeorologische Sondierung der troposphärischen Grundschicht unterhalb 3000 m", Freie Universität, Berlin.

MetAir (ed.), 1992: "Sommersmog-Melβflüge im Tessin und in der Westschweiz", 2 volumes, Illnau.

Yamada, T., Mellor, G., 1975: "A Simulation of the Wangara Atmospheric Boundary Layer Data", Journ. Atmos. Scien. 32, pp. 2309 - 2329.