Remotely operated PLUS-octocopter used as an aerosol measurement platform

P. Madl, C. Oberauer and F. Steinhäusler

Division of Physics and Biophysics, Department of Materials Engineering and Physics, PLUS University, Salzburg, A-5020, Austria
Keywords: unmanned aerial vehicle, flying aerosol measurement platform
Presenting author email: pierre.madl@sbg.ac.at

The herein presented design is part of the *BRIDGE* Concept Case Advanced Situation Awareness for proactive risk management. It will fill this gap by providing the user inter alia with real-time data on the extent of airborne pollution inventories.

One of the core-component is a manually controlled unmanned aerial vehicle (UAV), termed PLUS-Octocopter. As shown in Fig. 1, the system consists of a ground-station, a wireless communication link and the sensor-equipped flying platform. The latter houses 8 electric motors, Global Positioning System (GPS) for stabilized flying mode, two different cameras (visual (VIS) / infra-red (IR)) an onboard-computer and several solid state sensors (T, rH, p, β, γ) as well as a particle number counter (P_N) and a particle mass detector (P_M). Table 1 summarizes its core specifications:

Table 1. Technical specifications of the UAV.

UAV	Octocopter
Power supply	20Ah Li-polymer rechargeable batteries
Flying time	>15min, less at windy conditions
Weight	5 kg (incl. LiPo-pack)
add. payload	2.5 kg
Downlink	Radio-controlled @ 2.4 GHz
2D-sensors	2-servo-adjusted camera unit i) VIS camera (0.4 - 1 µm) i) IR-camera (7.5 - 13 µm)
1D-sensors	Atmospheric (T, rH, p) Radiation (β, γ) Particle mass (µg/m^3) Particle number conc. (1/cm^3) Gases (CO, CO_2, C_2H_6, CH_4, N_2O)
DPU	Win-OS ultra small PC
Flight rec.	120 GB shock resistant SSD
GPS	Flight control & auto-homing
Ground	
Downlink	Radio-controlled @ 2.4 GHz
Win-OS Laptop	Visualization of area (IR & VIS) and display of sensor data

UAV-Characteristics: Although the vehicle is controlled via the ground station, the onboard computer is used both as the data processing unit (DPU) for the control signals keeping the system airborne, as well as a flight recorder for logging flight-sensitive parameters; i.e. status of each cell within the LiPo-packs, GPS-data (location, altitude, flight path). At the same time the DPU-hub logs all the sensor data along with the VIS/IR-data streams. The up- and downlink system, which is likewise controlled via the DPU, is achieved using a commercially available high-power WLAN system operating in the 2.4 GHz-band. At any time, and at least at batteries in reserve capacity status, the UAV will be switched into GPS-guided automatic homing mode.

UAV-sensors: Apart from the 2-D-sensors and the standard atmospheric sniffers (see Table 1), the UAV features two aerosol sensors. The P_M-sensor detects mass-fractions <10µm with a sensitivity of <5ng (with the UAV grounded and slightly less in a stationary humming, airborne mode). The P_N-sensor records particle number concentration in three different size classes simultaneously (0.3, 2.5 and 10 µm). Both aerosol sensors require a data acquisition time of 10 sec, which translates into 6 readings per minute. A different set of sensors regard the solid-state pyroelectric sensors to detect gaseous substances. Their detection principle rests on the specific absorption bands in the IR-window in-between 3 to 5 µm (for the various gases listed in Table 1). The entire throughput of the sample air through the sensor-compartment is achieved via a miniature carbon-vein pump at a constant flow-rate of 5 L/min.

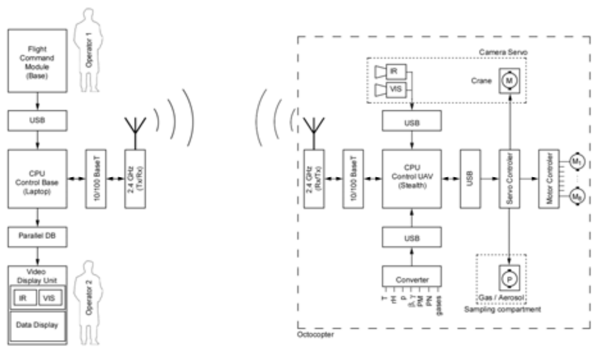

Figure 1. Schematic block diagram of the PLUS Octocopter-system, highlighting ground station and the UAV. *Legend*: Tx, Rx, Transmitter and receiver for the corresponding frequencies; M, Step-motor, M_1-M_8: lifting electric-motors; P, pump; VIS & IR, USB-compatible VIS and IR-camera units, CPU, Central processing unit; USB, Universal Serial Bus; Parallel DB, parallel Data Bus; 10/100BT, bidirectional Ethernet link; T, rH, p, β, γ, P_M, P_N, sensor compartment (see text).

Field of application: the above described system can be used for assisting incident commanders, fire-fighters, environmental air-quality monitoring at stacks, or other emission sources with limited access.

This work was partially supported by the 7th EU Framework Project No. 26.18.17. (BRIDGE).