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Prepared by:	Oliver Reitebuch (DLR, Oberpfaffenhofen, Germany)

0.1 Document Change Log

Issue.	Date	New pages	Modified pages (after introducing new pages)	Observations	Name
dr.	06.11.2007	--	--	draft prepared	Reitebuch
V1.0	13.11.2007			first version prepared with comments from Christian Lemmerz and Anne-Grete Straume	Reitebuch

0.2 Table of Contents

1 Introduction and Purpose of Document

This Technical Note TN 4.1 defines the implementation of the first ADM-Aeolus Airborne Campaign AC01. It covers tasks of workpackage WP 4100 of the study contract "Planning and execution of Aeolus Campaigns" by DLR from 5 April 2004, based on the Statement of Work from ESA SW-ESA-AD-015, Issue 01a (ESA 2004, DLR 2004). A draft of this TN was prepared by Oliver Reitebuch (DLR).

The AC01 Implementation plan is based on the campaign objectives defined in TN 1.2 (AE.TN.DLR.A2D.TN12.010305), the implementation plan for the ground campaigns defined in TN 3.1 (AE.TN.DLR.A2D.TN31.080906), the experience with operating the ALADIN Airborne Demonstrator A2D during two ground campaigns in Lindenberg (www.pa.op.dlr.de/aeolus and handouts of PM6, PM7) and the experience gained during two test flight campaigns in October 2005 and April 2007 (see handouts of PM8).

2 Objectives of the first ADM-Aeolus airborne campaign AC01

2.1 Recall of general objectives

The main objectives of the ADM-Aeolus campaigns are

- Validation of the predicted instrument radiometric and wind measurement performance.
- Establishing a dataset of atmospheric measurements obtained with an ALADIN type instrument to improve algorithm development for L1B (uncorrected horizontal line-of-sight HLOS wind speed), L2A (aerosol and cloud products) und L2B products (corrected HLOS wind speed).

The ADM-Aeolus campaigns should address the following questions:

1. a) Is the actual instrument radiometric performance (number of detected photons) in the expected range?

   b) Is the actual instrument wind observation performance (accuracy and bias of wind observation) within the expected range?
2. What is the influence of real homogenous atmospheres on the instrument performance including operational L1b algorithms?
3. Do temperature and pressure corrective schemes for Rayleigh winds operate well?
4. What is the influence of real atmospheres under mostly inhomogenous conditions (clouds, wind shear, and aerosol) on the instrument performance including operational L1b algorithms?
5. Can an improvement be achieved by other algorithm implementations and Quality-Control-methods? Have further correction schemes to be implemented in the processing?
6. What is the performance of the calibration using the laser pulse as internal reference? What are the implications of the Mie and Rayleigh response calibration modes, which rely on atmospheric targets and ground return?
7. What is the effect of the atmosphere on the ground return bin? Does the proposed detection scheme for the ground return work under different conditions?
8. What is the detectability and strength of the return from water under 0° (specular reflection) and 35°? What is the detectability and strength of the ground return over land, e.g. ice, snow surfaces or deserts?
9. What is the effect of real atmospheric conditions including inhomogeneity on L2B processing?
10. What L2A products (aerosol, cloud) could be derived under different atmospheric conditions?
11. What is the variability of geophysical parameters (atmospheric backscatter, extinction, ground return strength, clouds) during different conditions and over different locations?

2.2 Objectives of first airborne campaign AC01

The objectives for the first airborne campaign are as follow:

- Functional test of A2D and 2-µm wind lidar operation
- Obtain dataset for ground return detection and zero-wind calibration algorithm over different surfaces (sea, land, steep/flat orography)
- Calibration strategy during airborne campaigns
- Radiometric performance with downward looking geometry
- Stability of alignment (and thus wind retrieval) in the aircraft
- Establish strategy for intercomparison satellite/airborne LOS to ground-based wind-vector observations: observational geometry, temporal and spatial sampling

3 Instrumentation during AC01

3.1 Payload of the DLR Falcon aircraft

The payload of the DLR Falcon aircraft will consist of the A2D and the 2-µm Doppler wind lidar (Fig. 1), which will be integrated into the Falcon aircraft for the first time in this combination. 2 seats are available on the Falcon aircraft, which will be shared among the operators for the A2D and 2-µm lidar.

The “Unobjectionable Form” (“Unbedenklichkeitserklärung”) from the A2D Laser Test Flights (April 2007) is valid until October 26, 2007. As A2D flights are foreseen in November 2007, this form has to be re-issued. In addition the mounting of the 2-µm electronic rack had to be mechanically adapted and a stress analysis was performed and reviewed by DLR certification engineers. The required documentation to obtain a “Unobjectionable Form” were prepared and sent to the approval authority (“Musterprüfleitstelle”). A final approval is expected from that authority after a ground test related to EMC was performed inside the aircraft after integration of the A2D and 2-µm wind lidar.

The following improvements and modifications on the A2D have been performed since the end of the second ground campaign (August 2007):

- the refractive index-matching fluid inside the Electro-Optical-Modulator EOM of the receiver front optics was refilled; a visual inspection of the fluid level has been performed, but the signal transmission has not been verified with atmospheric signals. It was not necessary to dismount the EOM for this procedure, thus no issues with misalignment are expected.

- the Reference Laser Head RLH was modified by Innolight in order to achieve a different temperature and thus frequency for the reference laser in order to match the A2D power laser oscillator gain profile. This was verified at DLR with Optical Spectrum Analyser measurements. In addition the diodes from the seed laser were exchanged, because of degradation, and the heterodyne path of the seed/reference laser was realigned to solve the problems with the PLL locking range. It was verified at DLR, that the problems with the PLL locking were solved and the RLH can be tuned over a frequency range of about 11 GHz without mode-hopping.

- the light leakage of the OBA was identified at the connector bracket and the connector bracket were covered with additional tape.

- the settings of the Ramp-Fire electronic were tested in order to achieve a pre-trigger time of 60 µs before laser pulse emission. This was achieved by a longer time for the piezo ramp, and by using 3 interference peaks from the LPO laser cavity. A trigger electronic to provide the correct trigger scheme for the DEU was developed and tested.

- the A2D power laser head IR path and UV path was re-aligned and the UV beam expander was exchanged by a type with higher magnification (from 4 to 5); thus the beam diameter was increased and the divergence decreased. The laser energy was determined to be higher than 60 mJ and a beam divergence measurement with a 2-m lens was performed. Preliminary analyses show M^2 values of around 1.2 (before 1.8) and a laser divergence of below 100 µrad (± 3 σ).

- a small damage on the Falcon aircraft window of 2-3 mm was detected at the begin of August. The aircraft window was polished by an external company in order to remove the damage. A pressure test for certification purpose was performed at DLR with success and the documentation prepared.

The A2D and the 2-µm lidar will be pointing in the same line-of-sight LOS direction to the right side of the aircraft (in flight direction) with a nadir angle of 20°. The instruments are mounted as follow

- the A2D aircraft frame is mounted with a pitch angle of -6° (pointing to the back) along the aircraft axis; the telescope is mounted such that it points towards the right with an roll angle of 20°
- the 2-µm is mounted with a pitch angle of -2° (pointing to the back) along the aircraft axis. It is equipped with a double-wedge scanner, which allows to point towards -6° and a roll angle of 20°. Small offsets in the order of 0.1° of the 2-µm pointing direction will be determined in flight.

The nominal operation of the 2-µm lidar will be the measurement of the LOS wind. Some conical step-stare scans will be performed in order to measure the horizontal wind vector during flight.

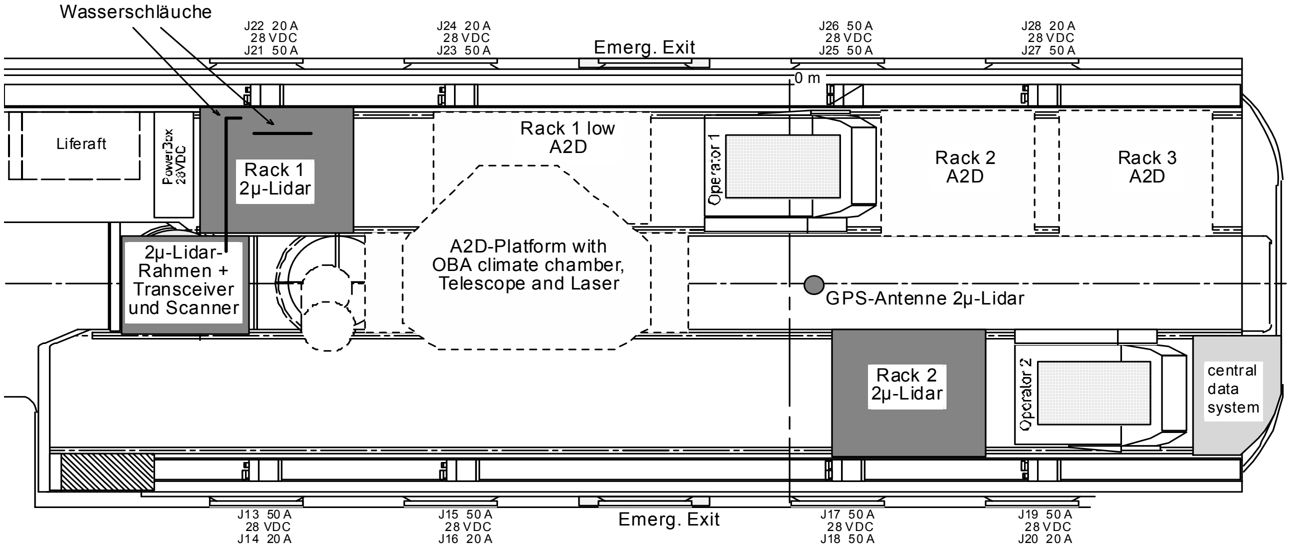

Fig. 1: Cabin layout of the Falcon aircraft with the A2D and the 2-µm lidar.

The vertical sampling of the A2D will be set such, that at least 2 range gates are below the ground of < 0 m ASL, and the first 3 km of the atmosphere are sampled with the highest possible resolution of 315 m (2.1 µs). The internal reference signal will be set in range gate 4, thus leaving a total of 20 range gates for atmospheric signals. Assuming a flight altitude of 10 km, which corresponds to a range of 10.6 km at a nadir angle of 20 °, the vertical sampling could set as:

- 1 range gate 4.2 µs = 630 m from range of -1.4 km to -0.8 km (Layer 24)
- 11 range gates 2.1 µs = 315 m from range of -0.8 km to 2.7 km (Layer 13-23)
- 2 range gates 4.2 µs = 630 m from range of 2.7 km to 4.0 km (Layer 11-12)
- 5 range gates 8.4 µs = 1.26 km from range of 4.0 km to 10.3 km (Layer 6-10)
- 1 range gate 2.1 µs = 315 m from range of 10.3 km to 10.6 km (Layer 5)

By rolling the aircraft with 20 °, a nadir angle of 0 ° for the A2D LOS can be achieved. This corresponds to a range of 10 km, and the range gates will be shifted towards lower ranges by 0.6 km, resulting in more ranges below ground. By rolling the aircraft with -18°, a nadir angle of 38° for the A2D LOS can be achieved, which corresponds to the satellite LOS nadir angle. Thus the range increases to 12.6 km, which corresponds to a shift of 2 km of all range gates. This has to be compensated by a different vertical sampling scheme, e.g. by change of 2 range gates from 8.4 µs to 16.8 µs, which corresponds to an increase in range of 2.5 km. Both rolling manoeuvres are foreseen to be performed over sea.

The 2-µm wind lidar will be operated in a fixed LOS pointing in the same direction as the A2D. The vertical resolution of the 2-µm is 100 m (for more details see AE.TN.DLR.A2D.TN31.080906).The laser pulse repetition frequency is 500 Hz and the signals from the atmosphere are sampled for every single laser shot and thus available every 2 ms. The signals will be averaged during post-processing stage within 1 s to obtain 1 LOS wind speed profile. Thus the horizontal resolution of the 2-µm LOS wind speed profile will be 200 m, assuming an aircraft ground speed of 200 m/s. It is possible to operate the 2-µm wind lidar in a conical scanning mode to obtain the horizontal wind vector. One scan is performed within about 20 s and thus the horizontal resolution of the wind vector profiles is about 4 km for 200 m/s aircraft ground speed. The accuracy of the horizontal wind speed is between 0.5 – 0.75 m/s, assessed during earlier airborne experiments by comparison with nearby dropsonde winds.

3.2 Instrumentation on the ground

It is foreseen to fly over Lindenberg and the sites of Bayreuth, Ziegendorf and Nordholz, which are equipped with the the same type of tropospheric 482 MHz windprofilers than in Lindenberg.

The following instrumentation will be operated at Lindenberg:

- 482 MHz windprofiler measuring vertical profiles of the horizontal wind vector, vertical wind speed and virtual temperature with a Doppler Beam Swing DBS technique during 30 minutes.
- the Raman lidar RAMSES operating at 355 nm during night hours (about 17:30 LT in November)
- 4 operational radiosondes at 0, 6, 12, 18 UTC for profiles of temperature, horizontal wind vector, relative humidity and pressure

No other ground instrumentation is installed at the sites in Bayreuth, Ziegendorf and Nordholz. The closest radiosondes to these sites are in the order of 100-200 km distance. It is foreseen to fly over the aerosol Raman lidar of IfT in Leipzig operating at 355 nm, 532 nm (and possibly 1064 nm, http://lidar.tropos.de/instrumente/ramanlidar.html).

The coordinates of the ground sites for AC01 from the network of aerosol lidars EARLINET (Fig. 2), windprofilers CWINDE (Fig. 3), and radiosondes (Fig. 4) are summarized in Table 1.

Site	Location	Instruments	next Radiosonde station
Lindenberg, North Germany	52.21 °N (52° 12.6') 14.13 °E (14° 7,8') 107 m	482 Mhz windprofiler (RASS), Raman lidar RAMSES, radiosonde	directly on site
Ziegendorf, North-Germany	53.31 °N (53° 18.6') 11.84 °E (11° 50,4') 55 m ASL	482 MHz windprofiler (RASS)	Greifswald (135 km), Bergen (140 km)
Nordholz, North-Germany	53.78 °N (53° 46.8') 08.67 ° E (8° 40.2') 18 m ASL	482 MHz windprofiler (RASS)	Schleswig (100 km), Emden (183 km)
Bayreuth, South-Germany	49.98 °N (49° 58.8') 11.68 °E (11° 40,8') 514 m ASL	482 MHz windprofiler (RASS)	Kuemmersbruck (63 km)
Leipzig, North-Germany	51.375 °N (51° 22.5') 12.446 °E (12° 26.8') 120 m ASL	Aerosol Raman lidar at 355 nm, 532 nm, (1064 nm)	Lindenberg (151 km)

Tab. 1: Coordinates of ground sites for AC01 from CWINDE network and EARLINET network

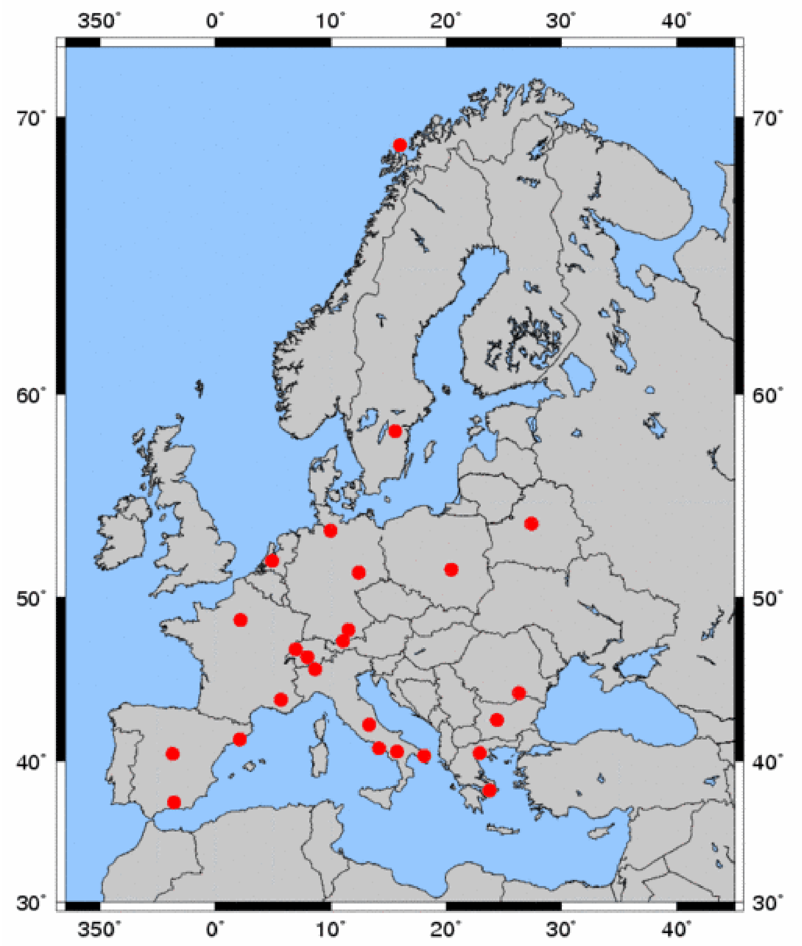

Fig. 2: EARLINET aerosol lidar network (http://www.earlinetasos.org/)

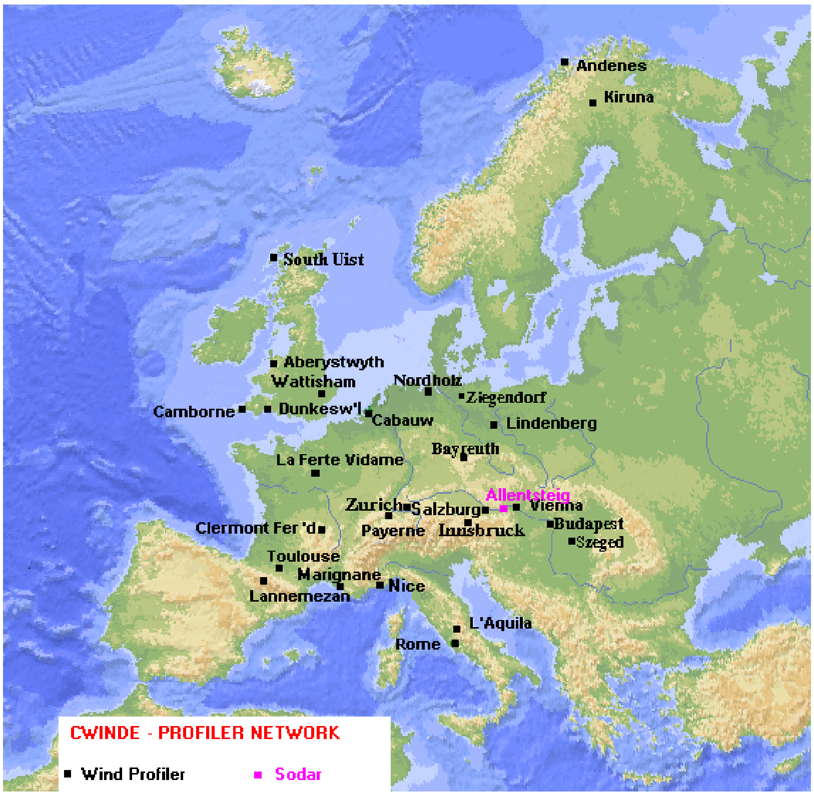

Fig. 3: CWINDE Profiler Network (http://www.meto.gov.uk/research/interproj/cwinde/)

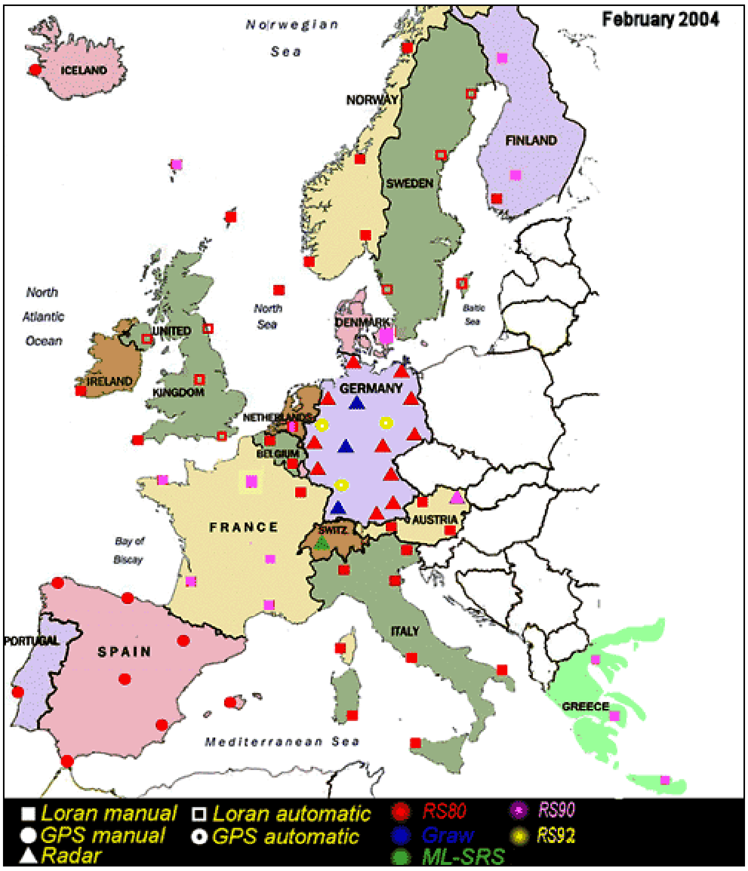

Fig. 4: Radiosonde Network (http://www.met-office.gov.uk/research/interproj/radiosonde/index.html)

4 Implementation

The aircraft will be based at DLR Oberpfaffenhofen. Integration of the A2D and 2-µm will start on November 8. The Falcon aircraft is available until November 30, but it is planned to finish the campaign by November 23. A ground test for EMC purpose is needed, because of the integration of the A2D and the 2-µm lidar, inside the Falcon aircraft for the first time. This test is foreseen for November 12. Thus the first flight is foreseen for November 13.

Flights can be performed during weekdays and during the weekend of November 17/18, if the weather allows. Weekend operation has to be decided on Thursday. Flight 1 has to be performed first; the order of flight 2, 3 and 4 can be exchanged. A flight altitude of 10 km (FL300) is foreseen for all flights. Each flight should have duration of about 4 hours. A total of 4-5 flights are foreseen.

The flights over sea should be preferably performed during calm wind conditions. The sea surface reflectance is strongly dependent on wind speed due to white cap reflections. Reflectivity is enhanced for higher wind speeds. In order to study the reflectance under different incidence angles (0°, 20°, 37,.6°), it is preferred to start with simple surface reflectance conditions for wind speeds below about 6 m/s.

4.1 Flight 1

Objective: Test A2D operation in the aircraft, test A2D laser triggering and frequency stability during flight, verify and possibly improve atmospheric path alignment

Weather: no clouds, or broken clouds during some parts of the flight needed

Flight Level: 10 km (FL300)

Flight path: no specific flight path requested, but some parts of the flight should have no/low cloud cover

Duration: up to 4 hours

Remarks: No operation of the 2-µm lidar, because no seat will be available for 2-µm operator, and 2-µm data acquisition will be used for A2D heterodyne measurements

4.2 Flight 2

Objective: Ground return flight

Weather: no clouds, or broken clouds during most parts of the flight needed; ground visibility, low surface wind speeds favorable, calm wind conditions over sea

Flight Level: 10 km (FL300)

Duration: up to 4 hours

Flight path:

1) Flight above Alps from North to South with possible overpass of Garda lake (3.6 km to the East off the N-S axis of the lake)

2) Flights above Mediterranean Sea:

    2.1) straight leg of 100 km,

    2.2) 1-3 circles with roll angle of 20° (right curve) for about 5 minutes per circle

    2.3) 1-3 circles with roll angle of -18° (left curve) for about 5 minutes per circle,

    2.4) straight leg of 100 km

3) Flight above Alps South-North with possible overpass of Garda lake (3.6 km to the West off the N-S axis of the lake)

4) Flight along Alps West to East from Bodensee to Chiemsee (or vice versa)

Remarks: Flight Level of 10 km and 20° off nadir angle results in separation of aircraft ground track to measurement ground track of 3.6 km

4.3 Flight 3

Objective: Study validation strategy

Weather: no clouds, or broken clouds during most parts of the flight needed, calm wind conditions over sea

Flight Level: 10 km (FL300)

Duration: up to 4 hours; flight will be performed during darkness; take-off in Oberpfaffenhofen at 17:30 (LT) and landing latest at 22:00 (LT)

Flight path:

1) Flight above windprofiler site Bayreuth (49.98°N, 11.68°E) with straight leg of 100 km centered at windprofiler

2) Flight above aerosol lidar site in Leipzig (51.375 °N, 12.446 °E) with straight leg of 100 km centered at Leipzig

3) Flight above windprofiler site Lindenberg (52.21°N, 14.13°E) with rectangular box of 100 km centered at Lindenberg (18 UTC = 19 LT radiosonde at Lindenberg)

4) Flight above windprofiler site Ziegendorf (53.31°N, 11.84°E) or Nordholz (53.78°N, 8.67°E) with straight leg of 100 km centered at windprofiler

5) Flight above Baltic Sea or North Sea, with possible circles of 20° (right curve) and -18° (left curve) roll angle

6) Flight above windprofiler site Ziegendorf/Nordholz

7) Flight above windproifler site Lindenberg

8) Flight above aerosol lidar site Leipzig

9) Flight above windprofiler site Bayreuth

Remarks: Flight Level of 10 km and 20° off nadir angle results in separation of aircraft ground track to measurement ground track of 3.6 km; permission for landing later then 21 LT has to be obtained.

4.4 Flight 4

Flight 4 is same as Flight 3 but during day hours

4.5 Flight 5

A possible 5th flight will be performed to repeat one of the flight patterns during flight 2, 3 or 4.