EUFAR Expert Working Group:

Instrument Design and Installations

Met Office, Exeter, UK. 21-23 November 2007

Meeting Report (deliverable N4.T2.M59.D9)

1) Introduction

This EWG was originally proposed to provide input on a number of areas that are of relevance to the overall aims of the EUFAR I3. These are, in particular:

- to improve expertise amongst the scientists using and operating the aircraft facilities and to ensure its continuity,
- to facilitate the transfer of expert knowledge to users and vice versa,
- to avoid unnecessary duplication of instruments or other associated facilities.

It is clear that both the EUFAR aircraft operators and many of their scientific user groups invest significant resources into the development of specialist instrumentation. Hence, it was considered a worthwhile activity to examine the process by which this happens.

2) Agenda

Wednesday 21 November

1200	Lunch available in Met Office staff restaurant	
1300	Welcome and introduction to EUFAR	Phil Brown
1330	Design/Installation case study: Radar / lidar systems	Noel Grand
1415	Design/Installation case study: AVIRAD aerosol sampling system	Paola Formenti
1500	tea / coffee	
1530	Design/Installation case study: Modification of the BAT probe for the BAS Twin Otter	Russ Ladkin
1615	Design/Installation case study: Laser-Induced Fluorescence NOx measurement	Piero Di Carlo
1700	close	

Thursday 22 November

0900	Design/Installation case study:	

	The introduction of modifications to aerial platforms Maria Molina
0945	Design/Installation case study: The Airborne MultiSpectral Sunphoto- and Polarimeter (AMSSP) for the HALO aircraft. Thomas Ruhtz
1030	tea / coffee
1100	Discussion – adaptation of commercial instruments to operate in the aircraft environment.
1300	Lunch in Met Office staff restaurant
1400	Discussion – standardization of data outputs
1530	tea / coffee
1600	Discussion – reduction of workload for instrument operators and complete automation.
1730	close

Friday 23 November

0900	Discussion – designing to assist the interchangeability of instruments between aircraft.
1030	tea / coffee
1100	Discussion of recommendations and outcomes of the workshop
1230	close

The first part of the agenda was devoted to presentations on a number of instrument case studies. The aim of these presentations was to show:

- the design specification for the instrument
- restrictions imposed by factors such as cost, weight, power requirements, physical size and aircraft certification issues
- what solutions were developed to overcome these constraints

Noel Grand (LISA) described the radar/lidar installation on the SAFIRE ATR-42 and Falcon-20.
Paola Formenti (LISA) described the AVIRAD aerosol sampling system.
Russ Ladkin (British Antarctic Survey) described the addition of meteorological instrumentation to one of the BAS Twin Otter aircraft.
Piero Di Carlo (univ. of Aquila) described the development of a laser-induced fluorescence instrument for NOx measurements.
Maria Molina (INTA) described the process of introducing modifications to the INTA aircraft.
Thomas Ruhtz (FUB) described the development of the Airborne Multispectral Sunphoto- and Polarimeter for installation on the forthcoming HALO aircraft.

All of these presentations are available from the EUFAR website via the link to this EWG and meeting.

Discussion areas:

3) Adaptation of commercial instruments

Some good examples of how commercial instruments or components have been utilized for airborne research applications were discussed. These included:

- Zeiss spectrometer modules used in visible and NIR instruments on the FAAM aircraft – now adapted with custom software but basically worked straight away.
- The TSI nephelometer used for aerosol scattering measurements by several groups. Whilst this is not well-packaged for airborne use since it takes a large amount of rack space, it does the job OK. The Met Office has introduced a minor adaptation for extra lamp cooling but this is for the special purpose use of the instrument as part of a twin-instrument package that measures both the dry- and moist-air scattering properties of the aerosol.
- Big Sky and SpectraPhysics lasers are used as key components of other systems.
- TSI 3010 and 3025 CN counters are widely used for condensation particle measurements.
- SHOALS lidar 1000T. This has been used by INTA to collect topographic and bathymetric data of the Spanish Mediterranean coastal zone. Results were quite promising and an extensive project to map the whole coast of Iberian Peninsula is under preparation.

Some common issues relating to the use of commercial instruments were identified:
- There are sometimes problems with the adaptation to aircraft power supplies eg. 28Vdc.
- Instruments may require protection from pressure changes (especially rapid changes of pressure and humidity during ascents / descents).

The provision of anti-vibration mounts was considered not to be a significant issue. Even where PC data logging systems are involved, these can often tolerate the sort of vibration levels found within aircraft cabins.

Some commercially acquired instruments have standard mounting footprints eg. Rosemount temperature sensor housings. These may be exploited for other purposes. For example, such Rosemount sensor housings are also used to provide air intakes for gas and aerosol sampling. The mounting-bolt layout is also used by other instruments.

However, some potential problems were also noted with commercially acquired instruments:

- Standard operating software can be a "black box" where it is difficult to make modifications to integrate with other systems.
- Space and power requirements – some commercial systems are not well-adapted to the requirements of small aircraft cabins. Even on the larger aircraft (146 / ATR) there are demands to minimize space occupied by existing instruments.
- Electronic noise generation by commercial systems – these may not be well-adapted to working with typical aircraft grounding arrangements.

How to pass on the expertise?
EUFAR technical reports. These need to be relatively informal to reduce the workload in producing them and can assume some basic pre-existing knowledge. It can be a

function of the Expert WGs to survey the community at intervals to ensure that as many useful developments as possible can be reported in this way.

4) Reduction of operator workload – automation

A number of issues were discussed:

- Remote operation via Ethernet – one person can operate more systems and this may also assist in the optimization of aircraft cabin layouts if the operator is not required to sit directly at the instrument.

- Use of real-time data transmission to ground to enable remote monitoring or control of research flights. The initial cost of SATCOM systems can be very high, and operating costs significant. It can, however, assist the control of flight projects by a central ground controller and enable up to date information (for example satellite cloud images or updated weather forecast charts) to be passed to the aircraft.

- The needs of data users should be noted. There is a need to maintain documentation on automatic processes that may be used by aircraft operators (for example, data acquisition and processing) in order to assist inexperienced users of aircraft data.

5) Standardization of data outputs or control systems

Pc-based control systems get obsolete quite quickly. There are advantages to using USB or Ethernet interfacing.

Labview software is in common use for data logging and instrument control. PCMCIA cards are available to replace standard National Instruments cards, to enable operation from a laptop. Labview is available to use under Linux although there may be some problems with device driver availability.

Software control is more easily adaptable than hardware. Access to external consultancy for software development is possible in some cases, as described in Paola Formenti's case study.

Some instrument systems require data inputs from other instruments, for example, attitude data from GPS or INU, temperature pressure etc. If systems are to be transferable between aircraft, then it is necessary to have common standards of data inputs. There are some possibilities for standardization across EUFAR fleet, starting with simple issues such as time-stamping of data. DLR is developing standard protocols for Ethernet distribution of real time data.

6) Assisting the interchangeability of instruments between aircraft

There is a clear need to maintain standards of physical, electrical and software interfaces. One example of this concerns PMS canister probes that are widely used across the EUFAR fleet but frequently modified eg. by changing details of cabling. Documentation can help in this issue in order to indicate to new developers which standards are being commonly exploited.

Certification issues. Documentation prepared for one aircraft is not usually acceptable to fit the instrument on another. There are some possibilities for harmonization between operators – eg. the preparation of electrical cable schedules.
Possibility of expending additional resources during initial fit to one aircraft in order to provide information that would assist wider certification.

Physical limitations may be imposed by the use of certain hardware such as equipment racks. The racks used on the FAAM BAe 146 racks would not fit on many other aircraft although reverse exchanges might be possible. DLR racks used on the Falcon-20 are already certified for use on the SAFIRE Falcon and can also enable instruments to be operated on the future HALO aircraft without modification. The seat rail gauge is standard to several aircraft, including for example the INTA CASA-212, and so is potentially a viable means of exchanging instrument installations between the larger and medium-sized aircraft in the EUFAR fleet.

We should seek out opportunities to try this process of rack-swapping where possible. For example the CASI/ATM could be trialled on the 146 using a DLR rack as has already been used on NERC/ARSF Do-228.

7) Provision of technical backup to instrument developers

The role of airflow-modelling for instrument design was discussed, both on the scale of whole aircraft and in a more detailed way for individual instruments or inlets. The ability to do this depends on having access to an appropriate digital model of the solid body to be modelled. Where this is a custom-built instrument or intake, this is likely to be easily available from CAD software. However, it is more problematic for an entire aircraft and may even be proprietary information to the manufacturer. There is a need for established relationships between user groups and aircraft operators.

FLUENT and other flow-modelling codes are commercially available. Alternatively, funding is needed to pay experts to do it for you. The status of research licence to use such software was not known. Some user groups already have access to such expertise within their own institute or national atmospheric science community eg. IfT in Germany. There are some issues with continuity of expertise in this area.

Chemical intakes – some reliance on systems already designed in the US.

DLR has a technical manual to assist new users. Something similar is in preparation for the FAAM BAe146.

The CNRS in France has ain internal mechanism for providing central technical support to proposals that have passed scientific review and obtained funding. This supports a wide scientific community in France. The provision of standard equipment racks accommodates some of this support requirement, since such racks normally have a specification of load, centre of gravity etc. that instruments should be designed to meet.

8) Funding for certification of new instruments

At SAFIRE and the DLR, the cost of installing instruments that are purely internal is essentially free although certification costs must be met for anything that is external to the aircraft. At DLR, if any testing is required then this must be separately funded.

Standard mountings such as pods or PMS canisters can make the process easier and/or cheaper. It was noted that DLR is designing a future new Ethernet interface to PMS canister instruments.

The question of funding for support of instrument test and calibration was discussed. This also covered data processing after flight as this may also require development.
Several EUFAR operators have around 10 flight hours per year that is centrally funded for testing but this was generally regarded as inadequate. The US IDEAS programme has provided dedicated flight time scheduled in a fixed period for new instrument test and development. There is no current equivalent to this within Europe.

Recommendations

1) To aircraft operators

- Promote a broad exchange information on standards (electrical, physical, software etc.) that are employed currently.
- Contribute EUFAR technical notes.
- If it does not presently exist, prepare a "User handbook" – documentation available to all potential users of an aircraft that shows them how to prepare instruments for certification. This should also be available via EUFAR website.
- Create supplies of key mechanical components that may be required by instrument developers (eg. mounting brackets to connect racks to seat rails, together with the racks themselves).

2) To scientific users

- Read the User handbooks at an early stage.
- It is better to build a new instrument for potential aircraft use straight away rather than re-engineering later.
- The main requirement for high-quality components comes in EMC protection and power supplies.

3) To funding agencies

- Future TA funding should be capable of accommodating some larger projects with more available flying time where exchange of instrumentation can be more cost-effective.
- Support a EUFAR technical coordinator to facilitate instrument exchanges and harmonization of eg. flight planning systems.
- Provide resources to support user access to key technical expertise (eg. numerical flow modelling at both aircraft and instrument scales).

4) To the EUFAR office

- Establish an Instrument Development Newsletter where both users and operators can give early information about their plans and promote exchanges with other groups.