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PU	Public	x
PP	Restricted to other programme participants (including the Commission Service)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (excluding the Commission Services)	

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Abstract: The purpose of this deliverable is to describe the improvements made to the Aarhus Planetary Environment facility at Aarhus University completed under the activity JRA2 and to verify the transfer of these new capabilities to the TA2 facilities.

All of the envisioned improvements/upgrades to this facility have been completed and most have already been utilized ahead of schedule in a series of TA2 projects.

There have been three major improvements to the Aarhus facility implemented under JRA2, these are;

1. A particle image velocimetry system,
2. A dedicated gas cooling system and
3. A UV solar spectrum simulator.

These upgrades are now fully functional and available for scientific studies (under TA2 access). Advertising of these new capabilities to the community for use in future TA2 calls is being made through Europlanet home pages and Facility sites.

Report;
In this deliverable the improvements made to the Aarhus planetary environment facility (PEF), Aarhus University will be presented. These were completed under the activity JRA2 and have now been transferred to the TA2 programme.
There have been three major improvements to the facility (PEF). These are; 1) a particle image velocimetry system, 2) a dedicated gas cooling system and 3) a UV solar spectrum simulator (LED based).

Details are described below;

1) A (Particle Image velocimetry) **PIV system** including high speed camera and laser sheet systems. (Deliverable; Milestone 64 under Task 8.2.1).
J. Merrison, J.J. Iversen (AU), M. Patel (OU), B. Weinzierl (DLR)

Major components for the PIV and high speed imaging system have been designed, procured and constructed somewhat ahead of schedule allowing installation around month 5 into the Europlanet 2020 RI project at which time some preliminary tests were performed. The tests involved both high speed imaging of wind driven dust/sand re-suspension and also of dust injection i.e. aerosol jets.
The systems functioned entirely as anticipated and already at the test stage interesting phenomena were observed which had previously not been possible within the facility, including dust aggregates being entrained (lifted), transported and breaking up to generate dust airborne dust.

Figure 1 Left: the high speed camera and lighting (laser) system installed within the AWTSII facility (within the pressurized chamber); center: a high speed image of dust and aggregates leaving a 4mm wide nozzle at high velocity into the AWTSII chamber (at 10mbar); Right: high speed images of volcanic ash being removed by wind flow within the AWTSII facility showing rolling sheets of cohered fine ash.

In addition to the procurement of a high-speed camera, an adequate lighting system was required as well as a mechanical system in order to allow its operation within the low-pressure environment of the AWTSII chamber.
Primary new science capabilities will be the possibility to study in-situ dust /sand transport dynamics occurring on short time scales (milliseconds and less).
The systems have functioned entirely as anticipated and have even been used for two of our TA2 access campaigns (ahead of schedule), specifically 15-EPN-005, 15-EPN-003 with also related presentation/publication of this work.

2) An **Air cooling system** (Deliverable; Milestone 67 under Task 8.2.2).
J. Merrison, J.J. Iversen (AU), M. Balme (OU), W. Goetz (MPS)

An air cooling system has been designed, procured and constructed somewhat ahead of schedule allowing the installation to occur already around month 12 into the Europlanet 2020 RI project and preliminary tests were performed. Although some technical issues were identified these have now been corrected for.
Primary new science capabilities will be the ability to independently control the gas (air) temperature within the facility, specifically with the possibility to produce and study ice and ice covered aerosol particles (also at low pressure). Important design parameters will be the radiative and conductive heat exchange with the gas, the cooling capacity, cooling time and uniformity of the system, and also the aerodynamic aspects i.e. not disturbing the air flow and dust suspension capabilities of the wind tunnel simulator.
Tests of this system involved measuring the air temperature under low pressure conditions (of order 10mbar) while applying liquid nitrogen cooling to the cooling system.

Figure 2 Left: air cooling system being installed into the AWTSII facility; centre: the cooling system (anodized aluminium fins and cooling blocks) having been installed within the wind tunnel; right: the specialized liquid nitrogen inlet/exit flange and valve system.

The new air cooler now functions as anticipated with a minimum (average) chamber air temperature of < -50°C while applying wind. Previously it was not possible to obtain air temperatures significantly below 0°C. This system has also been used in two TA2 access campaigns (ahead of schedule), specifically 15-EPN-016, 15-EPN-023 with also related presentation/publication of this work.

3) A **Solar Simulator system** (Deliverable; Milestone 69 under Task 8.2.3)
J. Merrison, J.J. Iversen (AU), M. Patel (OU), W. Goetz (MPS), W. Van Westrenen (VU)

Advantages of an LED based (far) UV solar simulator as compared to, for example, a traditional discharge lamp is that they do not emit significant amounts of other (unwanted) radiation, specifically they do not generate optical and thermal (infrared) radiation. This allows the effects of UV exposure to be separated from those of heating. Additionally their light emission is stable, reproducible and controllable.
An LED based (far) UV solar simulator has been designed, procured and constructed. Compromises in uniformity were made in order for practicality and affordability however the initial criteria for lamp operation were in fact exceeded. Installation and testing of the lamp demonstrated a higher overall optical irradiance than specified.
The systems functioned entirely as anticipated also at low pressure (10mbar) where stable operation was demonstrated for over 80 minutes.

Figure 3. Left: the UV LED system installed into the AWTSII chamber prior to testing at low pressure, centre: view inside the UV chamber during operation, right: a UV-optical irradiance spectrum obtained from within the chamber during operation.