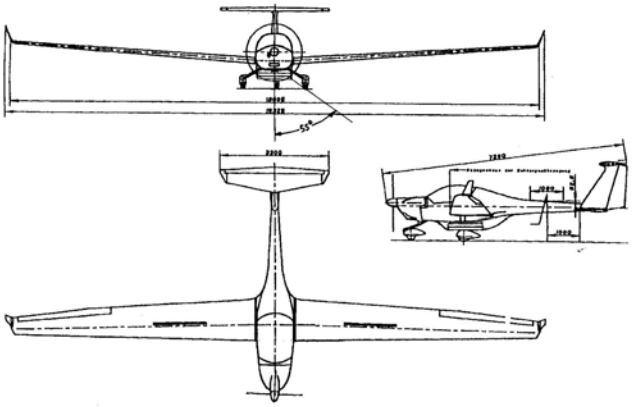
ECO-Dimona

(*VH-EOS & VH-OBS*)



Airborne Research Australia

Flinders University, Adelaide

Environmental Research

Version 14 July 2004

Aircraft specifications

Aircraft Type	HK 36 TTC ECO-Dimona	2 available: VH-EOS & VH-OBS
Manufacturer	Diamond Aircraft Austria and Canada	
Dimensions	• Length: 7.28m • Height: 1.80m • Wingspan: 16.33m	
Powerplant	• Rotax 914S, turbocharged, 115HP, constant speed propellor • preferred fuel is Premium Unleaded petrol, but can also use AVGAS	
Max Take-off weight	930kg	
Empty weight	636kg	
Payload	• 294kg total • 120kg typical scientific payload	incl. crew, fuel, instrumentation
Certification etc.	• Day and Night VFR operations • No cloud flying • Restricted Category	
Crew	1 or 2 (typically pilot/scientist + scientist)	
Cruising speed range	• 50 – 110kts • 92 – 203km/h • 25 – 55m/s	
Endurance / Range	• 4 – 8hrs depending on power setting and flight profile • 800 – 1,500km / 400 – 700NM depending on power setting	with standard fuel tanks
Ceiling	• above 6,000m / 18,000ft (with breathing oxygen for crew – cabin not pressurised) • normal ceiling without breathing oxygen: 3,000m / 10,000ft	
Special characteristics	• Extended operations over water possible, but if outside of gliding distance from land (based on glide ration of 1:20) require carriage of special equipment (lifejackets, liferaft, flares, emergency locator beacon, other survival equipment). • Maximum scientific payload AND maximum endurance can only be realised when operated single seated (pilot only, no additional operator). • Operations from sealed and unsealed runways (>500m in length) • For detailed flight options, contact operator.	
Electrical power	• 28VDC, 12VDC, 240VAC with total of 1kVA • for instrumentation requiring power of more than 100W on any supply, confirm with operator	
Aircraft avionics	• Garmin GNS430 GPS Moving Map navigation system (including VOR/ILS with markers) • slaved HSI-system • 2 VHF communications tranceivers • Stereo intercom • Transponder Mode C	
Special features	• 2 underwing pods (max 55kg each) – suitable to carry 19” rack mounted instruments • room for approximately 30kg of instrumentation in luggage rack in cockpit (plus 80kg in r/h seat/footspace, if operated with one crew only) • custom-designed r/h operator’s console in cockpit (no flight instruments – enhanced forward vision – foldable large data screen) • optionally no flight controls on r/h seat (more work space for operator) • fittings for scientific instruments at wingtip (light-weight only)	

Standard Instrumentation – Aircraft Parameters

Instrument	Parameter(s)	Range	Resolution	Accuracy	Comments
Trimble TANS Vector GPS	time	UTC	1ms 1Hz	1ns	using 1s-pulse
	position/altitude(lat/lon)	global	1m 1Hz	5..20m	better with differential correction
	ground speed (3-D)	0..200m/s	0.1m/s 1Hz	0.1m/s	better with differential correction
	attitude (pitch, roll, heading)	0..60˚ 0..360˚	0.1˚ 10Hz	0.1˚	
Novatel 12-channel GPS	time	UTC	1ms 10Hz	1ns	using 1s-pulse
	position/altitude(lat/lon)	global	1m 10Hz	5..20m	better with differential correction
	3-D ground speed	0..200m/s	0.1m/s 10Hz	0.1m/s	better with differential correction
Rockwell-Collins AHS-85 (in r/h wingpod)	attitude (pitch, roll, heading)	0..60˚ 0..360˚	0.1˚ 52Hz	0.1˚	
	angular rates (pitch rate, roll rate, yaw rate)		0.1˚ 52Hz		
	3-D accelerations				
King KRA10 radar altimeter	height above ground or water	5-800m	0.1m 10Hz	1..5m	depending on underlying surface and aircraft attitude
Radio transmission indicator	periods of transmissions on aircraft's VHF transceivers		50Hz		

Standard Instrumentation – Atmospheric Parameters

Instrument	Parameter(s)	Range	Resolution	Accuracy	Comments
BATprobe with FUST (mounted under r/h wing)	flow angles (angles of attack and sideslip)	±30º	0.02º 50Hz	0.1º	
	indicated and true airspeed	10..80m/s	0.1m/s 50Hz	0.2m/s	
	static pressure	1100..400hPa	0.1hPa 50Hz	0.5hPa	
	air temperature	-50..+100ºC	0.1º 50Hz	0.5º	
	3-D accelerations	±1.5g	0.001g 50Hz	0.01g	
	3-D wind and turbulence	0..100m/s	0.02m/s 50Hz	0.1m/s	
	turbulent fluxes	sensible heat flux latent heat flux (evaporation) – using LiCor 7500 for humidity CO_2 flux – using LiCor 7500 for CO_2 momentum flux			
LiCor 7500 open-path IR-gas analyser (mounted under r/h wing)	water vapour		20Hz		
	CO_2 concentration		20Hz		
MeteoLabor TP4 dewpoint mirror (in r/h wing pod)	air temperature	-50..+100ºC	0.1º 10Hz	0.5º	thermocouple
	dew point	-50..+50ºC	0..1º 10Hz	0.5º	

Standard Instrumentation – Remote Sensing

Instrument	Parameter(s)	Sensor resolution	Best ground resolution	Comments
TSLS AWI/ARA Tri-spectral line scanner	red, green, blue, near-IR, ndvi	2048 pixels 3 channels	0.7m	
FLIRTS SC60 IR-imager	IR-surface temperature	640 x 480 pixels 0.08K resolution ±2K absolute	depends on flying altitude	spectral range 7.5 to 13µm
PLMR Polarised Low-Frequency Microwave Radiometer	soil moisture in the root zone (~10cm depth) sea surface salinity	6 beams across track at 17º viewing angle (push-broom)	depends on flying altitude; 50m at 150m flying height	in combination with IR-imager
3-CCD digital video camera	progressive scan digital video	720 x 576 PAL		
Digital still camera		11.1 Mega-pixels		Canon EOS 1D-S
2 and 3-band VegMeters	irradiances (upwelling or downwelling) 630, 780, 830nm		<0.1m	viewing angle 2º
fwd-looking lipstick video camera		720 x 576 PAL		
Riegl LMS-Q140i Laser Scanner	height of underlaying terrain		1m horizontal 0.02m vertical	acquisition of LMS-Q280i planned

Standard Instrumentation – Data Systems

System	Capabilities	Comments
Central system	Several PC/104-based real-time systems	

Other Instrumentation available for VH-EOS

Instrument	Parameter(s)	Range	Resolution	Accuracy	Comments
2nd BATprobe with FUST	same parameters as 1st BATprobe				mounted under the other wing
Honeywell LaserNav INS	attitude (pitch, roll, heading)	0..60˚ 0..360˚	0.1˚ 52Hz	0.1˚	
	angular rates (pitch rate, roll rate, yaw rate)		0.1˚ 52Hz		
	3-D accelerations				
	3-D inertial position (lat/lon/alt)				
LiCor 6262 closed-path IR gas analyser	water vapour				
	CO_2 concentration				
LiCor 6251 closed-path IR gas analyser	CO_2 concentration				
PSI Ozone analyser	Ozone concentration	2ppb..1ppm	1ppb 4s	1..2ppb	UV absorption
MetAir NOxTOy 6-channel Luminol-detector with CrO3- and Mo-converters	NO2, NOx, NOy, HNO3, PAN, Ox	0.5..500ppb	0.1ppb 1..5s	0.5ppb	currently not operational
TSI particle counter	CNC, LPC				
Monitor Labs gas analyser	NO, NO_2, NO_x				chemiluminescence
Monitor Labs gas analyser	SO_2				fluorescence
TECO 48 gas analyser	CO				gas filter correlation
MRI Nephelometer	backscatter				
Horiba gas analyser	CH_4, NMHC				FID selective oxidation
Eppley hemispheric radiometers	up- and downwelling solar and terrestrial radiation				PIR, PSP
Net radiometer					
Heimann KT15	IR-surface temperature	-20..100ºC	0.1º	0.5º	4º viewing angle

Instrumentation for ECO-Dimona available from international partners

A wide range of additional instruments and sensor systems is available through ARA's international partners. These isntruments and systems can easily be fitted to the ECO-Dimona and are available to the users of the aircraft. For some of the sensors, special conditions exist – as listed. Some of the instruments would require an operator from the collaborating institution to participate in the measurements.

The partners include

- Forschungszentrum Jülich, Germany (FZJ)
- Forschungszentrum Karlsruhe, Germany (FZK)
- Hochschule Anhalt, Germany
- MetAir AG, Switzerland
- NOAA, ATDD Oak Ridge/Tenn., USA
- Paul-Scherer-Institute, Switzerland (PSI)
- UMIST – University of Manchester, Institute of Science and Technology, Manchester, UK
- University of Wales, Aberystwyth, UK
- York University, Toronto, Canada

Third-Party Instrumentation – Remote Sensing

Instrument	Parameter(s)	Sensor resolution	Best ground resolution	Comments
hyper-spectral imager **Specim AISA+**				see http://www.specim.fi/products-aisa-aisa+.html Owned by L Bannehr, Hochschule Anhalt
Aerosol Lidar				under developmen at York University (J Whiteway)

Third-Party Instrumentation – Air Chemistry/Pollution

Instrument	Parameter(s)	Range	Resolution	Accuracy	Comments
AirMotec gas-chromatograph HC-1010 (modified by MetAir)	speciated hydrocarbons (C_4…C_{10}) see list below	10ppt...10ppb	10ppt	10ppt/50ppt or 20%	
AeroLaser AL-5003 gas analyser (modified by MetAir)	CO	2ppb..5ppm	1ppb 10Hz	1..2ppb	vacuum UV-fluorescence
Gas analyser (Junkermann, IFU-IMK)	Peroxides (H_2O_2 and organic)	0.1..20ppb	50ppt 10s	0.1..0.5ppb	enzymatic fluorometry; owned by PSI
AeroLaser gas analyser	Formaldehyde (HCHO)				owned by PSI
Scintrex LOZ-3	Ozone	1ppb..1ppm	0.1ppb 10Hz	10ppb	
Fluorimeter	CH_2O		90s		
Manual sampling of up to 12 glass flasks					
Automatic sampling units for VOCs, biogenic VOCs, SF_6, etc.					

Third-Party Instrumentation – Aerosol / Particles / Radiation

(owned by IMU-FZK or MetAir)

Instrument	Parameter(s)	Range	Resolution	Accuracy	Comments
TSI Condensation Nuclei Counter	aerosols (>10nm)	0..10,000cm^{-3}	1cm^{-3}/1s	1/10cm^{-3}	
TSI 3010	condensation nuclei	>0.01..3µm	1s		
MetOne 4903 Laser particle counter	aerosols (number)	>0.3µ >0.5µ 0..150cm^{-3}	2s 1cm^{-3}	1/10cm^{-3}	2 channels
15-channel aerosol spectrometer	aerosols (size distribution)	>0.3µ..20µm			
FSSP 100	aerosols (size distribution)		6s		20-40 channels
nano SMPS	submicron aerosol size distribution				
TSI 3563 Nephelometer	backscatter coefficient	450, 550, 700nm	6s		
Schmitt Actinic Spectro-radiometer		290..600nm	2s		up- and downwelling
7 channel Magee Aethalometer	optical properties				see http://www.mageesci.com/

List of substances identified by MetAir/airmotec gaschromatography

short	name:	remarks
i4	isobutane	ev. coeluting with acetaldehyde
n4	n-butane	coeluting with 1-butene and probably with isobutene
tn4en	t-2-butene	tentative identification
cn4en	c-2-butene	tentative identification
i5	isopentane	
ace	acetone	coeluting with n-pentene, see below
n5	n-pentane	coeluting with 2-me-1-butene, n-pentane main component
ipe	Isopren	coeluting with trans-2-pentene, see below
cn5en	c-2-pentene	
cp	cyclopentane	coeluting with 2.3-dimethyl-butane
2mp	2-methyl-pentane	
3mp	3-methyl-pentane	coeluting with unknown, ev . secondary component
n6	n-hexane	
mcp	methylcyclopentane	coeluting with 2.4-dimethyl-pentane
bz	benzene	
cn6	cyclohexane	
2mh	2-methyl-hexane	coeluting with 2.3-dimethyl-pentane
3mh	3-methyl-hexane	
i8	isooctane	or 2.2.4-trimethyl-pentane
n7	n-heptane	
mch	methylcyclohexane	
tol	toluene	
2mn7	2-methyl-heptane	probably coeluting with 4-methyl-heptane
3mn7	3-methyl-heptane	
n8	n-octane	
ebz	ethylbenzene	
mpx	m&p-xylene	m&p-xylene coeluting
sty	styrene	
ox	o-xylene	
n9	n-nonane	
cum	cumene	or isopropyl-benzene
ap	a-pinene	
pbz	n-propylbenzene	coeluting with unknown, ev . secondary component
met	m&p-ethyltoluene	m&p-ethyltoluene coeluting
135	135-trimethylbenzene	
oet	o-ethyltoluene	partly coeluting with unknown, ev . secondary component
124	124-trimethylbenzene	ev. coeluting with unknown, ev . secondary component
n10	n-decane	
123	123-trimethylbenzene	

Introducing ARA's new SERAs

Two Diamond Aircraft HK36TTC ECO-Dimonas

VH-EOS: commissioned in Jan 2004 – operational with instrumentation

VH-OBS: to be commissioned in October 2004

ECO-Dimona *VH-EOS & VH-OBS*

Aircraft specifications and operations

Dimensions:	*7.28m length, 16.33m wingspan*
Powerplant:	*Rotax 914S, turbo-charged, 115Hp constant speed prop* *uses unleaded petrol (or AVGAS)*
Weights:	*636kg empty weight; 930kg max take-off weight* *typical scientific payload: 120kg*
Operations:	*Day and night VFR*
Crew:	*1 or 2 (typically 1 pilot/scientist + 1 scientist)*
Speed range:	*50 – 110kts; 92 – 203km/h; 25 – 55m/s*
Endurance/Range:	*4 – 8 hours; 800 – 1,500km; 400 – 700NM*
Ceiling:	*above 7,000m/20,000ft* *(above 3,000m/10,000ft with breathing oxygen for crew)*

ECO-Dimona *VH-EOS & VH-OBS*

Special features for research

Electrical power : 28VDC, 12VDC, 240VAC (total of 1,000W)

Two underwing pods (max 55kg each, suitable to carry 19" rack-mounted instruments)

Room for approximately 30kg of instrumentation in luggage rack in cockpit
(plus 80kg in r/h seat/footspace, if operated with one crew only)

Custom-designed r/h operator's console in cockpit
(no flight instruments – enhanced forward vision – foldable large data screen)

Fittings for scientific instruments at wingtip
(light-weight only)

ECO-Dimona *VH-EOS & VH-OBS*

Standard aircraft and atmospheric sensors

Several GPS receivers (differential positioning capable)

GPS-based attitude system (10Hz, 0.1deg accuracy)
(pitch, roll angle, aircraft heading)

Inertial navigation systems
(for higher resolution attitude)

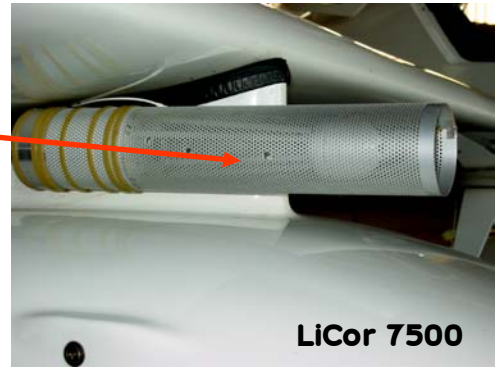
Radar altimeter

High resolution wind and turbulence probe

Fast air temperature sensors

Fast water vapour and CO_2 analyser

Modular data system with real-time
and telemetry capabilities
(wireless networked PCs, wireless Ethernet
or IRIDIUM down-link)



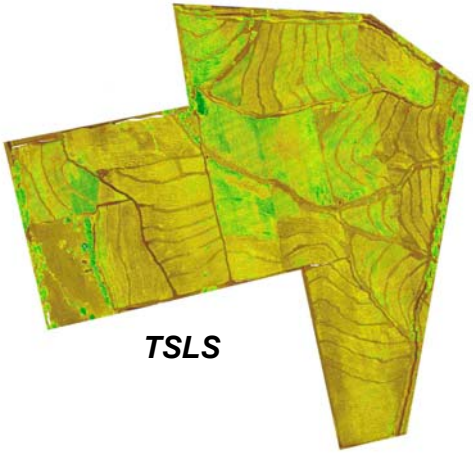
ECO-Dimona *VH-EOS & VH-OBS*

Remote sensing instrumentation

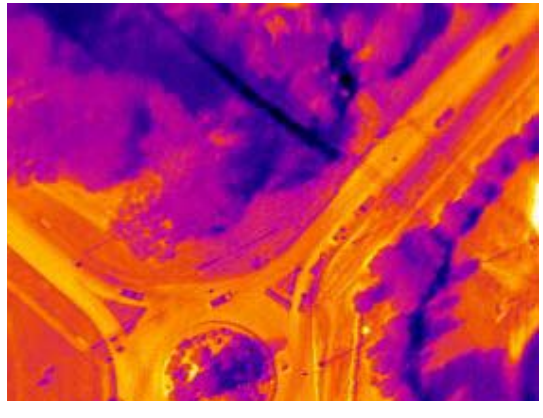
NDVI & false colour images: *ARA/AWI TSLS Tri-Spectral Linescanner (1024 pixels/line)*

IR-images: *FLIR S-60 Infra-Red Imager (640x480 pixels)*

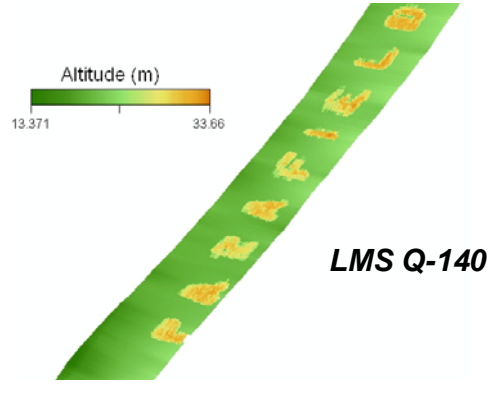
Terrain Altitude: *Riegl LMS Q-140 (to be upgraded to LMS Q-280)*
(funding pending)



TSLS



FLIR S-60



LMS Q-140

ECO-Dimona *VH-EOS & VH-OBS*

Remote sensing instrumentation – cont'd

Soil moisture: *PLMR Microwave Radiometer (from of end of 2004)*

Sea Surface Salinity: *PLMR Microwave Radiometer (from of end of 2004)*

Aerial photography: *Canon EOS D1s (11 Mega pixels)*

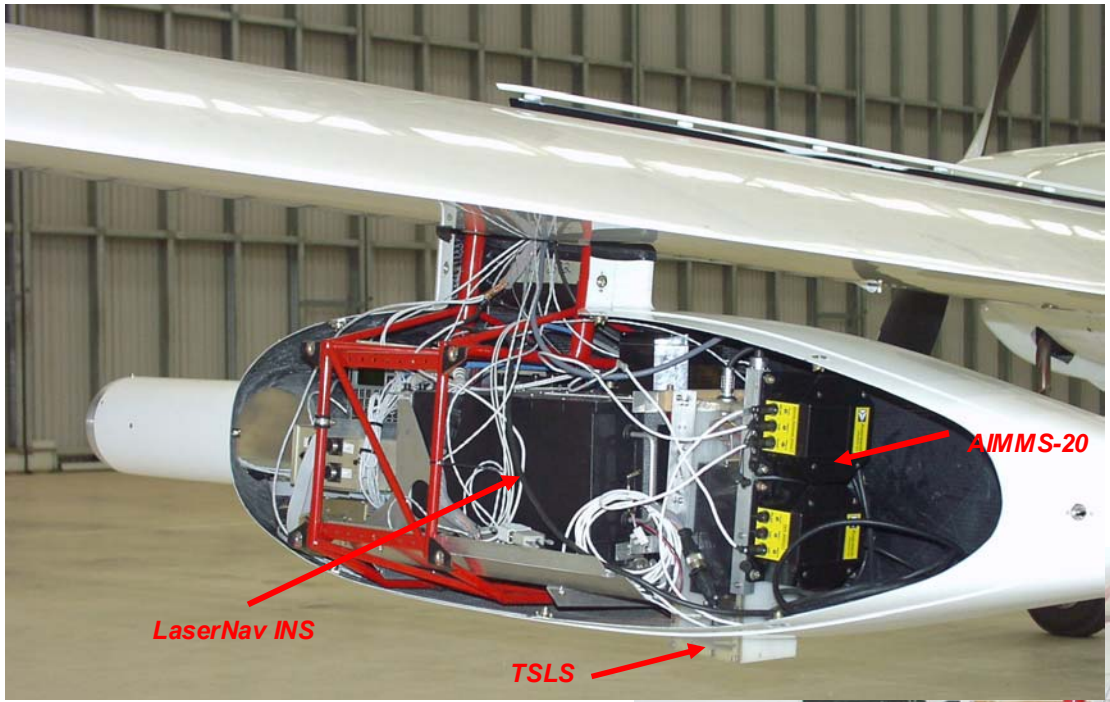
Aerial videography: *Various cameras (3CCD, progressive scan)*

Gimballed and stabilised camera mounts available, if required

FLIR S60 & EOS D1s

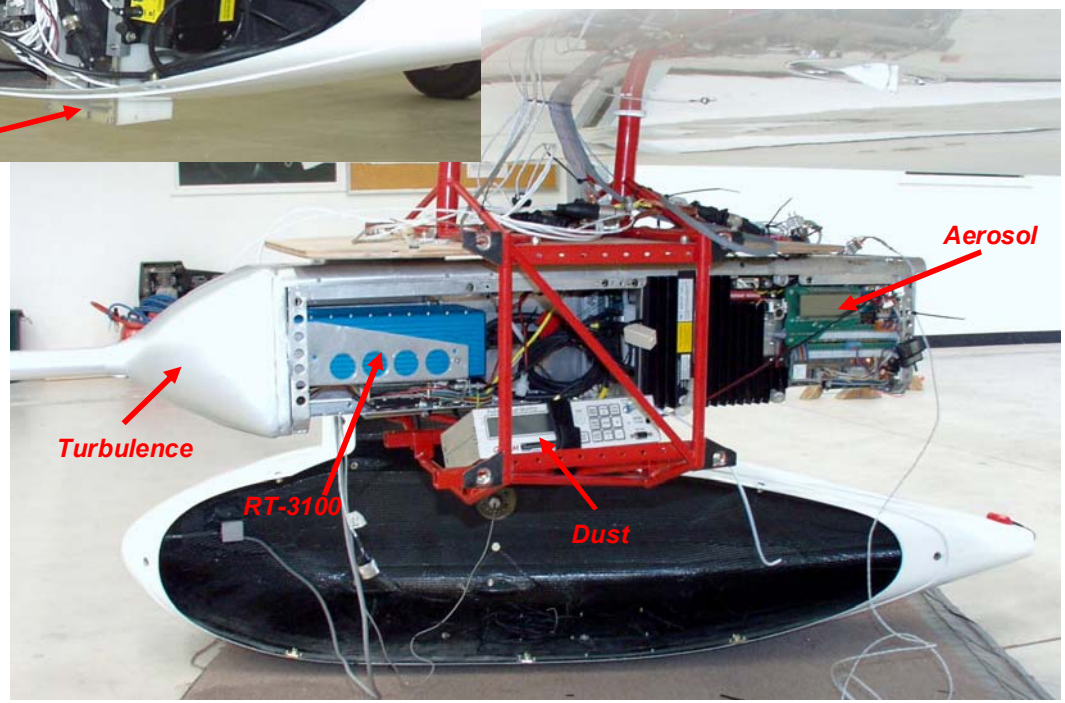
FLIR S60, EOS D1s and SONY DV

ECO-Dimona
VH-EOS & VH-OBS

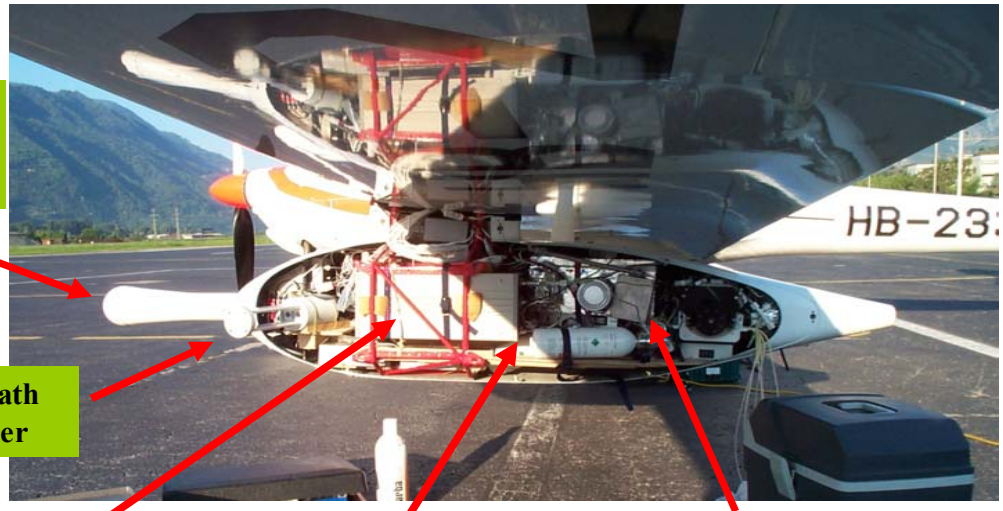


Aerosol & Turbulence pod of Research Centre Karlsruhe in right-hand wingpod; note OTS RT-3100 INS and dust monitor

Honeywell LaserNav INS, Aventech AIMMS-20 and ARA/AWI TSLS Scanner in left-hand win pod



Pods can be exchanged between operators...example MetAir, Switzerland



Wind, turbulence temperature, humidity

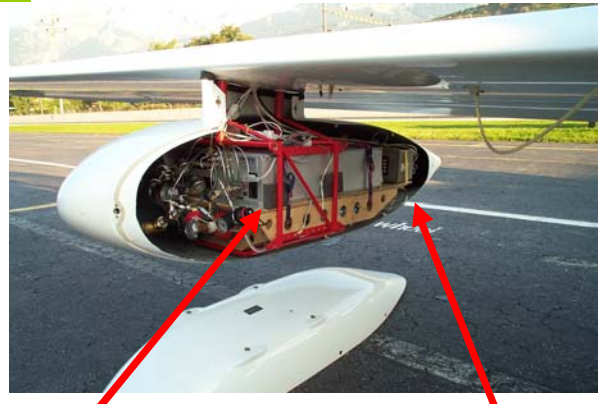
Fast, open path CO2 analyser

CO analyser

NO2 analyser

O3 analysers UV and Eosin

ECO-Dimona pods for air quality/ air pollution studies (Courtesy MetAir Switzerland)



MetAir/Airmotec gaschromatograph

LiCor 6251 CO2 analyser

MetAir

For examples of research projects carried out using SERAs, see

www.airborneresearch.com.au

www.metair.ch

http://www.ibimet.cnr.it/programmi/biosphere

http://www.atdd.noaa.gov/skyarrow.htm

www.naers.org

NAERS
Network of Airborne Atmospheric Research Scientists
www.naers.org

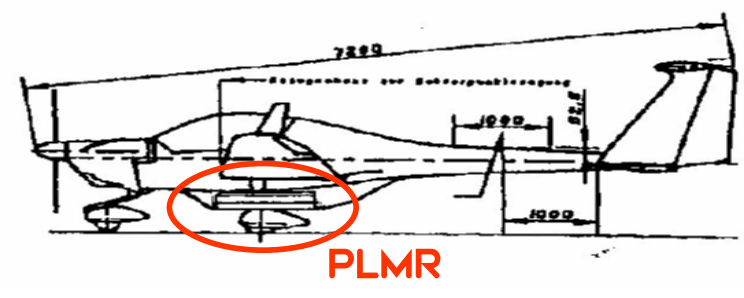
Two very exciting new developments...

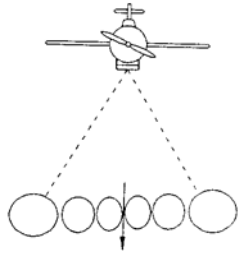
(together with partners at Melbourne University, University of Newcastle, James-Cook University, RMIT and University of Adelaide)

Remote sensing of soil moisture in the root zone and sea surface salinity

resolution: 0.3-times altitude (typically 150m/50m)

swath width: 2-times altitude (typically 150m/300m)





Airborne Laser Scanning (funding pending)

resolution: <25cm horizontal

2.5cm vertical

...to be flown simultaneously with many other sensors...

SUMMARY

- Focus on science, instrumentation and the application rather than the platform
- Very cost-efficient, often an order of magnitude less expensive than "traditional" platforms – no need to "minimise" number of flying hours
- Environmentally friendly technology (exhaust/noise from two 500hp "old" engines compared with exhaust/noise from one 100hp modern engine)
- Operationally often much safer than using "traditional" methods (parachute recovery systems, "crash-worthy" airframe, less occupants, less weight)
- Ease of instrumentation integration, modern avionics
- More flexible than unmanned aircraft (UAVs), also in most cases less expensive, and fewer operational restrictions
- "Aircraft-in-a-Box" concept for uncomplicated deployment worldwide
- Strong international collaboration and exchange of sensor packages

NAERS
Network of Airborne Atmospheric Research Scientists
www.naers.org

SERA

Small Environmental Research Aircraft

…probing the environment using the least intrusive and most cost-efficient airborne technology

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