DATA ACQUISITION &
ADAPTIVE AEROMAGNETIC REAL-TIME
COMPENSATION

2nd-Generation DAARC500

General-Purpose Data Acquisition
- Comprehensive, flexible data acquisition
- Embedded GPS receiver option (single-, dual- or triple-frequency)
- Eight isolated RS232 serial ports (115.2 kbps), two Ethernet (10/100/1000 Mbps)
- Flexible ASCII, binary and raw-data protocols, with large buffers
- 16 differential/32 single-ended analog inputs, 16-bit resolution
- Fully compatible with all leading sensors and instrumentation in airborne geophysics: spectrometers (RSI), navigation systems, etc.
- Serial/analog/Ethernet data synchronized to magnetics, with time & event tags
- Flexible and simple user interface via built-in TFT LCD and external display
- Full monitoring/control from any Windows device (via Ethernet, or through the Internet)
- Real-time graphical output to built-in display, external display and chart recorder
- Rugged and reliable embedded storage: onboard Flash (≥ 16 GB), and hard-disk / solid-state drive (≥ 160 GB)
- Real-time operating system (RTOS): QNX 6.5
- State-of-the-art HW & FW architecture based on advanced 64/32-bit processors
  - Compact and light: 19”-rack mountable, 5.25” height, 19 lb.

Magnetics & Compensation
- Magnetometer interface for up to 8 high-sensitivity sensors (Cs, He or K)
- Front-end sampling rates up to 1280 Hz
- Magnetometer processor: 0.32 pT resolution, < 0.1 pT system noise, ±10 ppb temperature stability
- Real-time compensation: up to 8 total-field magnetometers, and true gradients
- Proven, extremely robust compensation algorithms (AADCII legacy)
- Adaptive signal processing techniques – improved compensation and simplified calibration procedures
- User may customize Front End processing to specific installation requirements
- Data recording & output, up to 80 Hz: complete raw, pre-processed and compensated data sets
- NEW: Post-flight compensation utilities
- NEW: Dynamic compensation of on-board electronic systems
- NEW: Gating of magnetometer readings for concurrent use with EM systems
The RMS Instruments’ DAARC500 offers the ultimate in aeromagnetic compensation, together with comprehensive and flexible data acquisition and recording. Powerful, versatile and rugged, yet compact and light, the DAARC500 is ideally suited to airborne and mobile geophysical and environmental survey applications.

Aeromagnetic compensation in the DAARC500 has its roots in the AADCII, for many years the de facto standard in aeromagnetic compensation in the geophysical exploration industry throughout the world. The result of many years of R&D by RMS Instruments, and collaborations with the Flight Research Laboratory of the National Research Council of Canada, the DAARC500 continues the AADCII tradition of consistently producing outstanding data in a cost effective manner.

The system is built on the foundation of state-of-the-art, very reliable hardware and firmware, and sophisticated and robust compensation algorithms that have been proven in a multitude of installations. Consistent with compensation, data acquisition is delivered with unparalleled performance, accuracy and reliability.

Aeromagnetic Compensation

The quality of the data collected in aeromagnetic surveys is largely dependent on the quality of compensation. Despite the outstanding sensitivity of modern magnetometers, in the absence of good compensation anomaly signals can be completely masked out by the interference of the nearby magnetics of the aircraft.

The aircraft’s magnetic interference is related to its motions about its principal axes. A mathematical model may be built to accurately represent the aircraft’s magnetic signature. Careful optimization and implementation of this model, within the framework of sophisticated hardware and firmware technologies, can lead to real-time compensation that effectively eliminates the aircraft’s magnetic interference.

The RMS Instruments’ DAARC500 Data Acquisition System & Adaptive Aeromagnetic Real-Time Compensator provides real-time compensation of local magnetic interference for inboard magnetometer systems in fixed wing aircraft and helicopters, to the point where the full resolution of modern high sensitivity magnetometers can be utilized. The compensation accounts for the effects of permanent and induced magnetism, Eddy currents, and heading errors from the sensors.

The importance of real-time compensation

The magnetic signature of typical survey aircraft changes dynamically, even while in-flight. A simple tool-box or headphones misplaced in the cockpit, for example, will cause a significant DC-shift. Detecting subtle changes while monitoring uncompensated signals is practically impossible, as the disturbances introduced are “buried” under aircraft interference noise. State-of-the-art aeromagnetic surveying requires real-time monitoring of compensated data – problems are thus identified immediately and are promptly corrected. Relying solely on post-flight compensation is akin to “flying blind”.

 RAW_Text End
**Calibration mode, model and solution**

The DAARC500 uses a 3-axis fluxgate magnetometer to monitor the aircraft’s position and motion with respect to the ambient magnetic field while flying a set of standard maneuvers of rolls, pitches and yaws in orthogonal headings. This *calibration* process, which typically takes 6-8 minutes, yields a (mathematical) *solution* that models the aircraft’s magnetic signature. The solution is calculated instantly, upon termination of the calibration maneuvers. It is immediately available for use in compensated (i.e., survey) mode, or for further analysis and comparison with other solutions.

With the DAARC500 there is no need for any post-flight software. The calibration is effective for the full 360° range of headings. At very low dip angles, *partial calibrations* for each active zone can be readily combined to produce a single robust solution for the full 360° range.

**Compensation – total fields and gradients**

In *compensation* mode up to 8 total-field (TF) high-sensitivity magnetometers, as well as associated gradients, are compensated in real-time using the last solution obtained (or any other solution previously archived). Compensated and uncompensated data, along with the 3-axis vector magnetometer and other ancillary data, are monitored and recorded in real-time.

Importantly, the system provides *true* gradient compensation: independent calibration solutions are calculated for the lateral, longitudinal and vertical gradients.

**Adaptive compensation**

The DAARC500 incorporates adaptive signal processing techniques that allow the system to continuously “learn” from input signals, and adapt the solution coefficients for optimum compensation. The underlying recursive algorithm has significant computational advantages over the “conventional” alternative, and leads to improved band-passed and gradient compensation. Adaptive compensation substantially eases calibration procedures, and yields solutions that remain close to optimum as the aircraft’s magnetic signature changes with time.

In the DAARC500 adaptive compensation can operate in manual mode (controlled explicitly by an operator), or in an automatic mode whereby the system automatically engages and disengages adaptive mode at user-defined altitudes. The latter permits “continuous” optimization of a calibration solution, without operator intervention.

**Dynamic compensation of OBE systems**

The DAARC500 incorporates new technology that allows real-time dynamic compensation of the effects of DC currents from on-board electronic (OBE) systems, such as avionics, hydraulics, control systems and other instrumentation. The compensation model is augmented by a suitable set of terms calculated by running a simple “calibration” procedure, typically on the ground.

In real-time compensated run mode, the various terms for an OBE system are incorporated into the overall model under control of analog signals used to monitor the status of the system. The technology works for devices that draw fixed currents (discrete mode), as well as for devices that draw slowly-varying currents (continuous mode). As many as four independent OBE systems can be processed simultaneously.

OBE compensation is complementary to conventional compensation, and offers important benefits to users – it simplifies operational requirements for operators during survey flights, increases robustness and tolerance to electrical sources, and improves overall compensation performance.

**Data Acquisition System**

Comprehensive and flexible data acquisition and recording complement the aeromagnetic compensation functions in the DAARC500.

External devices with digital (serial) and analog outputs can be connected directly to the DAARC500. The system provides 8 high-speed, isolated, serial (RS232) inputs and outputs, 16 differential (or 32 single-ended) analog inputs, and two 10/100/1000Base-TX Ethernet interfaces (one dedicated to data acquisition).
Flexible serial protocols and practically unlimited buffering space, allow easy interfacing to most devices. All data sampling is at rates based on the same time base. All data streams are perfectly synchronized and are recorded with time and event tags that allow accurate reference to GPS time and position.

**Analysis, Control & Support Software**

**Post-flight compensation & analysis functions**
Advanced embedded functions allow post-flight survey compensation, in the event a suitable calibration was not available at time of flight. This complements the fundamental real-time compensation function, key for productive and efficient airborne magnetometry. Also included are functions for in-depth analysis of calibration data, and frequency-domain analysis.

**Data exporting software**
The data files recorded by the DAARC500 have a structure optimized for efficiency and performance. Exporting data to industry-standard formats (e.g., flat-ASCII, ‘XYZ’, Geosoft ‘GBN’).

**Remote control from Windows**
A remote connectivity tool for the DAARC500 allows users full control and operation of the unit from a remote Windows-based system, across an IP network. The user interface of the DAARC500 is seamlessly replicated in the Windows-based computer. The mouse and keyboard attached to the computer have the same effect as if they were directly connected to the DAARC500. The figure below illustrates typical connections and data flow.

This technology facilitates integration of complex systems, with a single computer/laptop being used to control and operate the DAARC500 and other instruments, while simultaneously running complementary software.

**System Architecture**
The DAARC500 is based on a flexible architecture with advanced 64/32-bit processors. It includes state-of-the-art COTS (industrial-grade) electronics, and a proprietary magnetometer interface.

**Front End subsystem**
The Front End is based on a high-performance, low-power, RISC PowerPC processor. The magnetometer interface, most critical for high-performance compensation, uses the latest in analog and digital electronics to provide excellent accuracy and synchronization for up to eight total-field magnetometers. It uses a highly stable and reliable time base (OCXO). The proprietary counter and synchronization hardware deliver outstanding performance with negligible noise and temperature drift.

A three-axis fluxgate (vector) magnetometer, used for attitude reference, is included with the system. Signals are processed using a high-resolution (16-bit) A/D converter.
Front End sampling rates are user-selectable, up to 1280 Hz. Finely tuned, user-selectable transfer functions deliver outstanding anti-aliasing characteristics. The user may also customize Front End processing to the specific requirements of an installation. For concurrent use with EM systems a gating signal is used to qualify magnetometer readings.

**Host subsystem**
The host subsystem is built around one of Intel’s most recent multi-core processors. The application software and real-time operating system (RTOS) reside in (solid-state) Flash memory. The RTOS is QNX 6.5 (or later). This is a deterministic and extremely reliable operating system tailored to mission-critical applications, that guarantees compliance with the strict timing constraints of all critical tasks.

Comprehensive statistical information is provided to assess the quality of compensation. The DAARC500 will typically achieve Improvement Ratios (IRs) in the range of 10–20 for total fields in large and magnetically complex aircraft. For gradients, figures in the range of 20–100 are typical, with better performance possible when using adaptive compensation. The Host software offers optional filtering with user-selectable bandwidths, and includes facilities for data analysis in the time and frequency domains.

All magnetics (raw and compensated) and ancillary data may be recorded and monitored in real-time, at rates up to 80 Hz. Monitoring, in graphical and numerical form, can be done simultaneously on the built-in display, an external display/monitor, and a chart recorder. Real-time data output via a serial port is also available.

Embedded recording options include on-board Flash (≥ 16 GB), and a mass-storage device (HDD or SSD, ≥ 160 GB). Direct recording on a Flash disk connected to one of the USB ports is also available.

In addition to comprehensive data acquisition functionality, the host subsystem also provides extensive general-purpose I/O: simultaneous output to the built-in display and an external one (via a standard VGA port), and multiple Ethernet, USB and UART interfaces. Configuration and control of the system are supported through an easy-to-use graphical user interface.

**Magnetometer power decoupler**
The DAARC500 is available with an embedded power/decoupler module for up to four or eight inputs. The decoupler separates the Larmor outputs of the magnetometers from 28-Volt power, and monitors the quality of magnetometer input signals.

**GPS receiver**
The system is available with an embedded (typically dual-frequency) GPS receiver. All magnetics and ancillary data are referenced to GPS time and position. A variety of receivers are available to satisfy different requirements in accuracy. The DAARC500 gives users direct access to two ports on the receiver. This provides, for example, the interface to a navigation system. The system can also be used with an external (user-supplied) receiver.

**ORDERING INFORMATION**

- **DAARC500-x**: DAS & Adaptive Aeromagnetic Real-Time Compensator. [x = # of magnetometer inputs; 2 ... 8]
  - Includes: – Vector (fluxgate) magnetometer.
  - License/Key for QNX (RTOS) & Phindows (remote control from any Windows computer via IP network over Ethernet).
- **Advanced Functions**: Multiple FE smpl. rates & transf. funcns., raw FE logging, in-field FW updating, mag. gating for concurrent use with EM.
- **Post-Flight Compensation**: PFC and calibration analysis functions. Requires the Advanced Functions option.
- **RMS4880A Magnetometer Power/Decoupler Module**: RMS4880A-1 (up to 4 inputs), RMS4880A-2 (up to 8 inputs).
- **RMS2938-f**: 32 single-ended analog channels (instead of the standard 16 differential channels).
- **GPS Receiver Option**: Internal (consult RMS Instruments for list of receivers available) or External.
- **Front-End-Sampled Analog Inputs**: 4 differential ips., 16-bit ADC (in addition to std. 16/32 chan. Analog Input Module). Required for OBE comp.
**Magnetometer Inputs:**
Up to 8 high-sensitivity magnetometers; any combination of:
- Cs: Typ. 70 kHz – 350 kHz
- K-41, K-39: Typ. 140 kHz – 700 kHz
- He: Typ. 560 kHz – 2.8 MHz

**Magnetic Field Range:**
Per the magnetometer’s range; e.g., [1]
- G-822A, G-823A: 20,000 – 100,000 nT
- CS-3, CS-L, CS-VL: 15,000 – 105,000 nT
- GSMP-30A: 20,000 – 100,000 nT

**Front End (FE):**
- Time base: > 100 MHz, OCXO
- Resolution: 0.32 pT [2]
- System noise: σ < 0.1 pT [3]
- Temperature stability: ±10 ppb [4]
- Sampling rate: 160, 640, 800 or 1280 Hz – user-selectable
- Transfer function (bandwidth): 1.6 Hz, 3.25 Hz, 6.4 Hz, 9.8 Hz, 20 Hz, 0.16Fsh [5] or Custom Transf. Funct.–user-select.

**Compensation Performance:**
- IR (total field): 10 – 20, typical
- IR (gradient): 20 – 100, typical
- (Further improvement possible with adaptive compensation, 2X to 5X typical, band-passed TF and gradient)

**Compensation Accuracy:**
σ = 20 pT for entire flight envelope, 0–1Hz

**Optional Filter (Host):**
User-selectable, 0.4–3.0 Hz BW

**Calibration Duration:**
6–8 minutes, typical

**Vector Magnetometer:**
- Included with the DAARC500
- 3-axis fluxgate
- Oversampling, 16-bit, self-calibrating ADC

**OBE Compensation:**
Dynamic compensation of up to 4 independent on-board elec. systems
Requires FE-sampled Analog option

**Data Output & Recording:**
- **Fsh:** 10, 20, 40, 80 [6] Hz (GPS-PPS or internal synch.); external-trigger
- Serial port: to 115.2 kbps, ASCII/Binary
- Recording media: internal Flash (≥ 16 GB), internal HDD or SSD (≥ 160 GB), USB-Flash disk
- Chart recorder
- Display (built-in and external)

**Event Inputs/GPS Synch.:**
- Four latched event inputs
- LS-TTL levels, edge-sensitive
- Event tags included with output data

**Display:**
- 6.5” colour TFT digital LCD
- VGA resolution (640 x 480)
- Antiglare surface treatment
- Backlight: LED (white)
- Luminance: 1000 nits

**Mouse:**
Silicone-rubber actuators
Pressure-controlled operation
No moving parts

**Remote Control:**
From any Windows-based computer, via IP ntwk. Ethernet – replica of DAARC500’s user I/F on computer.
Via serial (RS232) port – ASCII cmdns.

**Data Acquisition – Analog:**
- 16-bit, self-calibrating A/D converter
- RSM2938: (standard)
- 16 differential, 20-Hz AA
- RSM2938-1: (optional)
- 32 single-ended, 20-Hz AA
- Input range: ±10 Volts (standard), ±5 Volts
- Input over-voltage protection: –20 Volts to +52 Volts, power OFF
- SAMPLING & RECORDING: Fsh or submult.
- Input resistance: 1 MΩ, typical
- CMRR (60 Hz): 96 dB, typical

**Data Acquisition – Serial:**
- 8 isolated RS232 channels
- Up to 115.2 kbps, HW handshake
- Input: ASCII, Binary and Raw protocols
- Sampling & recording: Fsh or submult.
- Output: User-defined packets synch. to Fsh

**Data Acquisition – Ethernet:**
10/100/1000Base-TX
TCP/IP
Sampling & recording: Fsh or submult.

**Synch. to External Devices:**
Two independent pulse outputs
Rate: Fsh/k, with 1 ≤ x ≤ 255
Low-going pulses, > 10-µsec width

**Power:**
+28 VDC (+6 VDC), 3.75 A
For each mag. input connected through the RMS4880A Magnetometer
Power/Decoupler Module: 0.5 A typical; up to 1.0 A at turn-on

**Environmental:**
- Operating Temperature: 0 to +50°C
- Storage Temperature: –20 to +55°C
- Relative Humidity: 0 to 99%, non-cond.
- Altitude: 0–3,000 m (0–10,000 ft); HDD 0–6,000 m (0–20,000 ft); SSD
- Size (W x H x D): 483 x 133 x 381 mm, (19 x 5.25 x 15 in)
- Weight: 8.6 Kg (19lb)

**Indicators, General-Purpose I/O:**
- 8 LEDs for mag. input status
- 2 LEDs for Front End status
- Five USB 2.0
- Data output (RS232, 9-pin D-sub)
- Remote control (RS232, 9-pin D-sub)
- Two 10/100/1000Base-TX Ethernet, one for data acquisition (RJ45)

**GPS Receiver Option:**
Magnetics data tagged with GPS time, lat., lon., altitude and auxiliary data
Up to 10 Hz

**Post-Flight Compens. – Optional:**
Post-flight compensation & analysis functions for DAARC500 binary d-files

Notes:
[1] Per manufacturer’s specs. at print time: G-822A, G-823A (Geometrics), CS-3, CS-L, CS-VL (Scintrex), GSMP-30A (GEM Sys.).

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DAARC500 SPECIFICATIONS

**Accurac**: per Front End sampling rate

**Fe-Sampled Analog – Optional:**
Four differential inputs
16-bit resolution, self-calibrating ADC
Input range: ±5 Volts
Input resistance: 1 MΩ, typical

**Display:**
6.5” colour TFT digital LCD
VGA resolution (640 x 480)
Antiglare surface treatment
Backlight: LED (white)
Luminance: 1000 nits

**Mouse:**
Silicone-rubber actuators
Pressure-controlled operation
No moving parts

**Remote Control:**
From any Windows-based computer, via IP ntwk. Ethernet – replica of DAARC500’s user I/F on computer.
Via serial (RS232) port – ASCII cmdns.

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16-bit, self-calibrating A/D converter
RSM2938: (standard)
16 differential, 20-Hz AA
RSM2938-1: (optional)
32 single-ended, 20-Hz AA
Choose range: ±10 Volts (standard), ±5 Volts
Input over-voltage protection: –20 Volts to +52 Volts, power OFF
SAMPLING & RECORDING: Fsh or submult.
Input resistance: 1 MΩ, typical
CMRR (60 Hz): 96 dB, typical

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8 isolated RS232 channels
Up to 115.2 kbps, HW handshake
Input: ASCII, Binary and Raw protocols
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10/100/1000Base-TX
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Sampling & recording: Fsh or submult.

**Synch. to External Devices:**
Two independent pulse outputs
Rate: Fsh/k, with 1 ≤ x ≤ 255
Low-going pulses, > 10-µsec width

**Outdoor Configuration – For DAARC500:**
- 8 LEDs for Front End status
- Five USB 2.0
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+28 VDC (+6 VDC), 3.75 A
For each mag. input connected through the RMS4880A Magnetometer
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- Operating Temperature: 0 to +50°C
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