Eddy Covariance Flux System

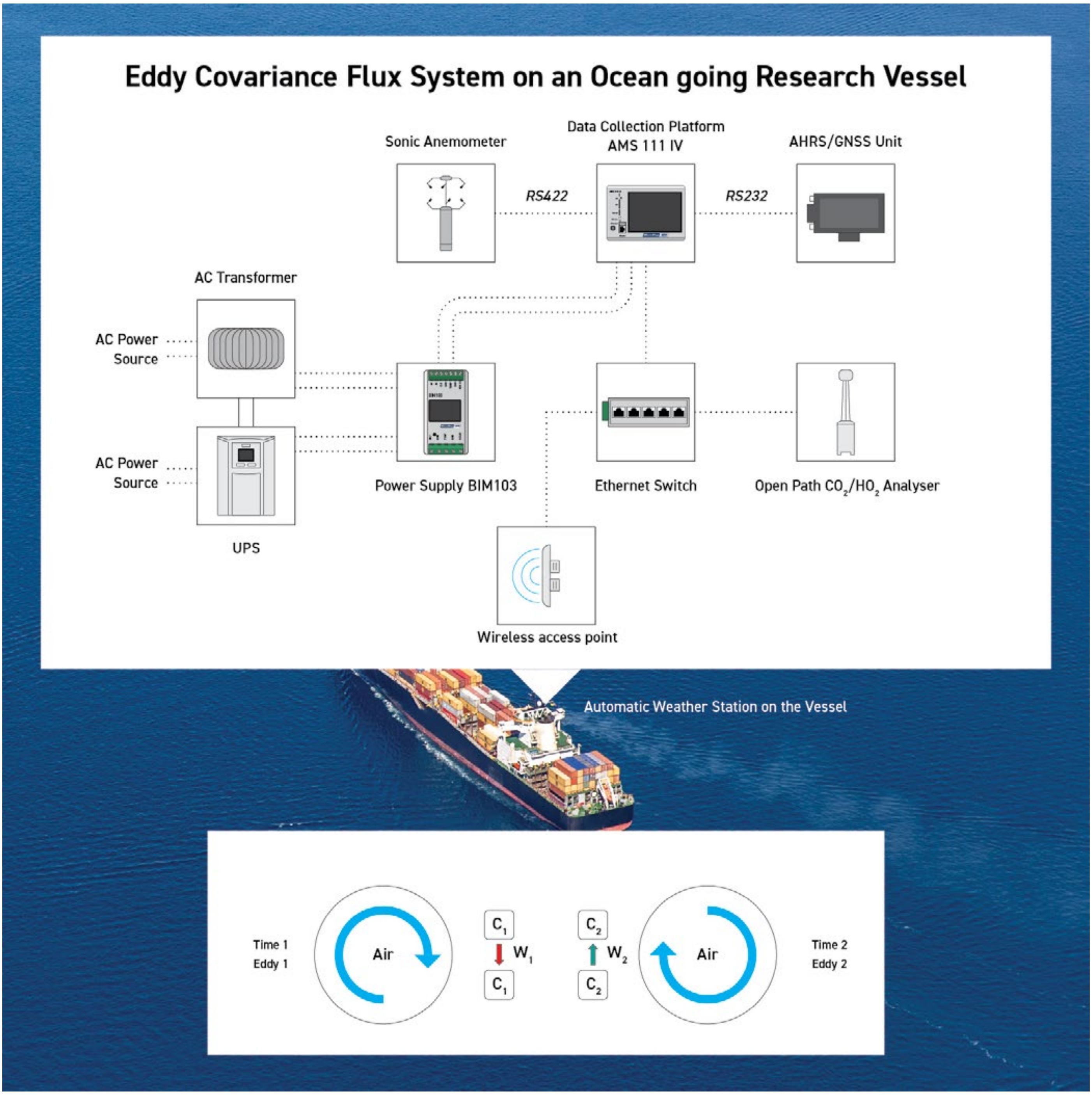
Vessel-based system for mapping the exchange of greenhouse gases above the ocean surface

Greenhouse gases have played a vital role in maintaining temperatures at sustainable levels to support life on our planet, Earth. Greenhouse gas molecules and clouds absorb most of the infrared radiation from the sun and re-emit it in all directions, effectively warming the Earth's surface as well as the lower atmosphere (troposphere). Without the natural greenhouse effect, heat emitted by the Earth would just pass outward into space, and the Earth would have an average temperature of about minus 20 °C.

Water vapor is the largest contributor to Earth's greenhouse effect, followed by non-condensable gases, of which carbon dioxide is the other dominant contributor. In the last two centuries, the levels of carbon dioxide in the atmosphere have unceasingly increased due to human activities such as increased use of fossil fuels and large-scale deforestation. This has led to a cycle of increasing global temperatures due to increasing carbon dioxide in the atmosphere, causing more water vapor to enter the atmosphere. It is widely agreed that the exchange of water vapor and carbon dioxide between the ocean surfaces and atmosphere has far-reaching implications for life, and the study to understand this process is an active area of interest for both climate scientists and marine researchers.

The Eddy Covariance technique (also known as Eddy Correlation and Eddy Flux) is a key method that provides direct measurements of vertical turbulent fluxes within atmospheric boundary layers. This technique has been employed for various applications, including determining exchange rates of trace gases over natural ecosystems and agricultural fields, as well as quantifying gas emission rates. A complementary strategy is to deploy Eddy Covariance Flux Systems on research vessels to sample a wide range of ocean environments for studying the exchange of water vapor and carbon dioxide between the ocean surfaces and atmosphere. The feasibility of this approach depends on developing Eddy Covariance Flux Systems that are sufficiently robust to overcome the technical and logistical challenges of measuring air-sea fluxes in harsh environments from moving platforms.

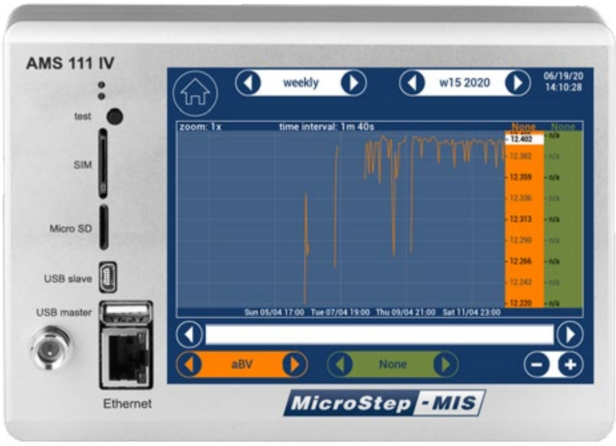
The solution for a shipboard Eddy Covariance Flux System (ECFS) consists of an integrated system with various components, including a fast-response infrared gas analyzer, a sonic anemometer, a position and velocity measurement system, a motion measurement system, and a high-speed Data Collection Platform (DCP) with interfaces to a central system with data validation and mapping capabilities.



An Open Path Analyser based on an Infrared Gas Analyzer is employed for high-speed measurements of ambient carbon dioxide and water vapor conditions. Based on the infrared radiation absorbed by carbon dioxide and water vapor in the sample path, gas densities are computed from the ratio of absorbed radiation to a reference. A scientific-grade anemometer based on ultrasonic measurement principles is employed for precise 3-axis measurement of wind speed and direction. The sonic anemometer provides a fast data output rate of U-V-W Cartesian components of speed as required for Eddy Covariance Flux measurements.

A combined navigation and motion measurement system based on a multi-constellation Global Navigation Satellite System (GNSS) receiver and Attitude Heading Reference System (AHRS) with low-noise, low-drift gyros and accelerometers is integrated for accurate and robust outputs of Position, Velocity, and Attitude. Sensor measurements are fully calibrated, temperature-compensated, and mathematically-aligned to an orthogonal coordinate system for highly accurate outputs.

Data logging based on MicroStep-MIS latest AMS III IV platform provided integrated data collection and management from all the sensor packages. The modular platform based on Linux Operating System with software features such as data validation and real-time quality control ensured the accuracy of the measured data. The Data Collection Platform based on 32 bit A5 core main processor plus a 32 bit M3 slave processor was configured for high speed data collection for up to 30 Hz. A built-in touchscreen graphic display provided user interface for previewing of measured values, adjusting system time, setting system variables directly on the Data Collection Platform.



Data Logger AMS 111 IV, developed and manufactured by MicroStep-MIS

The system is designed and developed for low power consumption for supporting autonomous operations and included a battery backed rechargeable uninterrupted powering system. The system is as well integrated with all necessary application software's installed to make a turnkey Eddy Covariance Flux System (ECFS) solution.

The innovative solution of employing an Eddy Covariance Flux System with built-in tracking and mapping capabilities supports studies of exchange of carbon dioxide and water vapours over large areas over our ocean surfaces. The ECFS solution is expected to play a crucial part in our larger quest towards studying and understanding multiplicity of areas vital for human civilisation like climate change, disruption of water cycle, global warming, ocean acidification, etc.