Experience from the Himalayan Soaring Expedition

Omega Navigational Aid in a Motorglider for Meteorological Research Flights

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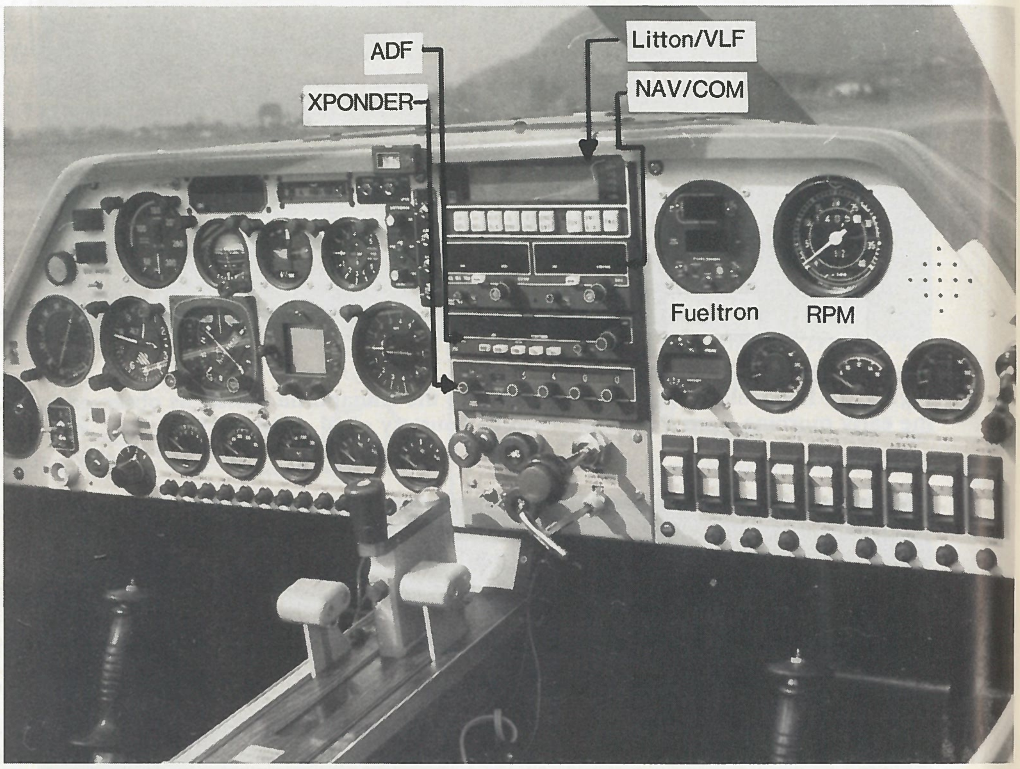
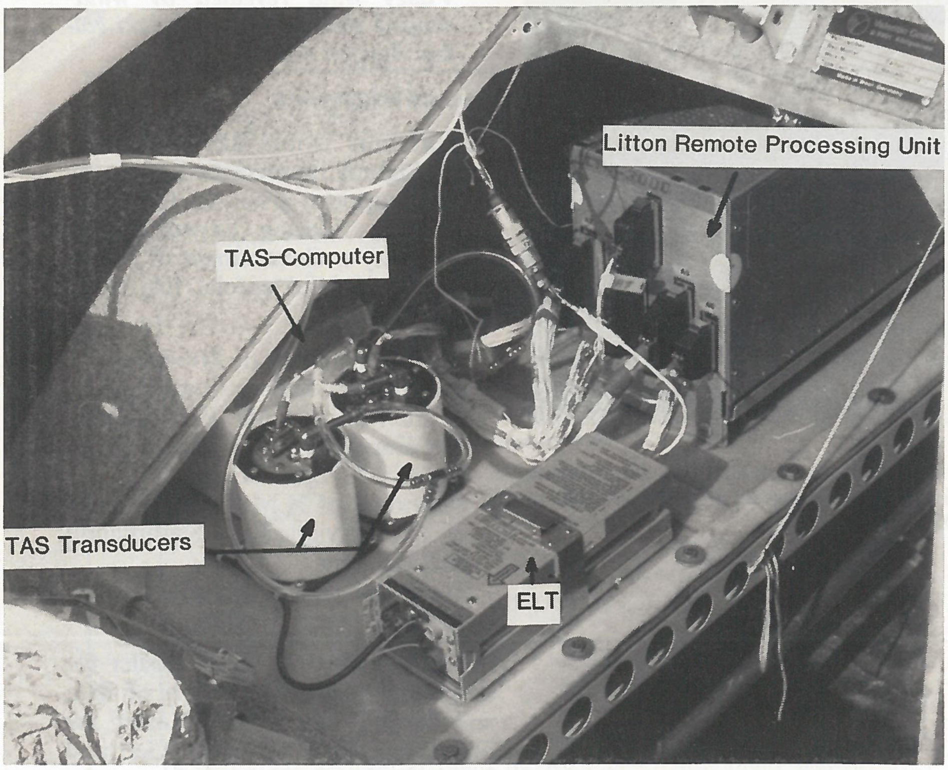
In order to carry out a first approximation wind measurement in the world's deepest valley, the Kali Gandaki in the Himalayan mountain range, a Litton LTN-3000 Omega/VLF navigation system has been successfully installed in a Valentin Taifun 17E motorglider.

Problems and solutions concerning the installation and operation of an Omega/VLF system in a small plastic (non-metallic) aircraft are reported.
Data collection and evaluation procedures and an estimate of the measurement errors are discussed.



▲ *Litton display unit in the front panel of the motorglider Taifun 17E, D-KHIM.*



◄ *Installation of Litton Remote Processing Unit, TAS-Transducer and - Computer and Emergency Locator Transmitter in the near compartment of the motorglider Taifun 17E, D-KHIM.*

Introduction

One of the objectives of the Himalayan Soaring Expedition was the measurement, at least on a first approximation basis, with the wind system of the Kali Gandaki valley, the world's deepest, between the Annapurna and the Dhaulagiri mountains.
The wind measurement has been made with one of a new generation of low cost Omega/VLF navigation systems.
Specifically, a Litton LTN-3000 was installed on a Valentin Taifun 17E motorglider (Fig. 1 and 2). According to the Litton Company, this was the first time such an installation was attempted, and a peculiar set of problems was encountered, mainly due to the non-metallic and therefore electromagnetically non-shielding structure of the aircraft.

Equipment selection

The LTN-3000 was chosen on account of its unique capability to accept a 12 VDC power supply; all other instruments require 24 VDC, therefore imposing either severe modifications to the aircraft electrical system, or a heavy dc/dc inverter.
Additional unique features of the Litton are its VOR/DME precision RNAV (area navigation) capability and its RS-232C data interface through which wind, time and navigational data were directly available in a common digital format.

The LTN-3000, like any similar system, requires heading and TAS signals to compute winds. These have to be supplied by other instruments, and again the choice of 12 VDC equipment is very limited; in fact, there is presently only one manufacturer willing to modify his TAS computer to 12 VDC operation.

Omega/VLF receivers are tuned to very low frequencies, in the 10 to 30 kHz range, and have two basic antenna configurations: either an E-field, which senses the electrical field of the electromagnetic wave, or the more expensive H-field antenna, sensing the magnetic component, and whose directionality requires computer control.

The E-field antenna is very susceptible to interference by electrostatic charge variations of the aircraft's structure; flights in rain, clouds and dust may cause excessively low signal to noise rations (SNR) of the Omega signals, impairing navigation. Behaviour of an E-field antenna on a plastic aircraft was unknown, and therefore Litton recommended installing an H-field unit.

The H-field antenna is very susceptible to magnetic interference; the main problems lie with inverter, generator and anticollision strobelight equipment.

The solution we used was strictly empirical; 12 kHz notch filters were designed and installed, and the 400 Hz 26 VAC inverter used for heading reference was installed by trial and error at a location where its radiated magnetic field would not affect the H-field antenna.

The main problem with a non-metallic aircraft was found to be caused by VHF transmissions; all the electronic equipment is interconnected by wiring acting as antennas, unlike conventional aircraft where the fuselage functions as a Faraday cage.

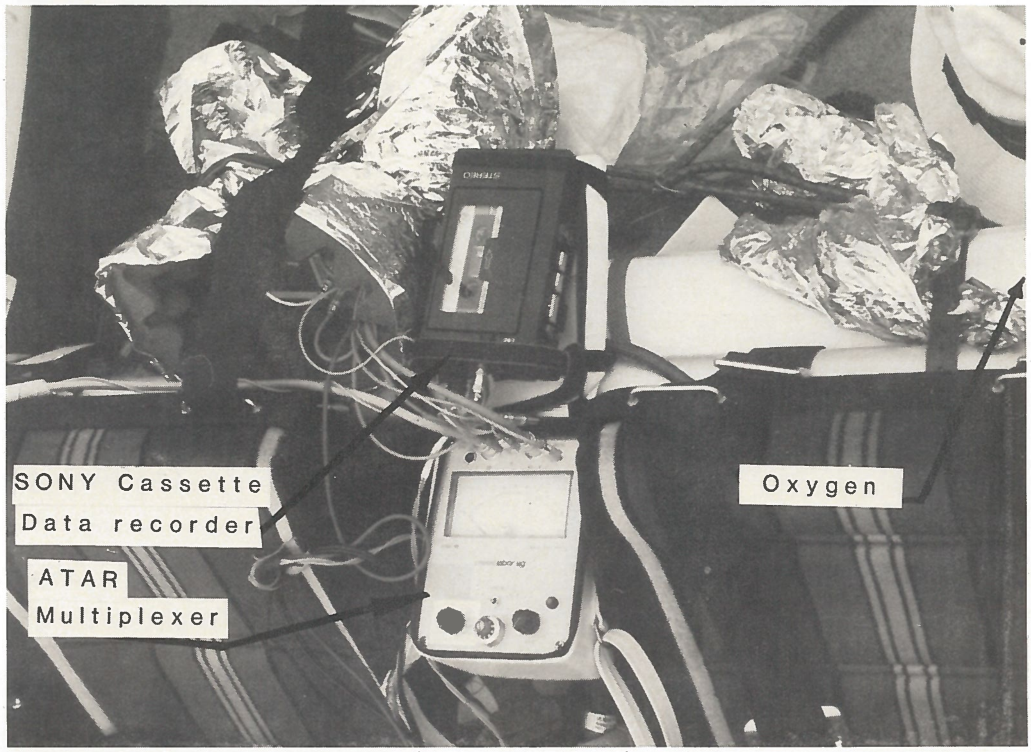
The LTN-3000 itself was totally immune to such VHF interference, but both the TAS computer and the directional gyro were heavily affected by it, usually causing alarm flags to be set, and supplying incorrect data to the Omega system.

The solution is filtering and shielding, using ferrite beads and high quality RF-shielded connectors, and then accepting a residual, tolerable level of VHF "pollution". Connecting all single electronic components with heavy copper braid produced surprisingly adverse results.

Operation

An Omega/VLF navigation system compares the phase differences of accurately syncronized signals emitted by eight Omega stations and (in case of the LTN-3000) nine VLF US Navy transmitters around the world.

Very extensive computations by a fast 16 bit processor correct the signal phases for statistically treatable noise and propagation variations due to geophysical parameters (earth ellipticity, season, day/night and land/water paths).



Data recorder of common cassette type with ATAR unit (ATAR = Akustisches Temperaturanzeige- und Registriergerät; developped by Schweizerische Meteorologische Anstalt SMA).

The aircraft position determined through Omega/VLF navigation is then compared every few seconds with position variation estimated by dead reckoning using heading and TAS; the difference is considered wind drift and is incorporated in the computations so as to reduce to zero the difference of predicted Omega vs. dead-reckoning positions.

It is obvious that calling "wind" all differences between these two positions means that any heading, TAS or Omega position error will be imputed to the wind; in practice this enables to calibrate the system easily by recording the winds indicated while flying a box pattern in an homogeneous air mass.

The wind vector uncertainty is of the order of 2 to 5 knots, depending on the calibration procedure used. The wind determination time constant is 50 seconds, with a 0.5 damping ratio.

Data collection and evaluation

Data collection during the measurement flights was automatic. Mr. Bruno Neininger of Lapeth, Zürich, designed and built an interface that enabled data (lat/long position, date, time to the second, TAS, heading and wind) to be recorded through a FSK modem on a common cassette type recorder (Fig. 3)

Mr. Neininger also wrote the computer programs that caused the data first to be transferred to the memory of the main ETH computer in Zürich, and then plotted on a topographical map of the area subject to investigation.

Conclusions

The combination of an Omega/VLF navigation system and a motorglider enables cost-effective first approximation wind measurements to be made in situations where low spatial and temporal resolutions are required.

Acknowledgements

The author wishes to thank the Litton Company, Scandinavian Avionics, Mr. Bruno Neininger and Mr. Peter Lert for all the extra effort they devoted in order to transform an idea into a working concept.