China - Hybrid airship for airborne electromagnetic (AEM) surveying

Peter Lobner, 15 June 2022

1. Introduction

In November 2015, the Chinese Academy of Sciences reported on a project that used a hybrid airship as the platform for conducting airborne electromagnetic (AEM) surveys with a ground penetrating radar.

> "The National Program 863 'ultra-deep ground penetrating radar system and its industrialization' theme project, undertaken by Laboratory Ten of the Institute of Electronics, was successfully completed in Linxiang County, Yueyang City, Hunan Province, during the period of September 7th to 26th, 2015.

This program demonstrated a substantial performance improvement over traditional AEM systems used on fixed-wing aircraft and helicopters, with the added benefits of much lower cost and higher efficiency.

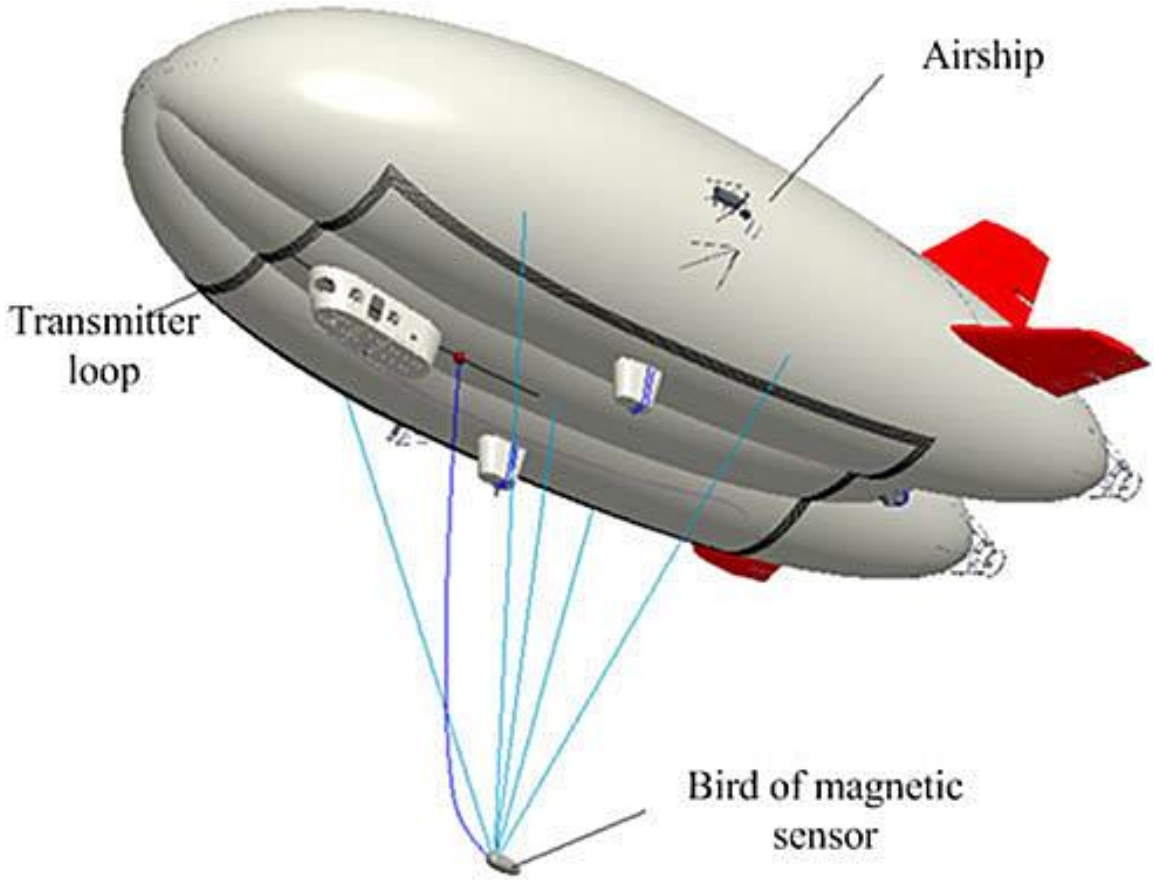
2. The AEM survey airship

The survey airship was a two-lobed hybrid airship with a gas envelope configuration generally resembling the much larger Hybrid Air Vehicles (HAV) Airlander 10 prototype. The Chinese Academy of Sciences described the survey airship as follows:

> "The flight test platform, developed by Base 068 of the China Aerospace Science and Industry Group, is a double ellipsoidal auto-controlled airship, with a length of more than 40 m (131.2 ft) and width of more than 20 m (65.6 ft), and is a system suitable for carrying ultra-deep ground penetrating radar equipped with high frequency bands. …".

The AEM survey airship on its truck-mounted mobile mooring mast. Note the three-point landing gear, with a nose gear under the central gondola and separate pods under the gas envelope for the main landing gear.

One of two flank-mounted, thrust vectoring, main propellers. Note the support framework attached directly to the envelope. Source, both photos: Chinese Academy of Sciences



General arrangement of the AEM system components. The "bird" of three-axis receiver coils is under the center of the transmitter loop with a vertical separation distance of 35 m (115 ft). Source: L. Liu, et al. (2017)

Regarding the use of a hybrid airship as the platform for an AEM survey, authors L. Liu, et al., reported in their 2017 paper:

> "…the double-gasbag airship is chosen as the AEM platform (for stability) compared to the traditional fixed-wing AEM system and helicopter-borne AEM system. The reasons why the (airship) AEM system has higher efficiency than existing schemes are the following:
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> 1) (An) airship …. is a much lower cost, safer, and more flexible alternative for this practical application. The fixed-wing plane is much more expensive for refitting the structure for the

AEM system and has much more (restrictive) requirements for landing and taking off.

2) The airship-based AEM system can have the advantages of both the fixed-wing airborne system and the helicopter-borne system. It can have a large transmitter–receiver separation and the transmitting moment is big enough for deeper penetration, just like the fixed-wing AEM system. At the same time, the “bird” of the magnetic coils is towed at a comparatively lower height to the ground, (at) a proper (lower) speed, as required to realize greater spatial resolution, just like the helicopter AEM system.”

The transmitter was mounted in the gondola of the airship and was powered by the combination of a petrol generator and an ac/dc inverter. For the AEM tests, a frequency of 25 Hz provided the desired detection depth and spatial resolution.

AEM airship in flight with the “bird “ deployed.
Source: L. Liu, et al. (2017)

3. Results of the airship AEM survey test

The Chinese Academy of Sciences summarized the airship AEM survey test results in 2015 as follows:

> "The National Program 863 'ultra-deep exploration radar system and its industrialization' theme projects, which creatively utilize the super-long pseudo-random pulse coding system, breaks through the technical bottleneck of the carrier-free pulse system of traditional ground penetrating radar, effectively improving the depth of exploration, and can reach a probing depth of more than 100 m (328 ft), so as to further expand the exploration engineering application scope of radar technology. The research results of this project provide a new technical means for the development of high-resolution, large-scale, high-efficiency surveys and geological surveys in China."

4. For additional information

- "The Achievement of Shipborne Experimental Verification of Program 863 "Ultra-Deep Ground Penetrating Radar System and Its Industrialization" Theme Projects," Institute of Electronics, Chinese Academy of Sciences, 10 November 2015: http://english.ie.cas.cn/ns/es/201511/t20151110_155472.html
- L. Liu, Z. Shi, Z. Geng & G. Fang, "A Bipolar Half-Sine Current Inverter for Airship-Borne Electromagnetic (AEM) Surveying," IEEE Transactions on Industrial Electronics, Vol. 64, No. 12, December 2017: https://www.researchgate.net/publication/317324617_A_Bipolar_Half-Sine_Current_Inverter_for_Airship-Borne_Electromagnetic_AEM_Surveying
- Y. Zheng, S. Li, K. Xing & X. Zhang, "Unmanned Aerial Vehicles for Magnetic Surveys: A Review on Platform Selection and Interference Suppression," Drones, 5, 93, 2021: https://doi.org/10.3390/drones 5030093

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