The 2015 World Congress on
Aeronautics, Nano, Bio, Robotics, and Energy (ANBRE15)
Incheon, Korea, August 25-28, 2015

Configuration design and aerodynamic performance of high altitude and long endurance vehicle

*Cheolwan Kim[1)], Yung-Gyo Lee[2)], Seung-Jae Hwang[3)] and Donghoon Park[4)]

[1), 2), 3), 4)] *Aerodynamics Department, KARI, Daejeon 305-806, Korea*
[1)] *cwkim@kari.re.kr*

ABSTRACT

Electric aerial vehicle for high altitude & long endurance flight has been developed by KARI for last several years. It is powered by the solar energy and its redundant energy is stored at the rechargeable battery for the night flight. It will be operated in the stratosphere for long time mission. The initial sizing and configuration design was performed for the limited mission because of the low energy density of the battery. Aerodynamic performance of the vehicle was estimated by CFD simulation and the propeller was designed for high altitude flight.

1. INTRODUCTION

High altitude long endurance (HALE) unmanned aerial vehicle (UAV) has been attained great attention for its potential values related to the performance and mission and being developed competitively over the world. Korea Aerospace Research Institute (KARI) has developed its own HALE series powered by the solar power. HALE UAV research was initiated in 2010 and continued to achieve the goal of HALE. EAV-1, the first version of HALE series, was tested to investigate the characteristics of the power combination of the fuel cell and the rechargeable battery. It recorded the flight time, 4.5hours and the study was succeeded by EAV-2 to test the power package combined with solar power, fuel cell and the battery. The power for the thrust and electric circuits was supplied and controlled by the power management system (PMS). The test flight recorded the flight time, 22.5 hours. With the accumulated knowledge and experience, a high altitude version, EAV-2H was newly developed with the solar power and rechargeable battery. The amorphous type solar cell was adopted to reduce the vehicle weight and it recorded the altitude, 10 km and flight time 25.4 hours. To penetrate the stratosphere and stay longer, another version, EAV-3 was designed and being manufactured. The mono crystal solar cell is applied on the flexible wing surface because of its efficiency. The propeller and the electric motor are also designed for the high altitude flight. EAV-3 will be climbed up to the stratosphere in 2015. At the presentation, EAV series will be introduced in detail and the potential values of HALE UAV will be discussed.

[1), 2)] Principal Researcher
[3), 4)] Senior Researcher

2. INTRODUCTION OF ELECTRIC AERIAL VEHICLES

Three electric vehicles have been designed to demonstrate the possibilities of high altitude and long endurance flight.

2.1 EAV-1

EAV-1, a modified version of the small unmanned aerial vehicle (RemoEye-002) developed by a Korean company, was developed to test the performance of the fuel cell. Its power package was equipped with the fuel cell and rechargeable battery. The fuselage was modified to fit the fuel cell and the wing was extended for better cruise performance. Its length and height were 1.7m and 0.38m respectively, and the wing span and aspect ratio were 2.72m and 8.5. The cruise speed of the vehicle was 13.9m/sec. Its flight performance was tested in KARI's flight center in 2010. It was powered by the fuel cell and recorded 4.5hour's flight time.

2.2 EAV-2

To investigate the characteristics of the power combination of the solar cell, fuel cell and battery, KARI developed EAV-2. KARI designed the vehicle from selection of the low Reynolds number airfoil, configuration design of the wing and fuselage, design of very light structure, even to some unique ideas to fabricate the mono crystal type solar cell on the wing surface, etc.

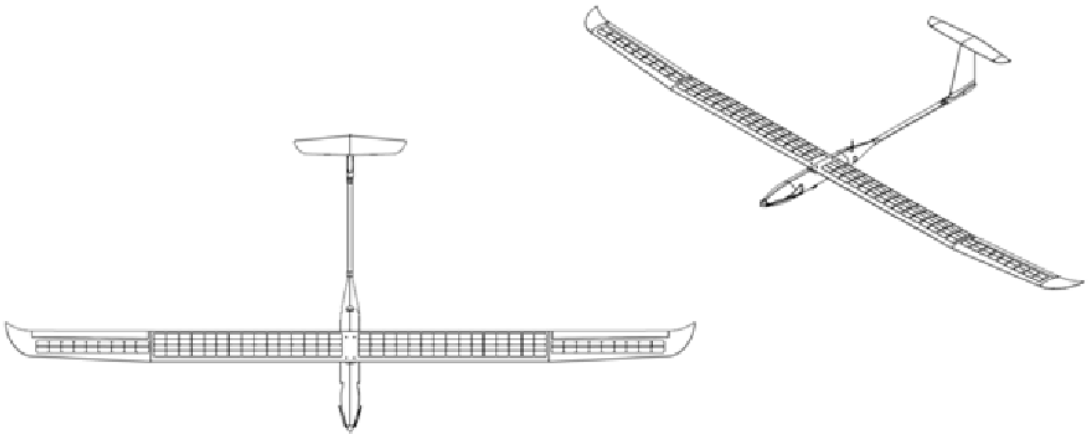

Fig. 1 Simplified configuration of EAV-2

KARI compared the aerodynamic characteristics of several low Reynolds number airfoils and selected SG6043, also adopted the raked wing tip to reduce the induced drag. Its length and height were 3.02m and 0.72m respectively, and the wing span and aspect ratio were 6.93m and 20. The cruise speed of the vehicle was 12.1m/sec and the total weight was 18kg. It recorded 22.3hour's flight time and 5km altitude.

2.3 EAV-2H

As a high altitude version of EAV-2, EAV-2H was developed to increase the possibility of climbing up to the high altitude. The configuration of EAV-2H is similar to EAV-2 but dimensions of the vehicle were extended. The length and height were 5.00m and 0.95m respectively, and the wing span and aspect ratio were 10.83m and 20. The cruise speed of the vehicle was 7.6m/sec and the total weight including the rechargeable battery was 20kg. It has twin propellers and recorded the longest flight time, 25.4hours and the altitude, 10km.

Fig. 2 Flight test of EAV-2H, twin propellers

2.4 EAV-3

For the flight in the stratosphere, EAV-3 was designed by extending the EAV-2 & 2H. The length and height were 8.80m and 1.56m respectively, and the wing span and area are 19.50m and 17.4. The cruise speed of the vehicle was 5.8m/sec and the total weight including the rechargeable battery is 46kg. The flight test is scheduled in July 2015. Fig. 3 is the brief configuration of EAV-3 and Fig. 4 is the simplified flight mission diagram. It will climb to 18km for 6.7 hours and descend to the ground for 5 hours after 1 hour loitering.

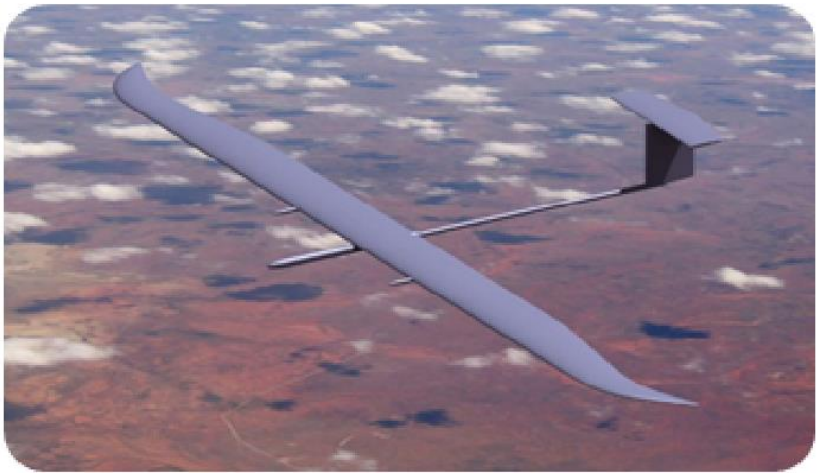

Fig. 3 Brief configuration of EAV-3, twin propellers

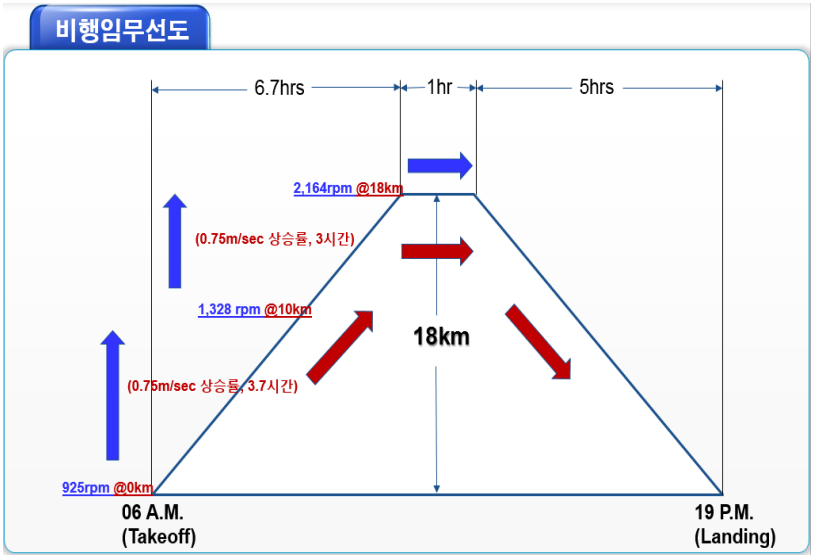

Fig. 4 Simplified flight mission profile of EAV-3

3. CONCLUSIONS

KARI has developed EAV series for the final goal by extending the flight time and altitude, and investigating the characteristics of the power packages. KARI also has tried to design the very light structure and low drag configuration. KARI recorded the flight time, 25.4 hours and the altitude, 10 km. The flight test of EAV-3 is being prepared to explore the stratosphere.

REFERENCES

Jin, W., Lee, Y., Kim, C., Ahn, S., & Lee, D., “Computational analysis of aerodynamic performance of a small-scale electric aerial vehicle”, Proceeding of the 2010 Korean Society for Aeronautical & Space Sciences (KSAS) Fall Conference.

Hwang, S., Lee, Y., Kim, C., & Ahn, S., “Empennage design of solar-electric powered high altitude long endurance unmanned aerial vehicle”, J. of the Korean Society for Aeronautical & Space Sciences(KSAS), vol. 41(9), 2013, pp.708-713