

Analysis of Design Directions for Ground Control Station (GCS)

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Abstract

This study is a preparation phase for integrated visualization of battlefield situation. To develop the ground control station for unmanned systems, many factors have to be considered from the design stages, such as layout, information component, representation scheme, and human operation methods. Considering such many factors can be very difficult, hence we conducted an in-depth investigation of design factors from major UAV stations around the world. We analyzed the design characteristics and the specifics. In conclusion, we were able to derive some common aspects of design characteristics, which lead to the successful design approach.

Keywords

Ground Control Station, UAV, Human Machine Interface, Situation Awareness, Task Load

1. Introduction

Unmanned aerial vehicle (UAV) means the aircraft that remotely or autonomously controlled without a pilot. Ground control station (GCS) is designed to control the UAV from a remote distance. The mission and characteristics of the UAV is usually different from the manned aircraft, hence the design of the control station is differentiated. Due to distant control of UAV, the GCS displays must be designed to provide the enough level of situational awareness to the operators. **Figure 1** shows the common characteristics of GCS. It is preferred that all mission flights can be conducted automatically with a minimal amount of human intervention. Human operators act as just a manager, and ensure that the mission unfolds as planned [1] [2].



Figure 1. Representative features and various conceptual diagram for the ground control station

2. Analysis of UAV GCS

To develop the ground control station for unmanned systems, many factors have to be considered from the design stages, such as layout, information component, representation scheme, and human operation methods. Considering such many factors can be very difficult, hence we conducted an in-depth investigation of design factors from major UAV stations around the world. We analyzed the design characteristics and the specifics. Those include the screen display information, display method, number of screens, tactical situation information, operation of the tactical map equipment, number of operators, operator's position, layout, and the operation environment. By doing so, we derive the common aspects of design characteristics, which lead to the successful design approach. Here is the list of seven major UAVs: MQ-TB Hunter, Scout, Searcher-II, Hermes 450, MQ-1 Predator, Avenger, and Global Hawk. **Figure 2** briefly illustrates the various GCS features, which bears much similarity among the different platforms [3] [4] [5] [6].

2.1. UAV MQ-TB Hunter

MQ-5 Hunter is an unmanned aerial aircraft, which was manufactured by the Israel aerospace industry. In the United States, Northrop Grumman also produced, and supplied to the US military. RQ-5 Hunter is a reconnaissance aircraft. MQ-5 Hunter is an



Figure 2. Various Ground control station design

attack version, which can carry the GBU-44/B laser-guided bomb that weighs about 20 kg.

2.2. UAV Scout

Israeli Aviation Company developed the unmanned aircraft called Scout. It was being put into combat in 1982. To propel the Scout, a piston engine that mounts 13-foot propeller blade made of glass fiber is used. This UAV is very small in size, which emits a small radar cross section. It is nearly impossible to shoot down. Furthermore, it can transmit the real-time, 360-degree monitoring data via the central television camera. During the 1970s, the Israeli military was becoming increasingly interested in battlefield UAVs. The Scout had a similar configuration as the Mastiff, with a pusher propeller and a twin-boom tail. **Table 1** illustrates the characteristics of both Hunter and Scout.

2.3. UAV Searcher-II

Searcher-II is produced by IAI-Malat, back in 1996. This aircraft has been deployed in the Indian Army and Air Force. More than 100 Searcher IIs are being operated by the Indian Air Force and the Indian Navy.

2.4. UAV Hermes 450

Israel, which has a state-of-the-art technology of the unmanned aircraft, has embarked aggressively on overseas sales of the above-mentioned drones. Recently, it is known for the focus on Indian market sales. Israeli Defense Ministry requests that the drone's flight performance should be important than the speed. It is also conjectured that the drones can substitute the conventional manned fighters. Currently, Israel leads the combat deployment of the Hermes 450 unmanned aircraft for long-term flight infor-

Table 1. MQ-TB Hunter and Scout GCS design factors.

	3	4
Number of Screen	3	4
Screen Layout	Line	Rectangle, Placed in the up and down
Touch interface	N/A	N/A
Number of Operator	Two or more	Two
Screen Style	Color coding	Color coding
Tactical Map Style	Color coding, 2D	Color coding, 2D
Interface	Button, Switch	Button, Switch, flight stick

mation collection. This is a large drone equipped with various sensors. **Table 2** illustrates the characteristics of both Searcher and Hermes 450.

2.5. UAV MQ-1 Predator

Predator is a model that was developed by the General Atomics, Inc. It is considered as one of the most successful unmanned machines in the US Military. It is manufactured for reconnaissance, and called by the name RQ-1. It is also equipped with weapons. This variant is called MQ-1. Predator is a huge drone, and its large scale system requires the full-time personnel of about 55 people to operate. Predator can conduct an automatic flight along a path that has been programmed in advance. By using the satellite communication and the encrypted data link, it can fly anywhere in the world remotely.

2.6. UAV Avenger

Avenger is the combat drone that has been developed by the General Atomics Aeronautical System Company. It is one of the latest unmanned aircrafts of the US Army. In 2012, the company improved the ground control station. Avenger uses the same ground support infrastructure as the MQ-1 and MQ-9, including the ground control station and existing communications networks. **Table 3** illustrates the characteristics of both Predator and Avenger.

2.7. UAV Global Hawk

Global Hawk is the product of the Northrop Grumman Corporation of United States. It is equipped with an all-weather synthetic aperture radar (SAR), electro-optical/infrared sensor (EO/IR), the moving target indicator, high-resolution electro-optical sensors, digital camera, and the third-generation infrared sensor. Its integrated sensor devices operate via a common signal processor that is comparable to the diameter of 1.2 m antenna and the supercomputer. Once it takes off, it can be flying up to 32 hours. It flies at a height that is not affected by the bad weather and the prevailing wind. Its flight altitude is out of anti-aircraft guns and most missiles intercept range. It is controlled via a dedicated radio channel and the satellite communication network. **Table 4** illustrates the characteristics of Global Hawk.

Table 2. Searcher-II and Hermes 450GCS design factors.

Number of Screen	5	4, 5
Screen Layout	Rectangle, Placed in the up and down	Rectangle, Placed in the up and down
Touch interface	N/A	N/A
Number of Operator	Two or more	One or Two
Screen Style	Color coding	Color coding
Tactical Map Style	Color coding, 2D	Color coding, 2D, 3D
Interface	Buttons, Switch, flight stick, keyboard, mouse	Buttons, Switch, flight stick

Table 3. MQ-1 Predator and Avenger GCS design factors.

Number of Screen	12 or more	6
Screen Layout	Rectangle, Placed in the up and down	Rectangle, Placed in up and down
Touch interface	Touch Screen	Touch Screen
Number of Operator	More than four	One
Screen Style	Color coding	Color coding
Tactical Map Style	Color coding, 2D, 3D	Color coding, 3D
Interface	Button, Switch, flight stick	Button, Switch, flight stick, keyboard

3. Conclusion

3.1. Development Direction of the Ground Control Stations

Most GCS design has been found that it provides enough level of battlefield information as well as the UAV flight information. It also emphasizes the minimization of the cognitive load. Operator reaction speed and accuracy are also very important. Improved visibility of battlefield situations has been realized using advanced graphical techniques, while enables the fast identification of threats. This early detection and identification of the magnitude of the threat allows the rapid decision making. The human interface is evolved into touch-screen and multi-screen system for fast reaction and vast presentation of necessary information. The individual convenience of the operator in terms of the configuration of a display screen has been implemented by the customization. A large screen is also being used to maximize the display size for information presentation.

3.2. Analysis of Ground Control Station Design Factor

Analysis of the unmanned system GCS, depending on the changing battlefield environment, has confirmed that the GCS is in the direction of maximizing quick judgment. The size of the screen tends to increase, as well as the number of screens. There is a tendency to place the screen up and down in order to reduce the fatigue of the operator. In addition, it uses a three-dimensional tactical map to express the battlefield situation in detail. The symbol for differing information has been classified by the colors. In order to reduce the work load of the pilots, additional operational personnel is present to work the system. **Table 5** summarizes the findings.

Table 4. Global Hawk GCS design factors.

Number of Screen	12 or more
Screen Layout	Various style
Touch interface	Touch Screen
Number of Operator	More than four
Screen Style	Color coding
Tactical Map Style	Color coding, 2D, 3D
Interface	Button, Switch, flight stick, keyboard, mouse

Table 5. Design directions for the GCS.

Design direction	Details
Rapid situation awareness	Exhibition through a number of symbols and geographical data Color coded for rapid recognition Symbols are simple, yet effective
Battlefield area settings	Battlefield situation is represented with ease of understanding User can zoom in or zoom out of display Display can be providing an enlarged view of a particular area, while simultaneously exhibits several display screens
Tactical map style	2D display or 2.5D, even 3D representation is possible, to indicate various enemies threats, ballistic, and geo-features User can set the style of representation to accommodate the varying situations
Information concentration on large screen	A large color-screen is used to display the necessary information The screen can be freely set in accordance with the operation

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