Research on Key Performance Evaluation Technology of Intelligent Unmanned Platform

Qi Zhang¹, Yiming Su¹ and Shuiwang Yang¹
¹Beijing Zhenxing Institute of Metrology and Measurement, Beijing, China, 100074
kakaxiqi123@sina.com

Abstract. According to the evaluation requirements of ground unmanned platform, this paper designs from three aspects: main function evaluation, technical index evaluation and tactical index evaluation, and preliminarily forms the evaluation method of unmanned platform, which lays the foundation for establishing relevant technical specifications of unmanned platform.

1. Introduction
In recent years, with the rapid development of intelligent unmanned technology, the successful application of ground intelligent unmanned platform and ground intelligent unmanned equipment in dangerous and distant fields has become a new research hotspot [1]. Intelligent unmanned platform is an unmanned, completely remote-controlled or self-operated system according to pre-programmed procedures. It can carry corresponding weapons, reconnaissance equipment or other task loads according to design purposes and operational requirements, and can independently carry out combat tasks such as battlefield reconnaissance and surveillance, personnel search and rescue in dangerous environments, transportation of materials and equipment, and fire attack. It is an indispensable and important part of the future weapons and equipment system. At the same time, the ground intelligent unmanned platform has gradually evolved into information-based high-performance weapons and equipment, which can quickly compete for battlefield space and play a very important role in information transmission and electronic warfare. The ground intelligent unmanned platform needs to act autonomously according to the perceived information and capture and locate the target. Therefore, the target positioning accuracy of the ground intelligent unmanned platform has a direct impact on capturing and locating the target, and has a profound impact on the completion of the specified task. The working environment of the ground intelligent unmanned platform is a dangerous, remote and complex environment, which has the characteristics that the operator or controller can't reach, can't go or don't want to go. Different working environments also put forward higher requirements for the environmental adaptability and autonomy of the ground intelligent unmanned platform. It is necessary to evaluate the autonomous capability of the ground intelligent unmanned platform under various simulated environments and meteorological conditions, so as to understand the performance of the ground intelligent unmanned platform and ensure that the performance of the intelligent unmanned platform meets the technical and tactical requirements.

2. Main direction of evaluation
There are three types of evaluation contents for the intelligent unmanned platform: main function evaluation, technical index evaluation and tactical index evaluation. The main function evaluation is to test and verify the qualitative functions that the unmanned platform can achieve to ensure that it meets...
the design requirements, usually including autonomous navigation, automatic duty, remote functions and identification functions; Technical index evaluation is to test and verify the measurement and control ability of unmanned platform with quantitative requirements to ensure that it meets the requirements, usually including running speed, positioning accuracy and measurement ability; Tactical index evaluation usually refers to evaluating the environmental adaptability, endurance and reliability of unmanned platform. The key performance evaluation methods are introduced by taking a certain inspection robot as an example.

2.1. Main function evaluation
Main function evaluation should follow these steps.

1) autonomous navigation function test: set an outdoor target point and judge whether the intelligent inspection robot can navigate to the point autonomously; Set a certain indoor target point to judge whether the intelligent patrol robot can navigate to this point autonomously.

2) Automatic duty function test: Set six fixed positions A, B, C, D, E and F, and perform basic actions such as orientation, circular patrol, pre-positioning, taking pictures and broadcasting at the six positions at a series of time intervals.

3) Reminder broadcast function test: broadcast three points for attention through the horn of the robot.

4) Abnormal alarm function test: set blacklist personnel, abnormal high temperature range and abnormal behavior and action, and test them by testers and standard blackbody.

5) Remote intercom function test: Testers talk to robots in the monitoring center to verify the remote intercom function.

6) Maskless identification function test: multiple groups of testers wear masks and do not wear masks to verify whether they have the identification function without masks.

7) Long-distance identification function test: several testers are at the position 100m away from the robot to verify whether they have long-distance identification function.

8) One-button reaching function test: set three different distance and path target points to verify the one-button reaching function.

9) Testing the accuracy and efficiency of body temperature detection: The standard blackbody is placed at a distance of 5 meters from the robot, and the accuracy of body temperature detection is verified by 100 tests; At least 10 testers pass through the robot field of view at the same time to verify the detection efficiency.

10) autonomous charging function test: turn on the autonomous charging function. when the power of the robot is lower than a certain percentage, verify whether to automatically charge.

11) Real-time audio and video monitoring function test: after the robot runs, the live audio and video are called by the monitoring center to verify whether the real-time audio and video monitoring function is normal.

2.2. Technical index evaluation

2.2.1. Running speed test method and steps
The standard distance of 1km is determined by GPS receiver, and the time for the inspection robot to pass this distance is measured by stopwatch. The specific steps are as follows:

1) measure the standard 1km distance, starting point is a and ending point is b;

2) Set the maximum running speed at point A of the intelligent inspection robot, and start the stopwatch while running the intelligent inspection robot;

3) When the intelligent inspection robot reaches point B, record the stopwatch value and record the data;

4) Repeat the measurement for three times to calculate the maximum running speed.

Judgment method:
The measurement results of three times are not less than 4km/h, which meets the index requirements.

2.2.2. *Maximum load test method and steps*
Measure the operation under the maximum load by standard weight. The specific steps are as follows:
   1) placing 50kg standard weight on an intelligent inspection robot and running the intelligent inspection robot;
   2) Repeat the test three times and record the data.

2.2.3. *Communication distance test method and steps*
Determine the communication distance of standard distance test by laser rangefinder. The specific steps are as follows:
   1) on the open field, three standard distances of 25m, 50m, 75m and 100m are determined by laser rangefinder;
   2) Determine whether wired communication and wireless communication work normally at four distances, and record the results;
      Judgment method:
      Wired communication works normally at 25m, and wireless communication works normally at 25m and 50m, which meets the requirements.

2.2.4. *Test method and steps of obstacle avoidance parameters*
The obstacle avoidance parameters are tested by personnel, obstacles, climbing verification device and universal angle ruler. The specific steps are as follows:
   1) Turn on the local autonomous navigation obstacle avoidance function, and the tester stands in front of the running path of the intelligent inspection robot to test whether to avoid the tester;
   2) Start that obstacle avoidance function of local autonomous navigation, placing obstacle with the size of 500mm * 500mm * 500mm in front of the running path of the intelligent inspection robot, and testing whether to avoid the obstacle;
   3) The climbing verification device is measured to be 20 by the universal angle ruler to verify whether the intelligent inspection robot can successfully complete climbing.
   4) Repeat the operation for three times and record the results.

2.2.5. *Test method and steps of navigation accuracy*
Test navigation accuracy by GPS receiver. The specific steps are as follows:
   1) select two measuring points a, b, c and D.
   2) Place the standard GPS receiver base station at point A, place the standard GPS receiver at points B, C and D, and record the position information of the GPS receiver;
   3) Place the standard intelligent inspection robot base station at point A, and place the intelligent inspection robot at points B, C and D respectively, and record the position information of the intelligent inspection robot;
   4) Repeat three times and record the results.

2.2.6. *Navigation attitude test method and steps*
The navigation attitude is tested by photoelectric autocollimator, master/sleeper turntable and stopwatch. The specific steps are as follows:
   1) placing a master-bedroom turntable on an intelligent inspection robot;
   2) controlling the intelligent inspection robot to deflect for a certain angle, respectively recording the azimuth angle and the attitude angle, measuring the azimuth angle and the attitude angle through a photoelectric autocollimator, and calculating the static azimuth angle and the attitude angle;
3) control that intelligent inspection robot to deflect for a certain angle, measuring the angle in the
deflection process through a stopwatch and a photoelectric autocollimator, and calculating the time
sequence with the internal data position of the robot to judge the dynamic attitude angle;

4) Repeat three times.

2.2.7. Temperature measurement test method and steps
The temperature measurement value is calibrated by the standard blackbody radiation source by
comparison method, which can be divided into two ways: field calibration and laboratory calibration
of temperature measurement subsystem.

1) selecting temperature points as -10 deg c, 20 deg c and 50 deg c, and setting the temperature
value of a standard blackbody radiation source;

2) Adjust the distance between the temperature measurement subsystem and the blackbody
radiation source to 5m;

3) align and focus the temperature measurement subsystem;

4) after the temperature control of the blackbody radiation source is stable, the temperature
measurement subsystem measures the temperature value of the blackbody radiation source;

5) Repeat the reading three times.

3. Tactical index evaluation
Tactical indicators of intelligent unmanned platform usually include endurance time, environmental
adaptability, electromagnetic compatibility and reliability, etc. The specific test methods are as follows.

3.1 Test method and steps of endurance time
Test battery life with stopwatch. The specific steps are as follows:

1) fully charging the intelligent inspection robot;

2) Run the intelligent inspection robot and start the stopwatch;

3) The stopwatch displays for 3 hours, and the remaining power is recorded;

4) Repeat the measurement 3 times.

3.2 Environmental adaptability test methods and steps
The five key environmental parameters of environmental adaptability test are: high temperature
working 55℃, high temperature storage 60℃, low temperature working -25℃, low temperature
storage -40℃, humidity test 80% (25℃), and humidity test relative humidity 95% (35℃). The
platform should be tested according to relevant regulations in GJB150.

3.3 Electromagnetic compatibility
Electromagnetic compatibility test shall be conducted according to the following table.

| Serial number | Projects                                      | Method                                                                                     |
|---------------|-----------------------------------------------|-------------------------------------------------------------------------------------------|
| 1             | Immunity to conducted disturbance induced by RF field | According to GB/T 17626.6-1998, the test grade is grade 2, and the effective value is 3v; The frequency is 150 kHz ~ 80 MHz; 1kHz sine wave 80% amplitude modulation. |
| 2             | Immunity of electrical fast transient         | According to GB/T 17626.4-1998, the test grade is Grade 3, with peak value of 2kV for AC line, 1kV for signal, control and DC line, rising time Tt=5ns, holding time Th=50ns and repetition frequency (5 ~ 100) kHz. |
| 3             | Electromagnetic radiation                     | According to GB 4824-2004, the frequency is 30 MHz ~ 1000 MHz, which meets the requirement of electromagnetic radiation |
disturbance limit of Class B equipment.

| 4 | Immunity to electromagnetic radiation |
|---|--------------------------------------|
|   | According to GB/T 17626.3-2006, the test grade is grade 2, and the field strength is 3v/m; The frequency range is 80 MHz ~ 1000 MHz; 1kHz sine wave 80% amplitude modulation. |

| 5 | Immunity to electrostatic discharge |
|---|-------------------------------------|
|   | According to GB/T 17626.2-2006, the test grade is grade 3, with 6kV contact discharge; 8kV air discharge. |

3.4 Reliability

Reliability verification adopts the method of calculating the mean time between failures, records the running time and failure times for the unified operation of multiple unmanned platforms (including various tests), and calculates the mean time between failures according to the working time and failure times.

\[
MTBF = \frac{\sum t_i}{\sum N_f(t_i)}
\]  

**MTBF** is the mean time between failures;  
\(\sum t_i\) is the total running time of multiple unmanned platforms;  
\(\sum N_f(t_i)\) is the total failure times of multiple unmanned platforms

4 Summary

Through the research on key performance evaluation technologies of intelligent unmanned platform, we have mastered and possessed the evaluation methods of unmanned platform, and accumulated data through the evaluation and verification of different types of unmanned platforms, which laid the foundation for formulating evaluation standards of intelligent unmanned platform and improving the development capability of intelligent unmanned platform.

References

[1] ISO/IEC 15420 Information technology – Automatic identification and data capture techniques-EAN/UPC bar code symbology specification  
[2] Ke-hu XU, Guo-sheng WANG, The Quantitative Assessment Research on Targets Attack Value of Land Battle Unmanned Platform, 2020 2nd International Conference on Advanced Control Automation and Artificial Intelligence, ACAAI 2020.  
[3] Hui XIE, Jing-kun HU, Yi-yang SUN, Yan-cheng SA, Research on wireless communication distance test methods for small ground mobile unmanned platform, 2018ICDT.  
[4] Zhong Chonghui, Jia Xihua, Review of the development of foreign ground unmanned combat platform military robots[J]. Robot Technique and Application, 2005(4):18-24. (in Chinese)