Generalized Measurability Design of Equipment

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Abstract. Equipment measurability is a design characteristic owned by each measuring (or testing) device of equipment that reflects its accurate value, reliable data, and the degree of convenience of measurement. Based on the concept of equipment measurability, this article puts forward the new concept of generalized measurability design of equipment, and designs it synthetically from three aspects: standard device, support model and support object.

Introduction

With the development of military technology, our military's modernization construction pace has been quickened, the complexity of the weapon system increases day by day, and a growing number of weapons are controlled and influenced directly by the quantity. However, the accuracy and reliability of the quantity depend on the metrological verification for the weaponry, which requires that weaponry have good measurability. Equipment measurability is a design characteristic owned by each measure (or test) device of equipment that reflects its accurate value, reliable data, and the degree of convenience of measurement. Besides, the equipment measurability runs through the life-cycle of the equipment [1]. Based on the basic conception of equipment measurement, this paper presents the concept of generalized measurability design of equipment.

Generalized measurability design of equipment

Generalized measurability design of equipment is a design characteristic that reflects the accurate value, reliable data, and the degree of convenience of measurement, and analyses elements correlation with measurement support of equipment or affecting testing result of equipment, instead of limiting to property of the equipment itself. The paper designs synthetically from three basic elements of generalized measurability of equipment, that is to say standard device; support model and support object (the equipment and its measuring/testing device). This is to make sure that equipment owes the good measurability to improve measurement security efficiency of equipment.

Measurement standard device

Parametric. The structures of military weaponry system are mostly complicated, and they have many calibration parameters. In order to improve measurability of weaponry system, the measured parameters and measuring resolution of designed measurement standard device should cover almost the parameters under calibration of equipment. For example, Automatic Test System (ATS), which is widely used in weapon integrated support equipment, is characterized by its more measured parameters, wide range of measurement and various structures. From the above, it can be seen that ATS is plenty to meet the measurability requirement of complicated weaponry. Meanwhile, given that the complexity structure of ATS, considering the whole uncertainty level and considering uncertainty level of the major parameters should be combined when analyze the uncertainty of ATS, so as to simplify middle stages and improve productivity.

Portability. Generally speaking, weaponry systems usually have great bulk, complex equipment and not easy to move. Therefore, it is necessary that measuring equipment is easy to move or convenient to carry, so as to suit measuring object when taking metrology support. Hence, in developing metrology support, it should be small but excellent as for as possible.

Environmental adaptability. The environmental adaptability of standard device describes the ability that under the normal operation, the whole measuring system can be adapt to all kinds of environment, realize measuring function and not be destroyed. There are generally two methods to improve the environmental adaptability of standard device: one is slowing the effect of external environment, that is to say, the condition of externalities should be controlled strictly when the standard device is working. For instance, setting blockers and insulation board to prevent electromagnetism interference and noise jamming; the second is improving their ability to resist environmental effect, that is to say, environmental adaptability should be improved fundamentally when designing the standard device. For instance, choosing the high temperature resistant materials or components can reduce the influence of the temperature; using the coating on the surface of the parts or adopting other surface treatment can be resistant to corrosion, and extend unit life.

Measurement support model

Laboratory measurement. Laboratory measurement is easiest and has relatively higher degree of accuracy and reliability in all measurement security models. Laboratory, which has advanced testing equipment, can strictly control the externalities responsible for the experimental result, and can set up stable Metrological Verification Platform, so as to reduce the influence of other factors and provide protection for the reliability of a measure. For example, a balance, which is often used in laboratory, can be directly applied for laboratory measurement because of small volume and moving conveniently. Such practice can guarantee the accuracy and reduce costs.

Real time measurement on line. Laboratory measurement mentioned above is not suited to all weaponry. For example, Unmanned Ground Vehicle (UGV), which is working in wide field, can't be provided for necessary environment by laboratory, so we can select a new mode named real time measurement on line. One core element of real time measurement on line is selecting appropriate high precision sensors. While weaponry is working, the sensor can transfer monitoring variables to figure signal, then dealing with experimental data and taking metrological calibration. In general, the process of real time measurement on line can be summarized: monitoring instruments on the scene collect data automatically under the control of data collection platform. At the same time, computer terminal connecting receiver disposes all data in real time [2].

Remote non-contact measurement. With the leap-type development of weaponry, requirements of information of equipment draw higher demand in the accuracy and reliability of measurement. However, considering the practical application environment of military weapons equipment, traditional transfer methods of magnitude can't satisfy the metering need of the weaponry. For example, military weaponry such as tanks working under the filed condition can't get in laboratory measurement. Besides in order not to delay using, aeronautic equipment of implement task also can't freely move to somewhere else to measure. So, for the above situation, remote non-contact measurement model is proposed. Remote non-contact measurement, to say it informally, is to test and calibrate parameter remotely, it means that it is not necessary that measured weaponry is sent to the superior measure technology organization to take verification and calibration, only need to connect the measurement and control platform of the superior measure technology organization through Internet according to special regulations, specialized standard and specific port, to realize its verification and calibration [3]. The metering model is a model with great development potentialities in society which can greatly shorten the time of verification and calibration, reduce maintenance cost, and improve the accuracy and reliability of measurement.

Mobile support measurement. Mobile support measurement is a support model which replaces inspected units trace to the source inspecting [4]. Even though our army has built relatively complete stair, secondary, three-lever measuring technique organization, as tested equipment develops, this support mode has its limitation that can't adapt to the measuring support requirements of scene, speediness parallel and maneuvering, especially be satisfied with the requirement of transregional urgent mobile measuring support. Mobile support measuring model means that the verification of tested equipment on the scene and the controlling of environmental conditions are important factors of influencing maneuvering measurement. Aiming at the question, we come up with a method for building mobile measurement platform, solving radically the trouble of environment. For the reliability of measurement magnitude, a mobile measurement platform has to provide the following features: anti-interference, damping, anti-static, allocating thermostats that work well and stable power supply system and so on.

Measurement support object

Measuring interface. The measurability of weaponry is a key factor of realizing equipment measurement support, and designing measuring interface according with rule is the requirement of realizing measurability. In past, due to lack of metrology consciousness during the exploitation and development of equipment, lagging standardization of equipment measuring interface, it results in the deficiency of measuring interface and brings in great trouble for verification of weaponry. Finally, subsequent preparing support can't be put into effect smoothly. Therefore, measuring support programs should be built and measuring interface should be designed in the stage of preparing weapons and realizing measuring accessibility. There are differences between measuring interface and test interface. Programmed measurement or roboticized measurement should be realized according to metrological characteristics and calibration method, except for realizing the basic function of test interface, so as to realize controllability of measurement [5].

Completeness of measurement. Generally speaking, test equipment is a kind of comprehensive equipment that features complex structure, multiparameter measurement and covers a wide range of knowledge. According to IVI (Interchangeable Virtual Instrument) standard, IVI foundation announced eight types of normative instrument: switch type, Digital Multipurpose Meter (DMM) type, oscilloscope type, frequency analyzer type, dynamometer type, wave form/function generator type, direct-current main type, radio-frequency signal generator type. In view of kinds of instrument mentioned above, it is known that parameter type needs to measure of completed weaponry is multiple. Completeness of measurement is aimed at ensuring whether all parameters are included to make sure all kinds of magnitude considerable and steerable during the whole measurement.

Internal traceability chain [6]. A weapon equipment maybe establish multiple positional points of test in the mock-up stage, however, signal parameter measured from positional points of test mentioned above or signal type measured from the same positional point of test is not the same. For example, ATS's parameters need to measure and correct have voltage, attenuation, offset frequency, temperature, stress and so on. As a result, measurement signal should be classified before calibration, then sorting the signal in accordance of accuracy class, lastly, determining internal traceability chain. Highest standard of relative precision is treated as the top of internal traceability chain—reference standard. Besides, we can trace to the source towards to the superior unit of measurement through traceability adapter. Moreover, other devices realize quantity transmission of the system internal through self-calibration adapter.

The normalized value. Normalization is a way that simplifies calculation. Considering of various parameter type of measurement signal above, it can't apply uniform standard to adjust parameters. As a result, it brings in great trouble to verifying instrument. So in dealing with parameter index, similar parameter number should be simplified as for as possible. There are normalization methods, for example, Principal Component Analysis (PCA) or min-max standardization. We can take advantage of them to analyze and adjust magnitude.

Support cost/ efficiency/ cycle/ environment. Support cost is more closely with support efficiency, support cycle, support environment and so on. External environmental factors influence calibration accuracy. For example, the interference of the external electromagnetic waves, differences in temperature and humidity, platform vibration and so on would affect experimental results of remote calibration system of torque sensor. Therefore, adaptive jamproof environment should be provided for weaponry as far as possible while adjusting torque sensor.

Conclusion

Generalized measurability design of equipment is a work that involves many-sided factors. Details need to consider are many. Aiming at three aspects: standard device, support model, support object, this article expounds how to take measurability design. However, for lacking of theoretical direction of measurability, we may meet with a great many difficulties in the practice process of carrying out the work of generalized measurability design. In order to resolve these difficulties, some improvements can be made in the following respects:

1) Developing advanced measuring technology: for example, measuring technology of information domain, limiting magnitude, and complicated electromagnetic environment, etc.

2) Innovating measuring support concept: for example, life-cycle support, system-wide support, and measuring support that crosses the services and arms joint, etc.

3) Carrying out new-style measurement model: for example, measurement on line, remote measurement, motor with measurement, etc.

4) Developing advanced measurement devices: for example, embedded device, networked device, comprehensive device, maneuvering device, etc.

5) Formulating or modifying standards: revising "General requirements for equipment metrology support-detection and calibration", increasing the content of measurability, and establishing "weaponry metrology support outline", "equipment measuring manual", etc.

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