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# A Fault Isolation Method Based on S1000D Fault Data Module

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**Abstract.** Fault diagnosis isolation is one of the important function in IETM application. Aiming at the problems existing in the integrated use of third-party fault diagnosis system and IETM and the low application level of fault reporting information in IETM, the fault reporting information structure in S1000D is analysed in detail. A new method which integrates the fault reporting data within IETM platform is presented.

## 1. Introduction

The Interactive Electronic Technical Manual (IETM) is a technical publication that is developed in standard data formats in the form of text, graphics, tables, audio and video etc., and provides basic principles, operation and maintenance procedures of equipment in an interactive manner[1]. It can improve the success rates of fault location, reduce fault time of repair, and improve the efficiency of equipment maintenance greatly with the help of multi-dimensional knowledge data in IETM. There are two different ways of the fault diagnosis implementation in IETM. One way is to form a diagnostic strategy description document, which is exported from a third-party diagnostic system such as TEAMS[2] or edited by a specialized editor in diagnostic language such as DiagML[3], and then import this policy file into the IETM platform to implement a diagnostic interaction process fully. The other way is to make use of the S1000D fault data module directly. The integration degree in the first way is not high because the external fault diagnosis strategy cannot link the internal data in IETM platform. On the contrary, the second way though owns a high degree of integration, the fault reporting information is only used to describe the common fault phenomenon and causes of the equipment which users can search and query[4], but fails to conduct a deep research on the S1000D fault reporting data in the fault isolation process up to now. The paper will present a new method of fault isolation process by the usage of S1000D fault reporting data.

## 2. Fault data module of S1000D

S1000D is one of standards for IETM which defines equipment data with a structured data module. Information about the equipment fault and isolation diagnosis process are standardized in form of fault data module, which can be divided into two parts: fault reporting information and fault isolation information. The fault reporting information describes the faults information such as fault parts, fault phenomena, fault causes and repair procedures that are detected or observed by the built-in monitoring system or the repairer. The data structure of fault reporting is shown as Figure 1. The fault types include isolated faults, detected faults, observed faults, and correlated faults.



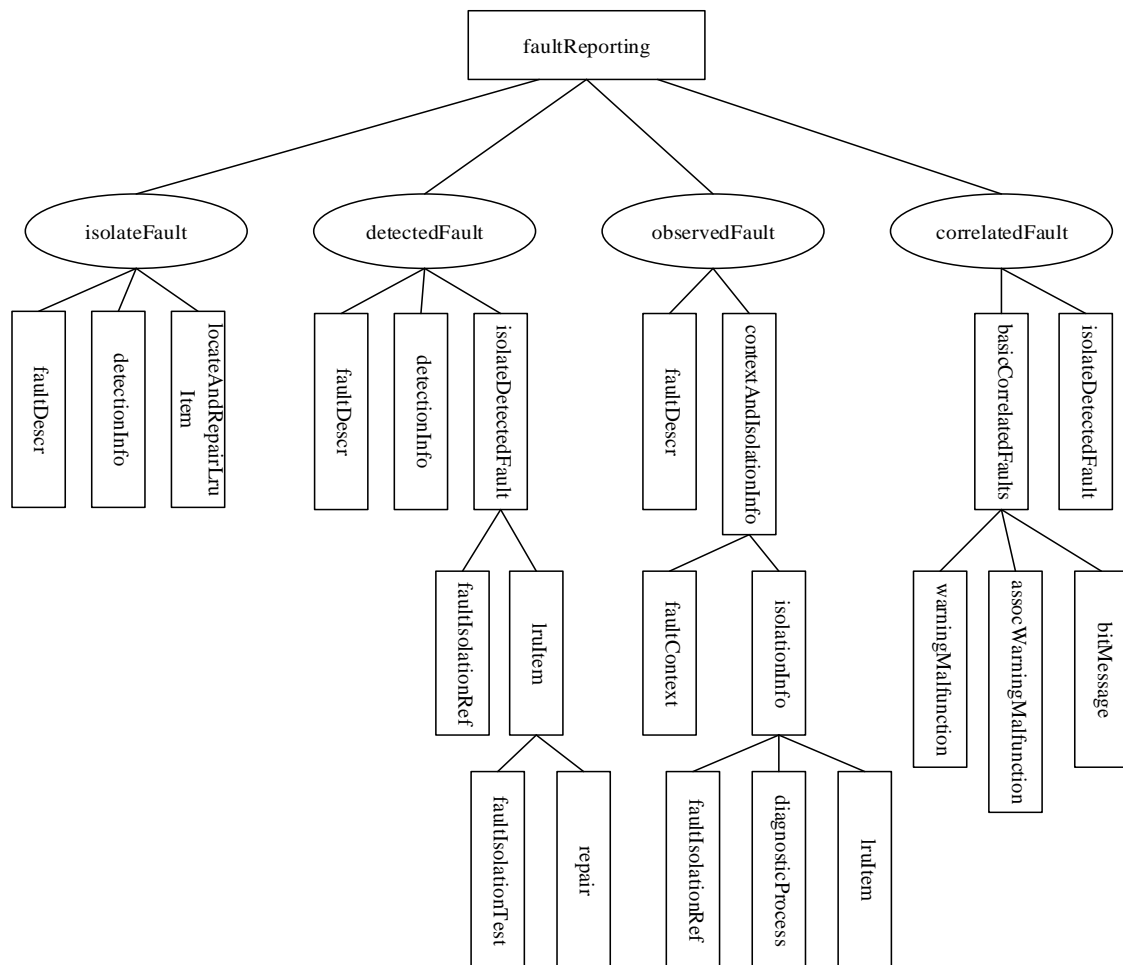


Figure 1 Diagram of fault reporting data structure

■ Isolated faults are those faults that can be detected and isolated by a built-in detection system and has only one cause for each failure. Although, they do not need to give the corresponding isolation process, a reference to the corresponding fault repair procedure should be indicated.

■ Detected faults are those faults that are detected by the built-in detection system and have several causes for each failure. The procedures of fault isolating and detection program for the detected faults should be given.

■ Observed faults are those faults such as oil fluctuation, door fail to open, vibration and abnormal tasting etc., which can be observed by operator or repairer, and not detected by the inspection system in equipment.

■ Correlated faults are a set of faults that resulted from one reason, and are detected, filtered and grouped by the monitoring system. Correlated faults establish a unique reference to a fault isolation procedure.

The data schema of observed faults is more complicated than other isolated or detected faults found by the equipment detection system, though they own many same data schema segments. Taking the observed faults as examples, this paper will analyze the S1000D fault reporting data schema deeply. The root element of observed faults in fault data module is <observedFault> whose schema is shown in Figure 2. It has three important child elements: <faultDescr> contains fault description, <contextAndIsolationInfo> includes the context and isolation information, and <remarks> describes the general remarks of faults.

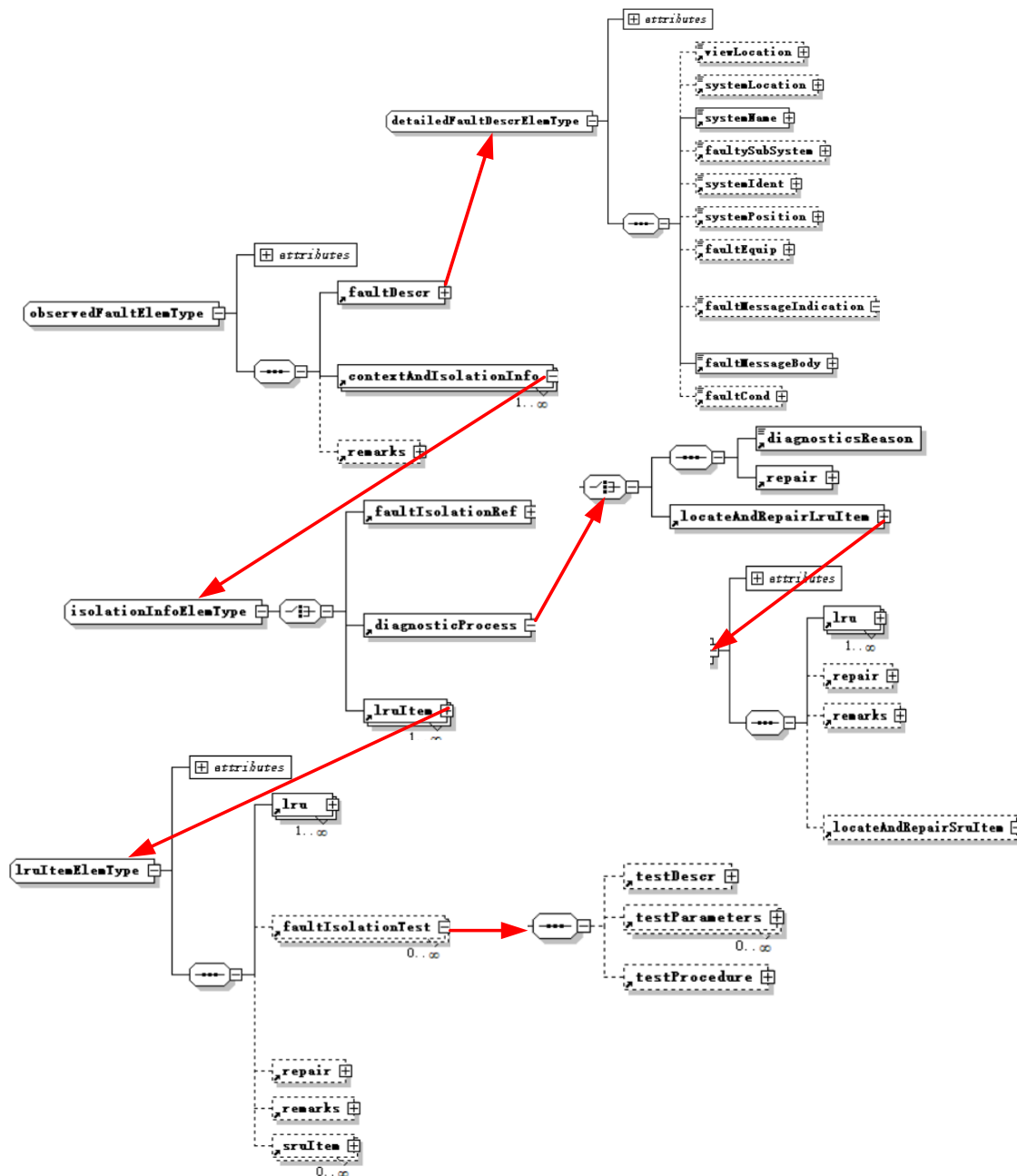


Figure 2 The observed fault data schema

The element <faultDescr> describes the fault phenomenon which provides important reference information for the development of repair strategy subsequently. It includes three child elements: <descr>, <detailedFaultDescr> and <refs>. The element of <descr> describes the fault phenomenon by simple text, <detailedFaultDescr> gives the detail description of fault phenomenon, and <refs> refers to other data modules to describe the fault further.

The element <contextAndIsolationInfo> explains the corresponding environment background and isolation information while the fault occurs. It is partitioned into two parts: <faultContext> and <isolationInfo>. The element of <faultContext> includes the basic environmental condition information of the observable fault, while the element <isolationInfo> is used to complete the diagnostic isolation process by three ways:

- The child element of <faultIsolationRef> is adopted to guide the process of fault isolation by

referencing an external link such as an external data modules, a publication modules, or an external publications.

■ The child element of <diagnosticProcess> is adopted to describe faults which has definite fault location of LRU and clear cause relating to the failure. Faults with clear causes and easy to repair can employ the child element <diagnosticsReason> to describe the causes of the fault identified by the diagnosis, and then use the child element <repair> to refer to the repair procedure. Faults that has unique reason and does not require the isolation process, can utilize the element <locateAndRepairLruItem> to isolate the fault, query the information like LRU name, abbreviation, and identification data from its child elements <lru>, and use its child element <repair> to reference the maintenance program of the related fault LRU.

■ The child element of <lruItem> is adopted to describe the fault isolation process while the fault has multiple failure causes. In the element of <lruItem>, the child element <lru> provides the name, abbreviation and identification information of all LRUs that may be malfunctioning; The child element <faultIsolationTest> contains the child element <testDescr> which provides the test description, the child element <testParameters> which provides the test parameters, and the child element <testProcedure> which references the required test program, the child element <testDescr> which provides a test name and a reference to the test-related description, and the child element <testParameters> which contains a set of conditional boundary parameters required for testing, such as "test duration from 1th to 2nd days", and the child element <testProcedure> which describes the relevant tests in detail by referencing information such as other data modules, publication modules, or external publications. The element <repair> are used to reference the repair process of a faulty LRU that the repair program describes a detected location.

Based on the analysis above, while the IETM editors are developing the equipment maintenance manual, they should fill in the fault report and isolation process information appropriately with aid of fault module editing system according to the fault cause and the troubleshooting method. Figure 3 shows the editing interface that for checking and processing the air pressure of an artillery balancer machine when the high and low steering of artillery is observed inflexible.

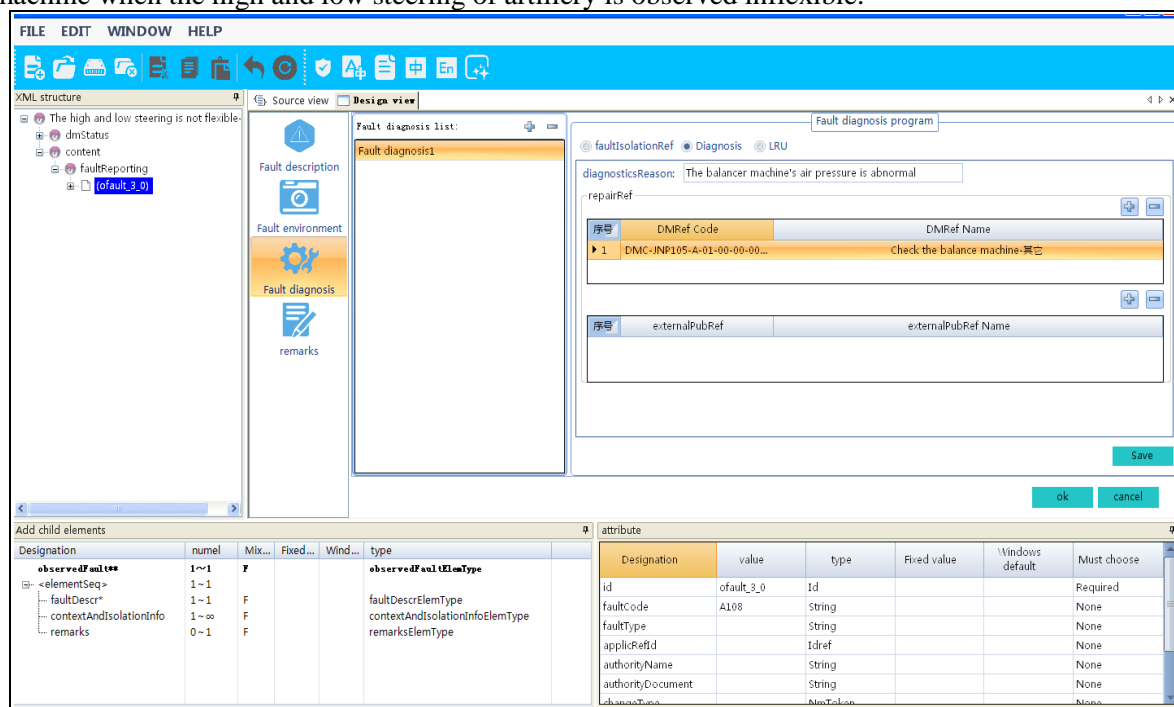


Figure 3 Editing the fault reporting information

### 3. Application of fault data in diagnostic isolation

Taking observed fault as example, the process of how to make use of the fault reporting data is shown in Figure 4. When the equipment is observed failed, the maintainers should firstly confirm what the fault phenomenon is, and input fault code or the key words about the fault in IETM system. The system searches the database of the observed fault, and checks whether the fault phenomenon stored in the query element <faultDescr> matches the user's inputs. If it succeeds, the similarity checking of the background information in <faultContext> will then performed, and fault isolation in term of the fault isolation information in <isolationInfo> will be conducted subsequently. There are three main isolation methods:

- If the fault cause and location are clear and there is no need to replace the LRU, the cause of the fault can be found in the element of <diagnosticsReason>, and the repair procedure is also available in the corresponding repair link in <repair>.
- If the fault cause is unique and the fault unit can be directly located to a certain LRU, the fault location information can be found in <locateAndRepairLruItem>, and the repair procedure is also available in the corresponding repair link in <repair>.
- If the fault is not determined by which LRU causes, it is necessary to isolate the fault to the certain LRU firstly. Two ways can be taken: one is to reference to the external fault isolation program to complete the fault isolation; the other is to test all relevant LRUs, and including some steps: viewing the relevant fault information in <lru> and test description in <testDescr>; testing the relevant LRUs for isolation according to the test condition parameters in <testParameters> and programs referenced in <testProcedure>; and starting to repair in term of the corresponding link in <repair> for the detected LRU.

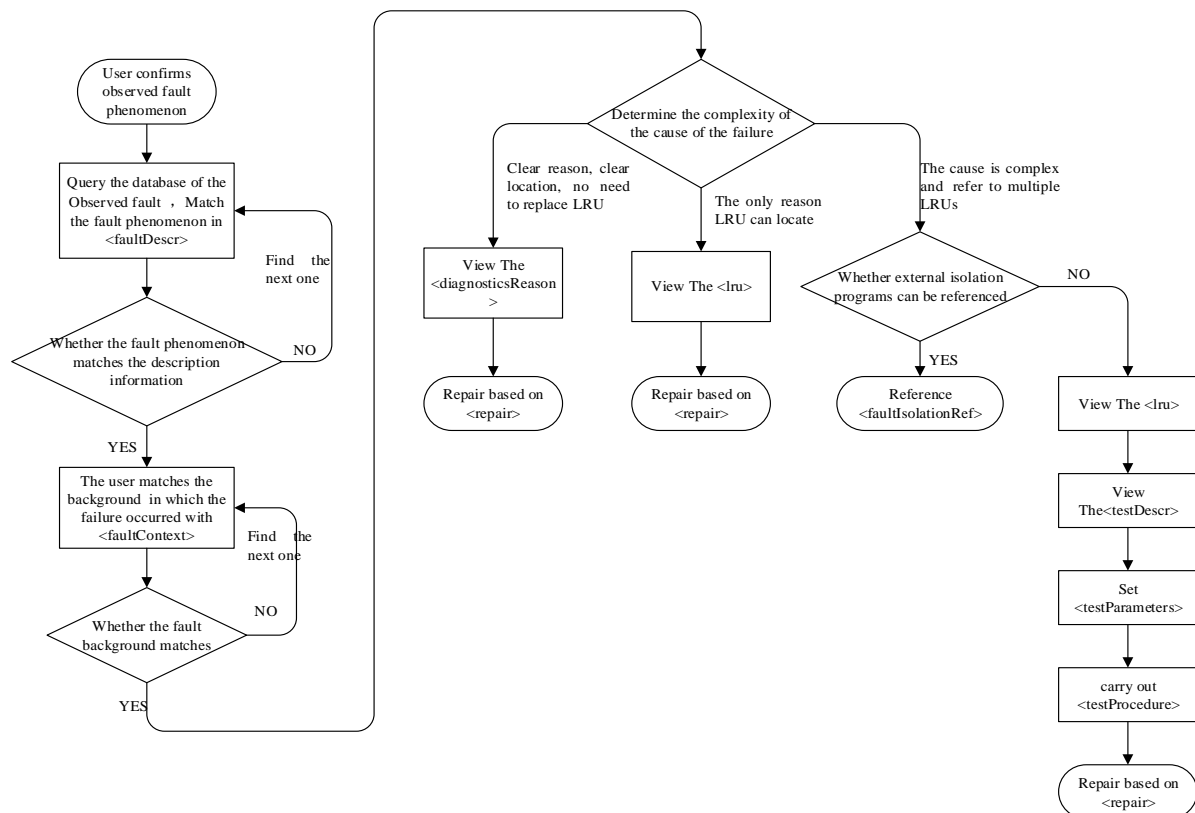


Figure 4 The observed fault isolation location process

The diagnostic isolation process shown in Figure 4 should be implemented in IETM platform with which the equipment maintainer can perform the fault isolation and repair the fault unit. Moreover, Figure 5 shows the diagnostic isolation human-machine interface which IETM supports. The diagnosis

result indicates that the final fault LRU for the inflexible high and low steering of the artillery is the artillery balancer machine.

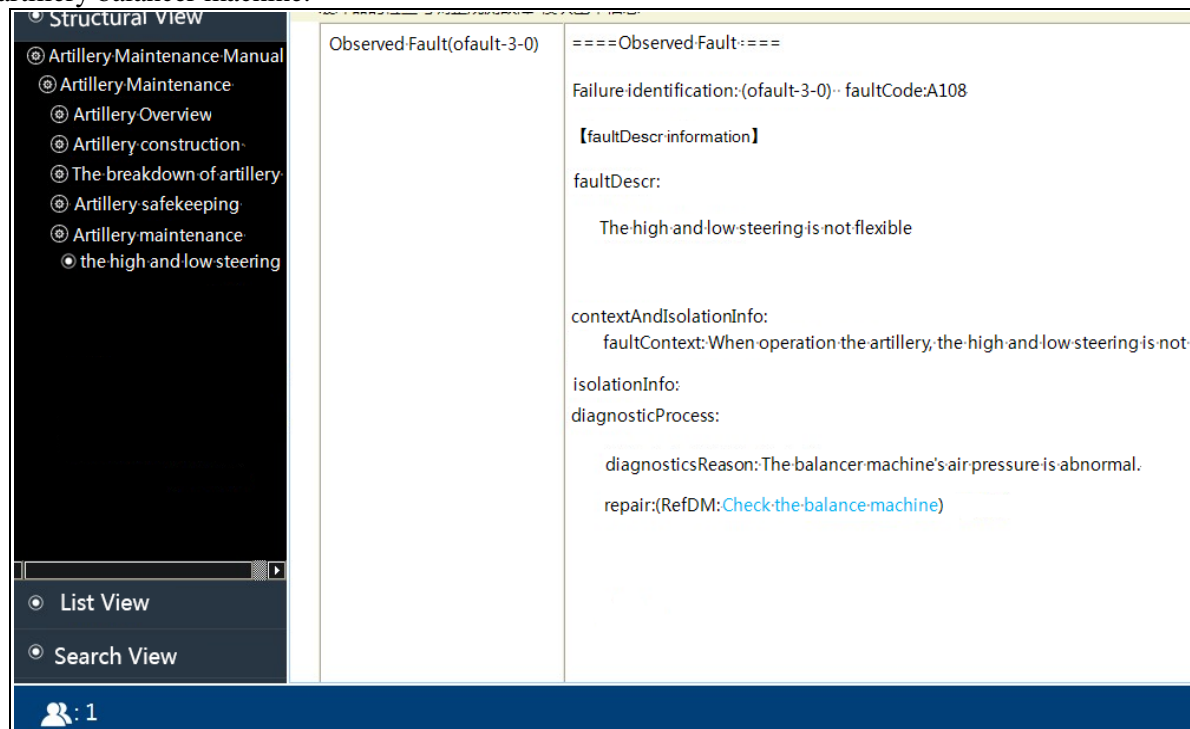


Figure 5 Fault report information diagnosis fault

#### 4. Conclusions

Comparing with the other fault diagnosis isolation processes in equipment maintenance support, the fault reporting data module based on S1000D provides a standardized implementation process. In this paper, the fault reporting data structure and its application in IETM is studied systematically. Regarding the problem of low integration between the third party diagnosis system and IETM, the research provides a new method by integrating the fault reporting data with IETM platform, and presents a guidance during the development of practical and advanced IETM system.

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