Development/Operation of an Automatic Evaluation Tool for On-Board Display Control Systems

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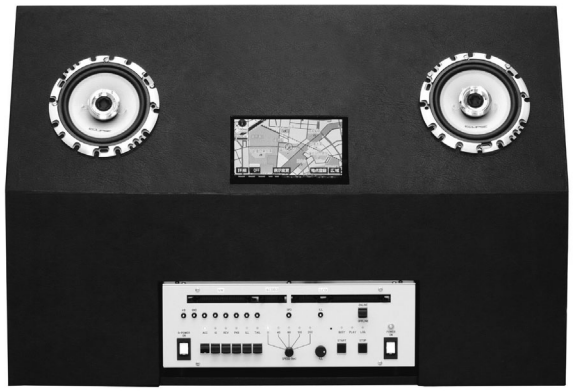

Abstract

Recently, the functions and capabilities of on-board vehicle devices have, in response to customers' needs, become multifunctional leading to an increase in man-hour for the development and assessment of "On-board display control systems".

In order to ensure product quality within a limited timeframe, it is essential to minimize unproductive man-hour related to system evaluation and to maximize the efficiency of the evaluation process.

With the goal of creating a more efficient system evaluation process, the authors have developed an "Automatic evaluation tool for on-board display control systems" that can replace human beings with automatic functions in the evaluation of on-board display control systems. In this paper, we present the operation results of this on-board system evaluation tool for the 2005 models.

1 Introduction

In response to customers' needs, such as the desire to listen to music or receive traffic information, the functions and capabilities of on-board vehicle devices have had to become multifunctional. This increase in the number of functions has led to a concurrent increase in man-hours for the evaluation of "on-board display control systems". In order to ensure system quality with a limited amount of evaluation man-hours, it is essential to maximize the efficiency of the evaluation process.

With the goal of creating a more efficient system evaluation process, the authors have developed and put into operation an automatic evaluation tool for on-board display control systems that is the focus of this essay.

The term "automatic evaluation tool for on-board display control systems" is abbreviated as "automatic evaluation tool" throughout this essay.

2 Development Aims

2.1 Definition of System Test

System test refers to the testing of the software that provides the structure of a system. A software test can be defined in the following manner:

"The dangers presented by software failure, whether due to something clearly established as an error or as correct, must be minimized to an acceptable limit."(1)

If this idea is expanded and applied to a system then it can be said that, "ensuring a constant degree of system quality is dependent on the amount of man-hours spent on system evaluation."

The relationship between system quality and evaluation man-hours can be expressed as shown in Fig. 1.

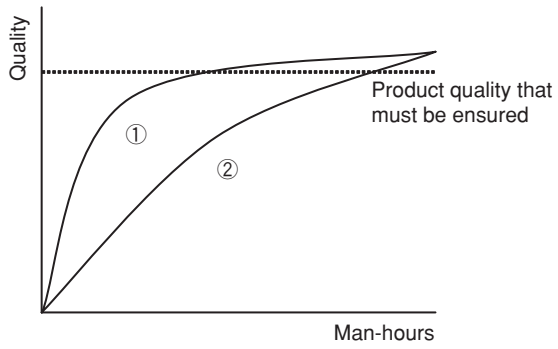

Fig.1 Relationship of system quality and evaluation man hour

A constant degree of system quality could undoubtedly be ensured if there were an unlimited amount of man-hours available. However, given the actual conditions of a system test site, the man-hours that can be dedicated to the test are indeed limited by human and chronological factors.

Furthermore, the ensuring of system quality is variable since even given the case where the same amount of man-hours are applied, there are differences in outcome due to an efficient evaluation process (line ① in the figure) versus an inefficient process (line ②).

In order to ensure system quality with a limited amount of man-hours, it is essential to maximize the efficiency of the evaluation process. The following two approaches can be used for such purposes:

(A) Perform an evaluation with a heightened error detection ratio

(B) Minimize unproductive man-hours related to system evaluation

2.2 Ensuring on-board display control system quality

Fujitsu Ten is currently developing on-board display control systems.

The evaluation of the developed system uses approach (A) and carried out with major emphasis on the following evaluation points:

- **Evaluation of newly added sections**
- **Evaluation of sections for which a large number of errors are detected during evaluation**

Meanwhile, for approach (B), the following problems were indicated when reviewing the development of the 2003 on-board display control systems.

Problem 1: The number of evaluation items increases as more functions are added.

The evaluation items for on-board display control systems increase as the functions of on-board devices increase. For example, when performing a screen transition test, the number of test items that must be assessed, even with only two screen transitions, is equal to the square of the number of screens. Normally, a single function of an on-board device will contain some 100 screens meaning that the number of evaluation items for a screen transition test increases by approximately 10,000 items for each function that is added.

Additionally, there is the case where new or updated software is released during the "acceptance test" of the development stage. In such cases, evaluation must be performed not only for new functions added since the last software version but functions assessed under the previous version must also be re-assessed every time a new version is released in order to verify that there is no degradation.*1 Due to this, the acceptance test involves repeating of identical evaluation items. (Refer to Fig. 2.)

(1) Degradation refers to a function that has been operating properly but fails to operate when the software is changed.

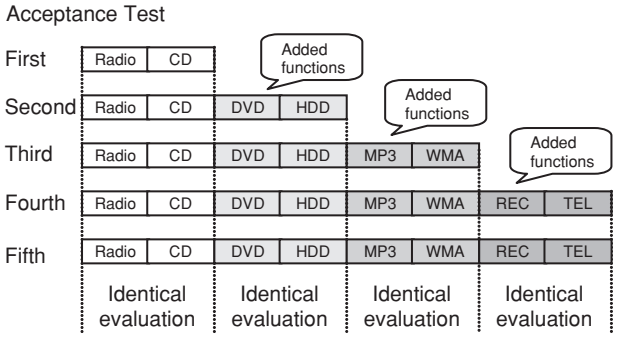

Fig.2 Repetition of identical evaluation items during acceptance testing

Problem 2: Increased evaluation man-hours for error reproduction testing.

When an error occurs during testing, it must be reproduced in order to investigate the cause of the error. In cases where the error only occurs at an extremely low probability rate, it is necessary to repeat the identical evaluation items until the error is reproduced.

2.3 Development of an automatic evaluation tool

As we have noted above, the "acceptance test" and "error reproduction test" require the repeated application of identical evaluation items. These types of evaluation require a massive amount of evaluation man-hours despite the fact that no special technical knowledge is required during the testing. For this reason, the use of an automatic evaluation tool for on-board display control systems was proposed in order to reduce the elevated amount of man-hours.

Normally when assessing the on-board display control system, the evaluation personnel must operate the on-board device and then compare the screen or voice that is produced with the expected results in order to make their judgment. The purpose of an automatic evaluation tool is to replace the human being in performing "operations" and "judgment".

An evaluation tool must meet the following requirements in order to perform automatic evaluation of on-board display control systems:

(Requirement 1) Ability to automatically operate on-board devices

(Requirement 2) Ability to judge evaluation results of image and voice data collected from on-board devices

There is already a general-purpose on-board device evaluation robot that can be used as an automatic evaluation tool since it fulfills these requirements. This robot can physically operate on-board devices, and is equipped with a camera and microphone allowing it to collect image and voice date in order to judge test results. (This is referred to as the robotic system.)

In addition to the robotic system, vehicle operations can be simulated by sending electronic signals along a signal line taken from inside the on-board device, and then judged according to the image and voice data received via the signal line. (This is referred to as the signal line system.)

Table 1 presents the results a study analyzing whether the robotic system or the signal line system is most appropriate to use for an automatic evaluation tool for on-board display control systems.

Table 1 Comparison of robotic and signal systems

	On-board device operation	Judgment of results	Ease of utilization	Cost
Robotic system	○ Physically operates on-board devices using an arm ○ Can insert/remove CD and similar media × Cannot perform repetitive operations at msec. intervals	△ Uses a camera to capture the screen image of the on-board device and by comparing it to saved image even small differences can be judged	× Special installation area required Not portable	△ High cost
Signal line system	○ Sends signals to on-board device to simulate operations × Can insert/remove CD and similar media ○ Cannot perform repetitive operations at msec. intervals	○ The image signal is directly input from the on-board device and compared with the expected image. Differences on a dot unit level can be judged	○ Can be installed in the same work area that is normally used Portable	○ Low cost Can be realized at 1/10th the cost of the robotic system

From the above results it was determined that the signal line system was the most appropriate to use with the automatic evaluation tool for on-board display control systems. Consequently, development of the signal line system automatic evaluation tool was carried out in collaboration with Fujitsu Limited, utilizing their technical knowledge garnered from the development of a signal line system automatic evaluation tool used for cellular telephones.

3 Outline of the Automatic Evaluation Tool

An automatic evaluation tool for on-board display control systems was then developed. Fig. 3 shows an overview of the tool.

The functions and operations of this automatic evaluation tool are described below.

Fig.3 Automatic assessment tool for on-board display control systems

3.1 Structure

Fig. 4 shows the structure of the automatic evaluation tool.

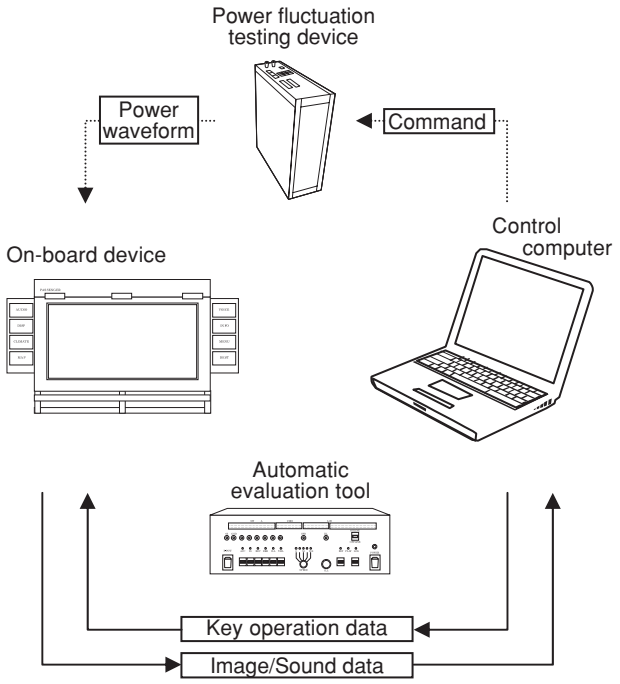

Fig.4 Structure of automatic evaluation tool

3.2 Functions

(1) Automatic operation

First, a file containing the operating sequence is created using the control computer and then the automatic evaluation tool simulates operation of the on-board device according to that operating sequence in order to perform automatic operation. The follow operations are performed:

- **Touch switch operation**
- **Panel switch operation**
- **On/Off of vehicle signal**
- **Use of a testing device to create a test pattern for power fluctuation.**

The file that contains the operating sequence is referred to as a "scenario file". A scenario file indicates the types, start times, running times and expected values of operations. A specialized application is used for the creation of scenario files.

(2) Automatic judgment

Checkpoints can be set as desired at any point in the scenario file so that when that point is reached the status of the on-board device is compared to the expected values and the evaluation results are automatically judgment.

The two types of on-board device data that can be compared are discussed below.

(2-1) Image data

- Proper screen transfer is judged by a comparison of the previously established expected image with the screen of the on-board device.
- To acquire the expected image, the scenario file operates in "expected image acquisition mode" in which the image data displayed on the on-board device can be automatically compared to the expected image.
- Though some sections of the screen are constantly changing (such as the time or flashing location indicator), automatic judgment can be performed with a single expected image even though it is not constant due to a specification that removes sections of the expected image from the subject of comparison.

(2-2) Voice data

- By connecting the voice signal line of the on-board device to the control computer, the frequency of the voice actually being output from the on-board device can be compared to the frequency of the expected voice.
- Each different sound source, such as CDs or MDs, are allotted different frequencies so that they can be compared with the expected frequencies and the automatic evaluation tool can judge whether sound mode shift is occurring properly.

(3) Other functions

- **Evaluation report creation**

When evaluation has been completed, an evaluation results report can be generated in HTML format that includes an evaluation record with judgment results and times, as well as detailed evaluation results such as actual and expected images. In this way, evaluation results data can be maintained. Fig. 5 shows an example of such a generated report.

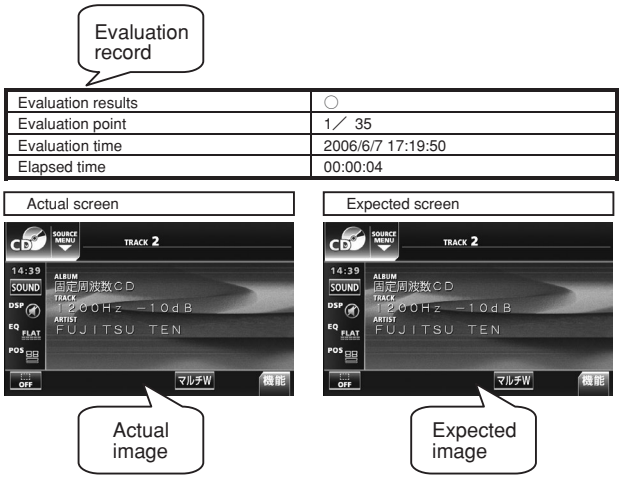

Fig.5 Assessment report

- **E-mail notification of error**

The control computer is connected to the Internet so that an E-mail can be sent to a preset mail address when an error occurs. This function allows evaluation personnel to be promptly notified of any error.

4 Operation Effectiveness

The automatic evaluation tool described above was utilized for system testing of 2005 on-board devices and the results are described below.

4.1 Implementation of effective evaluation

The automatic evaluation tool was utilized for the "acceptance test" and "error reproduction test", both of which require the repeated application of identical evaluation items.

As a result, the freed up man-hours of the evaluation personnel could be applied to performing the following evaluation tasks:

- **Major evaluation items**
- **Operability test**
- **Actual in-vehicle evaluation**

By dividing the roles between the automatic evaluation tool and the evaluation personnel, as clearly shown in Fig. 6, an efficient evaluation process was achieved.

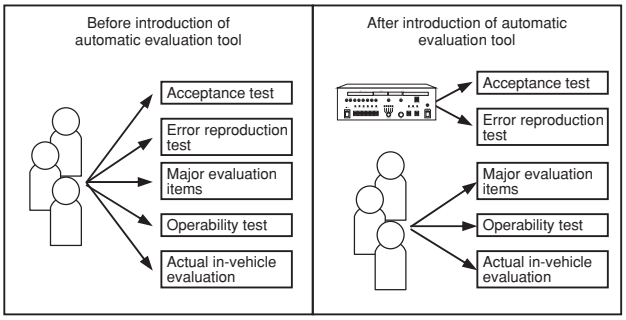

Fig.6 Division of roles for humans and an automatic evaluation tool

4.2 Reducing man-hours for acceptance test evaluation

The automatic evaluation tool was utilized for the acceptance test. The acceptance test is the first test applied right after release of new or updated software and no other function evaluation can be carried out until the acceptance test is passed. Before the introduction of the automatic evaluation tool, the acceptance test required 16 man-hours from evaluation personnel, but after introduction of the tool the time required has been reduced to two hours. As a result, the man-hours for one acceptance test have been reduced by 14 hours. As there are multiple software releases, this results in an overall reduction of 280 man-hours.

Thanks to the reduction in acceptance test man-hours, evaluation personnel can now begin function evaluation at an earlier point than before the introduction of the automatic evaluation tool. (Refer to Fig. 7.)

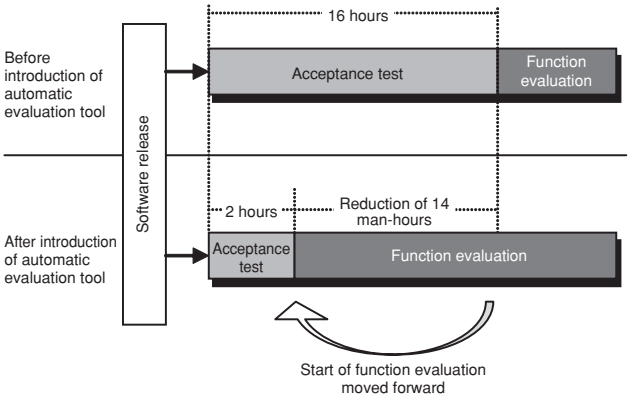

Fig.7 Reduction in evaluation labor hours for acceptance testing

4.3 Reducing man-hours for the error reproduction test

The automatic evaluation tool was utilized for the error reproduction test with low-incidence error reproduction testing carried out continuously for one month. A maximum of three automatic evaluation tools were operated simultaneously so that the total operating time used by the automatic evaluation tools for error reproduction test was approximately 2,400 hours thereby achieving a reduction equal to the man-hours of 15 persons for one month.

The surplus man-hours of the evaluation personnel created by this reduction can be applied to actual in-vehicle evaluation or other tasks in order to contribute to improving product quality of the on-board display control system.

4.4 Secondary effects: Preventing the recurrence of identical errors

Reproduction procedures of errors that occur during testing are integrated into the scenario file and incorporated into the acceptance test. Due to this, a framework can be created by which any error that occurs once is prevented from flowing out again at the acceptance test. (Refer to Fig. 8.)

Use of the acceptance test in this way to prevent the recurrence of identical errors every time they occur was not possible before the introduction of the automatic eval-

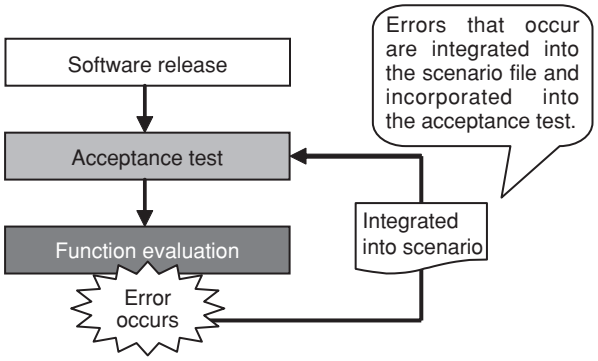

Fig.8 Preventing the recurrence of identical errors

uation tool. For this reason, introduction of the automatic evaluation tool has lead to improved capabilities for the detection of identical errors.

4.5 Overview of operational effectiveness

Due to the introduction of the automatic evaluation tool, evaluation efficiency has been achieved which has resulted in reduced man-hours to a point where the required product quality for on-board display control systems can still be ensured.

Additionally, due to the effective reduction of man-hours, the surplus man-hours of evaluation personnel can be applied to evaluation tasks that only humans can perform such as major evaluation items, operability test or actual in-vehicle evaluation. As a result, the product quality of on-board display control systems can be ensured. (Refer to Fig. 9.)

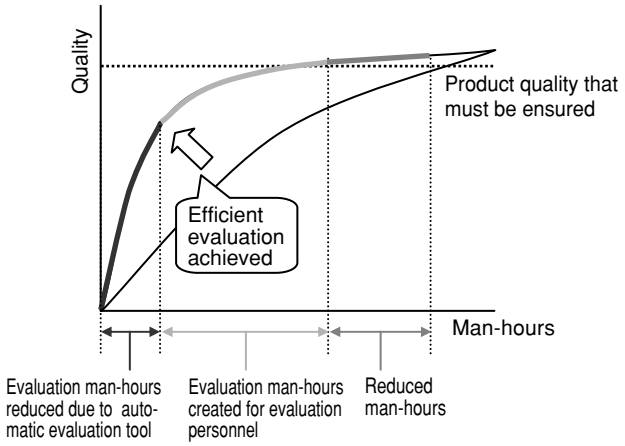

Fig.9 Ensuring the product quality of on-board display control systems

5 Conclusion

This paper has discussed the development and operation of an automatic evaluation tool for on-board display control systems.

Technical knowledge has been attained and accumulated from the 2005 model system testing such as the scenario files of the automatic evaluation tool created for systems testing that contain error reproduction sequences and repeat prevention data. These scenario files, with only slight modifications can be readily converted for use with other models.

In the future, the authors would like to see the automatic evaluation tool applied to other models and the technical know-how gained from its use in system testing of the 2005 models passed along and used in the development of future automatic evaluation tools.

References

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Profiles of Writers

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