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NASDA'S
ADVANCED ON-LINE SYSTEM
(ADOLIS)

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ABSTRACT

Spacecraft operations including ground system operations are generally realized by, large or small, various scale group work which is done by operators, engineers, managers, users and so on, and their positions are geographically distributed in many cases. In face-to-face work environment, it is easy for them to understand each other. However, in distributed work environment which needs communication media, if only using audio, they become estranged from each other and lose interest in and durability of work. It is an obstacle to smooth operation of spacecraft.

NASDA has developed an experimental model of new real-time operation control system called "ADOLIS" (ADvanced On-Line System) adopted to such distributed environment using multi-media system dealing with Character, Figure, Image, Hand-writing, Video and Audio, which is accommodated to operation systems of a wide range including spacecraft and ground system. This paper describes the results of the development of the experimental model.

Key Words: Spacecraft, real-time operation, control system, multi-media, video conference, groupware

1. INTRODUCTION

The ADOLIS is the next generation real-time control system for specifically complex operation required for the future space crafts featured by space experiment, on-orbit unit replacing service, etc.

Generally onboard crew are forced to perform many missions (experiments) within a limited time. Therefore, the most suitable possible operation environment for physical and mental aspects needs to be provided to the crew. NASDA has created environment making it possible on a single workstation to perform many tasks, such as planning coordination, video conferences, automatic checking and monitor display of engineering data, and they have evaluated and identified problems in the operability and technological maturity of such environment.

The evaluation is especially conducted on the following functions.

- (1) Multi-media Interactive Communication

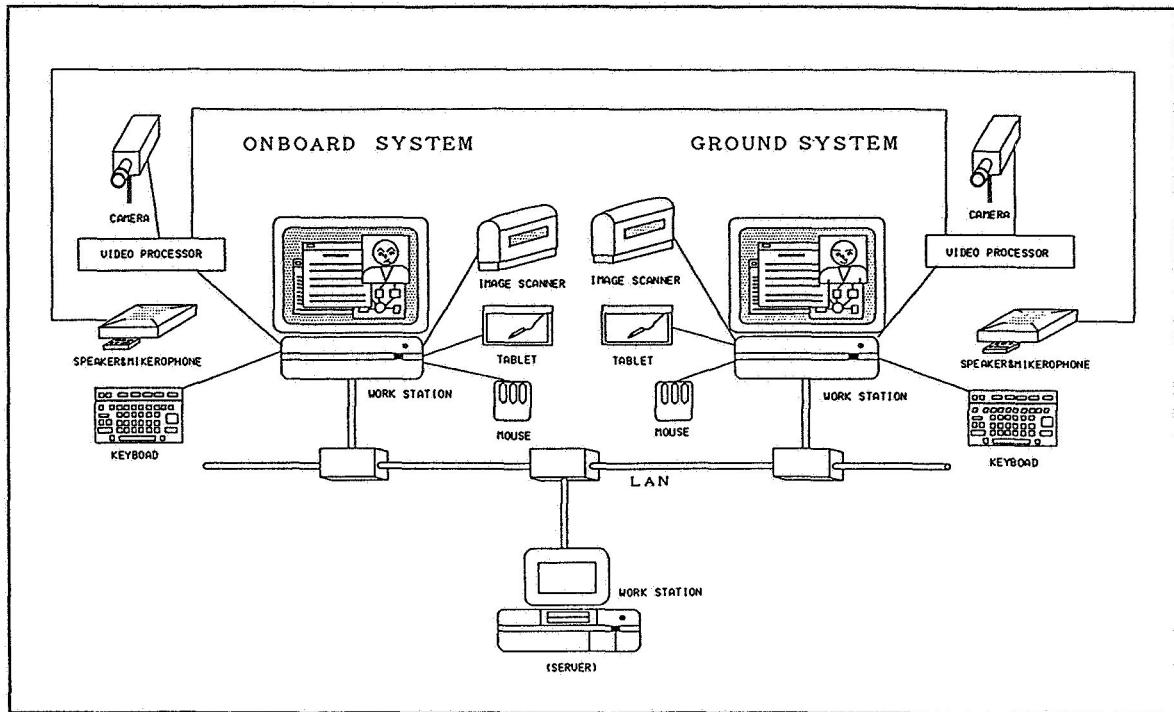


Fig.1 ADOLIS Testbed System Configuration

To simulate operation of space experiment by effective conversation and direction between onboard and ground using multi-media system (video conference system)

(2) Operation Plan and Procedure Management

To simulate coordination of operation plans and procedures and monitoring of the execution between onboard and ground seeing the same information on each screen input from common database.

(3) Contingency Support

To simulate confirmation of trouble occurred onboard, determination of recovery procedure and reconfiguration using semi-automatic support system

(4) Others

- Bilingual operation

Switching between Japanese and English on a screen by a touch

- International standard (Interoperable) human interface and user friendly system
- Security system

2. SYSTEM CONFIGURATION

The ADOLIS testbed system configuration is shown in Fig.1.

2.1 Hardware Configuration

The hardware system of the ADOLIS is composed of three workstations, a server and two terminals (onboard and ground), connected via LAN. Each terminal has a video camera, a video processor, a speaker, a microphone, an image scanner, and a tablet. It has an environment that treats video, graphics, image, handwriting, text on multi-window (X-window). It makes possible visual operation using graphics, etc. in

the environment and smooth understanding between operators by means of video, image, handwriting in addition to audio and text. A terminal system configuration of ADOLIS is shown in Fig.2.

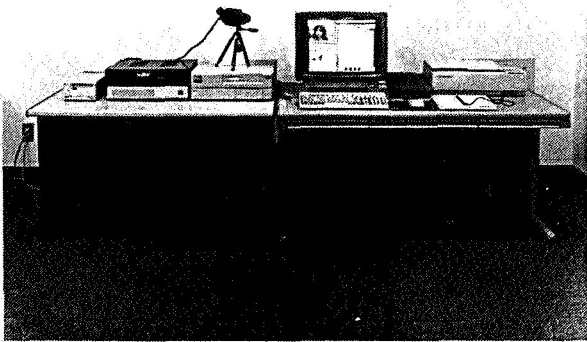


Fig.2 ADOLIS Terminal System Configuration

2.2 Software Configuration

The software configuration of the ADOLIS testbed is as follows.

- Multi-media interactive communication (MERMAID)
- Operation plan and procedure management
- Contingency support
- Telemetry monitoring
- Security management
- Database management
- Basic software (Unix, X-window, etc.)

Unix is used for the operating system of the testbed and a Ostandar d software product, "MERMAID" (Multi-

media Environment for Remote Multiple Attendee Interactive Decision-making), is used for the multi-media interactive communication function.

3. MULTI-MEDIA INTERACTIVE COMMUNICATION FUNCTION

Group work in distributed environment as spacecraft operation needs common space for transmitting understanding and information between the group work members, so called "Groupware", for efficient group work. The ADOLIS can treat the multi-media information (video, audio, image, handwriting, text) in common space between multiple operation positions.

The screen image of the multimedia interactive communication function is shown in Fig.3. There are two sub-functions in this function as follows.

(1) Video conference function

As operators are looking at the video of other operators on multi-window, they can talk to each other by audio function between multiple positions. They can check the attendees through the video with the image of attendees registered in advance.

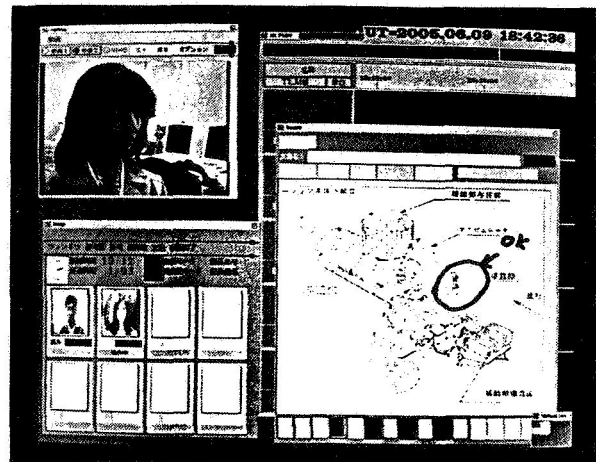


Fig.3 Screen Image of Multi-media Interactive Communication Function

(2) White board function

Operators can input image by scanner and display it on multi-window of each terminal which attends the conference. They can handwrite on the image or white board in multi-window through tablet in real-time.

The following merits are obtained by using this multi-media system.

- Operators can communicate each other based on common understanding and information.
 - Holding information in common through common space
 - Direction and notification through visual data
- Operators can communicate each other in face-to-face environment.
 - Direction and notification through video

Therefore, this function can improve certainty, reliability and easiness of direction and notification for operation.

4. OPERATION PLAN AND PROCEDURE MANAGEMENT FUNCTION

This function manages master time-line (MTL), detailed time-line (DTL) and operation procedures in database server. Operators can hold them in common. They can coordinate operation plans and procedures and monitor execution of procedures as they are looking at the same information.

This function makes possible paperless operation and can improve promptness and certainty of coordinating and updating plans and procedures. The screen image of the operation plan and procedure management function is shown in Fig. 4.

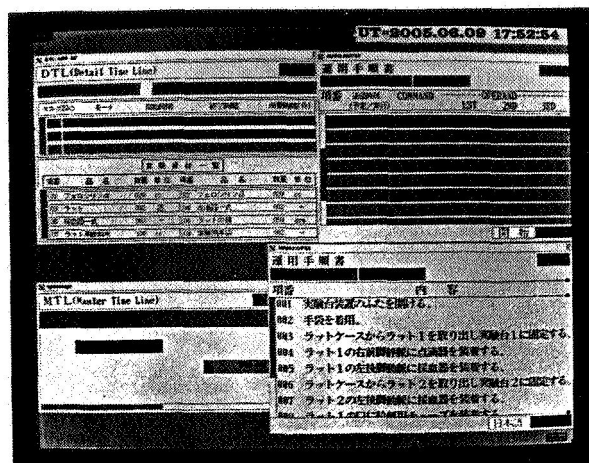


Fig. 4 Screen Image of Operation Plan And Procedure Management Function

5. CONTINGENCY SUPPORT FUNCTION

The function supports recovery operation for contingency semi-automatically. When a problem is occurred in a spacecraft, the system block diagram of the spacecraft is displayed and the problem related subsystem is identified by color automatically. When the subsystem is clicked by mouse, more detailed block diagram of the subsystem is displayed and the error component is identified by color.

Some estimated recovery procedures for the problem is also automatically displayed and executed by selection of operator.

The function can improve promptness and certainty of recovery operation and reduce load of operator. The screen image of the contingency support function is shown in Fig. 5.

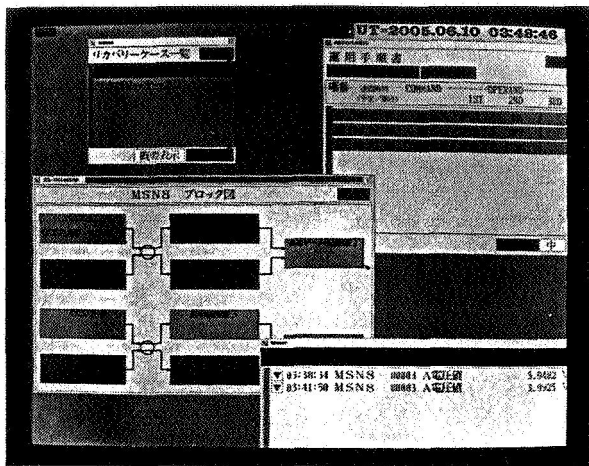


Fig.5 Screen Image of Contingency Support Function

6. OTHER FUNCTIONS

6.1 Bilingual Operation

As international projects such as the space station program are increasing, this function is supposed to become necessary. At this time, the simple function of switching between Japanese and English by a touch is provided in the operation procedure screen of this testbed. (See Fig.6) However, in future, an automatic voice translation function may be provided.

6.2 International Standard (Inter-operable) Human Interface And User Friendly System

The international standard human interface is also supposed to become necessary for international project and cross-support operation between agencies. The human interface of the testbed is designed by specialist taking account of the following point, aiming at standard and user friendly system.

- Monitor screen

- Proper quantity of information

on a screen

- Recognizability of status change
 - Identification by appropriate color
 - Turning his eyes on important part naturally
 - Unity and coordination
- Control screen
- Easy, smooth, intelligible and reliable operation
 - Recovery of operation miss
 - Recognizability of instruction result
 - Appropriate feedback (timing and expression)
 - Attractive and pleasant operation

The screen image of the telemetry monitoring function such as graph, level meter, etc. is shown in Fig.7.

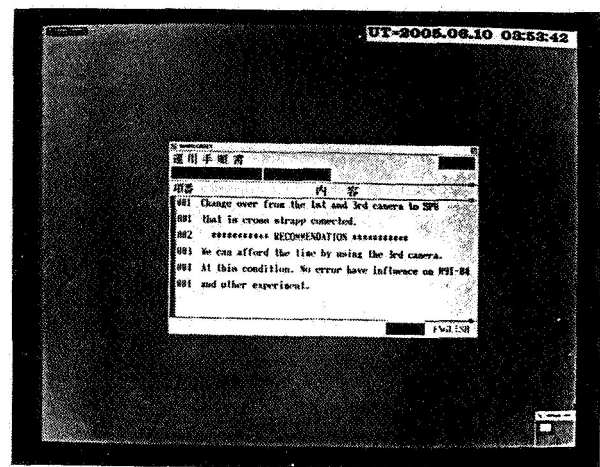


Fig.6 Screen Image of Bilingual Function

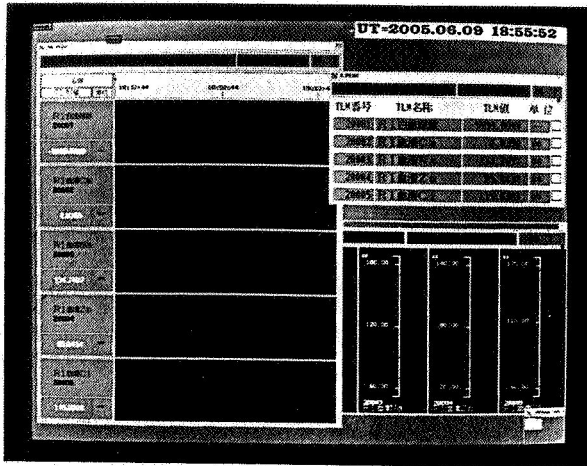


Fig.7 Screen Image of Telemetry Monitoring Function

6.3 Security System

The function establishes access level by kinds of user. For example, operators who permitted to transmit a certain command can access the function of transmitting the command by password.

7. CONCLUSIONS

The results of the experiment are summarized as follows.

- Demonstration of availability of multi-media communication functions through the simulation of spacecraft operation
- Evaluation of the experimental system by NASDA's expert operators and improvement of the system based on the evaluation results
- Human engineering interface design taking account of operability and monitorability by specialist

and the following issues has been identified.

- Remote test using domestic or international communication circuit
- Space link simulation test
- Development of standardized human interface
- Application of the system to a project

It is planned that these study results will be reflected in the operation system for experimental satellite for robot arm and rendezvous-and-docking that NASDA is independently working on and the manned-mission JEM.

8. ACKNOWLEDGEMENTS

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