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Crew laptop for payload operations

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CREW LAPTOP FOR PAYLOAD OPERATIONS

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ABSTRACT

It is anticipated that in the International Space Station, crew laptop computers will provide the operational interfaces between crew and payloads and between crew and ground-based experts for on-line team work. The effectiveness of these interfaces has a direct impact on the success and productivity of manned missions.

The crew laptop will be used for operation of payloads: for payload data collection and commanding and for crew activity support.

The interface for ground-based PIs will be implemented on ground-based versions of the (functionally identical) crew laptop. Working in a synchronised mode, both systems enable real-time crew/ground collaboration.

Support of crew activities is implemented by using a dataset for each payload, containing virtual control panels, crew procedures and multimedia reference material. Interlinking of these datasets allows easy access to the information at all times.

Already several prototypes of crew support systems have been implemented and evaluated, of which the Advanced Crew Terminal (ACT) is the most recent. The ACT study has validated the feasibility of a low-cost approach to on-board crew terminals and associated ground terminals, based on commercial available laptop computers and software. The study demonstrated a generic 'ACT Product Framework' providing basic services and allowing adaptation to experiment needs.

To improve the ACT concept even more, the method for crew interaction with the system, which still requires manual and visual activity from the crew, will be improved. To allow the crew to operate the system and access the presented information in a hands-and-

eyes-busy situation the ACT functionality will be extended with speech input/output capabilities.

1. THE CREW SUPPORT PHILOSOPHY

It is reasonable to expect a crew member on board the ISS will, during a normal working day, face a large number of tasks. These tasks involve several payloads and system elements and demand skills of various nature. The crew support philosophy will offer the crew a common 'look and feel' when interacting with any element of the payload and sub-system complement. This approach will result in increased crew efficiency and effectivity and reduced training effort.

It can be expected that not all tasks will be foreseen and therefore not being trained for. Hence it might occur that a crew member finds him/herself¹⁾ in a challenging situation, where an activity has to be performed that she is hardly, or not at all, familiar with.

It can be argued that the crew, with access to extensive information on the payload at hand, with communication possibilities with ground experts and possibly even with some on-the-job training possibilities for the task to be performed, will have increased chances of success. Information systems that provide the crew with the above described facilities can be implemented on current laptop computers.

Each payload has its own information dataset, so all related data is organised on one information carrier (e.g. a CD-ROM or an exchangeable harddisk) that is loaded on the crew laptop just before starting the task. Changing payload would only imply loading another disk. The sequence in which the disks are loaded is not critical, hence re-scheduling of activities causes no problems. Also the data preparation process is straight forward: the payload/experiment developer is

responsible for the compilation of the dataset. At delivery of the payload/experiment hardware, that dataset is also delivered by the developer, and no further processing is required.

2. POSSIBLE CONFIGURATION

When configured for payload operations³⁾, the crew support system will be referred to as the “On-board Payload Terminal (OPT)”. The OPT is integrated on a payload level: it is assumed to be part of the payload it controls. In the manned space laboratory hierarchy it is at the same level as a possible ground based equivalent (Ground Payload Terminal, GPT). Figure 1 shows a configuration with both OPT and GPT for payload control.

The operational tasks of the OPT have been highlighted in the previous section. For the GPT they comprise:

- remote operation of payloads via Virtual Control Panels (VCP)
- monitoring of crew activity using application synchronisation, and
- support of crew-ground voice communication, using the overlay application and application synchronisation.

In addition to its operational tasks, the GPT has several mission preparation tasks. During mission preparation, the GPT can be used by the PI or the payload developer to define and implement the experiment/payload specific databases and applications (e.g. VCPs or dataprocessing applications) and to test the results. To support this, the GPT can be equipped with database authoring tools and test tools, for instance payload simulation models.

During operations, the database authoring tools can be used for database maintenance. During long mission periods, changes in the database can be expected. These can be implemented using the GPT, after which the corrected database can be uplinked to the OPT.

3. PAYLOAD/EXPERIMENT DATASETS

For supporting the crew on payload/experiment related activities, the following types of data have been identified as required [2]:

- Crew procedures
- Multimedia reference data
- Payload/experiment Virtual Control Panels (VCP)
- And, on a higher, non-payload level, timeline information.

Each of these is discussed in some more detail in the following.

3.1 Crew procedures

Crew procedures comprise a step-by-step description of an activity to be performed. In principle all activities that can be performed in relation to a payload or experiment are covered in the set of crew procedures. Crew procedures are accessed by a dedicated application that allows actions like checking steps done and branching into more detailed descriptions of an activity. The latter allows the description of activities on a global level, while allowing the crew to go into a more detailed procedure when required. Hence a certain structure in procedures is required, as shown in Figure 2. Communication between the OPT and the GPT allows the ground-based expert to monitor the crew member's progress: procedure steps that are highlighted and ‘checked-done’ by the crew will also show as such on the ground display²⁾.

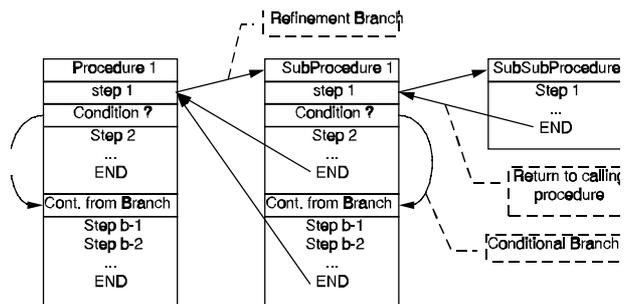


Figure 2: Example procedure structure.

A (global) annotation service allows the crew member and ground operator to attach personal remarks and comments to a procedure steps, that can be retrieved at other occasions.

3.2 Multimedia reference material.

Multimedia reference material in principle comprises all knowledge that is available on the payload/facility. It must cover hardware, operational and maintenance/troubleshooting as well as science related subjects. Also the database should allow for the incorporation of information of different types: text, graphics, pictures, slideshows, video- and audioclips. Information in e.g. a video clip will be very useful in showing how to perform a certain task.

A crew member will access information for a number of reasons:

- to familiarise with the payload/experiment;
- to acquire additional information on procedure steps or on a tasks to be performed;
- to acquire additional information on occurred

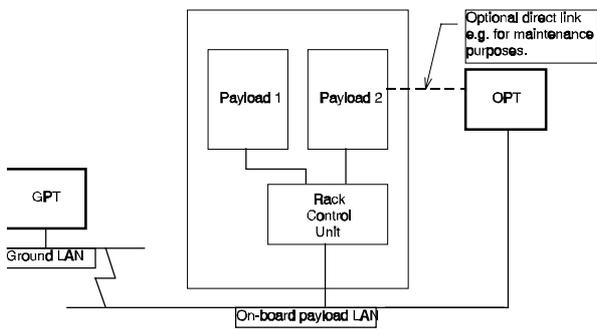
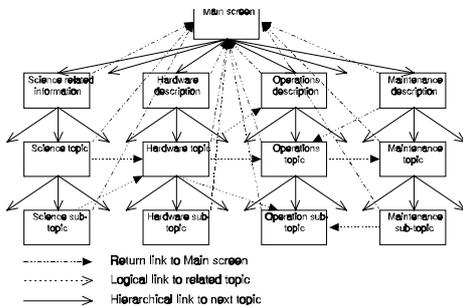


Figure 1: Sample OPT-GPT-payload configuration.

situations;

- to fresh-up on the payload/experiment.

For each access of the reference material the path of the crew member through the information will be different. The structure of the database must support these various ways through the information. A method to implement this is to organise the information, as on the WWW, in nodes. Each node presents a complete piece of information. The nodes are connected by means of (hyper)links. Links can be activated by the crew member, resulting in the associated node being presented. By creating links through the information, specific paths can be implemented in the information, thereby implementing each method of accessing the information. In a node, information of various types may be available, or a node may be dedicated to one type of information, for instance a photo. Figure 3 presents a graphical overview of how the node oriented dataset can be pictured. Comparable as with the procedures an annotation can be attached to a node in the multimedia reference material



3.3 Virtual Control Panels

Virtual Control Panels (VCP) provide the crew member with an on-screen-interface towards the payload. Assuming that the laptop is communicating

with the payload via some data-interface, housekeeping will be presented on the VCP and controls are available to operate the payload⁴). The use of a VCP has several benefits:

- On a VCP the amount and size of controls is not limited by the available panel space. Multiple VCPs can be defined that are called on demand.

This concept is shown in Figure 4.

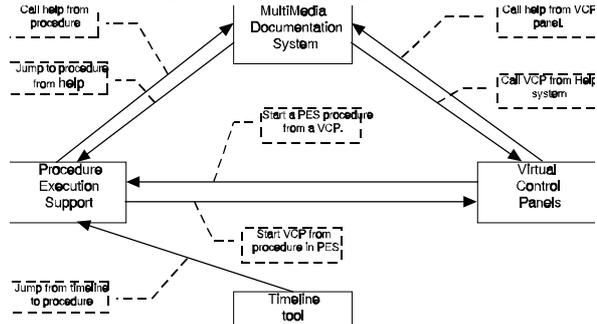
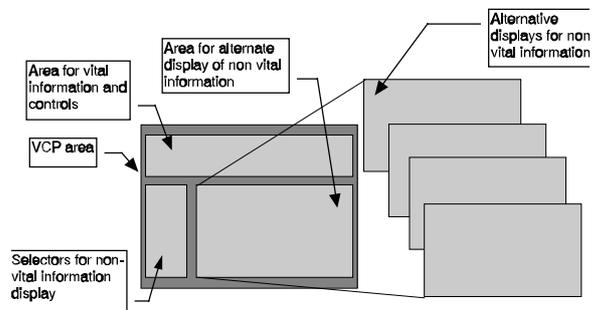


Figure 5: VCP structure.

- If required a VCP can easily be redesigned and reorganised (e.g. if a certain lay-out turns out to trigger operational errors). Even a different lay-out for each crew member is a possibility.
- The laptop with the VCP can be taken to another location where communication between the laptop and the payload is possible, so that the crew member can even monitor a payload while performing another task. The VCP can even be on ground on the GPT at the PI's laboratory.



A (global) annotation service allows the crew member and ground operator to attach personal remarks and comments to a procedure steps, that can be retrieved at other occasions.

3.2 Multimedia reference material.

Figure 1: Example procedure structure.

3.4 Timeline information

Even though not payload/experiment related, there is one more information set that is important enough for the crew to have available on a portable computer: timeline information. As the timeline determines their activities and the time available for performing them, they might want to refer to it regularly. A mechanism is foreseen, ensuring that the timeline information available on the laptop computers is refreshed each time the laptop is connected to the on-board network. This ensures that timeline changes prepared on ground become available where the crew expects them.

4. THE INTEGRATED APPROACH

To provide a crew member with real benefits, the applications implemented in the crew support computer should co-operate as much as possible. The applications available on the support computer should be able to start each other and to instruct each other to perform a required action upon user request. The structure envisaged is presented in Figure 5.

5. APPLICATION SYNCHRONISATION

Synchronisation of applications between OPT and GPT is one of the features that has proven to be very useful during demonstrations [3]. Synchronisation of applications is the key in improving the communication between crew and ground-based expert. It is based on the fact that OPT and GPT are functionally identical, meaning the systems have local access to the same applications and the same datasets. Additionally the concept assumes a low bandwidth communications capability between the two systems. When these conditions are fulfilled, synchronisation can be set-up and from that moment on, the systems on either side of the communication link will follow each others actions. Hence, if the crew member opens a certain procedure on the OPT, the same procedure will be opened on the GPT and vice versa. It is

obvious that this mechanism must be used with care, to avoid that actions on either side counteract each other. When exercised carefully, however, the feature can be very powerful when used in combination with a voice link. The concept ensures that both participants in a discussion have the same visual information in front of them. This multimedia telesupport capability drastically reduces ambiguity in the discussion. An additional feature to support voice communication is the 'shared overlay' function. This function is also synchronised and allows the user on either side to draw on top of the screen image. Her annotations appear simultaneously and in the same way on the other side of the communication link. By inserting marks on top of the screen image (e.g. showing a photograph), attention can be drawn unambiguously to specific items.

6. A CREW SUPPORT COMPUTER IMPLEMENTATION: THE ACT

Building upon experience gained in a number of ESA projects, a consortium of firms, comprising the National Aerospace Laboratory NLR (NL), CRI(DK), SAS (B), lead by ORIGIN (NL), have developed a product called the Advanced Crew Terminal (ACT). The work was funded by ESA and the Netherlands Agency for Aerospace programs NIVR.

ACT provides a generic solution for the implementation of crew and ground terminals as discussed in the previous sections. To cater for the needs of the ACT-users, both on-board as well as on-ground, an operational concept has been defined. This concept brings into context the operational environment and the facilities required to allow the users of the ACT to complete their tasks. The ACT-product comprises a framework rather than a completed product. The framework is based upon a (portable) computer and includes some basic services and an environment that allows for inclusion of user applications. The basic services, referred to as 'core services' comprise

- core communication services. These include communication between applications and application synchronisation.
- core applications. These include a Procedure Execution Service (PES) and a MultiMedia Database Service (MMDS)
- core database services.

The PES and MMDS service map perfectly to the procedure and reference material presentation referred to above. Virtual Control Panels are mostly payload-specific applications, which can however be plugged into the ACT framework as dedicated



application.

7. A SPEECH INTERFACE FOR THE ACT

As indicated above, a crew support computer, like the ACT, may be a vital clue in increasing crew performance, effectiveness, and efficiency. Still the implementation of such a system in the ACT has a major drawback in the way it is used by the crew: through manual interaction and by reading/viewing the information on the screen. In those cases where the crew is in an eyes-and-hands-busy situation this is inconvenient and can make the ACT useless. To cope with these situations, activities have been started to equip the ACT with speech input/output capabilities. A consortium, headed by the National Aerospace Laboratory NLR, and including Origin Nieuwegein, TNO Human Factors Engineering, Trinity College Dublin and IDIAP (CH), are working on this under contract with ESA and sponsored by the National Agency of Aerospace Programs NIVR. The results will allow the crew member to interact with the ACT by speech. The initial system will allow the crew member to have text information, like procedure steps, read out aloud to him, and to command a limited set of applications on the ACT by voice commands. The project implementing the speech interface is currently at the end of its first phase. During this phase the Speech I/O specific user requirements have been defined [4] and the architectural design for integrating the speech I/O into the ACT has been prepared [6]. Additionally a market survey of commercially available speech synthesisers (text-to-speech type) and -recognisers has been performed. By mapping the results against the user requirements a selection of commercial available speech synthesiser and recogniser has been performed. Phase 2 of the project will aim at implementing a flight prototype for use on board the MIR Space Station. This flight experiment is expected to yield valuable information on the use of the ACT and its speech interface under real flight conditions.

8. CONCLUSION

Crew laptop computers are a promising tool to implement the crew's interface to payloads and experiments. For each payload/experiment they can be configured with payload/experiment specific datasets and applications. Functionally identical ground-based systems can be integrated into the concept, including capabilities for pre-mission preparation tasks and allowing PI support to the crew and participation in the on-board tasks. A properly configured crew laptop

will:

- increase crew effectivity and efficiency,
- reduce pre-mission training effort,
- increase the PIs involvement in her experiment.
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9. REFERENCES

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