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THE NETHERLANDS

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"SPACE FOR THE USER"
DUC IN THE NETHERLANDS

by

F.B. Visser, M.P.A.M. Brouwer and E.A. Kuijpers

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The contents of this paper are based on the results of several user support related projects performed under contract with the European Space Agency, (ESA) and the Netherlands Agency for Aerospace Programmes (NIVR).

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SUMMARY

As a result of the ESA-USO study, the Netherlands initiated the development of a Dutch National User Support Organisation in 1989. In the past years the development went forward, involving Dutch industries, Dutch users, Dutch national agencies and the National Aerospace Laboratory NLR, The Netherlands. The latter acting as manager and coordinator of all Dutch support development activities.

This paper provides a short overview of the current status of development of the Dutch User Support Organisation (DUSO) and its associated support centre DUC (Dutch Utilisation Centre).
In detail some major achievements and future prospects in the fields of user support and telescience will be discussed.

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1 INTRODUCTION

User support, aiming at providing support to users of microgravity and space facilities, is since 1989 actively developed in the Netherlands. Activities have been started, or will be in the near future, both in the field of support service development and support provision. This paper provides a short overview of Dutch User Support activities and status at this moment (May '93).

Section 2 provides an overview of the current status of development of the Dutch User Support Organisation (DUSO). Some details on the concept are also provided.

The following sections provide details on passed and on-going projects related to DUSO. Section 3 reports on the "Dutch Utilisation Centre (DUC) in APM mission simulation (DAMS)", a project in which DUC will perform the utilisation centre function, including support to users, in a mission simulation scenario.
Section 4 reports on actual (remote) operational support provided by DUC to a Dutch user for an Anthrorack experiment during the recent Spacelab D2 mission. Section 5 reports on a similar activity that is currently being set-up for the support of a Dutch user on the IML-2 mission in July 1994. Section 6 finally gives some more details of (interactive) tele-science activities performed within the National Aerospace Laboratory NLR.

2 DUSO DEVELOPMENT AND STATUS

Since the start of the ESA study on a User Support Organisation, user support, as an issue, has been taken up by the Dutch space agencies and the National Aerospace Laboratory NLR, the central institute for aerospace research and development in the Netherlands. Having experience with experiments in Spacelab and on sounding rockets, it was recognised that support to users of such facilities, in line with the USO study results (Ref. 1), would indeed be beneficial for the further exploitation of micro-gravity as an experiment condition.

This resulted in the initiation of user support development activities in the Netherlands. This effort is performed by a consortium of Dutch firms, under the managerial and technical guidance of NLR, sponsored by the Netherlands Agency for Aerospace programs NIVR (see Fig. 1).

The development of the Dutch User Support Organisation and its associated user centre the Dutch Utilisation Centre, has proceeded along two different lines (Ref. 3):

- The so called formal approach, in which the development of the DUSO is performed step-by-step and top-down. This approach follows a clearly defined plan, recognising the definition of user requirements, the definition of system requirements, development of an architecture, etc.
- A pilot-type approach that can be characterised as "direct operation", in which a growing set pilot configurations for user support are formed. In the context of this pilot-type approach DUC already now provides actual support to several Dutch users. This approach also yielded involvement in other activities that result in experience useful for support providing organisations.

The formal approach led to the definition of an organisational and infrastructural concept. The infrastructure assumes the establishment of a centre for user support activities in the Netherlands. This centre, the DUC, will be the kernel for user support and will act as a recognisable point of contact for users seeking support. The DUC will be established as a function within the Northeastpolder premises of the National Aerospace Laboratory NLR.

From the beginning it was stated that DUSO should be kept realistic in size and capability. This implies that the growth of DUSO should be in line with the requirements and wishes of the Dutch user community. Also aspects like the developments with respect to flight opportunities should be seriously considered. As such the current uncertainties in the development of the Space Station Freedom and the European contribution to it certainly have their impact on DUSO development.

In the framework of the pilot-type approach, DUC has been, and still is, involved in several user support related projects. Roughly these projects can be divided in two groups:

- Simulation projects, which aim at further development of techniques and infrastructure by means of simulation of missions.
- Operational support, which are projects related with actual space missions, and which involve the provision of actual, mainly operational, support to Dutch PIs.

Emphasis in almost all projects lies on tele-science/ tele-operation, being a key issue in operational support.

The following sections will elaborate on some of these projects.

3 DUC IN APM MISSION SIMULATION

Already for a long period, activities have been going on at ESTEC to study and to evaluate crew activities and crew support in a Space Station Laboratory. These activities have been set-up around the Attached Pressurised Module mock-up in the Erasmus building at ESTEC. Crew performance is evaluated, among others, via the execution of simulations of a "day-in-the-life" of a crew member. Some simulation sessions have already been performed (Ref. 2), and some more are to follow.

During one of the next simulation sessions the DUC will also participate, simulating an operational utilisation centre. This project is named "DUC in APM mission simulations (DAMS)". Preparation of this participation is currently in progress, whereas the execution of the simulation scenario is foreseen to take place in November 1993. stand?

The objective of the DAMS project is to explore the added value of having a utilisation centre as an operational element in the experiment execution and to evaluate a tele-operation concept that can be described as "man-in-the-loop" tele-operation.

The DAMS project recognizes several elements through which DUC participates in the overall mission simulation project:

- Some hardware elements will be developed that are to be included in the APM mock-up, and that are used in the simulation scenario;
- Support will be provided to PIs involved in the project;
- A ground infrastructure will be set-up to facilitate operational support and tele-operation during the execution of the simulation;
- Two PIs will participate in the simulation and operate and monitor their experiment from the DUC.

Hardware elements.

The DAMS project includes the development of some model hardware elements, that are to be integrated in the APM mock-up at ESTEC. The development of a Biology Facility, as a mock-up class I facility, as well as the development of two class II payloads to be integrated in the Biology Facility, has started. The class II facilities under development are a Glovebox, for the manipulation of biological and other materials, and a High Performance Capillary Electrophoresis (HPCE) instrument, for fluids analysis. These two class II payloads are multi-user facilities that provide on-board services to the user.

During the simulation session, but also during the preparation of the simulation, the DUC will perform tasks on several levels:

- The DUC will act as an Experiment Support Centre (ESC) (as defined in the USO study). As such the DUC will provide the PI with support during the preparation, execution and post-processing of his/her experiment. The ESC function will be implemented for all three facilities: the Biology Facility, the glovebox and the HPCE. This implies that the DUC will be equipped to provide the PI with specific support on the use of these facilities for experiment purposes.
- The DUC will act as an extended ESC for the two class II multi-user facilities. This implies that in addition to special facility related support to the PI as mentioned above, the DUC will also perform the planning and operation of these two facilities. In terms of the definitions in the USO study (Ref. 1) this implies a mixture of FRC and ESC functions.

Zie volgende blz
Lijst van afkortingen gewenst?

- The DUC will act as a Facility Responsible Centre (FRC) for the Biology Facility, implying that the DUC is responsible for the acceptance of the two class II facilities that are to be integrated in the Biology Facility, and also for the utilisation and the operation of the Biology Facility.
- Outside the support concept, and only relevant for the simulation, the DUC has been assigned the role of space agency. This implies that the DUC will, only in the DAMS project, be responsible for the acceptance of the class I Biology Facility also.

As mentioned before the development of the Biology Facility, the Glovebox and the HPCE is performed as part of the DAMS project. The facilities will all be developed up to a level justified by the simulation character of the project. The resulting equipment will be comparable with breadboard level equipment. The development of the facilities will be performed by partners in the DUC consortium (see Fig. 1).

Support to participating users.

Major interest of the project, from a user support point of view, is the participation of two Dutch PIs in the project, who will have experiments performed in the APM mock-up. The following two experiments have been selected:

- Dr. Ubbels from the Hubrecht Laboratory for Development Biology, will perform an experiment involving the fertilisation of toad eggs and the observation of their development. For this experiment the crew will handle living toads to obtain eggs, fill experiment modules with sample material, refresh culture fluid and position modules in special video observation stands. Culture fluid samples will be analyzed using the HPCE analysis multi-user facility. Dr. Ubbels, located at the DUC, will be able to monitor and support the crew activities, to monitor the eggs development by means of video, look at the outcomes of the HPCE analysis and discuss items with the crew.

  Similar experiments, in fully automated modules and without crew intervention, have already been performed during several sounding rocket and Spacelab missions. In the near future it will be flown on MASER 5 and IML-2.

- Dr. Vermeer from the Biochemical Department of the University of Limburg, will perform an experiment related to the study of bone demineralisation in micro-gravity. In the framework of the DAMS project, Dr. Vermeer will analyze crew urine samples in the HPCE. The crew will, at regular times, produce urine samples and prepare them for HPCE analysis. Dr. Vermeer, located at the DUC, will monitor the outcomes of the HPCE analysis. As part of the experiment, the crew will be given vitamin K tablets (or placebos) to investigate the influence of vitamin K on the concentration of certain substances in urine.
  The experiment executed in the framework of DAMS can be considered a pre-runner of foreseen experiments in a space environment.

For both PIs the participation in the DAMS project implies the opportunity to gain experience with "real-time" interaction and crew interaction with their experiment.

Both PIs will be fully supported by the DUC during their involvement in the DAMS project. As part of the ESC functions of the DUC, the following services will be implemented and offered:
- Administrative and documentation support.
- User representation.
- Information provision to the user.
- Task performance by DUC on behalf of the user.
- Availability, at the DUC, of a tele-operation infrastructure.

The first four services are offered to the PIs (and used by them too) from the start of the project. The latter service, the availability of an operational environment, will be offered during the execution of the simulation and during training sessions shortly before the simulation. The interface of the PI with the DUC will be the Support Engineer (SE), a DUC-employee assigned to the PI, providing the PI with direct support.

Operational support infrastructure.

The envisaged operational environment, of which a first overview is presented in figure 2, will offer the users the following functionalities:

- Communication with the experiment: (low rate) data and (high rate) video, tele-commanding of the experiment.
- Voice communication with the crew, via the (simulation) Mission Control Centre.
- Use of the Multi-media Telesupport System (MTS) to improve communication with the crew.
- Data processing and presentation integrated with the experiment operations MMI.
- Data archiving and data retrieval possibilities, among others to correlate archived data with current data.

In addition to the user support function, the DUC will also provide the FRC function for the Biology Facility and the Extended ESC function for the two class II facilities Glovebox and HPCE. For this reason the DUC will be closely involved with the development of these facilities. This is in-line with the behaviour of an FRC as defined in the USO concept (Ref. 1).
During the operational phase these tasks of the DUC will be continued: a dedicated Facility Expert (FE) will be present in the DUC, and will from there operate and monitor the facilities (all three) in the APM mock-up. These facilities will be operated as service environments for the users experiment, implying that the user decides how the facility is going to be operated, while the Facility Expert is responsible for the operation and health of the facility.
As can be seen from figure 2, the FE has a dedicated position in the DUC infrastructure from where he/she performs his/her tasks.

It is expected that the DUC personnel will gain experience in the field of user support, tele-science and tele-operation of experiments and facilities. This experience will be offered to the Dutch user community for future experiments.

4 SUPPORT FOR REMOTE OPERATIONS

In the context of support for remote operations the DUC has been, and still is, involved in two specific projects. These projects comprise providing PIs with operational support services and tele-science/tele-operation possibilities during two Spacelab missions. These two projects will be described in more detail in the following.

Anthrorack support during D2-mission.

In the framework of Anthrorack experiments, a Dutch scientist, Dr. Karemaker (Academical Medical Centre, Amsterdam), acted as co-I for several experiments. The involvement of Dr. Karemaker was focused on blood-pressure measurement of the test-subject.
Blood pressure has been measured continuously and in real-time by means of the Finapress (tm) device. The Finapress generates a continuous signal from which several blood-pressure and other arteric parameters can be deduced. Also the correct placement of the Finapress sensor, a finger-cuff, can be verified with the device output.

In the framework of user support an infrastructure was set-up that allowed co-workers of Dr. Karemaker to monitor and analyze the Finapress output at the DUC (at NLR-Northeastpolder, the Netherlands). This set-up is schematically pictured in figure 3. The results of their analysis were to be communicated with Dr. Karemaker, who was at the German Space Operation Centre (GSOC), Oberpfaffenhofen.

The realised infrastructure consisted of:
- A communication part, allowing the transfer of the measurement data from GSOC to DUC-NLR. The communication infrastructure was based on using ISDN.
- A user room at the DUC, where the co-workers of Dr. Karemaker would be located, and where the measurement data (21 channels) would be received, stored, monitored and analyzed. As an additional service a TV-set-up was installed that presented the dedicated D2 mission television channel "ALL-TV", broadcasted via the Copernicus II satellite.

Due to the late start of this project and the fact that the blood-pressure measurements were considered "private medical data of NASA astronauts", the use of the above described set-up was, only few days before the mission, not permitted. This implied that no mission data were received at the DUC.

Note: During the mission the Finapress didn't work properly for a certain time period. The availability of remote support would have allowed the developer of the Finapress to have a quick look at the data. This could have helped to get the device on-line again, and likely quicker that was the case now.

CPF remote operations on IML-2. juni '94

As follow-on on the D2 Anthrorack activity, a 2nd utilisation project is in process of being set-up. It will provide user support to the team of Dr. Michels (van der Waals Laboratory, University of Amsterdam) for an experiment performed in the Critical Point Facility (CPF) during the Spacelab IML-2 mission.

The experiment is a follow-on of experiments performed during the IML-1 mission, also on the CPF.

Regarding the IML-1 mission, analysis of the results after the mission revealed that valuable experiment time had been lost due to the fact that the data from the experiment could not in time be evaluated properly. To prevent this from happening again the set-up of remote science operation is proposed. An infrastructure will be set-up that will allow real-time data analysis at the DUC or at the PI's home base. The use of on-line appropriate (image-)analysis software, hardware and specialist people, that can provide the PI-team with much needed accurate information concerning long duration effects in the experiment, is expected to improve the scientific return of the experiment.

The foreseen infrastructure could of course be realised at the POCC in Huntsville, USA. However, there are some arguments that promote the establishment of such facilities near the PI's homebase, e.g. at the DUC, or even <u>at</u> the PI's home laboratory.

To allow for tele-science in the framework of this experiment high-rate data-streams, coming from Spacelab, are required. At this moment the data-stream required is estimated at 700 kilobits per second, including overhead, formatting etc.

This implies the need for a communication infrastructure capable of coping with these data-rates. Currently a set-up is proposed that is comparable with the D2 set-up described in the previous section. For the CPF experiment the data capacity of the infrastructure is achieved by combining ISDN channels up to the required level (see Fig. 4).
On the Dutch side of the communication system, a set-up is planned that will allow storage, processing and visualisation of the in-coming data-streams. This ISDN connection will cover the data-transmission from ESOC to DUC. ESOC will provide the data-path from Huntsville to ESOC.

Direct (voice and possibly data) communication between the PI at the POCC in the USA and the specialist team in the Netherlands will be used to exchange the results of the data analysis and discuss these with the PI.

Even though conceptually already in a well defined stage, the actual execution of this project is still under discussion.

6 NLR TELESCIENCE ACTIVITIES

Telescience comprises technology which can be used to enhance science return of microgravity payloads by exploiting interaction feasible with telecommunication opportunities. To allow for telescience careful preparation and design of remote interaction is needed to maximize scientific return during a mission (which may even imply elimination of types of teleoperation which would effect the overall performance in a negative way). Many issues are involved. For instance to allow proper interaction during the mission, the design of optical diagnostics should allow easy interpretation of phenomena to be observed. For the preparation and post-analyses, various other remote operations can be included as well (e.g. tele-design, tele-testing, tele-training, tele-analyses).
NLR contributes in several ways to the development of telescience, of which some have already been addressed in this paper. In the following specific telescience activities of NLR-DUC will be elaborated.

Telescience related activities are required to improve the design of payloads to maximise science return remotely. Especially the design and remote use of optical diagnostics for life and fluid sciences is being emphasised at NLR.

General measurement requirements for fluid physics experiment facilities as identified in a pre-phase A study for a future space laboratory motivated the development of an instrument breadboard called PODI, an acronym for Prototype Optical Diagnostic Instrument. This breadboard has been extended to TelePODI, Tele-operated PODI, to allow the study of telescience and image processing in "microgee related instrumentation". Remote control of various types of optical diagnostics were studied in tele-operated mode, such as: a scene observation system, a Twyman-Green interferometer and a Schlieren system. TelePODI has been integrated in the Telescience Test Bed as part of a telescience pilot experiment program.

Constraints as foreseen for future space laboratory were simulated, such as delays in remote optics control, bandwidth limitations and use of CCSDS protocols. A thermal plume reference experiment formed the basis for evaluation of scientific operations. Several PIs executed the same reference experiment. This allowed for an evaluation of Man-Machine Interfacing aspects and their relationships with the design of the optical diagnostics. The experience gained has been integrated in various national projects varying from MMI design to automation and robotics.

Due to practical limitations in video bandwidth various image handling scenarios had to be exercised. Especially because NLR was interested in optimal use of optical diagnostics this element was emphasised during simulations. Some of the lessons learned were:

- Optical diagnostics control and video should be integrated in the interface to the user.
- Due to delays and limited bandwidth it will be difficult for a remote user to perform alignment, camera control and calibration tasks. By adding some automation in the payload tools can be developed to help the remote user.
- When properly designed a remote user can use optical diagnostics in a user-friendly way independent of many telescience related constraints and many other activities required for space laboratory operations.

- Telescience operations in a serious sense require much more preparation and documentation from the PIs. For example, detailed mathematical simulations of the experiment are needed to allow proper interaction during a telescience session. This is needed to avoid an automated or teleoperation mode in which during the scientific post-evaluation of visual information errors in experiment execution are identified.

A test bed to study more advanced image handling scenarios is being developed under ESA and NIVR contract. The test bed will be based on an advanced image acquisition system which allows for interfacing with high performance cameras. High spatial resolutions are being emphasised with a design target of cameras allowing for 1000x1000 pixels with a video frame rate. To be able to handle high performance cameras for space application various types of "smartness" needs to be added. A simple example is region of interest processing, integrated with the camera, needed to allow for remote observation using standard analog video formats, while storing the digital information for off-line processing. The problems identified in the TelePODI project will become even more apparent for high performance cameras. The objective of the testbed will be to evaluate and to propose a "smart telescience camera".

Telescience experiments using TelePODI included a simulation of the User Home Base concept in which TelePODI was integrated in the Telescience Test Bed at ESTEC, Noordwijk and controlled from NLR-Noordoostpolder via a digital ground network and in a more advanced simulation session via Olympus satellite (Fig. 5). This telescience simulation had many precursor elements for DUC operations.

During telescience simulations the need was identified for cost-effective approaches towards telecommunications. ISDN was identified to be an important candidate to reduce future costs. Experience using one ISDN channel has been developed in a pilot experiment to have remote visualisation of data for Anthrorack D-2 data. This experience will be expanded for a telesupport scenario for the Critical Point Facility and also for the DAMS project. Using inverse multiplexing techniques several ISDN lines will be used in parallel. The proposed configuration resembles in many ways the configuration used in TelePODI telescience simulations. A Twyman-Green interferometer is part of this facility which will be flown a second time in a Spacelab IML-2 flight in 1994. For the Critical Point Facility a phase B study was performed by NLR with Van der Waalslaboratory more than 8 years ago. Therefore, during this project user support and its relationships with instrument development and telescience will be demonstrated.

7 DISCUSSION AND CONCLUSION

User support has in the Netherlands been actively taken up. A Dutch Utilisation Centre, as kernel of the Dutch User Support Organisation, has been established, and is actively involved in user support related activities.
The activities concentrate on the one hand on creating a solid defined basis for user support and on the other hand on providing already now support to Dutch users. Experience is gained from participation in simulation projects as well as from assisting PIs that are preparing experiments for Spacelab and sounding rocket missions.
The development of user support in the Netherlands is expected to continue developing in the coming years, up to a size that is in balance with the size of the Dutch user community and the amount of flight opportunities available.

8 ACKNOWLEDGEMENT

The authors thank all participants in the DUC consortium for their contribution to the development of user support in the Netherlands an therefore indirectly to the results of this paper. In particular mr. D. de Hoop (NIVR) is to mentioned; he can be considered the driving force behind DUC.

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DUC
DUTCH UTILISATION CENTRE

NLR	project management and responsibility, DUC location, DUC implementation, support definition and implementation
Fokker	hardware development responsibility, biology facility development
Comprimo consulting services	HPCE development
BRADFORD engineering	glovebox development
BSO TECHNOLOGY IN BUSINESS	support functionalities implementation
BSO / CAT TECHNOLOGY IN BUSINESS	MTS/DFS-DAMS specific database implementation
ICT	support functionalities implementation, DUC integration support
HE Hernandez Engineering B.V.	consultancy

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Fig. 1 Overview of DUC consortium participants and their DAMS involvement

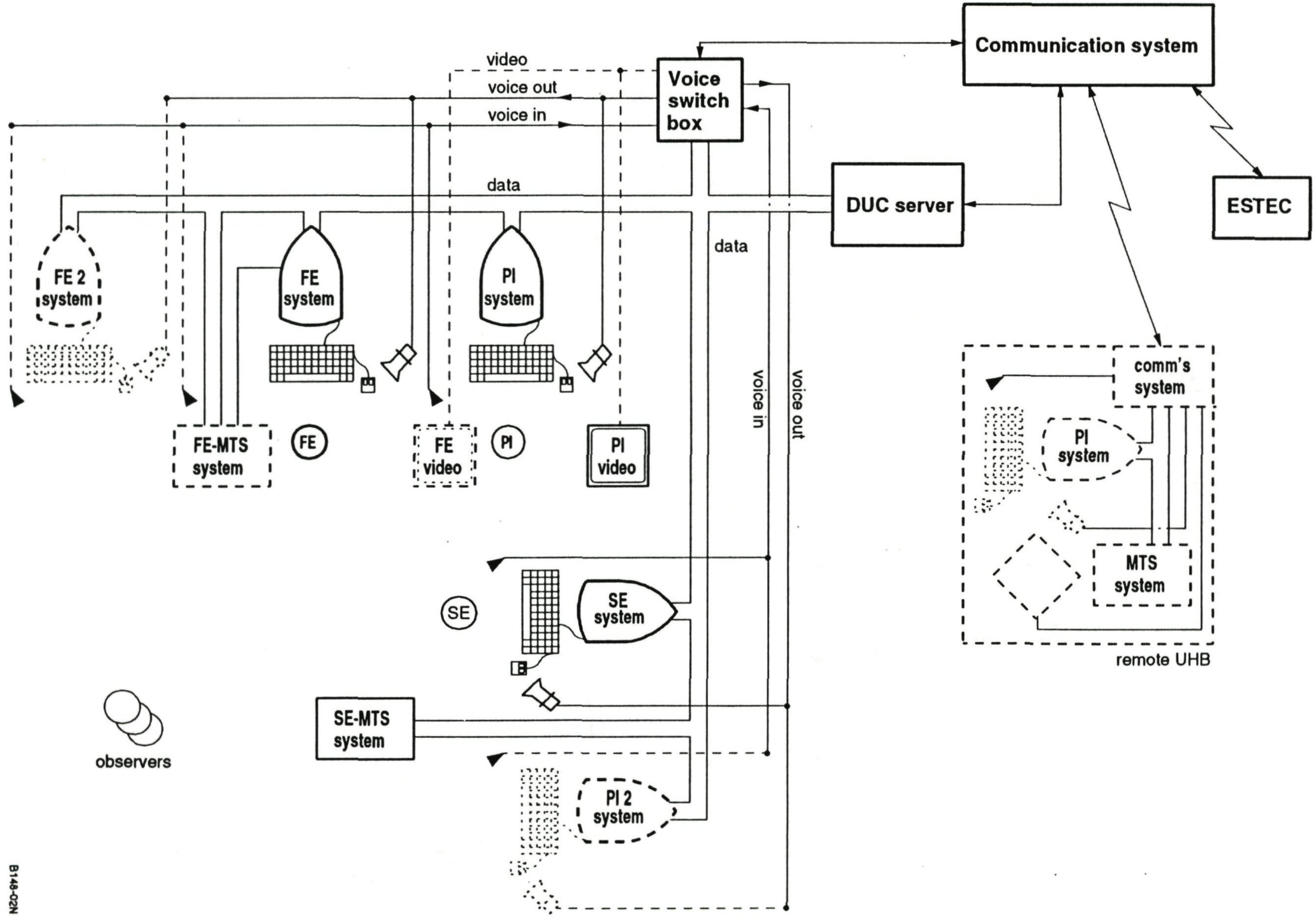

Fig. 2 Overview provisional architecture for DUC operational environment

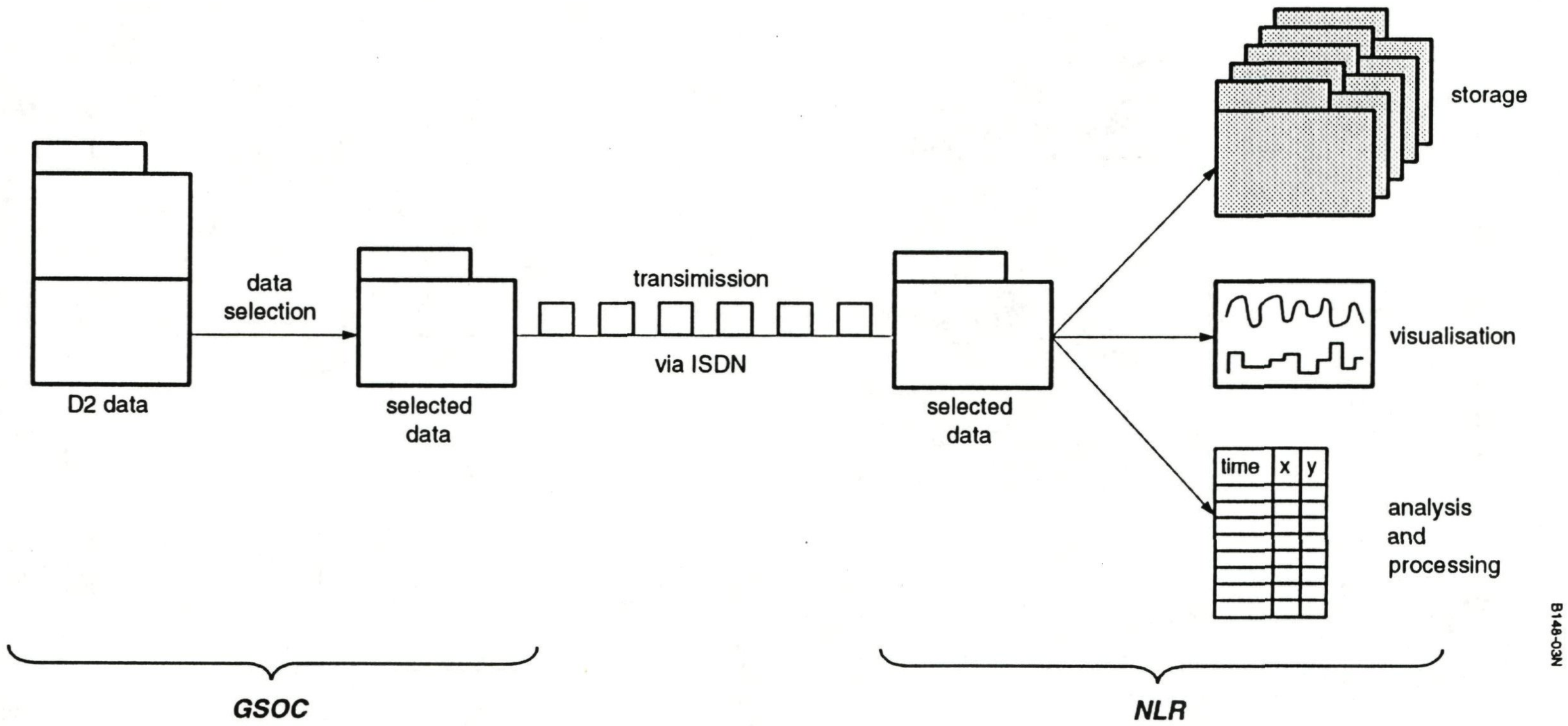

Fig. 3 Functional overview of D2 data handling.

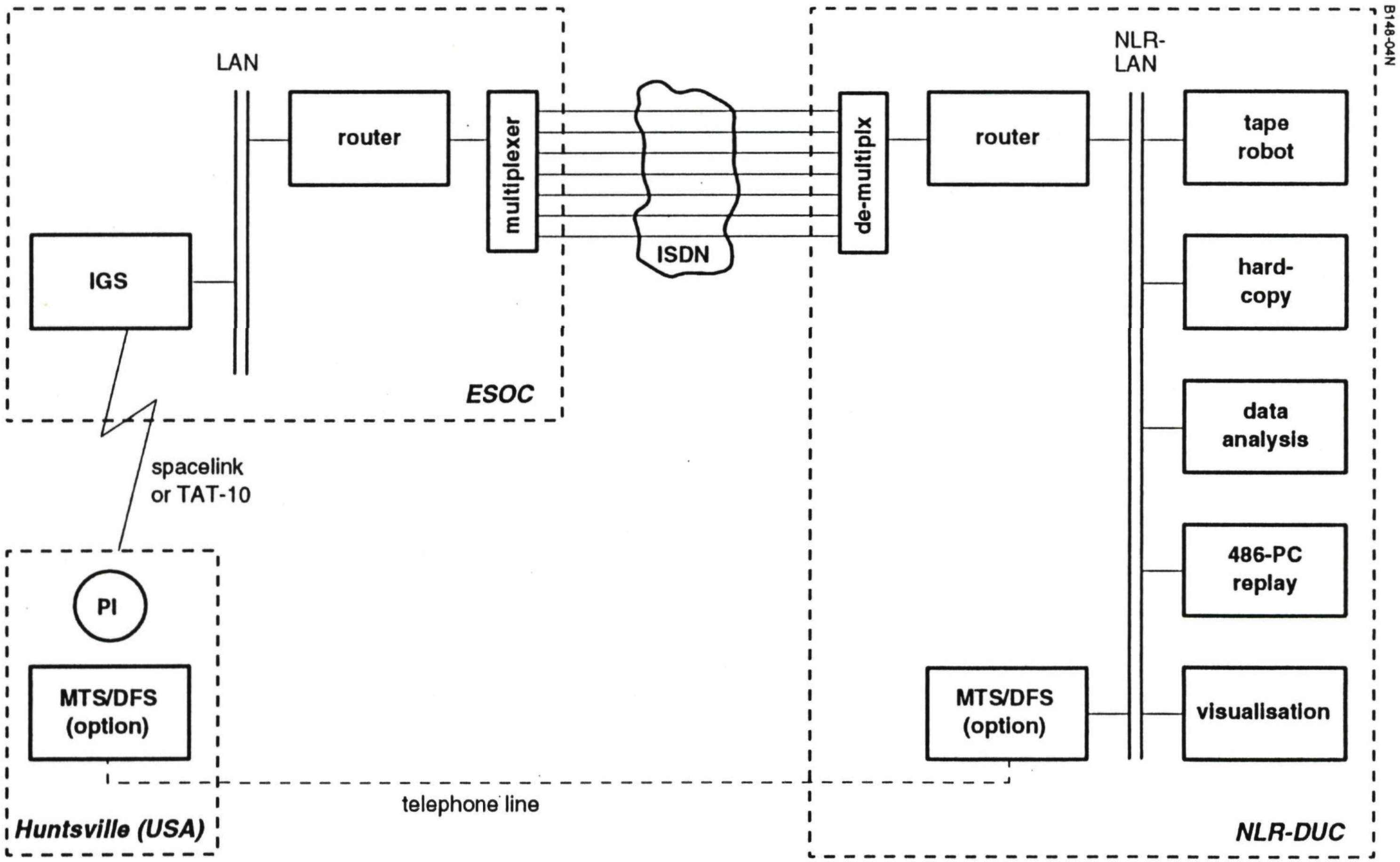

Fig. 4 Communication configuration proposed for CPF remote operation

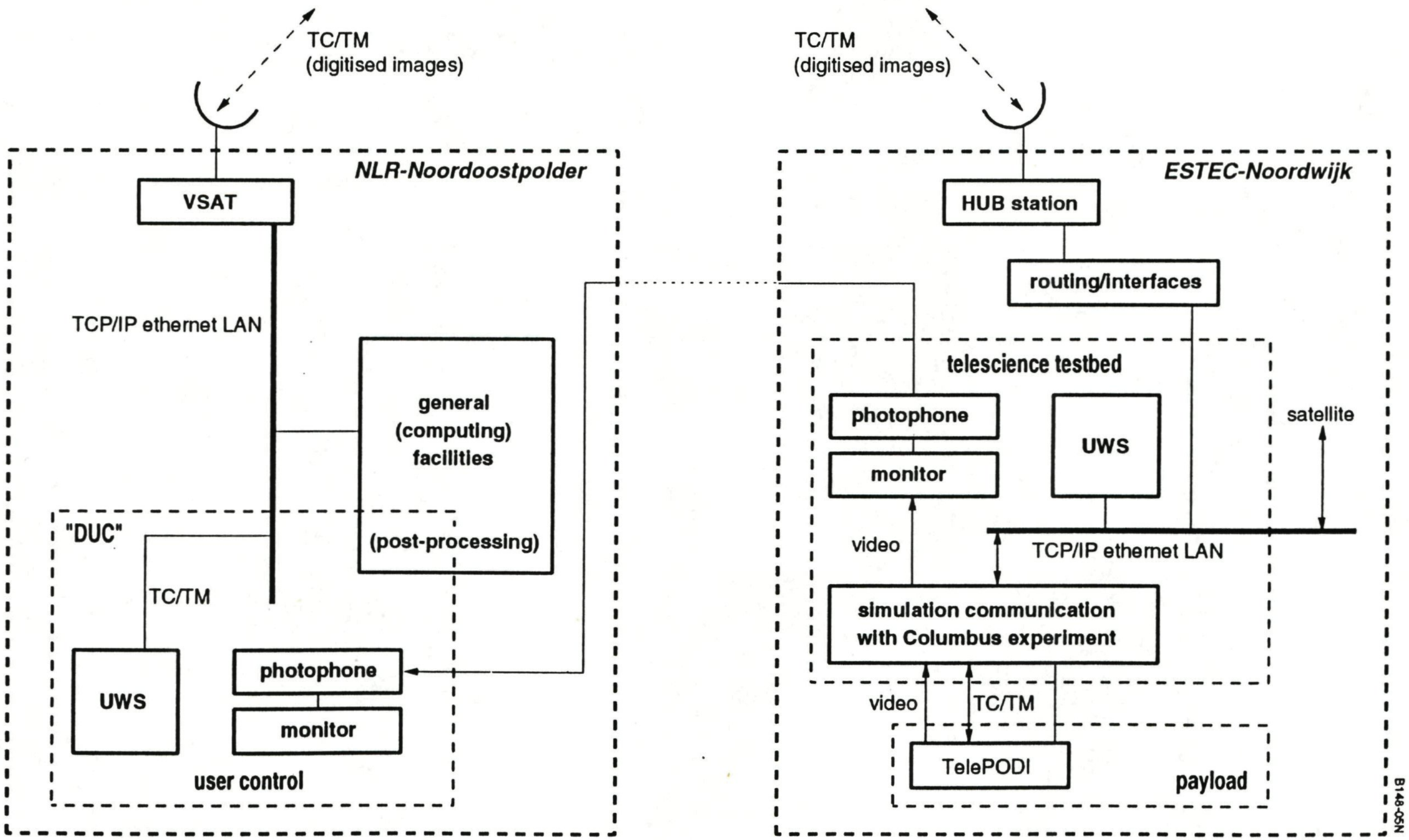

Fig. 5 Tele-PODI remote control via OLYMPUS