MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

INPE-9588-PRE/5216

ENVIRONMENTAL DATA SYSTEM FOR BRAZILIAN DATA COLLECTION SATELLITE

Maria de Fátima Mattiello-Francisco
Rubens Cruz Gatto

Paper presented at the European Symposium on Satellite Remote Sensing II – Palais des Congrés, Paris, France – 25-28 september 1995.

INPE
São José dos Campos
2003

Environmental data system for Brazilian Data Collection Satellite

Maria de Fátima Mattiello Francisco
Rubens Cruz Gatto

National Institute of Space Research - INPE, Ground System Division
São José dos Campos, SP, Brazil

ABSTRACT

The first Brazilian Satellite, one out of the family of three Data Collection Satellites -SCD, has been successfully operating as an automatic collector of enviromental data acquired by a set of a Data Collection Plataforms (PCD) distribuited in the Brazilian territory. The data have been used by the scientific community for several applications and studies such as Tropical forest regeneration, ozone layer, greenhouse effect, drifting buoys and so on. This paper addresses the software system developed for the Data Collection Mission Center, on tasks of storing, processing and distributing environmental data transmitted by SCD1. The analysis and development of this software were oriented to fulfil the needs of both the Mission Center operators and the users of the environmental data. Techniques for designing user interface centered on user needs were applied.

1. INTRODUCTION

In order to improve the use of environmental data the Data Collection Satellite SCD1, the first satellite of a mission of three satellites, was launched on 9 February 1993 into a low Earth orbit with inclination of 25 degrees and an altitude of 750 km. SCD1 main purpose has been to automate the environmental data acquisition by means of a network of Data Collection Plataforms that acquire, process and transmit messages to the satellite in a repetition period of 90 to 220 seconds.[1] The plataforms can be installed in any place in the Brazilian territory such as remote region of the Amazon forest and places where the access is still very difficult.

Due to existing Data Collection Plataforms network and the experimental characteristic of the SCD1 mission, the satellite receives all DCPs in operation with ARGOS compatibility in a visibility of Cuiabá Station. As the SCD1 has an orbit period of 100 min, it passes over the Cuiabá station 8 passes per day.[1]

In order to support SCD1 data reception in ground, Cuibá station provides equipments that receives down converted payload data and stores them in a floppy disk unit, in addition with auxiliary data such as carrier frequency, channel status, message length and a time stamp. According to the established operational procedures, the files with DCP messages are transmitted through the RECDAS to the Mission Center in Cachoeira Paulista, where these data are stored, processed to engineering units and kept available for remote user through the public Packet Switch Network (RENPAC). The Mission Center monitors the mission payload performance.

Nowadays the data collection operation networks transmitted through the SCD1 mission are:

- Amazon Program for environmental sciences, with 10 DCPs, related to Ozone Layer studies,

0-8194-1947-8/95/$6.00

greenhouse effects studies, biomass burning studies. The sensors available are atmospheric pressure, wind direction and speed, ultra violet radiation, CO2 concentration, CO2 temperature, Ozone concentration, air temperature. The DCPs have repetition rate between 205 and 215 seconds. [2]

- Amazon Program for studies of tropical forest regeneration with 3 DCPs installed near Manaus. The sensors acquire the following data: ground temperature, heat flow, air temperature, humidity, incident and reflected radiation, and wind speed, with a repetition rate of 180 seconds.
- Tide-gauge network allows, for the first time, a systematic data collection of South Atlantic (coast and oceanic area) with 4 DCPs installed acquiring sea level in an houly basis through the submarine pressure and water salinity will be installed. This data will make the fishing forecast possible for the northeast region based on better understanding of the sea level and temperatures of the ocean and its current. [3]
- INPE Magnetometer network with 2 DCPs for Earth magnetic field variation studies.
- INPE Hydrologic network with 8 DCPs installed in the Itajaiacu Basin (Santa Catarina State), Minas Gerais State and Ceará State.
- 24 DCPs installed by DNAEE (Department of Water and Power) for hydrometeorological and environmental applications. Other 250 DCPs will be added to this network earlier than 1996.

The launch of the SCD2 appointed to the end of 1995 will assure the continuity of Data Collection System service and will also cover the gap of approximately 10 hours without satellite passes. The SCD3 with a equatorial orbit and CBERS satellites with a polar orbits will increase significantly the number of satellites passes over Brazil for data collection purpose. [1]

2. SOFTWARE SYSTEM FOR THE MISSION CENTER

Improvements on the original system were required in order to provide the 3 different categories of users with a more friendly users interfaces and efficient way to access environmental data collected by SCD1. A list of these categories of users and their responsibilities is given below for a brief understanding of the system requirements:

- Mission Center operators who are responsible to keep the environmental data collected by SCD1 available in ground for the users;
- SCD mission manager who is responsible to analyse the mission performance from remote site;
- environmental data users interested to access the data in order to transfer them from CMCD to the user computational environment, according to the application needs.

3. METHODOLOGY DESCRIPTION

Since the requirement is to meet the different goals of the categories of users who interface with the system, the development was carried out based on the user centered principles. [4]
The software analysis, design and implementation were oriented to reach the users needs. The dialogue has been separated from the computational components of the system.
The system functions have been stated on the basis of the requirements of the potential users. These requirements have been obtained from a specification documment and complemented by user analysis, which studies how information about users, their tasks, their needs might be gathered and incorporated into design process. [5]

3.1 System design

From the system user requirements and user analysis, the Functional Design has been carried out by working out **scenarios.** The scenario approach permits the building of an incremental design because it deals with context. A detailed description of several scenarios has been made in order to highlight the logic sequence of steps followed by the 3 categories of different system users to reach their specific goals. The functional design has been finished by identifying role, tasks, activities, sub-activities and entities from the scenarios. This task analysis (identification of the user goals and tasks by a slightly less formal means)[5] has produced a graphic specification of the system.

3.2 Implementation

The Implementation phase has succeeded the Functional Design by prototyping objects, operations and properties in a set of screens using GUIDE (Unix). An important characteristic of prototyping approach is to permit a previous understanding of the final system and consequently an evaluation of the user expectations. This feature is very useful for fixing the boundaries of the software functions to be implemented. Also the implementation of a prototype permits a limited implementation effort, simulating certain functions end/or implementing a partial system. In Mission Center project almost all the functions were simulated using informations stored in Data Base.

3.3 Evaluation

The analysis of the dialogue has been carried out by both performing the **theoretical analysis** according to the **design inspection method** and evaluating the prototype. Users were invited to try the interface and their behaviours were analysed during the interaction and after that. The purpose of this phase has been to both demonstrate the ideas adopted by the system designers and to provide the users with a tool for evaluating the system earlier than the software development be completly finished.
User's problems have been observed in terms of a semantic nature, and an error analysis on the interface level has been carried out. On the basis of the error analysis results, the evaluation phase has been finished with a proposal to modify the system.

4. USER ANALYSIS

This section presents the studies of the user characteristics combined with the task analysis which give an understanding of who the users are, their goals and activities as well as the tools they use and the environment in which they work.
As mentioned before, the users interfacing with the Mission Center software fall into three categories: Mission Center **operators**, SCD1 Mission **managers** and environmental **data users**.

4.1 Mission Center operators

The operator at a Mission Center is responsible for the day-to-day operation of the Mission Center on the main following essential activities:

- **catalogue**

1. project/users of the system;
2. DCP information such as: localization, identification and amount of the sensors configured in it; sensor information necessary to data processing (calibration curves).

- **monitoring and reporting** data acquisition, data processing and user's access to the system.

This category of user is specifically trainned to perform operation tasks on this specific environment of operation. All the necessary knowledge and background are given to the operator. Therefore, he/she must be provided with user's interface facilities which do not make him perform a long path to reach a goal. The user interface must be simple, friendly and task-driven in order to not create a borring dialogue with the operator since he/she works every single day with the same system.

4.2 SCD1 Mission manager

The Mission manager processes inventory update or inventory quality control of the SCD mission. This person has a good understanding of the mission. He/she uses the system as a tool to acquire information that will be used in statistic studies of the satellite mission later on. For instance, the distribuition of the received messages per day related to DCPs located in Cuiabá, Atol das Rocas and Barreiras from March/93 to January/94.
Since the nature of the data is the same and the analysis process is totally done outside the Mission Center, not many interactions must be necesary to provide the Mission manager with the data that he/she needs. The user's interface for this class of user shall be simple and brief like getting a copy of a report.

4.3 Environmental data users

The system will be accessed by the scientific community, private and governamental instituitions which are owners of DCPs. The knowledge,experiences and attributes to the system are expected to differ a lot among the users. Although most of the users are considered to be familiar with the computer, the system does not have to consider this fact as a rule at all.
From these assumptions, the user's interface has been designed so that minimum computer experience is necessary. The user's interface must be fault tolerant to any kind of user is mistake and must be easy as well as interesting to be used. A help facility is essential.

5. SYSTEM DESIGN

5.1 Functional requirements

The functional requirements of the Mission Center software, as mentioned before (session 2), keep basically the functionality of the original system in operation, making improvements on the user's interface. The functional requirements are those functions expected to realize the activities selected by the users through the interface. Therefore, considering the 3 categories of users of this system, some of these functions are to:

- show forms to be filled by the Mission Center operator in order to catalogue users/project, DCPs and sensors on the system;
- present to the operator the status of DCP automatic data transference from ground station to Mission Center;
- present to the operator the status of DCP data processing (calibration);
- keep the operator informed about the users consulting with the system in order to get environmental data;
- permit the mission manager to access the system in order to get information about the events occured in each specific orbit such as the number of messages received by each DCP;

- permit the enviromental data users to access remotely the system in order to transfer to the application site a file containing all data concerning their DCP in an specific time interval.

5.2 Scenario descriptions

Because 3 different categories of users have interaction with the system through different way, 3 distinct user interfaces were designed. Only the operator user interface will be addressed in this paper, as an exenple. A description of 3 scenarios dealing with some operator activities is given below, in order to report this part of the process of software development. Two of these scenarios are presented to illustratr the first interaction and the third one illustrates the second interaction.

SCENARIO 1: According to the operation schedule, the Mission Center operator arrives at the operator room every morning to start the work day. On the screen he/she vizualizes the system status which displays data related with the automatic receptions and data processing over night. For each occured transference from Ground Station to Mission Center, it is logged both the total bytes received and the transference time interval. Also, information concerning the DCPs processing of the last receptions are displayed. Therefore, the operator might monitor the total of messages received, the amount of messages with and without error and the time interval spent for their processing. In order to have a complete understanting of the over night system operation, the operator is informed of the user requests to the system. Information related with this task are scrolled on screen through a list of contents:

- request time;
- user/project identification;
- transfer type (on-line or off-line);
- data request time interval;
- transferred messages amount;

In case of off-line transfers, the operator works in preparing the files which will be delivered to the users in flexible disks. During this task the operator vizualizes a list of all the data request which must be processed off-line. Each of them will be atempted individualy by the operator.
In the meantime, new transfers might be happening. They also shall be monitored by the operator, in the same way as described above.

SCENARIO 2: A new DCP was installed in Itajaiaçu Basin for hydrological purpose. It is a DCPadded to a network which is under control of a specific user/project.
The Mission Center operator selects the DCP catalogue option in order to fill a form with the specific data related with that DCP. As an exemple such form might contain:

- DCP identification;
- Frequency compatibility;
- Localization (alt, lat, long);
- the sensor list configured on DCP (using sensor identification as a key).

Buttons facilities support the operator on the tasks of both inserting the fulfilled form and deleting one under vizualization.
Since the new DCP is being included in a DCP network already in operation, it must be also associated with at least one user/project which works with this network. Therefore, the operator atempts to find out the user/project identifier(s) already catalogued in the system in order to include the new DCP identifier in the DCP list used by this project. By entering the user/project identifier in a specific screen field for

searching, the system shows the operator a form with all the catalogued information concerning that user/project, where the updating will be proceeded.

5.3 Grafical specification

The graph presented in Fig. 1 was devised on the basis of top-down methodology used during task analysis. The main purpose of the task analysis is to identify roles, tasks, activities and entities from the scenario descriptions, considering the functional requirements described at the begining of this phase. The **role**, in this project, is the OPERATION, **tasks** concern the system actions, **activities** are related to the user actions and **entities** intend to be associated with the system answer for the operator questioning when he/she interacts with the system. Entities must be the information which the user expects to find. The graphic shows the design during the first interaction.

6. IMPLEMENTATION and EVALUATION

Under software engineering the implementation phase also includes codification aspects. In user interface approaches the implentation phase does not have well defined boundaries because it includes the prototype behaviour. That process starts early in the previous phase (system design) during the user modelling when the system functionality is analysed under the conception of the user (what functions are expected by the user and what functions are not). The user modelling in this project was well defined after the first prototyping, Fig. 2, being presented to the Mission Center operator.
While working with the prototype, during interaction 1, none of the functionalities was really surprising to the operator. The operator was questioned on the following aspects:

- system functionality expected but not provided;
- system functionalities that were expected and already existed in the system;
- existing system functionality not expected.

Some remarks were made by the operator in terms of his expectations about system functionality not existing, such as:

1. possibility of visualization of a list with all the DCPs identifiers received in the last satellite transmission;
2. monitoring the DCP set installed in a specific region of Brazil (search by region).

Such operator remarks during interaction 1 were analysed by the software development team and another scenarios were described. One of them is presented below:

SCENARIO 3: The operator received a call from an user who was complained about the lack of data related with one of his DCP during the last two days.
The operator needs to investigate the last DCP message processing.
Looking at the map displayed on the screen, the color of the point which represents that DCP might be observed. Non highlighted point means no message related with that DCP in the last reception. Clicking that point on the map, the operator might see the last message time-tag transmitted by that DCP. This time is compared with the reference given by the user in order to detect a fault occurence on the file transfer, in case of no match. If time is the same, a fault in that DCP transmission then might be assumed what will require an investigation procedure in loco.

A new graphical specification, Fig. 3, was elaborated. From the analysis of the system and the kind of

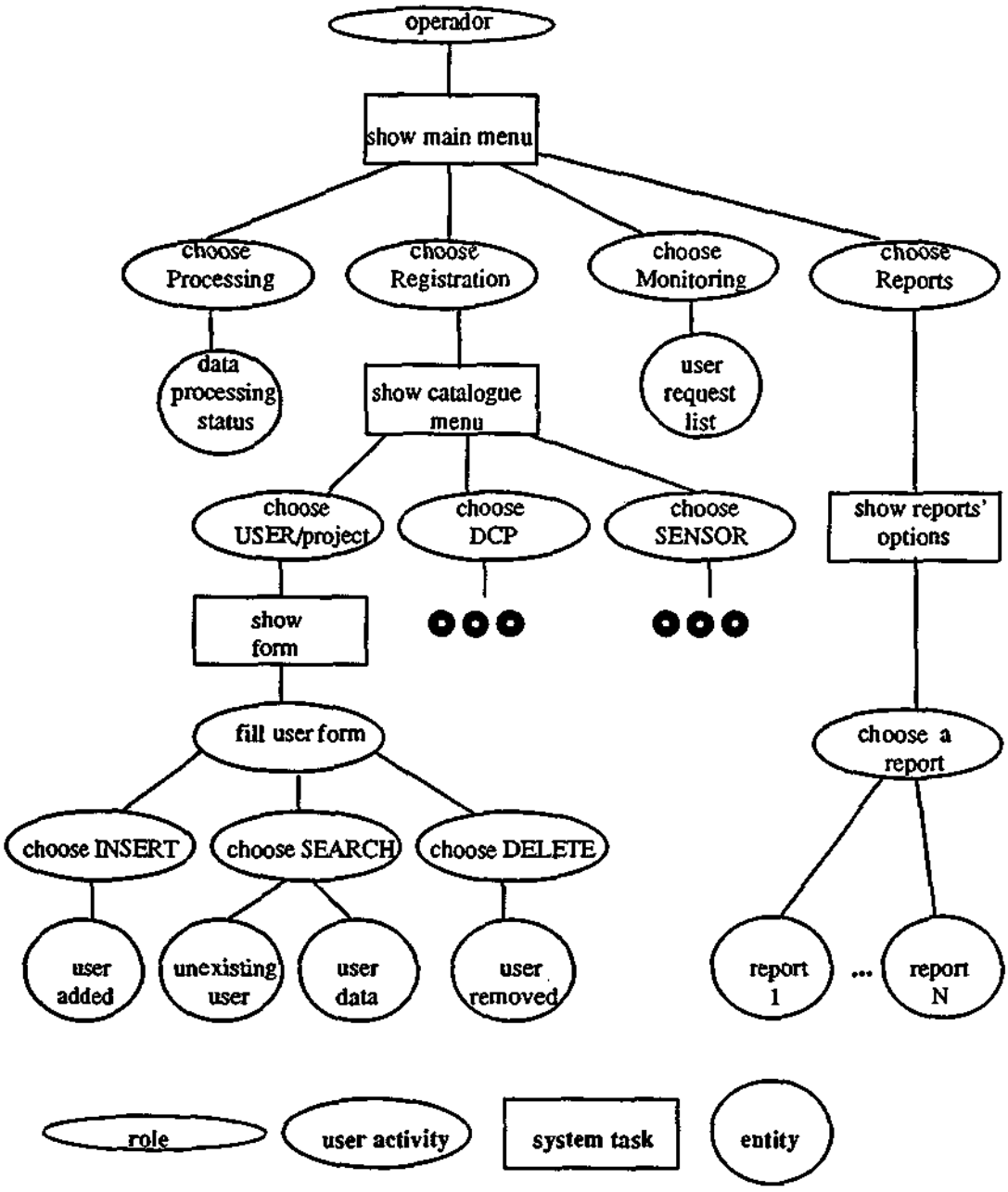

Figure 1: First user interface graphical specification.

user, actually a Mission Center operator, it is fact that the user is dealing with well defined tasks which include monitoring specific situations related with DCP localization in the Brazilian territory. Therefore the metaphor based on computer system (forms, scrolled list and so on) implemented in interaction 1 is very apropriated for an operation environment. But thinking about satellite orbit, data reception station localization and DCP networks in the Brazilian territory, the Brazil map picture included on the main screen permits an easy association of each DCP and its localization. On the map all DCPs are represented

by colored points. The DCP messages received in the last satellite transmission are highlighted. That metaphor simplifies the operator monitoring tasks besides being very pleasant for visualization.
The prototype of the new user interface system is presented in Fig. 4. In order to perform a practical evaluation during interaction 2, the operator was invited to try the prototype. It was observed that the design model corresponds in general to the user model. All topics included in the system were expected and no one was missing.

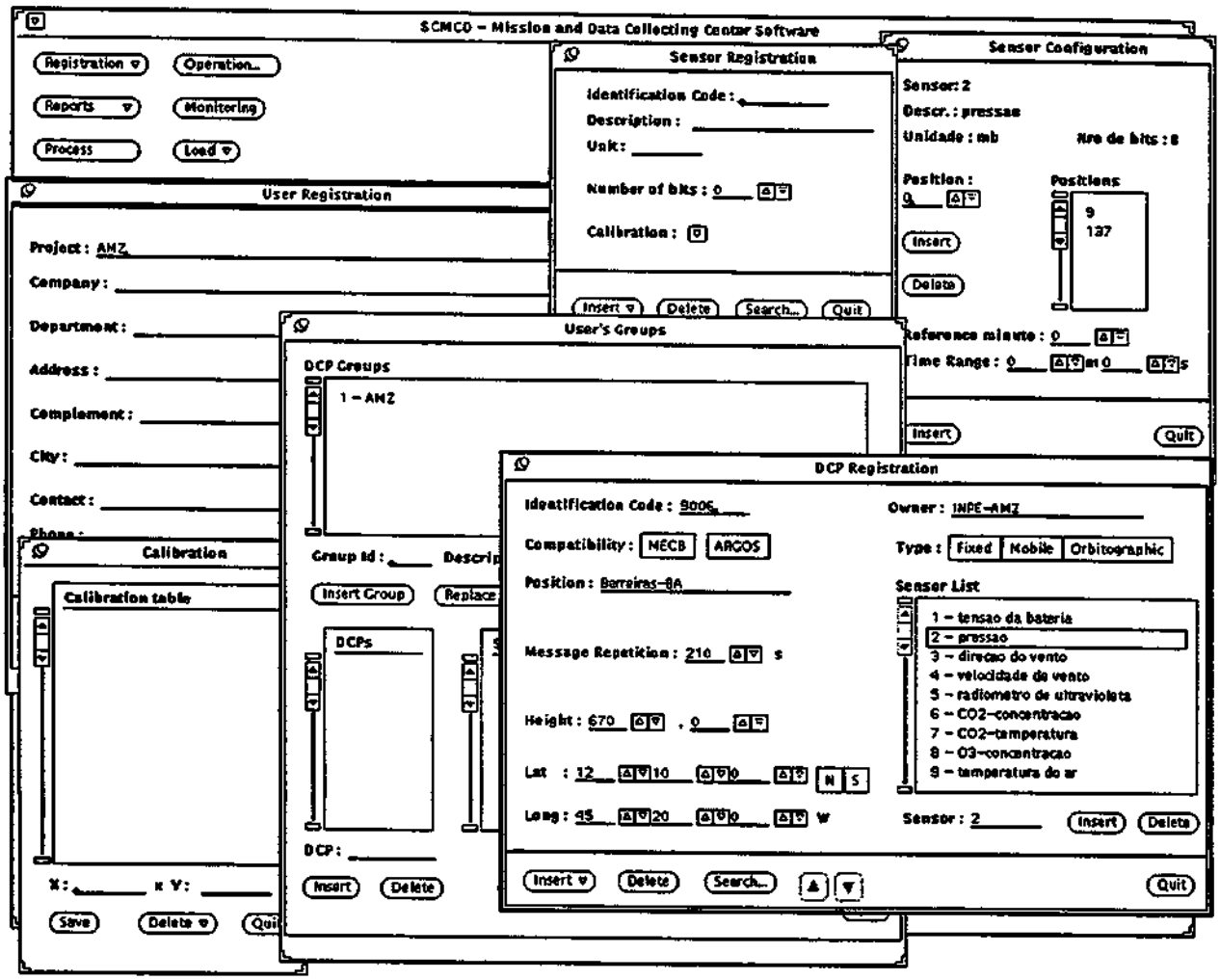

Figure 2: First prototype of the Mission Center Software.

The practical evaluation was almost finished. At that time, the interface design being prototyped fitted the user needs. That means:

- the designed tasks do not realize more than the user needs and it is consistent with the user's mental model;
- the interface is obvious in the sense that the user can manage it;
- the user operational faults neither crash the system nor let the operator get lost;
- the interface control is interesting for the user operating it.

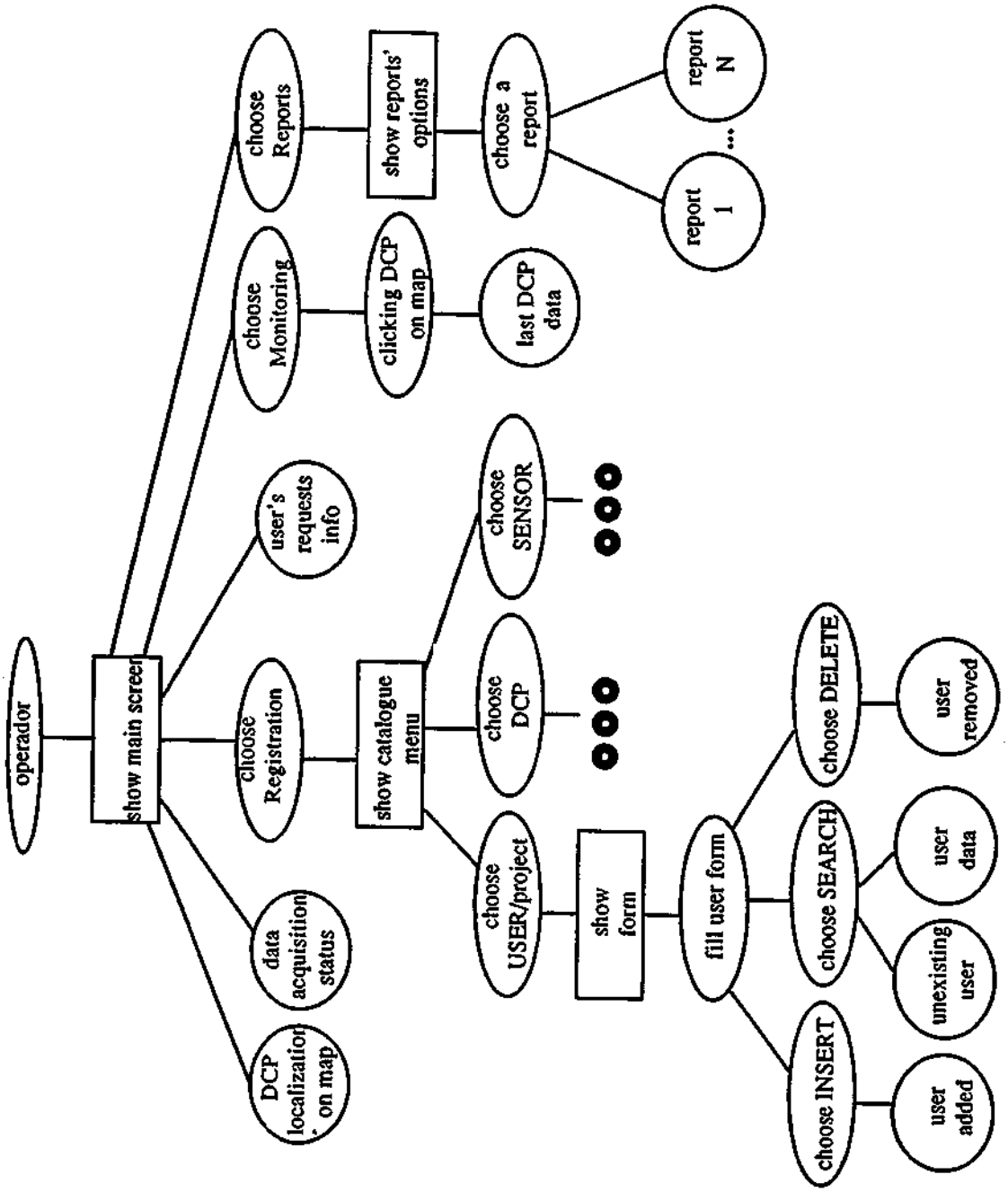

Figura 3: Partial view of the final user interface graphic.

These interface requirements have been checked out in terms of dialogue as part of the theoretical analysis. According to the design inspection method, the designed dialogue is evaluated by observing the user walkthrough the prototype during the interactions. The user's goals are listed (as for a test planning) in order to proceed the inspection. All the user's remarks, problems, faults, long breaks, questions are noted to be discussed later on.

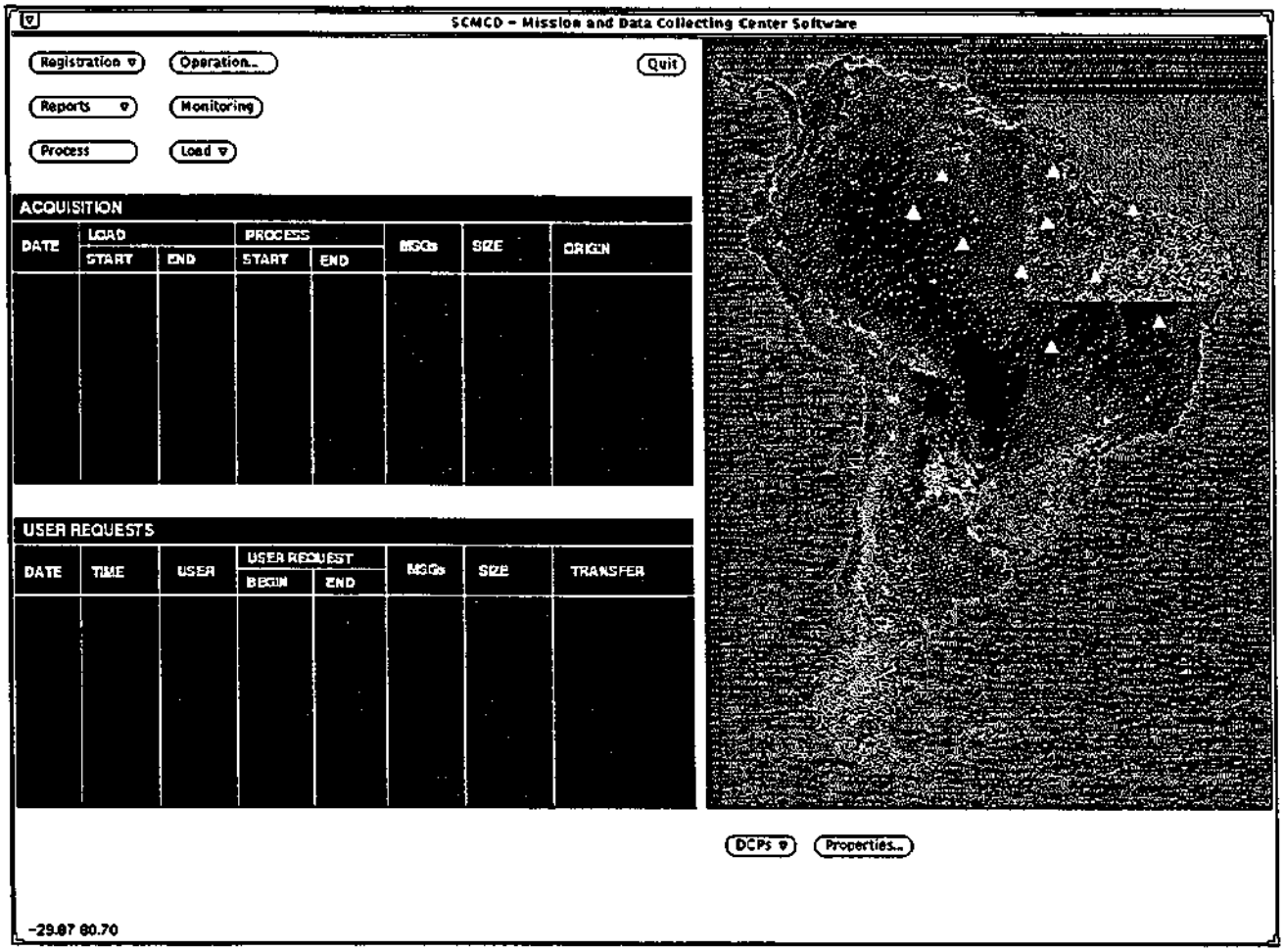

Figura 4: The final prototype of the Mission Center main screen.

7. CONCLUSION

In the development of computer systems for general purpose many efforts have been applied in using Human Computer Interface approaches for improving the system under the usability topic, a concept comprising the effectiveness, efficiency and satisfaction with which users can achieve specific goals in a particular environment. In the development of computer system for Satellite Control Center, Data reception Ground Station and Mission Center, usability has not been so much mentioned as important system requirement. Talking about users in that system means interfacing with the operator class, who is supposed to be trainned specificaly in that operation environment whatever user's interface the system provides.

With the new generation of small satellites the user conception for these system has been modified. More automatic operation tasks might be implemented at Satellite TT&C Ground Station for satellite control and data reception in order to diminish the operation cost since the on-board computer system reliability is increasing. On the other hand, as in case of scientific mission, many operators activities in the early systems are now becoming tasks of the satellite investigators payload. They have to monitor the satellite payload and participate of telecomand decisions concerning their experiments. So the user's interface concept in these computer system has changed.

Our experience in the development of the Mission Center software centered on the user needs has been successful in the sense of openning that computer system for 3 different categories of users with different goals and different skills. Besides the user analysis contribuition to the user's interface design being closer to the user mental model, it has also been helpful for a better understanding of the user's requirements and the software tasks boundaries.

8. REFERENCES

1.Yamaguti, W. at all "Collection and treatment of the environmental data with the Brazilian satellite - SCD1" - *RBCM Journal of the Brazilian Society Mechanical Sciences - vol XVI special issue*, 1994

2. Kirchhoff, V.W.J.H. "First Results of a Network of Tropospheric Ozone and Carbon Dioxide Sensors for Operation with the First Brazilian Satellite". EOS Transaction, American Geophysical Union, 1993 Spring Meeting, vol 74(16), Apr20.

3. Vianna, M. "Brazilian Network Gets Going". Eath Challenge, CLS Argos, July 1993, N(3).

4. Norman & Draper (Eds), "User Centered System Design", *LEA Publisher*, London,1986

5.Booth, P. "An Introduction To Human Computer Interaction", Lawrence Erlbaums Ass. Publ. Hove, 1989.

MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

AUTORIZAÇÃO PARA PUBLICAÇÃO

Número
EEI-160/2002

Título
Environmental Data System for Brazilian Data Collection Satellite

Autor
Maria de Fátima MATTIELLO-FRANCISCO, Rubens Cruz GATTO

Tradutor

INPE-5588-PRE-5216 **Editor**

Origem	Projeto	Série	No. de Páginas	No. de Fotos	No. de Mapas
ETE/DSS			13		

Tipo
☐ RPQ ☒ PRE ☐ NTC ☐ PRP ☐ MAN ☐ PUD ☐ TAE

Divulgação
☒ Externa ☐ Interna ☐ Reservada ☐ Lista de Distribuição Anexa

Periódico / Evento
In: Advanced and Next-Generation Satellites
European Symposium on Satellite Remote Sensing II
25-28 September 1995 **Convênio** Palais des Congrès, Paris, France

Autorização Preliminar
09/12/02
Data
Edenilse F. E. Orlandi
Chefe da Divisão de
Desenv. de Sistemas de Solo

Revisão Técnica
☐ Solicitada ☒ Dispensada
Recebida __/__/__ Devolvida __/__/__
Leonel Fernando Perondi
Titular de Nível "A"
Assinatura do Revisor

Revisão de Linguagem
☐ Solicitada ☒ Dispensada
Recebida __/__/__ Devolvida __/__/__
Titular de Nível "A"
Assinatura do Revisor

Autorização Final
__/__/__
Data
Edenilse F. E. Orlandi
Titular da Unidade
Chefe da Divisão de
Desenv. de Sistemas de Solo

Palavras Chave
environmental data - data colletion satellite - mission center software - distributed platforms

(continua na folha 2/2)

Autorização Para Publicação

Secretaria

__/__/__ Recebida __/__/__ Devolvida __/__/__

Data

_____ _____

Encaminhado Por Devolvido Por

Controle e Divulgação

__/__/__ Recebido Por: _____ Devolvido Para: _____

Data

Pronto Para Publicação em: __/__/__ ___/___/___

Data

No. _____ Quant._____ _____

Assinatura

Observações