

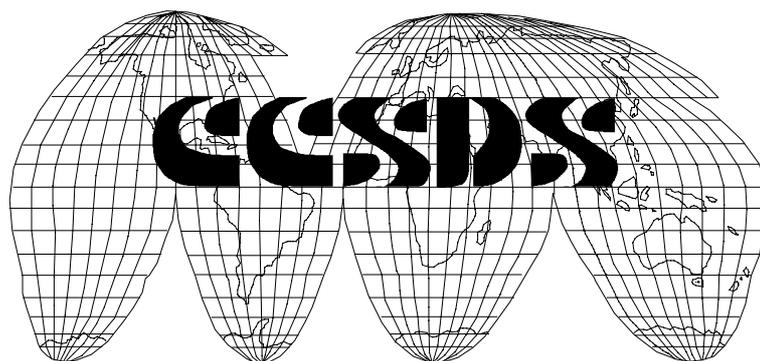
***Consultative  
Committee for  
Space Data Systems***

**ACHIEVEMENTS  
AND  
PRODUCTS**

**YELLOW BOOK**

**CCSDS A10.0-Y-5(CL/II)**

April 1995





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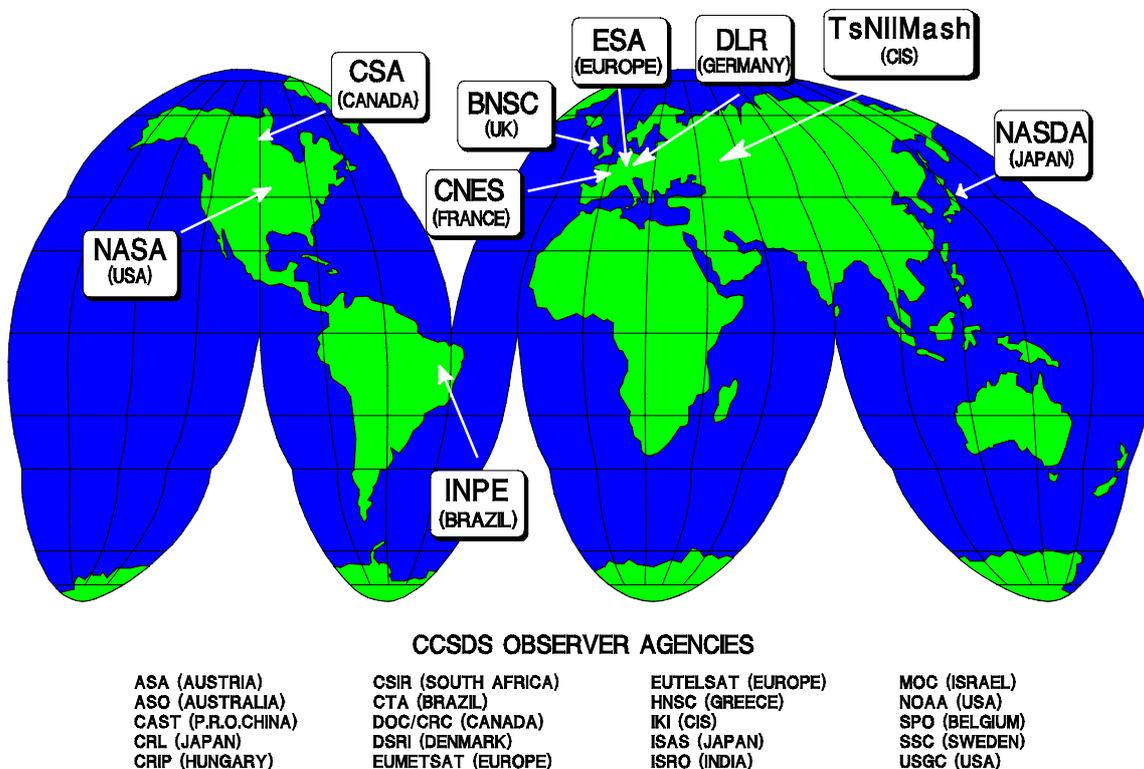
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## I. INTRODUCTION

In 1982 many of the world's space agencies met to discuss common problems relative to space information and data systems. It had long been realised that the growing complexity of space missions as well as their associated costs could adversely impact space endeavors in the future unless specific efforts were undertaken to meet these concerns. Accordingly, a Consultative Committee for Space Data Systems (CCSDS) was established to perform end-to-end system analyses and, through the collective efforts of its international experts, to develop advanced solutions to these common problems. These solutions, called CCSDS Recommendations, are reviewed and officially accepted by the CCSDS member agencies before they are released as approved Recommendations ("Blue Books" in CCSDS terminology). Although the participating agencies are not obliged to adopt the Recommendations, their use will not only reduce the cost and time impacts of unique systems developments to an agency but will provide further collective benefits through the promotion of cross support opportunities.



**FIGURE 1: CCSDS MEMBER AND OBSERVER AGENCIES**  
(as of January 1995)

CCSDS Recommendations address all aspects of space information and data systems: on-board, space-to-ground, and on ground. In addition, the Recommendations are "layered" much like the Reference Model of the Open System Interconnection (OSI) developed by the International Organization for Standardization. Accordingly, a mission can adopt only those Recommendations which it finds beneficial and is not required to be 100 percent CCSDS compatible. A growing number of space missions are adopting CCSDS Recommendations. While these missions are listed later in this brochure, it is worthy to note that the international Space Station programme is among them.



This brochure provides an overview of the CCSDS and its achievements. Chapter II includes a short description of CCSDS products (Recommendations), chapter III a listing of currently existing CCSDS documents including short descriptions of their contents, chapter IV information on the application of CCSDS Recommendations by the member agencies and their adoption by ISO, and chapter V some conclusions.

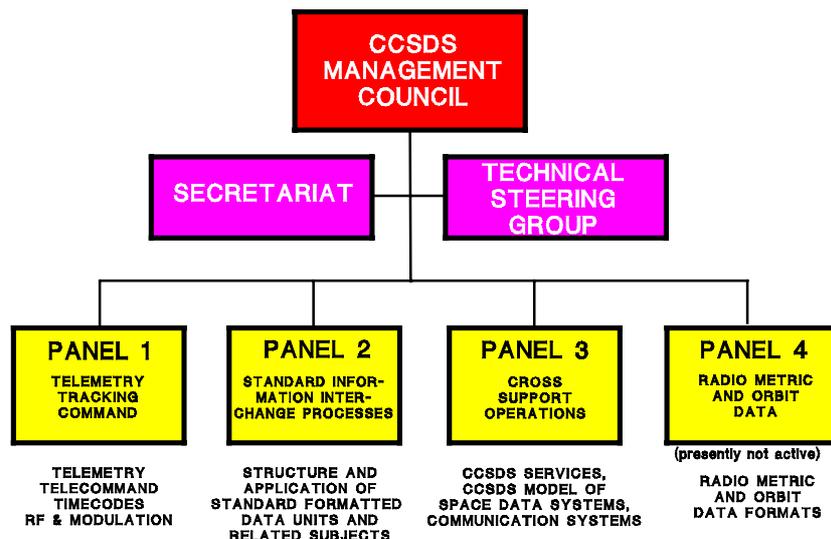
## II. HISTORY, FUNCTIONS, CURRENT POSITION AND ACHIEVEMENTS OF THE CCSDS

### A. HISTORY AND FUNCTIONS OF THE CCSDS

The space agencies have been using standards on data structures since the start of their activities at the beginning of the sixties. Most of these standards were adaptations of existing industrial standards and only used internally. Some of them were taken over from other agencies and thus a de facto interagency standardisation was achieved in selected areas. Examples are certain types of time division multiplex telemetry formats. With the growing complexity of space data systems, following the expansion of requirements, the problem of a diverging evolution of systems and standards was growing. Consequently space data system experts and managers of some space agencies started discussing the systematic harmonisation of space data system standards which led, eventually, to the foundation of the Consultative Committee for Space Data Systems in 1982.

The Committee's objective is to establish recommendations for standards in particular in those areas where interoperability between different space agencies is already, or is likely to become, important.

The Committee's activities are executed by four expert panels. They are supported by a Secretariat and coordinated by a Technical Steering Group and the Management Council, the latter being composed of the Senior Representatives of the Member Agencies plus the Panel Chairmen.



**FIGURE 2: ORGANISATION OF THE CONSULTATIVE COMMITTEE FOR SPACE DATA SYSTEMS**

The panels, the Technical Steering Group and the Management Council meet regularly, approximately once or twice per year.

Figure 1 shows the member and observer agencies and Figure 2 the organisational structure of the CCSDS. Industrial and academic organisations which indicate a desire to closely monitor CCSDS activities may join as CCSDS Associates. They receive all CCSDS documentation released for external dissemination and are welcome to submit comments as appropriate.

## B. CURRENT POSITION AND ACHIEVEMENTS

During its 10 years of existence, the CCSDS has produced recommendations in the fields of telemetry, telecommand, time coding, RF and modulation, standard formatted data units and radio metric and orbit data. Short summaries of the related products will be given in the following paragraphs.

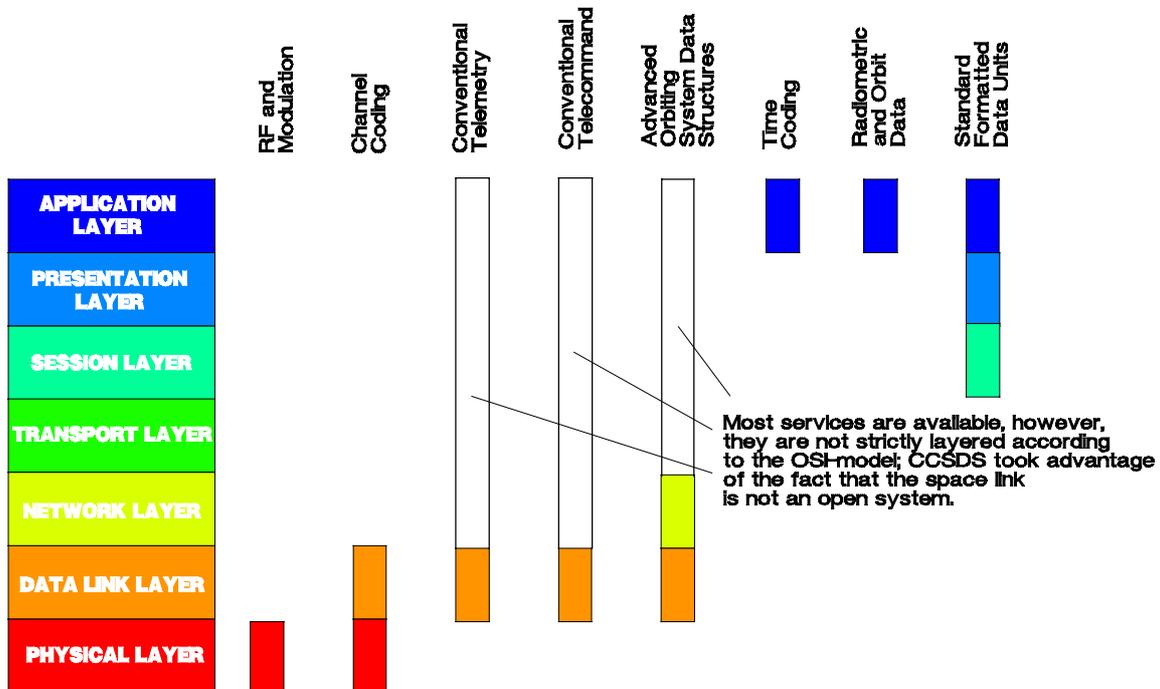


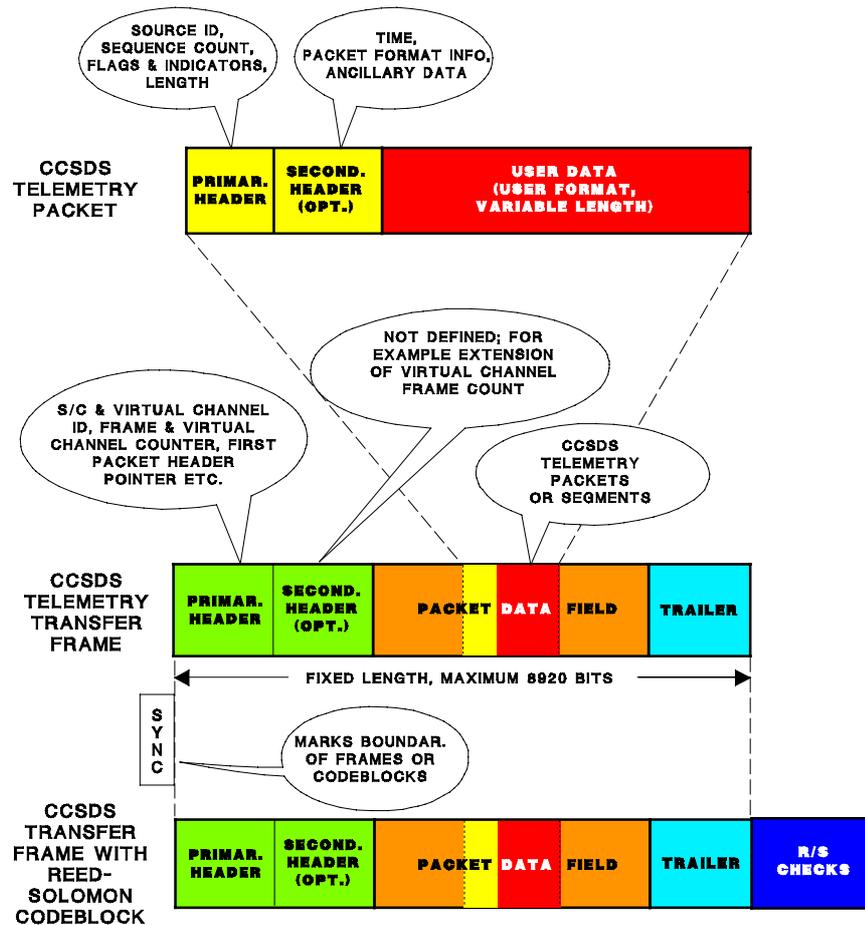
FIGURE 3: CORRELATION OF MAJOR CCSDS PRODUCTS WITH OSI LAYERS

### 1. CCSSDS RECOMMENDATIONS RELATED TO THE SPACE-GROUND-LINK SERVICES

**TELEMETRY:** In this category CCSDS approved its first two Recommendations which deal with "Telemetry Channel Coding" and "Packet Telemetry".

The **CCSDS Telemetry Channel Coding** document recommends a **small number of high performance error correcting codes** that are applicable to a large number of space missions. As we progress into modern data-driven processing, data compression, and automated, high volume ground data handling, errors in the data are simply unacceptable and cause many problems that can no longer be fixed "by hand". Powerful error correcting codes are now available which need only a small amount of overhead and which not only provide a dramatic improvement in output quality but also flag the user with a definitive indicator as to whether the errors have been corrected or whether they are so bad that the data cannot be corrected and should be eliminated (as opposed to a "best guess" error correction as used in the past). By standardising on these few well-engineered codes, project-unique encoding and decoding equipment is minimised and coding services become routine capabilities for inter-agency cross support.

The **CCSDS Packet Telemetry Recommendation**, addresses the **standardisation of the satellite down-link data**. The Packet Telemetry Recommendation uses two principal data structures, the Source Packet and the Transfer Frame. The technique provides the mechanism for multiple data sources to share a common communication channel. It requires each data source to label its data in a certain way to allow the data transport and level-zero data processing services to be accomplished without imposing any other requirements on the contained data. It does not dictate how the data contents should be arranged - this is still entirely up to the data source. In effect, the packet corresponds to the message being sent from the source, which, within certain constraints, may be any arbitrary length. The packet is inserted



**FIGURE 4: CCSDS CONVENTIONAL TELEMETRY DATA UNIT**

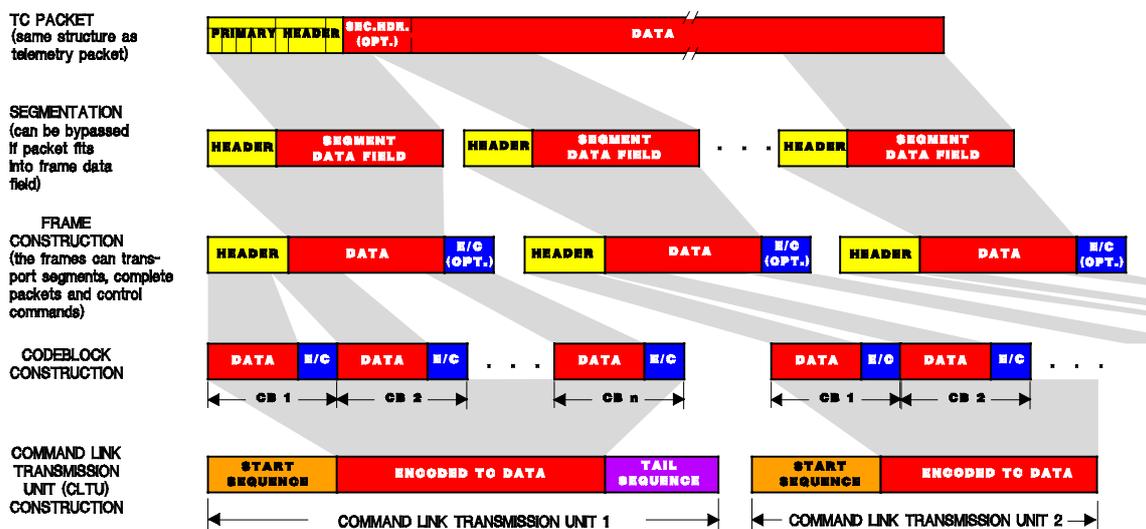
into fixed-length transfer frames which are optimised for high-performance transfer to the ground. The packets can subsequently be easily extracted using pointers in the transfer frame headers which locate the start of the next packet. The result of using this technique is that data transport and level-zero ground processing services become independent of message format and content and thus become standard services for missions which have adopted these standards.

Figure 3 shows the layered system used by CCSDS which follows the ISO principles on open system interconnection as far as possible in the light of the specific space-ground-link requirements. Figure 4 displays the principal elements of the Packet Telemetry data structures.

The layering of the data structure allows adoption of part of the Recommendation and the services associated with that layer in case adoption of the entire Recommendation and the entire suite of related services is not possible or not desired. This holds true in principle for all CCSDS Recommendations, i.e. also those addressed in the following paragraphs.



**TELECOMMAND:** The CCSDS released three Telecommand Recommendations which deal with "Channel Service" (telecommand code blocks), "Data Routing Service" (telecommand frames) and "Data Management Service" (telecommand packets). The first recommends synchronisation and coding techniques for correcting a small number of errors and improving the performance of somewhat noisy channels. The second deals with the accounting entities (telecommand frames) that may have to be re-transmitted by a specific "Command Operations Procedures" which is invoked in order to achieve complete and error free commanding when errors or outages are encountered; and the third deals with the aggregation and management of related command loads for various on-board applications. This layering generally parallels that of the Telemetry Recommendations, and similarly allows provision of standard services for each layer in which compatibility with the recommendation exists. Figure 5 shows the aforementioned data structures of the CCSDS Telecommand Recommendation.



**FIGURE 5: TELECOMMAND DATA STRUCTURES**

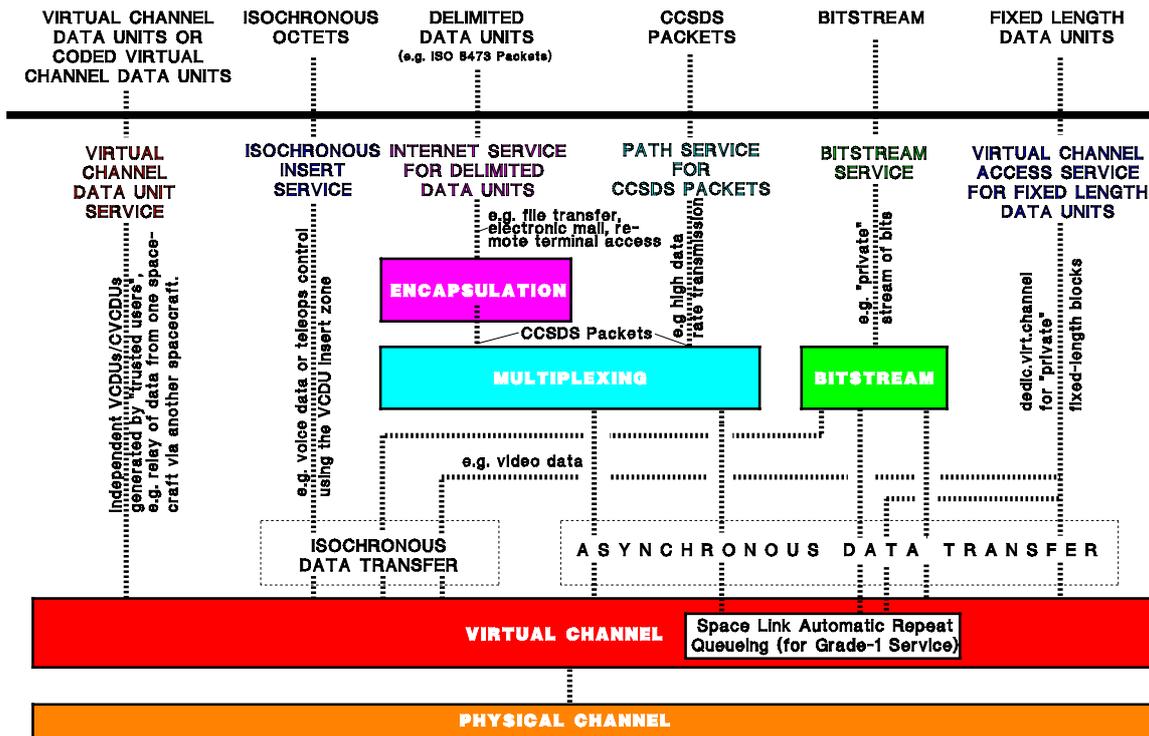
**SPACE LINK SUBNET FOR ADVANCED ORBITING SYSTEMS:** In view of new, important programmes of an international nature, such as those of the Space Station, CCSDS Recommendations also address **expanded telemetry and telecommand structures** for Advanced Orbiting Systems. The proposed solutions are using mostly the built-in flexibility of the recommendations for conventional satellites addressed above, i.e. they will not lead to a principal change but to their supplementation. Whereas the telemetry and telecommand system recommendations for these are applicable to free flying single science and application spacecraft with a small and static user community, centralised operations and moderate data rates the recommendations for advanced orbiting systems support complex constellations of spacecraft with a large and often changing user community, decentralised operations (i.e. need for a network) wide spread data rates (from Kb/s to hundreds of Mb/s) and communication through data relay satellites.

Figure 6 shows the 6 main services offered by the relevant recommendations.

- (1) The (coded or uncoded) Virtual Channel Data Unit Service allowing the "trusted user" to create his own virtual channel which may e.g. be used for the relay of data from one spacecraft via another spacecraft;
- (2) The Isochronous Insert Service supporting the isochronous transmission of data such as voice or tele-operations control data;



- (3) The Internet Service for Delimited Data Units which encapsulates these units forming CCSDS packets prior to multiplexing them with other CCSDS packets; this may be used e.g. for file transfer or electronic mail;
- (4) The Path Service for CCSDS Packets which multiplexes variable length CCSDS packets (together with the above mentioned encapsulated delimited data units) efficiently into fixed length virtual channel data units, e.g. for high data rate transmission along a particular path;
- (5) The Bitstream Service providing one dedicated virtual channel, e.g. for "private" stream of bits;
- (6) The Virtual Channel Access Service for Fixed Length Data Units providing one dedicated virtual channel for "private" fixed length blocks of data, e.g. video data.



**FIGURE 6: SPACE LINK SUBNET DATA FLOW FOR ADVANCED ORBITING SYSTEMS**

Two of these services can be used as end-to-end services, namely the Encapsulation and the Path Service. A bit-error-rate of  $10^{-5}$  is provided by the basic Quality of Service mode; for applications where error-free transmissions is essential or highly desirable, two enhanced Quality of Service modes are also defined to provide retransmission control and/or forward error correction of the data transmitted over the space-ground link.

**TIME-CODING:** In connection with the elaboration of the telemetry recommendations it became apparent that it is necessary to publish **recommendations on the coding of the time**, which is normally transmitted with the subsystem and payload information. It was found desirable to reduce the rather large number of different segmented time codes used in the past and to recommend only a small number of generally recognised computer-friendly codes. This was achieved by agreeing on the recommendation of two segmented binary codes, one segmented ASCII code, and one unsegmented binary code, which are described in the document "Time Code Formats".



**RF AND MODULATION:** There exists a great interest in **harmonising the characteristics of ground-space radio links** for space applications. They normally represent large investments. The CCSDS has therefore from the beginning of its existence studied this subject. As a first step an inventory of the CCSDS member agencies' relevant facilities were established and their detailed characteristics were described in the CCSDS document "CCSDS Radio Frequency and Modulation Report". Subsequently some 70 different recommendations have been agreed to and are contained in the blue book entitled "Radio Frequency and Modulation Systems, Part 1: Earth Stations and Spacecraft". Its contents are grouped into technical and policy recommendations. The technical recommendations cover (1) earth-to-space radio frequencies, (2) telecommand data modulation, (3) space-to-earth radio frequencies, (4) telemetry data modulation, (5) radio metric measurements (tracking) and (6) spacecraft characteristics related to RF and modulation. Policy recommendations are in accord with applicable regulations of other government bodies involved with spectrum management. It is planned to supplement this document as new recommendations are being worked out.

## 2. AUTOMATED INFORMATION INTERCHANGE

The growing complexity and the increasing decentralisation of information handling processes prompted the CCSDS to devote considerable effort to the harmonisation of information interchange between space agencies. "Information Interchange" refers not to the transport of data, but to the application-level packaging and the understanding of data or information, that is, data plus its description. A general information interchange scheme is depicted in Figure 7.

In this scheme, the users of the various types of data will in general be remote from the suppliers of data. Moreover, a given user may require all types of data (quick look data, data products as they are generated, archive data), i.e., these users are not necessarily mutually exclusive.

CCSDS has identified the requirements for interchanging information and has developed recommendations to meet these requirements. To facilitate automated information interchange a user must be able to perform the following 5 tasks:

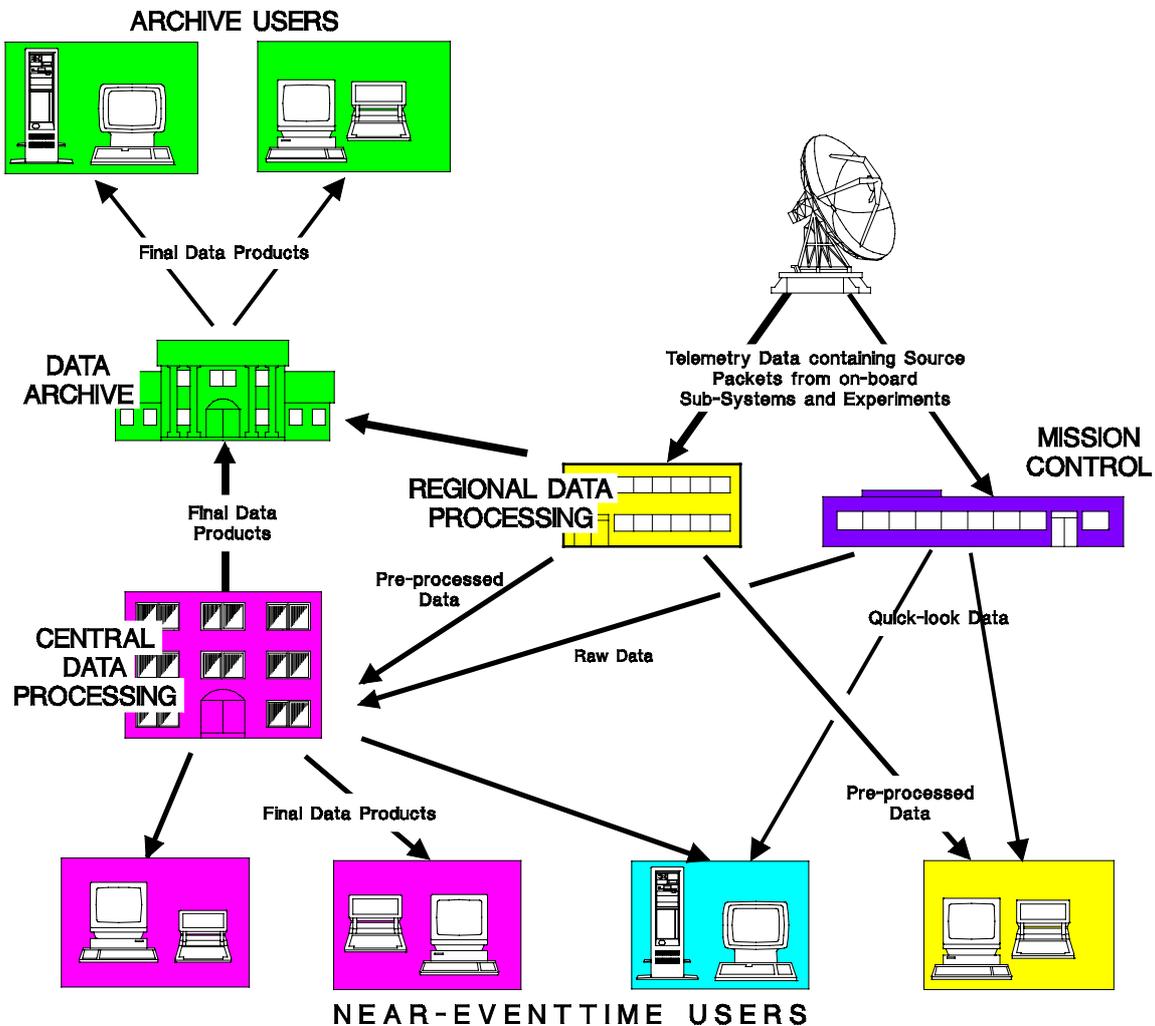
- (1) package data objects within data products, according to defined rules;
- (2) describe data objects via computer readable or processable data descriptions;
- (3) store and retrieve data descriptions;
- (4) parse data products to extract data objects;
- (5) interpret the contents of data objects down to the bit or byte level.

This information interchange must be supported within heterogeneous as well as homogeneous systems, where heterogeneous systems involve platforms and basic software from different manufacturers.

For a given space mission operations system, data formats are normally negotiated before launch and are, therefore, known and documented within the environment of that mission. However, in generic information interchange, the data being interchanged may be many years old or may involve different projects or disciplines. Thus it cannot be assumed that the user accessing the data is fully aware of the conventions, computer environment, etc. used in originally creating the data. Techniques therefore must exist to provide full description of the data at both the logical and physical levels, so that the data can be read and understood independently of the availability of the original system (hardware and software) on which it was created.

CCSDS has devised an approach to the problem of information interchange called the Standard Formatted Data Unit (SFDU) Concept. The SFDU is **not** a data format, but rather a comprehensive set of techniques for building data products, which include links to full descriptions of the data objects.

There are three major aspects of the SFDU, namely **Data Packaging**, **Data Description** and **Data Administration**. CCSDS Recommendations have been, or are being developed in each of these areas.



**FIGURE 7: GENERALISED SPACE DATA DISTRIBUTION ARCHITECTURE**

**DATA PACKAGING:** Two books have been produced in this area, namely **SFDU - Structure & Construction Rules**, containing the Recommendation, and a Tutorial to this book.

The Recommendation establishes rules for implementing standard data structures for data interchange. The basic SFDU building block is comprised of a LABEL field and a VALUE field, and is referred to as a Label-Value-Object (LVO). The LVO structure is shown schematically in Figure 8.

The LABEL field specification depends upon the value of a sub-field in the LABEL called the Version Identifier. The LABEL contains an identifier for the description of the format and the meaning of the data and a second identifier which gives a general indication of the type of data in the VALUE field. In



addition the LABEL provides information required to delimit the VALUE field.

The SFDU concept provides methods for (1) building hierarchical data products from LVOs and (2) referencing of objects (e.g. files) from within SFDU products. The latter technique can be used on random access media and also for incorporating data formatted using other standards.

A more complex SFDU product is shown in Figure 9. It demonstrates the way in which different types of labels permit the building of a hierarchical structure.

**DATA DESCRIPTION:** An essential feature of the SFDU concept is that it imposes the discipline of providing for each data object (i.e., LVO) a corresponding data description to permit complete understanding of the data in the value field of the LVO.

Data description falls into two main areas:

- (1) The description of the layout or formatting of the data (in essence the order, length and representation of data elements) - this is referred to as the **Syntax** of data.
- (2) The **Meaning (Semantics)** of the data.

Work on both of these aspects has been done, the former under the heading of the Data Description Languages, the latter under Data Entity Dictionaries.

**Data Description Languages** permit the writing of data descriptions. In the simplest case, the data description would be expressed in ASCII text. However, this is not computer processable and the CCSDS, with the aim of automated exchange and interpretation of data, has been examining computer-processable data description languages such as Parameter Value Language, Extended Abstract Syntax Notation One and Extended Ada Subset.

**Data Entity Dictionaries** are concerned with the naming and meaning of data entities: they thus focus on the **Semantics** of data.

Work is in progress on the definition of a structure for a standard Data Entity Dictionary. This concentrates on providing conventions and techniques for defining standard names, meanings and other attributes (such as ranges) of data items.

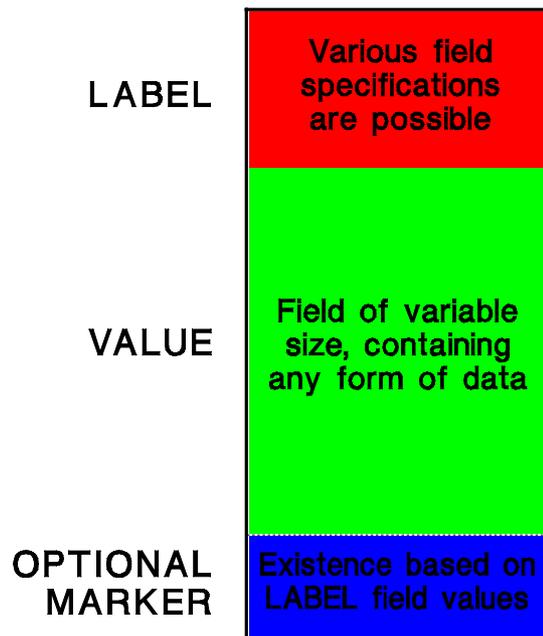


FIGURE 8: THE LABEL-VALUE-OBJECT STRUCTURE

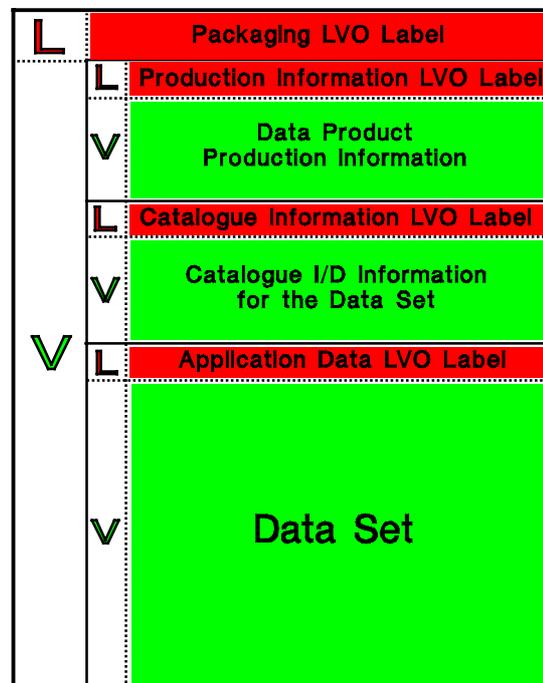
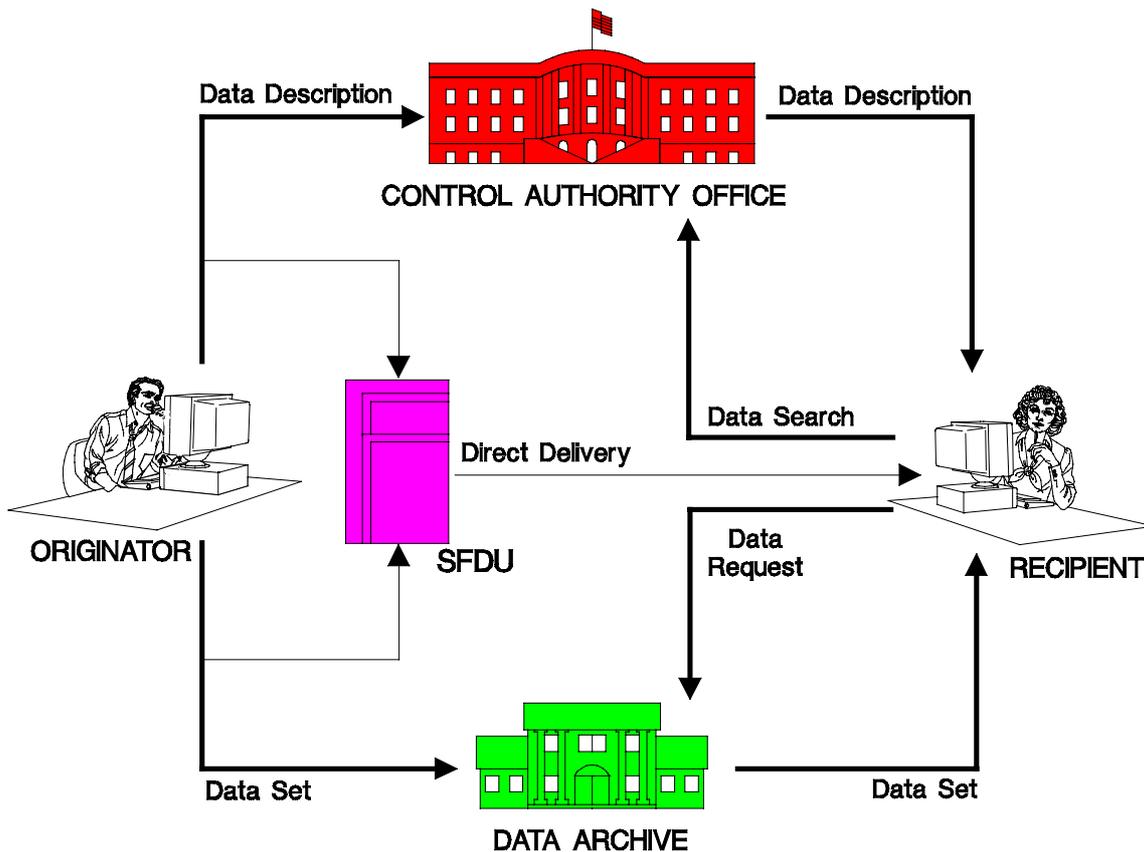


FIGURE 9: SCHEMATIC OF A MORE COMPLEX SFDU STRUCTURE

**DATA ADMINISTRATION:** While the SFDU concept requires that the data descriptions are provided for all data objects, it also provides for administrative services consisting of the registration and distribution of data descriptions. These administrative services are provided by the Control Authority Organisation. Figure 10 shows how the originator of the data can either supply the data directly to a recipient in an SFDU structure that includes the data description, or separately register the description with a Control Authority Office. In the latter case the recipient can request the data description from the Control Authority Office, irrespective of whether he is receiving the data directly from the data producer, or requests it at a much later date from a separate archive.



**FIGURE 10: DATA TRANSFER USING THE SFDU CONCEPT**

The fundamental **Control Authority Recommendation**, together with its Tutorial, is currently in the final stages of preparation. This Recommendation will establish the responsibilities of the CCSDS Control Authority organisation, which comprises the Control Authority Agent acting for the CCSDS Secretariat, and participating Agency Control Authority Offices reporting to it. This Recommendation also describes all the procedures to be followed within the Control Authority Organisation and by the user community to register/access data descriptions.

A Recommendation is also in preparation describing standard forms or templates for Control Authority Data Structures. These data structures contain the information needed to register, revise and request data descriptions from Member Agency Control Authority Offices. These data structures comprise the Registration Package, the Revision Registration Package and Data Description Package. These templates are in SFDU form and so may be used for automation of the Control Authority Procedures. Work on the standardisation of protocols and media for communication within the Control Authority organisation is also foreseen.



### 3. CCSDS RECOMMENDATIONS RELATED TO RADIO METRIC AND ORBIT DATA

Spacecraft trajectory determination, from processing tracking data acquired at ground stations, has in the past often been the subject of interagency cross support. Therefore, soon after its founding the CCSDS formed a Panel which completed a recommendation in 1986, covering the most important subjects in this area.

The Radiometric and Orbit Determination Recommendation has been partitioned into the areas **(1) transfer of spacecraft orbital elements from one agency to another, (2) the preferred reference system and (3) the semantics used for the transfer of tracking data.**

In the field of orbital data the main recommendations are (1) to use osculating rather than mean elements, (2) use the cartesian state elements as the fundamental coordinates, (3) express range in km, velocity in km/s, and area to mass ratio in sqm/kg, (4) use Coordinated Universal Time (UTC) as time reference. The preferred reference system is the inertial system recommended by the International Astronomical Union, the so-called J2000-system.

For the coordinated and controlled exchange of tracking data the contents for an Interface Control Document (ICD) are recommended. The ICD should be jointly produced by the Agencies participating in cross-support. The recommendation includes further guidance on the contents and the semantics to be used for the transfer of ranging and doppler data and all ancillary data required for their application.

It can be assumed that the application of the CCSDS recommendations will greatly facilitate all trajectory related interagency cross-support activities.

### 4. APPLICATION OF CCSDS SERVICES

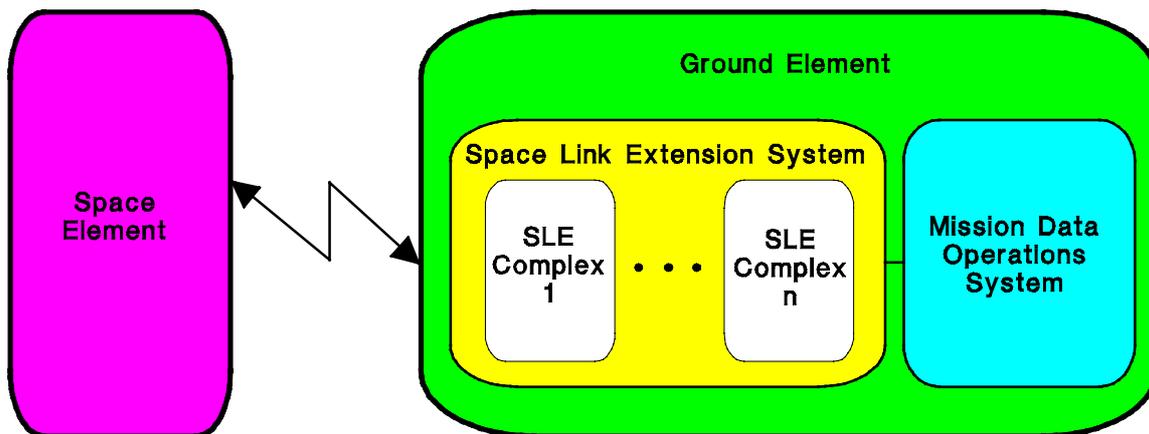
Soon after the publication of the first CCSDS recommendations, technical and practical aspects of inter-Agency cross support were discussed. It was recognized that in order to enable practical cross-support between two agencies for a particular mission a more general mechanism was needed to allow the interconnection of these agencies' infrastructure in a completely defined manner.

Based on the analysis of different cross support scenarios the notion of **CCSDS Cross Support Services** was introduced. Cross Support Services is a generic term that encompasses all services that can be provided by one Agency to support another Agency in operating a spacecraft. There are three types of Cross Support Services:

- (1) **Space Link Extension Services:** defined to extend CCSDS Space Link Services as defined in the Space-Ground Link Recommendations (see Section II.B.1 of this Brochure);
- (2) **Ground Communications Services:** to provide ground communications support, e.g. to relay operational data;
- (3) **Ground Domain Services:** to cover all services that handle data related to spacecraft operations but not directly mappable to space link data, e.g. tracking a spacecraft, exchanging spacecraft databases, mission planning.

The cross support documentation is divided according to these kind of services. And CCSDS is currently working on the first item, Space Link Extension (SLE) services. CCSDS is developing a Reference Model for these SLE Services largely based on ISO/ITU concepts and terminology, together with an introductory Green Book on the subject. Further plans include the production of an SLE Management Service Specification and of a set of SLE Transfer Service Specifications for forward (i.e. telecommand) and return (i.e. telemetry) data transfer.

A Space Mission Data System, i.e. the set of on-board and ground data systems that support a mission,



**FIGURE 11: SPACE MISSION DATA SYSTEM**

is described in the SLE Reference Model in terms of a space element and a ground element, which exchange forward and return data over a space link, as illustrated in Figure 11. The ground element comprises an SLE System, which extends the transfer and delivery of forward and return data between the space link termination point on the ground and the Mission Data Operations System (MDOS), which acts as a source of forward data and as a sink of return data. In the context of a mission, the SLE System is managed by the MDOS. The SLE System provides to the MDOS SLE Services, which comprise:

- (1) SLE Transfer Services, which transfer SLE data units from/to the space element to/from the MDOS,
- (2) SLE Management Service, which controls the scheduling and provision of instances of SLE Transfer Services by the SLE System.

From a management point of view, the SLE System is composed of several SLE Complexes as shown in Figure 11. The SLE Complex represents a single management authority, under which part of the SLE System functionality is provided. SLE Complexes are equivalent to Agencies, or to autonomous administrative authorities within an Agency. A Cross Support Contract starts with the negotiation between an SLE Complex and an MDOS of the SLE Services (including potential) options to be provided. Once this is agreed, the SLE Complex and the MDOS agree on the scheduled provision of a group of SLE Transfer Service instances for a specific pass. After the pass usually a debriefing takes place. The SLE Management Service Specification describes the interactions between an SLE Complex and an MDOS at the various stages of a cross support activity. The SLE Transfer Service Specification describes the interactions between the SLE Complex and the MDOS events during a pass in case of real time services, or after/before a pass in case of off-line return/forward services.

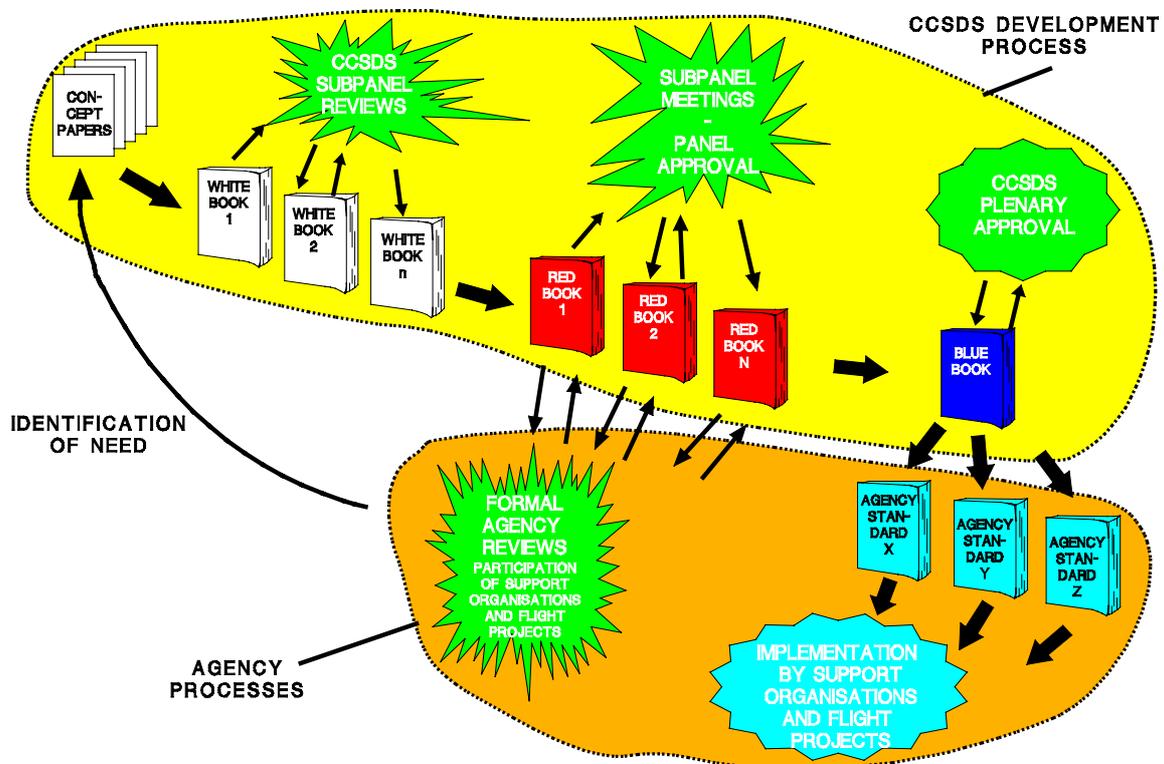
The current plan of CCSDS includes the finalization and approval of the first portion of SLE Services eventually contained in the CCSDS Cross Support Reference Model Recommendation, which will provide the framework for producing the CCSDS Recommendations on SLE Service Specifications. The next steps will consist of the production of these SLE Service Specifications, and of the extension of the Reference Model to cover the Ground Communications Services and later the Ground Domain Services.

## III. CCSDS PANEL PRODUCTS

The results of CCSDS activities are contained in so-called Blue and Green Books. The Blue Books contain the CCSDS recommendations and the Green Books represent technical reports which provide supplementary or supporting information relevant to the CCSDS activities.

The Blue Books are committed to the principle of long term technical stability. They are published after a process of technical discussion and review in the CCSDS Panels and by CCSDS member and observer agencies. During this process intermediate issues of the books are published. These are the so-called White and Red Books.

Figure 12 shows the procedures for the production of these books.



**FIGURE 12: CCSDS DOCUMENT PRODUCTION PROCEDURE AND ITS RELATION TO AGENCY PROCEDURES**

The following sections contain for the CCSDS Secretariat and each CCSDS Panel a list of the currently existing CCSDS procedural and technical documents (Green, Red and Blue Books) produced by the Secretariat or this Panel along with a brief description of their contents.



## A. SECRETARIAT

The CCSDS Secretariat publishes documents of procedural nature.

|           |  |         |                 |
|-----------|--|---------|-----------------|
| Blue Book | CCSDS Global Spacecraft Identification Field: Code Assignment Control Procedures | Oct. 93 | CCSDS 320.0-B-1 |
|-----------|--|---------|-----------------|

This book establishes control procedures for spacecraft identification codes. As such, it defines the procedure governing assignment, use, relinquishment, and management of spacecraft identifications.

## B. PANEL 1

This panel covers the CCSDS activities in the fields of space-ground-link telemetry, command and RF & Modulation. As a result of the work of this panel the CCSDS has published a number of Blue and Green Books in all three fields of its terms of reference as follows:

|            |  |         |                 |
|------------|--|---------|-----------------|
| Green Book | Telemetry - Summary of Concept and Rationale | Dec. 87 | CCSDS 100.0-G-1 |
|------------|--|---------|-----------------|

This book provides the overall concept and rationale for Packet Telemetry and Telemetry Channel Coding.

|           |                          |        |                 |
|-----------|--------------------------|--------|-----------------|
| Blue Book | Telemetry Channel Coding | May 92 | CCSDS 101.0-B-3 |
|-----------|--------------------------|--------|-----------------|

This book contains the recommendations which should be applied when using convolutional coding and Reed-Solomon coding on the CCSDS telemetry transfer frame. It also specifies synchronisation markers and randomisation techniques.

|           |                  |        |                 |
|-----------|------------------|--------|-----------------|
| Blue Book | Packet Telemetry | Nov 92 | CCSDS 102.0-B-3 |
|-----------|------------------|--------|-----------------|

This book contains the recommendations for the data structures of the "Conventional" Telemetry (Source Packet, Transfer Frame).

|            |   |         |                 |
|------------|---|---------|-----------------|
| Green Book | Telecommand - Summary of Concept & Services | Jan. 87 | CCSDS 200.0-G-6 |
|------------|---|---------|-----------------|

This book provides the overall concept for the telecommand recommendation describing in particular (1) the services provided on the different ground-space communication layers and (2) the command link operation procedures.

|           |                                       |         |                 |
|-----------|---------------------------------------|---------|-----------------|
| Blue Book | Telecommand - Part 1: Channel Service | Jan. 87 | CCSDS 201.0-B-1 |
|-----------|---------------------------------------|---------|-----------------|

This book contains the recommendation on the system architecture of the spacecraft telecommand channel service. It addresses primarily the data unit formats and functions which are implemented within the coding and the physical layer.

|           |  |         |                 |
|-----------|--|---------|-----------------|
| Blue Book | Telecommand - Part 2: Data Routing Service | Nov. 92 | CCSDS 202.0-B-2 |
|-----------|--|---------|-----------------|

This book contains the recommendations concerning procedures and data unit formats which are implemented within the segmentation and the transfer layer.

|           |  |         |                 |
|-----------|--|---------|-----------------|
| Blue Book | Telecommand - Part 2.1: Command Operation Procedures | Oct. 91 | CCSDS 202.1-B-1 |
|-----------|--|---------|-----------------|

This book describes the command operation procedures at the transfer layer and in particular provides the state matrices characterising the conditions of the command transmission service in the various operational states and describing how to recover from transmission errors.



## ACHIEVEMENTS AND PRODUCTS

|            |  |                        |                    |
|------------|--|------------------------|--------------------|
| Blue Book  | <b>Telecommand - Part 3: Data Management Service</b>   | Jan. 87                | CCSDS<br>203.0-B-1 |
|            | <p>This book contains the recommendation which defines the system architecture of the CCSDS telecommand data management service including telecommand packets and files.</p>   |                        |                    |
| Blue Book  | <b>Time Code Formats</b>   | Apr. 90                | CCSDS<br>301.0-B-2 |
|            | <p>This book contains recommendations for 4 different time code formats, one unsegmented and 3 segmented time codes.</p>   |                        |                    |
| Blue Book  | <b>RF &amp; Modulation Systems - Part 1: Earth Stations and Spacecraft</b>   | current <sup>(1)</sup> | CCSDS<br>401.0-B   |
|            | <p>At the time of publishing this brochure the Blue Book contained 81 Recommendations broken down in 3 areas, namely</p> <ol style="list-style-type: none"><li>(1) Technical Recommendations (earth-to-space RF, telecommand, space-to-earth RF, telemetry, radio metric, spacecraft),</li><li>(2) Policy Recommendations (frequency utilisation, power limitations, modulation methods, operational procedures, testing, spacecraft systems),</li><li>(3) Design Tools (selection of optimum modulation indices, telecommunication link design, standard terminology for telecommunications link performance calculations).</li></ol> <p>The recommendations are intended to promote an orderly transition to RF &amp; modulation systems which are internationally compatible.</p> |                        |                    |
| Green Book | <b>Report comparing Radio Frequency and Modulation Systems, Part 1: Earth Stations</b>   | June 90                | CCSDS<br>411.0-G-2 |
|            | <p>This report summarises the characteristics and capabilities of CCSDS Agencies' Earth Stations. It has been designed to</p> <ol style="list-style-type: none"><li>(1) serve as a reference work for persons seeking information about earth stations operated by CCSDS agencies and</li><li>(2) facilitate cross-support of one agency's spacecraft by another agency's earth stations by providing spacecraft designers with CCSDS Agencies' earth station locations and nominal operating parameters.</li></ol> <p>The capabilities enumerated in the report are those that the agencies state are either in place or will be constructed within the next two years after publication. The information is expected to be valid for the period 1990 - 1995.</p>                   |                        |                    |
| Green Book | <b>Radio Frequency and Modulation: Compatibility Test Procedures</b>   | May 92                 | CCSDS<br>412.0-G-1 |
|            | <p>This book contains the description of a minimum set of spacecraft-earth station tests required to ensure compatibility for cross support. The recommended tests are divided into five test groups, namely spacecraft radio frequency tests, telemetry tests, telecommand tests, ranging tests and earth station antenna tracking system tests.</p>  |                        |                    |
| Green Book | <b>Advanced Orbiting Systems, Networks and Data Links - Summary of Concept, Rationale and Performance</b>  | Nov.92                 | CCSDS<br>700.0-G-3 |
|            | <p>This book contains a summary of the key operational concepts, rationale and supporting information which underlie the requirements for the CCSDS principal network specified in the recommendation for advanced orbiting systems. At the time of publishing this brochure a new issue was under preparation planned to be released at the beginning of 1993.</p>  |                        |                    |

<sup>(1)</sup> This Blue Book is being supplemented as new Recommendations are becoming available; thus the book is produced as a loose leaf document.



## ACHIEVEMENTS AND PRODUCTS

|            |   |         |                    |
|------------|---|---------|--------------------|
| Blue Book  | <b>Advanced Orbiting Systems - Network and Data Links - Architectural Specification</b>   | Nov. 92 | CCSDS<br>701.0-B-2 |
|            | <p>This book provides the recommendation for the architecture of the space-ground and space-space data handling systems which are embedded within complex networks. It covers (1) a system level overview, (2) the path service and protocol specification, (3) the internet service and protocol specification, (4) the space link subnet service and protocol specification, (5) the space link Automatic Repeat Queuing (ARQ) service and protocol specification and (6) a description of the cross support options.</p> |         |                    |
| Green Book | <b>Advanced Orbiting Systems, Networks and Data Links: Audio, Video and Still Image Communication Services</b>  | May 94  | CCSDS<br>704.1-G-3 |
|            | <p>This book provides guidelines for the implementation of agency specific and CCSDS-standardised audio, video and still-image services on the base of the Advanced Orbiting System.</p>  |         |                    |
| Blue Book  | <b>Advanced Orbiting Systems, Networks and Data Links: Audio, Video and Still Image Communication Services</b>  | May 94  | CCSDS<br>704.0-B-1 |
|            | <p>This book defines a set of standardised CCSDS audio, video and still-image services for Advanced Orbiting Systems primarily used for cross support between agencies.</p>   |         |                    |
| Green Book | <b>Advanced Orbiting Systems, Networks and Data Links: Formal Definition of CPN Protocols, Methodology and Approach</b>   | May 94  | CCSDS<br>705.0-G-2 |
|            | <p>This book provides an introduction into the tools and methods used to describe the CCSDS Principle Network Protocols by the formal Language LOTOS (as standardised by ISO). It gives explanations how to use these descriptions to verify the consistency of protocol definitions and to test the compatibility between different protocol implementations.</p>  |         |                    |
| Red Book   | <b>Formal Definition of CCSDS Principal Network Protocol</b>  | Nov.92  | CCSDS<br>705.0-R-1 |
|            | <p>This book contains the LOTOS specification of the CCSDS Principle Network Protocol</p>   |         |                    |
| Blue Book  | <b>Advanced Orbiting Systems, Networks and Data Links: Abstract Data Type Library</b>   | Dec.93  | CCSDS<br>705.1-B-1 |
|            | <p>This book contains a library of Abstract Data Types used by the other books which provide formal LOTOS-based descriptions of AOS subjects.</p>   |         |                    |
| Blue Book  | <b>Advanced Orbiting Systems, Networks and Data Links: Formal Specification of the Path Service and Protocol</b>  | Dec.93  | CCSDS<br>705.2-B-1 |
|            | <p>This book contains the LOTOS specification of the CCSDS Path layer protocol and service.</p>   |         |                    |
| Blue Book  | <b>Advanced Orbiting Systems, Networks and Data Links: Formal Specification of VCLC Service and Protocol</b>  | Dec.93  | CCSDS<br>705.3-B-1 |
|            | <p>This book contains the LOTOS specification of the CCSDS Virtual Channel Link Control sublayer protocol and service.</p>  |         |                    |



## ACHIEVEMENTS AND PRODUCTS

|           |  |        |                    |
|-----------|--|--------|--------------------|
| Blue Book | Advanced Orbiting Systems, Networks and Data Links: Formal Specification of VCA Service and Protocol | Dec.93 | CCSDS<br>705.4-B-1 |
|-----------|--|--------|--------------------|

This book contains the LOTOS specification of the CCSDS Virtual Channel Access sublayer protocol and service.

### C. PANEL 2

This Panel is developing recommendations for the interchange of data which have different structures. For this purpose the Standard Formatted Data Units have been created. The following documents contain the results of these activities.

|            |   |         |                    |
|------------|---|---------|--------------------|
| Green Book | Standard Formatted Data Units - System and Implementation Aspects | Feb. 87 | CCSDS<br>610.0-G-5 |
|------------|---|---------|--------------------|

This book provides the concept for exchanging differently structured data between remote users on different media using different types of communication. It contains the definition of the structure of the system and the functional characteristics of its important elements. The basic idea is to enable the exchange of data which may be arbitrarily structured in a well defined way by providing a formalised description of the structure to the receiver of the data. The descriptions are administered by a control authority.

|           |  |        |                    |
|-----------|--|--------|--------------------|
| Blue Book | Standard Formatted Data Units - Structure and Construction Rules | May 92 | CCSDS<br>620.0-B-2 |
|-----------|--|--------|--------------------|

This book provides the description of the SFDU as the basic vehicle of data transport; it defines the headers containing type and length of data and the value fields. These type-length-value-objects can be aggregated in that a value field contains a number of lower level type-length-value-objects. This provides a flexible tool for data transport.

|            |  |        |                    |
|------------|--|--------|--------------------|
| Green Book | Standard Formatted Data Units - A Tutorial | May 92 | CCSDS<br>621.0-G-1 |
|------------|--|--------|--------------------|

This book replaces the Green Book with the reference 620.0-G-1. It explains the rationale of the SFDU concept and outlines the structure and construction rules with the help of examples.

|           |  |         |                    |
|-----------|--|---------|--------------------|
| Blue Book | Standard Formatted Data Units - Control Authority Procedures | June 93 | CCSDS<br>630.0-B-1 |
|-----------|--|---------|--------------------|

This book describes the administration of the data description records and the control authority procedures.

|            |   |         |                    |
|------------|---|---------|--------------------|
| Green Book | Standard Formatted Data Units - Control Authority Procedures Tutorial | June 93 | CCSDS<br>631.0-G-1 |
|------------|---|---------|--------------------|

This book provides application information on the Control Authority Procedures

|          |   |         |                    |
|----------|---|---------|--------------------|
| Red Book | Standard Formatted Data Units - Control Authority Data Structures | Dec. 93 | CCSDS<br>632.0-R-1 |
|----------|---|---------|--------------------|

This book defines standard data description languages and standard data structures to permit the writing and packaging of data descriptions.

|            |                                       |        |                    |
|------------|---------------------------------------|--------|--------------------|
| Green Book | Parameter Value Language - A Tutorial | May 92 | CCSDS<br>641.0-G-1 |
|------------|---------------------------------------|--------|--------------------|

This book provides a description of how and why one would use the Parameter Value Language to interchange information. It renders the rationale for the development of the language, its intended usage, its format and construction rules as well as suggested practices and cautions.



## ACHIEVEMENTS AND PRODUCTS

|            |   |         |                    |
|------------|---|---------|--------------------|
| Blue Book  | Parameter Value Language Specification  | May 92  | CCSDS<br>641.0-B-1 |
|            | <p>This book establishes a Recommendation for the specification of a standard keyword/value type language for the purpose of interchanging data within or among agencies. It provides an overview of the Parameter Value Language (PVL) and defines a formal syntax for this language.</p>              |         |                    |
| Green Book | Language Usage in Information Interchange Tutorial  | Oct. 89 | CCSDS<br>642.1-G-1 |
|            | <p>This book provides background information for users as they choose a language for use in the Data Description Record of an SFDU.</p>   |         |                    |
| Blue Book  | ASCII-Encoded English   | Nov. 92 | CCSDS<br>643.0-B-1 |
|            | <p>This book establishes a Recommendation that defines a natural language and its digital representation to be used to describe any data within the SFDU environment, in cases where a machine interpretable language is unavailable or for information which is best supplied in natural language.</p> |         |                    |

### D. PANEL 3

This Panel has been charged with the application of CCSDS recommended services in the widest sense (see Section II.B.4). This leads to the consideration of CCSDS Cross Support Services. Plans worked out during the last two years focus - for the time being - the panel's activities on the area of agency interconnections. In earlier years the panel has produced a number of books which address the issues of cross support in more general terms. These books are listed in the following text.

|            |  |         |                      |
|------------|--|---------|----------------------|
| Green Book | Existing Network Description   | June 88 | CCSDS<br>810.0-G-0   |
|            | <p>This book contains a high level description of current space data communication networks employed by the participating agencies. Each description is organised to provide an overview of the network configuration and facilities, the services provided, the near-term and mid-term upgrades, and the long term plans.</p>   |         |                      |
| Green Book | Ground Network Overview of System Architecture and Concept   | Sep.90  | CCSDS<br>820.0-G-3   |
|            | <p>This book defines a ground communication architecture and a high level set of CCSDS ground communication service requirements for cross support. These services support both conventional and advanced orbiting space missions. The service requirements are stated in terms of the functions needed to cross support CCSDS application services.</p>   |         |                      |
| Green Book | CCSDS System Description - Volume 1: Cross Support Concept and System Scenarios  | Apr. 90 | CCSDS<br>900.0-G-1.0 |
|            | <p>This book provides an introduction to the CCSDS cross support concept. It presents a generic space data system model for single and multiple agencies, and provides a broad range of scenarios for conventional missions and advanced orbiting systems including post mission information interchange. It serves as a high level user's guide to CCSDS cross support.</p>   |         |                      |
| Green Book | CCSDS Service Overview   | Aug. 89 | CCSDS<br>910.0-G-0   |
|            | <p>This book contains an overall description of the services and their operational requirements as derived from the cross support scenarios. It represents the basis for a blue book which will contain very precise descriptions of the CCSDS services in a formal language. This blue book will become an indispensable tool for the definition of access points for the use of CCSDS services in cross support scenarios.</p> |         |                      |



### E. PANEL 4

This Panel had been requested to provide recommendations the application of which would lead to a drastic simplification of data exchange related to orbital computation. The recommendation was completed in 1986. The Panel is presently in an inactive status.

Blue Book      Radio Metric and Orbit Data

Jan. 87      CCSDS  
501.0-B-1

The book contains the recommendations for establishing a common system for the exchange of data related to orbit computations. The topics addressed are radio metric data, spacecraft orbital elements, solar system ephemerides, tracking station locations, astrometric data, reference systems, astrodynamics constants and spacecraft dynamics parameters.



## **IV. APPLICATION OF CCSDS RECOMMENDATIONS BY SPACE DATA STANDARDS, PROJECTS, ISO AND OTHER INTERNATIONAL BODIES**

### **A. SPACE DATA STANDARDS**

The CCSDS Recommendations contained in the Blue Books represent the consensus of the CCSDS Member Agencies. The endorsement is entirely voluntary. It indicates, however, the understanding that whenever an Agency establishes a CCSDS-related standard, this standard will be in accord with the relevant Recommendation.

The CCSDS Member and Observer Agencies are in the process of adjusting their agency standards to the CCSDS Recommendations. The following table provides an overview of these standards which are either fully or partially derived from CCSDS Recommendations. Other CCSDS Member and Observer Agencies are expected to adopt these standards in due course.

| <b>STANDARDS ISSUED</b>  | <b>STANDARDS UNDER PREPARATION</b>  |
|--|---|
| <b>E S A</b>   |   |
| <ul style="list-style-type: none"> <li>- Packet Telemetry Standard, January 1988, (ESA PSS 04-106);</li> <li>- RF and Modulation Standard, March 1989 (ESA PSS 04-105);</li> <li>- Packet Telecommand Standard, April 1992, (ESA PSS-04-107, Issue 2);</li> <li>- Telemetry Channel Coding Standard, September 1989, (ESA PSS-04-103);</li> <li>- Packet Utilisation Standard, July 1994, (ESA PSS-07-101).</li> </ul>   | <ul style="list-style-type: none"> <li>- Time Code Formats and Procedures Standard, expected 1995, (ESA PSS-04-202);</li> <li>- Advanced Orbiting Systems, Networks and Data Links, expected 1995, (ESA PSS-04-108).</li> </ul> |
| <b>N A S A / G S F C</b>   |   |
| <ul style="list-style-type: none"> <li>- Inner Convolutional and Block Error Control Coding, date tbd., ADS 7.1</li> <li>- Packetized Telecommand, date tbd., ADS 4.6</li> <li>- more tbd.</li> </ul>  | <ul style="list-style-type: none"> <li>- Packet Telemetry, date tbd., ADS 3.3</li> </ul>  |
| <b>N A S A / J P L</b>   |   |
| <ul style="list-style-type: none"> <li>- Standard for Telemetry Channel Coding, July 1985, (D-1315:TLM-1);</li> <li>- Standard for Time Code Formats, July 1986, (TIM-1);</li> <li>- Standard for Radio Metric &amp; Orbit Data, July 1986, (ROD-1);</li> <li>- Standard for Command Channel Service, August 1989, (CMD-1);</li> <li>- Standard for Telecommand (Part 2) Data Routing Service, January 1993 (D-1350; CMD-2);</li> <li>- Standard for Telecommand (Part 2.1) Command Operations Procedure, October 1992 (D-1350; CMD-2.1);</li> <li>- Standard for Telecommand (Part 3) Data Management Service, October 1992 (D-1350; CMD-3).</li> </ul> | <p>JPL is developing a policy of adopting CCSDS Recommendations directly as JPL Standards wherever possible, and retiring separate JPL Standards. Slight differences, if any, may be noted in the JPL Standards List.</p>       |

The NASA Office of Space Communications (OSC) has baselined the CCSDS Advanced Orbiting Systems Recommendations for future earth orbiting satellites requiring the support of this office.



## B. PROJECTS

The prime purpose of the CCSDS activities is to provide harmonisation of space data systems for projects in which the systems of several agencies are included. It can be expected that the agencies will take these Recommendations into account for these projects because of the cost, schedule and risk savings in using existing capabilities and designs. This will, no doubt, lead eventually to the adoption of the CCSDS Recommendations by most other projects as well.

The tables and text in the following two sections list the projects and facilities for which it has been decided to follow the CCSDS Recommendations, either on the basis of the agency standards quoted above or through direct application of the respective Recommendation. The dots indicate compatibility with CCSDS Recommendations; a blank means either no compatibility or a decision has not been taken yet.

### 1. Recommendations concerning the Space-Ground Link

| PROJECT                     | TELEMETRY |       |        |      | TELECOMMAND |       |        |
|-----------------------------|-----------|-------|--------|------|-------------|-------|--------|
|                             | Code      | Frame | Packet | Time | Code        | Frame | Packet |
| <b>E S A</b>                |           |       |        |      |             |       |        |
| EURECA                      | •         | •     | •      | •    |             |       |        |
| SOHO                        | •         | •     | •      | •    |             |       |        |
| CLUSTER                     | •         | •     |        |      |             |       |        |
| DRS                         | •         | •     | •      | •    | •           | •     | •      |
| ENVISAT                     | •         | •     | •      | •    |             |       |        |
| METEOSAT Second Generation  | •         | •     | •      | •    | •           | •     | •      |
| COLUMBUS ORBITAL FACILITY   | •         | •     | •      | •    | •           | •     | •      |
| <b>I S A S</b>              |           |       |        |      |             |       |        |
| MUSES-A                     | •         | •     | •      |      |             |       |        |
| LUNAR-A                     | •         | •     |        |      |             |       |        |
| PLANET-B                    | •         | •     |        |      |             |       |        |
| <b>N A S A</b>              |           |       |        |      |             |       |        |
| INTERNATIONAL SPACE STATION | •         | •     | •      |      | •           | •     | •      |
| COMPTON                     | •         |       | •      |      | •           |       |        |
| EUVE                        |           |       | •      |      | •           |       |        |
| SAMPEX                      | •         | •     | •      | •    | •           | •     | •      |
| FAST                        | •         | •     | •      | •    | •           | •     | •      |
| SWAS                        |           | •     | •      | •    | •           | •     | •      |
| XTE                         | •         | •     | •      | •    | •           | •     | •      |



## ACHIEVEMENTS AND PRODUCTS

| PROJECT        | TELEMETRY |       |        |      | TELECOMMAND |       |        |
|----------------|-----------|-------|--------|------|-------------|-------|--------|
|                | Code      | Frame | Packet | Time | Code        | Frame | Packet |
| TRMM           | •         | •     | •      | •    | •           | •     | •      |
| ACE            | •         | •     |        |      | •           |       |        |
| SMEX-4, -5, -6 |           | •     | •      | •    | •           | •     | •      |
| EOS            | •         | •     | •      | •    | •           | •     | •      |
| MARS OBSERVER  | •         | •     | •      | •    | •           |       |        |
| CASSINI        | •         | •     | •      | •    | •           | •     | •      |

The ESA Director General has decided that for future ESA projects CCSDS derived standards will be mandatory. All ESA standards and the pertinent space data infrastructure is in the process of being supplemented accordingly.

Wherever applicable ESA's and NASA's Flight Dynamics Systems are using the CCSDS Recommendation on Radiometric and Orbit Data.

In addition, all these missions follow the CCSDS Recommendations for RF & Modulation as far as applicable.

The other European space agencies which are members of the CCSDS, i.e. BNSC, CNES and DLR, have in the past adopted most ESA standards. It can be expected, therefore, that the projects of these agencies will eventually follow most CCSDS Recommendations.

Currently INPE is considering the gradual inclusion of CCSDS Recommendations in the ongoing development of two different systems:

- the Data Collection and Dissemination Network System (RECODI System)
- the Data Network System for Space Control (REDACE System).

The Indian Space Research Organisation will be using the CCSDS Recommendation on Packet Telemetry for its SROSS satellite project.

### 2. Recommendations concerning Automated Information Interchange

| PROJECT                                 | DATA PACKAGING (SF DU) | DATA DESCRIPTION |     | DATA ADMINISTRATION (Control Authority Procedures) |
|---|------------------------|------------------|-----|--|
|   |                        | ASCII English    | PVL |  |
| <b>B N S C</b>                          |                        |                  |     |  |
| CLUSTER Data Handling Facility          | •                      | •                | •   |  |
| Solar Terrestrial Physics Data Facility | •                      | •                | •   |  |
| Earth Observation Ground Truth          | •                      | •                |     |  |



## ACHIEVEMENTS AND PRODUCTS

| PROJECT  | DATA PACKAGING (SFDU) | DATA DESCRIPTION |     | DATA ADMINISTRATION (Control Authority Procedures) |
|--|-----------------------|------------------|-----|--|
|  |                       | ASCII English    | PVL |  |
| <b>C N E S</b>   |                       |                  |     |  |
| Science Data Management Services (Archival/Distribution) | •                     |                  |     | •  |
| CST Control Authority                                    | •                     | •                |     | •  |
| MARS94   | •                     | •                |     | •  |
| Swedish Viking Archive                                   | •                     |                  |     | •  |
| ISEE 1/2 Archive   | •                     |                  |     | •  |
| PHOBOS Archive   | •                     |                  |     | •  |
| <b>E S A</b>   |                       |                  |     |  |
| EURECA   | •                     |                  |     |  |
| CLUSTER  | •                     | •                | •   | •  |
| HUYGENS  | •                     | •                | •   | •  |
| <b>N A S A</b>   |                       |                  |     |  |
| Data Distribution Facility                               | •                     | •                | •   | •  |
| National Space Science Data Centre                       | •                     | •                | •   | •  |
| Advanced Multi-Mission Operations System                 | •                     |                  | •   |  |
| JPL - Planetary Data System                              | •                     |                  | •   |  |
| UARS Control Authority                                   | •                     | •                |     | •  |
| JPL Control Authority                                    | •                     | •                | •   | •  |
| ISTP/GGS   | •                     | •                | •   | •  |
| SOHO Data Centre   | •                     | •                | •   | •  |
| Dynamics Explorer  | •                     | •                |     | •  |
| Pioneer 10/11  | •                     | •                |     | •  |
| Halley Watch CD-ROMs                                     | •                     | •                | •   | •  |
| ISEE   | •                     | •                |     | •  |
| Solar Maximum Mission                                    | •                     | •                |     | •  |
| Mars Observer  | •                     |                  | •   | •  |

The Brazilian Space Agency INPE is incorporating basic concepts of the Recommendations for Standard Data Interchange Structures for its REDACE-IGS/RP Version Service.



The National Space Development Agency of Japan NASDA has since 1990 prepared the application of CCSDS Recommendations - mainly in the fields of Advanced Orbiting Systems and SFDUs - by conducting extensive tests using simulated and real satellite and ground data systems. The formal introduction of relevant standards is presently under preparation.

### C. RELATIONS TO OTHER INTERNATIONAL BODIES

ISO has decided to adopt the CCSDS Recommendations as ISO Standards. The following table shows the current status.

| CCSDS RECOMMENDATION  | ISO REFERENCE <sup>(2)</sup> |
|---|------------------------------|
| Time Code Formats, Apr.90, CCSDS 301.0-B-2  | ISO 11104; 12/91             |
| Telemetry Channel Coding, May 92, CCSDS 101.0-B-3                                 | ISO 11754; 11/94             |
| Packet Telemetry, Nov.92, CCSDS 102.0-B-3   | ISO/DIS 13419; 10/94         |
| Telecommand - Part 1: Channel Service, Jan.87, CCSDS 201.0-B-1                    | ISO/DIS 12171; 05/92         |
| Telecommand - Part 2: Data Routing Service, Nov.92, CCSDS 202.0-B-2               | ISO/DIS 12172; 05/92         |
| Telecommand - Part 2.1: Command Operation Procedures, Oct.91, CCSDS 202.1-B-1     | ISO/DIS 12173; 05/92         |
| Telecommand - Part 3: Data Management Service, Jan.87, CCSDS 203.0-B-1            | ISO/DIS 12174; 05/92         |
| AOS, Network and Data Links: Architectural Specification, Nov.92, CCSDS 701.0-B-2 | ISO/CD 13420; 11/92          |
| SFDUs - Structure and Construction Rules, May 92, CCSDS 620.0-B-2                 | ISO 12175; 11/94             |
| SFDUs - Control Authority Procedures, June 93, CCSDS 630.0-B-1                    | ISO/DIS; 10/94               |
| Radiometric and Orbit Data, Jan 87, CCSDS 501.0-B-1                               | ISO 11103; 12/91             |

The **Inter-Agency Consultative Group for Space Science**, comprising NASA, ESA, ISAS and INTERCOSMOS has adopted a recommendation that one of its primary standards for data exchange is the SFDU.

### V. CONCLUSION

The CCSDS will continue to develop the series of Recommendations in those areas of space data systems which promise most benefit from these efforts due to their international application.

Sufficient progress has already been made in the development of recommendations, in the adoption of compatible agency standards and in their use by projects to justify the considerable investments made by the participating agencies in this venture. However, full success can be stated only after **all** participating agencies have applied these recommendations when establishing agency standards, when modernising their infrastructure concerned and after they have convinced their project managers that space projects benefit in the long term from a harmonisation of standards on an international level.

<sup>(2)</sup> It indicates: ISO - International Standard; ISO/DIS - Draft International Standard; ISO/CD - Committee Draft



For additional information (including procedures for ordering CCSDS documents) please write to

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