DRAFT

IOAG INFUSION PLANS AND ROADMAPS

(this version contains all IOAG agency(s) input)

(Draft IOAG-8 Version – July 2005)

(Draft IOAG-8 Version, Revision 1 – August 2005)

IOAG ROADMAP

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1 – INTRODUCTION

At the joint Interagency Operations Advisory Group (IOAG-7) and CCSDS Management Council (CMC) meeting held in Toulouse, France on 6-9 December 2004, it was agreed that the IOAG and CCSDS would formalize a customer-supplier relationship.

This relationship is to address three areas of common interest in the utilization of standards for the interoperability between IOAG member agencies, as follows.:

a) The long term strategy and the vision of the interoperability in terms of architecture and services; this area will be covered through the provision of IOAG comments and advices to the CCSDS related documentation;

b) The IOAG's High Priority Requirements to CCSDS for cross-support; when complete **(NOTE: This document is a living document; it changes over time)**, this document is intended to specify work items which the IOAG feels are needed to facilitate cross-support of one agency's missions by another agency's network; the document should also provide IOAG's views on priorities for the new CCSDS works;

c) The third area is based on a document describing the IOAG's plans in terms of using CCSDS standards in the cross-supports between the agencies and providing a Roadmap for achieving its objectives. This document represents a Strategy Plan describing the long term objectives of the IOAG members. The Roadmap accompanying the Plans will show how those goals will be achieved. This document represents that plan.

2 – STRUCTURE AND MANAGEMENT OF THE PRESENT DOCUMENT

2-1 STRUCTURE

The structure of the present document establishes the links between the three layers of the customer-supplier relationship between IOAG and CCSDS:

a) Section 3 of this document summarizes the objectives of IOAG, and descibes the specific areas of interest in the CCSDS works the IOAG has agreed to consider for the implementation of cross-supports between the member agencies; in particular, it reflects the space missions configurations considered by IOAG in their discussions. This section is in agreement with the IOAG vision of the long-term plan and support architecture established with CCSDS via comments on their corresponding documentation;

b) Section 4 of this document establishes the list of the 'Interoperability' items selected from CCSDS recommendations and for which there is an agreement within IOAG that they should be used in their cross-support configurations. This list is updated each time new recommendations are published by CCSDS and agreed upon via consensus by IOAG; those recommendations that are issued by CCSDS as a direct answer to the IOAG 'High Priority Requirements' document are added to this list without any delay or major discussion;

c) Section 5 of this document explains the presentation of the infusion plans and roadmaps for the implementation of the Interoperability Items listed in section 4; the actual plans and roadmaps of each of the IOAG member agencies are attached in the Annexes to this document.

2-2 DOCUMENT MANAGEMENT

It is planned that a new version of the present document is published on the IOAG server, shortly after each IOAG meeting.

Each version will update the previous ones and in particular:

a) Section 3 will be updated each time requirements for new mission configurations are established during the IOAG meetings;

b) The list in Section 4 will be updated each time new CCSDS (or other) standards are agreed upon for utilization in cross-support configurations between the IOAG member agencies;

c) The agency plans in the Annexes will be updated based on the presentations made by each member Agency according to the unified format defined in Section 5.

The intent is that this document is structured in a manner to permit the tracking of progress made in between IOAG meetings. The direct comparison of the different versions will allow for identifying the delays or changes in the implementations.

3 – IOAG STRATEGY PLAN

3-1 IOAG OBJECTIVES

From the beginning, IOAG has determined:

a) To establish and keep updated a list of interoperable facilities and services operated by the member agencies, including future implementation plans;

b) That each member organization shall submit the operations concept of its agency in terms of operations and systems management and contribute to the elaboration of common related policies and agreements;

c) To establish and keep updated a list of future missions in the member agencies candidate for cross support or space / ground network interoperability;

d) To monitor and report on the status of the requirements from missions in which each agency is involved (through ITCOP or other bi/trilateral agreements) and in which cross-support are planned for that agency either as a service user or as a service provider;

e) To monitor the status of the work of relevant standards organizations and identify the areas not or not sufficiently covered, considering the requirements of the upcoming missions;

f) To coordinate at the technical level with the representatives of its agency in the relevant standards organizations in order to inform them of the outcomes of the IOAG in terms of priorities or implementation difficulties.

3-2 IOAG AREAS OF INTEREST

a) General

Taking into account the above objectives, IOAG has concentrated their efforts in the identification of mission profiles and technical areas of common interest for which cross-supports are required. The following summarizes the main conclusions of this activity as of the date of the IOAG meeting corresponding to the present version of this document.

b) Mission Categories

For spacecraft, both Category A and Category B missions are considered. Supports to launchers are also considered by IOAG. IOAG has not identified any limitation in their discussions with respect to the manned or unmanned nature of the missions. Some limitations may exist with respect to some specific aspects of the military missions.

c) Mission Phases

The mission phases considered by IOAG in their discussions on future cross supports all relate to operations and fall into the following definitions:

1) Ground Segment: this may be initiated in phases A (feasibility), B (preliminary definition) or C (detailed definition) of a project, depending upon the operations scenario contemplated for phases E (utilisation) (-or F: disposal-); it covers the establishment of requirements, agreement and is based on a feasibility assessment.

2) Ground Segment Preparation and Qualification: this is usually in line with the project phase D (production, qualification and tests); it covers the required developments, adaptations and testing.

3) Launch and Early Orbit Phase: this belongs to the projects phase E (utilisation) and is the phase from launcher separation thru end of initial critical phases (few days or weeks) during which most of the cross support configurations between agencies were exercised.

4) Routine Operations: this also belongs to the projects phase E (utilisation) and is the phase that usually encompasses all or a major part of the satellite life time; it may be sub-divided into various categories such as "on-station control" (GEO's), "in-orbit control" (LEO's), "cruise" (Deep Space), etc…

5) Disposal Operations: this belongs to the projects phase F (disposal) and is the phase, close to the end of life of satellites, when de-orbiting or re-orbiting operations are conducted.

The IOAG Mission Model shows that the Launch and Early Orbit Phase and the Routine Operations are the most frequent cases of cross support operations currently identified among the member agencies.

d) Support Configurations

The main support configuration explored during the IOAG meetings is the case of utilization of the assets of one or several provider agencies by one user agency. All of the IOAG member agencies may play either one of those parts, depending upon the projects. The main areas considered in the definition of such support configurations relate to the ground to satellite and ground to ground interfaces; also, the management of the services and the exchanges of some information are also of interest for IOAG in this case.

On a case-by-case basis, other interface configurations may be discussed, as they happen to be used in the architecture of programs jointly conducted by two or more of the IOAG member agencies.

e) CCSDS Items of Interest

More than the production of the "System Engineering Area" of CCSDS, the vision of CCSDS in terms of data and information architectures, as well as in terms of services is of prime interest for IOAG, is critical for IOAG. The compatibility of that vision with the one developed within IOAG is the compulsory fundament for the adoption and implementation of CCSDS recommendations throughout the assets of the IOAG member agencies. To verify and achieve this compatibility is the prime objective of the customer-supplier relationship established between IOAG and CCSDS. Nevertheless, this is not specifically covered in the present Roadmap document as it is to be processed separately thru review of documentations.

The following areas of the CCSDS deal with subjects of global interest in the interfaces between IOAG agencies as implemented for cross-support configurations:

- Space Link Services
- Cross-Support Services

All of the recommendations produced in those areas should be considered by IOAG in terms of prioritization and utilization. All of the existing standards from those areas should be found in the lists of section 4 here after.

The following areas of the CCSDS deal with subjects of interest, at least in some of the working groups:

- Mission Operations and Information Management Services
- Space Internetworking Services

The relevant existing standards from those areas should be found in the lists of section 4 here after.

At this stage, there is no interest in the following area of the CCSDS, for what relates to the interoperability and operations between IOAG member agencies:

- Spacecraft Onboard Interface Services

4 – IOAG INTEROPERABILITY ITEMS

The table below summarizes the interoperability issues currently recognized by IOAG as necessary for their cross supports and in which interoperability items from CCSDS (or other standard bodies) should provide appropriate solutions; it is organized according to the standard areas of CCSDS and points out if and which appropriate solutions are proposed by CCSDS (or other standard bodies):

Interoperability issue	*Solution*
Ground to Satellite interfaces (Space Link Services)	
RF & Modulation	CCSDS Existing Standards
Spectrum Congestion at X-band	tbd
Ranging	CCSDS Existing Standards
Regenerative Standards	TBD
Delta DOR	TBD
Space Link Protocols	CCSDS Standards for Telemetry and Telecommand Packets
Coding and Synchronization	CCSDS Existing Standards
High Data Rate Coding Schemes	tbd
TC Channel Coding	tbd
Data Compression	TBD
Ground to Ground Interfaces (Cross Support Services)	
Ground Communication Services	TCP/IP, FTP
Security Interface	tbd
Telemetry Data Transfer Services	CCSDS existing SLE standards for RAF and RCF
Telecommand Data Transfer Services	CCSDS existing SLE standard for CLTU
Ancillary Data Transfer Services	tbd
Management of Data Transfer Services	TBD
Ground to Ground Interfaces (Mission Operations and Information Management Services)	
Predicted Trajectory Data	CCSDS Existing Standard for Orbit Data Message
Raw Or Pre-Processed Tracking Data Exchange	TBD
Space Data Packaging	XML standard as recommended by CCSDS
End to end interfaces (Space Internetworking Services)	
Reliable Data Delivery	CCSDS File Delivery Protocol

NOTE: The mention '**tbd**' in the above table doesn't reflect a question mark on the interest of IOAG on the corresponding interoperability issue but rather indicate that the IOAG requirements are not yet mature enough and may not yet be included in the high priority requirements of IOAG. A capital '**TBD**' delineates a priority item, which however reflects that the issue has not yet found a solution in the CCSDS standards or other standards.

5 – AGENCIES' INFUSION PLANS AND ROADMAPS

This section of the document is basically a guide for the production by the IOAG member agencies of the Annexes hereafter in a unified format.

It summarizes the synthetic information that is expected from each agency to report on the decisions and implementation processes with respect to each of the interoperability items in Section 4 above identified as having an appropriate and IOAG approved solution from CCSDS.

IOAG ROADMAP

At this stage, the interoperability items already addressed by IOAG members and therefore included in their respective infusion plans and roadmaps are:

RF & Modulation	CCSDS Existing Standards
Ranging	CCSDS Existing Standards
Space Link Protocols	CCSDS Standards for Telemetry and Telecommand Packets
Coding and Synchronization	CCSDS Existing Standards
Ground Communication Services	TCP/IP, FTP
Telemetry Data Transfer Services	CCSDS Existing SLE Standards for RAF and RCF
Telecommand Data Transfer Services	CCSDS Existing SLE Standard for CLTU
Predicted Trajectory Data	CCSDS Existing Standard for Orbit Data Message
Space Data Packaging	XML Standard as Recommended by CCSDS
Reliable Data Delivery	CCSDS File Delivery Protocol

For each item in this table, the following status and information are provided:

a) Decision Status. Clarifies the following:
   1) The Agency has approved or is reluctant with the adoption of the solution.
   2) The adoption of the standard was decided in the frame of a specific mission or more globally for future projects.

b) Implementation Plans. Clarifies the following:
   1) The list and details of which standards or part of, were approved for implementation by the Agency.
   2) Which implementations were already decided, including a brief description of the type of implementation.
   3) As part of which strategy (several phases, step by step approach, several components, intermediate architectures, global approach, etc…).

c) Status and Schedule. The status of each of the various implementation components identified in item b) above is characterized as:
   1) Under Development;
   2) Under Qualification; or
   3) In Operations.

In addition, those three levels of implementation are reflected in a summary planning schedule in the format in the following table.

IOAG ROADMAP

No.		2004				2005				2006				2007				2008				2009				2010				2011				2012				2013			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	**RF & Modulation**																																								
1a	Component 1																																								
1b	Component 2																																								
1c	Component 3																																								
2	**Ranging**																																								
2a	Component 1																																								
2b	Component 2																																								
2c	Component 3																																								
3	**Space Link Protocols**																																								
3a	Component 1																																								
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4	**Coding and synchronization**																																								
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5	**Ground Communication Services**																																								
5a	Component 1																																								
5b	Component 2																																								
5c	Component 3																																								
6	**Telemetry data transfer services**																																								
6a	Component 1																																								
6b	Component 2																																								
6c	Component 3																																								

- Development
- Qualification tests
- In operations

IOAG ROADMAP

No.		2004				2005				2006				2007				2008				2009				2010				2011				2012				2013			
		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
7	**Telecommand data transfer services**																																								
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8	**Predicted trajectory data**																																								
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10	**Reliable Data Delivery**																																								
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10b	Component 2																																								
10c	Component 3																																								

Development
Qualification Tests
In Operations

ANNEX-1 – ASI INFUSION PLAN AND ROADMAP

ASI-1: RF & Modulation

a) Decision Status

ASI uses CCSDS modulation standards. Uplink high bit rate standards have never been used. ASI supports the guideline to CCSDS in order to rationalize and reduce the RF & Modulation standard pattern.

b) Implementation Plans

There is no specific implementation plan for all CCSDS standards. Specific implementations are driven by the need of the single mission.

c) Implementation Status

Not applicable.

ASI-2: Ranging

a) Decision Status

ASI uses the CCSDS standards ranging schemes with tone configuration up to 512 Khz. Doppler and antenna angle collection still use “ad hoc” coding.

New missions (AGILE) are designed around specific needs which, in case of LEO, are progressively migrating to autonomous determination using navigation receivers (GPS).

b) Implementation Plans

None.

c) Implementation Status

Not applicable.

ASI-3: Space Link Protocols

a) Decision Status

ASI uses CCSDS standards for TLM and TC. No legacy of old standards are still operative. Ground stations have been updated to CCSDS standards.

b) Implementation Plans
New equipment is acquired following CCSDS standards.

c) Implementation Status
Not applicable.

ASI-4: Coding and Synchronization

a) Decision Status
ASI missions uses CCSDS standard for coding (Convolutional Viterbi [7-1/2) and Reed Solomon [255; 223]).

b) Implementation Plans
No Turbo code implementation is envisaged in the near future. ASI is waiting for a CCSDS decision on LDPC codes in order to start a pilot activity.

c) Implementation Status
Not applicable.

ASI-5: Ground Communication Services

a) Decision Status
ASI Ground Network (ASI-net) is based on TCP/IP(UDP).

b) Implementation Plans
ASI-net has a star shape with the Fucino Space Centre as center and legs reaching Turin (ALTEC), Malindi (BSC) and the JSC (Houston, Texas, USA).

c) Implementation Status
A new leg is foreseen in 2005 to support AGILE (ESA/ESRIN – ASI Science Data Centre) together with an upgrade to 1 Mbps in the Malindi/BSC – Fucino bit rate.

ASI-6: Telemetry Data Transfer Services

a) Decision Status
Cross support with NASA (Swift) is based on old protocols (Mark II modified). Current mission (AGILE, COSMO) do not support the SLE standard (RAF, RCF). The Malindi/BSC supports SLE only through the ESA installed base bands via the ESA/ESOC – Malindi connection.

b) Implementation Plans
SLE (RAF, RCF) compatibility at Malindi via the ASI-net Fucino gateway foreseen in the near future.

c) Implementation Status
Actually no SLE TLM service is active.

ASI-7: Telecommand Data Transfer Services

a) Decision Status

Cross support with NASA (Swift) is based on old protocols (Mark II modified). Current mission (AGILE, COSMO) do not support the SLE standard. The Malindi/BSC supports SLE only through the ESA installed base bands via the ESA/ESOC – Malindi connection.

b) Implementation Plans

SLE (CLTU) compatibility at Malindi via the ASI-net Fucino gateway is foreseen in the near future.

c) Implementation Status

Actually no SLE/TLC service is active.

ASI-8: Predicted Trajectory Data

a) Decision Status
ASI uses TLE and ESA STDM for the orbit data transfer.

b) Implementation Plans
No implementation plan for OPM EPH CCSDS standards.

c) Implementation Status
Not applicable.

ASI-9: Space Data Packaging

a) Decision Status
No decision has been taken on this subject.

b) Implementation Plans
None

c) Implementation Status
Not applicable.

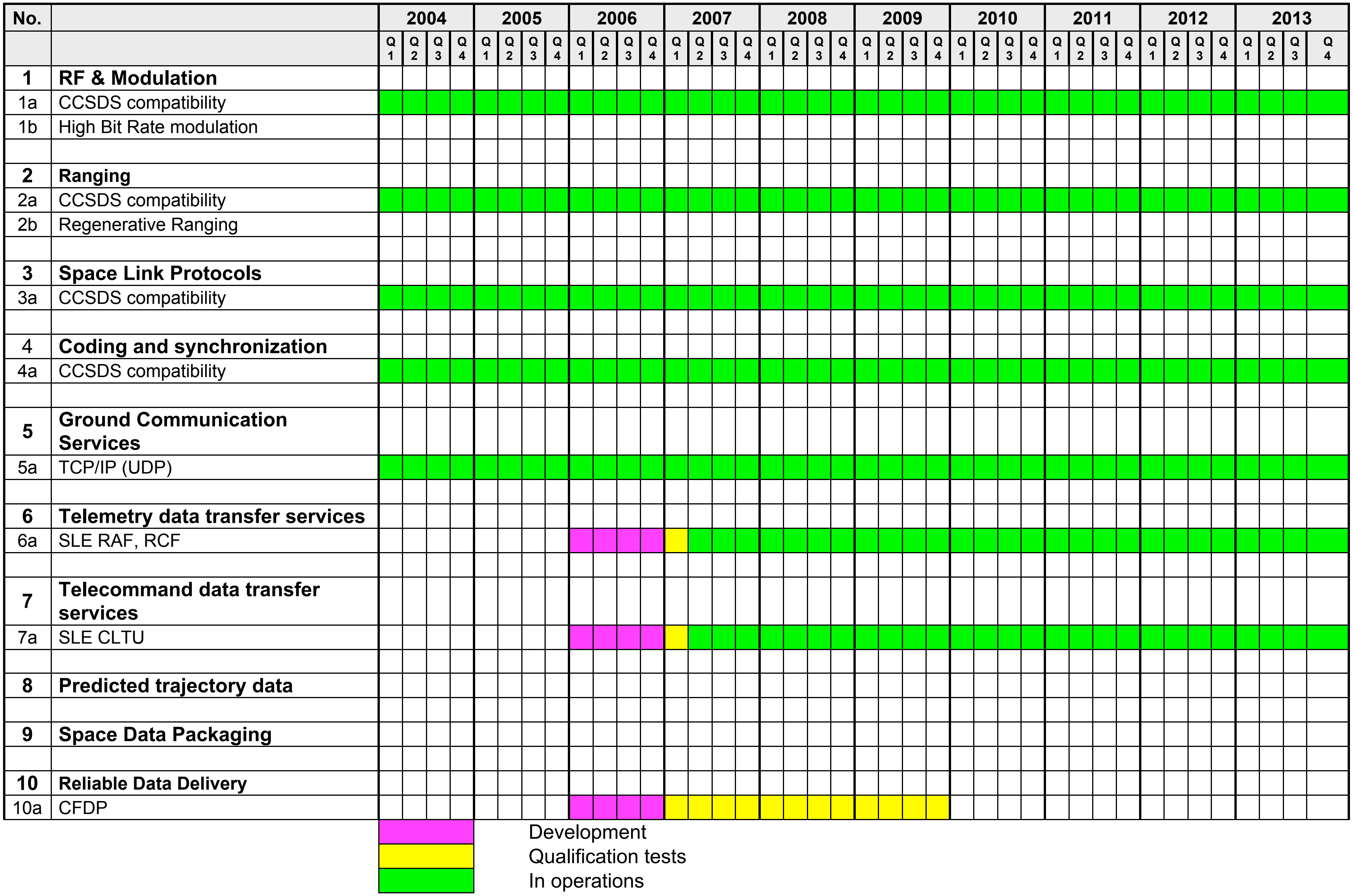
ASI-10: Reliable Data Delivery

a) Decision Status
ASI has no plan to use CFDP for future missions.

b) Implementation Plans
The implementation of an Italian CFDP test bench is considered for the near future with participation to the CCSDS test network.

c) Implementation Status
Not applicable.

ASI-S: Summary Schedule



ANNEX-2 – CNES INFUSION PLAN AND ROADMAP

CNES-1: RF & Modulation

a) Decision Status

CNES is using and willing to make use of CCSDS standards on RF & Modulation. Nevertheless, the CNES stations are not compatible with all CCSDS standards, in particular for high bit data rates, as it is estimated that the CCSDS standards are too many and the implementation is too expensive.

CNES supports the idea that a reduction of the number of RF standards is required at the CCSDS level. The GMSK (Btb=0.25) modulation looks very promising for the S-band interoperability of Category A missions.

b) Implementation Plans

For S-band downlink of category A missions, PCM/PSK/PM is used on the CNES missions using low bit rates (<50 Kbps) while Filtered-QPSK is used for higher bit rates (up to 1 Mps).
Decision was made in September 2004 that all CNES ground stations will be compatible of both CCSDS standards for low and higher bit rates. There will be two phases:

- harmonization on the modulation schemes
- harmonization on 1 Mbps capacity

For higher bit rates and future missions it is planned to implement GMSK (Btb=0.25) demodulation in the stations but no implementation schedule is available so far.

For S-band uplink of category A missions, PCM/PSK/PM is used on most of the CNES missions using low bit rates (<10 Kbps) while QPSK is used for higher bit rates (< 100 kbps). The latter is not supported in CCSDS standards.

No requirement for higher bit rates was identified or confirmed so far in CNES future missions, while it is discussed in the very early phases of some future missions.

For X-band downlink, CNES is using Filtered-QPSK on the downlink of its eldest satellites and 4D-8PSK-TCM on the downlink of its most recent ones. Both are CCSDS standards.

c) Implementation Status

The upgrade of CNES ground stations decided in September 2004 is in progress:

- the harmonization on the modulation schemes is under acceptance tests ;
- the harmonization on the 1 Mbps capacity is planned for end 2005.

NOTE:: GMSK is currently used in some R&D projects of CNES.

CNES-2: Ranging

a) Decision Status

CNES multi-mission stations currently use a tone ranging system (ESA 100 Khz tone standard) associated with Doppler or Angle data measurement systems. This is intended to be maintained in particular for the support to the GEO missions.

Most of the new CNES LEO missions have autonomous on-board orbit determination systems (Doris, GPS) and do not implement ranging relays in their transponders. Doppler and Angle measurements may serve as back-up methods for orbit determination.

For future CNES missions, targeting the Moon or Lagrange regions, new ranging systems may be required and CNES is expecting the CCSDS regenerative RNG in the short term, so that this may be compatible of such missions' schedule.

b) Implementation Plans

None.

c) Implementation Status

Not applicable.

CNES-3: Space Link Protocols

a) Decision Status

For many years, CNES satellite missions have been using packet TLM and CMD standards of CCSDS. For those, the COP-1 loop is closed in the control centers.

Only a couple of follow-on satellites using old fashioned PCM standards (ESA PSS-45 and PSS-46) are still to be launched and will not be modified to minimize the impact on the existing ground assets that also control the existing fleets.

Because of the dual requirements on their ground stations (CCSDS and legacy standards) a decision was made in September 2004 that CNES multi-mission stations will be compatible of both CCSDS and PCM standards.

b) Implementation Plans
The upgrade of the station base band equipment to allow this dual CCSDS-PCM mode was then initiated.

c) Implementation Status
The upgrade of the station base band equipment to a dual mode is currently under acceptance tests.

CNES-4: Coding and Synchronization

a) Decision Status
Most of the CNES missions currently use Viterbi (7-_) and Reed Solomon (255 ; 223) coding schemes on their downlink.
Some missions also use DVB-S standards proposed by the ETSI (convolutional 2/3, _, … and RS 255, 239).
For the future, there is an interest on the LDPC codes but an agreement is needed soon from CCSDS WG in that respect.

b) Implementation Plans
None in the very short term.

c) Implementation Status
Not applicable.

CNES-5: Ground Communication Services

a) <u>Decision Status</u>
All ground communications in CNES Ground Networks make use of IP protocol and TCP and FTP transport services.

b) <u>Implementation Plans</u>
All upgrades from eldest legacy protocols were completed in 2003 – 2004.
No other upgrade is planned, except for some internal interfacing of various LAN’s.

c) <u>Implementation Status</u>
Not applicable.

CNES-6: Telemetry Data Transfer Services

a) <u>Decision Status</u>
Decision was made in September 2004 that all CNES future missions will have their ground segments based on SLE concepts.
RAF and RCF services will be implemented.
The first CNES project to be based on such protocols is Pléiades (2008).
CNES will need intermediate configurations to support ESA METOP-1 mission by end 2005.

b) <u>Implementation Plans</u>
The implementation strategy will have four components :
- an SLE Gateway on the provider side, to be used in support of ESA during METOP-1 LEOP ; that gateway will be validated during DLR SarLuppe mission (mid-2005).
- an SLE Gateway on the user side, to be used internally in CNES for validation of future implementations of SLE in station or with control centres still using CNES legacy protocols.
- an SLE implementation in the ground stations, to be used in support of Pleiades or of external cross-supports as required.
- an SLE implementation in the Control Centres, of Pleiades first and later on in the ones of the CNES mini and micro satellites.

c) <u>Implementation Status</u>
- the SLE Gateway on the provider side is under qualification tests;
- the SLE Gateway on the user side is in a specification phase.
The implementation of the other components is anticipated as shown in the overall implementation schedule of CNES.

CNES-7: Telecommand Data Transfer Services

a) Decision Status

Decision was made in September 2004 that all CNES future missions will have their ground segments based on SLE concepts.
Only the CLTU service will be implemented.
The first CNES project to be based on such protocol is Pléiades (2008).
CNES will need intermediate configurations to support ESA METOP-1 mission by end 2005.

b) Implementation Plans
The implementation strategy will have four components:
- an SLE Gateway on the provider side, to be used in support of ESA during METOP-1.
- an SLE Gateway on the user side, to be used internally in CNES for validation of future implementations of SLE in station or with control centres still using CNES legacy protocols.
- an SLE implementation in the ground stations, to be used in support of Pleiades or of external cross-supports as required.
- an SLE implementation in the Control Centres, of Pleiades first and later on in the ones of the CNES mini and micro satellites.

c) Implementation Status
- the SLE Gateway on the provider side is under qualification tests;
- the SLE Gateway on the user side is in a specification phase.
The implementation of the other components is anticipated as shown in the overall implementation schedule of CNES.

CNES-8: Predicted Trajectory Data

a) Decision Status
The decision was made in early 2004 to process the OPM-EPH standards of CCSDS at the level of the Orbit Computation Centre (OCC) of CNES, in order to allow the interface with external users or providers of Network Services.

b) Implementation Plans
A first implementation was made in 2004 based on the CCSDS red book.
An upgrade is currently in progress to make the system compatible with the recently issued blue book.

c) Implementation Status
Availability of software for processing the CCSDS BB formats as they are received or dispatched by/from the OCC is planned by mid-2005.

CNES-9: Space Data Packaging

a) Decision Status
No decision was made so far (TBC) on the utilization of XML protocols of CCSDS in the CNES Ground Segments.

b) Implementation Plans

None (TBC).

c) Implementation Status

TBD.

CNES-10: Reliable Data Delivery

a) Decision Status
No decision was made so far on the utilization of CFDP protocols of CCSDS (TBC).

b) Implementation Plans
None.

c) Implementation Status
Not applicable.

IOAG ROADMAP – CNES

CNES-S: Summary Schedule

2004				2005				2006				2007				2008				2009				2010				2011				2012				2013		
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3

No.	CNES PLANS
1	**RF & Modulation**
1a	Harmonization of Modulation Schemes in Multi-Mission stations
1b	Harmonization of Modulations at bit rates up to 1 Mbps
1c	GMSK (Btb=0.25) - TBD
2	**Ranging**
2a	
3	**Space Link Protocols**
3a	Dual Packet – PCM modes
4	**Coding and synchronization**
4a	
5	**Ground Communication Services**
5a	Migration to IP
6	**Telemetry data transfer services**
6a	SLE Gateway – Provider side
6b	SLE Gateway – User side
6c	SLE implementation in station
6d	SLE in the control centres
7	**Telecommand data transfer services**
7a	SLE Gateway – Provider side
7b	SLE Gateway – User side
7c	SLE implementation in station
7d	SLE in the control centres
8	**Predicted trajectory data**
8a	OPM-EPM Blue Book upgrade
9	**Space Data Packaging**
9a	
10	**Reliable Data Delivery**
10a	

Development
Qualification tests
In operations

ANNEX-3 – DLR/GSOC INFUSION PLAN AND ROADMAP

GSOC-1: RF & Modulation

a) Decision Status

GSOC uses CCSDS modulation standards. Uplink high bit rate standards have never been used. GMSK is not available at Weilheim Ground Station. There might be a necessity for implementation, but no decision is taken till now. GSOC supports the guideline to CCSDS in order to rationalize and reduce the RF & Modulation standard pattern.

b) Implementation Plans

There is no specific implementation plan for all CCSDS standards. Specific implementations are driven by the need of the single mission.

c) Implementation Status

Not applicable.

GSOC-2: Ranging

a) Decision Status

GSOC uses the standards ranging schemes provided with the cortex baseband equipment. with tone configuration up to 500 Khz. Beside Ranging Doppler and Angle Measurements are used for Orbit determination.

b) Implementation Plans

None.

c) Implementation Status

Not applicable.

GSOC-3: Space Link Protocols

a) Decision Status

GSOC uses CCSDS standards for TLM and TC. Support for non CCSDS standards may be mission specific solutions but not standard support.

All GSOC missions use the COP-1 loop closed in the control center.

There are no plans to implement SCPS.

b) Implementation Plans
None.

c) Implementation Status
Not applicable.

GSOC-4: Coding and Synchronization

a) Decision Status
GSOC missions uses CCSDS standard for coding (Convolutional Viterbi [7-1/2) and Reed Solomon (255; 223)).

b) Implementation Plans
No Turbo code implementation is planned for the near future.

c) Implementation Status
Not applicable.

GSOC-5: Ground Communication Services

a) Decision Status
GSOC Ground Network is based on TCP/IP.

b) Implementation Plans
V-LAN passed network at the ground station and to the Control-Center to separate project specific traffic.

c) Implementation Status
Implementation is planned in 2006.

GSOC-6: Telemetry Data Transfer Services

a) Decision Status
All upcoming missions should use SLE. This will be supported on different layers, for Checkout Systems as well as for Cross Support.

If needed, the SLE interface can be used directly on the cortex baseband units. The normal way is to use a SLE provider located at the station. This solution is implemented for redundancy issues. Today no offline services are available for return services.

The control center also acts as a SLE user for CLTU, RAF and RCF services. With the implemented SLE gateway service GSOC can also provide SLE services from other DLR stations then Weilheim.

b) Implementation Plans
The above mentioned services are still under test for DLR TerraSAR-X and SAR-Lupe mission. They are available for external usage as for ESA missions Smart and Integral.
There will be further upgrades of the services. These will include an SLE proxy, as well as Return offline services. There are today no plans to implement OCF, and return space packet service..

c) Implementation Status

Basic implementation finished end of the year 05. Additional features will be implemented in 2006.

GSOC-7: Telecommand Data Transfer Services

For the forward services the same timeline applies as for return services. The only implementation will be done on CLTU services. There is no positive decision on implementing FSP services.

In the GSOC implementation, the throw event feature in the CLTU service is not available.

GSOC-8: Predicted Trajectory Data

a) Decision Status

GSOC will follow the standardization of CCSDS. Implementation of the standards for operational usage will be done after the standard is issued. Today OPM is in implementation status.
Beside the OPM the TDM tracking data standard will be implemented at GSOC. Today there are no plans for implementing the ADM standard.

b) Implementation Plans

- OPM
- TDM
- XML formats for these datatypes.

c) Implementation Status

OPM is currently in test with CNES.
TDM and the XML formats will be implemented in the year after the standard is issued.

GSOC-9: Space Data Packaging

a) Decision Status

No decision was made on the utilization of XML protocols of CCSDS in the GSOC Ground stations.

b) Implementation Plans

None

c) Implementation Status

Not applicable.

GSOC-10: Reliable Data Delivery

a) Decision Status

GSOC has no plan to use CFDP for future missions. On a mission basis there might be requirements for a CFDP service. If that is the case CFDP will be implemented.

b) Implementation Plans

None.

c) Implementation Status

Not applicable.

IOAG ROADMAP – DLR/GSOC

GSOC-S: Summary Schedule

No.	DLR PLANS and CAPABILITIES	2004				2005				2006				2007				2008				2009				2010				2011				2012			
		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
1	**RF & Modulation**																																				
	Modulations at bit rates up to 4 Mbps																																				
2	**Ranging**																																				
	Tone Ranging																																				
3	**Space Link Protocols**																																				
3a	TM/TC packet standards																																				
4	**Coding and synchronization**																																				
4a	convolutional Viterbi (7;1/2)																																				
4b	Reed Solomon (255; 223)																																				
5	**Ground Communication Services**																																				
5a	Migration to IP																																				
6	**Telemetry data transfer services**																																				
6a	SLE Gateway – Provider side																																				
6b	SLE Gateway – User side																																				
6c	SLE implementation in station																																				
6d	SLE in the control centres																																				
7	**Telecommand data transfer services**																																				
7a	SLE Gateway – Provider side																																				
7b	SLE Gateway – User side																																				
7c	SLE implementation in station																																				
7d	SLE in the control centres																																				
8	**Predicted trajectory data**																																				
8a	OPM																																				
8b	TDM																																				
8c	XML Schemas																																				
9	**Space Data Packaging**																																				
9a																																					
10	**Reliable Data Delivery**																																				
10a																																					

Development
Qualification tests
In operations

ANNEX-4 – ESA INFUSION PLAN AND ROADMAP

ESA-1: RF & Modulation

a) Decision Status

ESA is compatible with the CCSDS standards on RF & Modulation. Rarely used modulation techniques for high Bit rate transmissions, like FQPSK-B, are not supported ad-hoc, but can be supported following development.

b) Implementation Plans

For specific mission requirements, the required modulation schemes will be implemented.

c) Implementation Status

ESA-2: Ranging

a) Decision Status

ESA is compatible with the ECSS standard.

b) Implementation Plans

None.

c) Implementation Status

Not applicable.

ESA-3: Space Link Protocols

a) Decision Status

Most of the ESA satellite missions have been using packet TLM and CMD standards of CCSDS. For commanding ESA supports two implementations:

- COP-1 loop is closed in the control centers.
- COP-1 is closed at the ground station

b) Implementation Plans

None.

c) Implementation Status
None.

ESA-4: Coding and Synchronization

a) Decision Status
Most of the ESA missions currently use Viterbi (7 ; _) and Reed Solomon (255 ; 223) coding schemes on their downlink.

b) Implementation Plans
Turbo Code is available on a test bed implementation and is planned to be operational by 2007.

c) Implementation Status
Not applicable.

ESA-5: Ground Communication Services

a) Decision Status

Over the last 20 years X.25 was used for ground communication. It is planned to migrate all ground communications in ESA Ground Networks to IP protocol and TCP and FTP transport services by 2006.

b) Implementation Plans

All upgrades will be completed by end 2005.

c) Implementation Status

Not applicable.

ESA-6: Telemetry Data Transfer Services

a) Decision Status

All ESA future missions will have their ground segments based on SLE concepts and for telemetry RAF and RCF services are current being deployed to the ground stations and this will be completed by mid 2006. Thereafter only SLE RAF and RCF will be supported from ESA ground stations.

Today SLE is available using a gateway at ESOC.

b) Implementation Plans

The new ground station equipment is called TMTCS and is currently supporting the RAF and RCF compatible with the red books and compatible with Integral, Rosetta and DSN. The blue book recommendations are currently under development and both will be available on the TMTCS until an agreement has been reached with DSN to move to the blue book implementation. After such an agreement the red book implementation will not longer be maintained.

c) Implementation Status

The OCF service to provide the CLCW is currently under development and will be available beginning of 2006.

ESA-7: Telecommand Data Transfer Services

a) Decision Status

All ESA future missions will have their ground segments based on SLE concepts. Currently only the CLTU service is implemented and currently being deployed to the ground stations and will be completed by med 2006. Thereafter SLE CLTU and FSP (TBD) will be supported from ESA ground stations.

b) Implementation Plans

The Forward Space Packet service is currently under development.

c) Implementation Status

None.

ESA-8: Predicted Trajectory Data

a) Decision Status
ESA supports the standards of CCSDS n order to allow the interface with external users or providers of Network Services.

b) Implementation Plans
None.

c) Implementation Status
None.

ESA-9: Space Data Packaging

a) Decision Status
No decision has been made on the utilization of XML protocols of CCSDS in the ESA Ground Segments.

b) Implementation Plans
None.

c) Implementation Status
None.

ESA-10: Reliable Data Delivery

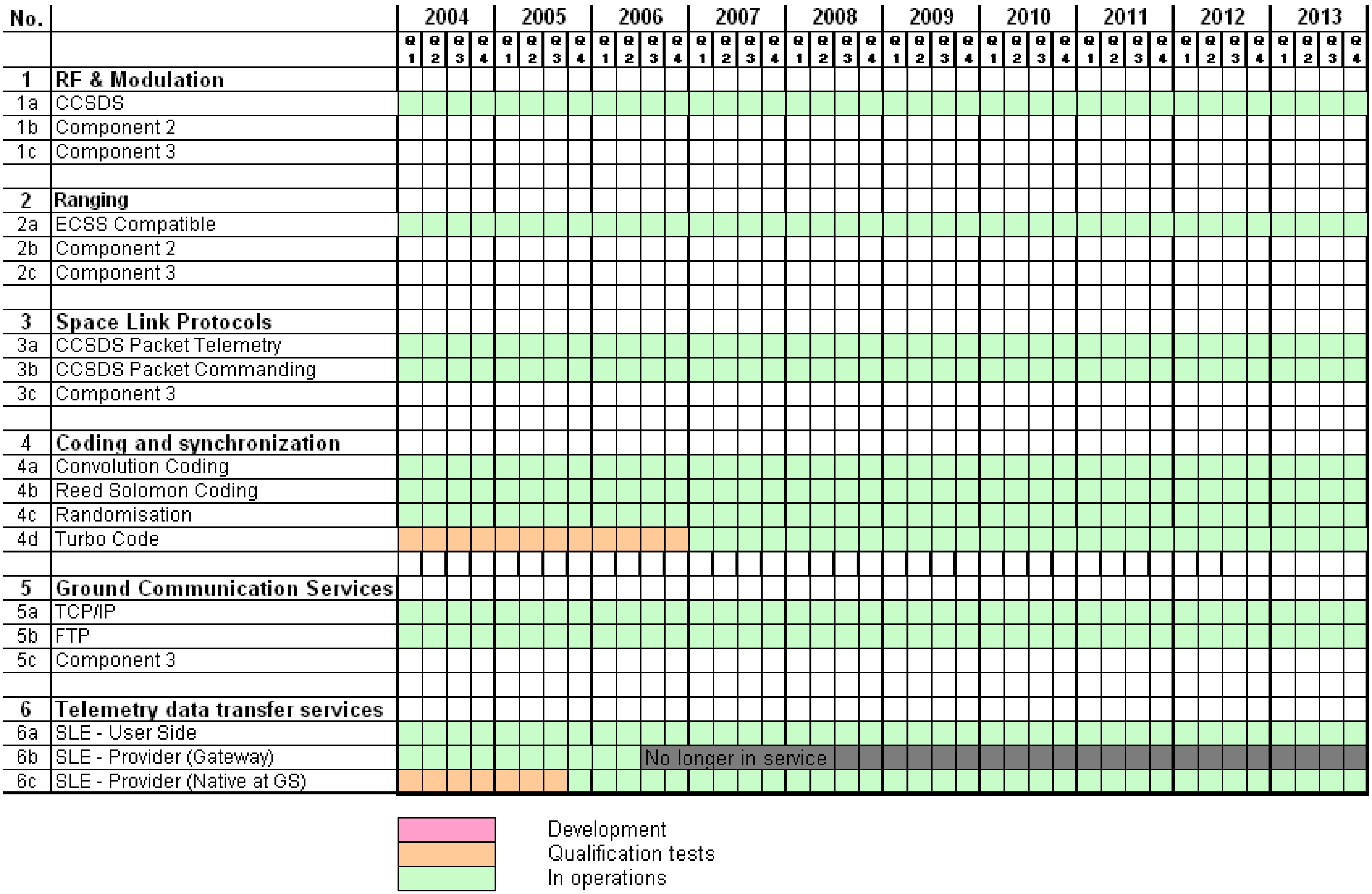
a) Decision Status
No decision has been made on the utilization of CFDP protocols of CCSDS

b) Implementation Plans
None.

c) Implementation Status
None.

ESA-S: Summary Schedule

IOAG ROADMAP - ESA



IOAG ROADMAP - ESA

No.		2004				2005				2006				2007				2008				2009				2010				2011				2012				2013			
		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
7	**Telecommand data transfer services**																																								
7a	SLE - User Side																																								
7b	SLE - Provider (Gateway)											No longer in service																													
7c	SLE - Provider (Native at GS)																																								
8	**Predicted trajectory data**																																								
8a	CCSDS OPM																																								
8b	CCSDS EPM																																								
8c	Component 3																																								
9	**Space Data Packaging**																																								
9a	CCSDS XML standard																																								
9b	Component 2																																								
9c	Component 3																																								
10	**Reliable Data Delivery**																																								
10a	CCSDS File Delivery Protocol																																								
10b	Component 2																																								
10c	Component 3																																								

Development
Qualification tests
In operations

ANNEX-5 – JAXA INFUSION PLAN AND ROADMAP

JAXA-1: RF & Modulation

a) Decision Status

Most of CCSDS RF & Modulation standards was adopted to JAXA space link communication system design criteria, except for bandwidth efficient modulation.

b) Implementation Plans

Next generation JAXA earth exploration satellite, named GOSAT, is designed to use filtered OQPSK for X-band high rate downlink in order to be met with ITU-R rec SA.1157.

c) Implementation Status

The following modulation method is in operations.
For S, X-band low rate downlink with residual carriers: PCM/PSK/PM, PCM/PM
For S, X-band low rate uplink with residual carriers: PCM/PSK/PM
For X-band high rate downlink with suppressed carriers: QPSK
For S-band space-to-space forward link with suppressed carriers: UQPSK
For S-band space-to-space return link with suppressed carriers: SQPN, SQPSK
For Ka-band earth-to-space and space-to-space forward link with suppressed carriers: BPSK, QPSK, UQPSK
For Ka-band space-to-earth and space-to-space return link with suppressed carriers: BPSK, QPSK, UQPSK, SQPSK

JAXA-2: Ranging

a) Decision Status

JAXA uses PN ranging system for space research missions and space network system using data relay satellite, while Tone ranging system is used for other missions including earth exploration missions.

b) Implementation Plans

X-band Digital Transponder with Regenerative Ranging processor is planned to use for future deep space mission.

c) Implementation Status

Tone ranging system and PN ranging system are in operations.

Prototype Model of X-band Digital Transponder with Regenerative Ranging processor was developed.

JAXA-3: Space Link Protocols

a) Decision Status
All JAXA future missions except micro-satellite will apply AOS standard for downlink and some missions will apply TC standard for uplink.

b) Implementation Plans
AOS standard is applied for ALOS, ETS-VIII, WINDS, SELENE, GOSAT, ASTRO-EII, ASTRO-F, SOLAR-B, LUNAR-A, HTV and JEM.
TC standard is applied for ALOS, ETS-VIII, WINDS, SELENE, GOSAT and HTV.

c) Implementation Status
AOS/TC onboard processors are in operations.
AOS/TC processors on ground stations are in operations.

JAXA-4: Coding and Synchronization

a) Decision Status
JAXA ground stations are compliant with CCSDS Synchronization and Channel Coding standards with Convolutional and Reed Solomon coding schemes for downlink.

b) Implementation Plans
Turbo Code Decoder compliant with CCSDS standard would be implemented.

c) Implementation Status
Turbo Code Decoder is under studying.

JAXA-5: Ground Communication Services

a) Decision Status
JAXA decided the adoption of TCP/IP, FTP as Ground Communication Services protocols.

b) Implementation Plans
Obsolete protocols (e.g. HDLC, X.25) will be decommissioned in the near future.

c) Implementation Status
TCP/IP based LAN/WAN system is in operations.
SMTP+FTP File Delivery system is in operations.

JAXA-6: Telemetry Data Transfer Services

a) Decision Status
JAXA promotes the adoption of SLE services for cross support.
For the future, JAXA is interested in SLE Service Management.

b) Implementation Plans
Part of RAF service will be implemented on SLE GWs.

c) Implementation Status
SLE User GW for ISAS-JPL interface of MUSES-C mission is in operations.
SLE User GW for ISAS-JPL interface of SELENE mission is under qualification.
A set of SLE Provider GW and SLE User GW is under development for internal connection between former NASDA and ISAS ground networks.

JAXA-7: Telecommand Data Transfer Services

a) Decision Status
JAXA promotes the adoption of SLE services for cross support.
For the future, JAXA is interested in SLE Service Management.

b) Implementation Plans
Part of F-CLTU service will be implemented on SLE GWs.

c) Implementation Status

SLE User GW for ISAS-JPL interface of MUSES-C mission is in operations.
SLE User GW for ISAS-JPL interface of SELENE mission is under qualification.
A set of SLE Provider GW and SLE User GW is under development for internal connection between former NASDA and ISAS ground networks.

JAXA-8: Predicted Trajectory Data

a) Decision Status
JAXA decided to use ODM standard for SELENE mission supported by JPL.

b) Implementation Plans
ODM software module will be implemented on flight dynamics system for SELENE.

c) Implementation Status
ODM module for SELENE mission is under qualification.

JAXA-9: Space Data Packaging

a) Decision Status
No decision was made on the utilization of XML for data packaging across JAXA.

b) Implementation Plans
No implementation plan at the present time.

c) Implementation Status
Metadata is supported by reliable legacy internal protocols.

JAXA-10: Reliable Data Delivery

a) Decision Status
No decision was made on CFDP implementation.

b) Implementation Plans

No implementation plan at the present time.

c) Implementation Status

CFDP prototype software was developed for CCSDS standard evaluation.

JAXA-S: Summary Schedule

See schedule on following two pages.

IOAG ROADMAP - JAXA

No.		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
		Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4
1	**RF & Modulation**										
1a	Space Link Design Standard										
1b	New EES X-band Transmitter										
2	**Ranging**										
2a	ToneRanging System										
2b	PN Ranging System										
2c	Regenerative Ranging X-band Transpoder										
3	**Space Link Protocols**										
3a	AOS Space Data Link protocol										
3b	TC Space Data Link protocol with COP-1										
4	**Coding and Synchronization**										
4a	Convolutional (R=1/2, K=7)										
4b	Reed Solomon (255/223)										
4c	Turbo Code										
5	**Ground Communication Services**										
5a	TCP/IP based LAN/WAN system										
5b	SMTP+FTP File Delivery System										
6	**Telemetry Data Transfer Services**										
6a	SLE User GW for MUSES-C										
6b	SLE User GW for SELENE										
6c	SLE Provider GW for Consolidated GN										
6d	SLE User GW for Consolidated GN										
7	**Telecommand Data Transfer Services**										
7a	SLE User GW for MUSES-C										
7b	SLE User GW for SELENE										
7c	SLE Provider GW for Consolidated GN										
7d	SLE User GW for Consolidated GN										
8	**Predicted Trajectory Data**										
8a	ODM module for SELENE										
9	**Space Data Packaging**										
10	**Reliable Data Delivery**										

ANNEX-6 – NASA INFUSION PLAN AND ROADMAP - DSN

NOTE: NASA has three networks: the Deep Space Network (DSN), the Ground Network (GN), and the Space Network (SN) [a.k.a TDRSS]. These are sufficiently different that they are handled separately in the following sections.

As a matter of policy, missions seeking to utilize DSN services must be CCSDS compliant. In the early 1990s, it was determined that ad hoc designs are far too expensive to construct, operate, and maintain to indulge their use in the DSN. Accordingly, standards were sought which could be implemented by both projects and the DSN to establish compatibility. The standards selected were those promulgated by the CCSDS and SFCG.

NASA-1: DSN RF & Modulation

a) Decision Status

The DSN is compliant with RF frequency standards of the ITU, SFCG, and CCSDS. Modulation / Demodulation systems are also currently compliant with CCSDS Recommendations, except for the bandwidth-efficient modulation methods (CCSDS 401 (2.4.17A, 2.4.17B, and 2.4.18). However, a receiver is being purchased for evaluation, which provides a GMSK (BT_B = 0.25, 0.5) demodulation capability to 150 Mbps. The DSN is of the opinion that there are too many CCSDS bandwidth-efficient modulation types. GMSK is the preferred type because it can be equalized to reduce the end-to-end losses to a very small level. When the DSN implements bandwidth-efficient demodulation, it will be GMSK (BT_B = 0.5) for Category B missions and GMSK (BT_B = 0.25) for Category A missions to ensure compatibility with Europe.

b) Implementation Plans

Plans exist to implement a 26 GHz (25.5-27.0 GHz) *Space Research* service capability in a 34M Beam Wave Guide (BWG) subnetwork, or equivalent, in the next few years. The DSN will also implement a capability for HEDS in 38-39 and 40.0-40.5 GHz bands when the need arises. All implementation will be fully compliant with the ITU and SFCG requirements. Some NASA missions (JWST [2012], LRO [2008], and Lunar Exploration missions) are planning higher data rates (28 Mbps and 150 Mbps). The CCSDS Medium Rate Telecommand standard (CCSDS 401 (2.2.7) B-1) is being implemented and the High Rate telecommand standard will be implemented when a user requires megabit rates.

c) Implementation Status

All CCSDS compliant RF and modulation Recommendations, except for bandwidth-efficient modulation, are currently implemented for the *Space Research* service allocations in the 2, 7, 8, and 32 GHz bands. That is so for both Category A and B missions. Currently, the following modulation [demodulation] methods are acceptable:

TELEMETRY

PCM/PSK/PM (Subcarriers should be less than 300 kHz [SFCG Rec. 23-1])
PCM/NRZ/PM (Data rates to 12 Msps)
PCM/Bi-Ph/PM (a.k.a. Manchester) (Data rates to 6 Msps)
BPSK (Data rates to 12 Msps)
QPSK (Data rates to 12 Msps)

TELECOMMAND

PCM/PSK/PM (Data rates to 4 kbps on 16 kHz sinewave subcarrier)
PCM/Bi-Ph/PM (Data rates to 64 kbps, CCSDS 401 (2.2.7) B-1)

NASA-2: DSN Ranging and Radio Metric Systems

a) Ranging Decision Status

Since currently there are no CCSDS earth station ranging equipment Recommendations, there is no issue of compliance. Currently, the DSN has sequential, square wave deep space ranging systems at all stations. Some stations (26M, 34M HSB) also have the GSFC Sidetone ranging equipment; however, these are in the process of being de-commissioned.

The DSN is fully compliant with CCSDS Recommended transponder turnaround ratios. In fact, Block V receivers, present in DSN 34M and 70M stations, can handle any turnaround ratio.

b) Ranging Implementation Plans

At some future time, when a very deep space mission (≥ 30 AU) requires it because the inverse fourth power losses are too great, a Pseudo Noise (PN) ranging system may be implemented which will enable the use of a code reconstructing transponder on a spacecraft.

c) Ranging Implementation Status

Sequential ranging and Sidetone ranging equipment currently exist, but the Sidetone system will be decommissioned in the future. A code reconstructive transponder using a PN code will be implemented for the New Horizons mission and will become operational when the mission passes Jupiter in February 2007

1) Doppler and Delta DOR Decision Status

A decision was made several years ago that the DSN will collect both Doppler and Delta-DOR data. With regard to Doppler, the DSN captures both 2-way (1-station coherent) and 3-way (1-station coherent and a second station non-coherent) data. 1-way (non-coherent) Doppler data is discouraged for deep space missions unless the spacecraft's ultra stable oscillator is exceptionally good (Hydrogen Maser stability). Delta-DOR has been in use in the DSN for several years and the DSN maintains a catalog of Quasars for navigational use.

2) Doppler and Delta-DOR Implementation Plans

2, 7/8, and 7/32 GHz Doppler data exists and will remain a DSN capability indefinitely. X-band Delta-DOR is currently implemented and the DSN is in the process of implementing a like capability at 32 GHz.

3) Doppler and Delta-DOR Implementation Status

Both systems exist throughout the DSN today and are in regular use. Beginning with the Mars Recognizance Orbiter (MRO) the DSN Delta-DOR accuracy will be 5 nano radians at X-band. The KA Band system, when implemented, is expected to have a somewhat higher accuracy.

NASA-3: DSN Space Link Protocols

a) Decision Status

Missions planning to use the DSN must employ CCSDS Packet telemetry protocols on their telemetry streams. The DSN supports both the CCSDS Conventional and AOS recommended standards. Projects should use virtual channels in lieu of subcarrier data separation whenever possible. In compliance with SFCG Recommendation 23-1, mission subcarrier frequencies should not exceed 300 kHz, absent a compelling technical reason. For higher data rate missions, the CCSDS File Delivery Protocol (CFDP) is the preferred method for transferring data between a spacecraft and the DSN.

b) Implementation Plans

The capabilities described above have been implemented.

c) Implementation Status

The capabilities described above have been implemented.

NASA-4: DSN Coding and Synchronization

a) Decision Status

The DSN is compliant with CCSDS Coding Recommendations for deep space missions. Bit synchronization is accomplished with a Digital Transition Tracking Loop (DTTL) synchronizer. It is based on a squarewave bit model and will have to be modified or replaced when bandwidth-efficient modulation is implemented. Early development work on a Maximum A Posteriori (MAP) synchronizer showed great promise, but a decision to develop these devices to replace DTTL synchronizers has not been made.

b) Implementation Plans

Investigations and research is underway to develop rate = 1/2 Low Density Parity Check (LDPC) codes. Current plans are to maintain DTTL synchronizers indefinitely.

c) Implementation Status

Currently, the DSN has the following decoding capabilities in its stations Rate = 1/2, 1/3, 1/4, and 1/6; with Constraint Lengths up to 15. However, the MCD-3, which provides many of these capabilities, will be decommissioned in the future. Therefore, the longer term plan is to provide the following decoding capabilities.

Convolutional (CCSDS R = 1/2,; k = 7)
Reed Solomon (CCSDS 255/223)

Concatenated Convolutional / Reed Solomon
Turbo Coding
 Frame Sizes 1784, 3568, 7136, and 8920
 Rates 1/2, 1/3, 1/4, and 1/6
LDPC Rate _ (around 2009)

A DTTL symbol synchronizer is contained in all Block V and MFR receivers.

NASA-5: DSN Ground Communication Services

a) Decision Status

NASCOM blocks are being retained for data exchange with those organizations that have failed to modernize their interfaces. However, most ground communications utilize TCP/IP as the preferred protocol. CCSDS File Delivery Protocol (CFDP) is the preferred method to transfer data from spacecraft to the DSN whereafter a File Delivery Protocol will be used to route data from the DSN to the Mission's Operation Control (MOC) Center. The DSN plans to implement a full CFDP system for the JWST mission. Currently, the DSN has implemented a basic CFDP system.

b) Implementation Plans

NASCOM, TCP/IP, are implemented and work is underway to develop and implement CFDP for JWST. CFDP/FTP are the planned protocols for the future

c) Implementation Status

Currently, the DSN provides NASCOM blocks and TCP/IP communication protocols. A basic CFDP system has been implemented for MRO.

NASA-6: DSN Telemetry Data Transfer Services

a) Decision Status

In the year 2000, it was decided that the CCSDS Space Link Extension (SLE) services interface would become the standard interface for DSN support of ESA's Integral mission. Since then, several IOAG agencies have implemented SLE and it is now the standard interface between the DSN and both ESA and JAXA. An SLE services interface has been used for support of ESA's Integral mission for several years.

Initially, the telemetry SLE interface was placed at JPL's Control Center; however, plans are underway to place these interfaces at each of the three Earth station complexes operated by the DSN as originally intended by the CCSDS in 2008.

b) Implementation Plans

Service Management is a high priority item and will be implemented when the CCSDS specification has matured. Rosetta and Muses-C will provide flight demonstrations.

c) Implementation Status

SLE RAF, and RCF services are currently operational and supporting missions. The DSN has implemented both Provider and User APIs for RAF and RCF, services. Other services will follow when their respective CCSDS specification is complete.

NASA-7: DSN Telecommand Data Transfer Services

a) Decision Status

Like the SLE services interface for telemetry, a decision was made in the year 2000 to support ESA's Integral mission with an SLE telecommand services interface. The CLTU service was implemented and is providing support today.

b) Implementation Plans

CLTU service is currently implemented in DSN stations.

c) Implementation Status

The CLTU provider service is currently operational at DSN stations.

NASA-8: DSN Predicted Trajectory Data

a) Decision Status

Spacecraft Ephemeris Message (EPM) and Orbit Ephemeris Message (OEM) are currently implemented in the DSN. EPM will be decommissioned sometime in 2009. Currently, there are no plans to implement either the Orbit Data Message (ODM) or the Orbit Parameter Message (OPM)

b) Implementation Plans

EPM and OEM are currently implemented; however, EPM will be decommissioned in the future, probably in 2009. There are no plans to implement either ODM or OPM.

c) Implementation Status

EPM and OEM are currently implemented at DSN stations.

NASA-9: DSN Space Data Packaging

a) Decision Status

One or more files of Mete-Data are included with other information from DSN stations. These data describe the conditions that existed during the capture of telemetry data.

b) Implementation Plans
Meta-Data is currently provided to investigators.

c) Implementation Status
Meta-Data accompanies the telemetry data and includes: navigation, timing, spacecraft pointing, instrument events, data quality, etc.

NASA-10: DSN Reliable Data Delivery

a) Decision Status
Data accountability and reliable data delivery are very high priority items for the DSN. A decision has been made that both are required services which must be provided. Reliable data delivery will be based upon CFDP while data accountability is on top of CFDP.

b) Implementation Plans
CFDP exists in the DSN at this time. The DSN will add data accountability in the near future (2007).

c) Implementation Status
CFDP exists in the DSN at this time. Projects (Deep Impact, Messenger, JWST, MRO etc.) are using or are planning to use CFDP. Data accountability will be added in the near future.

NASA-S: DSN Summary Schedule
See schedule on following two pages.

IOAG ROADMAP – NASA DSN

1	**RF & Modulation**	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Remarks
1a	RF & Mod Frequency Stds.												SR 2, 7, 8,32 GHz
1b	RF & Mod Frequency Stds.(26 GHz)												Based on 26 GHz LRO Requirement
1c	RF & Mod HEDS Frequencies												37-38; 40.0-40.5 GHz
1d	Telemetry Demodulation, Conv.												
1e	Bandwidth-Efficient Mod (GMSK)												Earlier if DSN Supports Hershall Plank
1f	Command, Conventional												PCM/PSK/PM, 4 kbps; 16 KHz Subcarrier
1g	Command, Medium Rate												
2	**Ranging & Radio Metric**												
2a	Sequential Ranging System												2 MHz > 1 Hz Codes sequentially Transmitted
2b	Side Tone Ranging System												Terminated When Close 26 M Stations
2c	Earth Station Group Delay Stability												CCSDS Rec 401 (2.5.2B)
2d	S/C Group Delay Stability												CCSDS Rec 401 (2.5.3B)
2e	Ranging Transponder Bandwidth												CCSDS 401 (2.5.4B)
2f	Pseudo-Noise Ranging (Regen.)												
2g													
2h													
3	**Space Link Protocols**												
3a	SCPS Network Protocol												CCSDS 713.0-B-1
3b	SCPS Security Protocol												CCSDS 713.5-B1
3c	SCPS Transport Protocol												CCSDS 714.0-B-1
3d	SCPS File Protocol												CCSDS 717.0-B-1
3e													
3f													
3g													
3h													
4	**Coding and Synchronization**												
4a	Convolutional (R=?, k=7)												CCSDS 101.0-B-6
4b	Reed-Solomon (255/223)												CCSDS 101.0-B-6
4c	Turbo (1784, 3568, 7136, 8290)												CCSDS 101.0-B-6
4d	Low Density Parity Check												
4e	Synchronization (Frame)												CCSDS 131.0-B-1
4f	De-Randomizer												CCSDS 131.0-B-1
4g													
4h													
5	**Ground Communications Serv.**												
5a	SLE Return All Frames												CCSDS 911.1-B-2
5b	SLE Return Channel frames												CCSDS 911.2-B-1
5c	SLE Forward CLTU Serv.												CCSDS 912.1-B-2
5d													
5e													
5f													
5g													
5h													

Development
Qualification
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IOAG ROADMAP – NASA DSN

		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Remarks
6	**Telemetry Data Transfer Serv.**												
6a	Telemetry, Packet Telemetry												CCSDS 102.0-B-5
6b	Telemetry, Advanced Orbiting Sys												CCSDS 701.0-B-3
6c	Telemetry, Packet Serv. Spec.												CCSDS 103.0-B-2
5d	Telemetry, Space Data Link												CCSDS 132.0-B-1
6e	Telemetry, Space packet												CCSDS 133.0-B-1
6f	CCSDS File Delivery Protocol												cads 727.0-B-2
6g													
7	**Command Data Transfer Serv.**												
7a	Command, Channel Serv.												CCSDS 201.0-B-3
7b	Command, Data Routing Serv.												CCSDS 202.0-B-3
7c	Command, Operation Procedures												CCSDS 202.1-2-B-2
7d	Command, Data Management Serv.												CCSDS 203.0-B-2
7e													
7f													
7g													
7h													
8	**Predicted Trajectory Data**												
8a	S/C Ephemeris Message (EPM)												Discontinued in 2009
8b	Orbit Ephemeris Message (OEM)												
8c	Orbit Data Message (ODM)												No plans to implement
8d	Orbit Parameter Message (OPM)												No plans to implement
8e													
8f													
8g													
8h													
9	**Space Data Packaging**												
9a	Meta-Data												
9b													
9c													
9d													
9e													
9f													
9g													
9h													
10	**Reliable Data Delivery**												
10a	CFDP												CCSDS 727.0 B-3
10b	Data Accountability												
10c													
10d													
10e													
10f													
10g													
10h													

Development
Qualification
Operational

ANNEX-6 – NASA INFUSION PLAN AND ROADMAP - GN

NASA-1: GN RF & Modulation

a) Decision Status

The GN uses VHF, UHF, L, S, C, and X-Bands & PCM, PM, AM, FM, BPSK, and QPSK modulations. GN shall consider Ka-Band and bandwidth efficient schemes of GMSK, FQPSK and optical communication as mission requirements develop for additional ground to space interfaces.

b) Implementation Plans

X-Band Uplink & Ka-Band Downlink: X-Band uplink has been implemented at McMurdo Ground Station (MGS). Three Ka-Band and S-Band ground stations are currently being implemented for the LRO and SDO missions.

b) Implementation Status

System design and procurement have occurred; assembly and integration are in progress.

NASA-2: GN Ranging

a) Decision Status

The GN uses CCDSS Standards for one or two way Doppler Tracking/Ranging (coherent or non-coherent). GN shall consider other CCSDS emerging standards for regenerative standards and Delta DOR (Differential One-Way Ranging) as mission requirements develop for additional ground to space interfaces.

b) Implementation Plans

None.

c) Implementation Status

None.

NASA-3: GN Space Link Protocols

a) Decision Status

The GN uses CCSDS Standards for Telemetry and Telecommand Packets and AOS (Advance Orbiting System) virtual channels. Additional standards may be evaluated as mission requirements develop for additional ground to space interfaces.

b) Implementation Plans

None.

c) Implementation Status

None.

NASA-4: GN Coding and Synchronization

a) Decision Status

GSFC missions use CCSDS Standards of Convolutional Viterbi (length = 7 with rate of _) and Reed Solomon (255; 223). GN shall consider CCSDS existing standards of Turbo Coding and LDPC (Low Density Priority Coding) as mission requirements develop for additional ground to space interfaces.

b) Implementation Plans

None.

c) Implementation Status

None.

NASA-5: GN Ground Communication Services

a) Decision Status

TCP/IP protocol and FTP file transfer services are in place for ground to ground communications. NASA is planning to transition to IPv6.

b) Implementation Plans

Not applicable.

c) Implementation Status

Not applicable.

NASA-6: GN Telemetry Data Transfer Services

a) Decision Status

GN shall consider CCSDS SLE Standards for RAF (Return All Frame) and RCF (Return Channel Frame) as mission requirements develop for additional telemetry data transfer services.

b) Implementation Plans

GSFC Network Integration Center plans to implement SLE for testing with DSN as well as other organizations using SLE.

c) Implementation Status
GN MOSAR system has been evaluating products for SLE implementation.

NASA-7: GN Telecommand Data Transfer Services

a) Decision Status
GN shall consider CCSDS SLE Standards for CLTU as mission requirements develop for additional ground to ground cross support service interfaces.

b) Implementation Plans
GSFC Network Integration Center plans to implement SLE for testing with DSN as well as other organizations using SLE.

c) Implementation Status
GN MOSAR system has been evaluating products for SLE implementation.

NASA-8: GN Predicted Trajectory Data

a) Decision Status
CCSDS Standards of ODM (Orbital Data Message) are in place for mission operation service for ground to ground interfaces. No decision for other CCSDS standard adoption, i.e.; SLE.

b) Implementation Plans
None.

c) Implementation Status
None.

NASA-9: GN Space Data Packaging

a) Decision Status
No decision has been made whether or not to adopt XML in the current missions for Web based documentation. Future missions such as JWST and LRO are planning to use XML for information management services in ground to ground interface.

b) Implementation Plans
None.

c) Implementation Status
None.

NASA-10: GN Reliable Data Delivery

a) Decision Status
No decision has been made whether or not to adopt CCSDS CFDP (CCSDS File Delivery Protocol) for the current missions. Future missions JWST and LRO are planning to use CFDP for space to ground file delivery.

b) Implementation Plans
None.

c) Implementation Status
None.

IOAG ROADMAP - NASA GN

NASA-S: GN Summary Schedule

Development | Qualification Tests | In Operations

No.		2004				2005				2006				2007				2008				2009				2010				2011				2012				2013			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	**RF & Modulation**																																								
1a	CCSDS Standards																																								
1b	Ka -band																																								
1c	Component 3																																								
2	**Ranging**																																								
2a	CCSDS Standards																																								
2b	Component 2																																								
2c	Component 3																																								
3	**Space Link Protocols**																																								
3a	CCSDS Packet Telemetry																																								
3b	CCSDS Packet Telecommand																																								
3c	Component 3																																								
4	**Coding and synchronization**																																								
4a	CCSDS – Convolution Coding																																								
4b	CCSDS - Reed Solomon																																								
4c	Component 3																																								
5	**Ground Communication Services**																																								
5a	TCP/IP																																								
5b	FTP																																								
5c	IPv6																																								
6	**Telemetry data transfer services**																																								
6a	CCSDS - SLE - RAF																																								
6b	CCSDS - SLE - RCF																																								
6c	Component 3																																								

NASA-S: GN Summary Schedule *(continued)*

Development | Qualification Tests | In Operations

		2004				2005				2006				2007				2008				2009				2010				2011				2012				2013			
		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
7	**Telecommand data transfer services**																																								
7a	SLE - CLTU																																								
7b	Component 2																																								
7c	Component 3																																								
8	**Predicted trajectory data**																																								
8a	CCSDS - ODM																																								
8b	Component 2																																								
8c	Component 3																																								
9	**Space Data Packaging**																																								
9a	XML																																								
9b	Component 2																																								
9c	Component 3																																								
10	**Reliable Data Delivery**																																								
10a	CCSDS - CFDP																																								
10b	Component 2																																								
10c	Component 3																																								

ANNEX-6 – NASA INFUSION PLAN AND ROADMAP - SN

The SN is comprised of nine TDRS GEO satellites (TDRS 1, 3-10) operating at three longitudinal nodes: East Nodes (041W, 046W, 049W), West Nodes (171W, 174W), and Zone of Exclusion (ZOE-275W) using three Ground Terminals (GT's); WSGT/WART and STGT located in New Mexico at the White Sands Complex (WSC) and GRGT located on Guam. Each WSC GT (WSGT/WART and STGT) has three Space-to-Ground-Link Terminals (SGLT's) providing user services for a total of six WSC SGLT's. GRGT has one full SGLT with a backup SGLT (RF antenna system only, no user services) currently being installed. The SN maintains TDRS orbital positioning using its S-Band tracking services with the world wide Bilateral Ranging Transponder System (BRTS). Both TDRS and customer tracking services provide orbital ephemerides through the processing performed by the Flight Dynamic Facility (FDF) at GSFC. SN has simulation services using End-to-End (ETE) systems at WSC and Guam to conduct user and service testing.

NASA-1: SN RF & Modulation

a) Decision Status

The SN is compliant with RF frequency standards of the ITU, SFCD, and CCSDS. Modulation/Demodulation systems for the basic S-Band (MA and SSA) and K-Band (Ku and Ka) services are compliant with CCSDS recommendations.

1) SN has implemented, via SSAF service, a GN Mode of commanding (direct modulation and subcarrier) for lower data rates given the GEO space loss involved.

2) SN has implemented an MAR Demand Access Service capability that provides global coverage for up to 6 simultaneous user (expandable to 50).

3) The Guam (GRGT) SGLT is not able to support any Ka services and is not intended to be upgraded.

4) Although TDRS 8-10 spacecrafts have a single 650 MHz KSAR channel capability for supporting much higher data rates, there is no SN or user requirements to upgrade the SN ground terminal receiver equipment to accommodate a 650 MHz service channel. However, a 650 MHz KuSAR and KaSAR IF service has been implemented that will allow future feasibility demonstrations and testing to be performed.

b) Implementation Plans

There are many CCSDS bandwidth-efficient modulation types, to numerous to implement in total.

1) The SN is currently considering upgrading the TDRSS KSAR ground terminal services (TDRSS KSAR Upgrade - TKUP Project) to increase the 225 MHz KSAR service channel for higher data rate allowing usage via any TDRS. There are no current CCSDS modulation/coding recommendations for the K-Band frequency. The SN will evaluate using SQPSK & 8-PSK with TPC & LDPC (see NASA-4, SN Coding and Synchronization below) up to 650 Mbps.

2) Upgrade planned for KuSAF and KaSAF service to support Telecommanding data rates from 7 Mbps to 25 Mbps.

3) An MA Fast Forward (MAFF) capability is being considered for implementation. MAFF will be a data driven, store/forward telecommand system available on demand for user service via MAF and SMAF.

NOTE: SN Expansion (SNE) is being implemented at Guam to add another SGLT. SNE SGLT user services will not be available to IOAG members.

c) Implementation Status

1) TKUP feasibility demonstration is to be performed and evaluated done in summer of 2006. After deciding which modulation and coding scheme is best to implement, installation completion is not anticipated until September 2008.

2) KSAF upgrade (7-25 Mbps) has no current requirements or schedule.

3) MAFF will have an SN Operational Concept review in July 2005. Currently, there are no users or schedule.

NOTE: At GRGT, SNE and the backup SN SGLT (RF antenna system only) should be completed in late 2006.

TELECOMMAND CAPABILITY

1) PCM/PSK/QPSK (SN Mode)

- MAF, MAFF, SSAF, KuSAF, KaSAF - PN Spread Unbalanced (10dB) QPSK.

I-Chnl - PSK telecommand data rates .1 to 300 kbps,

Q-Chnl - 3 Mcps PSK PN code is used for ranging.

2) PCM/PSK/BPSK (SN Mode)

- SSAF - Non-PN Spread (Q-Chnl PN disabled). Telecommand data rates 300 kbps - 7 Mbps

- KuSAF, KaSAF - Non-PN Spread (Q-PN disabled). Telecommand data rates 300kbps - 7 Mbps (25 Mbps planned)

3) PCM/PM - Direct Carrier PSK Modulation (GN Mode)

- SSAF - NRZ - L, M, S. Data rates 0.125 kbps to 1 Mbps

Biphase - L, M, S. Data rates 0.125 to 500 kbps

4) PCM/PSK/PM - Subcarrier frequencies of 2, 4, 8, or 16 kHz (GN Mode)

- SSAF - NRZ-L, M, S. Data rates 0.125 kbps to 8 kbps

Biphase - L, M, S. Data rates 0.125 to 4 kbps

TELMETRY CAPABILITY

NOTE:
Date Group 1 (DG1) TDRSS RF signals are PN Spread (3 Mcps).
Data Group 2 (DG2) TDRSS RF signals are non-PN Spread.

TDRSS PN Codes supported are defined in PN Code-SNIP, Rev 1, Dated Nov 1998. All PN gold codes for NASA/ESA/NASDA in SNIP document are supported by TDRSS.

All TDRSS Return links support BPSK, SQPSK, SQPN and QPSK modulation and use NRZ and Biphase data formats to achieve the maximum data rates defined below (Refer to SN Users Guide - Rev 8 for more details).

MA Service

MAR - TDRS 1-7, DG1, Modes 1&2, Rate 1/2 Viterbi coding - up to 300 kbps

SMAR - TDRS 8-10, DG1 and DG2, Modes 1&2, Rate 1/2 and 1/3 Viterbi coding - up to 3 Mbps (Rate 1/2)

DAS - MAR service, DG1, Mode 2 only, Rate 1/2 Viterbi coding - up to 150 kbps on each channel (I/Q)

SSA Services

SSAR - TDRS 1&3-10, DG1 and DG2, Modes 1, 2&3, Rate 1/2 and 1/3 Viterbi coding - up to 6 Mbps (Rate 1/2)

KSA Services

KuSAR - TDRS 1&3-10, DG1 and DG2, Modes 1&2, Rate 1/2 Viterbi coded & uncoded - to 300 Mbps (uncoded)

NOTE: GRGT can support KuSAR up to 150 Mbps.

KaSAR - TDRS 8-10, DG2, non-coherent, Rate 1/2 Viterbi coded & uncoded - to 300 Mbps (uncoded).

NOTE: A 650 MHz KaSAR IF service is installed at WSC SGLT's for possible data rates up to 850 Mbps.

NASA-2: SN Ranging

a) Decision Status

1) The GSFC FDF processes all TDRSS Range and Doppler tracking data to derive ephemerides and provides user State Vectors for operational use by the SN and user projects with distribution to most all world wide trackers.

2) The SN, for DG1 Modes 1&3 (coherent transponder modes), uses the PN Code Epoch to measure 2-Way (Forward and Return) Ranging for users. KaSA service does not provide a Ranging service. SN is CCSDS compliant with recommended transponder turnaround ratios (S-Band 240/221, Ku-Band 1600/1469).

3) Doppler service, for DG1 and DG2, is frequency difference between the return carrier frequency received and a scheduled reference frequency. Both 2-Way coherent and 1-Way non-coherent Doppler measurements are provided for all SN services.

4) SN uses the six SNIP/SFCG recommended center frequencies for KaSA forward service to constrain spectrum use from 22.55 to 23.55 GHz.

5) SN also provides 2-way Time Transfer (UTC and a user spacecraft clock time difference), and 2-way/1-way Return Channel Time Delay (RCTD) measurements.

b) Implementation Plans

SN is considering providing a full period MAF broadcast Beacon (TDRSS Augmentation Service for Satellites - TASS Project). This joint venture with JPL will provide a differenced GPS S-Band beacon signal derived from NASA's Global Differential GPS System (GDGPS). A special GPS receiver, adding the TDRSS MAF Beacon receiver channel, would be required for users to obtain higher accuracy GPS derived position information. Centimeters of user onboard position accuracy is anticipated. There appears to be no current CCSDS standard for this type of service.

c) Implementation Status

SN has committed to a 1 year TASS Demonstration using TDRS-1 (046W) planned for calendar year 2006. Beyond this TASS Demo period the SN has no permanent TASS Beacon requirement.

NASA-3: SN Space Link Protocols

a) Decision Status

1) Currently new users planning SN support should employ CCSDS Packet telemetry protocols. The SN supports the CCSDS recommended conventional standards (no AOS support). Virtual channels should be used for telemetry data separation. Both SN I&Q channels can be used to transmit independent data streams as desired.

2) The SN sponsored and successfully supported the CANDOS experiment on the STS-107 mission that demonstrated the SN ability to support the Mobile IP protocol. The NISN portion of the Mobile IP capability is still available for use, but the SN and GN CANDOS support equipment capability was removed.

b) Implementation Plans

After CANDOS support in 2003, the SN has been studying various methods for implementing a permanent IP in Space capability (SN IP in Space - SNIS Project) for communications. SNIS Project is working close with spacecraft builders at GSFC who are pursuing IP C&DH systems on-board spacecrafts. The SNIS Project and NISN are investigating two TDRSS/NISN architectures both using HLDC and Mobile IP protocols to support lower data rate (<10 Mbps) users via TDRSS S-Band (MA, DAS, SSA) and K-Band (KSA) services. End-to-End IP in Space demonstrations at GSFC were successfully completed in June 2005 using a prototype SNIS and a hardened spacecraft capability. SNIS SRR was completed in March 2005. SNIS Project was put on hold in July 2005, just prior to PDR, lacking users and funding to proceed.

c) Implementation Status

SNIS implementation has no schedule.

NASA-4: SN Coding and Synchronization

a) Decision Status

1) Currently, the SN has the following TDRSS decoding capability at WSC/GRGT.

2) Convolutional (CCSDS R=1/2; k=7), R=1/3; k=7

3) Reed Solomon (CCSDS 255,223) for WDISC users only (done in software for low data rates)

4) Concatenated Convolutional Rate 1/2 (inner code)/Reed Solomon (255,223) R-S outer code

NOTE: Periodic Convolutional Interleaving (PCI), not currently CCSDS recommended, is recommended for S-Band user with concatenated coding with data rates >300 kbps.

b) Implementation Plans

The SN TKUP project has planned a feasibility evaluation demonstration of the Ku/KaSAR 225MHz channels ability to support:

1) SQPSK/Rate 7/8 - Turbo Product Code (TCP) and Low Density Parity Check (LDPC) - 150 Mbps to 410 Mbps

2) 8-PSK/Rate 7/8 - Turbo Product Code (TCP) and Low Density Parity Check (LDPC) - 150 Mbps to 625 Mbps

c) Implementation Status

TKUP feasibility demonstration is to be performed and evaluated done in summer of 2006. After deciding which modulation and coding scheme is best to implement, installation completion is not anticipated until September 2008.

NASA-5: SN Ground Communication Services

a) Decision Status

NASCOM 4800 bit blocks are being retained for data exchange for older NASA user control centers that have not modernized their interfaces. NISN SN ground communications use three distinct IP based networks (Closed-IONet, Open-IONet, and Restricted-IONet) depending upon security requirement needs. Circuits to users now utilize IP protocols (TCP or UDP). The SN is encapsulating in IP packets, as needed, any 4800BB traffic until older users upgrade to TCP/IP or their project terminates. Newer customers are required to use TCP/IP protocols. The SN does not currently support FPT interfaces for operational command and telemetry data via NISN IONet's. SN has six basic ground communications interface capabilities:

1) MDM/IONet - 7 Mbps per channel with Line Outage Recording (LOR) capability

2) High Data Rate Service - 48 Mbps per channel with LOR between 1.5-50 mbps

3) Local Interfaces (LI's) - 7 Mbps Forward, 300 Mbps Return

4) WDISC - 50 kbps Forward/per channel, 512 kbps Return/per channel with LOR capability

5) DAS (Demand Access Service) - 150 kbps Return/per channel with LOR capability

6) IF Service - operate at 370 MHz up to max TDRSS 300 Mbps data rates, except for KaSA return 650 MHz IF service that operates at 1.2 GHz.

b) Implementation Plans

c) Implementation Status

NASA-6: SN Telemetry Data Transfer Services

a) Decision Status

1) The SN WDISC uses TCP/IP protocols and has 12 channels from all WSC/GRGT ground terminals available for Telemetry. The 12 Return channels are capable of 512 kbps to meet current transfer requirements. Six of the WDISC Return channels are capable of 5 Mbps, but there is no requirement for rates beyond 512 kbps to be supported.

2) DAS uses TCP/IP protocols and has 6 service channels for each of three TDRS nodes that provide global coverage.

3) The SN has not committed to supporting CCSDS Space Link Extension (SLE) services.

b) Implementation Plans

The SN will participate in an SLE capability demonstration after the Roadrunner spacecraft is launched (mid 2006). A minimal SN SLE capability (RAF) for telemetry will be temporary implemented at one SGLT and then removed. There is no user requirement or funding to implement a permanent SN SLE capability.

c) Implementation Status

SN SLE Roadrunner Demonstration will occur in 2007.

NASA-7: SN Telecommand Data Transfer Services

a) Decision Status

1) The SN WDISC uses TCP/IP protocols and has 12 channels to all WSC/GRGT ground terminals available for Telecommand. 12 Forward channels are capable of 56 kbps to meet current transfer requirements. Six of the WDISC Forward channels are capable of 5 Mbps, but there is no requirement for rates beyond 56 kbps to be supported.

2) The SN has not committed to supporting CCSDS Space Link Extension (SLE) services.

b) Implementation Plans

c) Implementation Status

NASA-8: SN Predicted Trajectory Data

IOAG ROADMAP - NASA SN

a) Decision Status

b) Implementation Plans

c) Implementation Status

NASA-9: SN Space Data Packaging

a) Decision Status

b) Implementation Plans

c) Implementation Status

NASA-10: SN Reliable data delivery

a) Decision Status

b) Implementation Plans

c) Implementation Status

NASA-S: SN Summary Schedule

To be developed.

IOAG ROADMAP - NASA SN

No.		2004				2005				2006				2007				2008				2009				2010				2011				2012				2013			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	**RF & Modulation**																																								
1a	Component 1																																								
1b	Component 2																																								
1c	Component 3																																								
2	**Ranging**																																								
2a	Component 1																																								
2b	Component 2																																								
2c	Component 3																																								
3	**Space Link Protocols**																																								
3a	Component 1																																								
3b	Component 2																																								
3c	Component 3																																								
4	**Coding and synchronization**																																								
4a	Component 1																																								
4b	Component 2																																								
4c	Component 3																																								
5	**Ground Communication Services**																																								
5a	Component 1																																								
5b	Component 2																																								
5c	Component 3																																								
6	**Telemetry data transfer services**																																								
6a	Component 1																																								
6b	Component 2																																								
6c	Component 3																																								

Development
Qualification tests
In operations

IOAG ROADMAP - NASA SN