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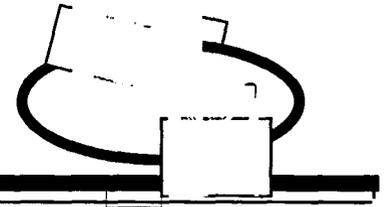
Introduction to Standardized Spacecraft Onboard Interfaces

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**Joseph F. Smith
Jet Propulsion Laboratory/Caltech
NASA/US Rapporteur to CCSDS SOIS Work Area
1-818-354-3328
joseph.f.smith@jpl.nasa.gov**

with

**Chris Plummer, Cotectic Ltd, Overijse, Belgium
Patrick Plancke, ESA ESTEC, Noordwijk, Netherlands**



Agenda

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- **CCSDS Missions**
- **Overview of SOIS**
- **SOIS Standard Services in the Reference Model**
- **SOIS Services**
 - **Message Transfer Service**
 - **File Transfer Service**
 - **CCSDS Packet Service**
 - **Command and Data Acquisition Service**
 - **Time Distribution Service**
 - **Plug & Play Service**
- **Two Paths from the Services to the Data Link Layer**
- **Conclusions**

A View of a Space Data System Themes

5. Develop Interoperable Spacecraft Onboard Interfaces

❖ "Network Ready" and "Plug & Play" Space Devices, Subsystems, and Instruments

4. Develop Space Missions as Extensions of the Earth's Internet

Interface with Near-Earth Constellations
Interface with Commercial Near-Earth Navigation Systems
Interface with Public Media Distribution Systems
Extension of the Internet into Near-Earth Vicinity
 ❖ *Extension of the Internet into Deep Space*

3. Develop Standard Mission Operations Services

Space Link Access
Spacecraft Monitor and Control
 ❖ *Ground System M&C Service Requests*
 ❖ *Tracking and Navigation Services*
Mission Planning Services
Telecommunications Services

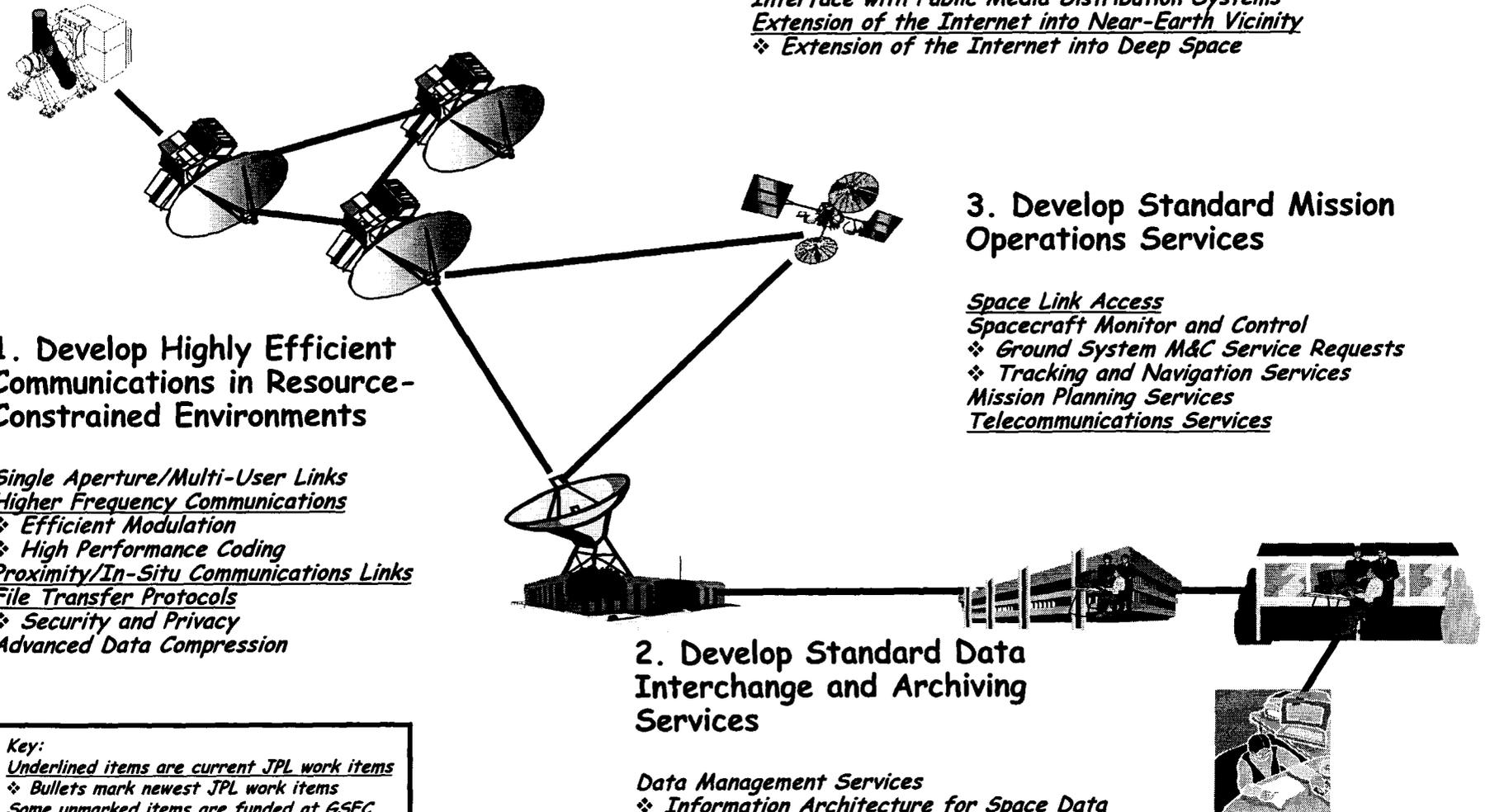
1. Develop Highly Efficient Communications in Resource-Constrained Environments

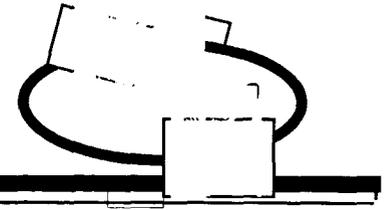
Single Aperture/Multi-User Links
Higher Frequency Communications
 ❖ *Efficient Modulation*
 ❖ *High Performance Coding*
Proximity/In-Situ Communications Links
File Transfer Protocols
 ❖ *Security and Privacy*
 ❖ *Advanced Data Compression*

2. Develop Standard Data Interchange and Archiving Services

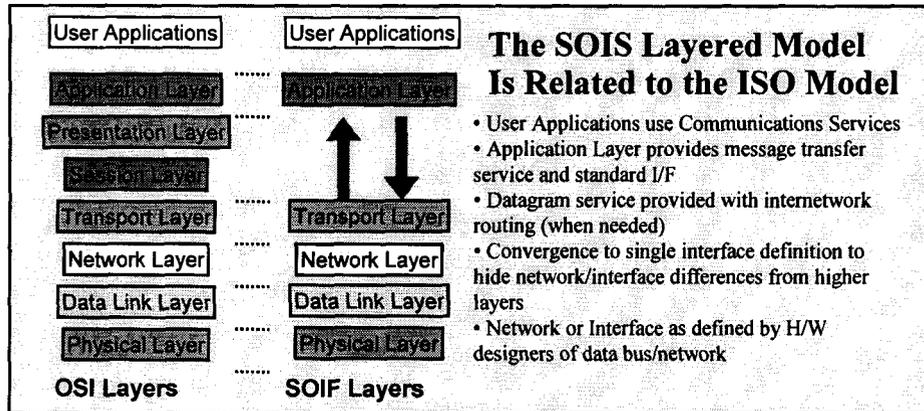
Data Management Services
 ❖ *Information Architecture for Space Data*
Space Data Archiving Techniques

Key:
Underlined items are current JPL work items
 ❖ *Bullets mark newest JPL work items*
 ❖ *Some unmarked items are funded at GSFC*





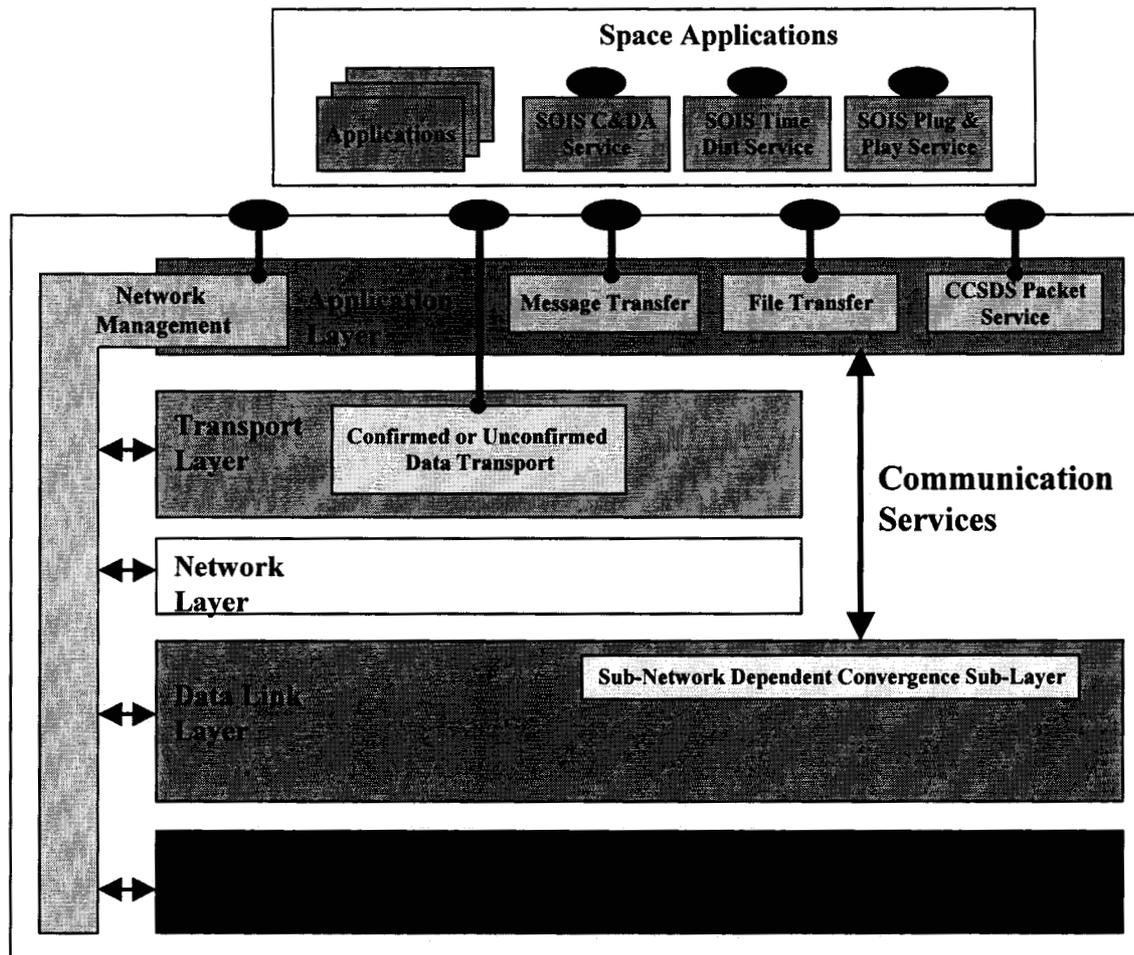
Overview of SOIS



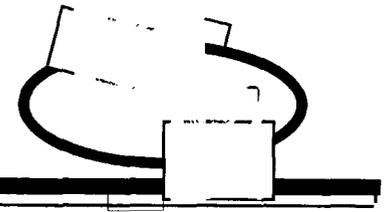
- **Standardized spacecraft interfaces should lead to:**
 - Plug and play components, devices, and sensors
 - Reduced development costs and risks
 - Shorter development times
 - Shorter spacecraft integration time
 - Shared design and test documentation
 - Increased reuse of flight equipment, including instruments
 - Increased reuse of test equipment
 - Increased quality of flight and test equipment
 - Development of standard components
 - Second-sourcing of flight and test equipment
 - Potential for secondary or “quick ride” payload opportunities
 - Easier adoption of new and evolving technologies
 - Hardware and Software upgrades
 - Autonomy
 - Vehicle Health Management
- **SOIS could impact all areas of spacecraft avionics development, including the hardware, software, and the test environment**



Standard Services in the SOIS Reference Model

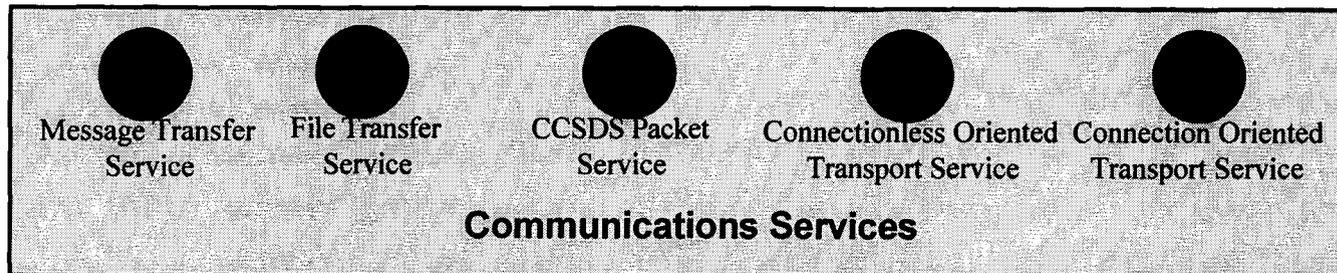
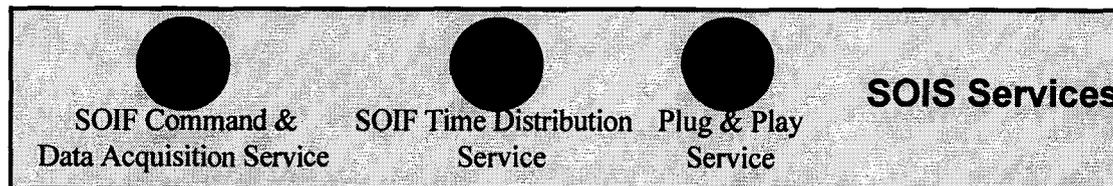


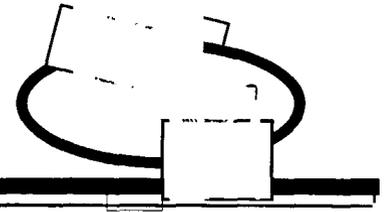
- **SOIS has two types of standard services, located in the Transport, Application, and Space Application Layers**
- **The SOIS Services are located in the Space Applications Layer, and provide enhanced capabilities for the applications**
- **Communications Services are located in the Application Layer**
- **Transport Layer services not fully covered in this paper, since they are beyond the scope**



SOIS Services Provided

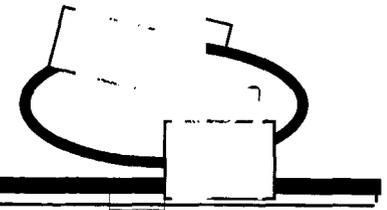
- There are two classes of services provided to SOIS users for the movement of data onboard the spacecraft
 - SOIF Services provide for the transport of specific data types for specific uses that are commonly required for spacecraft applications
 - Communications Services move generic data for any generic use
- These services can be used to move data off of the spacecraft
 - These services can also be used to move data to other nearby spacecraft that are part of a constellation, formation flying, or co-operating
- The SOIF services are dependent on the communications services in order to provide the required capabilities to the User





The SOIS Reference Model layers are directly related to the ISO OSI Model

- **The Space Applications Layer contains the applications (users) and access to SOIS spacecraft user services**
- **Applications Layer is used to provide common message transfer, file transfer, and CCSDS packet transfer services to the User Application Services**
- **The Transport and Network Layers provide communications protocols to the higher services**
 - **Transport Layer provides connection and connectionless services**
 - **Network Layer provides inter-network services**
- **The Data Link and Physical Layers are the different busses and networks moving bits & words around the S/C**
 - **Data Link Layer also interfaces with the underlying bus/network**
 - **For inter-S/C applications the Data Link will be one of the space link protocols, such as Proximity-1**
- **SOIS Network Management is an application, which has access to the internals of the layers “on the side” to manage the layers**



Application Layer: Message Transfer Service

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- **The Message Transfer Service (MTS) mediates the transfer of data between application processes**
 - **Between different onboard processes**
 - **In different processors, or**
 - **Within the same processor**
 - **MTS is an application layer service**
 - **Operates in a distributed space environment (usually space-to-space, but can be used space-to-ground)**

- **The MTS is an API that contains common functions for message transfer, and for Quality of Service (QoS) management**

- **MTS sits within the Application layer**
 - **Makes use of the Transport Layer of the Communications Stack**
 - **Can directly use the Data Link Layer, but this will reduce its ability to interoperate in other spacecraft**

- **Assumptions:**
 - **Can run in single or multiple systems, homogeneous or heterogeneous**
 - **Network can be LAN, WAN, (wire or RF) or the Internet**
 - **Transport functionality may be provided by: TCP/IP, SCPS, direct Data Link, or other efficient IPC mechanisms**

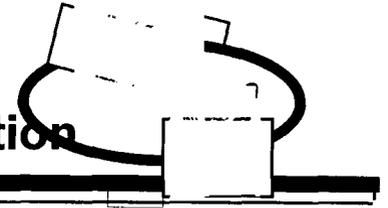
Spacecraft Onboard Interface Services (SOIS)

Application Layer: File Transfer and CCSDS Packet Services



- **File Transfer Service is intended to move files around the spacecraft and vicinity**
 - **File formats would be preferred in many cases: scientific observations (telemetry), sets of commands, software updates, etc.**
 - **Could use file transfer protocols already in service for space applications, such as CFDP**

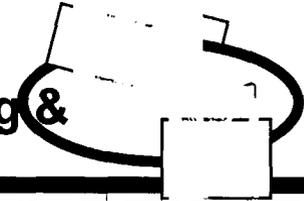
- **CCSDS Packet Service is used to move particular type of source packet (CCSDS) from location to location**
 - **Of use for the Space Applications Layer services that are specifically designed to use packets of this particular format**
 - **Specific user of this packet type is the European Packet Utilization Standard, and is used by European Space Agency**



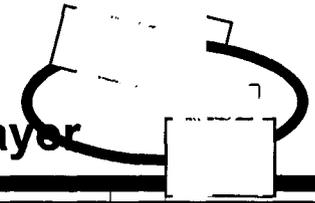
Space Applications Layer: Command & Data Acquisition

- **C&DA provides low overhead access to read data from simple sensors and to write to simple hardware interfaces**
- **Provides access to any sensor or effector to any user**
- **Six capability sets:**
 - **Device Access:** conversion of user-supplied logical address into the network address, allowing device to be addressed from anywhere in the network
 - **Engineering Unit Conversion:** conversion of raw sensor data (digital number) into a specific quantity with engineering units
 - **Data Product Acquisition:** data from multiple sensors are accessed with a single read command, and the resulting product is a result of calculations based on data from the multiple sensors
 - **Data Monitoring:** comparing of monitored sensors against certain limits, such as red and yellow limits
 - **Device Virtualization:** where devices are read and controlled by using a virtual generic device image or model
 - **Data Pooling/Data Base:** collection of data from sensors into a data pool (or data base) of recent readings

Spacecraft Onboard Interface Services (SOIS)
Space Applications Layer: Time Distribution and Plug & Play Services



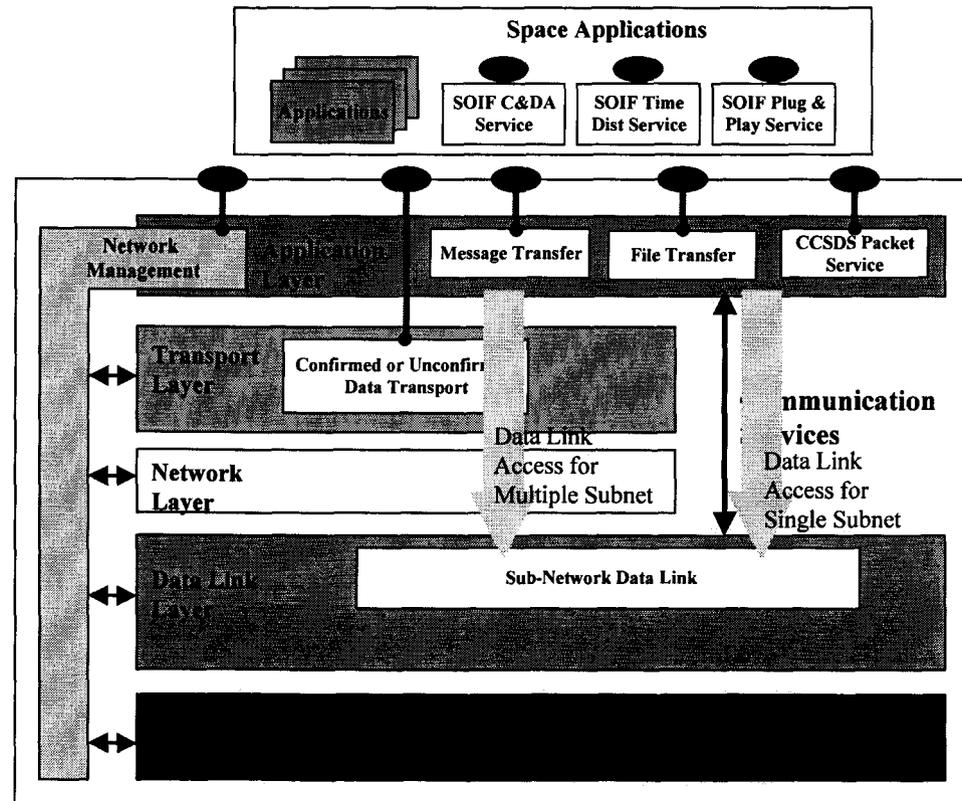
- **Time Distribution Service allows users to obtain time that is correlated to the central spacecraft clock**
 - Time is distributed to from the central clock to the user clocks around the spacecraft
 - Does not keep spacecraft central clock synchronized to ground clocks, this must use other techniques
- **Plug and Play Service provides capability of software components and complex instruments (payloads) to dynamically be inserted into the spacecraft, while operating**
 - Allow software upgrades to operating system
 - New instrument inserted or turned on while spacecraft is operating
 - Space subsystem or device can replace a failed subsystem or device

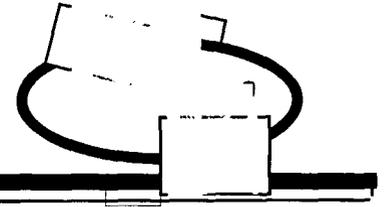


Two Data Paths for SOIS Services to the Data Link Layer



- One path is from the Applications Layer to the Data Link Layer through the Transport and Network Layer
 - For multiple subnetworks (busses) onboard the spacecraft
 - Other path is direct to the Data Link Layer
 - For single subnetwork (bus) onboard the spacecraft
- Use of the Applications Layer services with the same interfaces can be used to access either path without impact to the Users
 - Can have access to any possible Data Link/Physical Layers (bus)





Conclusions and Acknowledgements

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- **SOIS is an active international initiative of the CCSDS**
 - Supported by the major space agencies and industry
- **The broad scope of this work is likely to have a beneficial effect on many aspects of spacecraft onboard systems**
- **In this presentation paper we have not been able to describe the work of many aspects of SOIS**
 - Especially for the work in Network Management
 - These and other aspects of this work have and will be published in other papers
- **The products of the SOIS Work Area can be followed from the CCSDS web site, at <http://www.ccsds.org>**
- **For more information, please contact Joseph Smith at JPL**
 - 818-354-3328
 - joseph.f.smith@jpl.nasa.gov