Implementation of Space Link Extension Services in NASA/JPL's Deep Space Mission System

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JPL

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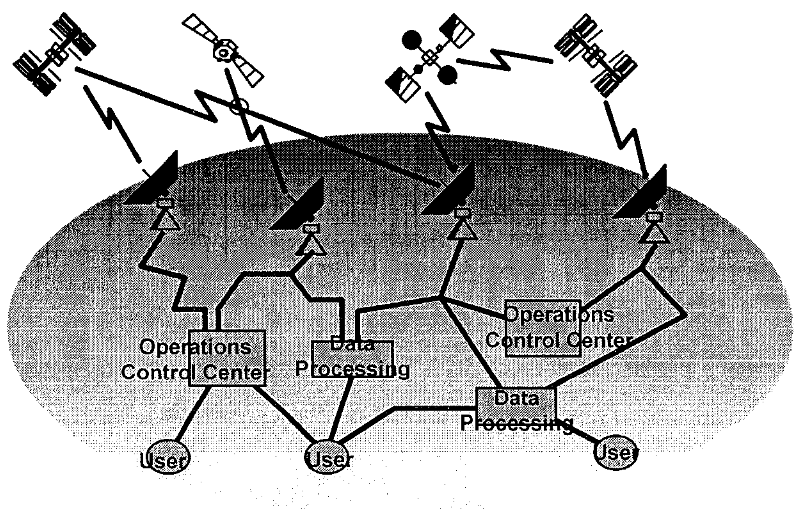
Introduction

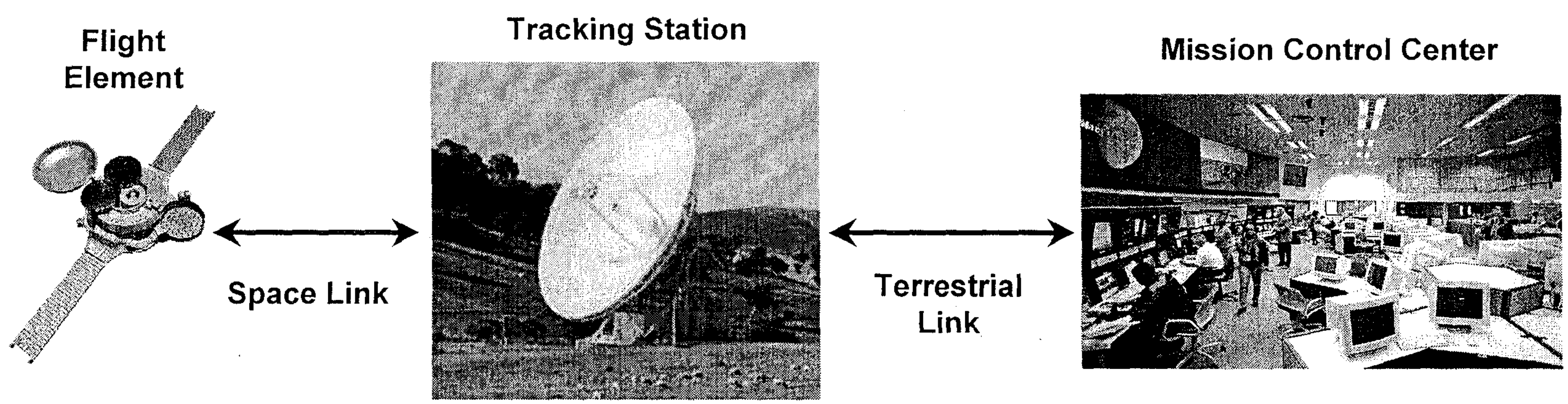


Typical Space
Communications
Scenarios

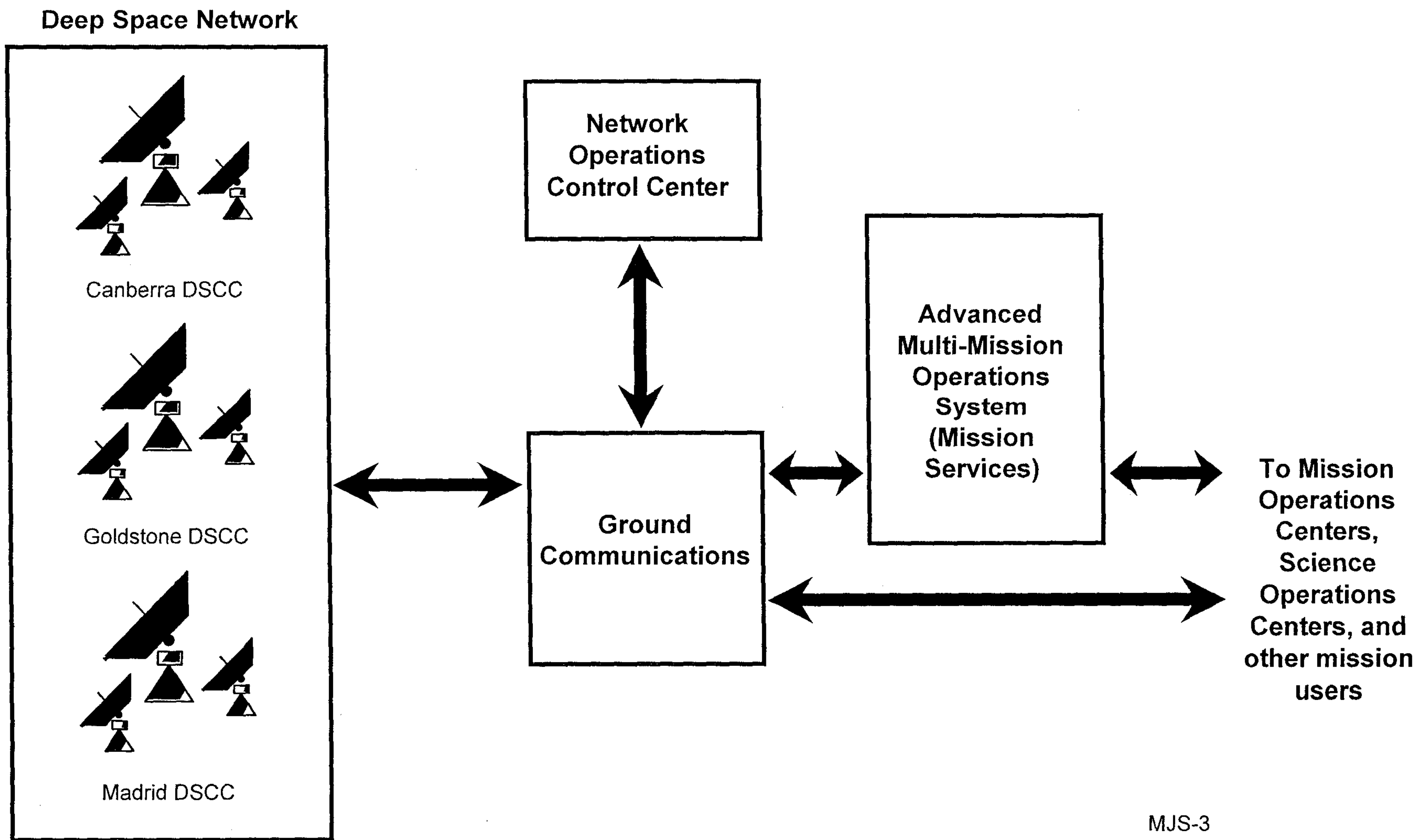
- Space Link Extension (SLE) is a CCSDS initiative to standardize basic telemetry and command service interfaces within a mission ground system
- Builds on the widespread acceptance of CCSDS standards for the space link
  - Space link standards only address the interface between the flight element and the ground
  - Lack of standards for ground-to-ground interfaces
- Goal is to reduce the cost of space mission operations and promote cross support operations

Rationale for Space Link Extension

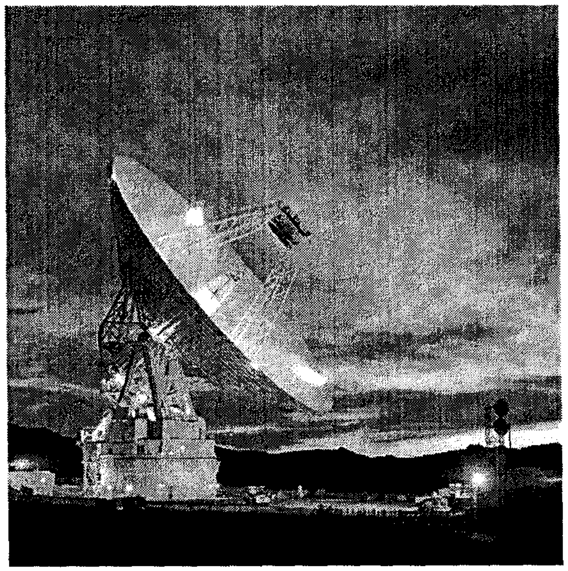
- Facilitate cross support operations
  - Optimize resource utilization
  - Obtain additional mission coverage
  - Reduce risk during critical operations
- Promote development and commercialization of standard components
- Eliminate multiple, redundant interfaces



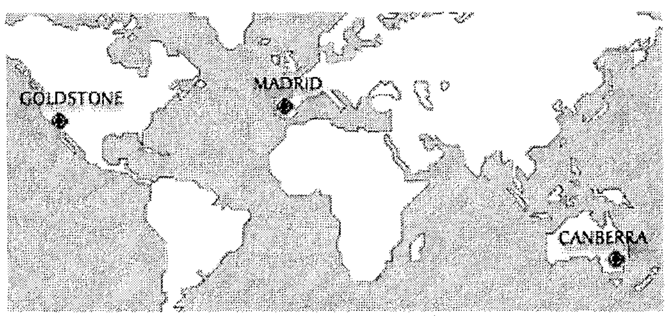
NASA/JPL Deep Space Mission System



NASA/JPL Deep Space Network



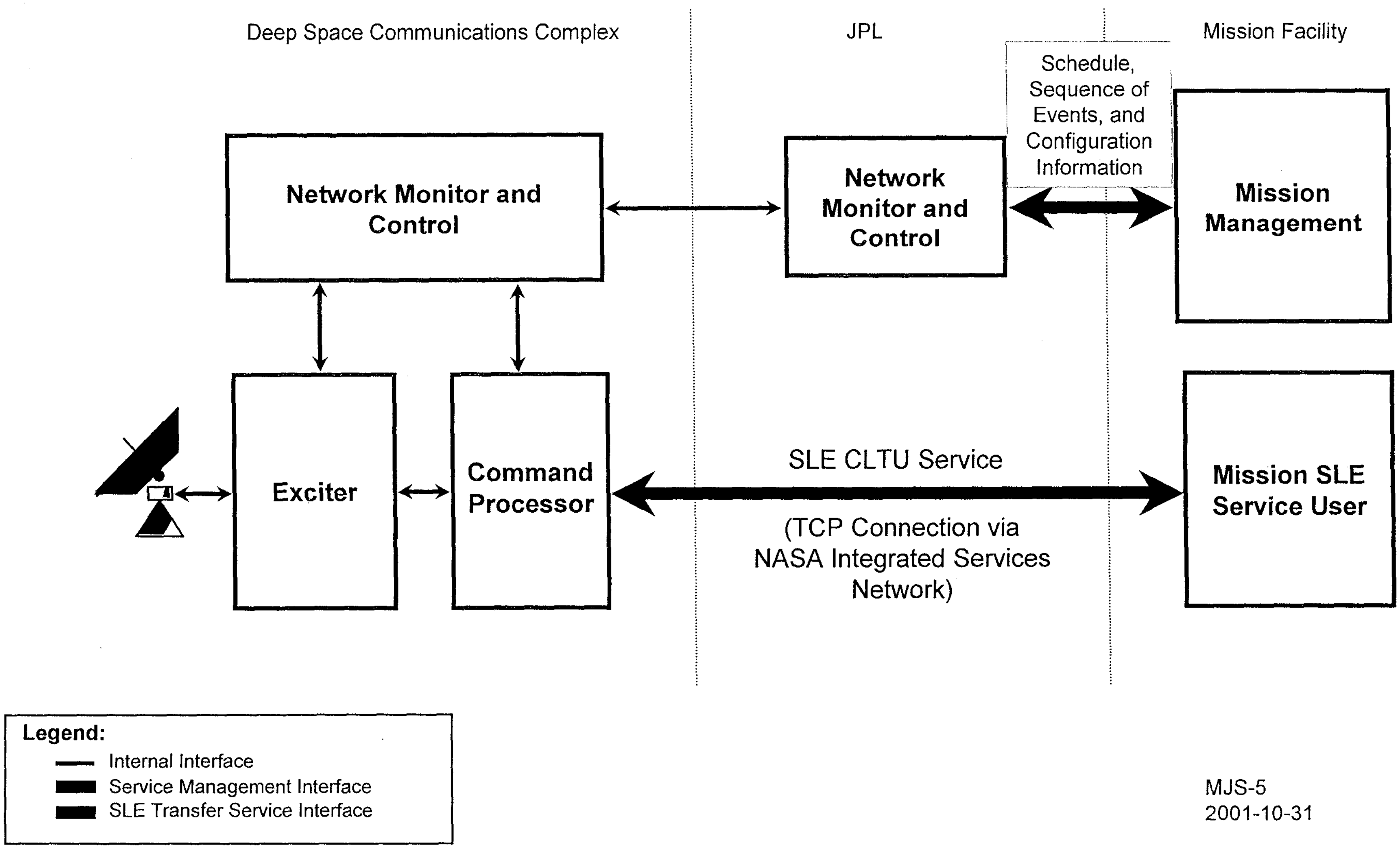
DSN 70-meter antenna



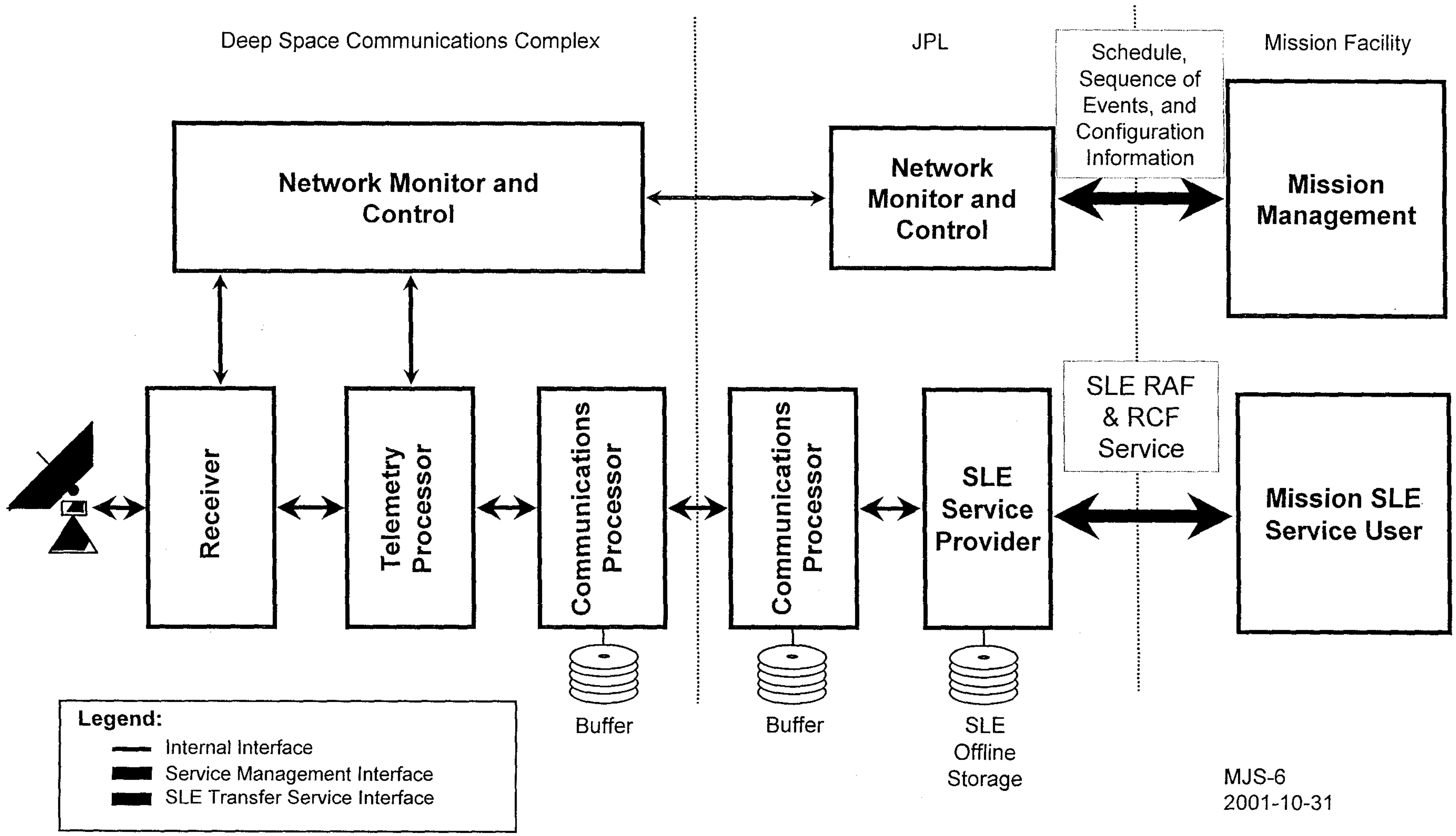
Locations of DSN Deep Space Communications Complexes

- The Deep Space Network (DSN) is an international network of antennas that supports inter-planetary spacecraft missions, radio and radar observations, and selected Earth-orbiters
- Largest and most sensitive scientific telecommunications system in the world
- Three deep-space communications facilities approximately 120 degrees apart around the world
- Tracking, telemetry, command, VLBI, radar and radio science, network monitor and control

SLE Forward CLTU Service (Command)



SLE Return All Frames and Return Channel Frames Services (Telemetry)



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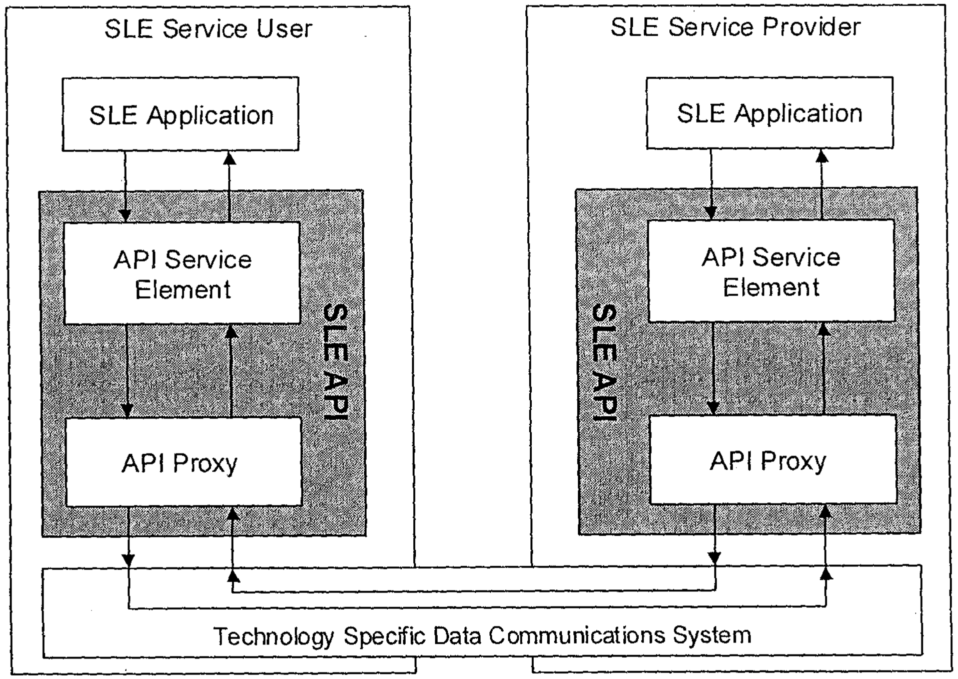
SLE Application Program Interface



SLE API Architecture

- **SLE API Service Element provides a technology-independent, reusable implementation of SLE core functionality**
- **SLE API Proxy provides a communications abstraction layer that insulates the rest of the software from the details of the actual communications service, facilitates transition to new communications technologies**
- **Based on Common Object Model, using C++ as the IDL**
  - **In principle, supports binary component reusability**
  - **For now we can say that, in practice, the resulting source code has proven to be highly reusable and highly portable**

Lessons Learned

- Implementation proceeded very smoothly, due to several factors
  - CCSDS cross support model, service model, and architecture are well conceived
  - Substantial up-front work on design approach, detail design
  - Close cooperation throughout between JPL and ESA
- SLE API contributed to substantial source code reusability
  - Implemented first for CLTU, reused for RAF/RCF
  - Implemented first on Solaris, ported to Windows NT, Linux
- Experience has confirmed the value of "object oriented"
  - Production versus provision
  - Implementation versus interface
- BIND operation has been key at all stages of the process
  - From earliest discussions within CCSDS all the way up to yesterday's test
- Importance of service management information

JPL

Lessons Learned (cont'd)

- Able to integrate new SLE interface to legacy production processes, except for some minor deviations:
  - On user abort of command radiation, one extra CLTU radiated
  - Reporting of telemetry production status
- Telemetry service provision remote from production made data delivery quality-of-service issues more difficult (timely mode)
- TCP/IP not well suited for very high rate telemetry
  - CCSDS service specifications could be mapped to communications services more suitable for high rate
- On some platforms (e.g., Windows), PEER-ABORT does not function as expected because it depends on a little used and sometimes unimplemented feature of the TCP protocol specification (urgent data)
- Built-in security features of SLE protocol offer some (very limited) protection but are not secure
  - SLE can be made secure (e.g., by using VPN)

Status and Plans

- A series of inter-agency tests conducted between JPL and ESA in CY2001 successfully demonstated SLE functionality and inter-operability
- Deployment as an operational DSMS capability is in process
- Plan to test RAF & CLTU services with ISAS MUSES-C (10/2001)
- Plan to support JHU/APL CONTOUR launch (6/2002) with CLTU service
- Plan to support ESA INTEGRAL launch (10/2002) with CLTU, RAF, and RCF services
- Plan to transition all JPL missions to CLTU service in 2002