CCSDS Space Link Extension Services
Case Study of the DERA Implementation

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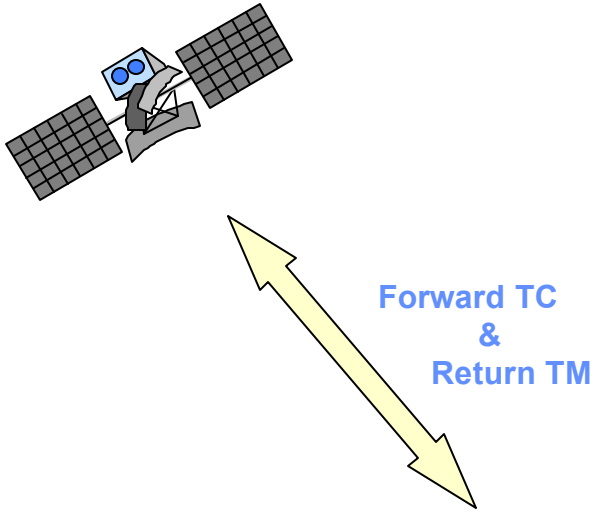
Presentation Overview

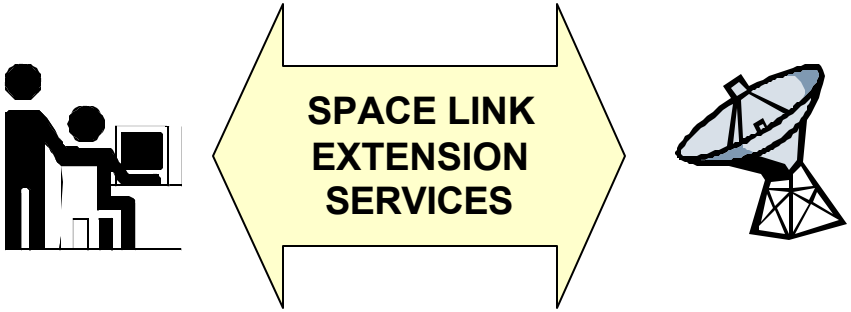
- What are SLE Services?
- Why are SLE Services important?
- Forward SLE Services
- Return SLE Services
- SLE Data Transfer
- SLE Service Management
- The DERA Implementation - Programme
- The DERA Implementation - Architecture
- Future Developments
- Conclusion

What are SLE Services?

- The SLE Services *extend* the Telecommand (TC) and Telemetry (TM) spacelink protocols defined by CCSDS Panel 1 and already in use by the major space agencies.



- SLE Services transfer TC and TM data units between control centres and ground stations in a well-defined and standard way.



Why are SLE Services Important?

- They enable the ground segment assets of space agencies, ground station operators and space data users to interoperate without the need for ad hoc and complicated gateways specifically designed for each new mission.

  e.g. JPL is providing F-CLTU and R-AF services to ESA for the INTEGRAL mission.

- In the commercial area, they enable ground station operators to offer CCSDS services in a much more efficient way than is possible today.

  e.g. the VEGA ground station services team members (ESA, DERA, RAL and Inmarsat) will be able to provide more efficient ground station services to NASA via the Lockheed Martin CSOC service.

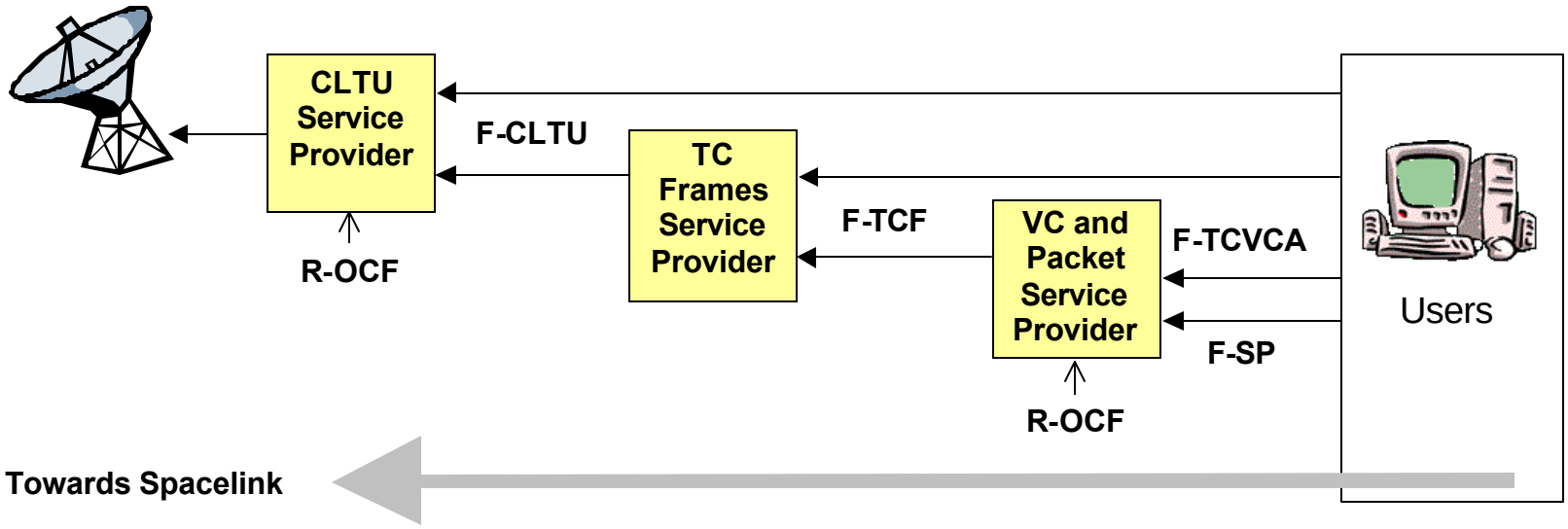
- They enable remote access to space through conventional communications media such as the internet and ISDN.

Forward SLE Services (1 of 2)

- Forward Space Packet (F-SP)
  - enables single users to provide packets for uplink to a spacecraft without needing to co-ordinate with other users of the spacecraft.
- Forward Telecommand Virtual Channel Access (F-TCVCA)
  - enables users to provide complete VCs for uplink.
- Forward Telecommand Frames (F-TCF)
  - enables users to supply TC frames to be transformed to CLTUs ready for uplink.
- Forward Command Link Transmission Unit (F-CLTU)
  - enables users to provide CLTUs for uplink to spacecraft.

Forward SLE Services (2 of 2)

- Forward SLE services are implemented as a layered software architecture in 3 discrete stages:

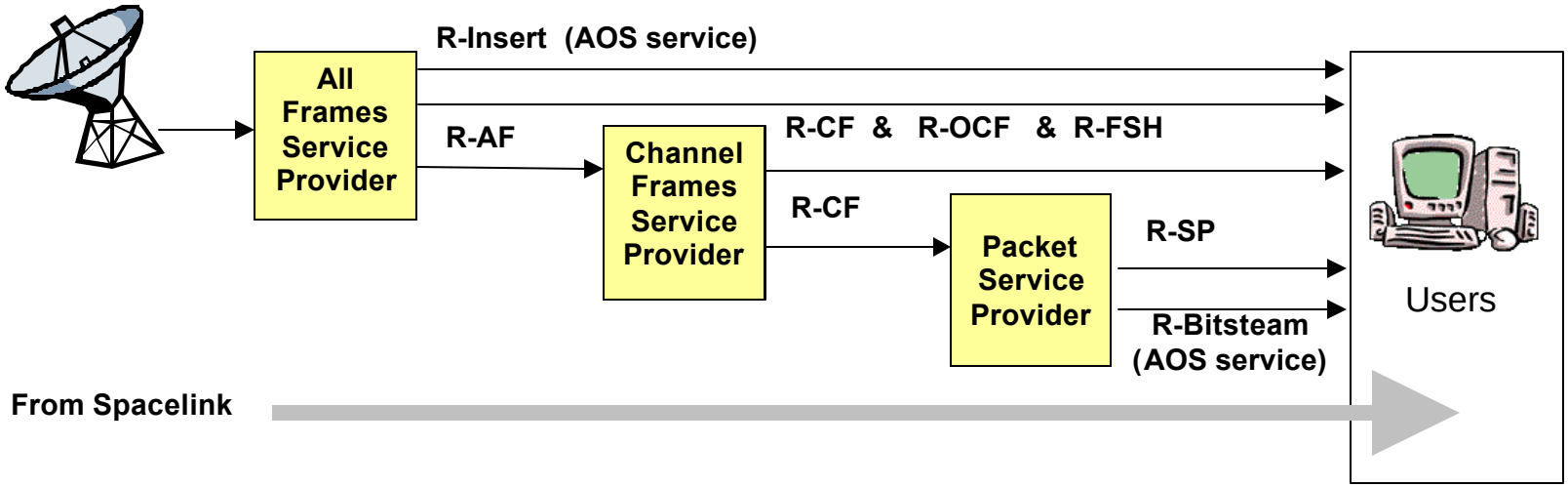


Return SLE Services (1 of 2)

- Return All Frames (R-AF)
  - provides a complete set of TM frames from a single spacelink physical channel to spacecraft operators and other users who might need them.
- Return Channel Frames (R-CF)
  - provides Master Channel (MC) or specific Virtual Channels (VCs) extracted from an RAF channel, as specified by each R-CF service user.
- Return Frame Secondary Header (R-FSH)
  - provides MC or VC FSHs extracted from an R-AF channel, as specified by each R-FSH service user.
- Return Operational Control Field (R-OCF)
  - provides MC or VC OCFs extracted from an R-AF channel, as specified by each R-OCF user.
- Return Space Packet (R-SP)
  - enables single users to receive packets with selected Application Process Identifiers (APIDs) from one spacecraft VC.

Return SLE Services (2 of 2)

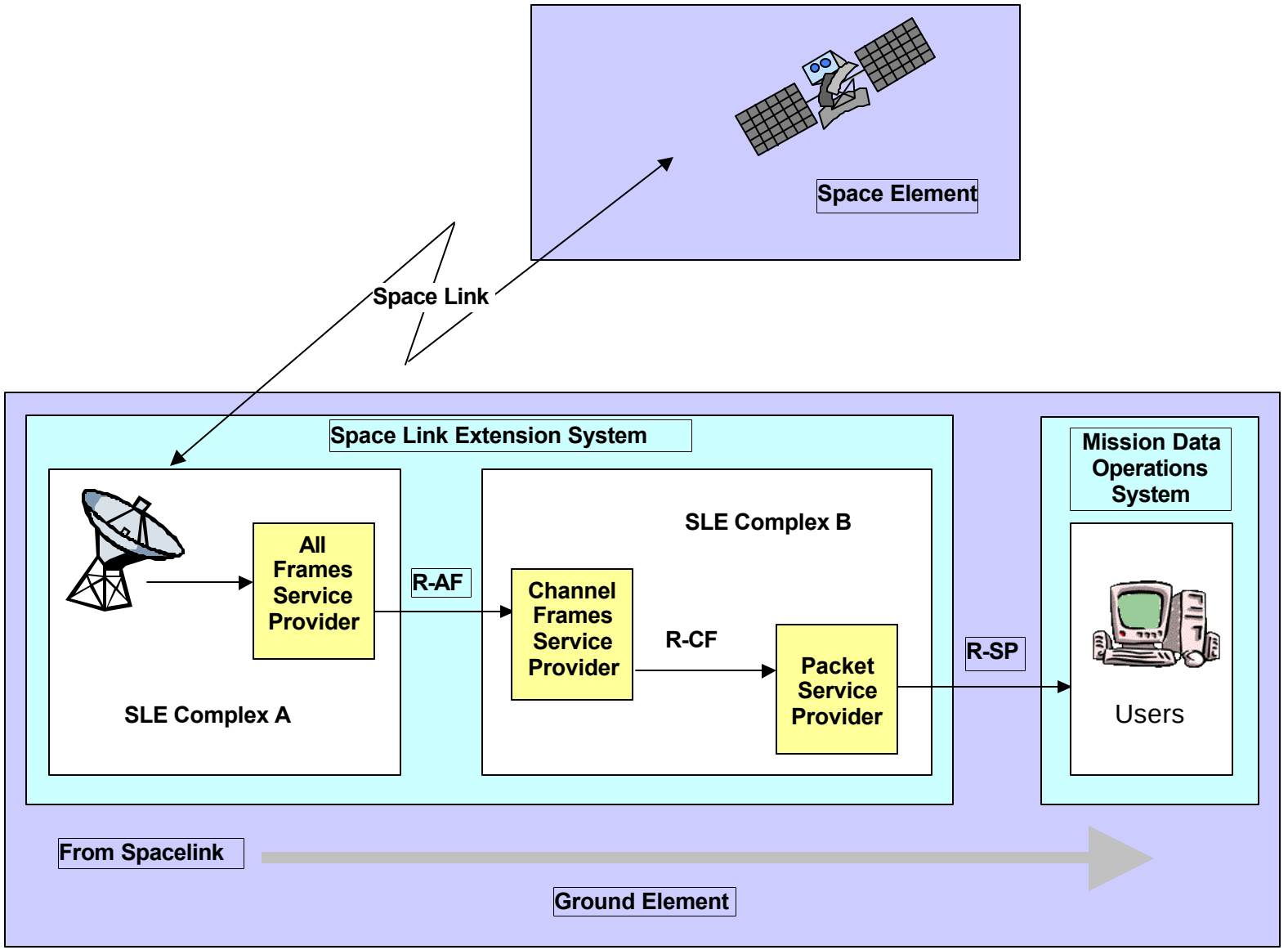
- Return SLE services are also implemented as a layered software architecture in 3 discrete stages:



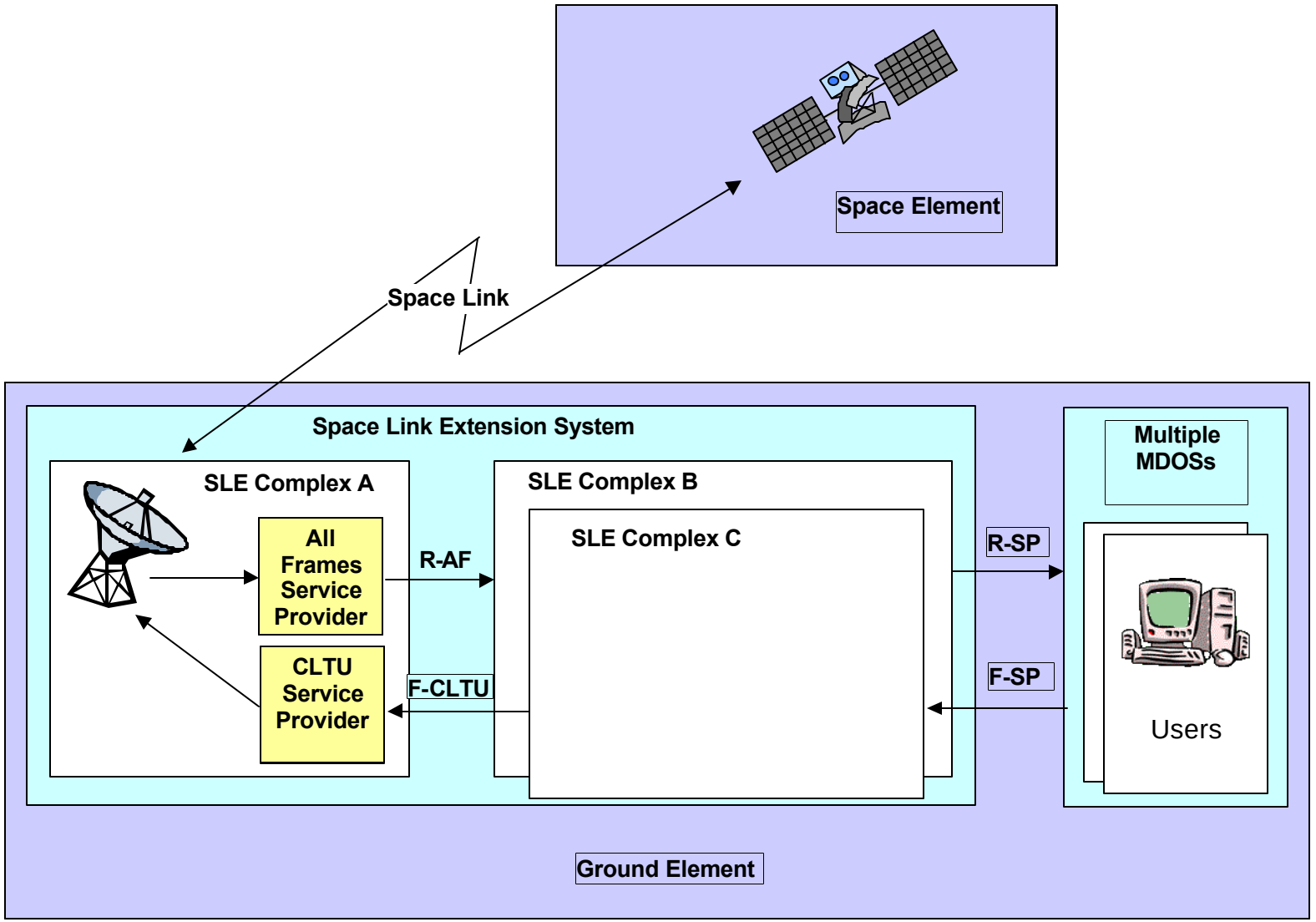
SLE Data Transfer

First, some SLE jargon and “rules” ….

- The “Service Provider” boxes in the previous diagrams are known as “SLE Functional Groups” (SLE-FGs).
- The term “SLE Complex” is attached to sets of SLE Functional Groups that are implemented to provide a range of SLE services.
- One SLE-FG represents the minimum implementation that an agency can make to provide an SLE service.
- SLE Complexes from different agencies can be combined to provide end-to-end SLE services.



SLE Return Data Transfer in Context



SLE Complexes may provide both Forward and Return SLE Services

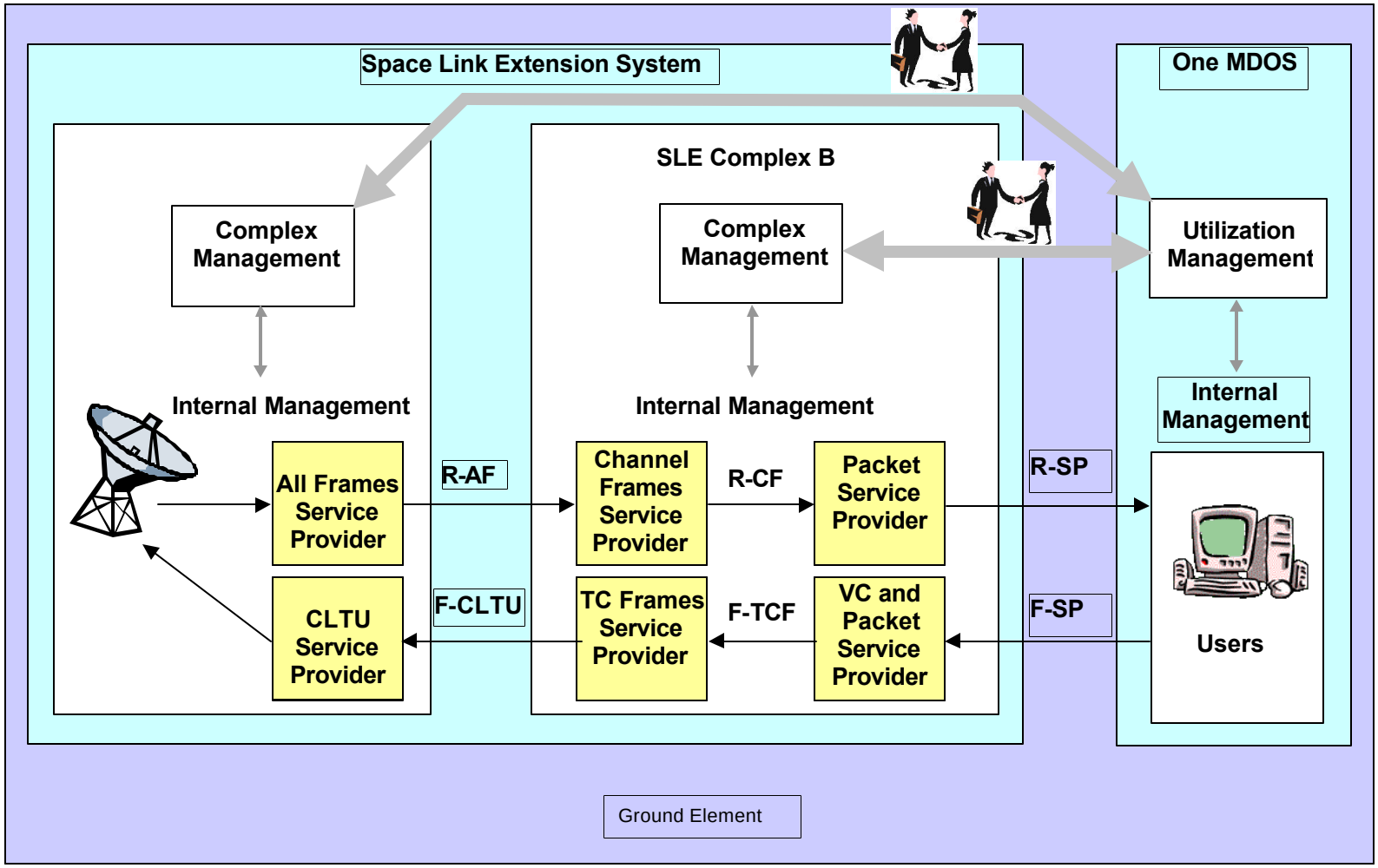
SLE Service Management (1 of 2)

- SLE services can be introduced into existing systems by first implementing SLE Data Transfer protocols. The next stage is to implement SLE Service Management.

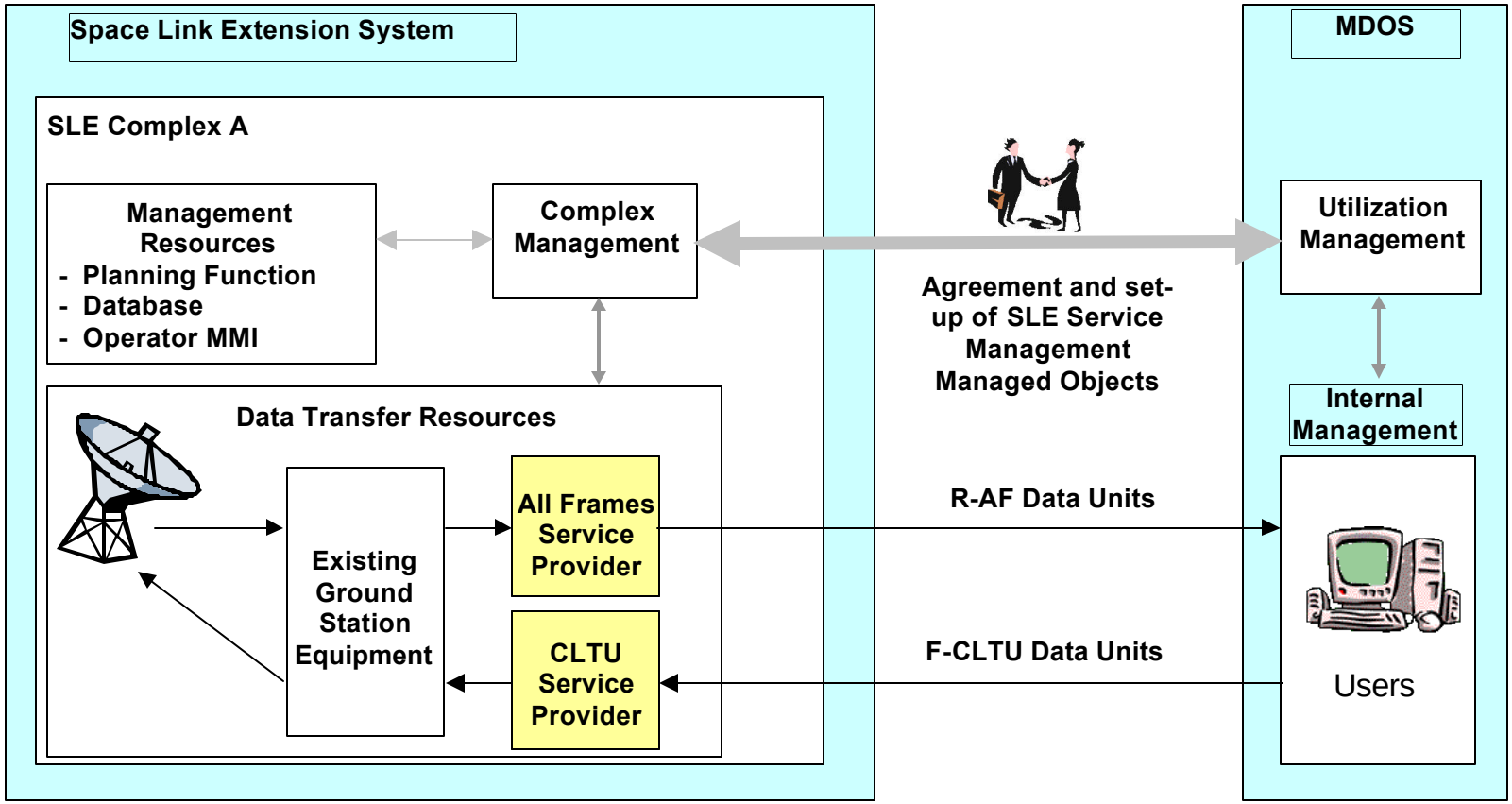
- The purpose of SLE Service Management is to:
  - standardise and automate, as far as practicable, those interactions between users and providers of SLE services that are required to agree and schedule the services;
  - provide the means to monitor and control the resources needed in the provider complex(es) and the MDOS to execute the service.

SLE Service Management (2 of 2)

- SLE Service Management is responsible for:
  - agreeing the values of parameters involved in an SLE service.
  - allocating the SLE Complex resources needed for the execution of SLE services.
  - configuring, monitoring and controlling the SLE Complex resources during the execution of the service.
- SLE services are managed jointly by:
  - “Complex Management” in one or more SLE Complexes.
  - “Utilization Management” in a Mission Data Operations System.



SLE Utilization and SLE Complex Management



Interfaces with SLE Complex Resources

The DERA Implementation - Programme (1 of 2)

- Phase 1 (June to November 1999):
  - evaluated the feasibility of implementing SLE services, including SLE Service Management, in the existing TT&C ground segment at DERA.
  - the Phase 1 analysis showed that relatively minor modifications to the existing DERA ground segment software would be required to introduce the F-CLTU and R-AF services.

- Phase 2 (December 1999 to March 2000):
  - prototyped a few features of the F-CLTU service to validate the implementation approach in a software development environment that includes:
    - the existing DERA software (Windows NT)
    - a simulated ground station interface (in software)
    - a F-CLTU SLE interface
  - In addition, a first draft of the CLTU-MOs was produced in GDMO and ASN.1, in co-operation with ESOC.

The DERA Implementation - Programme (2 of 2)

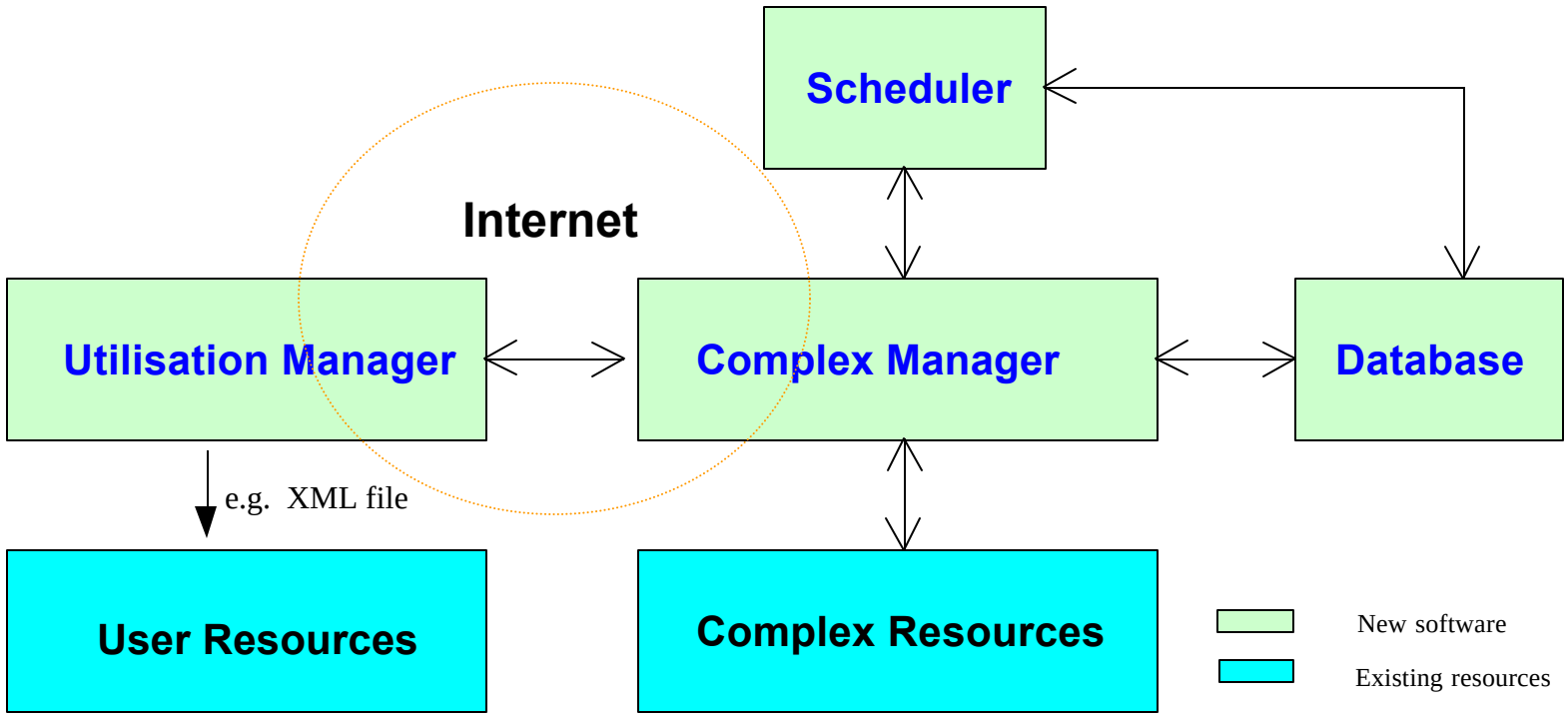
- Phase 3 (April 2000 to March 2001):
  - The full F-CLTU service is being implemented, using a UNIX version of the ESA SLE API.
  - The service management is being implemented, using the latest version of the CCSDS Panel 3 documents.
  - Simple command-line interfaces are being used for internal functions.
  - a web-based interface is being developed and was demonstrated at the Panel 3 meeting in Orlando FL in December 2000.

- Phase 4 (April 2001 to March 2002):
  - The R-AF service will be implemented and tested using STRV 1c/d and the Windows NT version of the ESA SLE API.
  - The command line interface will be replaced with a GUI.
  - Interoperability tests will take place with RAL and ESOC (TBC).
  - The formal specification of MOs in GDMO, ASN.1 and UML will be available to Panel 3.

The DERA Implementation - Programme (1 of 5)

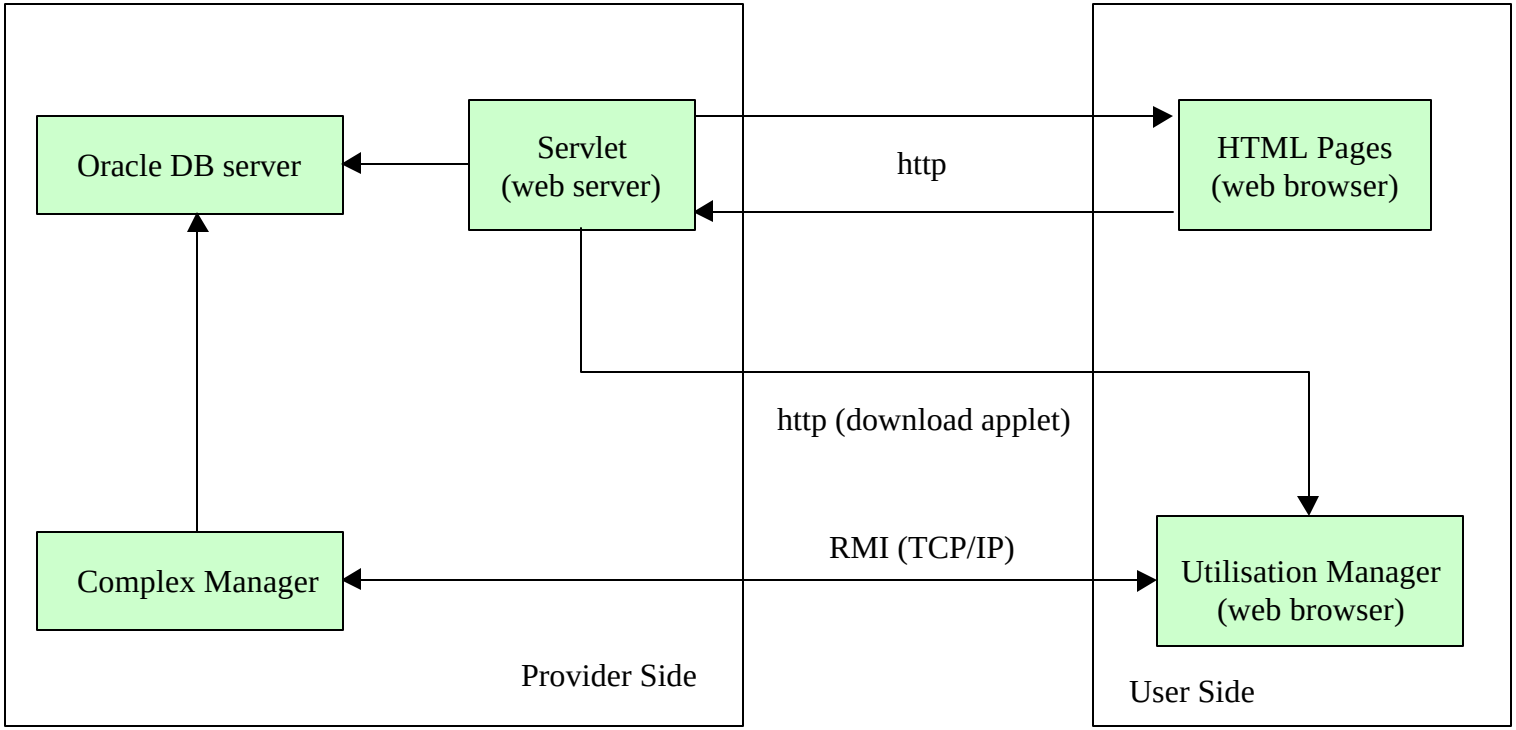
- The new software includes:
  - A “Utilisation Manager” applet, to allow Service Users to generate SLE Service Agreements and SLE Service Packages interactively with the Service Provider via a web interface.
  - A “Complex Manager” that interfaces with the Utilisation Manager and manages the service provider’s resources.
  - A central database that stores information about the provider’s resources and how they are allocated to different users.
  - A scheduler that maintains an event list and that drives the operations of the complex.
- The new software interfaces with both the existing CCSDS-compliant DERA software and the ESA SLE API software.
- The design can be easily adapted to the existing systems of other organisations wishing to offer CCSDS SLE services.

The DERA Implementation - Architecture (2 of 5)



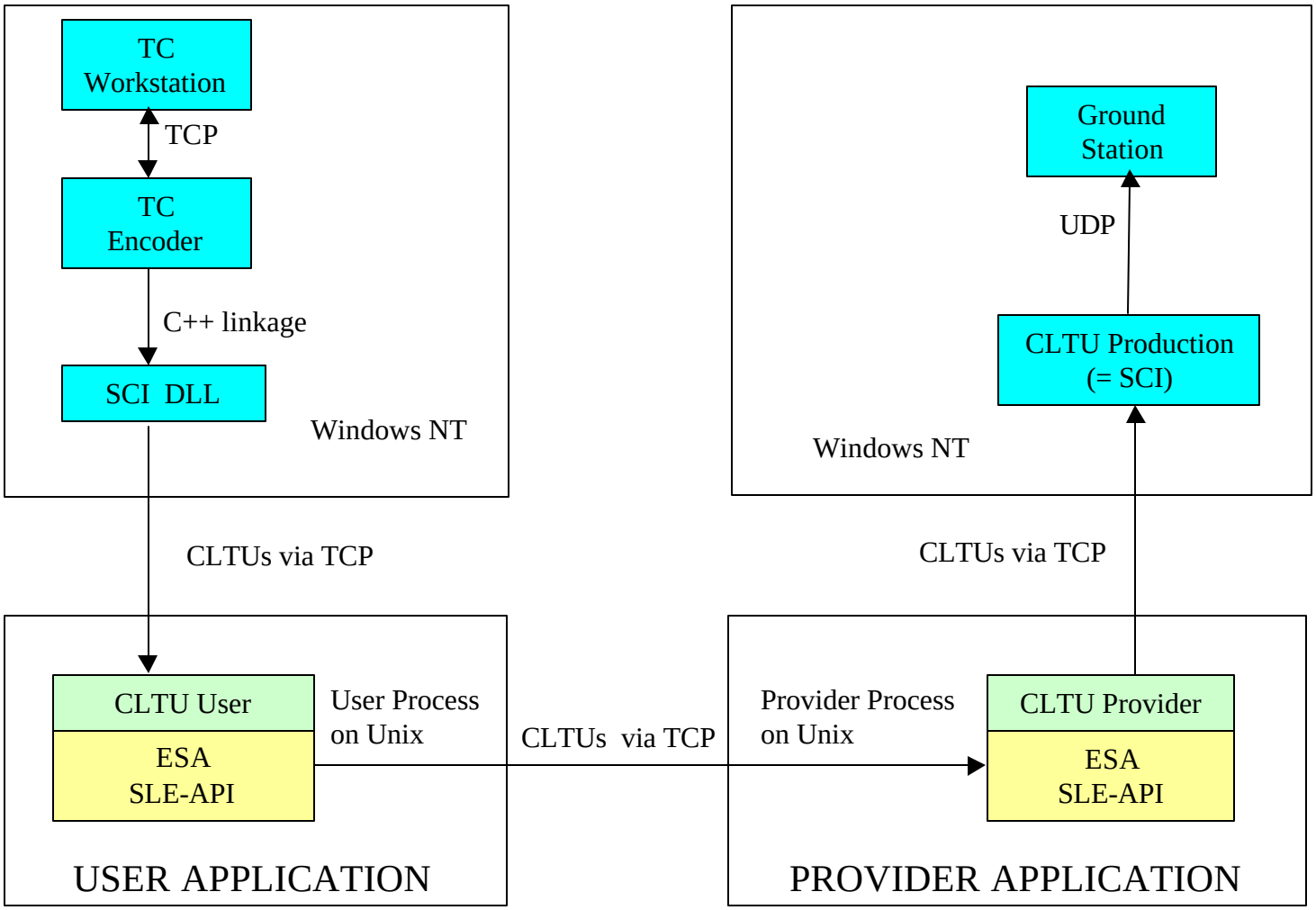
Context of the New Software in the DERA Implementation

The DERA Implementation - Programme (3 of 5)



Web-based MMI for Users to book CCSDS SLE Services

The DERA Implementation - Programme (4 of 5)



Role of the SLE API in the CLTU Data Transport

The DERA Implementation - Programme (5 of 5)

- Uses the ESA implementation of the SLE API
  - takes care of the SLE data transfer operations;
  - runs over TCP/IP;
  - currently uses the Unix implementation but will move to the Windows NT version in the next phase of the development.

- First implementation of SLE Service Management
  - requires active participation in CCSDS Panel 3 meetings, to define SLE service management;
  - formal definition of SLE managed objects (MOs) in GDMO, ASN.1 and UML;
  - implementation of MOs in C++ and JAVA;
  - uses an Oracle 8i database to store the state of the ground segment and all SLE service parameters;
  - implementation of web-based MMI to allow users to book services.

Future Developments

- Ground Station Planning
  - the current implementation assumes a simple ground station planning interface. This will need to become more automated in the future with different approaches for long-term, medium-term and short-term planning.
- Tracking and Orbit Propagation
  - the implementation will interface with a standard software package such as STK. However, the interface parameters should be standardised more to enhance interoperability (a task for CCSDS Panel 1?).
- Interface between Utilisation Manager and Complex Manager
  - there may be a requirement to implement the service management interface using middleware such as CORBA to replace the current web-based MMI.
  - Or, the interface between the Utilisation Manager and the User Complex may be defined more rigorously.

Conclusion

- The first fully-compliant F-CLTU service is being implemented in the DERA TT&C Ground Segment, using the latest issues of the CCSDS SLE transfer service and service management specifications.
- During 2001, the R-AF service will be implemented in the DERA TT&C ground segment.
- A web-based interface will enable users to interact with the DERA ground segment and book F-CLTU and R-AF services.
- The new SLE software (including the SLE API) is designed to be portable to other TT&C ground systems.

Acknowledgements

Thanks go to the British National Space Centre (BNSC) for funding the work and supporting CCSDS Panel 3 …

… and to DERA for their enthusiastic support for the implementation.

... and to ESA for supplying the SLE API …