Planning and Scheduling User Services for NASA's Deep Space Network

C. Borden, Y.-F. Wang, G. Fox

Background

NASA is currently developing and operating "faster/better/cheaper" unmanned space flight missions. This is resulting in a significant increase in the number of missions NASA's Deep Space Network (DSN) will have to support. Increases in the number of missions to be supported is occurring concurrently with these new missions (1) testing new spacecraft telecommunication technologies, (2) having less project resources available for operations planning related to the DSN, (3) a shorter development cycle from project start to spacecraft launch, and (4) rapid, realtime changes in mission coverage requirements (e.g., Mars Pathfinder). In this environment, DSN management faces an increased demand for decision-making on a larger number of more uncertain missions, and with quick response time.

New ground telecommunication system technologies and operating procedures are also being developed by the DSN to provide more effective mission support. New technologies and approaches include (for example):

- simultaneous communication with multiple spacecraft from a single ground antenna
- spacecraft using multiple, arrayed ground antennas
- automated, self-configuring, unmanned ground stations
- automatically processing high level DSN service requests into detailed, individual equipment level requirements
- automated DSN Complex and/or Station operations
- reduced antenna pre- and post-calibration (setup) times.

The rapid change in mission and ground system capabilities implies a significant impact on DSN's ability to optimize their capacity evolution plans and mission scheduling on ground resources. In addition, rapid change in information technology and desktop computing capability provides an opportunity to use modern software architectures and tools for improved decision-making. Analysis tools can now readily interoperate with relational databases, Web browsers and other value added software tools and environments. Optimization, simulation and computational intelligence techniques continue to advance in terms of desktop capability and software interoperability.

To adequately capture the effect of these changes in the DSN and space flight project environment, JPL is implementing a prototype analysis capability that provides data access, load forecasting and scheduling in a single integrated environment. This system links to a relational database and shares the same user interface for both DSN and space project users. Existing analysis tools provide a useful point of departure for improving the DSN's planning and scheduling capability.

The Current System

JPL currently uses the FASTER Tool Suite for DSN load forecasting and scheduling (Loyola, 1993), (Fox and Borden, 1994). This capability has been used for many years as the basis for DSN commitments of ground resources to missions.

Major FASTER capabilities include:

- Load forecasting
- Schedule editing
- Viewperiod graphical display and management
- Antenna usage listing (including unused time)
- Graphical display of critical events over time

The FASTER software was designed to answer questions relating narrowly to DSN load forecasting and mission scheduling. With the change in NASA direction to a large number of small missions, life-cycle cost-driven mission commitments, and a new programmatic focus on Mars using multiple simultaneous spacecraft, operating the current FASTER software system is becoming very time-consuming. Multiple local data sets and non-integrated and unoptimized tools contribute to an inefficient user environment. Though FASTER is useful for DSN planning and scheduling, the opportunity to improve these tools (and the embedded processes) can lead to significant improvements in data management, timeliness of analyses, and extended analysis capability to evaluate and optimize new technologies and approaches.

Proposed Implementation

A new prototype tool is being implemented in response to requirements for extended load forecasting and scheduling capability and to provide mission and DSN users with an integrated, graphical environment for mission design and ground system planning and scheduling studies. The architecture implementing this integrated system, TIGRAS (Covington and Wang, 1997), provides both DSN and space flight project users access to the same computational engine and database (MADB) (Zendejas, 1997). The TIGRAS prototype provides an end-to-end analysis environment that includes an embedded work flow manager, secure access to user-owned products, configuration management, and an audit trail.

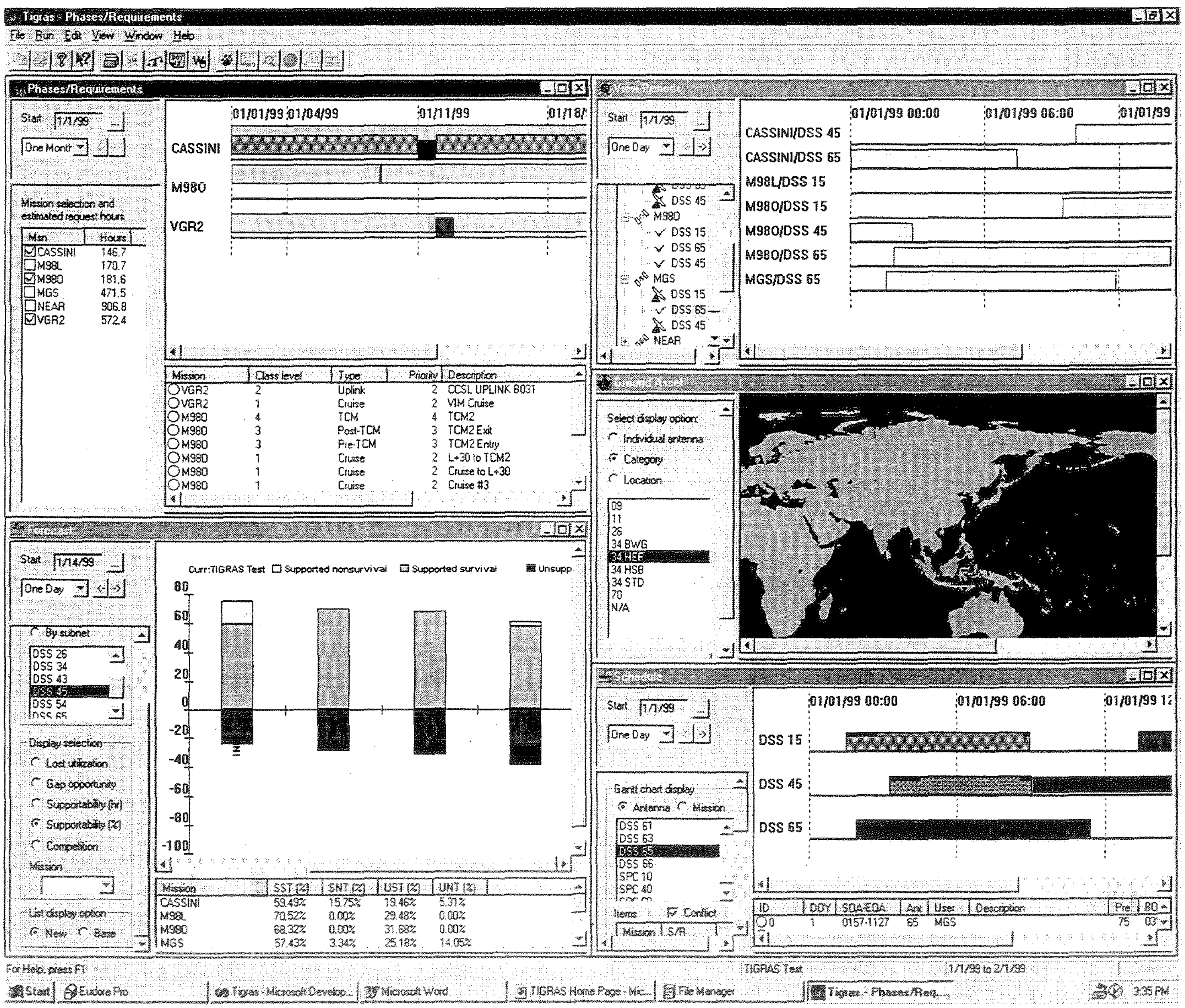
The TIGRAS user model is designed to improve efficiency in access to data and tools, establish use of DSN ground support as a mission design variable, and facilitate better communication between missions and DSN. Mission users can access quantitative baseline DSN loading and scheduling products and tools for further analysis. Links to trajectory products and visualization are supported through MADB. Web-access to TIGRAS data is available. Software to support online schedule change requests with rapid conflict resolution is being prototyped. The anticipated new approach for user interface with the DSN called the Service Request Processor will also be supported.

TIGRAS is a Windows-based application with linkage to MADB (SQL server) via ODBC (Open Database Connectivity). Figure 1 is the screen of the TIGRAS environment. Users can examine requirements, view periods and antenna properties then perform forecasting and scheduling studies all in the same environment, using the standard Windows operating system.

Future Developments

In future versions computational intelligence approaches such as Neural Networks (Wang, Cruz and Mulligan, 1994) and Fuzzy Logic will be used to enhance the current forecasting algorithms to provide an extended, more optimized, automatic allocation engine. This engine expands the scheduling scope from antenna level to equipment level allocations with more constraint checking and optimization. Using the current scheme, what-if simulation and sensitivity analysis can be preformed to optimize the allocation. On the software side, we are investigating DCOM and MS Transaction server approaches to enable TIGRAS functionality as reusable, distributed objects. This will ensure an extensible, maintainable object implementation of functions used in this enhanced resource allocation analysis process.

FIGURE 1:



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