COMPUTER ASSISTED INTERACTIVE RESOURCE SCHEDULING SYSTEM

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Several years ago it became apparent that the task of scheduling mission support for spacecraft was becoming more difficult with the increasing complexity of spacecraft and of on-board experiments. It was clear that manual methods then in use would not be suitable for coping with the expected increase in the scheduling workload. Therefore (refer to Figure 1), the development of the Computer Assisted Interactive Resource Scheduling (CAIRS) System was undertaken to assist in the preparation of the necessary mission support schedules.

Schedulers were working with 45 spacecraft across 20 network stations (Figure 2). Individual schedules were required for telemetry data and associated commands, communications circuits, and four types of tracking capabilities.

Approximately 20,000 individual spacecraft station contact points were available in each scheduling week. Of these possibilities about 3000 were being scheduled for telemetry data, 2500 for tracking data, and about 1500 for spacecraft commanding purposes.

Complexity in the scheduling process resulted not only from the scheduling types required and quantities involved, but from the nature of the mission themselves (Figure 3). Scheduling considerations were based on the type of spacecraft and capabilities available for ground support. The variety of tracking capabilities and the multiple nature of the ground support capability complicated the scheduling of resources.

COMPUTER

ASSISTED

INTERACTIVE

RESOURCE

SCHEDULING

SYSTEM

Figure 1. CAIRS.

NUMBER OF SPACECRAFT SUPPORTED	45
NUMBER OF NETWORK STATIONS	20
NUMBER OF SPACECRAFT-STATION CONTACTS	20,000 WEEKLY
NUMBER OF SCHEDULED TASKS:	

TELEMETRY	3000 WEEKLY
TRACKING	2500 WEEKLY
COMMANDS	1500 WEEKLY

Figure 2. Quantities.

1. FIVE SUPPORT TYPES
2. VARIABILITY IN SCHEDULING REQUIREMENTS
   - SPACECRAFT FREQUENCIES
   - ANTENNA TYPES
   - COMMANDING REQUIRED
   - VOICE OR DATA LINES NEEDED
   - Q/L OPERATIONS REQUIRED
3. MULTIPLE NETWORK CAPABILITY
4. THREE ORBITAL CATEGORIES
5. REAL-TIME RESCHEDULING

Figure 3. Scheduling complexity.

A further consideration in the scheduling process was the type of orbit presented by the spacecraft. Three orbital categories were represented: namely, near earth, elliptical, and synchronous. Changes to the weekly schedule were necessary after transmission of the original schedule. These changes occurred because of updates to the ephemeris data, changes in mission support requirements, spacecraft anomalies or emergencies, loss of station resources, and rescheduling due to new launches.

Prior to CAIRS, schedules were built on charts using colored pencils and symbols to keep track of spacecraft differences and support types. Ephemeris data, station capabilities, and spacecraft requirements were obtainable only from hard copy sources which required considerable lookup time.

The theory behind the development of the CAIRS System was to provide the scheduler with a tool he could use to more efficiently produce the mission schedules. Conflicts in mission support were to be resolved by the scheduler, utilizing the CAIRS System to point out the conflicts and the nature of the resource deficiency. Concurrent with the improvement in scheduling capability would be a quick turnaround capability for real-time rescheduling, as well as quick access to information for improvement in mission control.

The mission scheduling process begins with the ephemeris data being input to the CAIRS System (Figure 4). Requests for support are defined in three ways:

- The Project Operations Control Centers inputs are entered from punched cards. Approximately 3500 of 5000 requests are input in this manner.
- Additional support requirements are input interactively through the CRT.
- The computer automatically requests support where mission requirements have been specified. This capability is used sparingly at this time.

After all the mission requests for support have been entered, the CAIRS System begins the scheduling process utilizing a previously entered priority table. When a request for support cannot be satisfied because of insufficient resources, that request is output to a printer listing along with a notation as to the nature of the deficiency.

When the system processor has completed all priority levels, a "no conflict" schedule has been created. At this point roughly 90 percent of the requests for support have been satisfied. The power of the CAIRS System is exemplified in that 1600 M/T events are

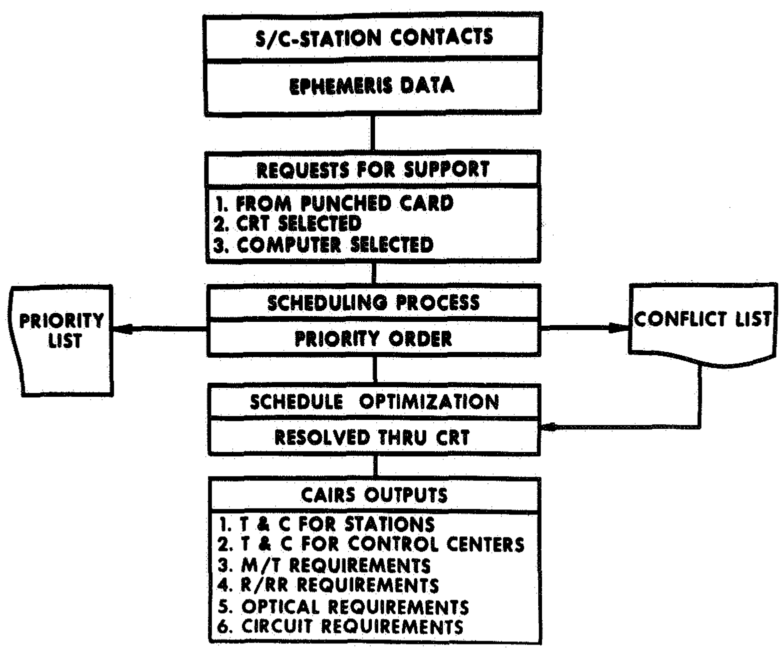

Figure 4. Scheduling process.

scheduled by this processor in 14 minutes. The operator now takes the conflict listing and refits those events lacking support, using the interactive CRT capability for resolution.

After optimization, the CAIRS System outputs the mission requirements schedules in teletype format, ready for transmission.

The net result of the CAIRS development has been a system which more effectively schedules complex mission support requirements faster, and with less error than was possible with manual methods, thereby improving the overall mission support (Figure 5). Spacecraft requirements, station capabilities, and ephemeris data are all contained in the CAIRS data base, thereby negating the need for stacks of paper, colored pencils, symbolic representations, and good memories.

The CAIRS System saves time by reducing the scheduling operation from hours to minutes. Also, since the system outputs the mission schedule requirements ready for transmission, the hours previously required for teletype tape generation – the operation most prone to error – has been eliminated.

The time needed for rescheduling has been greatly reduced, due to the interactive and schedule creation capabilities of the CAIRS System, and the display of current schedules and resource availability on demand readily accomodates the dynamic nature of the real-time scheduling problem.

The CAIRS System has been in operational use since October 1971.

1. MORE EFFECTIVE SCHEDULING

- **IMPROVED MISSION SUPPORT**
- **SAVINGS IN TIME**
- **REDUCTION IN ERRORS**

2. REAL-TIME RESCHEDULING

Figure 5. CAIRS results.