N92-11050

FLEXIBLE ENVELOPE REQUEST NOTATION
(FERN)

December 13, 1990

David Zoch
David LaVallee
Stuart Weinstein

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Agenda

- Background
- FERN Language Concepts
- FERN Syntax Examples

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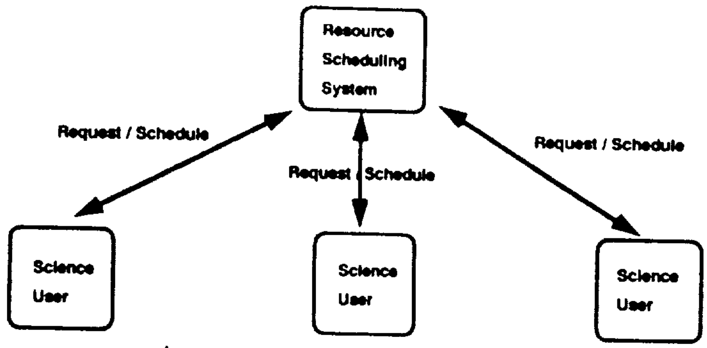
Scheduling Application



- Science users send requests to the Resource Scheduling System.
- Requests are requirements for planned instrument operations and are written in FERN.
- The Resource Scheduling System, which may reside in a POCC, processes the requests and generates a schedule.
- The schedule specifies the timeline of user activities and is distributed to the science users.

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Motivation for FERN

- Science users must represent their resource requirements and constraint relationships in a format that can be interpreted by computers.
- If their initial resource requests cannot be satisfied, science users need to propose reduced resource amounts or alternative experiments for their instrument operations. Thus, some of the science user requests may be flexible and complex rather than simple.
- FERN uses a language format. For example, "TAPE_DUMP for 5 minutes to 10 minutes" is more user-friendly than "TAPE_DUMP,5,10." This format allows users to state their requirements in a more direct and natural manner.

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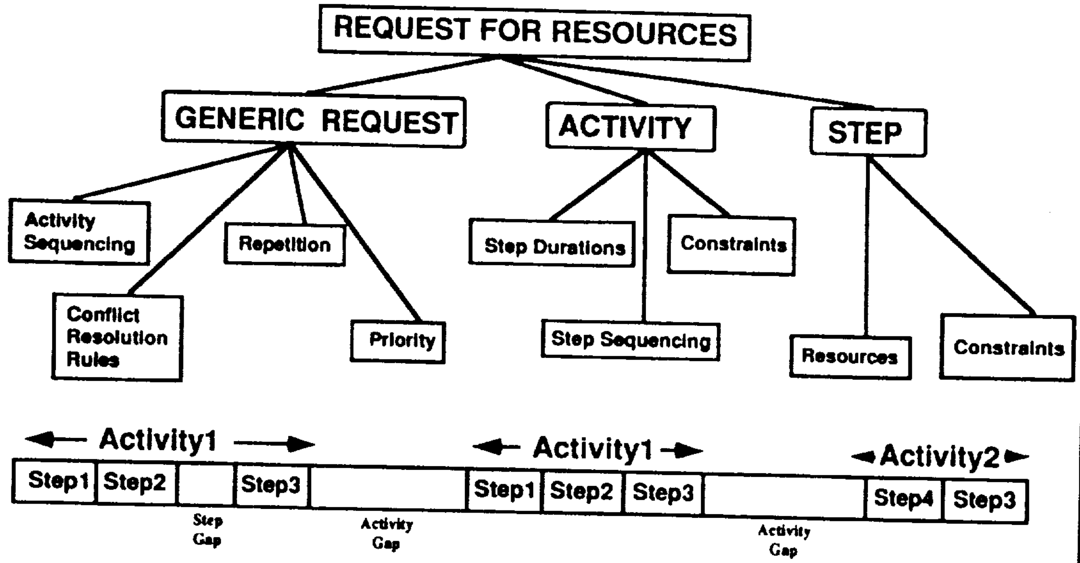
Characteristics of FERN

- **ROBUST**
  - Supports a variety of user resource requirements and constraints.
  - Supports alternative resource amounts and requests.
  - Supports repetitive requests ("generic requests") based on orbital events rather than specific start times.
- **READABLE**
  - Keyword based, not positional. For example, avoids "ROB1,2-4,60,200-300."
- **FLEXIBLE**
  - Time durations and relaxable constraints
- **OBJECT-ORIENTED**
  - Data abstraction
  - Reusable data objects

Types of Information Needed in Requests

- ***Flexible*** resource requirements
- ***Flexible*** request durations
- ***Flexible*** experiment timing / coordination requirements between activities
- Scheduling information for repetitive activities
- ***Alternative*** activities
- Relative importance of each requirement

Where Information is stored in Requests



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FERN Structures

GENERIC REQUEST

- Pattern of replication of activities
- Alternative activities
- Rules

ACTIVITY

- Sequence of steps that comprise the activity
- Duration of steps
- Constraints common to whole activity
- Defined in database, then referenced by name in GENERIC REQUEST

STEP

- Amounts of resources
- Constraints
- Defined in database, then referenced by name in ACTIVITIES

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FERN Structures (cont'd)

RESOURCES

- Support user operations.
- Are represented as scalars that vary over time.

CONSTRAINTS

- Restrict the times when a request can be scheduled.
- Are specified with respect to timegraphs, activities, steps, or other requests.

TIMEGRAPHS

- Are used to specify time windows, view periods, preferable scheduling times, spacecraft events, calendar events, etc.

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Generic Request

Generic *GENERIC_NAME* **is**
3 to AS MANY AS POSSIBLE activities per *Sun_in_view*
With default min start time separation 5 minutes,
With default max start time separation 10 minutes,
With summed duration 4 hours, -- sum of multiple activity durations is 4 hours
With priority 2,
With strategy Maximizing_Separation
Schedule
ACTIVITY1 **and** *ACTIVITY2*
Or schedule
ACTIVITY3
Or schedule
ACTIVITY4 **With min start time separation** 4 minutes
End generic

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Activity

Activity *ACTIVITY_NAME* **is**
Steps
STEP1 **for** 1 **to** 8 minutes,
idle *STEP2* **for** 2 **to** 5 minutes,
STEP3 **for** 5 minutes,
interruptable *STEP4* **for AS LONG AS POSSIBLE**,
STEP5 **for** 5 minutes
With activity duration 30 minutes
End activity

Interruptable Step - resources of step can be re-allocated without disrupting activity.

Idle Step - same as interruptable, but not displayed on timeline. Used to represent idle periods.

Step

Step *STEP_NAME* **is**
Resources
INSTRUMENT_X,
POWER 5 watts,
TDRSS_SA 1,
...
Constraints
Occurs entirely during *ORBIT_DAYLIGHT,*
Starts at the same time as *ACTIVITY_X,*
...
End step

Resources

- Initial amount may vary over time in discrete steps
- Pooled resources contain equivalent or nearly equivalent items:
  - TDRSS is (TDRSS_E, TDRSS_W)
  - Crew member is (commander, pilot, mission_specialist)
  - Redundant equipment is (line_recorder_1, line_recorder_2)
- Some resources are available at different times to different users (e.g., TDRS)
- Resources may be either durable or consumable

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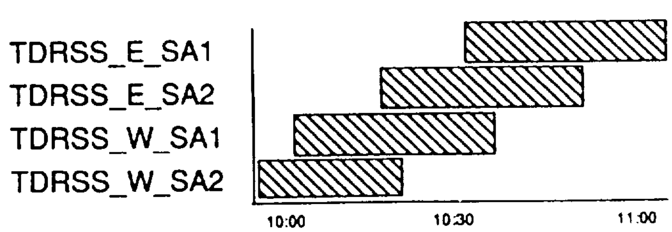
Pooled Resources

Resource *TDRSS_SA* **is**
(Forever (*TDRSS_E_SA1, TDRSS_E_SA2,*
TDRSS_W_SA1, TDRSS_W_SA2))
End resource

TDRSS_SA Allocation



Even though some TDRSS_SA is available at every point, no single antenna is continuously available. Thus, a request for 50 minutes of TDRSS_SA is NOT satisfied.

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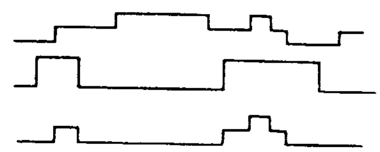
Resource Availability for Pooled Resources

Some resources are available at different times to different users

For example, TDRSS communication resources are available at different times to different satellites, depending on the position of the satellite with respect to TDRSS.

Step *DATA_LINK* **is**
Resources
TDRSS_E
Constraints
Occurs entirely during *TDRSS_IN_VIEW*
End step

TDRSS_E
TDRSS_IN_VIEW
Availability



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Expressive Notation

Supports non-specific durations:

VIEW_STAR_STEP **for AS LONG AS POSSIBLE**
RECALIB_STEP **for** 2 **to** 8 minutes

Supports flexible requests where the resource amounts and duration of the request are selected by alternative relaxation levels. This capability allows the scheduling algorithm to reduce resource amounts or shorten the duration of the request in order to fit the request on the schedule:

RESOURCE1 15 units,
RESOURCE2 (25 units, 23 units **AT RELAXATION** 4,
19 units **AT RELAXATION** 8,
15 units **AT RELAXATION** 12)

STEP1 for (30 minutes, 28 to 30 minutes **AT RELAXATION** 5,
25 to 30 minutes **AT RELAXATION** 15)

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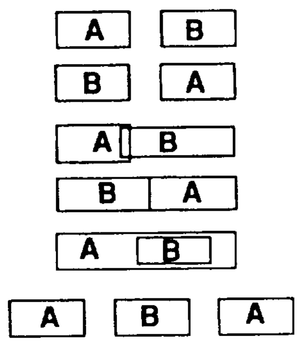
Temporal Constraints

- Temporal Constraints specify when a request can be scheduled with respect to:

  Calendar Events, Orbital Events, Requests, or User Defined Events
- Allow for precise activity sequencing and coordinated activity dependencies.
- Sample temporal relationships between request A and object B are:



Occurs before B

Occurs after B

Ends 5 minutes after the start of B

Occurs right after B

Overlaps all of B

Does not overlap B

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Profiles

Things that vary over time

FOREVER

CREATE

CREATE PERIODIC

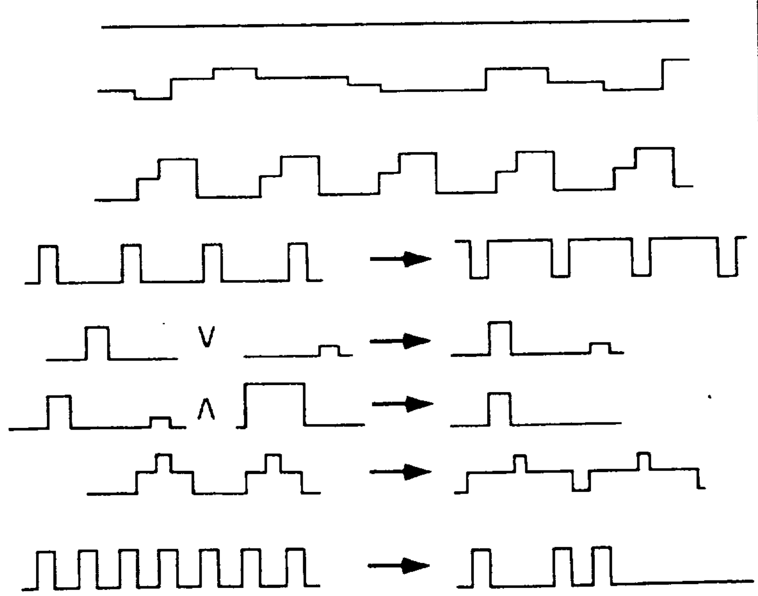
INVERT

UNION

INTERSECT

MODIFY
With start earlier by 5,
With end later by 5

SELECT 1,3,4



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Time Formats

Representation of Absolute Time:

• 1990/120/09:00:15.12	April 30, 1990, 9:00:15.12 am
• 1990/120-09:00:15.12	April 30, 1990, 9:00:15.12 am
• 1990/4/30-09:00:15.12	April 30, 1990, 9:00:15.12 am

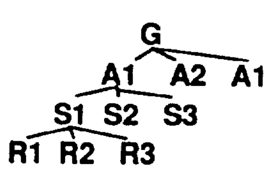
Representation of Relative Time:

• 3/2:30	3 days, 2 hours, and 30 minutes
• 2.5	2 hours, 30 minutes
• 2.5 hours	2 hours, 30 minutes
• :24.25	24 minutes, 15 seconds
• 24.25 minutes	24 minutes, 15 seconds

Changes to FERN

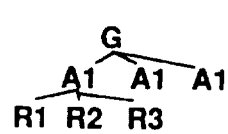
New FERN

- UIL like - keywords
- Generic repetition by iteration or user-defined windows
- Direct support of alternatives
- Flexible duration
- Pooled resources
- Database of steps



Old FERN

- LISP like - ( )
- Generic repetition by iteration
- Alternatives by mutual exclusion
- Fixed duration only
- No pooled resources
- Unnamed phases



Sample FERN Requests

Support the following features:

-- Temporal relationships between steps or activities

-- Maximum activity length to limit step delays

-- Alternative requests

-- Idle resource usage between steps of the same activity

-- Flexible request durations

-- Relaxable constraints

-- Event driven planning/scheduling concepts

-- ESP and UIL time formats

-- Step oriented (generics -> activities -> steps)

-- Min and max delays between steps and activities

-- User priorities

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Temporal Relationship between Two Steps

Problem: The steps ERBS_TR_DUMP and ERBS_RANGING occur concurrently when command uplink and telemetry downlink are available (coherent transponder mode). This example shows how to specify relationships between steps by using a constraint expression.

Step *ERBS_TR_DUMP* **is**
Resources
TDRSS_I_CHANNEL_FORWARD_LINK, *-- mode 1.0 kbps*
TDRSS_I_CHANNEL_RETURN_LINK , *-- mode 1.6 kbps*
TDRSS_Q_CHANNEL_RETURN_LINK *-- mode 32 kbps*
End step

Step *ERBS_RANGING* **is**
Resource
TWO_WAY_RANGING_AND_DOPPLER 1,
Constraint
Occurs entirely during *ERBS_TR_DUMP*
End step

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Maximum Activity Length to Limit Step Delays

Problem: The transition between steps is flexible and does not need to occur at a specific time. Switching from command uplink only mode to command uplink and telemetry downlink mode may begin from 5 to 7.5 minutes after the ERBS activity start time.

Activity *ERBS_NORMAL_CASE* **is**
Steps
ERBS_CMD_LOAD_AND_DOPPLER **for** 5 minutes **to** 7.5 minutes,
ERBS_CMD_LOAD **for** 2.5 minutes **to** 5 minutes,
ERBS_TR_DUMP_AND_RANGING **for** 13 minutes,
ERBS_TR_DUMP **for** 10 minutes
With activity duration for 33 minutes
Constraint
Starts during *ERBS_WINDOW*
End activity

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Alternative Requests

Problem: In some cases, all of the activities (instances) belonging to a generic request cannot be scheduled. Alternative requests are backup requests which tell the scheduling system how to resolve conflicts. In this example, the last alternative request applies only to those activities (instances) that remain unscheduled after the nominal request and first alternative request were processed.

Generic *ERBS_SUPPORT* **is**
1 activity per *EVERY_TWO_ERBS_ORBITS*
Schedule -- schedule nominal first
ERBS_NORMAL_CASE
Or schedule -- move ranging step to try to resolve resource conflict
ERBS_RETURN **and** *ERBS_SMALL_WINDOW_TRACKING*
Or schedule -- if one of the ERBS activities cannot be scheduled, place it within the next 3 orbits
ERBS_BIG_WINDOW_RETURN **and** *ERBS_BIG_WINDOW_TRACKING*
End generic

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Temporal Relationship between Two Activities

Problem: The CLAES instrument normally views for three days on and three days off. However, during a spacecraft yaw manuever, the science user wants to interrupt the normal view activity to close the instrument's aperature door. The normal view activity resumes after the spacecraft yaw manuever.

Activity *CLAES_CLOSED_DOOR_VIEW_ACT* **is**
Steps
CLAES_CLOSE_APERATURE_STEP **for** 1 minute,
CLAES_DOOR_CLOSED_VIEW_STEP **for as long as possible,**
CLAES_OPEN_APERATURE_STEP **for** 1 minute,
Constraints
Overlaps exactly *UARS_YAW_MANUEVER*
Occurs entirely during *CLAES_NORMAL_VIEW_ACT*
End activity

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Idle Resource Usage between Steps

Problem: The HALOE instrument alternately views the sunrise and sunset. In between, it is stowed. The idle step is used to maintain the minimum resources required for stowing between viewing.

Activity *HALOE_NORMAL_ACT* **is**
Steps
HALOE_SUNRISE_VIEW_STEP **for** 15 minutes,
HALOE_SUNRISE_SLEW_TO_STOW_STEP **for** 20 seconds,
idle *HALOE_STOW_STEP* **for** as long as possible, -- limited to about 25 minutes
HALOE_SUNSET_VIEW_STEP **for** 15 minutes,
HALOE_SUNSET_SLEW_TO_STOW_STEP **for** 15 seconds,
idle *HALOE_STOW_STEP* **for** as long as possible – for remainder of orbit
End activity

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