

Global Schedule File Design Document

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Overview

This document describes a proposed design for an Orbiting VLBI (OVLBI) global schedule file, which is used to coordinate activities of Satellite Control, Tracking Stations and the Ground Radio Telescopes (GRTs) during satellite observations. The global schedule file will contain a Global Sequence of Events (GSOE), in chronological order, for all OVLBI mission elements.

The present document does not fully specify the proposed file, leaving many details to future documents. However, the philosophy, major principles, and a top-level design are given. It must be emphasized that the Green Bank Earth Station is being implemented on the basis of these principles, and that the station is nearing completion; future funding may not permit major changes to this approach, although adjustments to the details will remain possible. Therefore, comments and suggestions by all concerned are urgently requested.

Background

The Global schedule file implements the second of a three step process for creating commands to control the mission elements during satellite observations. These three steps are:

Science Schedule: A scientist, whose observing proposal was accepted, creates a plan for observation of radio sources, considering allocated observing time for satellites and ground radio telescopes.

Global Schedule: Experts (under RSOG or VSOG) create a global sequence of events for all mission elements, including the satellite, ground radio telescopes, tracking stations and (to some extent) correlators.

Local Schedule: Each mission element will receive the global schedule file and extract events relevant to that element. From these it will generate a local schedule containing the detailed commands specific to that element needed to achieve the tasks assigned in the global schedule file.

The global schedule file is based on the science schedule and knowledge of the constraints of the mission elements, but not implementation details. The local schedule files will be created by each mission element based on the global schedule file and the specific implementation of the element's hardware.

Design Philosophy

The global schedule file contains a high level description of the operation, including A) astronomical coordinates and frequencies to be observed, B) tracking station assignments for the satellite(s), C) the start and stop times for tracking events (uplink transmission and recording, etc.), D) satellite events (calibration tone transmission, changes of frequency and data rates), and E) destination (and format) of down-link data and GRT observations. One global schedule file will be provided to all mission elements, and each element will select schedule events relevant for that element. The details of the schedule file syntax should not be important for the overall design.

The idea that everyone receives an identical copy of the complete GSOE is important. It avoids the need for any mission element's operators to explain to the global scheduling team exactly what information is of interest to them, especially considering that the set of relevant information might change. The GSOE files should be short enough that their wide distribution is not overly burdensome, even if they contain considerable information that is irrelevant to any one user.

The global schedule file will contain only lists of events in chronological order, and will not contain conditional statements (e.g. "if" statements or loops), in order to simplify the implementation and increase reliability.

Additional information, not contained in the GSOE file, may be needed by some mission elements. This occurs when the necessary information is not available when the GSOE is prepared (we estimate that this will be 30 to 60 days in advance of an observation). For example, tracking stations require a file giving the predicted ephemeris of the satellite, and this may be determined only a few days in advance so as to make use of the latest tracking data. In general, all control information that is known should be included in the GSOE, and separate interfaces for other information should be implemented only if needed.

Times

Each event in the global schedule file will be marked with the UTC date and time at which it is intended to occur. It is the responsibility of the appropriate mission element to cause the event to occur at this time or as soon thereafter as possible. Determination of actions needed in preparation for the event (e.g., hardware initialization, running diagnostic tests, slewing an antenna into position) and the scheduling of those actions is a local responsibility and is not covered in the GSOE.

Format

The global schedule file is an ASCII file written in free format (extra blanks, tabs will be ignored). It will consist of one record per event, tagged by time, mission element and satellite. The event will be described by a keyword and optional parameters, the meanings of which will be precisely defined in later documents. It is expected that the schedule file will be fairly terse. The following is a preliminary list of GSOE items required by the Green Bank Earth

Station (GBES) and probably required by all tracking stations:¹

Track Start: Start tracking pass for specified spacecraft: causes the antenna to be pointed and receivers to be tuned so as to be ready to *receive* signals from the spacecraft at or before the specified time. Thereafter, acquisition of down-link signals will occur automatically, and all signal normal processing will occur *except* that the up-link transmitter will not be turned on and the tape recorders will not be started.

Transmit Start: Turn on up-link transmitter, begin transmitting timing reference signal, verify acquisition by spacecraft, and begin recording two-way time residuals. When this has been accomplished, perform timing initialization sequence.

Record Start: Begin wide-band tape recording of down-link data. Recording will actually begin when valid data is being acquired or at the specified time, whichever is later. Thereafter, recording continues until a "Record Stop" event is specified, even if the data becomes invalid. Gaps in recording may be caused by tape reversals and tape changes; such tape management issues are regarded as internal to the tracking station and not part of the global schedule file (however, such events will be logged and known *post facto*).

Record Stop: Stop tape motion. This does not imply any other tape management function. Tracking and transmission continue if previously started.

Transmit Stop: Turn off uplink transmitter. Tracking and recording continue if previously started.

Track Stop: Station is no longer assigned to track this spacecraft, and may do something else until the next relevant event in the schedule file (including maintenance, tape changing, or sitting idle). It will force "Transmit Stop" and "Record Stop" if these have not already occurred. If a new "Track Start" occurs first, then "Track Stop" is done automatically before starting the new pass.

Tone Start: The satellite will inject a calibration tone at a specified frequency into the astronomy receiver. The tracking station will synchronously detect this tone.

Tone Stop: End satellite calibration tone injection.

Tape Format: Set recording mode to the specified value, and use this mode until it is changed.

The GBES also desires, but does not absolutely require, additional records in the GSOE. These desired records are:

Spacecraft Mode: Specify a change in the operating mode of the spacecraft (includes observing frequency and channelization). This is primarily a direction to the spacecraft controllers, but if this information is available at the tracking station it will be used to check the status bits in the down-link headers against the intended state; if they disagree, that fact will be logged.

¹In the schedule items list, "reasonable" default states are assumed. For example, a default tape format will be used if none is specified. Also certain actions are assumed; if record start is scheduled, but transmit start has not, transmission will not start. However, if track stop is encountered before transmit and record stop, transmit stop and record stop will be scheduled.

UTC Time	Element	Satellite	Action	Parameter
93 April 13 1:05	GBES	VSOP	Tape Format	< Parameters >
93 April 13 1:00	GBES	VSOP	Track Start	
93 April 13 1:05	GBES	VSOP	Transmit Start	
93 April 13 1:10	GBES	VSOP	Record Start	
93 April 13 1:15	GBES	VSOP	Tone Start	< Parameters >
93 April 13 1:20	GBES	VSOP	Tone Stop	
93 April 13 2:05	GBES	VSOP	Frequency Change	< Parameters >
93 April 13 2:50	GBES	VSOP	Record Stop	
93 April 13 2:40	GBES	VSOP	Track Stop	
93 April 13 2:55	GBES	VSOP	Transmit Stop	
93 April 13 2:55	Goldstone	VSOP	Transmit Start	
93 April 13 3:00	Goldstone	VSOP	Record Start	
93 April 13 3:00	GBES	VSOP	Track Stop	
93 April 13 4:00	GBES	ASTRON	Track Start	
93 April 13 4:10	GBES	ASTRON	Transmit Start	
93 April 13 4:15	GBES	ASTRON	Record Start	
93 April 13 5:55	Goldstone	VSOP	Track Stop	
93 April 13 5:55	GBES	ASTRON	Track Stop	

Table 1: Hypothetical global schedule file, showing example events for two tracking stations for both VSOP and RADIOASTRON. In a complete global schedule file, additional scheduled events are required for GRTs and for satellite control. The components of the Parameters fields are to-be-determined.

- Start Slew:** Start time of satellite antenna slew.
- Stop Slew:** Stop time of satellite antenna slew.
- Coordinates:** Commanded satellite pointing direction on the sky.

Many other events, including those needed for the satellite control and the ground radio telescopes, will be in the global schedule; the formats for specifying these events will be given in other documents. A straw-man GSOE file containing only tracking station events is shown in Table 1.

Implementation

For each mission element, a global schedule conversion program will handle details such as planning hardware initialization, slewing an antenna pointing position and executing test procedures, as well as translating the specified events into a set of local commands.

An important special consideration for tracking stations and GRTs is tape handling. The GSOE shall contain no tape management information (such as specifying tape serial numbers or the times of tape changes); these are to be determined locally.

The software for conversion of global schedule files to local command files is the responsibility of each mission element. The ground radio telescopes should be able to develop a common local command file format, and may therefore be able to share a single set of software.