# **Planning Systems in Hubble Space Telescope**

Doing planning for HST is a complex problem for many reasons. In a year HST can analyze thousands of targets. There are a large number of interacting constraints with timescales covering several orders of magnitude (minutes to years). The Schedule is modified constantly as observations are made.

HST implements a two level hierarchical approach for its scheduling. Scheduling has been divided in two: Long-term scheduling, which allocates observations over a 1-2 year interval, and short-term scheduling, which covers a one-week period and creates a detailed timeline of activities.

Short-term scheduling program is called Science Planning and Scheduling System (SPSS). Long-term scheduling programm is called Spike. On this text we are going to focus on Spike.

Spike combines different techniques such as Constraint Satisfaction, Heuristics and techniques that are similar to Simulated Annealing.

Constraint Satisfaction is used to schedule observations based on several parameters. Those parameters can be: exposure, number of photographs, position of the HST (if the telescope pass through a high radiation zone), position of the target (if the target is hidden by earth or another object).

Many Hillclimbing Repair Methods and Heuristics are used in order to solve conflicts between observations. One of the heuristics used is called Min-conflicts, which moves activities to times when the number of conflicts is minimized.

Spike has been implemented in other NASA telescopes, this was possible because it was developed as a framework instead just for HST. It was developed using Lisp and Texas Instruments electronics.

When it launched, HST showed many issues with its lenses. This problem affected observations significally and was agravated by other software and hardware malfunctions. One of the things that engineers learned about this mission was that change was the norm and their main recommendation when developing planning/scheduling systems was that, at least for systems similar to HST, **planning must be built in the expectation of change from the outset.**

**References:**

- **Spike: AI scheduling for Hubble Space Telescope after 18 months of orbital operation**s <https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19910013462.pdf>

- **Long Range Science Scheduling For The Hubble Space Telescope** <https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19910013462.pdf>

**Planning and the Human Brain**

The human brain has an area within the frontal cortex called the lateral frontal pole. It is responsible for the planning and desition making processes according to studies. Being able to plan into the future is considered a key feature of human cognition.

According to a team of researchers from Oxford University this is not just a complex task that humans perform like any other, but there are also significant differences between the lateral frontal pole in humans and other areas in monkey frontal cortex.