Commentary on "Automated Scheduling for TerraSAR-X/TanDEM-X" by Christoph Lenzen, Maria Th. Wörle, Falk Mrowka, Michael P. Geyer, and Rüdiger Klaehn

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The Lenzen, Geyer, and Mrowka paper reports on an automated system that schedules many different tasks of the TerraSAR-X (TSX-1) and TanDEM-X (TDX-1) satellites. The scheduling system is part of nominal operations for the missions. Operational applications of automated planning and scheduling are few and far between because of difficulties in domain knowledge elicitation, modeling, validation, usability, changing requirements, and customer acceptance. Thus, this application is an extraordinary accomplishment because of these difficulties and other unusual requirements.

One difficulty that this application avoids is customer acceptance. TerraSAR-X is required to allow as many as 1000 SAR imaging requests per day as late as six hours before execution. The only way to meet these requirements is to automate the scheduling process. So, instead of having to convince users to adopt their software, the mission depends on it.

An unusual aspect of the scheduling problem is that some requests are coordinated between the TSX-1 and TDX-1 satellites for stereo imaging. Their operations are also coordinated to avoid communication interference and irradiation of one satellite's instruments by the other's transmission when they are close. If close enough, the satellites are both able to communicate with the same ground antenna. Fortunately, TDX-1 is an upgraded "copy" of TSX-1, so there is no great difficulty in human coordination across missions. However, requests for TDX-1 are scheduled as much as a year in advance, complicating scheduling decisions. The requesting customers include public and private interests, but prioritization is provided as input to the automated scheduling system.

The scheduling system uses a modeling language for describing resources, hierarchical tasks, and timing constraints. The base scheduling algorithm is greedy with backtracking. Some specialized scheduling code augments this algorithm to ensure that in certain situations lower priority requests are satisfied and that TDX-1's greater memory capacity is utilized. In order to address the issue of satisfying requests for TDX-1 far in advance of those for TSX-1 while still allowing TSX-1's to move TDX-1's, the authors devised a technique based on time windows of flexibility that alters the usual ordering of requests by priority.

Scheduling takes two hours for a three-day schedule and is dominated by power model calculations as part of a "modification handler." Often, automated planners use an abstracted model of states and resources to simplify problem solving and avoid heavy computation like that for the power model. These abstractions often use conservative estimates to ensure safe plan solutions. The disadvantage is that the conservative estimate can eliminate more efficient solutions. Are there possible simplifications of the power model or other ways to streamline this computation?

The approach does mention a few possible parallelizations of modification handlers (which apply schedule changes and update resource projections) but that the single garbage collection thread is a bottleneck. It would be interesting to know if there is enough memory to suspend garbage collection until after scheduling has finished. Given that the power calculations dominate performance, what would be the expected outcome of the suggested approaches?

The authors state that that they considered potential optimization criteria, but "optimization was not desired." It would be interesting to find out what criteria were considered. While the operational constraints provided complexity, it would also be interesting to hear about any customer-specific constraints or preferences.

Academia, governments, and industry have built many automated planning and scheduling systems and many for space. Some have been adapted for multiple missions but only by the same developers of the system. Like that of many others, the scheduling system for TerraSAR-X/TanDEM-X was built to be adaptable for other missions based on a modeling language. Based on this history, it remains unclear whether a new mission should try to adapt an existing planning and scheduling system on their own, ask the system's developers to adapt it, or build their own from scratch.