Stottler Henke
Smarter Software Solutions

MIDAS

MANAGED INTELLIGENT DECONFICTION AND SCHEDULING FOR SATELLITE COMMUNICATION

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OVERVIEW OF CHALLENGE

- The **Air Force Satellite Control Network** (AFSCN) provides support for the operation, control, and maintenance of a variety of Department of Defense and some non-DoD satellites (NOAA).

- Each constellation of satellites operate independently

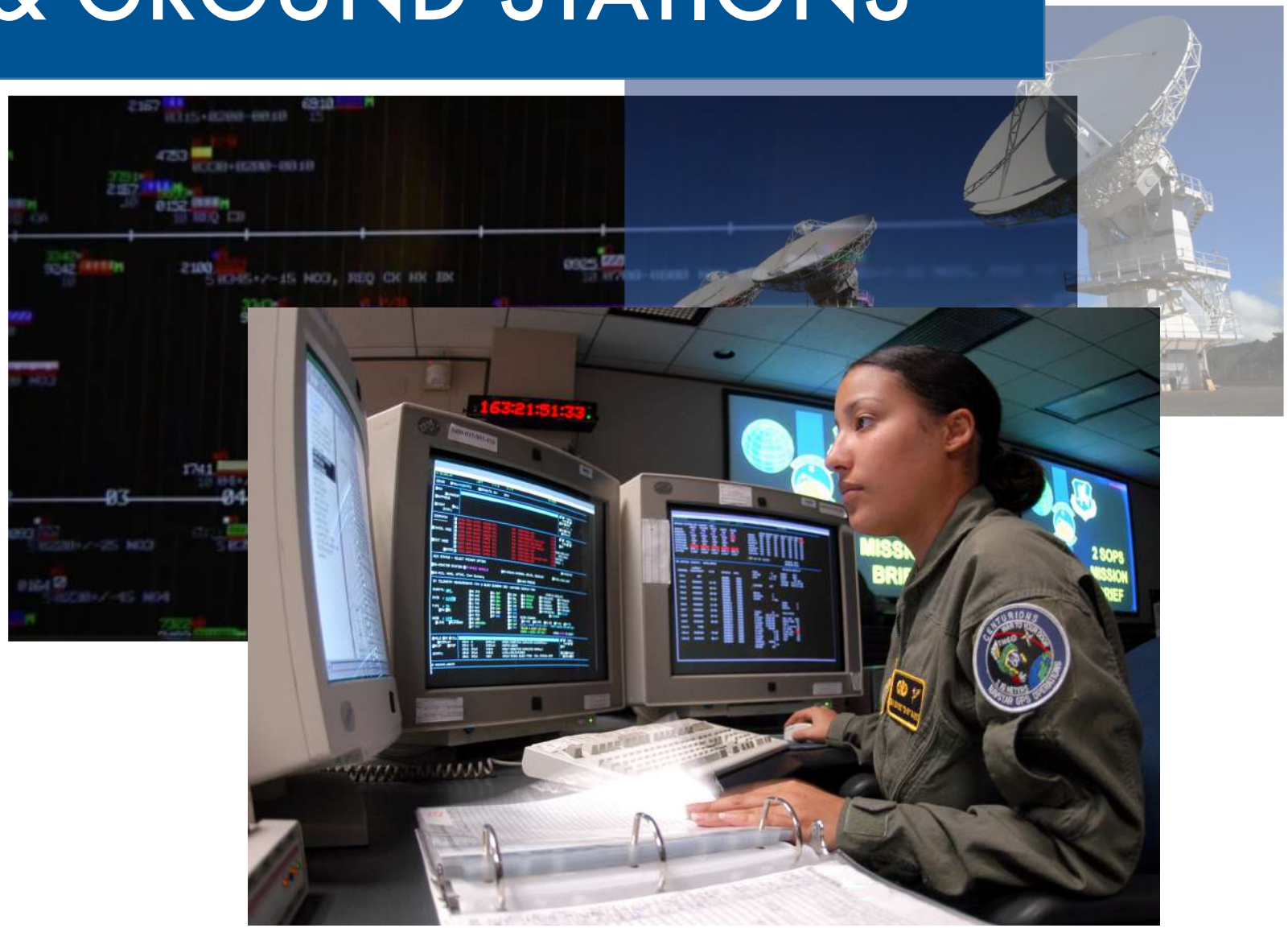
- Requests are put through a central scheduling organization to deconflict competing requests

- Constraints
  - Line of sight between the antenna and the satellite is required
  - Limited ground stations

CLIENT: AIR FORCE SPACE COMMAND

SATELLITES & GROUND STATIONS

- Over 450 contacts performed per day with over 100 changes to support requests daily
- Before MIDAS: Generated solutions were time-intensive and required a high-level of expertise
- Fluctuating priorities cause complications that require reshuffling communication plans



SOLUTION OBJECTIVES

Provide automated scheduling and deconfliction module for AFSCN operations

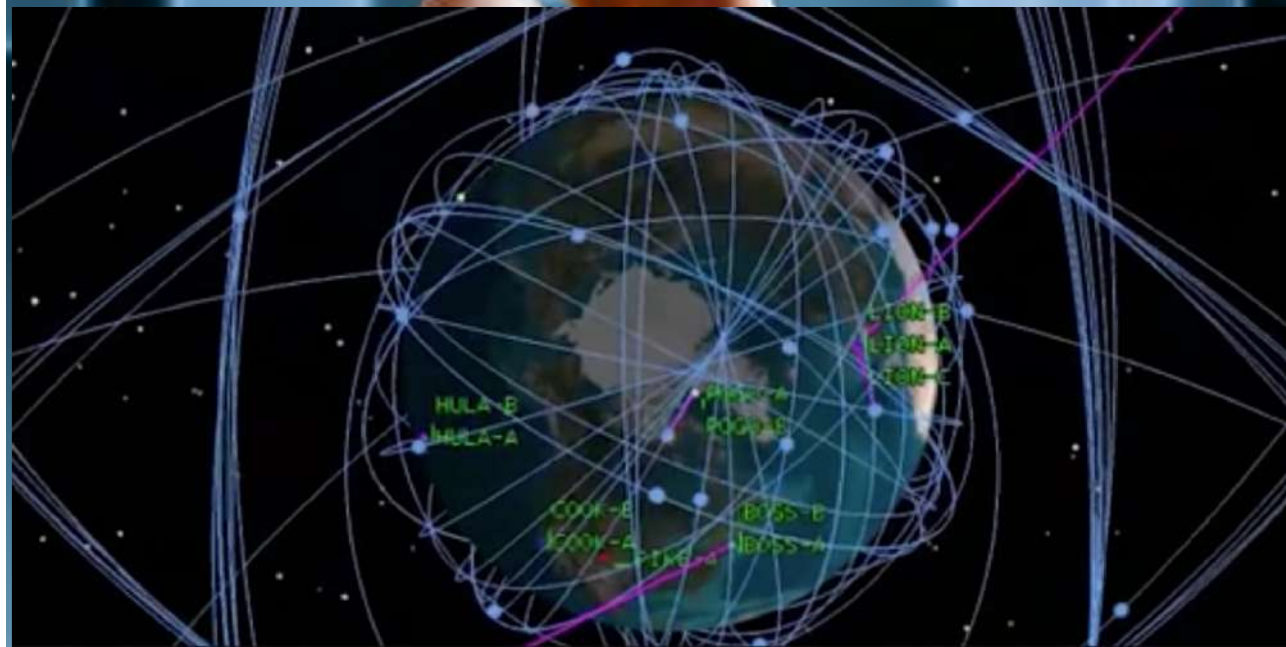
Minimize unnecessary conflicts within request constraints

Use existing expert knowledge to guide deconfliction process

Flexibility to integrate with various systems at different levels

- Read and write existing file formats

Provide a general purpose scheduling service accessible via JSIP (Joint Systems Integration Planning)

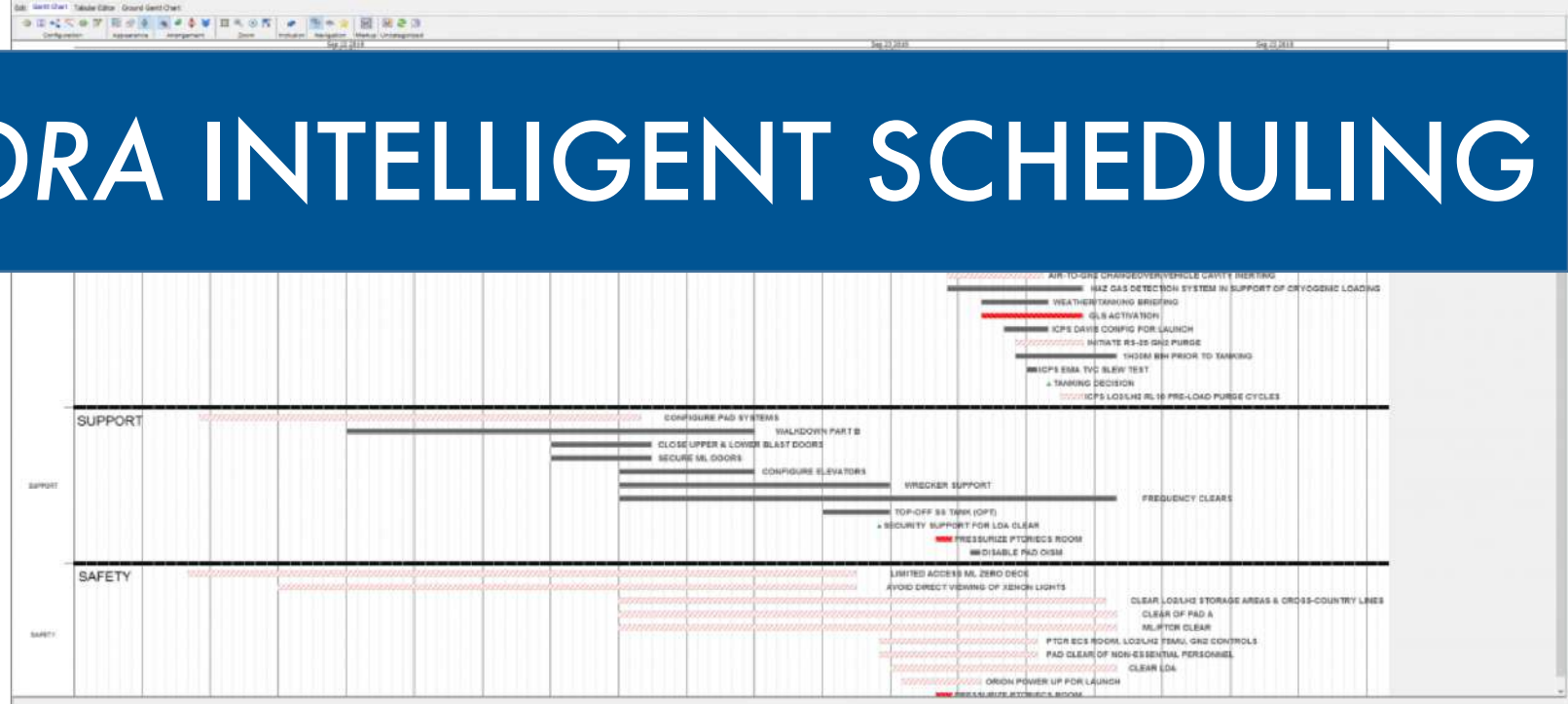


HISTORY OF FAILED ATTEMPTS

- Hundreds of millions of dollars spent on previous failed solutions

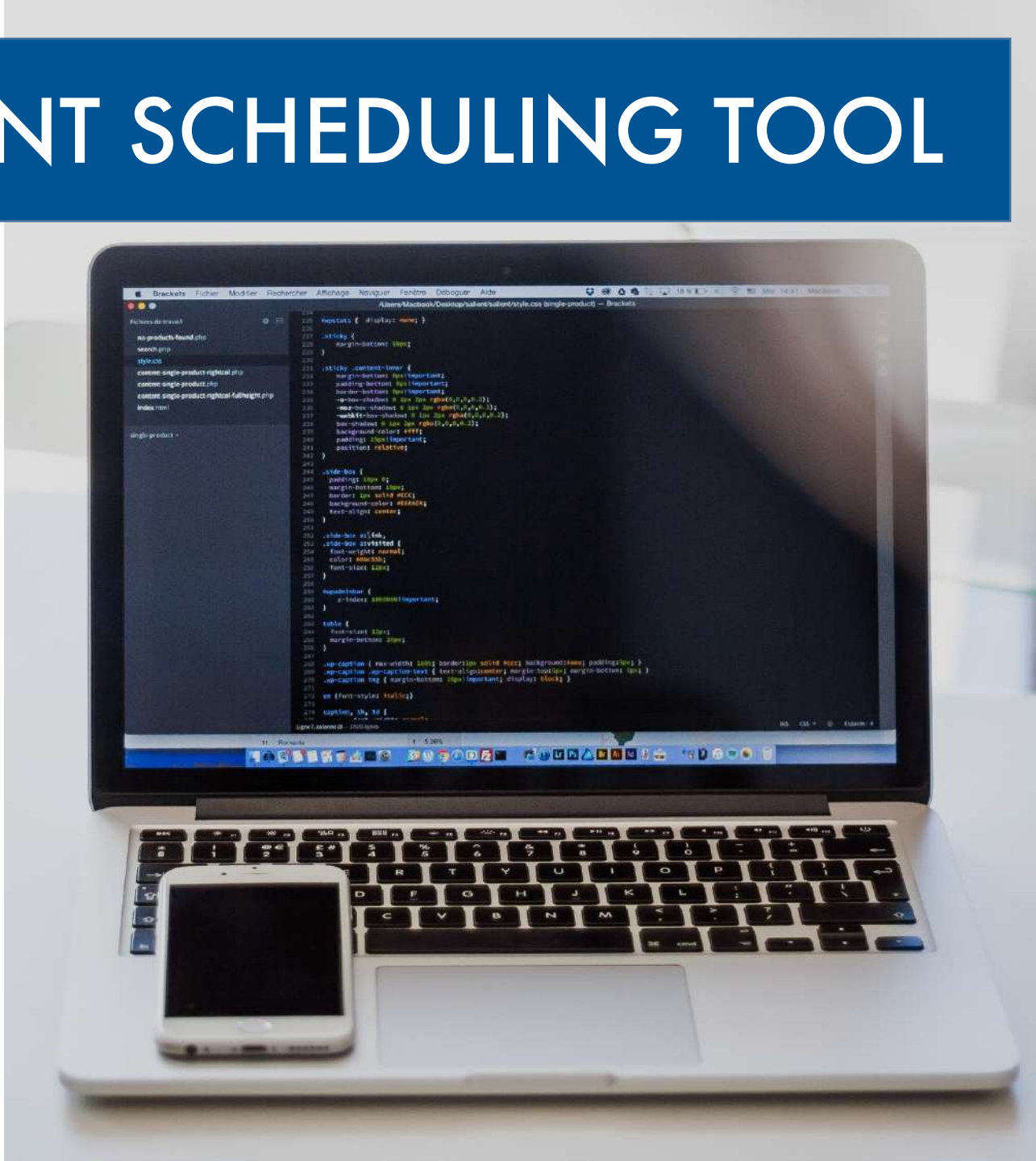
LEVERAGE *AURORA* INTELLIGENT SCHEDULING

- Utilizes scheduling heuristics from expert schedulers in multiple domains
- Complex constraint support
- Mixed-mode scheduling providing both forward and backward scheduling, available on a task-by-task basis
- Schedule Rationale – Aurora includes the rationale for each task on why it was schedule where it was schedule



AURORA INTELLIGENT SCHEDULING TOOL

- Aurora: general architecture for creating intelligent scheduling systems
- Aurora mimics human scheduling decision processes
- Typically algorithms are linear (or nearly so) and run very fast
- Plug-ins for different steps in the scheduling process (preprocessing, **ordering queue**, selecting resources/time windows, propagating constraints, solving conflicts, post-processing optimization)
- Library of general and specific methods/heuristics for each

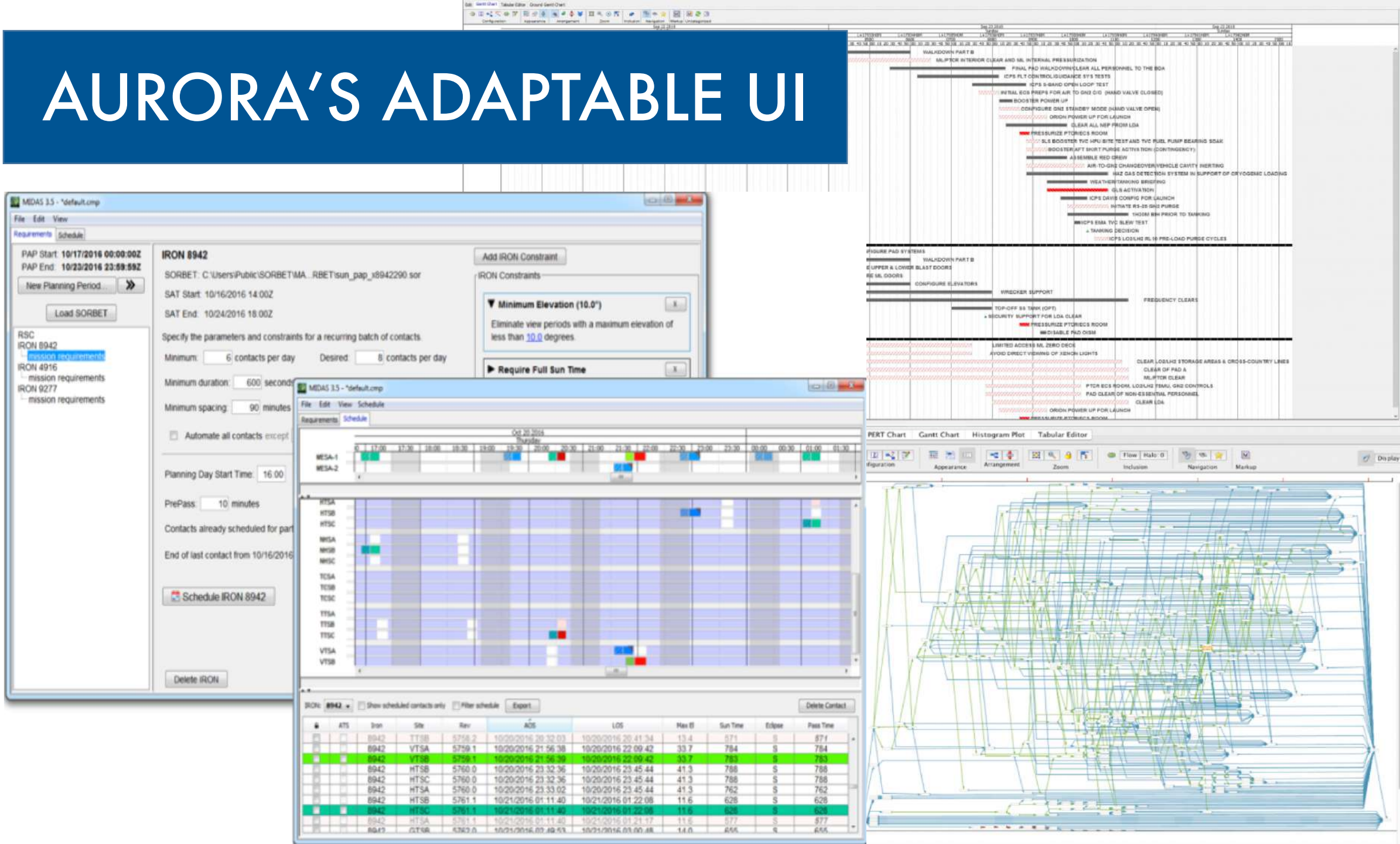


AURORA RELATED SUCCESSES

- NASA Near-earth network antenna scheduling
- Ballistic Missile Engagement & Sensor Planning
- Various NASA Applications
  - Space Launch System (SLS) Ground Processing (GP)
  - Shuttle MRO
  - Space Station Processing Facility (SSPF)
- Boeing 787 Dreamliner and other aircraft production scheduling

More optimal than all competitors in every domain tried

AURORA'S ADAPTABLE UI



SOLUTION: MIDAS

MIDAS: Managed Intelligent Deconfliction and Scheduling

Air Force Satellite Control Network (AFSCN) Scheduling Challenges

- Mission requires 100% support allocation within time/resource constrained environment (little offloads)
- High resource contention with tight time constraints
- Complex requests: Resource Combinations
- Multiple satellite priorities for same satellite
- Soft constraints/Preferences (duration, sites, antenna, etc.)
- Human edits, dynamic changes, resource failures
- Handle real-time events that require requests to be rescheduled (moved to another resource, etc.)
- Strong goal of scheduling 100% of requests
- System must be able to evolve
- Allow for rule exceptions to deconflict competing requests
- Integration of high priority missions i.e. Launches, Satellite Emergencies

SSI – USER INTERFACE

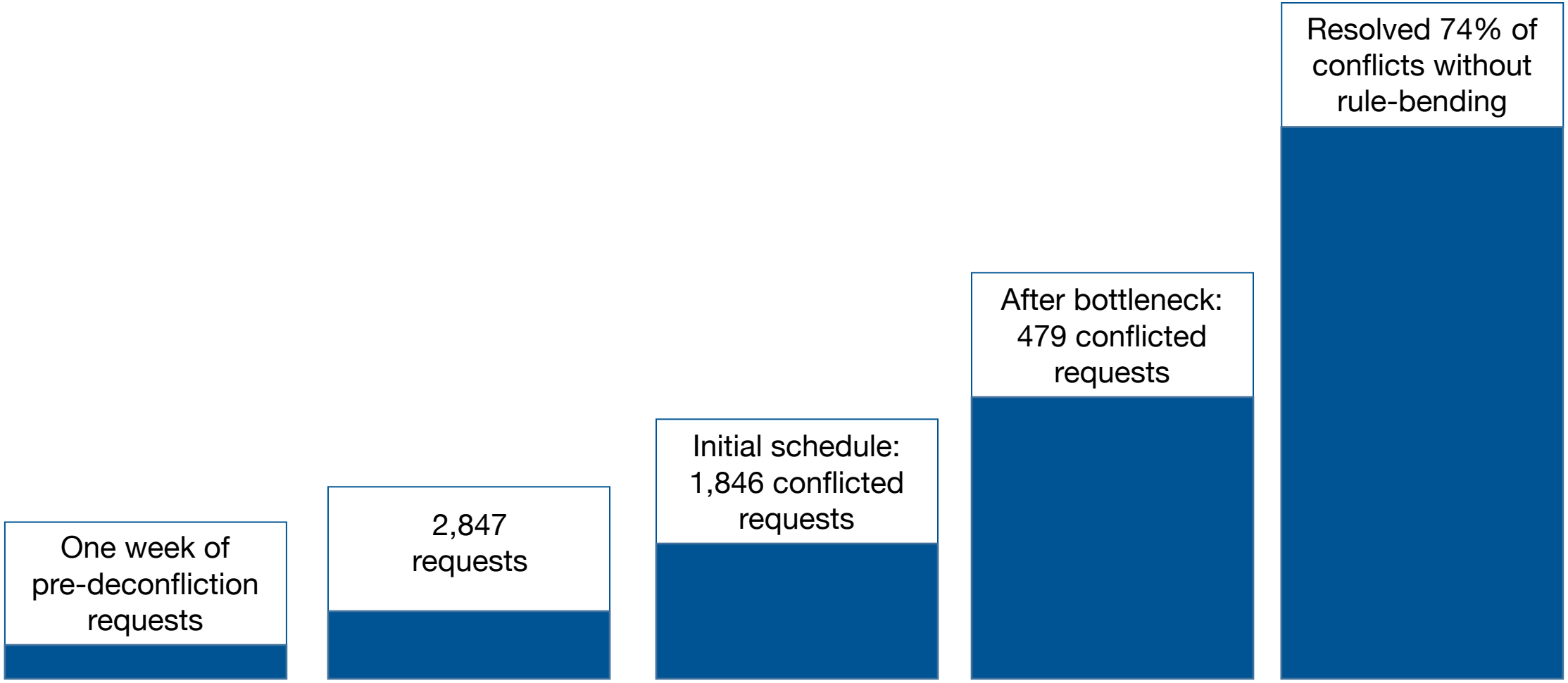
Satellite Scheduler's Interface (SSI)

- Mimics ESD Network Display
  - Display tasks, identify conflicts
  - Move tasks with drag and drop
  - Review task properties in Task Detail Display
- Currently supports MIDAS scheduling
  - Import SAT, PAP, DEFT files
  - Display and scheduling based on real ESD Environment file
  - Baseline scheduling upon load, bottleneck scheduling on demand

AURORA – SATELLITE SCHEDULING

- Adapted Aurora's suite of scheduling algorithms for satellite domain
- Bottleneck Avoidance Algorithm developed
    - Schedule the least flexible tasks before the most flexible tasks. Flexibility is defined using several dimensions: temporal flexibility (like the LEO-before-HEO approach), the degree of contention for resources in that time window, and the current state of tasks that have already been scheduled.

MIDAS – BOTTLENECK AVOIDANCE



MIDAS – BENDING THE RULES

- Leverage existing expert knowledge
- Relax or modify constraints to resolve unavoidable conflicts
- Support for “assisted” conflict resolution

Shorten Prepass

Change Slide/Station

Change Revolution

Shorten Pass

Move out of Window

MIDAS – AUTOMATED CAPABILITIES

Delivered features

- ✓ Aurora bottleneck avoidance scheduling
- ✓ User defined business rules for special cases, individually or in combination
- ✓ Conflict resolution that requires multi step solutions
- ✓ ~97% fully automatic 24 hour deconfliction
- ✓ Use of past de-confliction precedents

- ✓ Automatic deconfliction requires just a few minutes

- ✓ Frequent feedback and testing by 22 S0PS / familiar user interface

CONCLUSION

- SCN scheduling largely consists of resolving disputes between competing support requests
- MIDAS can now solve in minutes what previously took highly skilled human schedulers circa 8 hours per day
- About half of the conflicts can be solved by shuffling the requested supports within the constraints supplied with the requests.
- The other half require some degree of relaxation of the constraints: MIDAS can thus automatically resolve the large majority of remaining conflicts
    - Using a representation of parameterized business rules,
- More accurate study of future loading (and associated required resources)
- More accurate response to what-if questions relating to the impact of failed resources and required emergency supports
- Cost 2 orders of magnitude less expensive than history of failure