Prioritization and Oversubscribed Scheduling for NASA's Deep Space Network

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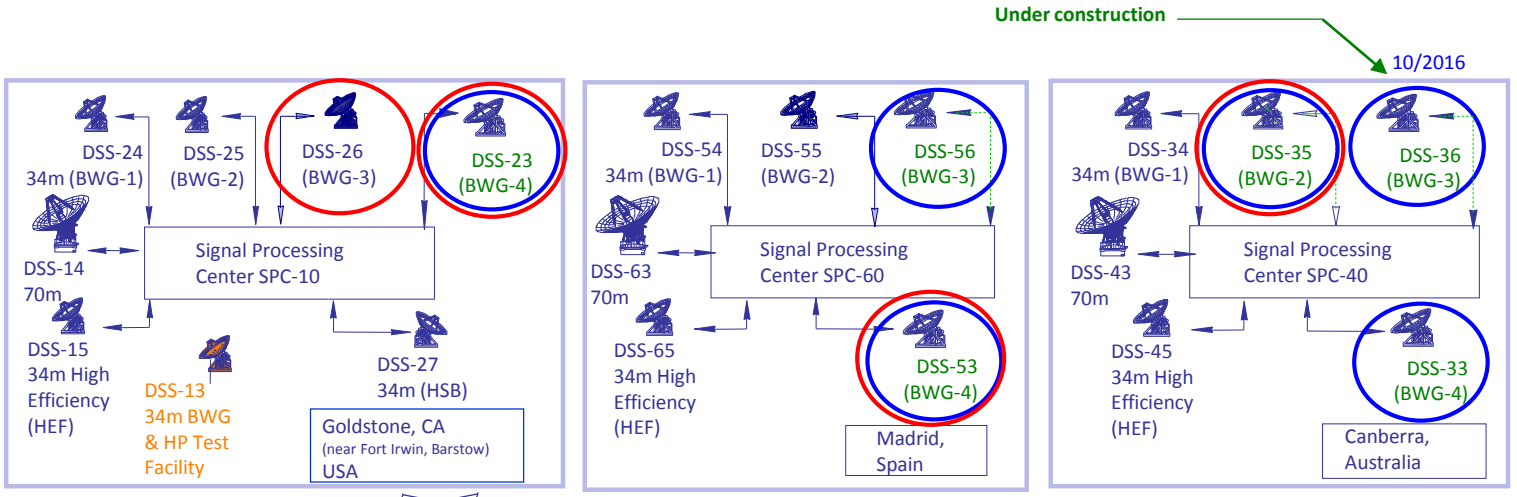
Deep Space Network

Global Facilities Map



LEGEND

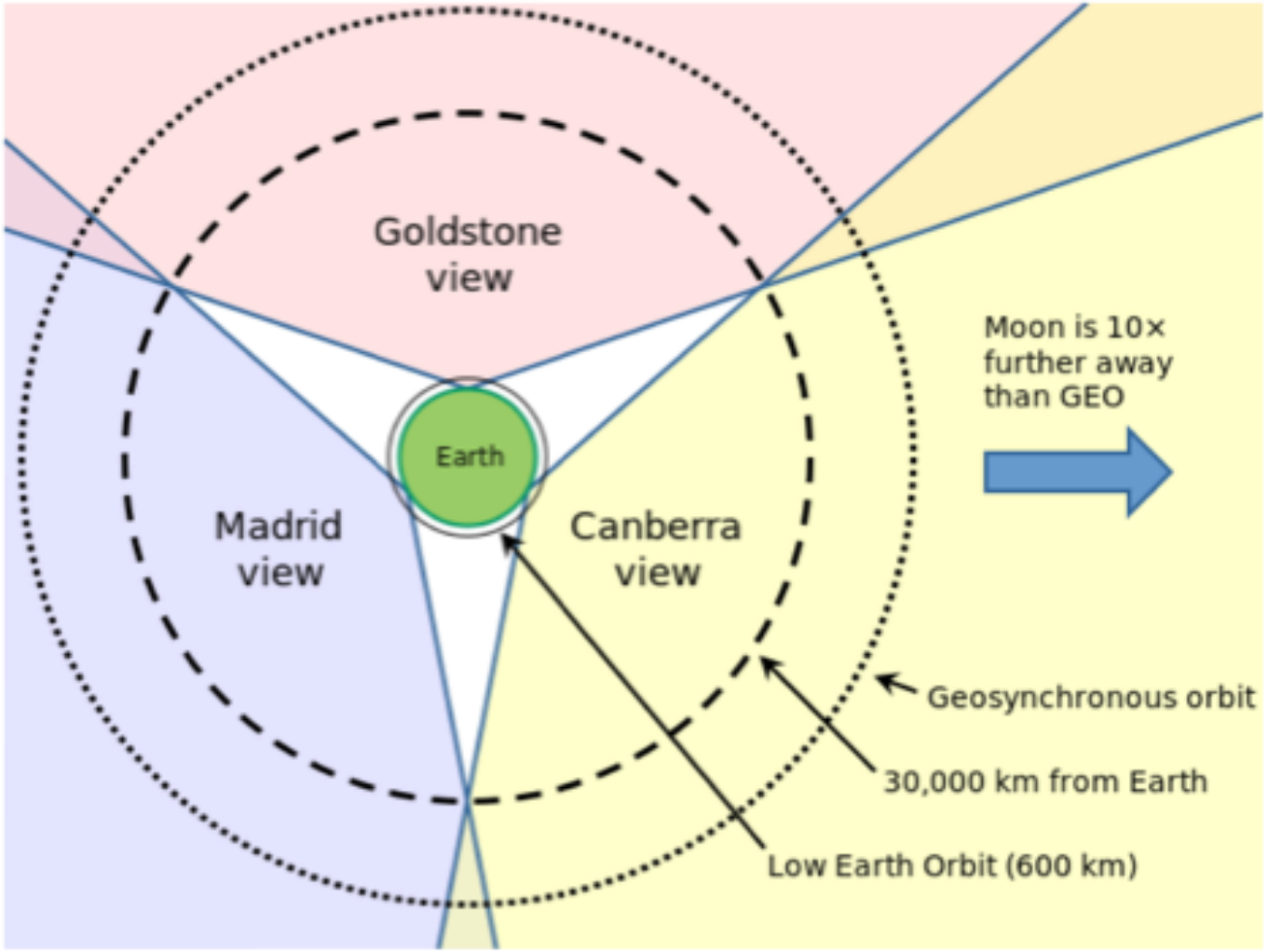
New 34m BWG Antenna

New 80 kW Transmitter

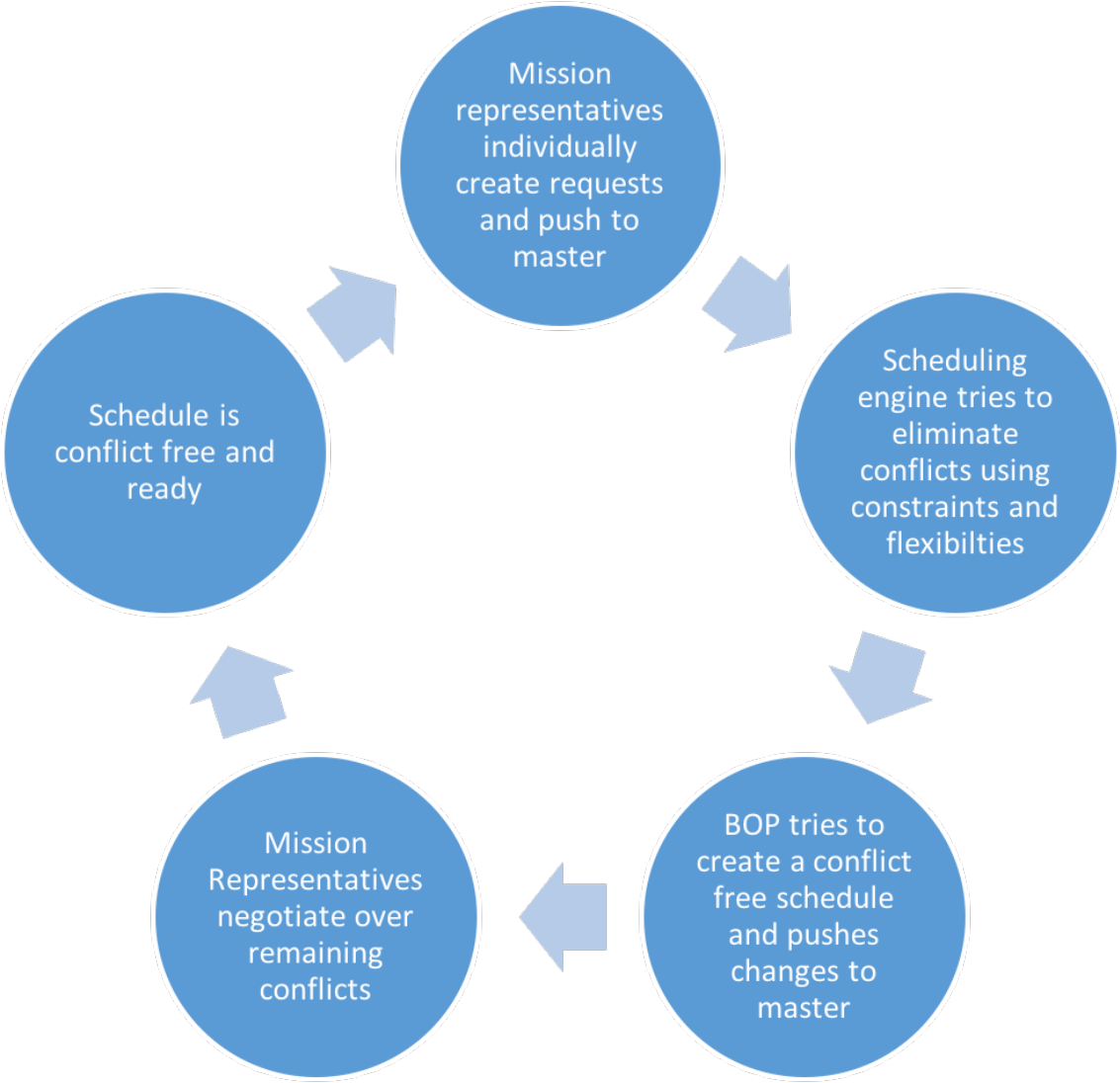
Antennas
Operational Dates
DSS-35 9/2014
DSS-36 9/2016
DSS-56 9/2019
DSS-53 9/2020
DSS-33 9/2022
DSS-23 9/2024

80 kW XTR
Operational Dates
DSS-26 9/2015
DSS-53 9/2020
DSS-35 9/2022
DSS-23 9/2024

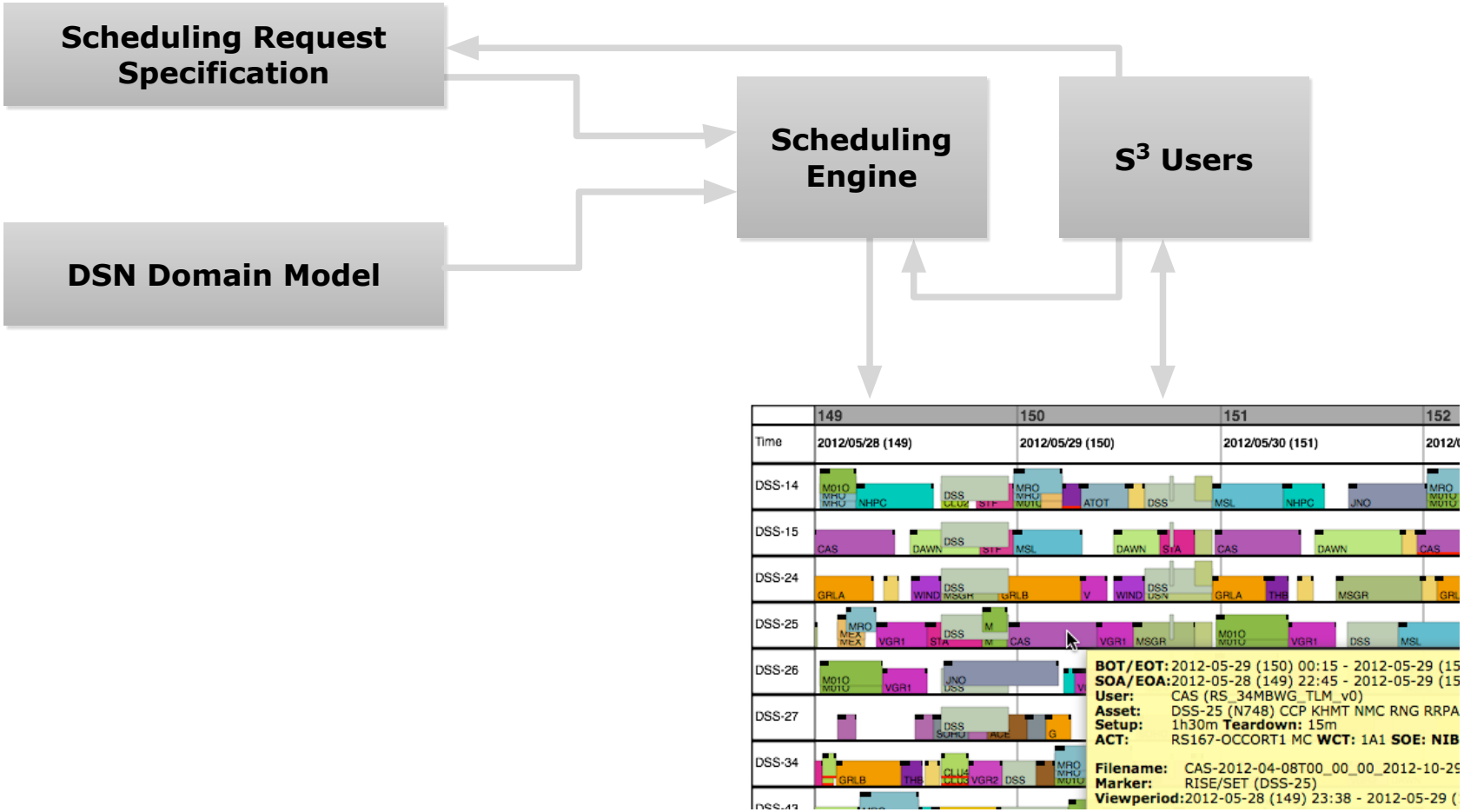
In view of DSN antennas



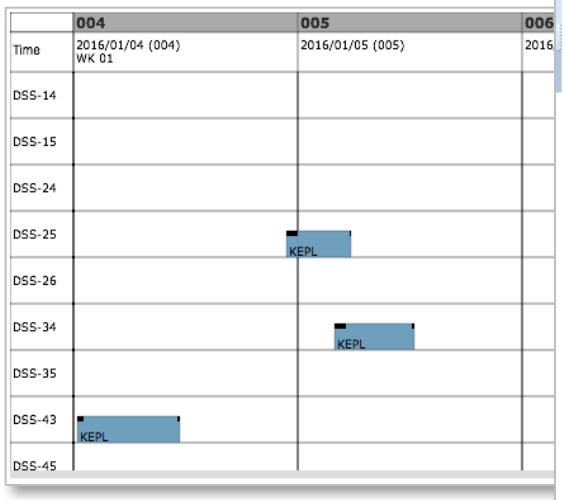
Scheduling DSN: the process

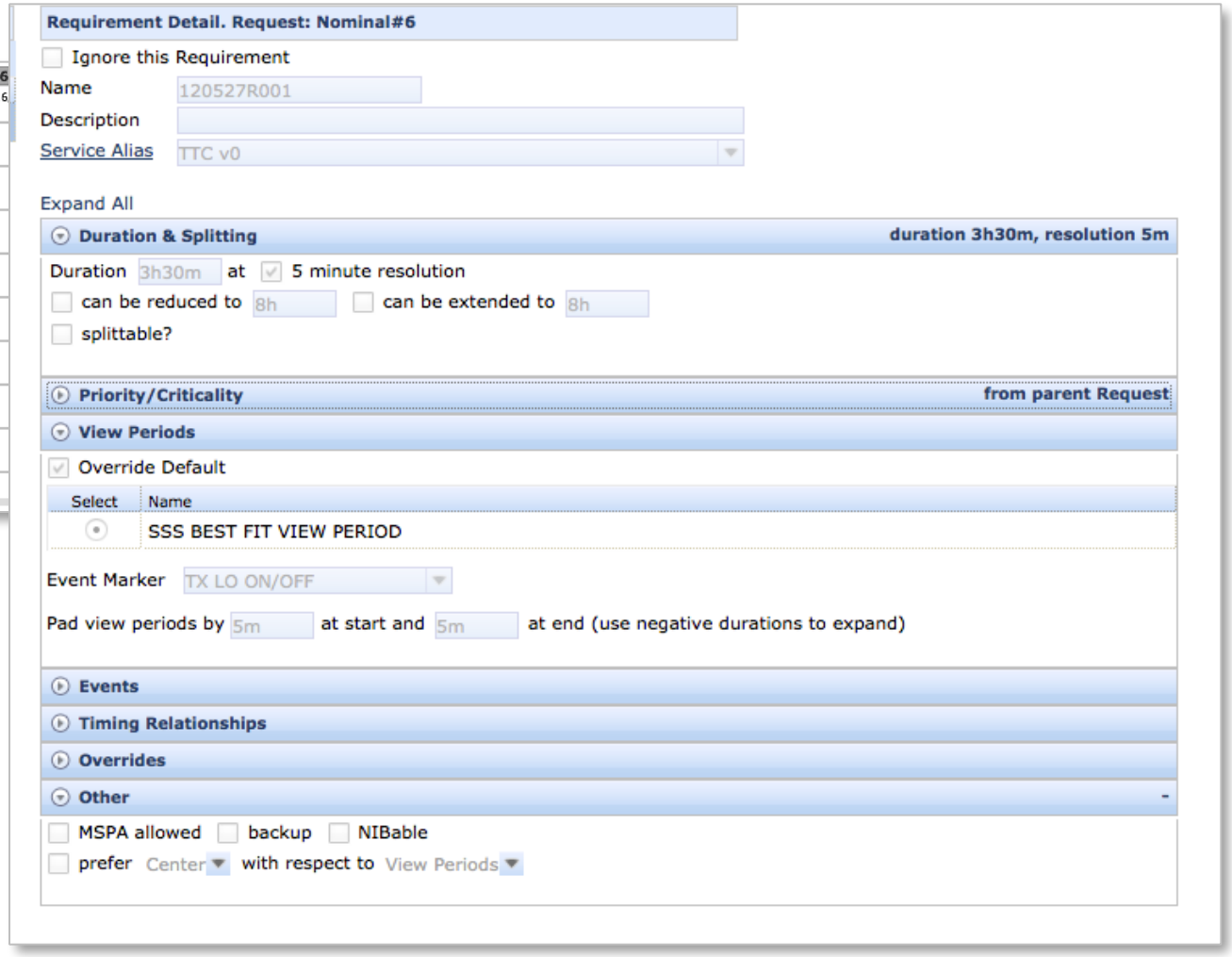


Service Scheduling Software

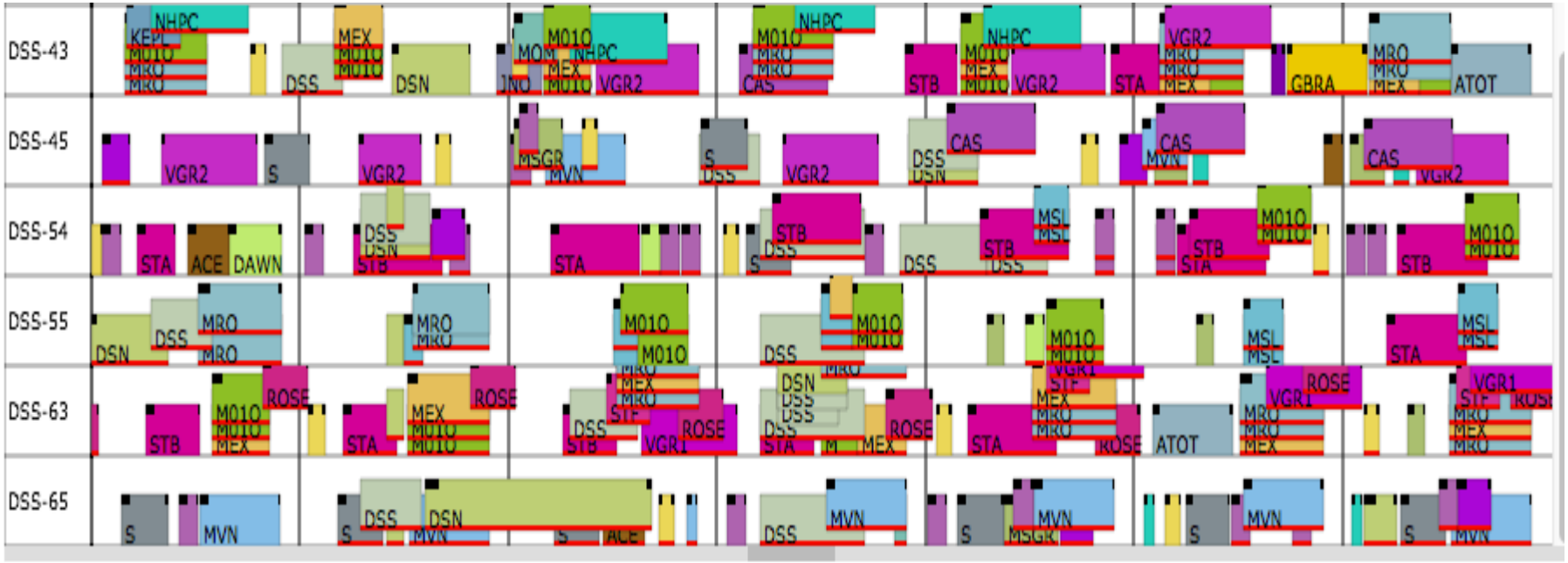


Requirements and Tracks

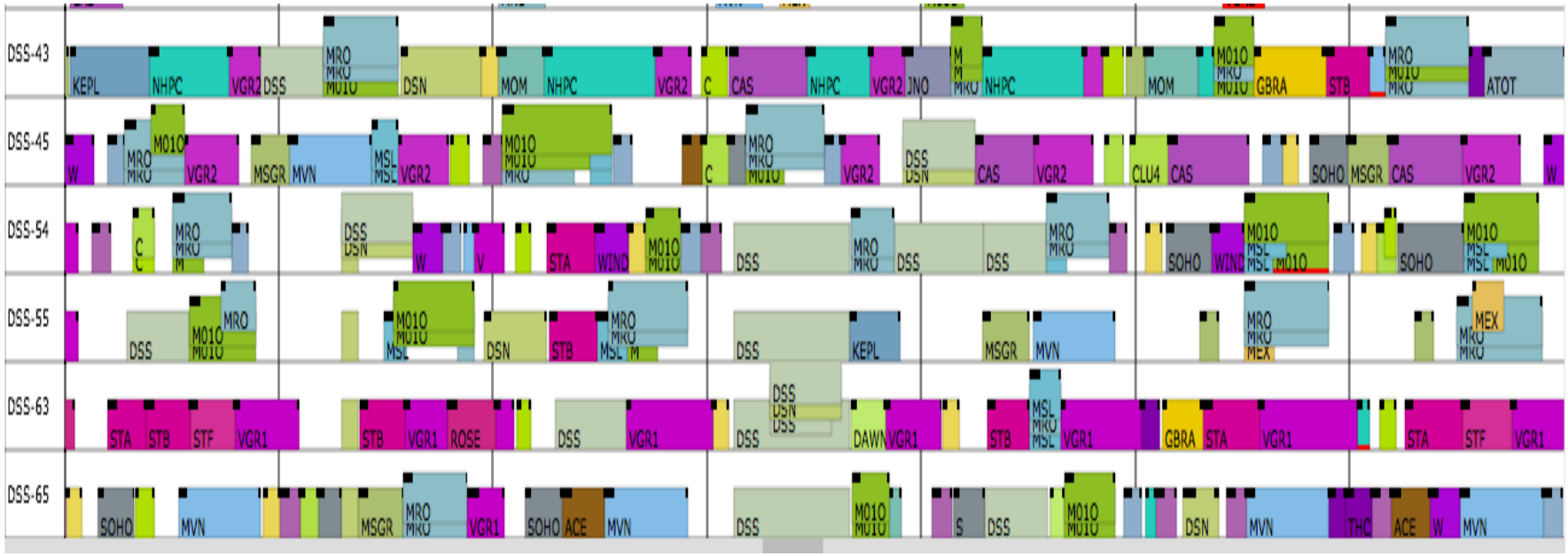




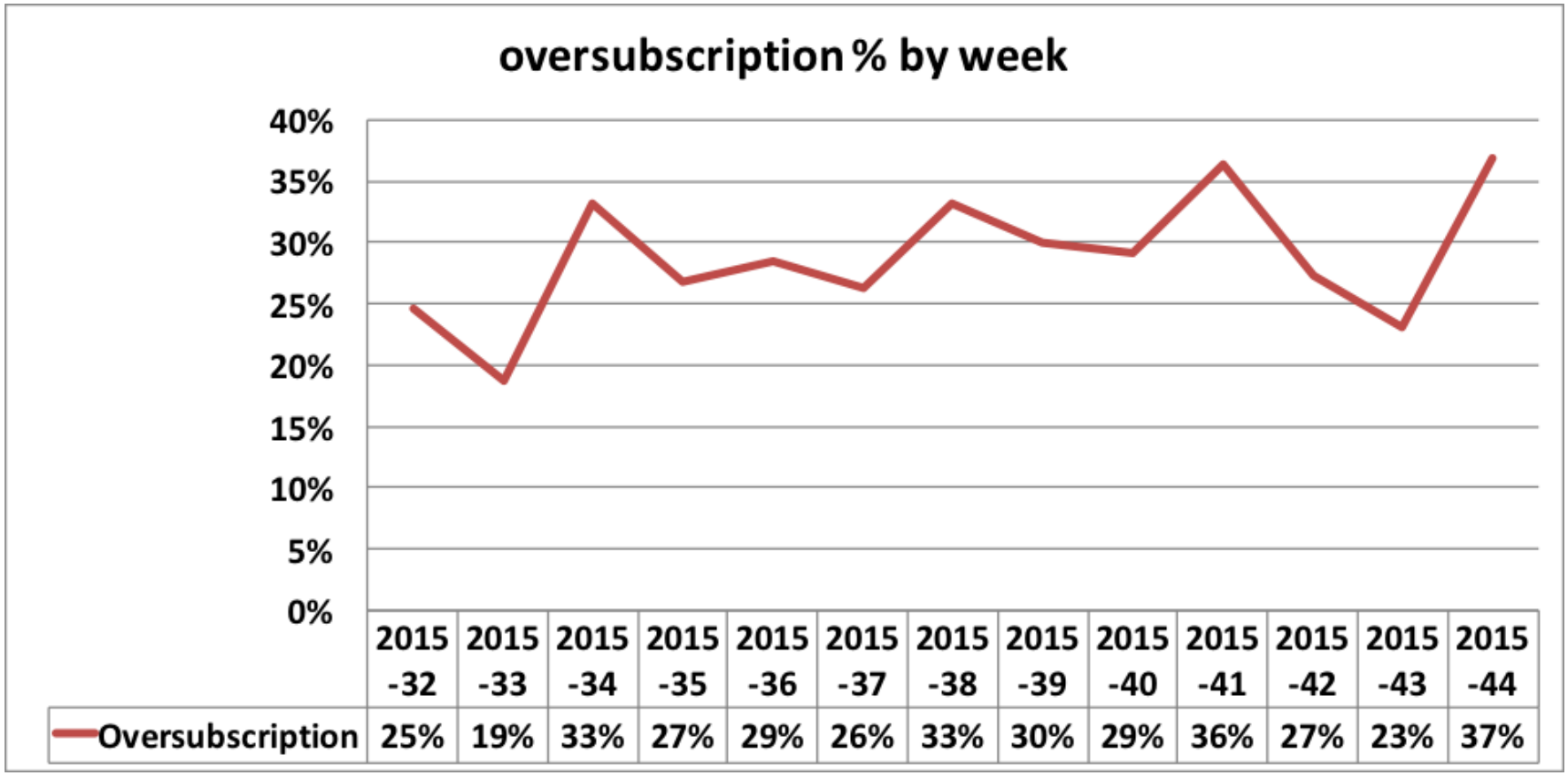
A Conflicted Schedule Example



Conflict Resolution



Oversubscription of antenna time

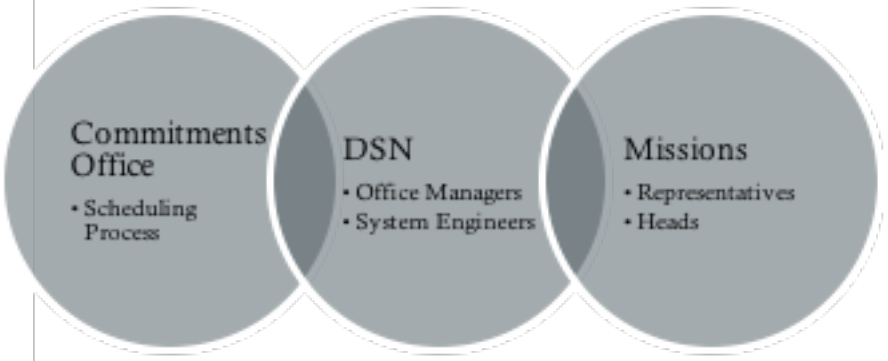


	2015-32	2015-33	2015-34	2015-35	2015-36	2015-37	2015-38	2015-39	2015-40	2015-41	2015-42	2015-43	2015-44
Oversubscription	25%	19%	33%	27%	29%	26%	33%	30%	29%	36%	27%	23%	37%

Stakeholder Interviews

QUESTIONS:

1. What is your opinion of the current priority system? Likes? Dislikes? What would you change?
   a. Biggest problem?
   b. Most helpful?
2. What is your opinion on a new and updated priority system? Do you see a need to revisit the rules?
   a. SUGGESTIONS:
      i. Difference between NASA and non-NASA missions? Yes or No? Agree vs. disagree?
      ii. Distinction between Primary and Extended Missions? Yes or No?
         - In critical situations?
         - In ordinary situations?
      iii. Priority among all missions? Mission-by-Mission ranking? Similar to the Near Earth Network but could change weekly based on needs?
         - Concerns?
         - Benefits?
         - How would you distinguish one priority over the other?
            - Visibility, Amount of antenna time, flexibility?
3. How would you feel about changing the initial requirements/inputs themselves?
   a. Putting in a true minimum or historical average as the requirements, based on....
      i. Priority algorithm, allow additional time through a priority system- negotiate up rather than down.
         OR
         How close to hitting ideals. Priority based on who is closer to their asking amounts
   b. Do you think it would be beneficial to give different levels of requirements? Start the process at the nominal and then increase or decrease as necessary?
      i. Pref- 4hr/we 10 hr
      ii. Nom-3hr/we 8 hr m-w-f _____
      iii. Min- 2hr 6hr/ m-thur ok to split
      iv. Survival- 1 hr/ 4 days – 3 hr
4. How would you feel about changing the scheduling engine? **
   a. Engine would run through priority schema and add items based on wants/minimums/historical averages until an item can no longer be placed on a track. If an item can no longer be placed on a track, it is added to a box of "Can not place item" and moves onto the next event. At the end, the BOP can manually look at the "Can not place item" box and decide which events can or cannot be placed.
5. Anything else that you think is important?



Current DSN Priority Categories

Current Priority Categories (RAP)

1. **Spacecraft emergency, Determined in real time**
2. **Mandatory for achievement of primary objectives, Support essential to spacecraft survival, Uplink to reset critical systems, launch, planetary orbit insertion**
3. **Major, unique scientific event, Time critical, Planetary encounter, major unforeseen scientific event**
4. **Minimum DSS maintenance, Minimum support to maintain science validity, Critical maintenance, short spans of data acquisition to assure data continuity**
5. **Mandatory for achievement of primary objectives, Not time-critical, Certain TCMs*, included spacecraft health and condition monitoring, planet astronomy**
6. **Time-critical events not essential to primary mission objectives Includes radio astronomy**
7. **Repeated scientific opportunities: Not time critical, Improvement upon minimum science return, includes host country radio sciences**

*Trajectory Correction Maneuvers (TCMs) fall into two categories:

(1) TCMs that are constrained to a particular time may be considered Priority 2, e.g., Injection into planetary orbit

(2) TCMs that offer more flexibility in planning are considered Priority 5. In this instance, projects are expected to make every effort to avoid conflicts by coordinating their plans

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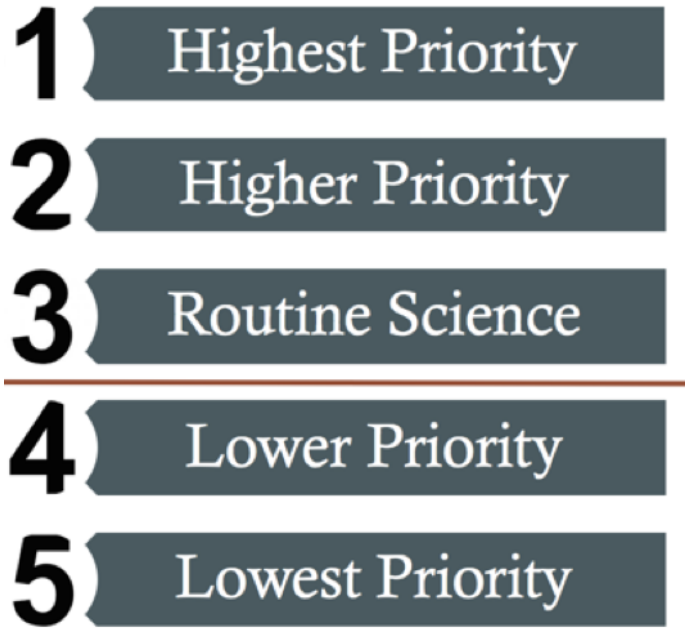
Some Priority Considerations for DSN

- Prime vs extended missions
- NASA vs non-NASA missions
- Intra-mission priority tiers
- Enforced reduced input levels
- Time-dependent priority

Experiments — Setup

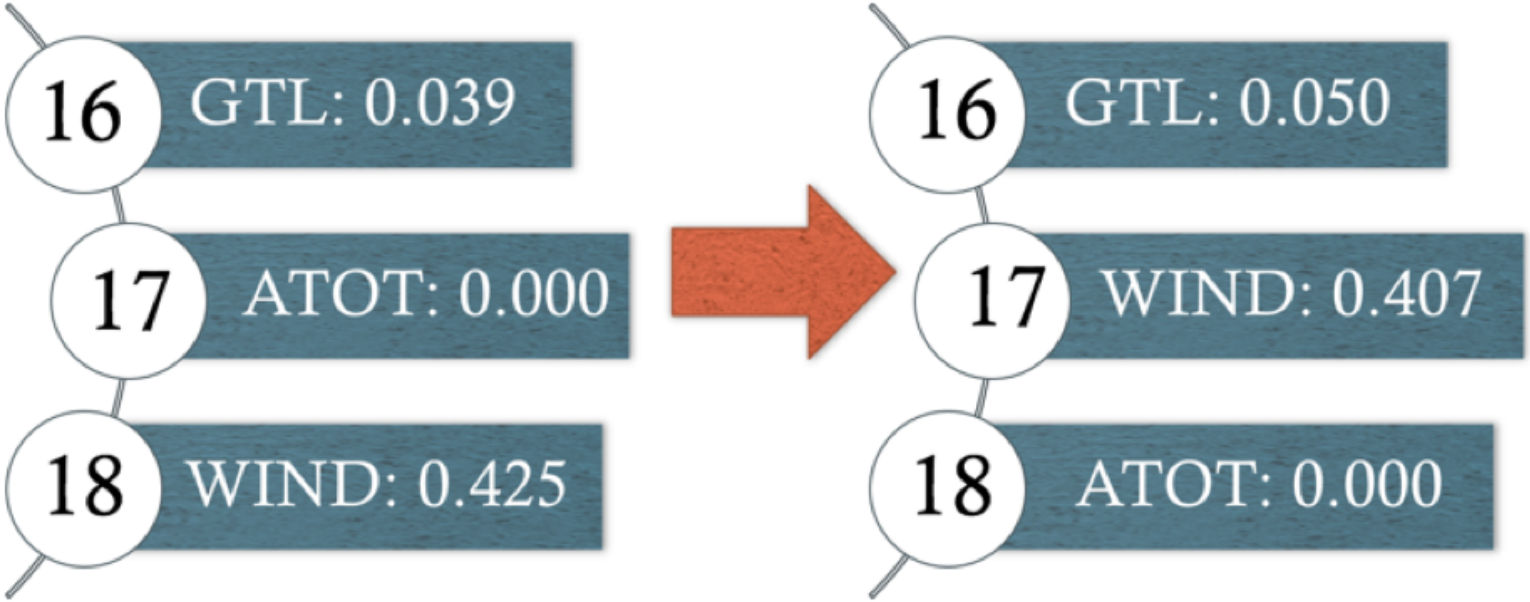
- 16-weeks in 2012
  - ~4,000 requirements
  - 31 missions
  - scheduled/requested tracking time: 88%

Priority Tiers



- Tiered priorities for requirements
  - arbitrarily assigned
- All missions received 90-100% of Tier 1&2
- 75% received 90-100% of Tier 3
- Overall scheduled/requested: 84%
- A worthwhile tradeoff?

Squeaky Wheel Optimization & Dynamic Priority



- Objective function: sum of requested/scheduled for all missions
- Initial priority assignment: largest requested time order
- Some manual tweaking required to keep a few missions from zero time allocation
- Best result: 91% of requested time scheduled

Conclusions

- Results to date are encouraging: a combination of approaches looks like a good fit to the DSN problem

1. Time Reduction – can help ensure requested time better matches available time, reduces work to eliminate conflicts
2. Tiered Relative Priorities – missions indicate their most important activities, then can add in lower priority activities if opportunities are available
3. Squeaky Wheel Optimization – dynamic priority assignment, best quality schedules based on requested time, with input time reduction to ensure fairness