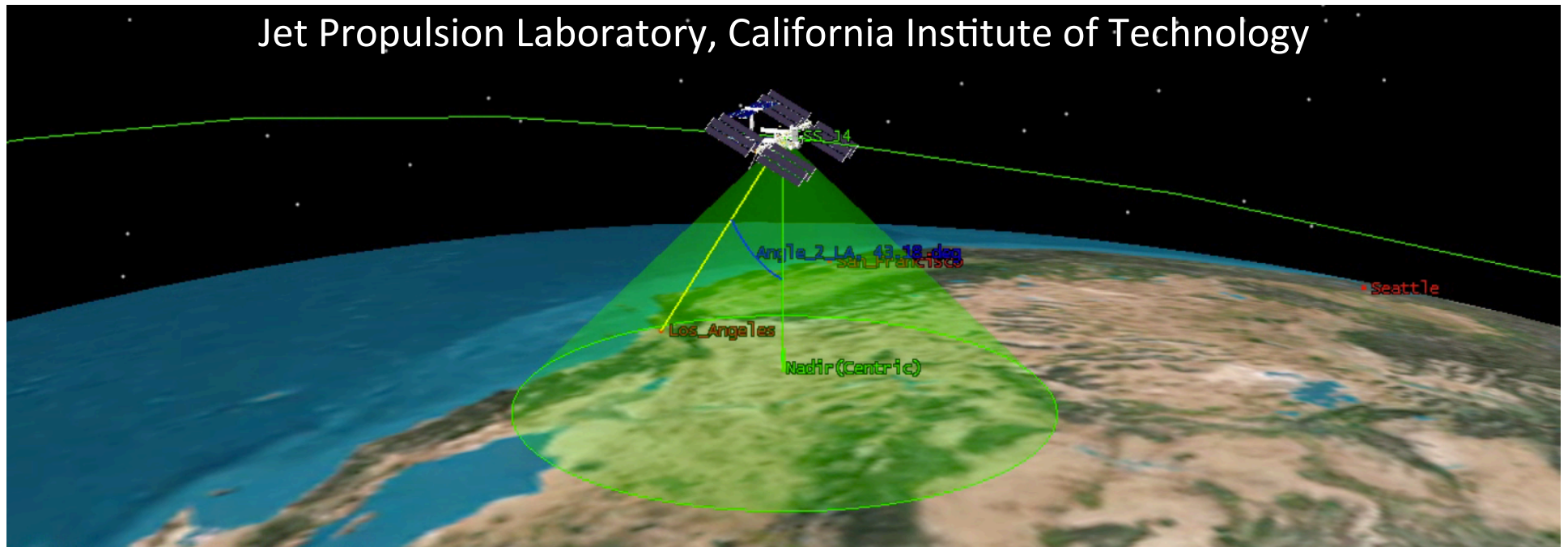


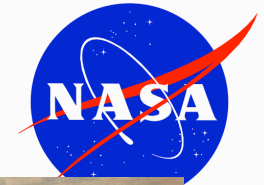
Mission Design Evaluation Using Automated Planning for High Resolution Imaging of Dynamic Surface Processes from the ISS

Russell Knight, Andrea Donnellan, and Joseph J. Green

Jet Propulsion Laboratory, California Institute of Technology



Proposed Eagle Eye Mission



- Understand how Earth's vulnerable systems reflect changes in climate
 - Measure glaciers and sand dunes over time
- Increase understanding of natural hazards
 - Volcanoes, fire, landslides, faults, flooding, coastal change



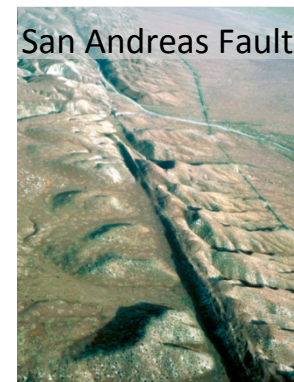
Vegetation changes can mobilize dunes



Taiwan

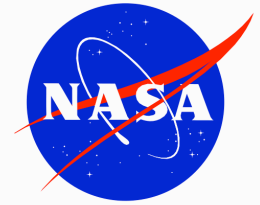


New Orleans

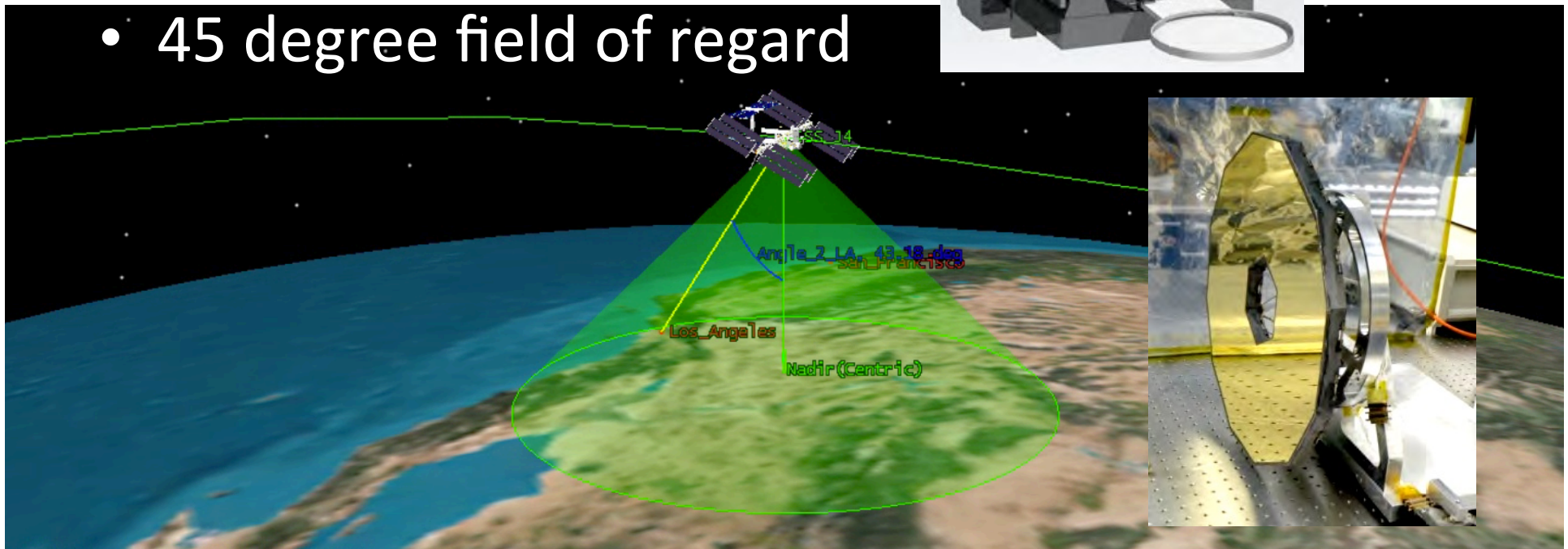


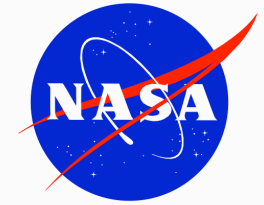
San Andreas Fault

Instrument

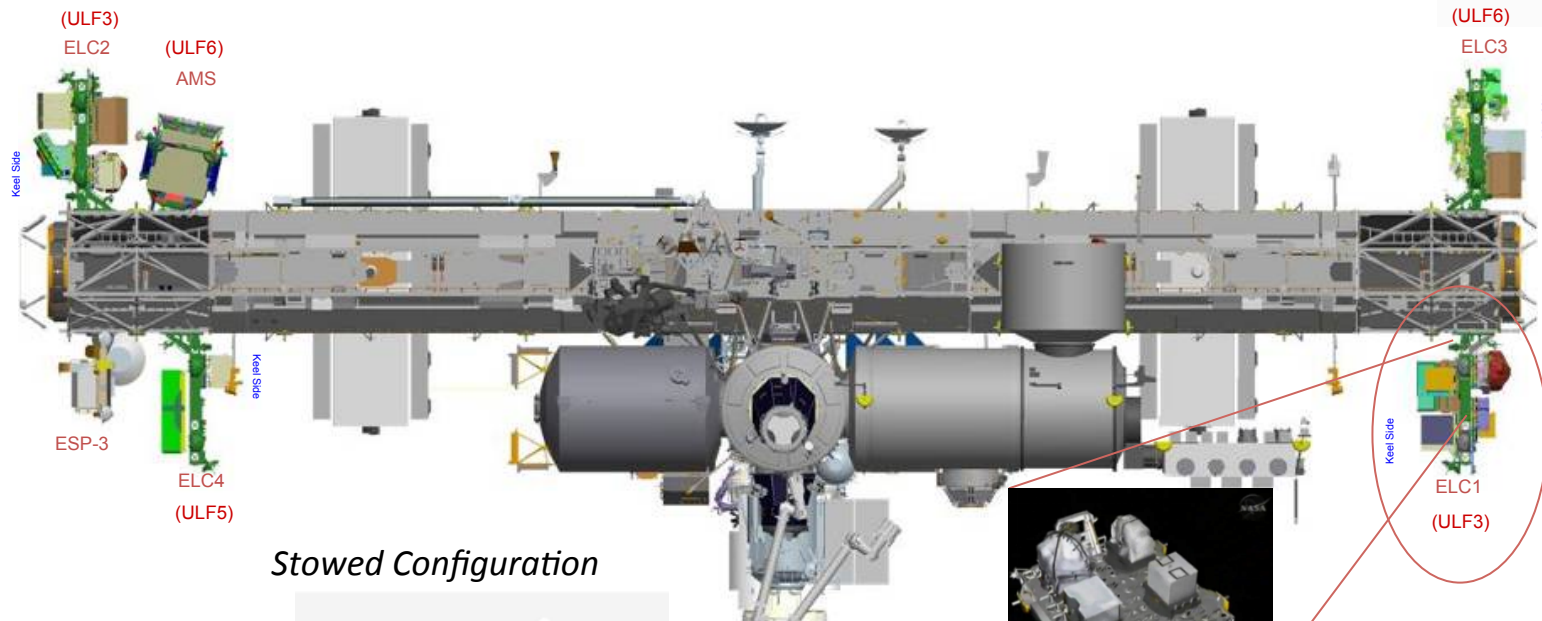


- 0.5m integral active control
- 1-2 km² visible area
- 45 degree field of regard

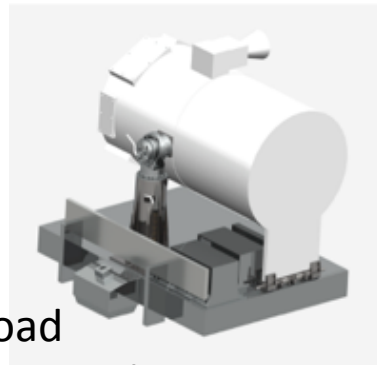




ISS Location

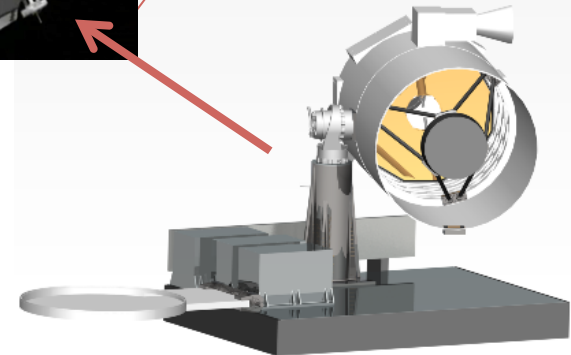


Stowed Configuration

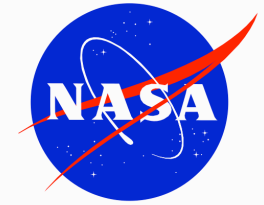


FRAM-based payload
Fits within Dragon capsule

During Operations



Unique Measurement Capability

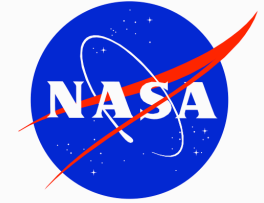


Fixed-point retrieval

Current Platforms

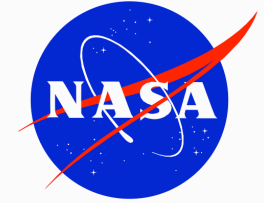
- Near nadir view
- Off-pointing single images (up to 35)
- Push broom technology
- Stereo Imagery
- Difficult retrieval with uniform albedo
- Off-pointing up to 45°
- Collect 10X more images (up to 350)
- Persistence
- 3D recovery
- Take advantage of varying sun angle

Scheduling



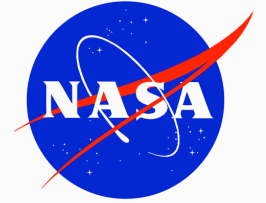
- Given
 - Observation targets
 - Lat, Lon, Alt, FPS, Priority
 - based on National Snow and Ice Data Center (NSIDC) glacier inventory
 - Approximately 100,000 points
 - Spacecraft and Instrument description
 - Ephemerides, memory (1Tb), collection rate, downlink rate
 - Slewing is fast (1s), but settle is slow (20s)
 - Communications sites (Synthetic, likely use ISS comms)
 - Lat, Lon, Alt, min. Elevation

Scheduling (cont)



- Choose a time-stamped ordering of telescope pointing coordinates
 - Cancelling a scheduled lower priority target never enables scheduling of an unscheduled higher priority target
 - Targets are imaged at the optimal times, given a “black box” function that computes quality based on elevation angle, sun angle, and distance to target
 - Twofers are OK

Algorithm



For each observation point, in priority order

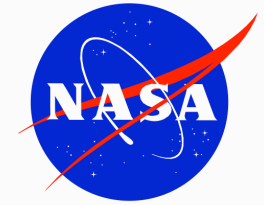
Check for feasibility

Memory, Slewing to previous and subsequent points

If feasible, introduce into the schedule and propagate

Extract a solution from the pointing timeline

Check for feasibility



Check that frame rates and data usage cause no constraint violations, and if they do, return **failure**

Generate the set of reasonable pointings P

Remove any member of P that is unreachable given the previous or simultaneous pointing

If P is empty, return **failure**

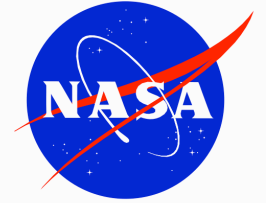
Let $nextP$ be the subsequent set of reasonable pointings

If the intersection of P and $nextP$ is not empty, return **success**

If no transition is possible from any member of P to any member of $nextP$, return **failure**

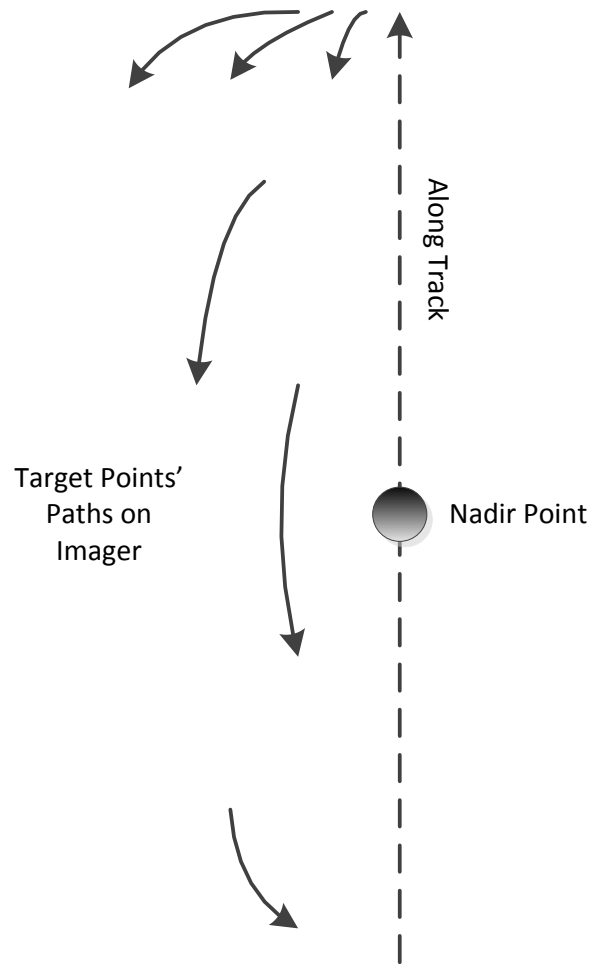
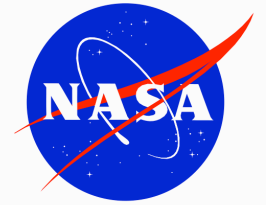
Return **success**

Generate the set of reasonable pointings

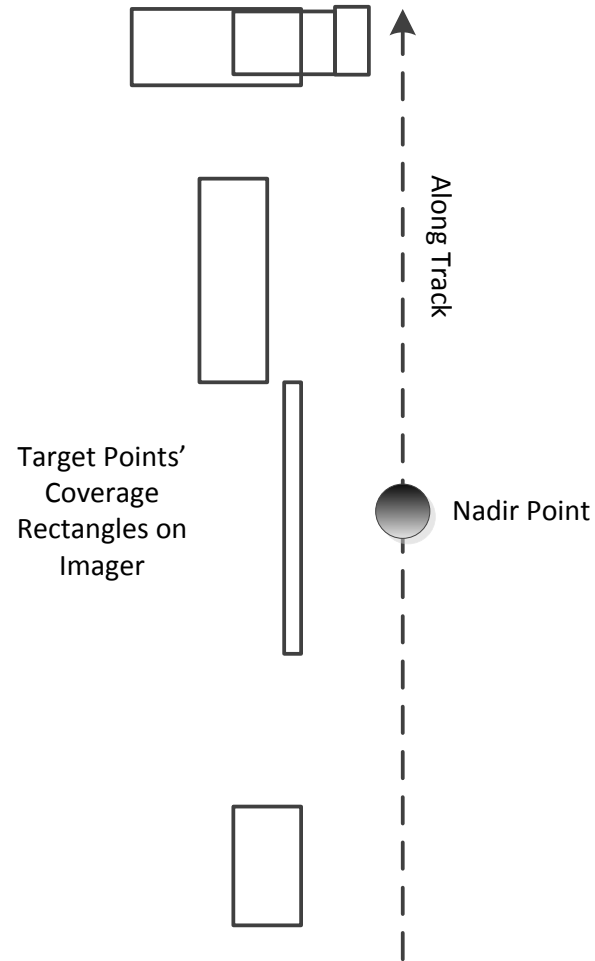
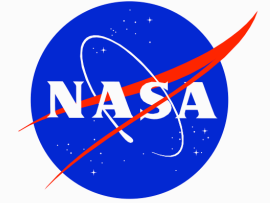


- Given a target point p
- For all points that are within a reasonable distance to the target point, project the point paths onto the imager
- Convert to rectangles
- P = the set of squares that cover at least one point and p
- At most quadratic in the number of points simultaneously image-able with p

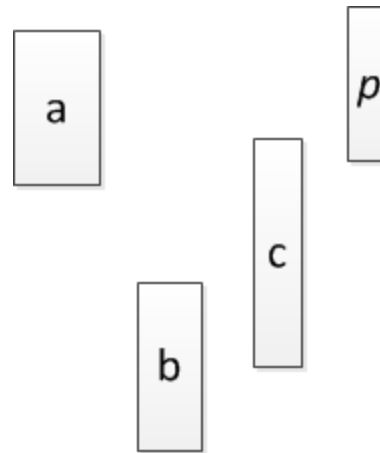
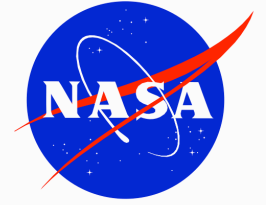
Paths of Points on the Imager



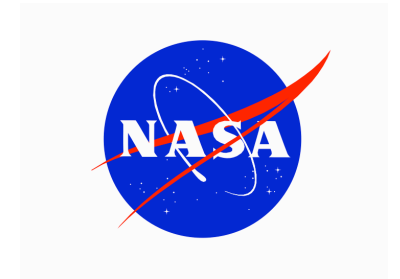
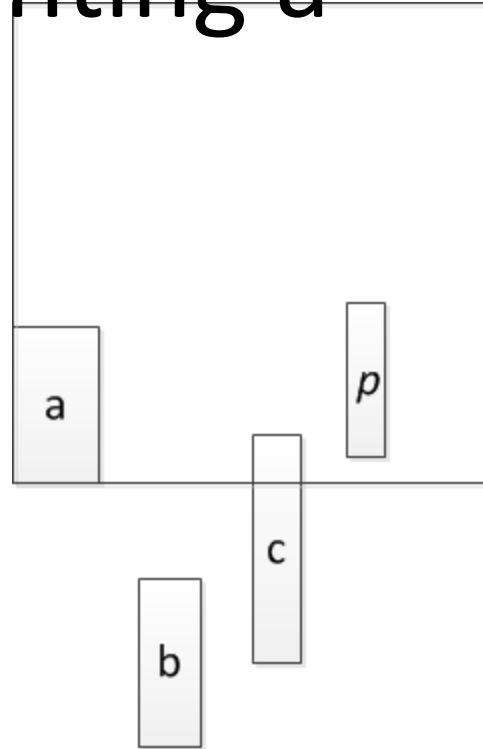
Rectangles on the Imager



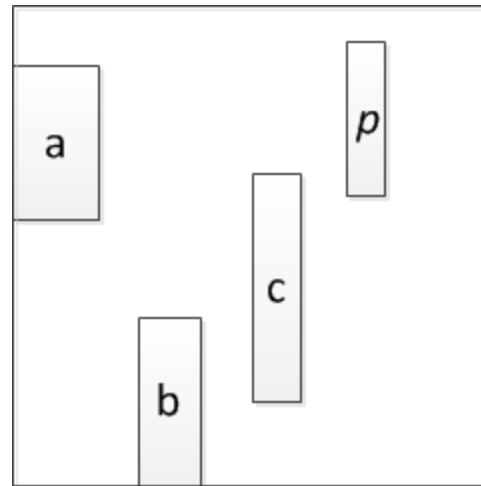
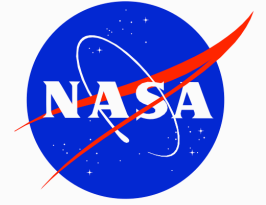
Point rectangles a, b, c and p



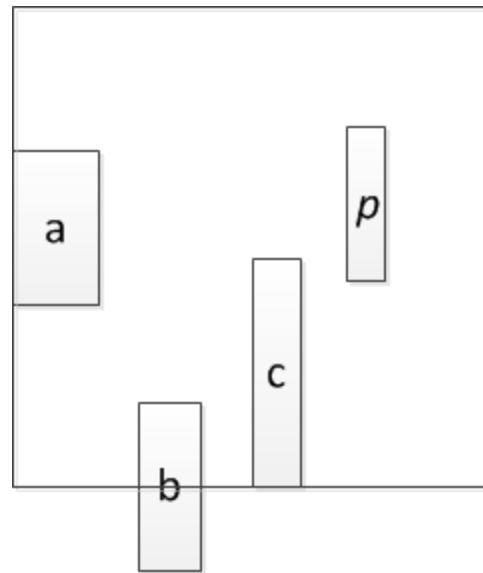
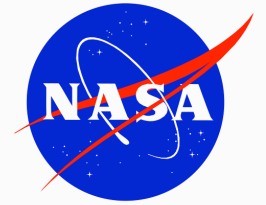
Pointing a



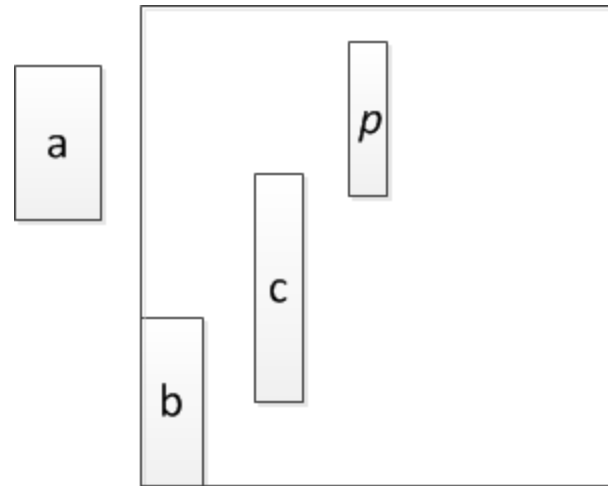
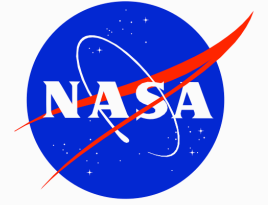
Pointing a,b



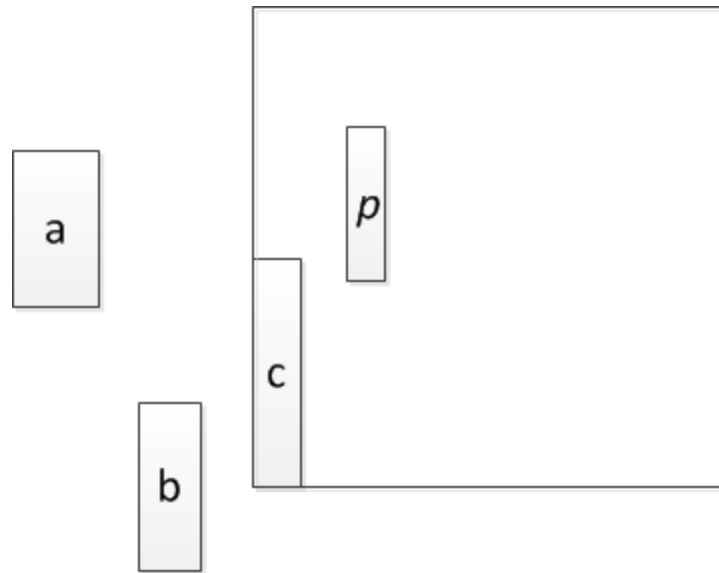
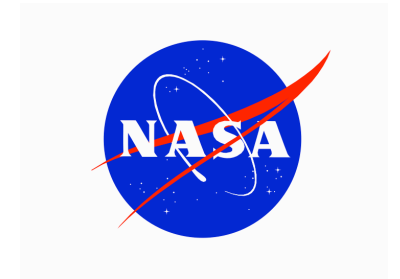
Pointing a, c



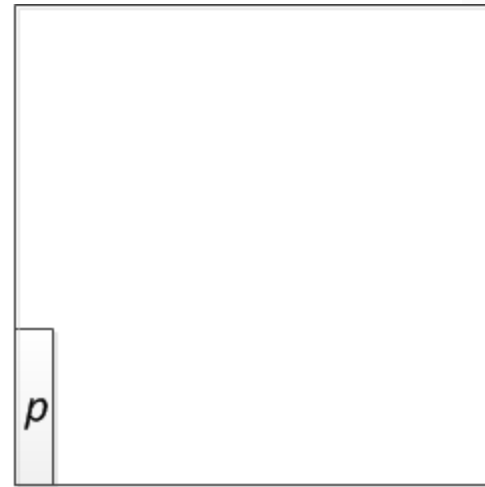
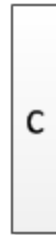
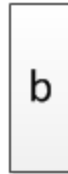
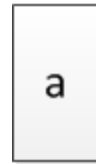
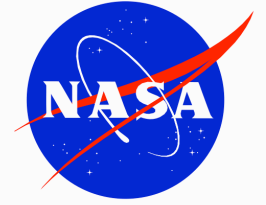
Pointing b



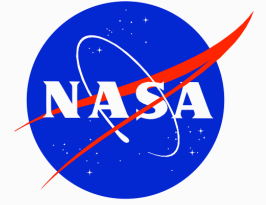
Pointing c



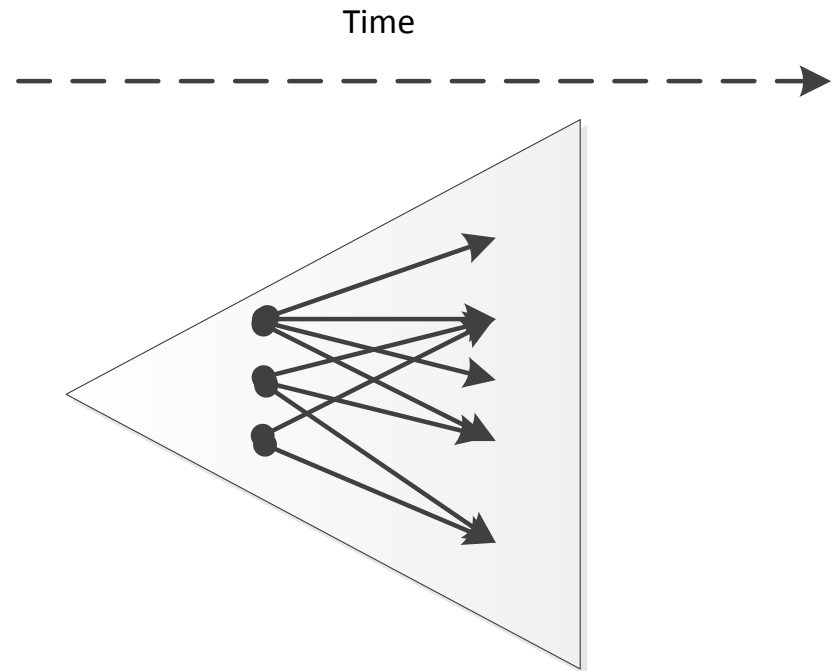
Pointing p



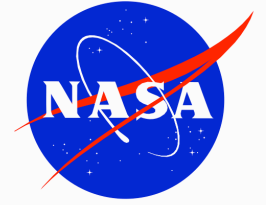
Propagate



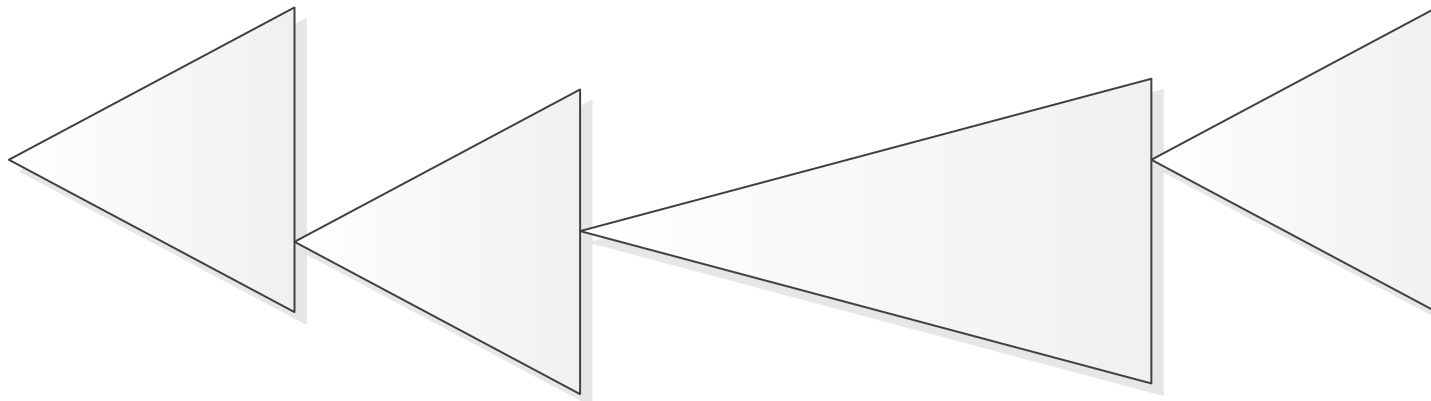
- Remove any subsequent pointings that are not compatible with P
- Conceptual transition between pointing sets



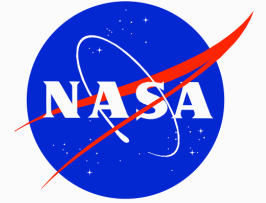
Schedule without the pointing set that contains p



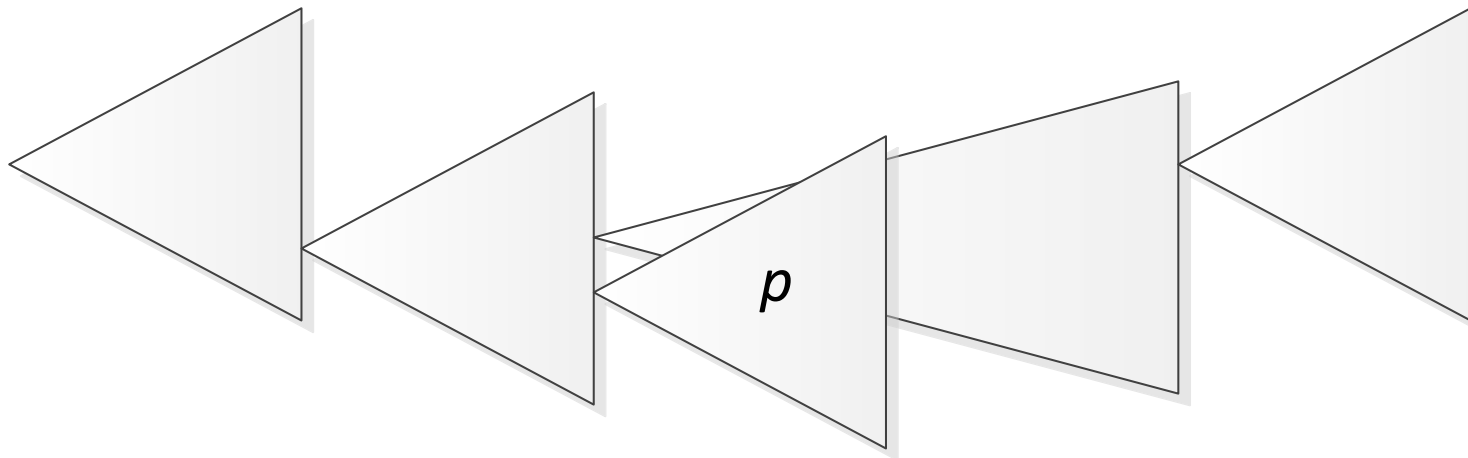
Time



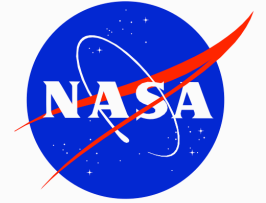
Schedule before propagation



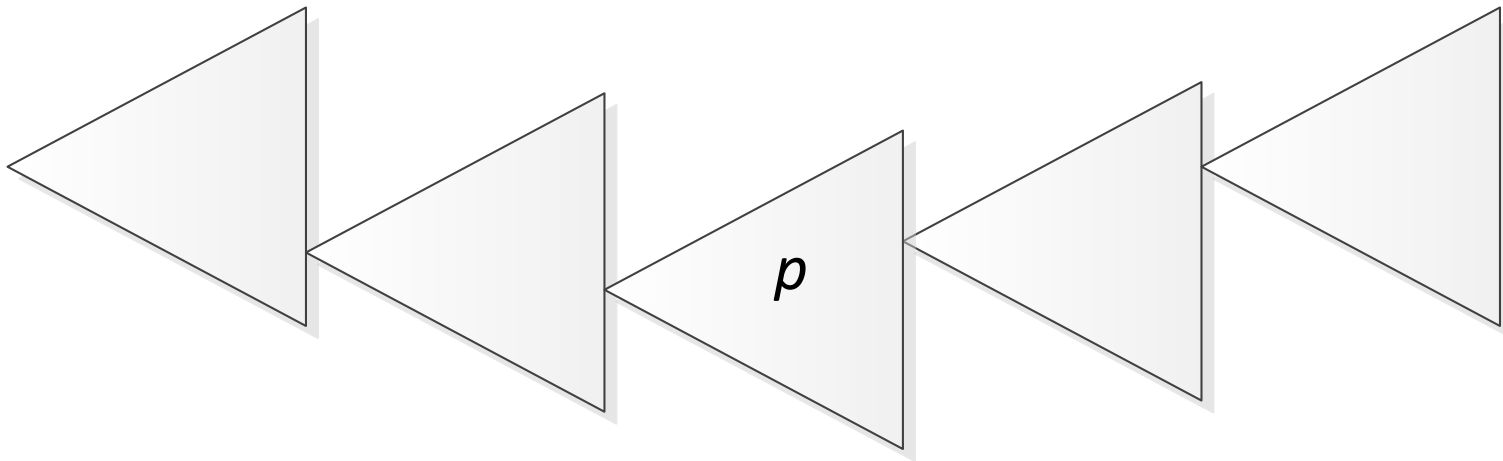
Time



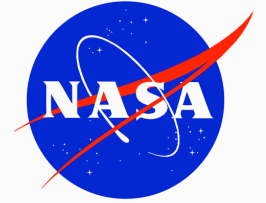
Schedule after propagation



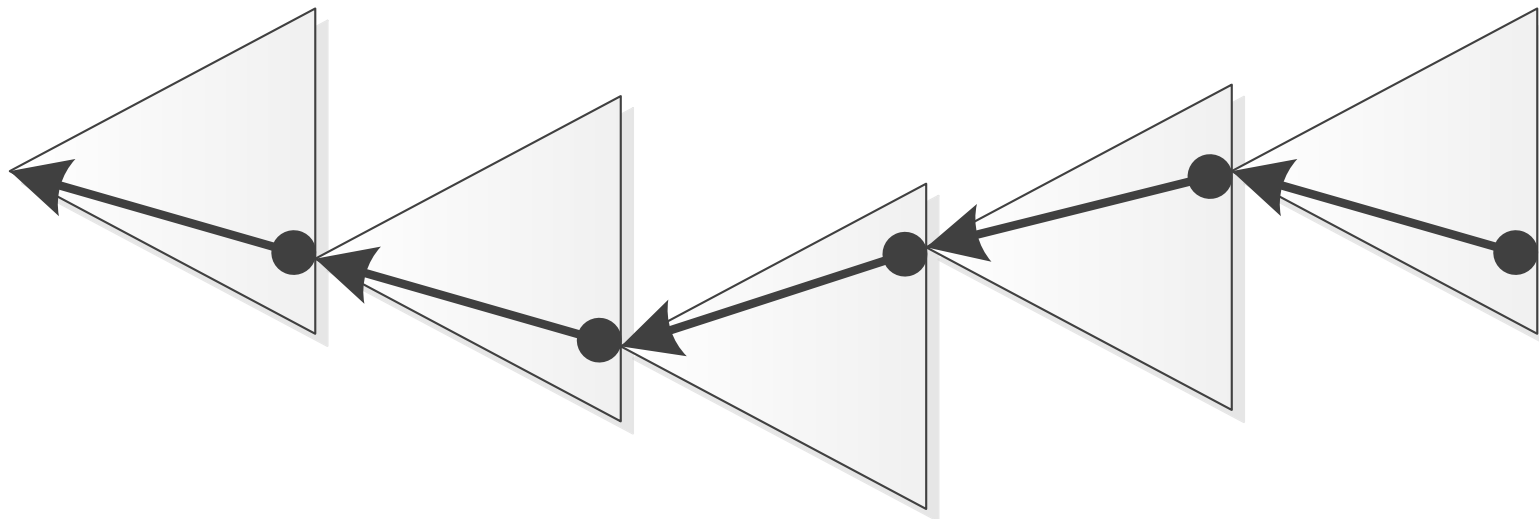
Time



Extract a Solution



Time



Schedule Fragment in KML

