

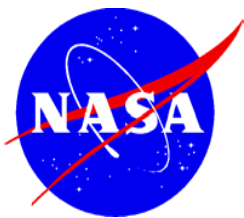
Johnson Space Center

Return to Flight Status of Launch Window Changes

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September 2003

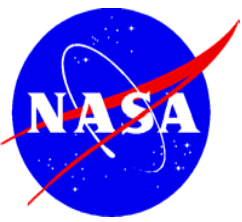


New Lighting Constraints Recommended



CAIB Recommendations –

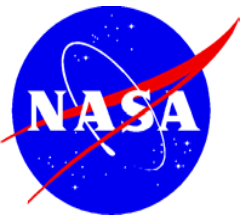
- 3.4-1: Upgrade the **imaging** system to be capable of providing a minimum of three useful views of the Space Shuttle **from lift-off to at least Solid Rocket Booster separation**, along any expected ascent azimuth. The operational status of these assets should be included in the Launch Commit Criteria for future launches. Consider using ship or aircraft to provide additional views of the Shuttle during ascent.
- 3.4-2: Provide a capability to obtain and downlink **high-resolution images of the External Tank after it separates**.



New Lighting Constraints Reduce Launch Opportunities



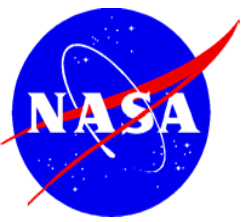
- New Lighting Constraints enable high-resolution imaging for analyzing possible debris shedding from the External Tank
 - Launch in day light
 - External Tank imaging post separation
- Launch opportunities will be reduced by over ~50%



The Making Of The Launch Window



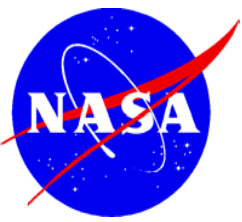
- Launch window comprised of multiple constraints
- Primary factors include:
 - Planar geometry
 - Orbital Nodal Regression
 - Solar Beta Angles
 - Daylight Launch (New)
 - Post-separation External Tank Lighting (New)
 - Others



Building a launch window: Planar Geometry



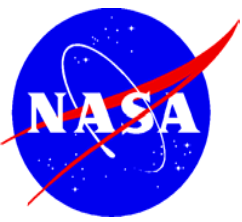
- For all rendezvous missions, the earth rotates the launch pad under the target satellite's (ISS) orbital plane once per day
- The Shuttle expands this launch time into a 5 minute window by steering out-of-plane to reach to target plane



Building a launch window: Nodal Regression



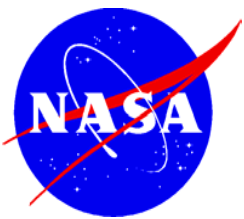
- The effect of nodal regression causes the launch pad to rotate into the target plane in less than 1 day (~23 hours and 36 minutes).
- Therefore, the launch time shifts ~24 minutes earlier each day.
- Why?
 - The earth is not a perfect sphere; but rather broader around the equatorial mid-section (oblate shaped).
 - This oblate earth effect imparts a torque on the orbit which rotates the plane to the west (clockwise as seen from above the north pole)
- Video 1: Earth rotating launch pad under ISS Orbital plane



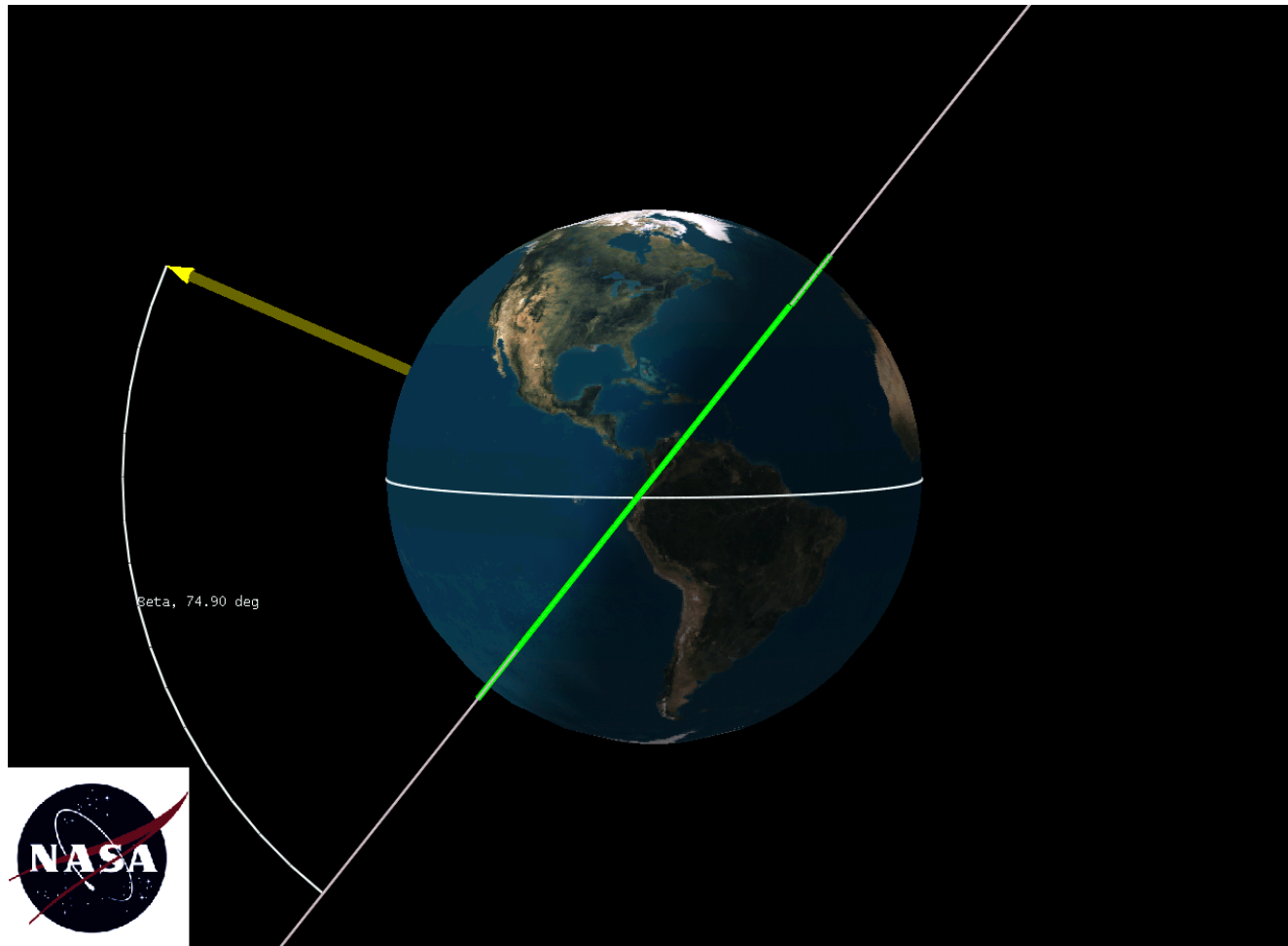
Building a launch window: Solar Beta Angles

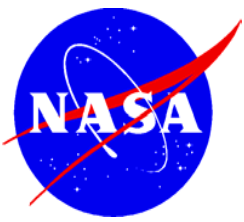


- While docked to the ISS, the Orbiter has limits on continuous sunlight it can be exposed to.
- Solar Beta is the angle between the Orbital Plane and the line-of-sight to the sun.
- Generally, the Solar Beta angle must not exceed 60 degrees – which represents approximately $\sim 72\%$ sunlight per orbit.



Building a launch window: Solar Beta Angles

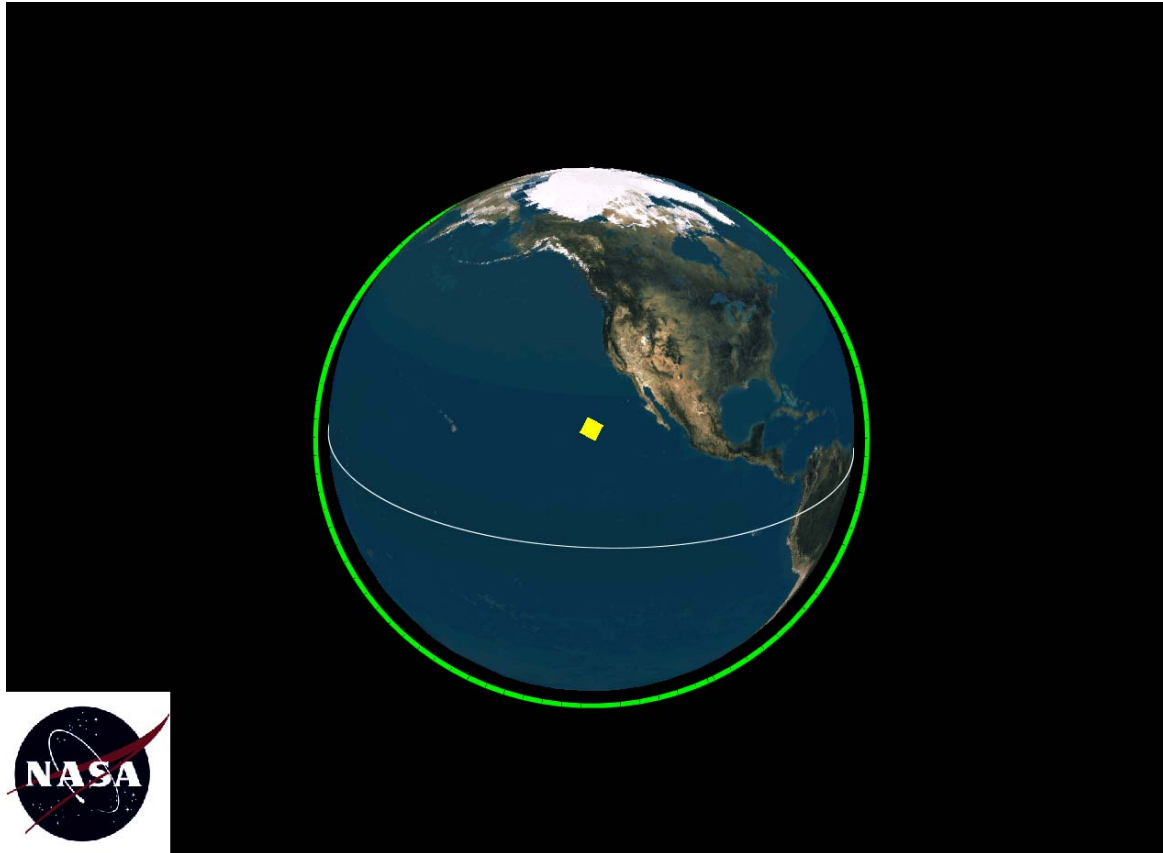


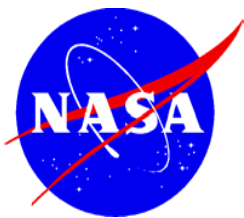


Building a launch window: Solar Beta Angles



- Orbit with High Beta Angle exposure:

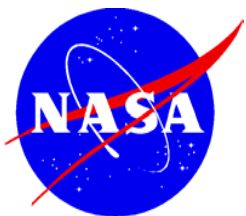




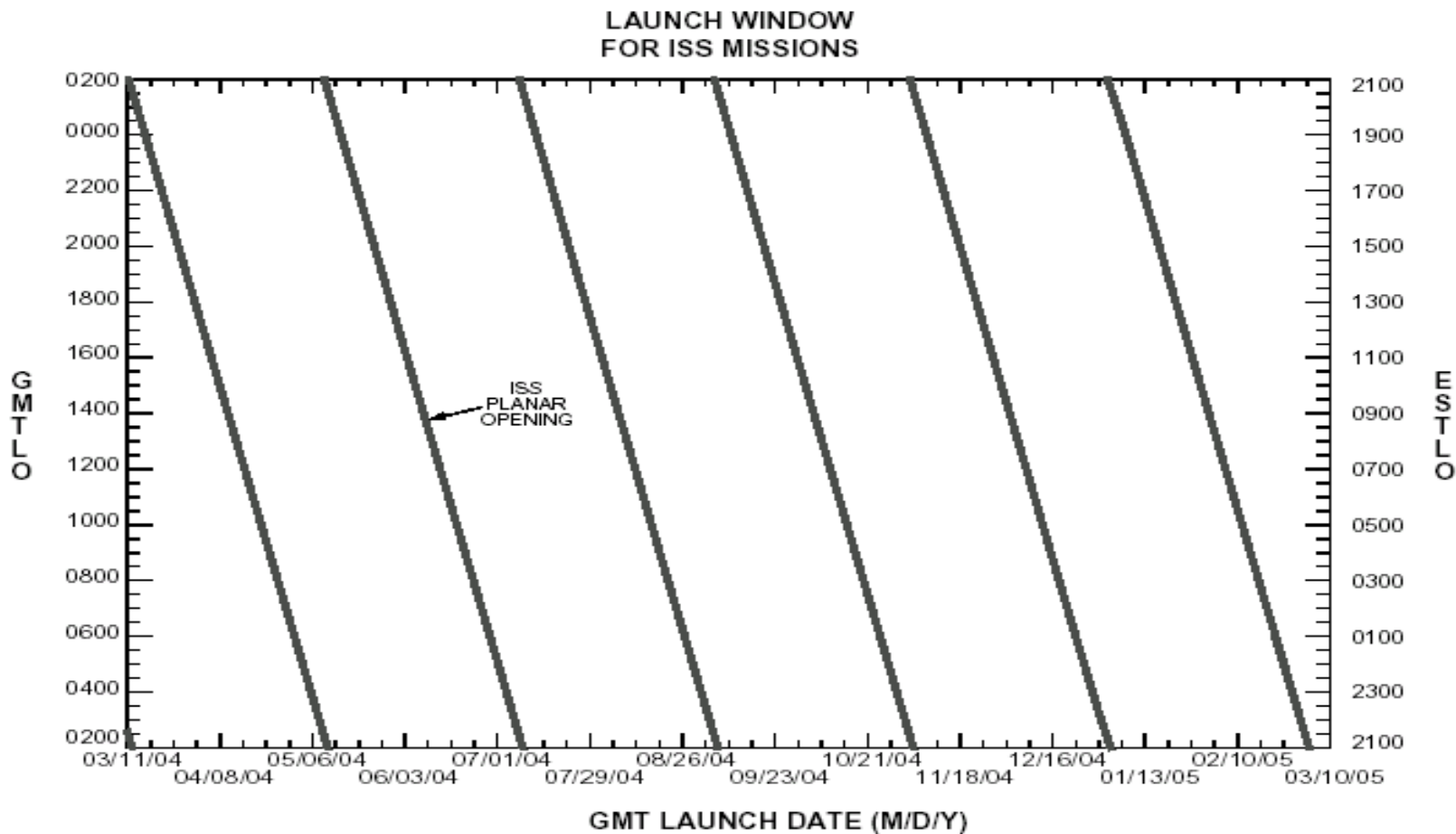
Building a launch window: New Lighting Constraints

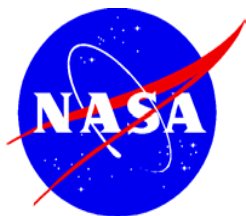


- Daylight Launch
 - Generally eliminates about 50% of the launch opportunities
- Orbital daylight for ET Photography
 - External Tank viewing after separation is required for analysis of any potential debris shedding off of the tank
 - Two options are being pursued to retrieve these photos:
 - ET umbilical well camera
 - Crew photographs through the upper cockpit windows
 - The sequence for performing this photography is still being studied
 - Preliminary results indicate that the ET must be in “orbital sunlight” for about 6 to 15 minutes after Main Engine Shut-down



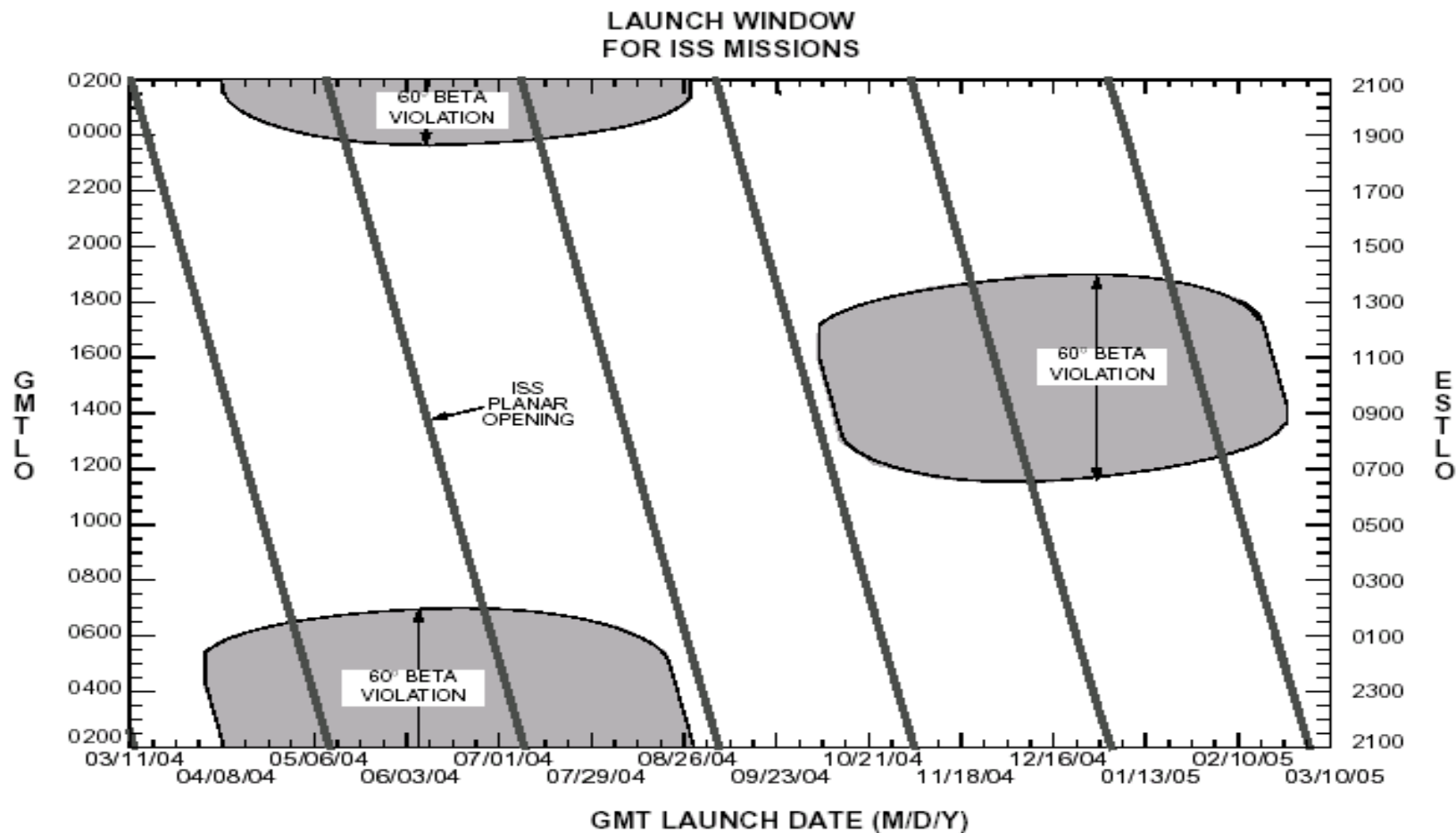
Launch Window Planar Windows

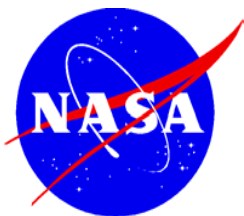




Launch Window

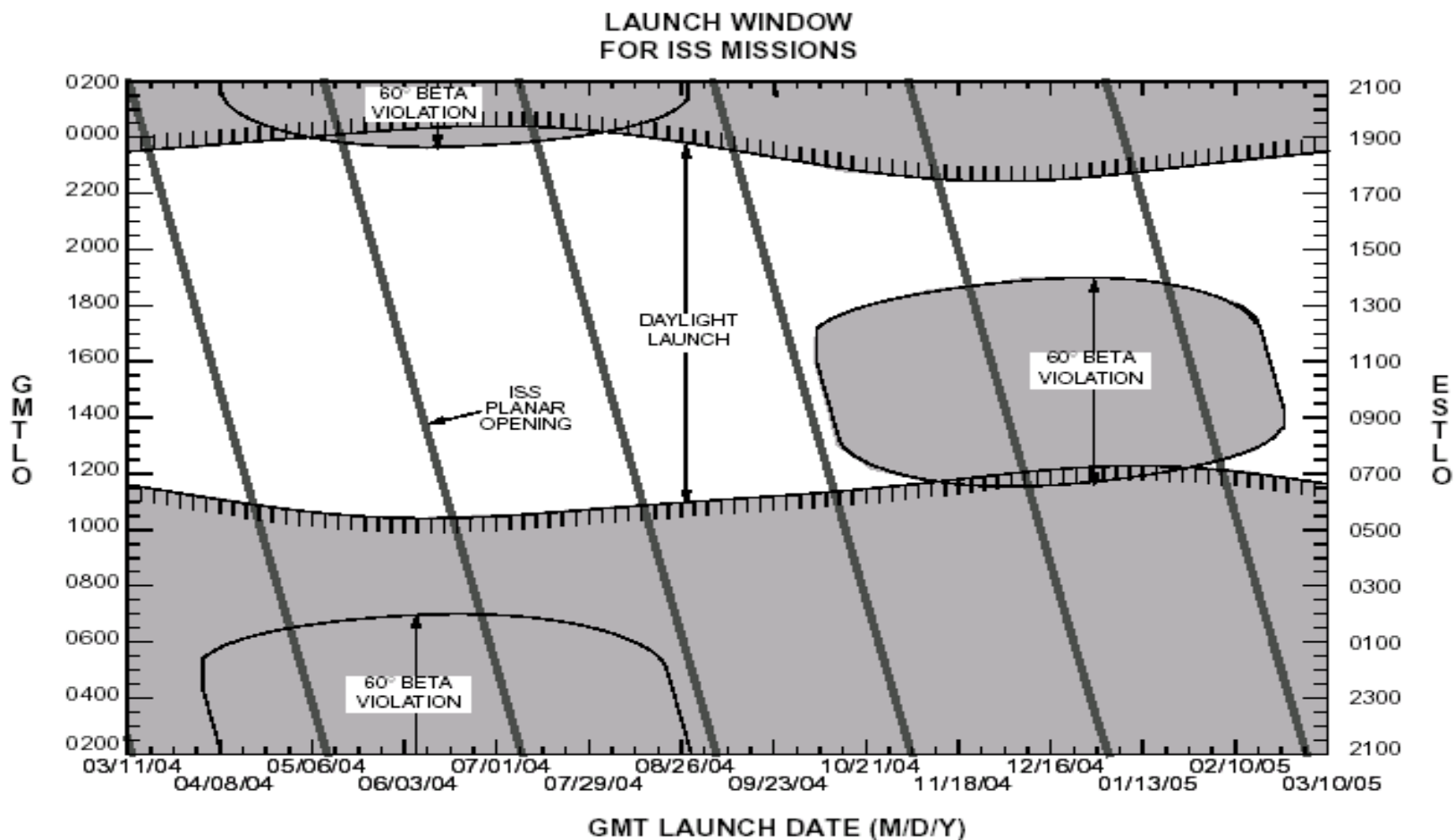
Adding Solar Beta Limits

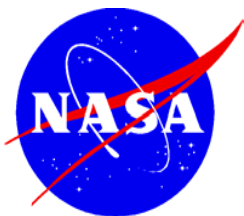




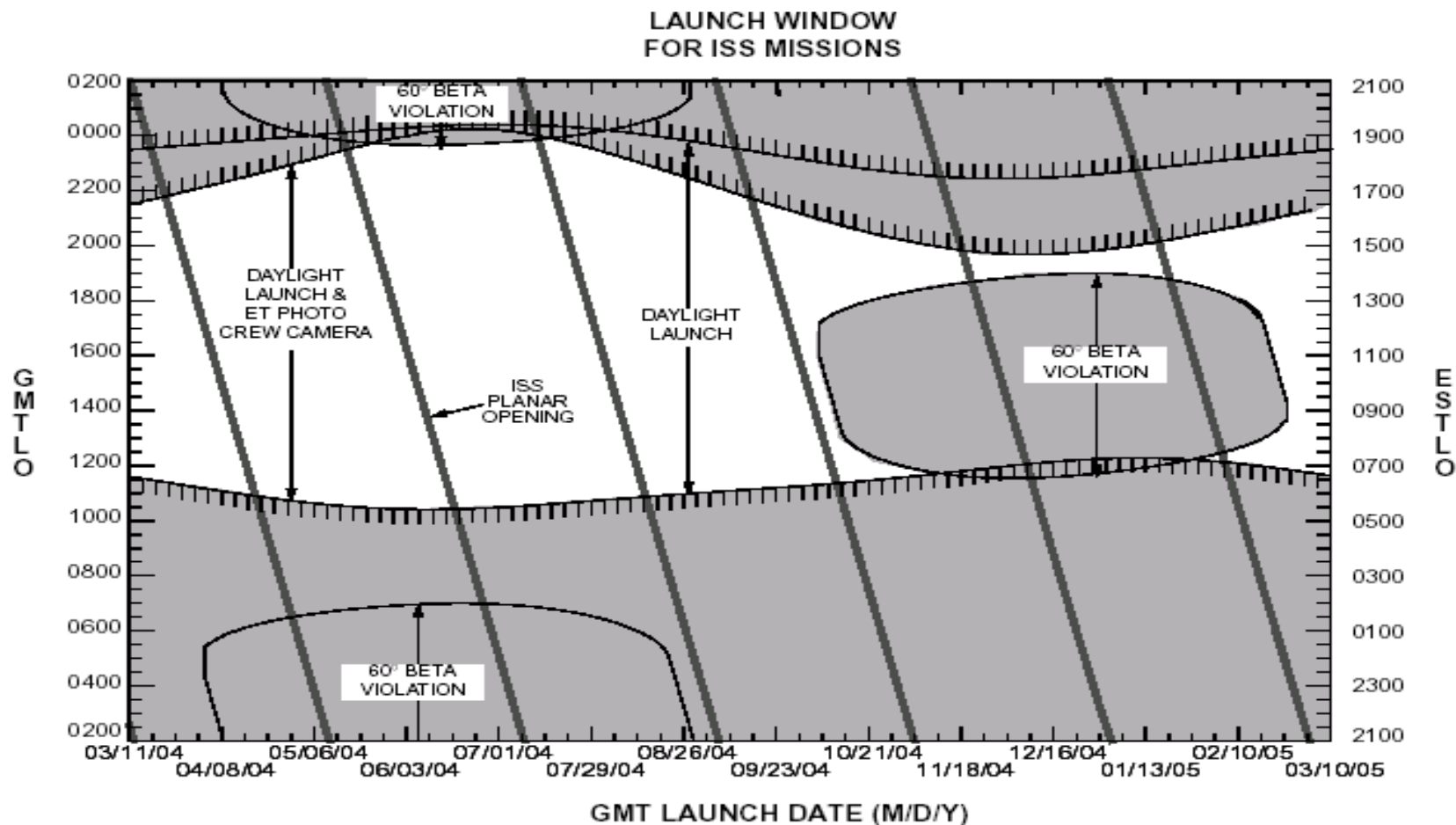
Launch Window

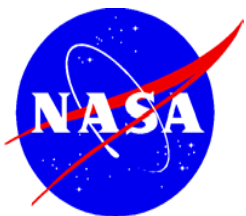
Adding Daylight Launch Limit





Launch Window Full Composite

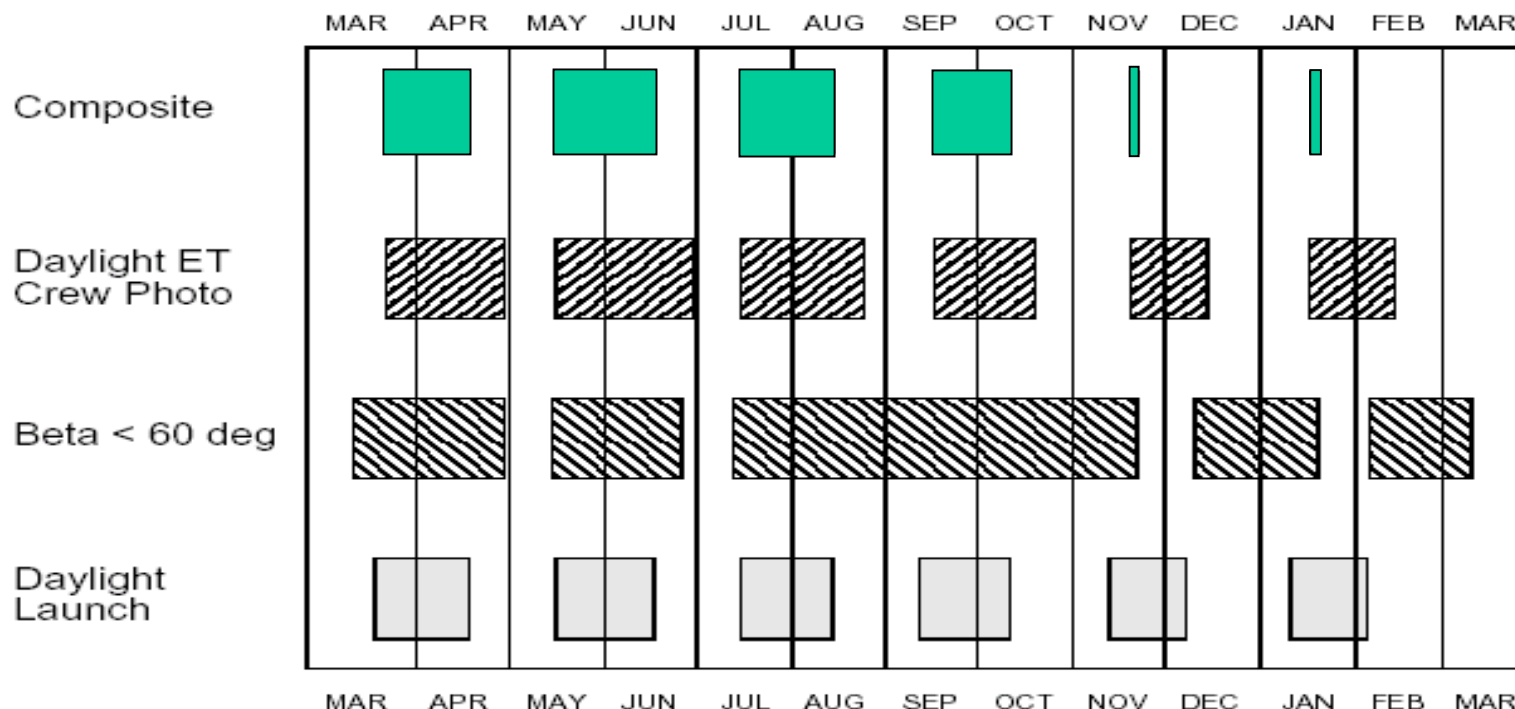




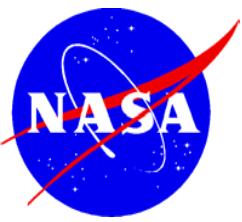
Launch Opportunities



LAUNCH DATES FOR ISS MISSIONS



LAUNCH DATES 2003 - 2004



Summary



- New Lighting Constraints enable high-resolution imaging for analyzing possible debris shedding from the External Tank
 - Launch in day light
 - External Tank imaging post separation
- The new requirements significantly reduce the viable launch opportunities
- Many additional factors contribute to the complexity of launching on a particular day (weather, ground/vehicle systems, phasing, etc.)
- Mission design constraints and Launch Commit Criteria will be defined for Return-to-Flight