With the retirement of Space Shuttle cargo delivery capability and the ten year life extension of the International Space Station (ISS) more emphasis is being put on preservation of the service life of ISS critical components. Current restrictions on the United States Orbital Segment (USOS) Solar Array (SA) positioning during Russian Vehicle (RV) departure from ISS nadir and zenith ports cause SA to be positioned in the plume field of Service Module thrusters and lead to degradation of SAs as well as potential damage to Sun tracking Beta Gimbal Assemblies (BGA). These restrictions are imposed because of the single fault tolerant RV Motion Control System (MCS), which does not meet ISS Safety requirements for catastrophic hazards and dictates ±16 degree Solar Array Rotary Joint position, which ensures that ISS and RV relative motion post separation, does lead to collision.

The purpose of this paper is to describe a methodology and the analysis that was performed to determine relative motion trajectories of the ISS and separating RV for nominal and contingency cases. Analysis was performed in three phases that included ISS free drift prior to Visiting Vehicle separation, ISS and Visiting Vehicle relative motion analysis and clearance analysis. First, the ISS free drift analysis determined the worst case attitude and attitude rate excursions prior to RV separation based on a series of different configurations and mass properties. Next, the relative motion analysis calculated the separation trajectories while varying the initial conditions, such as docking mechanism performance, Visiting Vehicle MCS failure, departure port location, ISS attitude and attitude rates at the time of separation, etc. The analysis employed both orbital mechanics and rigid body rotation calculations while accounting for various atmospheric conditions and gravity gradient effects. The resulting relative motion trajectories were then used to determine the worst case separation envelopes during the clearance analysis. Analytical models were developed individually for each stage and the results were used to build initial conditions for the following stages.

In addition to the analysis approach, this paper also discusses the analysis results, showing worst case relative motion envelopes, the recommendations for ISS appendage positioning and the suggested approach for future analyses.