

SRMS Assisted Docking and Undocking for the Orbiter Repair Maneuver

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Abstract

As part of the Orbiter Repair Maneuver (ORM) planned for Return to Flight (RTF) operations, the Shuttle Remote Manipulator System (SRMS) must undock the Orbiter, maneuver it through a complex trajectory at extremely low rates, present it to an EVA crewman at the end of the Space Station Remote Manipulator System to perform the Thermal Protection System (TPS) repair, and then retrace back through the trajectory to dock the Orbiter with the Orbiter Docking System (ODS). The initial and final segments of this operation involve the interaction between the SRMS, ISS, Orbiter and ODS.

Previously, a technique entitled "SRMS assisted docking" for installation of a payload to the ODS had been developed and was utilized for the Russian provided Docking Module on STS-74 during Shuttle-Mir missions and both the Node 1 and FGB elements on STS-88/Flight 2A. This procedure consisted of the SRMS grappling the respective payload, maneuvering it to a pre-install position inches above the ODS Androgynous Peripheral Attachment System (APAS) ring, commanding the SRMS into Test mode (which allows brakes-off motion of the joints), and then down-firing Primary Reaction Control System (PRCS) jets in order to effect a capture of the APAS latches. Once a successful capture had been achieved, then the APAS was operated through its nominal retraction sequence to complete the mating sequence.

While this technique can once again be used for the tail end docking portion of the ORM, the initial undocking of the orbiter and ISS vehicles with the assistance of the SRMS has yet to be attempted on orbit. The objective here is to determine the most efficient means to separate or extract the vehicles. Two techniques were analyzed in support of RTF: (1) the 'nominal' demating from the mated interface, and (2) the SRMS performing the operation (either in an active or passive fashion). In the first operation, the demating process would replicate standard undocking operations, with the exception that the SRMS is allowed to arrest the resulting motion. The second operation would be to extend the APAS ring to a ready to dock position, open the capture latches, and then detach the vehicles using the SRMS either actively or passively. In the active case, the APAS ring

is extended and latched, and the SRMS is commanded to pull the two interfaces apart (assuming that the effective pull force of the SRMS can overcome the spec values of the combined latch resistance). In the passive case, the SRMS brakes are engaged and the APAS mechanism is commanded to retract, pulling the two interfaces apart.

Since the emphasis of both STS-74 and STS-88 had solely been on the installation operation, as opposed to the separation operation, two new models required development and incorporation within simulation tools designed to analyze those scenarios. These enhancements included: (1) a detailed demating dynamics model to characterize the pusher spring characteristics during undocking, and (2) contact and mechanical system modeling of the back side of the latches to represent unlatching dynamics.

This paper first provides an overview of the Monte-Carlo screening analysis for the installation (both nominal and contingency), including the variation of separation distance, misalignment conditions, SRMS joint/brake parameter characteristics, and PRCS jet combinations and corresponding thrust durations. The resulting 'optimum' solution is presented based on trade studies between predicted capture success and integrated system loads. This paper then discusses the upgrades to the APAS math model associated with the new SRMS assisted undocking technique and reviews simulation results for various options investigated for either the active and passive separation of the ISS from the Orbiter.