

522-18
N93-22248
146733
p. 3

ABSTRACT

Title: Rendezvous Strategy Impacts on CTV Avionics Design, System Reliability Requirements, and Available Collision Avoidance Maneuvers

Author: William J. Donovan and John E. Davis, Rockwell International, Autonetics Strategic Systems Division, Telephone (714)762-2472, FAX (714)762-0766

Technical Details: Architectural studies and rendezvous trajectory modeling have indicated that the CTV approach trajectory and collision avoidance methodology will have a major impact on the design and reliability requirements of the avionics.

History: These results are based on continuing studies to define vehicle guidance, navigation and control architectures that provide high value while meeting all mission requirements.

Current Status: Initial trajectory modeling of velocities and control requirements has defined an avionics architecture. More detailed analysis and consideration of specific reliability impacts will continue.

Funding: The investigation is funded by Rockwell at \$250,000 per year.

Rockwell International is conducting an ongoing program to develop avionics architectures that provide high intrinsic value while meeting all mission objectives. Studies are being conducted to determine alternative configurations that have low life-cycle cost and minimum development risk, and that minimize launch delays while providing the reliability level to assure a successful mission. This effort is based on four decades of providing ballistic missile avionics to the United States Air Force and has focused on the requirements of the NASA Cargo Transfer Vehicle (CTV) program in 1991. Current CTV analysis efforts draw on a number of internally funded programs. Support from internal research and development (IR&D) funding to the CTV program is currently budgeted at \$250,000 in FY92.

During the development of architectural concepts it became apparent that rendezvous strategy issues have an impact on the architecture of the avionics system. This is in addition to the expected impact on propulsion and electrical power duration, flight profiles, and trajectory during approach.

A number of approach trajectories have been developed with the CTV moving from a higher orbit down to Space Station Freedom (SSF) by decelerating and with the CTV moving upward to SSF by accelerating. While all of these trajectories require similar guidance, navigation, and control (GN&C), their impact on required reliability differs markedly. Many types of system failures when accelerating from a lower orbit will result only in the CTV failing to rendezvous. If it is necessary to abort an

approach from below, the resulting CTV orbit will have an apogee that is below the orbit of SSF. However, the deceleration associated with an approach from a higher orbit will result in the CTV eventually crossing the orbit of SSF. If this orbital crossing follows a system failure resulting in a total loss of control it presents a potential risk. Any orbit for the CTV that will intersect the orbit of SSF places additional requirements on the CTV design. The impact on the avionics (and related attitude control system components) is to require a higher level of fault tolerance to assure continued control when in an orbit at or above the orbit of SSF.

While the direction of approach has the ability to minimize the possibility of collision, the inclusion of a collision avoidance maneuver (CAM) has proven to still be required. A wide range of possible CAM methodologies has been developed and evaluated based on the safety provided versus their impact on system design. Many relatively straightforward concepts prove either to be difficult to implement or to require major portions of the system to remain operational through faults. Because a CAM will often result from an extensive failure of the system, an optimum solution will require a minimal hardware set to remain operational.

The CAM concept developed by Rockwell that best meets these requirements is based on an approach from a lower orbit and an approach guidance mechanization with a closing velocity decreasing with distance from SSF. The approach from below allows a reversal of the approach by decelerating the CTV. An approach from a higher orbit would require a CAM consisting of either an acceleration to a higher orbit that could deteriorate to a crossing orbit, a lateral divert that could result in a crossing orbit, or a deceleration to pass below SSF that could also create a crossing orbit. Maneuvers that depend on passing SSF must also consider available clearance. The proposed approach guidance concept includes a velocity decreasing with distance in order to allow sufficient time for the CAM system to reverse the closing velocity at all distances.

In any type of CTV failure it can be assumed that the CAM control system has available the attitude, velocity, and position of the CTV. From this information the CAM system can determine what thruster or thrusters can best counteract the motion towards SSF and decelerate the CTV to a lower orbit. If a total system failure occurs, these data may be what was last recorded prior to the failure. While this data will not be current, its accuracy will be sufficient to allow the CAM to proceed. Preliminary analysis of the mass properties of the CTV has indicated that firing of thrusters without the guidance or control system being functional would be effective in countering the motion toward SSF. Prolonged firing without other controls would eventually result in a loss of stability. However, this will occur after a sufficient decrease in velocity to allow clearance. A CAM while departing SSF (without a payload) would result in the same thrust being applied to a lesser mass. This will cause a loss of stability in less time. However, the greater acceleration of the lesser mass would provide an acceptable displacement before stability was lost.

This concept continues to be refined in greater detail. It currently provides an

effective CAM with a simplified system architecture. Additional analysis will translate the system and reliability impacts to a detailed system architecture. Open issues remain in the de-orbiting following CAM and possible reentry over land areas.