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COLLISION AVOIDANCE FOR CTV REQUIREMENTS AND CAPABILITIES

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Statement of technical details of the capability being described

CTV operations near Space Station Freedom will require positive collision avoidance maneuver (CAM) capability to preclude any chance of collision, even in the event of CTV failures. This paper discusses the requirements for CAM, and reviews the CAM design approach and design of the Orbiting Maneuvering Vehicle (OMV); this design met requirements for OMV operation near the Space Station, provided a redundant collision avoidance maneuver capability. Significant portions of the OMV CAM design should be applicable to CTV. The paper will summarize the key features of the OMV design and relate the CTV mission design to that of OMV's.

CAM is a defined sequence of events executed by the CTV to place the vehicle in a safe position relative to a target such as the Space Station. CAM can be performed through software commands to the propulsion system, or thorough commands pre-stored in hardware. Various techniques for triggering CAM are considered, and the risks associated with CAM enable and execution in phases are considered. OMV CAM design featured both hardware and software CAM capability, with analyses conducted to assess the ability to meet the collision-free requirement during all phases of the mission.

History of the origins and evolution of the capability

The OMV operated autonomously in the phase from Shuttle deployment through transfer orbit (although with ground command capability for certain operations) and then under pilot command after reaching a transfer point near the Space Station or target satellite for the purpose of final closure and docking. CAM protection was required in both phases of the mission with the system specification requiring "the capability to move safely away from a target payload or base of operations . . . ". OMV CAM design addressed the requirement that CAM operation could be initiated by the pilot on command, or automatically in the programmed mode of operation if critical failures occurred. Redundancy management onboard detected and responded to failures; the paper will describe this logic. To provide for fail-safe operation in both piloted and automatic modes, a dual mode CAM was designed: 'software' CAM, controlled by the onboard computers, and 'hardware' CAM, using updated parameters stored in hardware (registers) providing firing commands to the thrusters which would move the vehicle to a safe position.

Hardware CAM was designed to provide full fail-safe operation in the event of dual failures that made the vehicle impossible to control, notably in the computers. Onboard computers kept updated firing commands stored in the hardware CAM registers which would provide safe separation maneuvers in the event of complete failure in the onboard computing and control system. Superimposed on the dual mode CAM operation was an intermediate automatic backaway maneuver designed to operated in the event of communication link loss during rendezvous and docking operation. During terminal phase operation, the TV link providing the remote pilot with visual data is obviously critical, and the link loss mode, which would lead to automatic stationkeeping at a safe range, added an additional capability to provide safe operation while not requiring full CAM operation.

The level of maturity of the capability

Figures 1 and 2 illustrate the logic flow of the OMV CAM operation. Performance estimates were made of the CAM operation in various scenarios, including phases of automatic rendezvous operation (with the OMV under the control of the primary rendezvous sensor, a radar) and terminal rendezvous phases under pilot control (via the communications link through TDRS to the ground).

Test experience and/or experimental results

Software CAM, which is basically a form of the rendezvous guidance mechanization for OMV, can be initiated by the pilot and will transfer the vehicle to a point on the V bar at an operator selected distance. Performance verification of this CAM mode was accomplished by exercising the rendezvous guidance algorithms, using various V bar standoff distances, for selected closing scenarios (range and range rate). Hardware CAM evaluation was performed by computing the stored engine firing commands for various scenarios, and then simulating the response of the OMV to hardware CAM initiation. Trajectories of the vehicle were computed and confirmation of collision avoidance was confirmed. Hardware CAM registers were designed, built and tested, providing test firing commands in sequence to the attitude control thrusters.

Source/sponsorship and current funding estimates

TRW's OMV work was supported under contract to Marshall Space Flight Center. Current work on CTV applications and requirements is being supported under contract to MSFC as part of the NLS program and by IR&D funds in the area of servicing vehicles and autonomous spacecraft design.

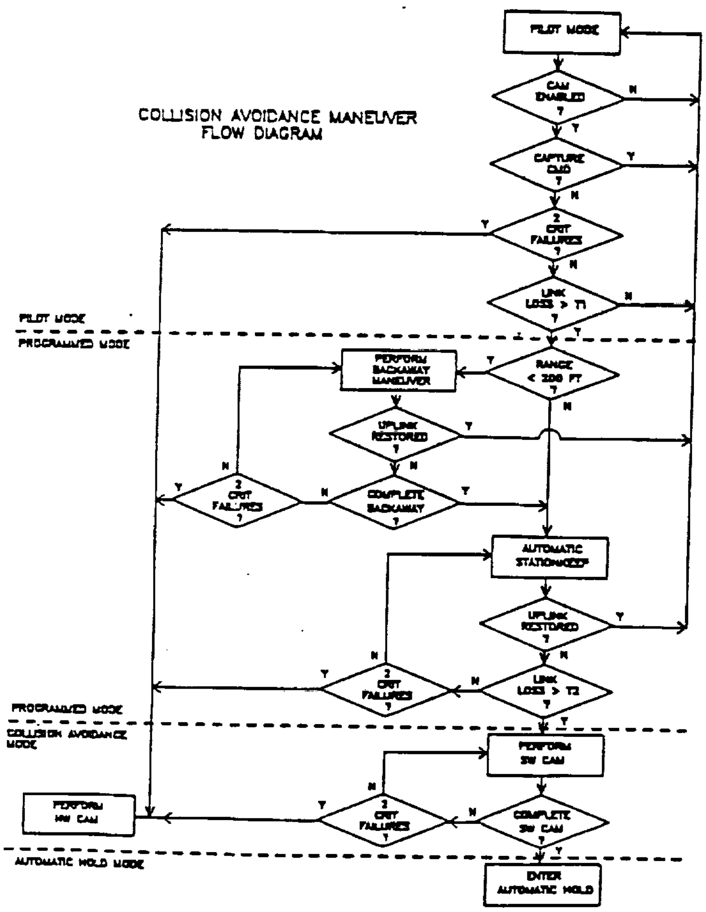

Figure 1

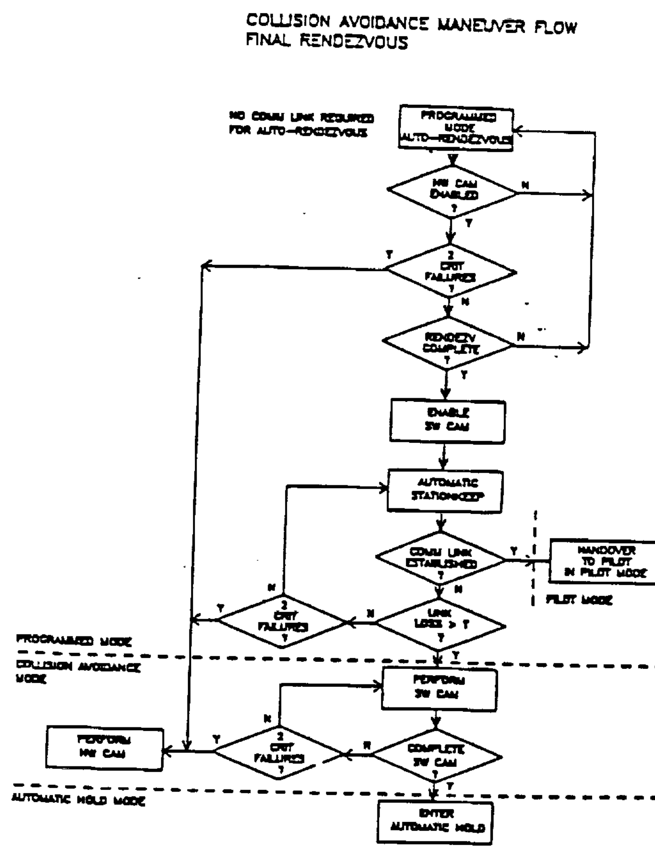

Figure 2