Automated Rendezvous and Capture Technology Description

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In the past, all U.S. rendezvous and docking operations have been piloted or ground-controlled, but autonomous rendezvous and capture has become a required technology due to the need for resupply of the space station by unmanned rockets. Significantly reduced operations cost and increased repeatability, reliability, and safety are but a few of the benefits automated rendezvous and capture offers.

Although the Russian docking system is available, it is not fully autonomous during all mission phases, requiring ground radar tracking and command for rendezvous and producing high contact velocities, which are not acceptable to space station needs without expensive, energy-absorbing mechanisms or structural enhancements. The current NASA MSFC Automated Rendezvous and Capture project will bring the technology to satisfactory levels by late 1997 if funding continues as budgeted; test facility upgrades are complete, and system integration is well underway. The technology requires no real-time human commanding of the resupply vehicle, allows automated mission design prior to flight, and fully automates vehicle operations, incorporating onboard mission/trajectory updates from real-time navigation data.

A typical automated rendezvous and capture mission flight profile includes chase-vehicle docking from behind (fig. 70); approaches from ahead of and below the target are also supported. A complete system block diagram is shown in figure 71. Necessary hardware consists of a short-range video guidance sensor, global positioning system antennas/receivers for long-range navigation, and a three-point docking mechanism (fig. 72). Software elements include absolute and relative global positioning system navigation filters, as well as guidance, navigation, and control for automated mission planning, automated orbital phasing maneuvers, automated proximity operations and docking, and automated collision avoidance maneuvers.

Maturity of the automated rendezvous and capture system will be substantially increased upon completion of the ongoing ground demonstration project, including verification and documentation of specific hardware and software. Extensive integrated ground testing will be performed to validate reliability and performance of the complete system, followed by flight (if funding permits) of an automated rendezvous and docking experiment as a payload on the shuttle or an expendable vehicle to identify any unexpected problems.

Three-point docking mechanism: As depicted in figure 72, the active three-point docking mechanism consists of three electrically redundant latching mechanisms, a control unit, and supporting structure: the passive part is composed of three capture trunnions. The latching mechanisms and trunnions will be equally spaced, and docking status (undocked, captured, or locked) will be provided by the mechanism to the resupply vehicle. At least two trunnion bars must be within their capture envelopes before any latch can begin to capture its trunnion, closing to the locked position only after all three latches have reached alignment.

Dabney, R.W., and Howard, R.T. April 28, 1992. Closed-Loop Autonomous Docking System. U.S. Patent 5,109,345.

Howard, R.T.; Dabney, R.W.; and Bryan, T.C. June 4, 1991. Standard Remote Manipulator System Target Augmentation for Automated Docking. U.S. Patent 5,020,876.

Sponsor: Automated Rendezvous and Capture Ground Demonstration Program Office

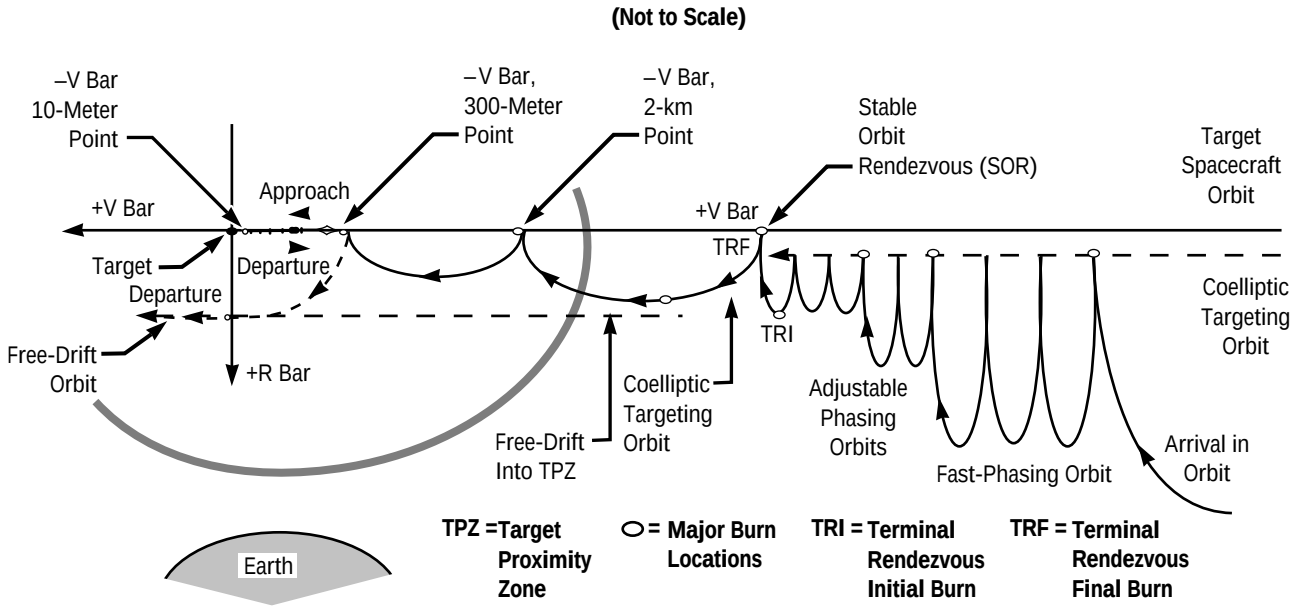

FIGURE 70.—Typical automated rendezvous and capture mission flight profile.

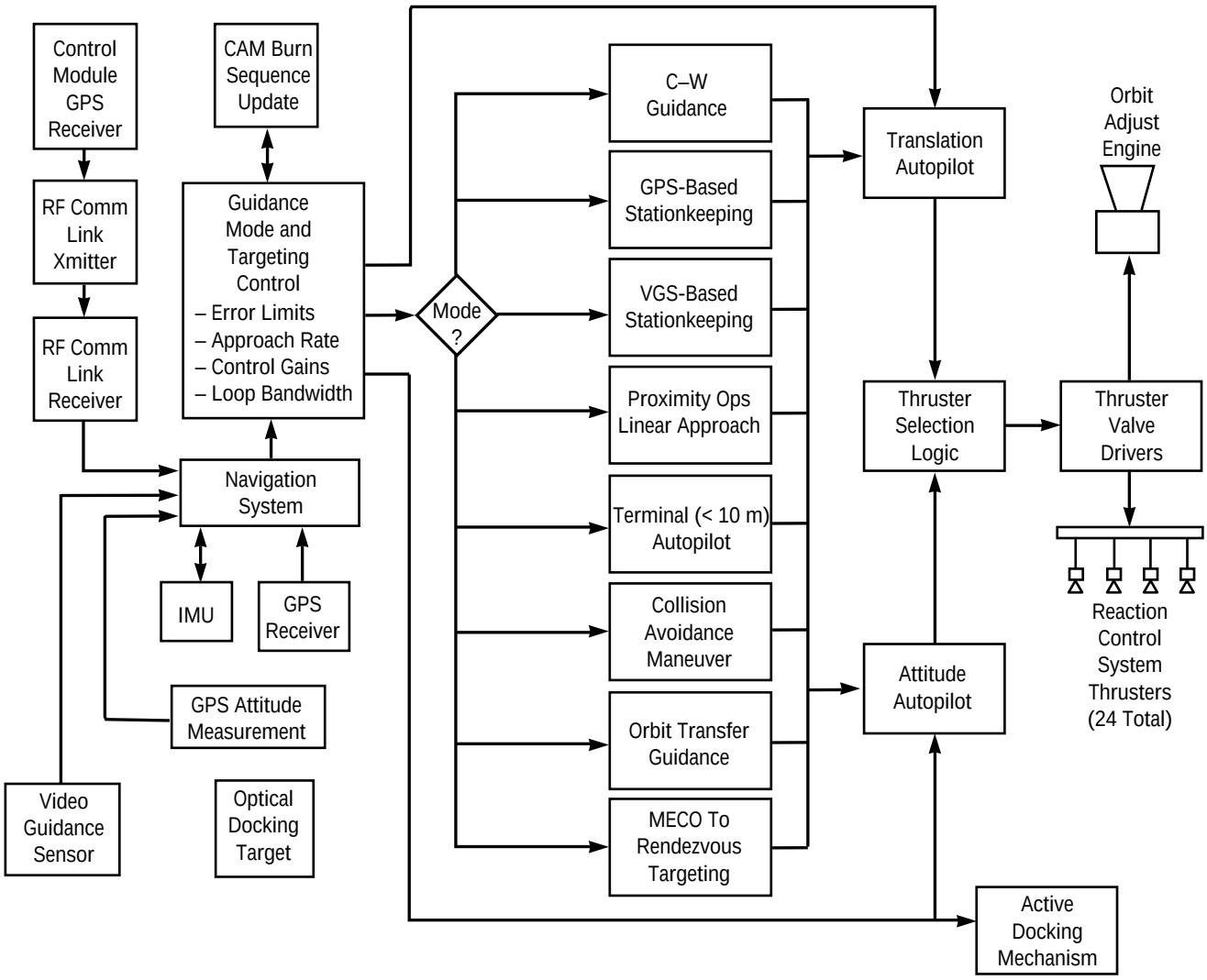

FIGURE 71.—Automated rendezvous and capture system block diagram.

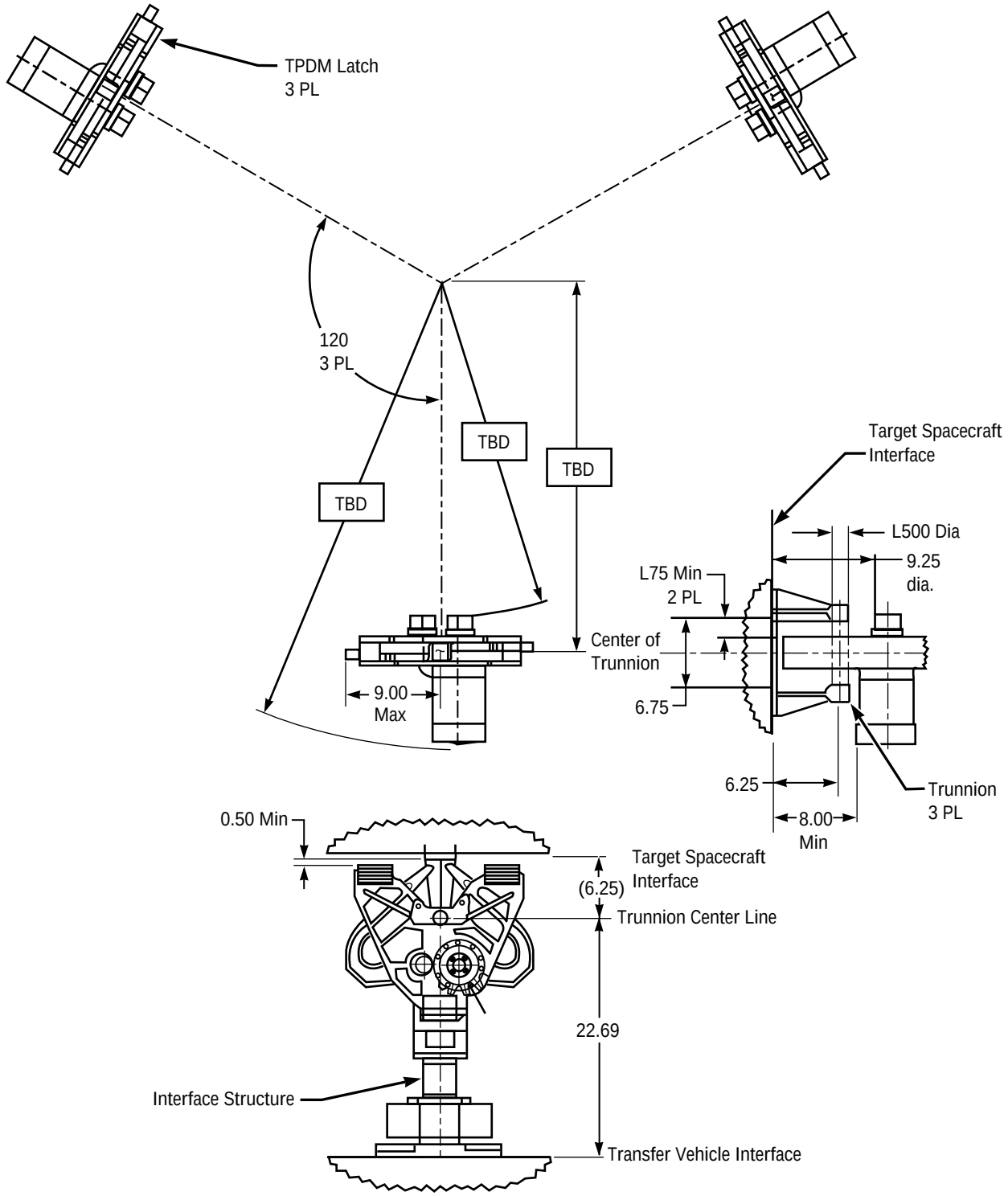

FIGURE 72.—Three-point docking mechanism.