

STATE-OF-THE-ART COCKPIT DESIGN FOR THE HH-65A HELICOPTER

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Abstract

The design of the US Coast Guard HH-65A "Dolphin" cockpit employs advanced integrated electronics systems technology to achieve several important goals in this multimission aircraft:

- 1) Integrated systems operation with consistent, simplified cockpit procedures
- 2) Mission-task-related cockpit displays and controls
- 3) Reduced pilot instrument scan effort with excellent outside visibility

In order to meet these goals, Rockwell-Collins has implemented the integrated avionics system to depend heavily upon distributed but complementary processing, multiplex digital bus technology, and multifunction CRT controls and displays. This avionics system has been completely flight tested and will soon enter operational service with the Coast Guard.

Introduction

"On weekend duty, I always expected to be awakened in the middle of the night," recounts a veteran pilot of the USCG, "and when flying search and rescue (SAR) off San Francisco Bay in summer, I always expected fog." So it came as no surprise when an early morning call interrupted his sleep. Tasked with finding an overdue sailboat and two-man crew, the pilot and copilot strapped themselves in their HH-52 and lifted off. Passing over the harbor lights, they soon disappeared into the night. Searching amidst dense fog, the pilot contacted the harbor radar control and asked for position confirmation plus advisories of nearby objects or vessels. The controller quickly warned him of a ship at his twelve o'clock position and asked if he could see it. "I don't see anything," responded the pilot. Suddenly, the drone of a fog horn cut through the night fog. Max power! Positive climb! Forward airspeed! With reflex action, the pilot executed an instrument take off, a Coast Guard maneuver which transitioned the helicopter up into San Francisco's terminal control area—also, a less than desirable flight situation, but in the pilot's judgment, the better option.

Communication, navigation, flight control, and search sensor management are classical avionics functions which constitute every SAR operation. In theory, however, communication, navigation, and flight control are merely handmaids to the search effort—the sole reason for the mission. Yet, how much attention could the pilot in this account devote to finding the missing sailboat? Because routine cockpit duties often monopolize crew attention during SAR operations and thus impair crew effectiveness, the United States Coast Guard presented industry with a challenge: Build an avionics system that automates the routine tasks of communication, navigation, mission management, and flight control, and therefore, frees the crew to focus on the mission tasks which only they can perform—the visual search and FLIR or RADAR interpretation.*

On 14 June 1979, the USCG awarded Aerospatiale Helicopter Corporation (AHC) a contract for a Short Range Recovery (SRR) helicopter, the HH-65A. Teamed with AHC, Collins Government Avionics Division of Rockwell International designed the avionics system for the SRR helicopter.

Integrated Cockpit Design

The Rockwell solution to the Coast Guard design mandate exceeds mere automation. The HH-65A cockpit design achieves three additional goals: (1) integrated systems operation with consistent, simplified cockpit procedures, (2) mission-task-related cockpit displays and controls, and (3) reduced pilot instrument scan effort with excellent outside visibility.

To achieve these goals, Collins Division of Rockwell has designed the avionics system to rely heavily upon distributed but complementary processing, multiplex digital bus technology, and multifunction CRT controls and displays.

Distributed but complementary processing is an important integration concept used in the HH-65A. Its architecture does not hinge on one centralized computer for processing all navigation signals, displays, control inputs, etc. Instead, distributed processors perform specialized functions. The system coupler unit (SCU) manages communications between the boxes and controls radio tuning. The control display unit (CDU) provides pilot access to all flight management operations. The horizontal situation video display (HSVD) driver unit generates the navigation displays, and the mission computer (MCU) acts as both navigator and flight engineer. Without pilot action, the MCU calculates a "best estimate" of present position and velocity, automatically tunes the navigation sensors, enables flight planning, RNAV-style (including the generation of special USCG patterns), monitors fuel consumption, and records the engine and transmission condition (Fig. 1).

These specialized processors perform distinctive tasks; yet, they cooperate as a single integrated system to accomplish mission objectives. A high-speed multiplex digital data bus enables uninterrupted communication between the avionics. Using discrete addresses, any two boxes can communicate with each other on the bus. To fly to a point, for example, the pilot indicates his intent on the CDU, which in turn communicates that intent to the mission computer. The MCU computes and displays the aircraft's navigational situation on the HSVD and CDU, then, sends roll commands to the flight director (FD), which executes the commands through the automatic flight control system.

Although centralized versus distributed processing does not necessarily alter cockpit operation, system survivability argues for distributed processing. A mission computer failure, for instance, impacts only RNAV capability; automatic navigation via TACAN, VOR, or localizer is not impacted. LORAN, controlled through the system coupler unit, also remains valid; and since the HSVD display drivers process all VOR and TACAN signals plus generate the navigation displays, the crew retains display guidance.

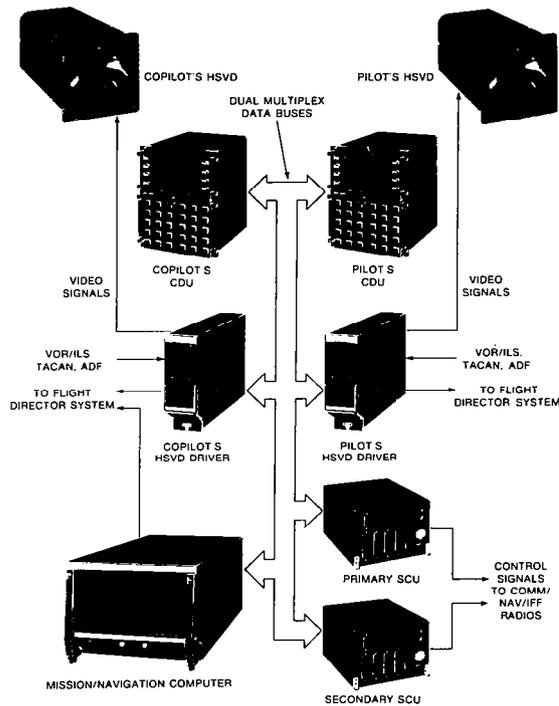


Fig. 1. Distributed but complementary processing.

Another important integration tool is using one device to do the work of many. Four multifunctional CRT devices, dual control display units (CDU's) and dual horizontal situation video displays (HSVD's), inhabit the HH-65A cockpit (Fig. 2).

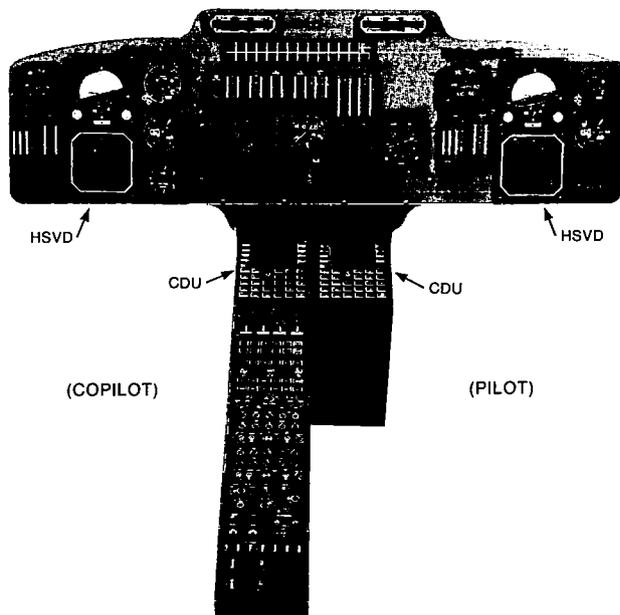


Fig. 2. HH-65A panel and console layout.

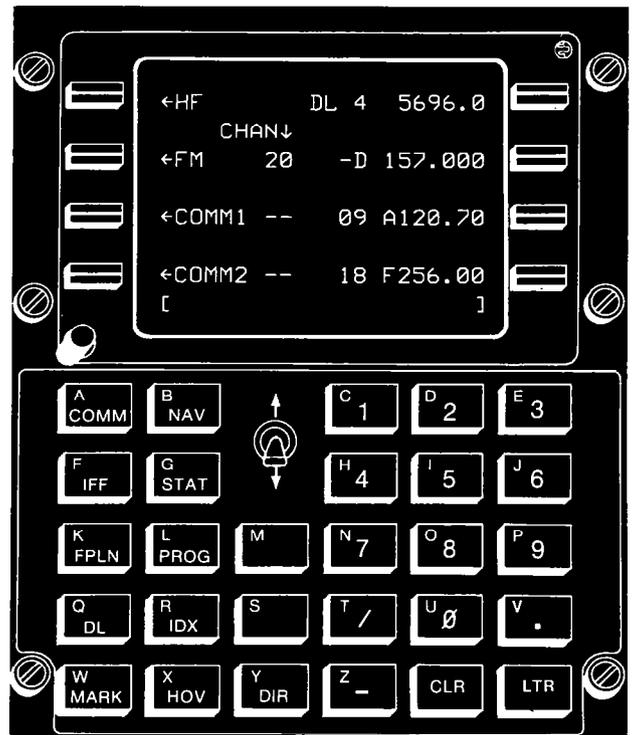


Fig. 3. Control display unit (COMM radio control display).

The CDU is a single-point control for all flight management operations. By incorporating "function keys," the CDU controls numerous mission tasks: For example, pushing the COMM or NAV button dedicates the CDU to COMM or NAV radio tuning. Selecting FPLN dedicates the CDU to flight planning. Likewise, pushing the PROG or STAT keys transforms the CDU into a flight progress or status reporting device. Having assigned the control display unit to a particular function, the crew uses the "line select keys" adjacent software labels to (1) tune individual radios, (2) set transponder codes and modes, (3) insert waypoints, plus a host of other functions (Fig. 3).

Because the CDU centralizes all operational inputs, it simplifies pilot procedures. He communicates, navigates, flight plans, etc. without having to manage dedicated controls scattered throughout the cockpit. Furthermore, CDU pilot procedures are uniform. Whether the pilot tunes a COMM/NAV radio, changes the transponder code, or enters a waypoint, he uses identical procedures.

As the CDU is a central point of avionics control, so the horizontal situation video display (HSVD) is a central point for flight situation displays. The HSVD supplants several dedicated instruments: the conventional HSI, projected map, RADAR and FLIR displays, as well as a hover indicator (Fig. 4).

Nonetheless, merely replacing conventional instruments is not the purpose of the HSVD. Rather, it organizes data into "task-related" modes which not only present the pilot information needed for specific mission phases but also eliminate extraneous information. Consider the low altitude hover over water at night. Because the pilot generally faces a centrally

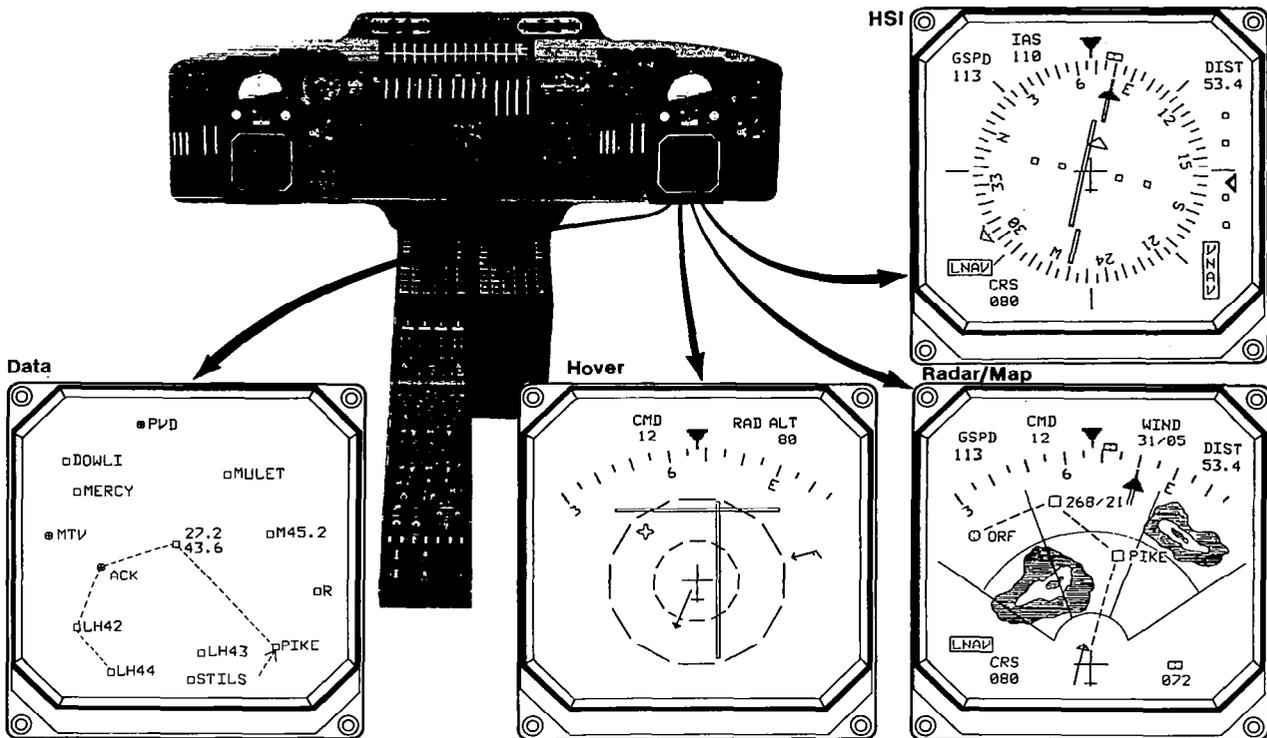


Fig. 4. Horizontal situation video display modes.

positioned HSI which provides virtually no hover information, he scans several other instruments to interpret his hover situation. The HSVD's hover mode integrates all hover data into one central display: omnidirectional airspeed, longitudinal/lateral drift, radar altitude, computed wind, plus target position.

Remaining HSVD modes, likewise, satisfy other flight phase requirements: The HSI mode is primarily an approach display. The MAP mode serves en route navigation, where the flight plan ahead may be viewed. The RADAR and FLIR modes display the video images from these sources for searching. The RADAR MAP mode relates radar returns (weather/ground) to the flight plan. And the DATA mode, a north-up chart presentation, facilitates impromptu flight planning.

Besides suiting information to flight phases, task-related displays denote "complementary formatting." For example, because a pilot navigating cross-country uses wind information to plan the flight, the MAP mode incorporates a digital wind readout. By contrast, the pilot in a hover does not need wind information for flight planning; he needs to visualize wind velocity relative to the helicopter. Consequently, the hover mode incorporates a modified Beaufort wind arrow, which instantly pictures the changing wind velocity. Each pilot needs computed wind information but in a complementary format—dictated by the flight situation.

Typical SAR Operation

Thus far, we have described technical features of the HH-65A avionics system. At this juncture, one might ask, "How does the integrated avionics system aid the pilot in the context

of the SAR environment?" The following scenario intends to demonstrate integrated system operation, specifically, as it impacts cockpit procedures and workload in the SRR helicopter. Assume that a pilot were flying a routine patrol when the rescue coordinator calls and instructs him to proceed directly to the site of a ditched aircraft, initiate a search and rescue reported survivors.

To navigate to the downed aircraft, the pilot types in the LAT/LONG position on his CDU (the mission computer also recognizes LORAN TD's, place-bearing-distance, or identifiers) and selects DIRECT TO. The mission computer creates a direct course to the point. It also continuously plots present position using dual LORAN, dual VOR, TACAN, dual compass systems, and precision omnidirectional airspeed sensor inputs; manages the navigation sensors (ie, automatically selects navigation stations and tunes the LORAN, VOR and TACAN receivers); and flies the aircraft to the waypoint through the flight director. The HSVD MAP mode simultaneously displays the flight plan. This mode combines a tactical map presentation of flight plan waypoints and an abbreviated HSI, which the pilot uses with the progress and flight plan displays of the CDU to monitor en route progress.

Meanwhile, the mission computer has already assessed the fuel situation. Accounting for wind, the MCU calculates the fuel required to fly to the search point, proceed to the destination, and leave a 30-minute reserve. If on-board fuel is insufficient, the system warns the crew by announcing FUEL ALERT on the CDU. If sufficient fuel exists, the STATUS display translates the fuel reserve (ie, fuel in excess of what's needed to fly to the destination) into hours and minutes of flight time, labelled BINGO. MCU fuel management gives the pilot instant visibility of his fuel status, and thus, how long he can search.

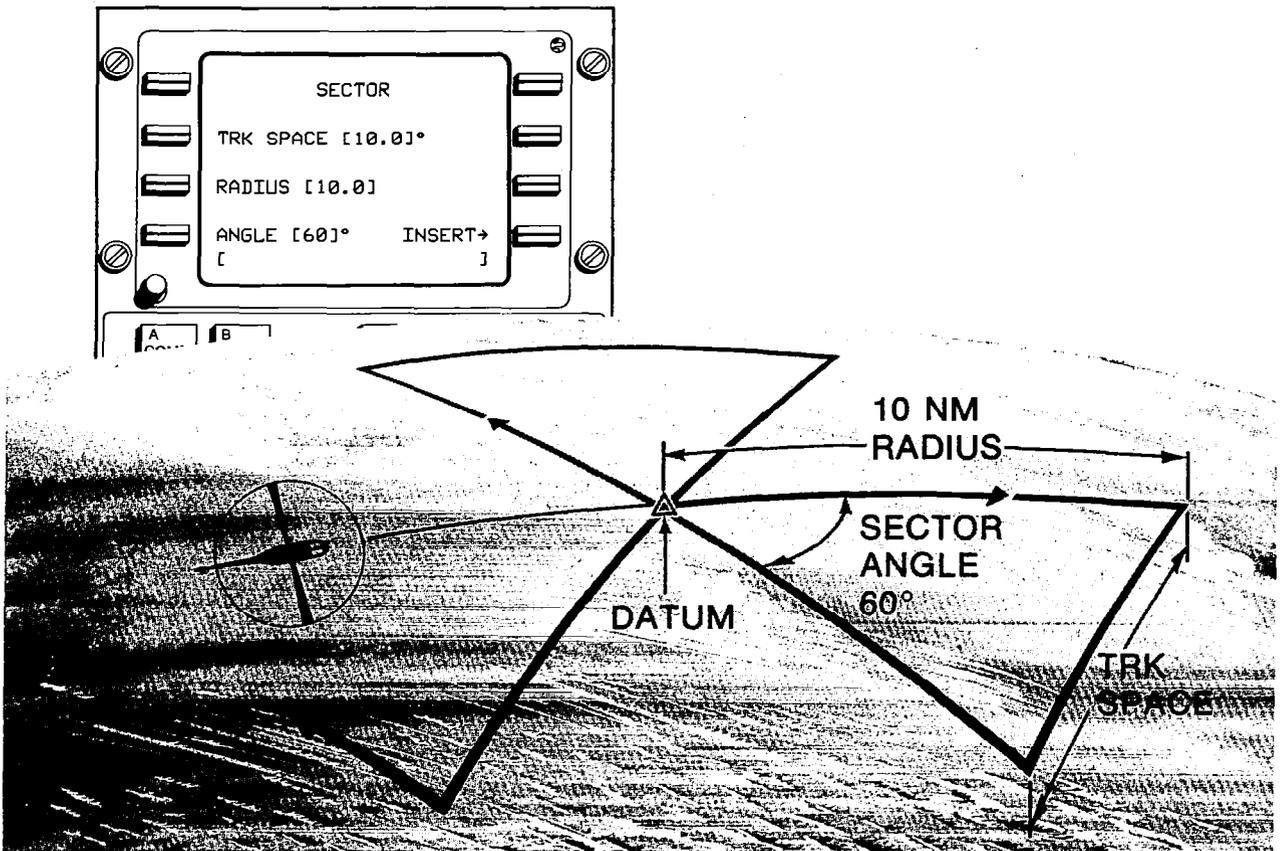


Fig. 5. Sector search entry into flight plan.

While the mission computer monitors fuel consumption, the data link system reports en route progress to the search coordinator, relieving the pilot of routine position reporting. He merely designates the communication radio and transmission interval on the CDU DATA LINK display. At the specified time, the integrated system automatically downlinks 9 pieces of information regarding aircraft position, status, and flight progress.

Eliminating routine flight management tasks frees the pilot to concentrate on system performance and flight progress. Pushing the PROG key on the CDU calls up the computed present position (LAT/LONG) and ground speed. Pushing the line key adjacent any flight plan waypoint provides instant access to "waypoint data" for that geographical point—time, distance and course to the waypoint via the flight plan or via direct.

As the aircraft nears the search area, the pilot plans his search. He selects one of three available patterns (sector, ladder, or expanding square) and then defines the pattern parameters. For example, if he selects a sector search, the computer asks what track spacing is desired (Fig. 5). (NOTE: The pilot may request search advisories by entering the sea state, visibility, cloud cover, and altitude; the MCU will compute the optimum track spacing.) Selecting "INSERT →" displays the flight plan, where inserting the pattern requires only pushing a line key at the desired datum point. The mission computer automatically plots the pattern waypoints and displays them on the HSVD.

Upon reaching the target area, the aircraft automatically initiates the search while the crew concentrates on the search RADAR, FLIR (forward-looking infrared), and DF radio homing, or they scan the white caps below. When the target is spotted, the integrated system, with minimal crew effort, abandons the search and expedites the rescue operation. Over-flying the target location, the pilot pushes two buttons: MARK — to mark the target's location, and HOVER — to call up the approach-to-hover pattern into the flight plan and selects APPR on the flight director panel — triggering a chain of operational events. The system turns the aircraft downwind to ensure a final approach into the wind, directs a minimum time procedure turn, and computes a five degree descent to the hover transition point. Using the FD speed beep, the pilot may vary the approach speed. At 100-foot radar altitude, the FD APPR mode drops; T-HOV mode captures and slows the helicopter to zero ground speed at 50 feet RA — just short of the target (Fig. 6). During the transition to hover, the HSVD automatically displays the HOVER mode. The computed wind, HOVER velocity commands, omnidirectional airspeed vector, and the marked target position enable the pilot to monitor the approach-to-hover maneuver as well as modify the hover conditions. If the pilot beeps either radar altitude or longitudinal/lateral airspeed, the indicators instantly verify his input.

While the survivors are hoisted to safety, the pilot decides his next course of action. Should a victim require immediate medical attention, he may choose to fly to a medical center

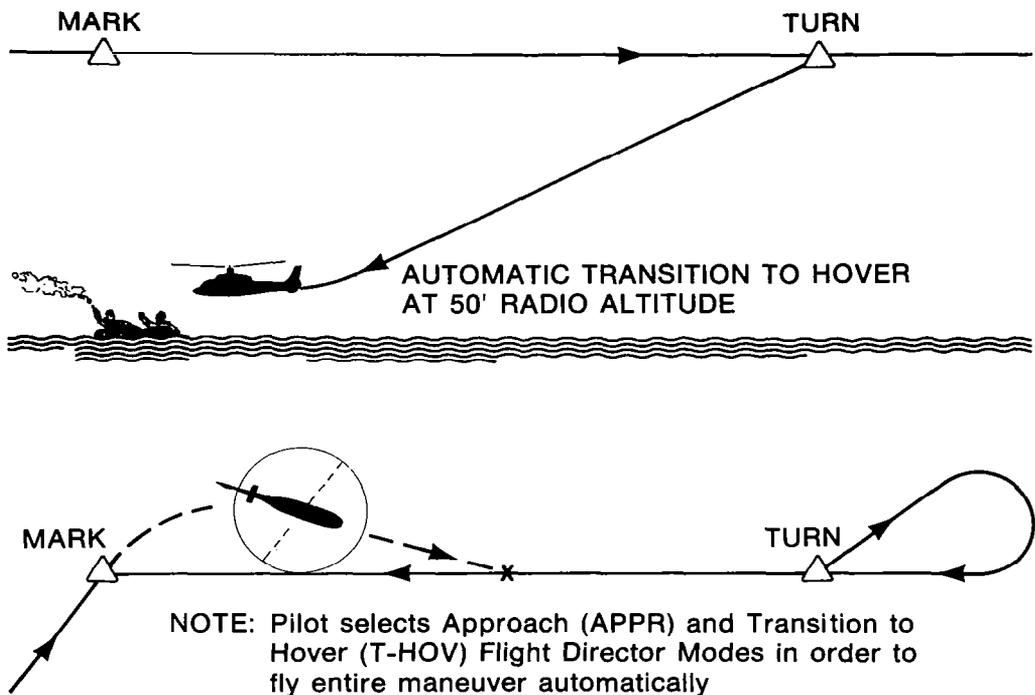


Fig. 6. Approach-to-hover maneuver.

rather than home base. With the push of the DATA mode button, the HSVD displays surrounding hospital locations in a north-up, chart presentation (Fig. 7). To examine direct distance, time or course to any viable alternate, the pilot simply calls up waypoint data for the respective hospital through his CDU. If desired, the MCU will also compute the maximum range on that course. Once again, minimal pilot action activates integrated system response, to enhance crew effectiveness.

The technological tools of digital data bus communication, distributed but complementary processing, and multifunction CRT controls and displays have effected integrated cockpit operation in the HH-65A. Although this system has been implemented for a SAR application, these techniques and this approach to operational cockpit integration will adapt to any helicopter mission. A system coupler unit and CDU which currently controls radios could as easily control weapons systems. A mission computer and HSVD might as easily display terminal area approach procedures or tactical combat command and control data. Meanwhile, the HH-65A with its integrated cockpit operation, will benefit Coast Guard line pilots who undertake SAR despite adverse conditions.

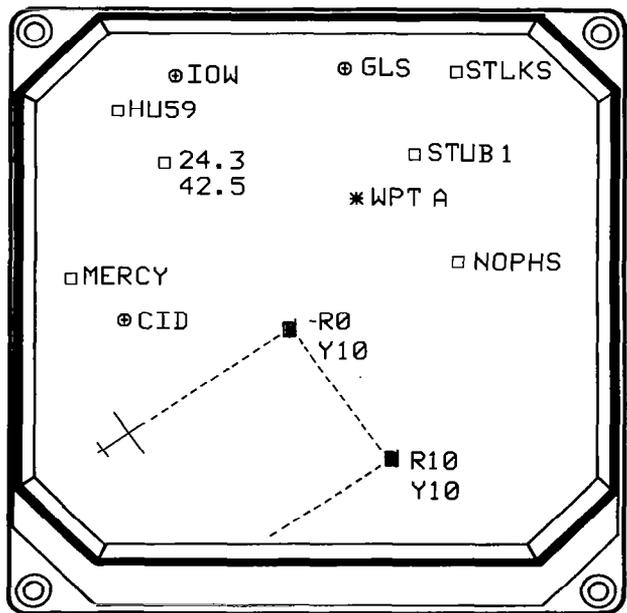


Fig. 7. HSVD data mode.

*Cdr. David A. Young, "Avionics System Design Requirements for the United States Coast Guard HH-65A Dolphin": Presented at the Sixth European Rotorcraft and Powered Lift Aircraft Forum, Bristol, United Kingdom, September 16-19, 1980.