Beyond the Lens

By Commander Frank G. Pfeiffer, U.S. Navy

Nearly four decades ago, we began to replace the landing signal officer's (LSO) paddles with optical systems to assist carrier pilots. In 1951, the Douglas Aircraft Company proposed the visual approach path projector for carrier landing operations. This was the precursor to the mirror optical landing system, first tested on board the USS Wasp (CV-18) and USS Midway (CV-41) in 1952. Less than five years later the prototype Fresnel lens optical landing system (FLOLS) entered testing. By 1960, the Control Instrument Company, a Burroughs Corporation subsidiary, had installed the first production FLOLS on board the USS Franklin D. Roosevelt (CV-42). In 1962, the manually operated visual landing aid system (MOVLAS) found its place on our carriers as the final replacement for the LSO's paddles -- but certainly not the LSO, who remains indispensable.

The result was a system that gave the pilot better feedback concerning his position relative to the ideal glide slope. Since 1962, "meatball, lineup, and angle-of-attack (AOA)," have been the watchwords that keep carrier pilots safe. The first reminds the pilot to keep the meatball centered-aligned with the horizontal array of green datum lights. The second reminds him to make the slight, but almost constant, corrections necessary to land on the carrier's centerline. And the last cautions him to keep the aircraft's attitude, hence airspeed, under control. All three must be skillfully controlled if the result is to be precise touchdown on a moving target area one hundred and twenty feet long by twenty feet wide. Twenty feet low and the aircraft crashes into the ramp; twenty feet high and it bolters, missing the wires. More than ten feet left or right of centerline and the ship's arresting-gear engines may suffer damage; more than twenty feet off-center and the aircraft may hit other planes parked alongside the landing area.

In 1964, the drop line, or drop lights, appeared, along with the first sequenced strobe flashers. The carrier landing aid stabilization system brought electronic analog computer processing and heave stabilization to our visual capabilities as early as 1967, but a full system is currently installed only in the USS Kitty Hawk (CV-63).

After almost 30 years without significant change, visual landing aids aboard our aircraft carriers are on the verge of taking a tremendous step forward. Today, a wide range of optics technologies, digital microcomputer-based control and stabilization systems, and better hardware offer a tremendous opportunity to make significant operational and safety improvements to shipboard operations. It is time to decide precisely what is needed to do our job more safely and efficiently, particularly in today's climate of quick-response and surprise operations, conducted routinely under conditions of emissions control (EMCON), including complete electronic silence.

Consider a night EMCON recovery using technology now under development. At the designated time, the pilot commences an approach; at 10 miles and an altitude of 4,000 feet, he picks up a laser glide slope and centerline and commences a visual straight-in approach. At approximately four miles, where lineup resolution becomes more critical, he picks up the precision lineup display of a system designated Crossbar. Glide-slope information is also provided by a pulse and color-coded display -- the fore-and-aft system. At two miles, the covert aircraft recov-

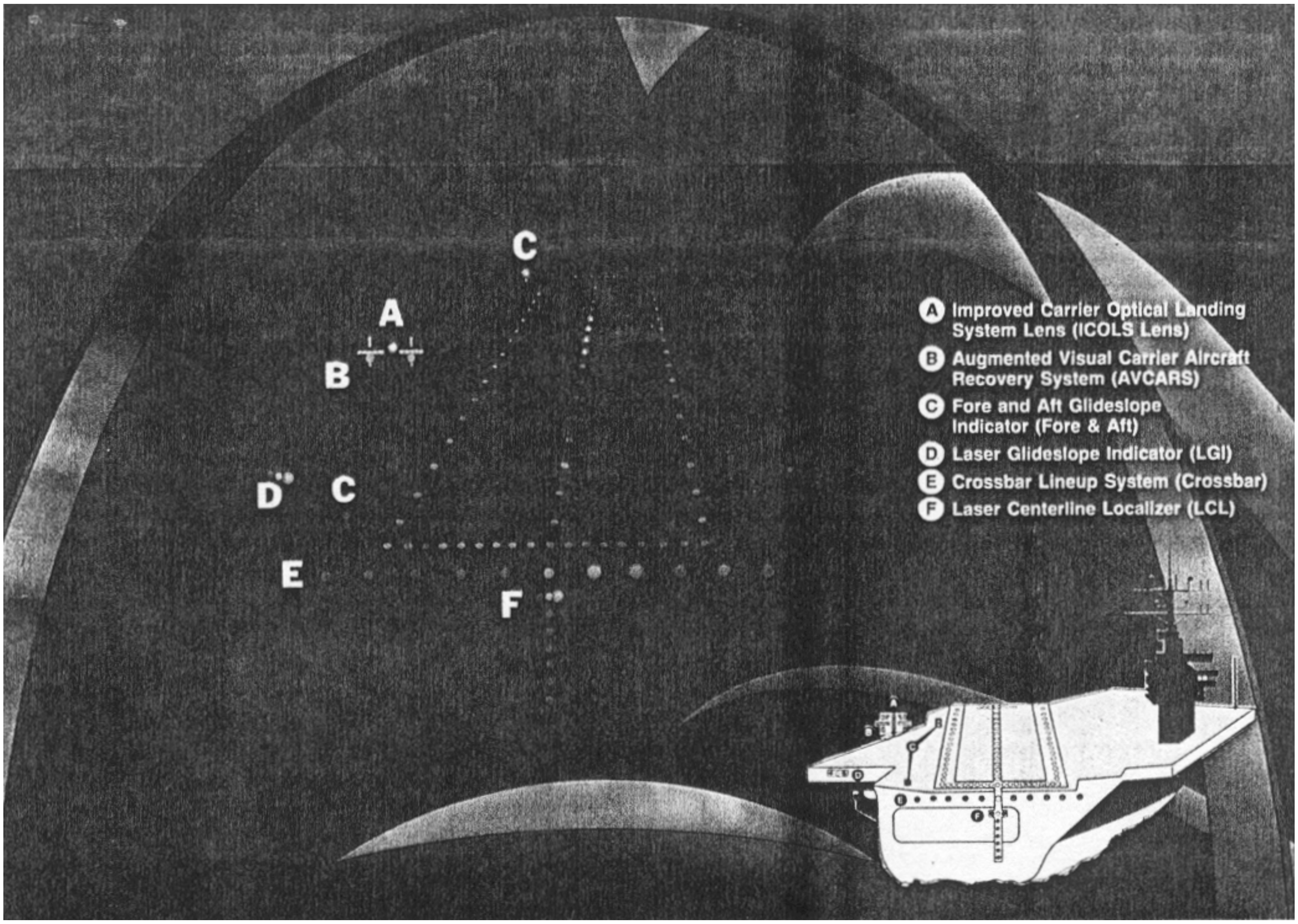
Improved Carrier Optical Landing System

The ICOLS lens is a replacement for the FLOLS. This lens incorporates a significantly higher-resolution glide-slope display with a stabilization system that is capable of compensating for ship's pitch, roll, and heave-in virtually all sea states. It is similar to the Marine Corps's vertical/short takeoff and landing optical landing system (V/STOL OLS), formerly designated the close-in approach indicator (CAI Mod 2), designed to facilitate AV-8B Harrier II operations on amphibious assault ships (LHAs). (See "Helping the Harrier Home," by George E. Bray, August 1989 Proceedings).

The fore-and-aft glide-slope indicator shares some of the characteristics of current land-based visual approach-slope indicators. It consists of two incandescent light sources, one of which is placed approximately 250 feet forward of the lens and one 250 feet ft. Together they provide four discrete corridors, as an indication of the pilot's position relative to the optimum glide slope. Low is indicated by flashing red, on-glide slope by the absence of a light, high by a white light, and well-above glide slope by flashing white. The center corridor's vertical dimension is a nearly constant forty feet, opening up slightly at a distance from the ramp. This provides the pilot with essentially a constant-gain system when on glide slope. No matter how far astern of the ship, as long as he is in the no-lights or null corridor, he will be within twenty feet of the optimum glide slope. During the initial field evaluation, these visual cues were visible at approximately three miles.

The eye-safe laser glide slope indicator (LGI) has five corridors: flashing red-unsafe low; steady red-low; amber-on glide slope; steady green-high; flashing green-well above glide slope. The pilot sees a very distinct point of light to the left of the landing area and that helps him determine his position relative to the optimum glide slope. (ed. note: The LGI has since been moved to the right of the landing area.) Systems under development offer visibility out to ten miles. The LGI offers high resolution and color recognition at all visible ranges. The fourth element is AVCARS, the augmented visual carrier aircraft recovery system. Although developed and tested a number of years ago, it is a new landing aid that provides vertical deviation rate cues in the form of two vertical lighting arrays on either side of the ICOLS source lights. The system is an active-not passive-one, in that it requires precise aircraft position data from the SPN-42/46 automatic carrier landing system or the covert aircraft recovery tracking system. The two vertical arrays of green lights operate together to show the pilot that his rate of descent is too low, too high, or optimum.

The system can be operated in either of two modes: rate or command. The rate mode has proved the more effective. In this mode, for example, if a pilot were one ball high and had no AVCARS lights, he could expect the ball to remain stationary. If he then made a correction to center the ball, he would see a number of the AVCARS lights go on below the datum lights, in proportion to the degree of increase in his rate of descent. The same would be true for any change in rate of descent. In addition to error



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correction, AVCARS provides anticipation cues before ball movement occurs, to help maintain a stable glide slope.

The long-range lineup system is the final element in the system. Two entirely different concepts are being considered to satisfy the operational requirement. The laser centerline localizer (LCL) is designed with pulse- and color- coded, low-intensity, eye-safe lasers that are visible out to 10 miles at night. It provides seven distinct corridors: fast-flashing through slow-flashing and then steady red, for aircraft lined up left, and similar green cues for aircraft lined up right; when on centerline, the pilot sees only an amber point of laser light. The digital presentation provides clear lineup cues in EMCON conditions well outside the final approach environment, and does so passively.

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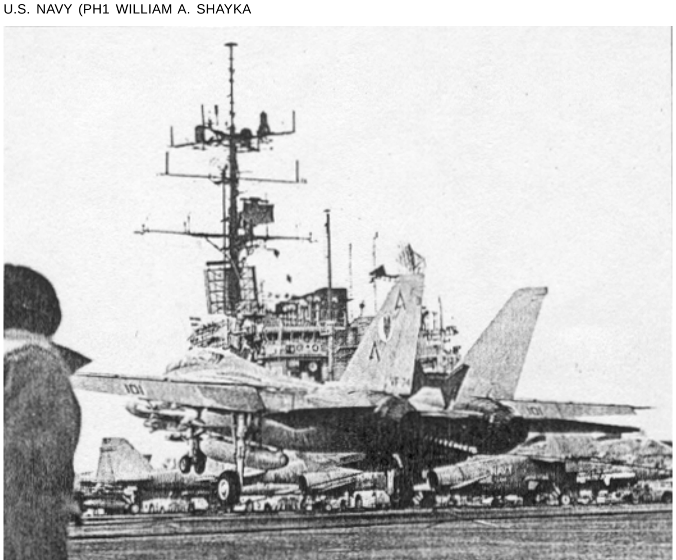
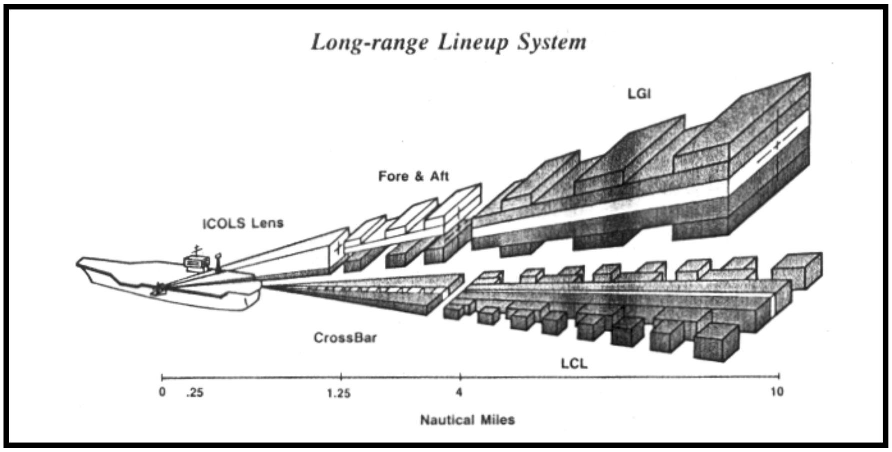


The second concept, the crossbar centerline system, offers significant range improvement over the current centerline strobe, edge, and drop lights, while providing a major improvement in precise lineup control. It incorporates 11 focused lamps spaced at 10-foot intervals, just below the ramp. Five red lamps are oriented to the left of a flashing amber datum lamp. Five green lamps, in turn, are oriented to the right of the datum. The array presents lineup information in both digital and analog cues. As a pilot flies farther right or left of centerline, more lights become visible right or left of the center datum. A pilot on centerline will see only the amber datum.

Each lamp is focused to be seen digitally as it comes into view, yet each blends smoothly with the lamps already visible, to create an apparent analog or thermometer display. The crossbar system is clearly visible at 3-4 miles in daylight and 4-5 miles at night. Although not as visible at night as the LCL, the crossbar offers precise lineup deviation cues from a significant distance astern of the ship in to one-quarter mile. At that point, information from peripheral carrier-deck lighting provides the pilot with traditional lineup cues. Flight evaluations have indicated that retaining the display inside one-quarter mile provides too much information at a time when pilot workload is at its peak.



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Pilots can use the laser centerline localizer (LCL) early in the approach, shift to the Crossbar System, and then use traditional cues when close to the landing area.

ery tracking system provides the LSO, air boss, and arresting-gear officer with a full image of the aircraft; arresting-gear engines are then set. Wheels and hook are also confirmed down, verifying the indications from the approach lights, and tracking data are sent to the augmented visual carrier aircraft recovery system (AVCARS). At one and one-quarter miles precise glide-slope and descent-rate information is available from an improved carrier optical landing system lens and its AVCARS display, and from one-quarter mile to touchdown traditional lineup cues replace the masked-out Crossbar information.

Lower ceilings will cause the visual portion of the approach to be commenced at a lower altitude. Nevertheless, pilots will be afforded visual cues at ranges-up to ten miles-far in excess of those available today. From a tactical perspective, the carrier could be less vulnerable, because returning aircraft will not create a track to the ship as they come into the break overhead; they will make a low-profile, straight-in approach and land.

All of this will come from an operational requirement for an improved carrier optical landing system (ICOLS) was approved in December 1987.

ICOLS is designed to "improve carrier landing performance by allowing earlier response to glide slope and lineup deviations through display of more precise information at greater range." Specifically, the OR calls for a capability to display glide-slope visual cues and descent-rate error information from one and one-quarter nautical miles to touchdown and lineup visual cues from one and one-half to one-half nautical mile from touchdown. ICOLS is composed of several elements, each a stand-alone system. These are:

- ICOLS lens
- Fore-and-aft glide-slope indicator
- Laser glide-slope indicator
- Augmented visual carrier aircraft recovery system (AVCARS)
- Long-range lineup system

An optimum ICOLS configuration combines the improved ICOLS lens and AVCARS for a clearer and more stable short-range glide slope; traditional edge, centerline strobes, and drop lights for precise short-range centerline control; the crossbar centerline display for medium-range cues, and the LCL and LGI for long-range (4-10 miles) information. (See box for a more detailed description of each element.) Given fiscal realities, ICOLS architecture has been designed to allow independent growth, production, and shipboard introduction of each element. We must now set priorities for the individual elements.

Carrier-landing-mishap rates have steadily declined over the years. Better engine response, reduced approach speeds, and improved flying qualities all have played a part. Nevertheless, we continue to land aircraft right and left of centerline, often mixing moving wingtips with parked aircraft.

The carrier aviator's lateral margin for error is only 10 feet right or left of the centerline, which is itself moving to the right at approximately 10 knots as the carrier proceeds on course. Staying within these limits remains one of the most difficult problems facing any pilot.

We need not continue to accept these limitations. Both normal and EMCON operations can benefit in quantum measure by early visual resolution of lineup. Accordingly, a long-range lineup system must be ranked first in priority.

The LGI or the fore and aft system to provide long-range glide slope information ranks second. These will optimize the crossbar's presentation. With glide slope information now available at 10 miles, the LGI's extremely long-range capabilities must then be complemented with incorporation of the extremely long-range lineup information of the LCL. Ceiling and visibility permitting, approaches could then be commenced from 4,000 feet and 10 miles. Or, operating under today's procedures, the LCL can simply offer extremely long-range visual lineup for level approaches from 10 miles to glide slope intercept at 3 miles.

No one with carrier experience will disagree that the key to a good, safe carrier pass is a good start, followed by small corrections. With the current visual system, we get to a reasonably good start with basic visual cues. Subsequent corrections, however, are relatively gross when compared to what they could be with available systems. By providing ICOLS' optics and stabilization improvements, we will improve carrier safety.

The long-range lineup system will provide initial Case I (day, visual meteorological conditions) and Case II (marginal visual/instrument conditions) lineup cues, as the aircraft rolls into the groove at approximately three-quarters of a mile. In Case III recoveries (night, instrument meteorological conditions), either the SPN-42/46 ACLS or the SPN-41 independent landing monitor to reach a point from which a visual approach can be commenced. If this precision approach information is denied to us because we are operating in EMCON conditions, or because it is unavailable, ICOLS' long-range glide-slope indicator and centerline display will get the pilot off to a good start as accurately as radar, and with less probability of detection by enemy forces.

With a better start, on centerline, we will be taking a tremendous step toward improving carrier landing safety, particularly when operating under EMCON.

Full-scale testing of the prototype systems began in 1990.

Commander Pfeiffer is the visual landing aids technical officer at the Naval Air Engineering Center, Lakehurst, New Jersey. He has extensive carrier experience in the E-2C and A-6E, and has served as a squadron, replacement air wing, and air group LSO.