NAVIGATION

Journal of The Institute of Navigation

Vol. 5, No. 4 DECEMBER 1956

NAVIGATIONAL PROBLEMS PECULIAR TO FIGHTER BOMBERS*

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The single-seat fighter bomber is taking over certain important segments of the bombing mission requirements of the Air Force.

A comparison of the fighter-bomber with the heavier bombers shows that the smaller airplane has simplicity, versatility, and a compact crew. It is hard to see and to hit, and can operate efficiently in a little or a big war, with bullets or A-bombs.

It also has disadvantages. Compared with the heavier bomber it has limited range. Its all-weather and navigational capabilities are relatively limited. In these respects the fighter-bomber must concede to the broader capabilities of the B-47 and the B-52.

However, in both weather and navigational capabilities, which go hand in hand, the gap between the heavy bombers and the fighter-bombers can be narrowed to a considerable degree. If the smaller airplane can be more effective in poor weather, it qualifies for a big job. It can relieve the heavier bombers of certain mission requirements.

The key to the effectiveness of this smaller airplane is the man in the cockpit. What are the problems of this pilot who must perform the duties of pilot, navigator, flight engineer, bombardier, and radio operator?

Can this man navigate? He certainly can if he has the proper equipment and a reasonable level of training.

Presented at the Annual Meeting of The Institute of Navigation, Santa Monica, California, June 28–30, 1956.

What should his equipment presentation be? What training must he have? At what point will his job become so complicated that he begins to slough off important details, and lose his ability to navigate satisfactorily?

It would be presumptious to take a rigidly positive stand on questions that are as complex as these. However, a few suggestions based on practical experience may prove to be helpful.

The area most conducive to practical solution falls between the two extremes of complete automaticity and the superman. Complete automaticity is achieved by filling the airplane with black boxes and crowding the pilot in between them with only two buttons to push—one to start, and one to stop. Unfortunately we haven't developed equipment to this degree of automaticity, accuracy, reliability, flexibility, and maneuverability. The superman is an interesting possibility, but we can't even find one example of the species. Consequently, we must study the levels in between these two extremes.

We need electronic equipment. A combination of light weight celestial, doppler, and inertial devices in one system would be of great interest. At the same time individual component reliability and independence would be required, because we can't afford a chain reaction should one component fail. Then before the equipment can be of maximum utility, the pilot must be instructed carefully in the outputs, the inter-relations of his equipments, and the emergency repairs or checks it may be possible for him to make.

Give him a good autopilot that can fly the mission from beginning to end. This will provide spare time for navigational purposes. Then train him in all dead reckoning procedures, and show him how to hitch the new devices to his dead-reckoning skills. Go lightly on classroom training until he has had a chance to become well acquainted with both equipment and procedures. Thus he will attain a degree of motivation to learn more in the classroom.

Make the procedures simple. Rig up a training device and hammer the procedures home. If there is a simulator that can be modified, fly the whole mission in it, on the autopilot.

Install the equipment in the most convenient location. If it isn't handy it won't be used. Even such an innocuous device as the dead-reckoning computer will get little use unless there is a minimum of adjustment.

Of all phases of fighter navigation, one of our toughest jobs has been to present celestial navigation in a form that is usable in the fighter cockpit.

Except for fighter pilots who have previously been navigators, and these are a scarce commodity, we have found that navigation by celestial fix has been difficult to apply in fighters, even with a simple presentation. We have resorted almost entirely to precomputed speed and course line navigation. These lines of position are geared to a dead-reckoning flight plan.

We have an automatic sextant which has suddenly taken the hard work out of celestial. It tracks the sun or the stars, and gives us a highly accurate observation at the flick of a switch. It can also be an effective astrocompass.

We would like to see accelerated development of celestial data computers. In struggling with the tables we waste untold man hours and we sacrifice accuracy. On certain missions, if the celestial data computer is not available, the use of celestial is too cumbersome to be practical.

In an attempt to overcome this difficulty we have installed a photo-electric sextant in a specially assigned F-84F *Thunderstreak* fighter. We went to Air Training Command at Luke Air Force Base with this airplane to try an experiment with our celestial procedures. Five fighter pilots, representing a cross section of experience, were selected. These men were essentially unacquainted with sextants and with celestial navigation. We gave each man a 30-minute briefing on the use of the automatic sextant and our celestial procedures, and then dispatched him to 40,000 feet. Generally speaking, he came back with the right answers, and a healthy respect for what celestial, simply applied, can do for him. In their report they recommended as a group that we stretch the briefing, their initial course in celestial, to one hour.

Incidentally, I would like to emphasize that we're in the business of designing operational procedures, not in the business of testing new equipment. However, in testing our procedures we have come up with considerable operational information relative to this new equipment, which we try to coordinate with the responsible agencies.

In April of this year we embarked on a special mission to look further into our procedures. This mission was set up as *Operation Sharkbait*, the name being appropriately descriptive for a non-stop trans-Atlantic flight in single engine aircraft. The point of departure was McGuire Air Force Base in New Jersey and the destination was Wethersfield RAF Station near the east coast of England. The aircraft were F-84F *Thunderstreaks*. I understand it was the first non-stop flight of jet fighters on the direct great circle route between the United States and Europe, and the first with only one in-flight refueling. Of all the 668 flights the writer has made across the Atlantic this was the most interesting.

The distance was 3145 nautical miles and the flying time 6 hours and 50 minutes, including mechanical and weather delay at the tanker rendezvous which cost at least 45 minutes. Average wind component was 30 knots on the tail.

The writer acted as *Sharkbait* leader and was accompanied by two wingmen; Major R. C. Tomlinson of the Fighter Branch, Directorate of Operations, Headquarters USAF, and Captain Cesar Martinez, Operations Officer of the 509th Fighter Bomber Squadron, 405th Fighter Bomber Wing at Langley AFB. This was a Tactical Air Command mission.

Sharkbait leader's F-84F was equipped with the Kollsman photo-electric sextant. It was further equipped with a simplified, small package doppler device, manufactured by General

Precision Laboratories, which furnished indications of groundspeed and drift.

The flight was pre-computed celestially for speed lines on the sun at Yarmouth and Sydney, Nova Scotia; Torbay, Newfoundland, 45 degrees west, 40 degrees west longitude, and then on the stars to destination beyond London.

Allowance was made in the precomputations for one hour of delay. We experienced almost that much delay at the tanker rendezvous, so that the writer was working at the bottom of each precomputation page after leaving the tankers.

The radio compass on *Sharkbait* leader's aircraft was wired off so that there would be no temptation to navigate by conventional means, other than celestial and doppler, except in case of emergency the wires could be cut. (The writer invested $1.87 in a wire-cutter.) However, the wire-cutter was not used, and to make the radio failure more complete, *Sharkbait* leader's UHF radio obligingly failed while en route.

Using the operating equipment and simple procedures *Sharkbait* flight missed no estimated time of arrival by more than a fraction of a minute, arriving over London at midnight.

Shannon was our celestial landfall, and it appears that the maps of Ireland are accurate. Shannon turned up just about when and where its coordinates indicated it should.

The electronic equipment performed well. Shifting the star tracker from Venus over the tail to Polaris over the port side gave good speed and course lines to zero in the doppler dead reckoning. Later the tracker was allowed to remain on Polaris in order to bracket the parallel of latitude at 52 degrees, 40 minutes north. We maintained track on this latitude for well over an hour by simply referring to the H_0 counter on the star tracker and making the small corrections required. When Arcturus became handy as a speed line the MA-1 "stubby" sextant was used. Precomputations for Arcturus had been corrected for canopy refraction.

Celestial was occasionally used for heading information, to make deviation corrections on the J-2 compass, as well as for its major function of course lines and precise ETA.

The doppler gave us accurate and continuous indications of groundspeed and drift. Although the overall component on the tail amounted to only 30 knots we did have a fairly powerful jet stream in the Newfoundland area. The wind over Torbay, according to the doppler was from 200 degrees at 120 knots. This was the strongest breeze we encountered.

We had been eager to try the doppler out in a full blown jet stream, in order to search for its core, but other considerations directed the performance of our mission on a day when the big wind wasn't out there.

Summing it up, we found this to be an easy way to navigate the Atlantic, or anywhere else, without radio. The procedures worked well, and as for the equipment, we'd like to see more of it in fighter bombers.

NAVARHO*

United States Air Force Air University Quarterly Review

This fall a new air navigational aid will begin a year of intensive operational testing. Beaming its signals over a substantial portion of the Northern Hemisphere, "Navarho," as the system is named, shows promise of becoming the long-awaited global aid to air navigation. It will mark one more large contribution of electronics to man's conquest of space.

In directing an aircraft along its course the navigator is constantly faced with three basic problems. He must know at all times the exact position of the aircraft over the earth's surface. He must be able to infer position for any given time during the flight. And he must calculate, compensating for the drift effects of wind, the precise direction to head the aircraft to reach destination.

Not long ago this was a relatively simple matter. In the days of low-flying, short-range aircraft passing over familiar territory, the pilot or navigator could keep track of his position by mere visual observation of identifying landmarks. This navigating by checkpoints is known as pilotage. But with the steady increase in aircraft range, flights over unfamiliar territory became the order of the day. As an aid to air

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