The doctrine of "universal assignability" has been defunct since April, when navigators began to graduate with specialties.

Navigators With a Difference

BY BRUCE D. CALLANDER

With the introduction of Specialized Undergraduate Navigator Training, the Air Force has made drastic changes in its program for turning out navigators. Before the trainees head off to one of the specialized tracks, though, everybody passes through a sixty-five-day course in the basics of navigation. Before getting into an airplane, the trainees practice on some ground-based simulators, as this lieutenant is doing at Mather AFB, Calif.

IN mid-1986, the Air Force broke with a tradition as sacred to some members as is the memory of Billy Mitchell. On the face of it, it was no more than yet another revision of the Undergraduate Navigator Training (UNT) program at Mather AFB, Calif.

This time, however, the new program was redesigned so dramatically that it had to be renamed. This past April, when the first students received their wings from the new Specialized Undergraduate Navigator Training (SUNT), they were unlike the graduates who had preceded them for decades. They were not generalists but experts on specific weapon systems.

Therein lay a fundamental change of Air Force philosophy. Almost from the time the Wright brothers trained the first Army officers to fly, it was assumed that a pilot who could fly one plane could fly any other. From that assumption grew the doctrine of "universal assignability." When other officers joined aircrews as navigators and bombardiers, it was assumed that they, too, were qualified to serve on any aircraft that had positions for their specialties.

Under the new SUNT program, that is no longer the case. After a brief period of common training, navigation students now are shunted into one of three specialized tracks: (1) fighter/attack/reconnaissance, (2) tanker/transport/bomber, and (3) electronic warfare officer. From now on, it will be almost as easy to train a new student from scratch as to make a transport navigator into, say, an electronic warfare officer.

Radical as this new approach may sound to some traditionalists, it is less a revolution in thinking than it is a recognition that specialization had already made a myth of universal assignability for navigators. Technological advances have long since overtaken the jack-of-all-trades.

In fact, specialization began almost with the birth of military aviation. The Army bought its first flying machine from the Wright brothers, and the first pilots were trained on it. The second plane, supplied by Glenn Curtiss, had a radically different control system. Flyers switching from one to the other virtually had to learn how to fly all over again.

By World War I, control systems

—USAF photo by SMSgt. Don Sutherland

had been standardized, but by then a new type of evolution had begun. The all-purpose machine gave way to specialized types for observation, pursuit, bombardment, and transport. By World War II, student pilots were branching into single or multiengine trainers in the last phase of their undergraduate training. Even before they received their wings, they had begun to specialize.

Preserving the Principle

Still, the Air Force clung to the principle of universal assignability as the ideal, and at times it proved valuable. Early in the Vietnam War, officials adopted the policy that no pilot should be returned to combat until all had served there once. USAF made periodic levies on MAC, SAC, and other commands to supply pilots to transition into fighters.

It might have been more difficult to shift pilots from one type of plane to another if technology had not already worked major changes in the flying specialties. In the early decades of aviation, pilots were expected not only to fly their planes but also to navigate, operate radios, drop bombs, and—when necessary—make their own repairs. In planes with two or more pilots aboard, officers tended to specialize in some of these nonpiloting roles.

In the buildup for World War II, larger crews that included several nonpilot specialists became a necessity. There was no time to train pilots to handle all the chores, even if they had been physically able to do so. Bombers carried bombardiers, radio operators, gunners, and—to get them all where they wanted to go—navigators.

By war's end, still newer technologies were emerging that would work further changes in the specialties. Not long after the Air Force became a separate service, the navigator and bombardier specialties were merged into the aircraft observer rating. A few years later, the pure bombardier became obsolete, and the title of navigator was restored to cover both skills.

The electronic revolution was still in its infancy during World War II, however. Soon afterward, miniaturized computers were added to the flight decks of bombers and transports, and navigating became less a matter of plotting courses than of managing an array of sophisticated electronic devices. In some cases, there were too many for one person to manage. Such planes as the F-4 had backseats to carry navigators. Called weapon systems officers, they not only navigated but also ran the radar and helped find the targets.

Then came yet another spurt of technology. While USAF was perfecting its electronics systems, the opposition was doing the same. In World War II, bomber crews had thrown metal foil from their planes to disrupt ground radar. In the age of advanced electronics, disrupting the enemy's defenses became far more sophisticated. The job fell to a new subgroup of navigators known as electronic warfare officers.

Still, in principle, the Air Force considered any officer who wore navigator wings to be interchangeable with any other. Up to a point, it was a valid assumption. All students received the same basic, 120-day UNT course at Mather before receiving their wings.

Postgraduate Differences

The catch was that none of the new graduates was considered ready for an operational assignment at that stage. Each still had to complete a specialized graduate course.

In effect, the Air Force's universally assignable navigators had become a collection of narrowly specialized experts. All navigators did have a common core of training. But the six months of shared UNT included learning some skills that many would never use in later assignments. All were taught celestial navigation, for example, including those going into fighters, where they would have neither the time nor the need to take sun shots.

The system had other flaws. The graduates of the six-month UNT course had their aeronautical ratings, but still faced what many found to be the most difficult phase of training. If a student could not pass the graduate course, he remained a navigator, but for practical purposes was of little use to the force.

But, most important, the policy of universal assignability was rarely applied. Some ninety-five percent of those trained in a given weapon system were staying in that system throughout their active flying careers. The answer, the Air Force

—USAF photo by SMSgt. Don Sutherland

During the basic phase of the SUNT program, the trainees are given four flights in a T-37 for training in basic airmanship and low-level navigation. The venerable Tweet is also used in the advanced phase of the fighter/attack/reconnaissance track.

The Ancient Art of Navigation

You still begin by learning the same skills that brought explorers across the oceans.

Navigation is one of humanity's most ancient arts, and throughout its long history, it has been spurred by myriad technological advances. Before humans settled down to raise crops, they were hunters and gatherers, wandering endlessly in search of food. Even after they learned how to farm and to domesticate animals, some continued to wander—to expand their territory, to make war on their neighbors, to trade with distant communities, or simply to see what lay beyond the next hill.

In the beginning, it was simple. They followed the herds that provided food and clothing or sought the sources of fish and edible plants. In time, they learned to follow established routes, identify landmarks along the way, and even sketch crude maps. Today, we call the technique "pilotage," and navigation students still learn it.

Soon they found more sophisticated points of reference. Someone discovered that the sun, the moon, and the stars followed predictable paths through the heavens. Knowing where they would be at a given time, a traveler could set his course accordingly. Today's students also learn that skill as "celestial navigation."

Even in early times, technology provided tools to make travel simpler and safer. The mysterious lodestone, always pointing in a given direction, became an invaluable aid to navigation. This bit of magnetized iron ore was later imprisoned in a circular box and became the compass that still guides today's travelers.

An optical device, at first no more complicated than a tube attached to a scale for measuring angles, made the task of sighting the stars more accurate. This device evolved into the sextant—still a basic tool of many mariners and flyers.

Mathematics contributed to the art of navigation in countless ways. It gave travelers the means to translate their star sightings to lines on a chart and to find their position by calculating where the lines crossed. It provided tables to show the effects of magnetic variations on compasses anywhere in the world. It produced the system for calculating the effect of winds on a vessel's speed and course. That system is basic to the technique of "dead reckoning," still one of the first skills taught in navigation schools.

In time, mathematics and mechanics joined forces to produce devices to simplify calculations. As early as the 1600s, the slide rule was providing instant answers to problems that had taken hours to work out mathematically. Three centuries later, aerial navigators still use a circular slide rule to solve wind, speed, and course problems.

If technology has eased the burden of the navigator through the ages, however, it has also increased the demands on him. Early vessels, powered by sails, moved slowly and at the mercy of the winds. By the early nineteenth century, steam power had freed mariners from the tyranny of the winds in one sense, but had increased the need for accurate navigation. Wind no longer gave ships their power, but it still affected their speed and course. A knowledge of weather became more important than ever to the navigator trying to make a beeline to a destination. Accurate charts, careful plotting, and the ability to keep track of one's position also gained importance.

If faster ships taxed the skills of the navigator, however, the invention of the airplane would give him a whole new set of problems. Flying placed him in a new three-dimensional environment. A land traveler moves over solid ground with nothing but the terrain to impede him. The mariner travels partly through the water, with its tides and currents, and partly concluded, was to abandon the idea of training navigators as generalists and concentrate on producing specialists in the skills most needed by the using commands.

Col. Roy D. Sheetz, a product of the old UNT program, says the change was long overdue. A master navigator with deep roots in the "old-school" training approach, Colonel Sheetz, a 1966 UNT graduate, might well have been against changing the system that gave him his skills. But, in 1982, when he became director of navigator/survival and life support for Air Training Command, he supported a specialized approach to training. Now, as commander of the 323d Flying Training Wing, he is convinced SUNT is the only way to go.

SUNT still provides a common core of training in basic navigation and flying skills, but this phase has been cut by almost half, from 120 training days to sixty-five. All students must complete it, but they do not receive their wings and aeronautical ratings until they finish one of the three advanced tracks.

Alumni of Mather's early classes would probably find themselves most at home in the core phase of today's program. It begins with such basics as an introduction to aeronautical charts and meteorology. Four flights in the Cessna T-37 provide training in basic airmanship. The flights also provide a taste of low-level visual navigation, but one of the main purposes is to see how the students handle themselves in the air. Their reactions may be early clues as to whether they are likely candidates for fighters or would do better in heavier, more predictable aircraft.

The first serious training in navigation would also be familiar to old grads. It is in dead reckoning *(see box on p. 72)*, the time-honored art of getting from Point A to Point B when the wind is determined to drive you off course. This DR phase includes several flights in the T-43, a military version of the Boeing 737-200. With compasses and plotting tools that would not have been unfamiliar to Magellan and Columbus, the students plod through missions of three or four hours each and then a check ride.

With each succeeding step, students are exposed to new equipment and to more intricate problems. They learn to fix their positions with the most modern electronic gadgets and, under a phase called "integrated operations," to mesh their findings with their continuing DR calculations. As one instructor put it, they are given more and more balls to juggle, and about the time they have mastered all of the equipment, some of it is taken away to see if they can still manage with their basic skills.

There are more flights, more check rides, and nine academic exams. Toward the end of the core period, students are selected for one of the three advanced tracks. The top ten percent automatically receive their first choice of tracks, and the rest are allowed to express a preference.

Top Guns

The FAR (fighter/attack/reconnaissance) track is the most popular. In many ways, it is also the most physically demanding. Candidates must be both competent and ag-

through the air, with its own influences. But the flyer moves entirely through a body of air that shifts almost constantly and takes his vessel along with it.

Aerial navigation was no great problem at first, of course. On their first flights, the Wright brothers couldn't stay aloft long enough to get beyond sight of the places where they took off. When they did, they were never far from familiar landmarks.

By 1909, however, the Army had laid down specifications for a flying machine that could stay aloft for an hour and fly a set course at a speed of at least forty miles an hour. The Wrights satisfied the endurance requirement by flying in circles over the field, but the speed trial required a cross-country flight of five miles.

Lt. Benjamin Foulois, one of the Army observers at the Wright trials and an experienced mapmaker, laid out the course from the Army post at Fort Myer, Va., to Shooter's Hill in Alexandria. He had a captive balloon raised at the hill and another about midway on the course. Foulois, later a pilot and chief of the Air Corps, made his first flight as the observer/navigator on the trial. In effect, the Army had a navigator before it had any trained pilots.

Most navigation was done by the pilots in those days, either flying alone or riding with another pilot as operator. The range of planes was limited, and unless they ran into unexpected bad weather, they were rarely out of sight of the ground. Army flyers began to draw their own aerial maps. A compass was the main navigation instrument. Railroad tracks were a good ground reference, and as flying became more popular, arrows pointing to the nearest towns began to appear on barn roofs. When pilots became hopelessly lost, they could let down in a farmer's field, ask directions, and take off again.

Unfortunately, this informal approach to navigation had its cost in planes and pilots. Many of the early fatalities occurred when flyers got lost and either ran out of gas or crashed trying to land to get their bearings. In any case, airplanes weren't going to be very useful if they were to fly only by day in perfect weather. Just being able to fly was not enough. To be effective, a pilot had to be able to get to his destination and return in one piece.

As usual, technology was rising to the occasion. In 1911, the gyrocompass appeared. By 1913, gyros were being used in an automatic pilot system that would free flyers from the tedium of long flights and give them time to check their maps without going into a dive. In 1914, pilots began taking radios aloft to talk to ground stations.

In the 1920s, airways were lighted by electric arc beacons. Radio directional beacons followed, allowing flyers to "home" on the signals with their airborne radios. In the mid-1930s, Maj. Ira Eaker flew coast-to-coast "blind," using only his radio and cockpit instruments to navigate. By then, navigation had been refined into a full-time job in itself and the job of a specialized crew member.

Since World War II, whole generations of electronics have been born, grown up, and married into that new family of gadgets called computers. Modern inertial navigation systems use the latest in electronic capabilities and the technology of the mid-1800s, which gave us the direction-setting gyroscope. Told where it is at takeoff, the INS can remember every change in direction and altitude and give an accurate fix on its position hours later. In seconds, it can make the kind of calculations that human navigators need hours to perform.

Future systems will be able to do celestial navigation, not from the stars but from man-made satellites in permanent orbits. Lasers will soon completely replace moving gyroscopes, and computers already do battle with other computers in the whole new world of electronic warfare.

Navigation students now graduate as specialists on specific weapon systems. For all the technology at their disposal, however, they begin their training by learning the same skills that brought explorers to America centuries ago. They still come in handy when the computers break down.

—B.D.C.

The Eternal Triangle

In every airplane, something—either a human or a black box—must resolve the problem of the wind.

Whether it is done by a human navigator or a collection of computer-based electronics gadgets, getting from Point A to Point B is still largely an exercise in basic geometry. It is a problem almost as old as travel itself. Point A is the starting place, whether it be the Spanish port of Palos in 1492, a World War II airfield in England, or a modern MAC base in the United States. Point B is the destination, be it the Indies (or the New World), an industrial target in Germany, or some distant air base in the Pacific Ocean.

The problem is the wind, that moving mantle of air endlessly circling the earth. To early explorers, it was both the source of power and the force that blew them off course. To flyers, it is the element in which they move and that, for good or ill, helps to move them. A friendly tail wind speeds their flight. A hostile head wind slows their progress and gulps their precious fuel. A crosswind can send them miles out of their way, perhaps into disaster.

The trick that navigators have known for centuries is to steer slightly to the left or right of the destination so that the wind will push them back on the desired course. The question is how much to the right or left is enough?

The answer is a technique called "dead reckoning" or, less formally, solving the wind triangle. It amounts to making a scale drawing of the trip to include a picture of the wind. All it takes is a piece of paper, a pencil, a ruler, and something to measure angles with, such as a protractor. Here's how it works.

Make one dot and label it Point A, your starting point. Draw a line from it in the direction you plan to go. Make it due north in this case, to keep things simple.

Now, make a second dot five inches out on this line and label it Point B, your destination. Again, to keep things simple, we'll say the line represents 500 miles, one inch for every 100 miles.

Next, decide how fast you will be flying. Let's call it 100 miles an hour so you can get there in five hours. That's your airspeed, incidentally. We don't know yet how fast you'll be flying over the ground.

Now, draw in the wind. Normally, you'd have to call the Weather Bureau to find out what it looks like, but we'll say that it's blowing from the southeast at twenty-five miles an hour. Draw a line from Point B in that direction. You can probably guess pretty much where it should go, but if you want to be accurate, the angle is 135 degrees north, toward the lower righthand corner of your paper.

Now you can see the direction of the wind, but you also want to know how much it will affect you. Remember that we figured that you'd be out for about five hours and that the wind will be blowing at twenty-five miles an hour. Five hours' worth of wind will total 125 miles, so you must measure an inch and a quarter along the wind line and make a third dot. Call this one Point C. Note that the wind is blowing from Point C to Point B, however, not the other way around. You can draw a little arrow on it to remind you.

Now draw a third line from Point A to Point C. Admittedly, you don't want to go there, but Point C is where you want to aim your aircraft. So why head for a place you don't want to go? Because while you are flying toward imaginary Point C, the wind will be pushing you to the left and you'll actually be moving dutifully along line A–B to your destination.

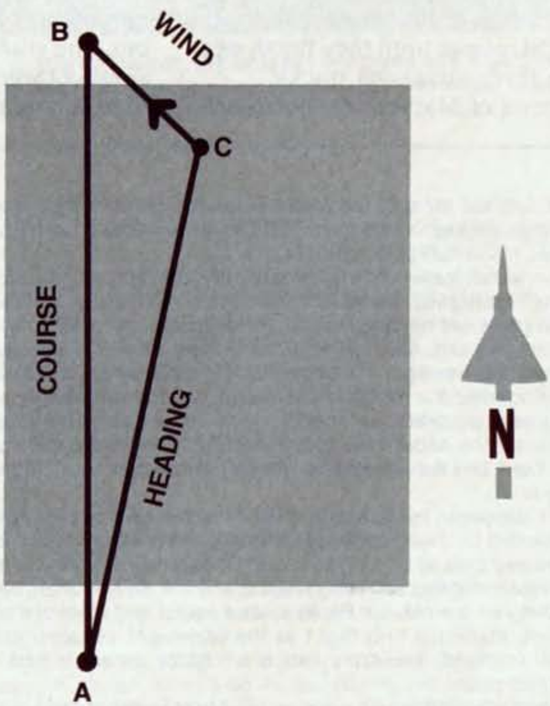
Your drawing can tell you something else, too. Look at the wind line (C–B). While it is pushing you slightly to the left, it is also pushing you slightly from behind. That means that you will be traveling a little faster than the 100 miles an hour you figured. Instead of taking five hours to reach Point B, you'll probably make it in about four and a quarter hours. This time, the wind is a friendly force.

Anyway, you now know how to get from A to B by the shortest route. Well, that's not exactly how a professional navigator would do it. He or she would use an aerial chart and a circular slide rule and approach the thing a little differently.

There are some other calculations involved—compensating for compass errors and weather changes, for example—but this gives you the general idea of dead reckoning. It's a very old approach, but it's still basic to the whole process of navigation.

One way or another, navigators still have to know the same basic things—where they are starting, where they are going, and which way they have to aim so that the wind won't send them somewhere else. Something, whether it's a nervous human or a dispassionate black box, is forever solving and then resolving the ancient puzzle of the wind triangle.

—B.D.C.



gressive. They must know the aircraft's systems as well as the pilot does, and they must be able to take the stress of the high-G environment of the F-111, the F-4, and—eventually—the new two-place F-15E.

In a sense, their job is almost that of copilot. Modern fighters have more gear to manage than did the ten-man bombers of World War II. In the F-15E, for example, the navigator, a weapon systems officer (WSO), will have an "office" in the rear cockpit. It will include four video displays, two of them in color. The WSO will be able to call up moving maps, radar images, flight information, and an electronic picture of the battle situation.

The FAR track is tailored to prepare the navigator for that kind of job. The training includes a number of round-robin flights to other California bases. Student navigators direct the planes, give all the headings, and make all the radio calls. Instructors say that the practice with real-world navigational aids gives students the sort of confidence that those trained in the old UNT program did not gain from the sterile environment of the simulator.

A series of low-level missions gives the FAR track similar realism. In the core program, all students learned to work radar from high altitudes. Now, flying down on the deck at high speeds, the demands of knowing the systems and of staying on top of the navigation problem become dramatically apparent.

The low-level missions are followed by training in electronic warfare, bombing, and, finally, the put-it-all-together phase, called integrated tactical navigation. At this stage, students are given realistic practice missions. Told the basic ingredients of target, enemy threats, and available corridors, the students must plan their routes and provide for air refueling en route. Then they must "fly" the missions on simulators. To complicate things, their instructors change the conditions in midflight, so the students have to alter their plans to compensate. The students then have another series of eleven activity-intensive T-37 flights.

After 160 training days, the students in the FAR track are awarded their navigator's wings. They have mastered an array of electronic gear that earlier navigators could not have imagined. But they have never learned to use the sextant, which was the primary tool for earlier generations.

Celestial and the Heavies

Celestial is still taught at Mather, however, in the tanker/transport/bomber (TTB) track. The navigators on these heavy aircraft fly long distances over water, and the ability to take their positions from sun and star sightings can be essential in those conditions.

The TTB track is a blend of the old UNT and the advanced navigation course formerly given to the UNT graduates who were bound for the heavy aircraft. Under SUNT, it is an extension of the core training. It begins with the same kind of navigation procedures taught in core. Now, however, students learn for the first time to keep a log—a running diary of each flight. There is more drill in dead reckoning, and students are introduced to flight planning and fuel management.

Day celestial navigation is added. Students must spend ten minutes of every hour taking sun shots. They must also continue to work out their positions and, at the same time, maintain their logs and keep track of their other equipment. The individual elements are relatively simple, but in combination, they take the students close to the point of "task saturation."

But there is more to come. Night celestial training is added. Students learn to take sightings on three stars, translate each sighting line to an aeronautical chart, and determine their position by plotting where the lines cross.

After a check ride on their celestial skills, students move to the global navigation phase. Here they are introduced briefly to the highly accurate, satellite-based Navstar Global Positioning System. The eighteen-satellite system is not yet fully operational, but when it is, training on Navstar will be expanded and become a major element of Mather's curriculum.

For now, the global-navigation phase emphasizes more conventional skills. Since the graduates will be flying to all parts of the world, for example, they are taught international flight regulations and the kaleidoscope of rules that governs flying in individual countries.

After that phase, the TTB track splits into separate channels, one for the students going to MAC transports and the other for those going to SAC tankers and bombers.

The transport students learn a technique first used by the Air Force some thirty years ago. Called "pressure pattern" navigation, it involves studying the weather on and near the plane's route. By studying high-pressure and low-pressure patterns, the students can tell the direc-

A number of students can be trained at one time in the fleet of Boeing T-43As run by the 323d Flying Training Wing at Mather. The T-43s replaced the piston-engine T-29s in the early 1970s, and the Air Force and Air National Guard operate eighteen T-43s, which are derivatives of the 737-200 jetliner.

—USAF photo by SMSgt. Don Sutherland

tions and speeds of the winds they are likely to encounter. Using this information, they can lay out courses to take advantage of tail winds and minimize the effects of head winds. The courses they fly may not be the most direct, but with the help of the winds, they are often the quickest and most economical in terms of fuel use.

While transport students are learning to fly the pressure patterns, the SAC students are learning another technique used by bombers and tankers that fly in polar areas. Since compasses are useless near the poles, they use a pattern of imaginary grid lines laid out over the regions.

The TTB students return to the single track again for training in electronic warfare. It is similar to the EW course for fighter types, but adapted to the equipment carried on the heavies.

Like those in the FAR track, the TTB students also wind up their training with a phase combining the skills they have learned so far. Integrated operations on this track concentrate on low-level navigation. It is another case of adapting to technology. To escape radar detection, heavy bombers often fly at very low level. Like those in fighters, the navigators in the heavies must now learn to tell where they are and where they are going when they no longer have the panoramic view from 35,000 feet.

At the end of 160 days, the students in the FAR and TTB tracks get together to receive their wings. By graduation, they will have had a total of 225 days of training.

—USAF photo by SMSgt. Don Sutherland

The T-43A aircraft are mainly used to teach the fledgling navigators dead reckoning, the ancient art of getting from Point A to Point B while taking the wind into account. These students are practicing one of the oldest navigator skills—that of telling the pilot where to go.

The EWOs

Students in the third track are still not ready for their wings at this point. The electronic warfare officer (EWO) track is 210 days, some fifty days longer than the other two.

If the FAR and TTB navigators are the offensive systems operators, the EWOs are the mainstays of the defensive team. They specialize in taking out the opposition's electronics systems to clear the way for strikes. In something close to a real-world version of video games, the EWO may win or lose the electronics battle before a shot is fired.

The EWO track begins with a thorough grounding in basic electronics and the workings of US radar systems. Students must also learn what equipment the opposition has and how its air defense systems work and on what frequencies. The training also looks ahead to new generations of equipment, including reprogrammable systems that can meet new threats.

Like the navigators on the heavies, however, EWOs have different chores depending on the aircraft they fly, and as under the TTB track, their training is tailored accordingly.

About midway through the course, the EWO track also splits. While the students who are bound for SAC concentrate further on their basic systems, those headed for tactical aircraft are groomed for that highly specialized environment. Their job is to move in ahead of the tactical forces and degrade the opposition's electronics. Like those coming from the FAR track, they will fly in high-performance aircraft, often at low levels. The students return to advanced tactical navigation, including another eleven flights in the T-37, before receiving their wings.

Throughout their training, all of the SUNT students have sweated out missions in real aircraft and in the make-believe of realistic simulators. In both, the ever-present element is "The Tube." The tiny lighted screen that was as mysterious as a crystal ball to the navigators of World War II is as familiar as the pocket radio to today's students.

One instructor who teaches traditional navigation techniques admits to some discomfort in the presence of the busy display screens. But he says his students find nothing unusual about gazing at the tiny electronic pictures, even when flying upside down at close to the speed of sound. Being a whiz at video games may not assure success as a navigator, the instructor said, but a student who is really good at programming a home computer is probably going to have an edge.

The SUNT approach is still in for some fine tuning as the using commands send back their evaluations of the new graduates. Until some latter-day Wright brothers invent the all-purpose airplane, however, the days of the all-purpose navigator seem unlikely to return. ■

A Fifteenth Air Force B-24 bombardier during World War II, Bruce D. Callander was recalled to active duty as an information officer during the Korean War. Between tours of active duty, he earned a B.A. degree in journalism at the University of Michigan. In 1952, he joined the staff of Air Force Times, *becoming Editor in 1972. Now a free-lance writer, Mr. Callander has written several articles for* Air Force *Magazine this year.*