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## CONTENTS

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# Headaches of Strategic Bombing

## By Lieutenant Colonel Jesse O. Gregory

EDITOR'S NOTE: *Colonel Gregory joined the Eighth Air Force July 1943 in England as Assistant Flak Analysis officer and was head of that Section from April 1944 to July 1945.*

It is axiomatic that AAA matériel can be most efficiently deployed and controlled only after we know and understand the capabilities and limitations of the enemy air arm we are defending against. The following discussion of strategic bombing is presented with a view to giving the antiaircraftsman a basic understanding of those Air Corps problems that reflect in the AAA mission.

So far as strategic bombing is concerned, bombing by formations of planes is desirable because of the increased mutual protection from enemy fighters, the need of a smaller number of experienced and well-trained pilots, navigators and bombardiers, and the simplicity of control. In addition, friendly fighter escort is simplified, larger forces are enabled to be concentrated at single objectives without danger or fear of collision or of bombing one another, radar countermeasures are generally more efficient, and only one aircraft per formation is required to be manned and equipped with the increased weight of personnel and equipment required for non-visual bombing techniques.

Bombardment aircraft are so constructed and loaded that they can carry a light load of bombs over long distances or a heavy load of bombs over short distances. In the first case, the aircraft would carry a full load of fuel and in the latter case the heavier bomb load would be compensated for by a lighter fuel load. In either of the two loadings the cruising range (endurance) can be considerably increased if routes and altitudes can be selected so that the aircraft will be flying with the wind. Conversely, an aircraft which flies against the wind will be slowed down and its range reduced. Before any air operation a staff navigator must compute the speeds, distances, times and fuel consumption for the projected flight path. When the computed fuel consumption exceeds a value which has been determined as excessive it will be necessary to make some compromise on loading or route plan.

At 25,000 feet, and in still air, the B-17 aircraft will fly at a ground speed of about 240 mph; a headwind of 100 mph decreases the ground speed to 140 mph and a tail wind increases the speed to 340 mph. At the slower speed the aircraft becomes a much more desirable target from the antiaircraft gunnery point of view, for two to four times the number of projectiles can be fired than would be possible if the wind were used to increase the ground speed. (It is interesting to note that few, if any, of the many German flak commanders interrogated after V-E Day advocated the shifting of gun defenses toward the prevailing wind.)

In visual bombing, high ground speeds have a tendency to increase the range error of the bomb pattern while slow ground speed tends to decrease this error. Although the advantages of high ground speed usually outweigh the disadvantages of slower ground speed, there is some indication that, as ground speeds approach 500 mph, the effect on bombing accuracy with current methods will be pronounced.

In practice it is seldom feasible or desirable to make a bomb run directly into or with the wind. The normal condition is when one component of the wind vector blows the aircraft to the right or left and the other component increases or decreases the air speed. The aircraft is then said to "drift" and the drift angle, the difference in direction between the ground track and the longitudinal axis (heading) of the aircraft, must be set into the bomb sight by the bombardier. Modern bomb sights are mechanically constructed to compute drift corrections as high as twenty-five to thirty degrees, but large drift settings usually result in a low order of bombing accuracy. The command bombardier prefers that the drift angle not exceed eight to ten degrees. When flying at 25,000 feet altitude and 250 mph true air speed this condition is met with a fifty mph wind not greater than 45° from the rear or 30° from the front of the aircraft.

Targets which are poorly illuminated are difficult to identify and to keep centered in the bomb sight during the sighting operation. Bombardiers prefer to have the target illuminated by a source of light (the Sun) which is behind the bombardier. The direction and altitude of the sun varies with the season of the year, the time of day, and the latitude of the target area. The writer is unaware of any studies conducted to determine the effect of sun direction and altitude on bombing accuracy; however, in at least one air force operating over Germany a lateral angle of 50° on either side of the sun in winter and decreasing to 30° in summer was avoided whenever possible.

Propeller-driven aircraft produce a considerable amount of turbulence in the air which is commonly called "prop wash." This turbulent air results in the inability of a single aircraft to fly straight and level or for a formation to stay together when the interval between successive elements in the same sky volume is less than two minutes. For this reason elements of bombing formations are stacked in altitude within the limitations imposed by the fact that aircraft fly somewhat faster at higher altitudes, and winds are usually stronger at higher altitudes but not always from the same direction. One form of attacking unit which was considered standard was a thirty-six aircraft group composed of four squadrons of nine aircraft each, so stacked in altitude that the whole group formation was approximately 1,000 feet deep. These groups were then flown in column at two-minute intervals. At the target each squadron bombed separately, the maneuver at the initial point being arranged so as to bring the separate squadrons across the target in approximately thirty-second intervals. Exact timing of air operations is extremely difficult and the timings described here were seldom made good in combat, but they were values selected for planning as being within the limits of capabilities.

Enemy fighter aircraft constitute the most serious threat heavy bombardment operations. The most efficient defense against enemy fighters is the friendly long-range fighter escort which can harass or engage the enemy fighters and prevent their attacking the bombing force. The escort fighter is a much faster and shorter endurance (time) aircraft than the bomber which it protects. For this reason, successive forces of the escort in ETO rendezvoused with the bomber stream at prearranged points along the route and stayed with the bomber force until forced to return to base because of fuel shortage, at which time a fresh escort force would rendezvous with the bomber stream. Thus escort fighters worked in relays along the bomber route. On very deep penetrations the fighter escort capabilities were overtaxed and became less efficient than normal. In order to compensate for the thinning of escort on long missions, the approach and withdrawal were likely to be made so as to require the bombing force to be in enemy controlled skies a minimum length of time.

The development of electronic aids to navigation and bombing has reached a state of perfection sufficient to permit the planning of air attacks on targets which weather forecasts indicate will be totally obscured by clouds. The expected accuracy of this form of attack is far below that of visual bombing techniques but many targets, because of size or the strategic consideration of time, will be subjected to this form of attack. It is beyond the scope of this article to discuss the techniques of the several systems employed except to point out that a third member, the radar navigator, is added to the bombardier-navigator team and that the instruments used often require the aircraft to fly predetermined approaches. Depending on the technique, approaches are limited by the following considerations: location of ground equipment, ease of recognition of route, ease of identifying initial point and ease of target identification. The initial point to target run is considerably longer (eight minutes being a general average) than is necessary when visual bombing is planned and flight is virtually straight and level from initial point to target. Low altitudes will limit the range of some systems of unseen bombing because of limitations imposed by the curvature of the earth's surface.

Under favorable surface weather conditions, and with adequate air warning service, smoke screens become an efficient defense against high level precision bombardment. Visual sighting of bombs requires a maximum of visibility in the bomb sight. In planning air operations, where troublesome smoke is anticipated, it is desirable to have the ground track parallel to and from the same direction as the surface wind. The bombardier will thus be in the best position to observe between plumes created by the smoke generators and will more readily pick out the target or other familiar feature in the target area.

Air Intelligence can provide the air commander with maps which indicate the shape and density of areas defended by antiaircraft guns. One intelligence agency in the European Theater during World War II estimated that it could outline defended areas with a degree of accuracy of better than 90% and could state the gun density within the area to an accuracy only slightly below 90%. Information of this type is used by the planning echelons in determining routes, selecting the aircraft heading for attack, and determining the bombing altitude.

Routes will usually be selected so that the aircraft are exposed to a minimum of fire from gun defenses other than those at the target. Occasionally, because of considerations previously mentioned and because large formations do not turn easily (a turn in route greater than 70° is usually considered undesirable), flight over known defended areas had to be made. At such times evasive action and radio countermeasures were used to reduce the effectiveness of the AA defenses.

The selection of aircraft heading at the target, from the antiaircraft point of view, is made after careful consideration of the gun disposition around the target and the direction and velocity of the forecast wind. Then it is possible to compute the relative chance of damage for aircraft approaching the target on any of several headings. These computations are made by "Flak Analysts" who are usually especially trained antiaircraft officers on permanent duty with the Intelligence Section in Air Force Headquarters.

The accuracy and effective range of antiaircraft weapons is considerably affected by the altitude of the target aircraft so that the expected efficiency and intensity of the ground defenses is a primary factor in the selection of bombing altitudes. Excessive altitude, on the other hand, introduced certain undesirable factors some of which were: decrease in bombing accuracy; decrease in bomb loadings, range, or both; increased load on engines with a resultant increase in engine failure; increase in the supply of oxygen and warm clothing required for aircrews and a resultant increase in casualties due to anoxia and exposure.

Formation flying becomes difficult because a rarefied atmosphere renders control surfaces less efficient.

### Weather

Weather is probably the first and most decisive factor in planning air operations. Since flights of ten hours and greater are not uncommon, it is essential that the planning echelons be reasonably certain of the weather conditions over a period of time that will include take-off, assembly, route, target and landing. These conditions can, in most cases, be forecast to a remarkable degree of accuracy and are presented to the air planning staff in their primary subdivisions of weather—clouds, visibility, wind, icing conditions, and frontal conditions.

Clouds interfere with successful air operations when there is no clear area for assembly or no clear layer of sky in the altitude brackets along the courses considered for route approach. Pure instrument bombing is unaffected by cloud cover or visibility but many successful missions are the result of an alert bombardier sighting through a break in the clouds while on an instrument approach. Of course the accuracy of visual bombing decreases when clouds cover the target. Cloud formations normally exist in layers and are reported and forecast in terms of per cent of earth covered, and altitude of the base and top of the cloud layer. Since a four-tenths cloud condition may nullify an entire mission, the bombardier listens carefully to the cloud forecast which, in complete code might read: "Six to eight tenths strato-cumulus, base 1,000 feet, tops 3,000 feet.

Visibility is the measure of the distance along the earth's surface at which objects are clearly discernible. Air operations become restricted when take-off and landing visibility is less than 500 to 1,000 yards, and returning aircraft are frequently diverted from their home base when visibility falls below these safe limits. Unlike cloud conditions, visibility is a more localized condition and, since it may consist of fog, haze, smoke or dust, is considerably more difficult to forecast accurately. A typical forecast might read: "Five hundred to 1,000 yards at base becoming six to ten miles at continental coast." A visibility of six-plus miles at the target is desirable for successful visual bombing though this figure is often dependent upon altitude, type of bomb, ease of recognition of the target and skill of the navigator-bombardier team.

Wind varies in both direction and velocity at various locations and altitudes but can, in most cases, be forecast within a range of accuracy of about fifteen degrees in direction and ten miles per hour in velocity. The importance of wind effects on aircraft flying at altitudes of about 25,000 feet can be better realized by pointing out the fact that, over targets in Europe, wind velocities were commonly in excess of fifty mph and occasionally exceeded 100 mph. Over Japan, B-29's at the same altitude frequently experienced winds of 100 to 200 mph. Flight characteristics of aircraft are not affected to any great degree by wind, however certain other effects such as endurance, ground speed and bombing accuracy are functions of wind velocity and direction and must be considered.

Ice will form on various surfaces of an aircraft under certain conditions of humidity and temperature. Although many of the lesser annoyances caused by icing conditions can be remedied, the formation of ice on the air foil surface and on propellers is very serious. Ice layers on the air foil surfaces change the aerodynamic characteristics resulting in a loss of both lift and air speed, the additional weight being of little consequence. Ice on the propeller may upset its aerodynamic efficiency, produce serious dynamic unbalance and damage the air-foil structure when thrown off by centrifugal force. In reporting and forecasting, an icing condition is described in terms of the minimum altitude, severity, type of ice and the type of air mass which will contain the ice. A typical forecast of icing conditions might read: "5,000 feet; light rime in frontal cloud." Rime ice is a granular, whitish and rough deposit; it breaks away easily and is not considered a great hazard to flying. Glaze ice is clear, dense, solid ice which adheres firmly to structures on which it forms. Air operations which would likely encounter severe conditions of glaze ice are not considered feasible.

Frontal conditions occur when a cold air mass and a warm air mass meet, producing a weather phenomenon called a warm or cold front. It is beyond the scope of this article to discuss all of the ramifications of frontal conditions though it is pointed out that turbulent air and clouds at all altitudes, two factors which seriously interfere with air operations, are usually present in a frontal condition. Air attacks may be routed around a frontal condition and occasionally over a weak front, but attack through a front is generally prohibitive.

From the foregoing, it becomes evident that air planning is a very complex process involving the careful consideration of all the factors influencing air operations. Then, after carefully considering all details, the best compromise plan, the one which offers a reasonable chance of success with a minimum exposure of the force to enemy action, is finally evolved.

By careful compilation of facts and a reasonable understanding of the capabilities and limitations of the enemy air arm, an alert and progressive air defense commander should be able to predict the enemy intentions with a reasonable degree of accuracy at all times. Obviously intelligence of this nature would be of inestimable value.

# Underwater Spearhead★

## *The job these unsung heroes did was one of the war's most closely guarded secrets*

Their job was to blast the way for invasion. Their tools of war consisted only of a knife, as many high explosive charges as they could carry and small rubber boats. They worked under the very muzzles of enemy guns—without foxholes.

These were the underwater demolition teams, made up of courageous and unpublicized men whose work uniform was a pair of swimming trunks. From the Mediterranean to Normandy to the Pacific they successfully spearheaded D-day operations by removing thousands of mines, posts and a variety of other enemy-placed obstacles designed to impede beachhead landings.

One of their biggest jobs in the Pacific was at Okinawa, where they removed more than 3,000 separate obstructions. At Guam they took out nearly a third of that number.

Demolition operations were always hazardous, but the job on Omaha beach in Normandy ranks as one of the most perilous. There three out of every five men became casualties. But in doing their job the teams distinguished

★From *All Hands.*