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PHYSIOLOGICAL PROBLEMS OF BOMBER CREWS IN THE EIGHTH AIR FORCE DURING WWII

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Major James J. Carroll

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Preface

History books dealing with great air battles, often recount how aircraft target and destroy the enemy. What is often neglected in the history books is the how the aircraft crashes on final approach to its home base. The cause of the crash is an overworked and fatigued aircrew member expected to "gut it out" for the sake of the mission. During World War II high accident rates were prevalent and possibly misunderstood or overlooked by the U.S. Army Air Corps leadership and war planners. The main question to answer is why were the accidents overlooked or misunderstood? A possible answer was the incorrect employment of Aerospace Physiologists who are concerned about aircrew members and the hazards of high altitude flight. This career field has been in existence since the early forties, and the information about high altitude flight should have been available to the war planners of Air War Planning Document - 1 (AWPD-1).

The bomber aircraft of WWII, specifically the B-17, were formidable machines, but they were inadequate for the job envisioned by the war planners. High accident rates accompanied the bomber force throughout the war, and evidence strongly suggests that the accidents were perceived as "the cost of doing business." Overall, the war strategists overlooked the most important and limiting component of the air missions, the human being. This research will center on the planners of AWPD-1, the B-17 itself, the role of Physiologists during the war, problems experienced by the aircrew, and the accident rates

resulting from human error. I wish to acknowledge the assistance of Dr Richard Muller who guided me in my research topic.

Abstract

Aviation physiology is a highly relevant field to flyers of unpressurized aircraft that flew at altitudes in excess of 25,000 feet. Crew members had to contend with severe environmental factors while flying long bombing missions during WWII. The limits of human physiology must be the main concern of any battle plan involving flyers and fatality/mortality rates should be the primary focus in evaluating the success or failure of such a plan. The purpose of this research project is to determine if human factors were overlooked intentionally or by accident. If they were overlooked unintentionally, then what was done to resolve the physiological problems of the aircrews? The project will also underscore the continued need to address the human machine during any plan in today's demanding aviation environment.

Chapter one explores whether or not the limits of the human being was taken into account when the WWII bombing planners developed AWPD-1. It provides an insight into why AWPD-1 was created without regard to the aircrew members, and how this neglect could have possibly been remedied. Chapter two examines the machines of the day, in particular the B-17, to see if it was ready to carry out the assigned missions envisioned by the war planners. The early wartime experience of the B-17 by the Royal Air Force was disappointing, but nevertheless it was looked upon by the United States Army Air Force (USAAF) as the ultimate bomber that could complete any assignment. This chapter also provides some insight into a "typical" mission the B-17 aircrew had to

endure and the aircraft's ability to carry out the assigned bombing missions. Chapter three deals with the physiological problems experienced by the aircrews and what was done to alleviate them. Chapter four focuses on the non-combat accident rates of the Eighth Air Force, what they meant, and how the leadership reacted to them. The last section is a conclusion of the research findings. It provides suggestions as to why the leadership did not do enough to arrest the accident rates, and what could have been done to increase aircrew survival.

Chapter 1

The AWPD-1 Planners

> *Some fighters may be superior to the bomber and capable of shooting it down, but it is none the less a fact that the bomber is the essential nucleus of an Air Force. The fighter is a defensive type of aircraft strategically, but the bomber is distinctively offensive in character. Battles and wars are won by a vigorous offensive and seldom, if ever, by the defensive.*
>
> —Major General H.H. Arnold

The overall aim of the Allied strategic bombing offensive was to bring the enemy's war-making potential to a standstill and bring the Germans to the peace table. During the early years of WWII, Allied leaders spoke confidently about the ability of long-range heavy bombers to penetrate deep into the German heartland, strike accurately, and return with minimum losses. The early realities of the bombing campaign between 1942 and 1943 did a lot to dispel these simplistic views. Grand projections about the ability of air power to win the war by itself were painfully dispelled in the first months of the war. The general notion of a swift, bloodless air campaign was put to rest when the realities of mounting losses and indecisive bombing results were highlighted. To understand where all the "grand strategies" and optimistic viewpoints came from, we have to look at the formulation of AWPD-1 from the planners' point of view. How was AWPD-1 planned and how long did it take to gather all the information needed to plan for a potentially long war?

In July 1941, General Henry H. Arnold, Chief of the United States Army Air Corps (AAC), requested Lt Colonel Harold L. George, then commanding officer of the Second Bombardment Group at Langley Field, to become the Chief of the Air War Plans Division at Washington. With the ongoing war in Europe, there was a strong possibility that within several months the United States would become involved. George realized this and accepted the job thinking he could be in a good position to command a fighting unit. Lt Colonel George reported to Brigadier General Carl Spaatz, General Arnold's Chief of Staff, and became part of the nucleus of the air campaign planning staff that would dictate the course of American involvement.[1] George quickly gathered a handful of colleagues to complete the staff, including Lt Col Kenneth N. Walker, Major Haywood S. Hansell, and Major Laurence S. Kuter. General Arnold was pleased with the selection of planners because he had known all four men since the early thirties when they were instructors together at the Air Corps Tactical School (ACTS) at Maxwell Field, Alabama. All four individuals were seasoned veterans of the AAC and were convinced of the supremacy of airpower. They were tasked to write the air annex for a war plan that would guide the United States in a campaign against the Axis powers. The plan was being formulated in response to President Roosevelt's letter of 9 July to the Secretary of War and Secretary of the Navy.[2] President Roosevelt's letter indicated that he wanted to have the plan completed as soon as possible, but a completion date was left open. Since no completion date was requested, they assumed the President's intent was to have the plan written and approved as soon as possible.

With an undetermined completion date hanging over their heads, the group's initial problem was to define its task. General Arnold initially tasked the group with only production requirements needed to defeat Germany. Instead, the air planners decided to articulate not only production requirements, but a plan to defeat the potential enemies. Lt Col George formulated the basis of the plan as a “strategic air offensive to debilitate the German war machine and topple the German state if possible, and to prepare for the support of an invasion.”[3] George took the initiative and expanded the mission of the planning team. He turned to what Douhet had called the most difficult and delicate task in aerial strategy—targeting. The planners resorted to their experiences at ACTS and settled on four basic targets: electrical power production, transportation, synthetic petroleum, and the Luftwaffe.[4]

The Force Structure

In AWPD-1, the planners had to formulate a force structure that would effectively destroy the German war machine. Normally, the force structure should include the replacement of the crew members, but the focus of their plan was on how many machines it would take to complete the job and neglected to add in human fatality rates into the equation. A review of the plan’s development, revealed that they only concentrated on how many aircraft it would take to destroy the Nazis by using peacetime bombing experiences and probability tables. During the force structure calculations, the planners formulated that 220 bombs would be necessary to destroy a target 100 foot square. They also determined that bombing errors were over two times greater during actual combat than during peacetime bombing missions. [5] This forced the planners to rely on thirty groups of bombers to destroy a target. The resulting force structure numbers showed a requirement of about 7,000 bombers needed to execute a successful air campaign.[6] This was the total number of bomber aircraft the United States needed to produce in order to destroy all the projected targets. One vital error was made by the planners, human fatality rates were left out of the calculations. Apparently, the planners did not think the crew members were going to be a problem or they created an aberration in the equation. As a result of all the scientific analysis, the planners developed a plan to defeat Germany, but forgot to include the human element in the equation. The most remarkable fact was all of this was accomplished in *only nine days* during July 1941.

However, the planners did not completely disregard human numbers. They did plan for an initial force. The scope of AWPD-1 included not only the stated objectives for the production of vast quantities of aircraft, but also for the training of many personnel. The plan called for over 135,000 pilots, navigators, bombardiers, observers, and machine gunners; 900,000 technicians, 60,000 non-flying officers, and over 1 million non-technical personnel.[7] This amounted to over 2 million men. The total number of *aircraft* of all categories required to accomplish the objectives stipulated in AWPD-1 came to just over 68,000. With an initial force calculated, war planners began to formulate attrition or replacement rates. A review of AWPD-1, indicates replacement rates were only centered on one thing—the machines. The most telling realization came from General Hansell himself, in his book; the *Air Plan that Defeated Hitler*. He states, "Vast numbers of replacements will be needed throughout the war and anticipated attrition calls for a monthly replacement rate of 2,133 *aircraft*." [8] No mention of air crew attrition rates was discussed and clearly, his only concern was the aircraft attrition rate and not that of the men who flew in them. The impression given by the AWPD planners was that the men were an inexhaustible resource to be utilized when necessary.

After the attack on Pearl Harbor, the Combined Chiefs of Staff accepted AWPD-1 as a guide for the development of the air forces of the US Army. It was also accepted as a schedule of production requirements for the US Army Air Forces. This approval carried with it a tacit acceptance of the strategic plan on which the production schedule was based. AWPD-1 was modified only twice after it was adopted as the guide for the creation of US air power. It was updated and revised during the development of AWPD-42 and the Plan for the Combined Bomber Offensive. These new revised plans should have caught the early mistakes of the planners, but repeated the same mistakes and neglected to account for air crew attrition rates. The only significant changes to AWPD-1, during the ensuing plans, was the prioritization of targets. No evidence was found to contradict how the planners envisioned a bomber. They thought only of the bomber and failed to regard the more critical component—the crew.

Overall, the most striking aspect of the formation of AWPD-1 was the business like approach the group took. The planning team was confident that precision bombardment offered a new, revolutionary means of warfare. They thought that precise bomber formations could operate independently and, ignoring all hostile forces, decisively destroy both the means and will of the enemy nation to resist. The basic premise the planners used was the ACTS theory of precision bombardment that George, Walker, Hansell, and Kuter had developed. Their bombardment targets, and the means to destroy those targets, were determined by using mathematical and scientific analysis. The scientific analysis pinpointed the key links in the enemy economy whose elimination would cripple enemy capacity to wage war or shatter enemy will to continue fighting. The mathematics were be used to figure out how many bombs and bombers it would take to destroy a target. The planners used this method of scientific analysis to establish the amount of replacement *equipment* needed to carry out the plan, but neglected to calculate the number of *human components* needed to carry out a successful campaign.

The success of AWPD-1 was dependent upon the B-17 and its degree of bombing accuracy. The strategy to effectively utilize the B-17 was daylight precision bombing, formulated by the ACTS in the mid to late 1930s. ACTS believed that a formation of bombers could independently knock out an industrial web and bring an enemy to its knees. The aircraft envisioned to do this mission was the B-17. In 1935, when ACTS devised their precision bombing theory, the B-17 was a tough and impressive airplane. The only problem was that it was not well suited for the air battles over Europe. This was because it was lightly armored, unpressurized, and lacked power turrets and tail guns. In order to validate AWPD-1, the B-17 had to be proven in battle. This rested in the hands of the Royal Air Force in 1941.

Notes

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[7] Ibid., 75

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Chapter 2

The B-17 In Action

> *Statistical experts delighted in describing a warplane as a flyable apparatus with 16,000 parts, 70 per cent aluminum, 15 per cent steel alloy, 5 per cent magnesium, and a 10 per cent combination of bronze, brass, wood, Plexiglas, rubber, copper, and nylon, all held together with 334,250 rivets. Ground crews could reply: "Hell, man, that's no airplane! That's an empty shell. Dig a little deeper into a plane and you will find bone and muscle and sweat, and a portion of blood. We mixed those into your aluminum and steel before we sent a ship out on a combat job.*
>
> —Author Unknown, October 1942

American airmen of the Eighth Air Force faced extraordinary dangers during their combat missions over enemy territory. Apart from the numerous physical threats of violence or death, these airman completed the seemingly routine but hazardous job of flight. Aircraft technology had advanced rapidly in the years just before WWII. Advances in metallurgy, design, engines, electronics and weaponry led to the swift introduction of the newer and far more sophisticated combat aircraft. All of this sophistication however, came with a human price. More complicated aircraft systems called for better and more extensive training and more intelligent operators. Higher operating altitudes forced aircrews to labor against the restrictions of bulky flight-crew clothing and oxygen-support equipment. The aircraft that brought all this new equipment and the additional training requirements was the B-17 Flying Fortress.

The early B-17 models were disappointing and did not live up to their pre-war hype. The pre-war hype can be summed up by the Surgeon General of the Army Air Corps. In 1939 he was given a tour of the newest B-17 aircraft in the inventory. This was his impression:

> One look into the pilot's cabin of the B-17 will convince you that its flight is actually an engineering operation demanding manual and mental skills that put the driving of an automobile into the kiddy-car class. The cockpit is lined, on all sides, with controls, switches, levers, dials and gauges. I once counted one hundred and thirty. The coordinated operations of all these gadgets would be difficult in the swivel-chair comfort of your office. But reduce your office to a five-foot cube size, engulf it in the constant roar of engines, and increase your height to around five miles…that will give you an idea of the normal conditions under which these men worked out the higher mathematical relationships of engine revolutions, manifold and fuel problems, aerodynamics, barometric pressure, altitude, wind drift, airspeed, ground-speed, position and directions. [1]

The B-17 was indeed a technical marvel of the late thirties and poised for greatness. Just how did it become the beloved aircraft of ACTS? In 1933, a development request was issued to manufacturers for the design of a new bomber. Most of the subsequent submissions were of two engine types and in an attempt to out beat its competitors, Boeing offered a four engine bomber design. The accepted bid yielded the XB-17, built by Boeing in 1935. The new machine could carry a modest payload of 2,500 pounds of bombs and had a range of 2,260 miles. The production run, B-17A, had the newest technology applied to the engines and had a maximum ceiling of 40,000 feet. The airplane had some early problems with engine icing at altitude, but once supercharging was added it could reach an assigned altitude faster without the icing problems.[2] The first of these new machines was accepted in July 1939 and by 1940, bombardment technology appeared to have finally caught up with the ACTS doctrine. As a result, the USAAF, at the outbreak of WWII, had both the mainstay for a modern bomber force and a high altitude precision bombing doctrine to guide its use.

The Early Missions and the RAF

The first time the B-17 saw combat was at the hands of the RAF in early 1941. These early B-17 missions were completed with anything but sterling results. Despite neutrality at the time, the supply of war equipment to Britain was under the lend-lease agreement and the availability of the B-17 was both appealing and requested by the RAF. With the lend-lease agreement came the understanding that the RAF would use the B-17, as it was intended, as a high altitude day-light precision bomber. The USAAF would have preferred not to have the RAF test its concept of high altitude bombing with the B-17, but with war on everybody's mind, many factions in the US administration were anxious to bring the US aircraft industry into the spotlight. Consequently, no sooner had the first Fortresses arrived than pressure was placed on the RAF Bomber Command to commit the aircraft to battle action.[3]

Problems Encountered By The RAF

The mission of the B-17 was high altitude daylight precision bombing and when the RAF took possession of the bombers, the USAAF assumed they would be used in that role. Because of this initial assumption, the crews had to be hand picked to make sure they could withstand the physical demands of operating at what were then incredibly high altitudes. The first problem the RAF encountered was the selection and training of aircrews to operate in a high altitude environment. The first test of any potential crew member was to complete training in the hypobaric chamber at Farnborough, spending four hours at a simulated 32,000 36,000 feet. This was done to eliminate individuals susceptible to the bends or chokes—pain caused by bubbles in the blood, body fluids and tissues. Many men were eliminated due to their susceptibility to the bends and over 60 percent of the crews were rejected on medical grounds.[4]

The second problem for the RAF to overcome was training in correct oxygen procedures, for a failure in supply could produce a lack of oxygen or anoxia. Anoxia could result in unconsciousness in minutes and death in ten minutes at altitudes over 30,000 feet. Training was done by trial and error and often done at altitude during actual missions. The third and most obvious problem to overcome would be coping with extreme cold during stratospheric flight and the risk of frostbite. In order to overcome the extreme temperatures, crews had to wear electrically heated suits. In light of the many physical hazards of high altitude operations, it comes as no surprise that so many problems were reported by the RAF and USAAF crew members throughout the war.

B-17's First Test In Combat

By the end of the third week in May 1941, 14 of the 20 Fortresses had reached Britain and five of these had been modified and delivered to the RAF's No.90 Squadron.[5] Both the US and British governments were eager to see the new Fortresses in action. Averell Harriman, the US Ambassador, explained to the British that the question of using the B-17 operationally had become a political question of some importance. The B-17 was now ushered into combat.

This initiation of the Fortress into combat action highlighted many problems the crews were not trained to deal with. The first two problems to surface during actual combat was the freezing of oxygen equipment, and oil-throwing by the engines. These problems had not been seen during the validation of the B-17 in the states because it had only been subjected to the low humidity environment in the USA. In the high humidity environment of Europe, over half the engines of the squadrons' Fortresses were throwing excessive oil out of the crankcase breather at high altitudes; this generally began at an altitude of 27,000 feet.[6] Extensive loss of oil lowered the engine crankcase capacity to dangerous levels and oil spewing off the aircraft accumulated on the tail and froze on the control surfaces, thus endangering control of the aircraft. Another difficulty was contrails forming behind the aircraft at certain unpredictable levels in the upper atmosphere. These contrails immediately gave away the position and direction of a bomber to any hostile interceptor and the Fortress had to either climb higher or descend to avoid the contrail level. The inability to avoid the trail was the reason for the failure of a prestigious raid on Berlin by three Fortresses on July 23, 1941.

Overall, during combat the bomber formations suffered significant losses and put into question the daylight precision bombing concept for the RAF. On ensuing missions, the various mechanical and environmental difficulties continued and bombs were usually dropped wide of the assigned aiming points. Through all this the RAF crews also noted, with extreme emphasis, that the Fortress did not have adequate armor to protect the crew. With all these initial problems, something had to be done. Many American hopes and plans hinged upon the performance of this aircraft, and the RAF knew it.

RAF Solutions

The RAF made an effort to eliminate some of the difficulties the aircrew were having by experimenting with some Fortresses at Polebrook Airfield. The first thing they tried to do was ascertain the maximum safe altitude of the B-17. On one occasion, a lightly loaded Fortress was flown to 36,000 feet where the lack of atmospheric pressure brought additional discomforts for crew members—bladder incontinence. With this new problem came an innovative fix designed by the RAF. To avoid wet clothing which consequently froze, a rubber tube was rigged up to run down inside the leg of the flying suit and then out of the flying boot onto the cockpit floor. This would allow the crew member to urinate without having to leave his position. This new fix led to a disconcerting experience for a young Flight Sgt. who, while piloting a Fortress at 35,000 feet, found he could not move his leg. His immediate thought was that he was paralyzed, but upon further investigation, he discovered that escaping urine had frozen his boot to the cabin floor![7]

Since these early experiences with the B-17 were disappointing, Gen Arnold increased the number of American technical experts at Polebrook during August 1941. He was anxious to see the RAF experiment have every chance of success. Nevertheless, despite intensive crew training and attempts to eliminate technical problems, it was never possible to dispatch more than four Fortresses on a single operation and bombing results were always poor. The experimentation results for the RAF were disappointing and they did not see the B-17 as a very reliable or safe daylight precision bomber. The two month trial run ultimately expanded into nine months and the results were that nine of the twenty B-

17s delivered to the RAF, were destroyed because of some type of mechanical or human error.

US Reaction to the RAF Experiment

The American leadership was appalled to hear that it's "Battleplane" was not fit for duty or that it had some design problems affecting the safe operation of the machine. General Arnold later wrote in his book that "The RAF never gave the Fortress a chance and that the B-17 had been badly handled by Bomber Command." [8] This was not surprising since his thoughts were probably influenced by reports from his observers of the RAF project. Arnold knew about the RAF's preconceived notions that it was futile to employ the Fortress in daylight and he used this as an excuse for the RAF failure.

Overall, the RAF was disappointed with the B-17s' bombing accuracy and survivability, but the USAAF disputed the results, disagreeing with the way the aircraft was flown and how the bombing results were measured. The problem centered on how each service made measurements. The advised technique of the USAAF differed from the RAF technique. The USAAF would have operated the B-17 from 20,000 feet and flown the aircraft in close formation to obtain a better defense through the coordinated fire of several guns. This was in response to the RAF's contention that the B-17 was too lightly armored and that the crews could not concentrate on the bombing portion of the mission. While this would have provided better bombing results in delivering bombs on targets, the inadequate armament and armor of early Fortresses gave little reason for supposing such a formation would have been effective.

The RAF provided for themselves and their Allies some knowledge of high altitude operations and highlighted weaknesses in the B-17 and its equipment. As evidenced by the RAF experience, the dangers the crews faced were awesome and their losses sometimes staggering. What the experience showed was the inherent dangers of high altitude flight and the problems of how to train crew members to operate the B-17. Training crew members was going to be a problem and some deaths were to be expected. This problem was highlighted in 1943, when 850 Allied airmen died in 298 bomber training accidents in the United States, leaving survivors "scared to death of their airplanes."[9]

From these early endeavors, the Fortress emerged with a tarnished image for the British, hope from the Germans, and doubts in America about its prowess. But the USAAF was by then committed to large numbers of B-17s for daylight precision bombardment—a weapon that would win the war and validate the doctrine conceived by ACTS.

The Eighth Air Force and Its B-17 Experiences

The men of the Eighth Air Force were a particular breed who flew out of England and became the principal American Air Force engaged in bombing Germany. 1943 found the bomber formations of the Eighth Air Force trying to complete their missions and prove daylight bombing a success. Before it was all sorted out, the crews themselves would be fighting for their very existence.

As glamorous as the Army Air Forces seemed to those eager to join the war, there was a crushing reality: flying a multi-engined heavy bomber and keeping it in formation was an arduous task. Throughout the war, the crews suffered from the cold temperatures of high altitude flight and the shock of being shot by enemy fighters. Early losses began to mount among the bomber crews and the men began seeking answers to the immediate problem of surviving the mission. In 1943 the majority of B-17s used by the Eighth were F models, which were very similar to the early E models. The main visible changes were the new plexiglas nose and the paddle-blade propellers. Other production changes in the F model included new and more powerful engines, a new electrical system, and an improved oxygen system. The field modifications to the B-17 included fitting nose guns through the plexiglass and adding "cheek" guns to counteract the Luftwaffe's head-on attacks. The modifications brought the aircraft up to standards the crew could accept, but there was still one other problem—leadership. Leadership in the aircraft did not appear to be a problem, but as Gen Eaker and his staff knew at Eighth AF Headquarters, "not every pilot could lead; not every navigator could find the target; and not every bombardier could drop bombs on the target." [10]

The missions over enemy territory were demanding both physically and mentally. The B-17 was a solidly built aircraft that went through numerous changes during its production run. Sadly, the modifications were done largely in response to crew complaints and recommendations determined during actual combat, sort of an "on the job training" (OJT) modification program. In 1943, this OJT was being done by over 31,000 combat personnel in the Eighth Air Force. About 22,000 of these were in heavy bombers and the balance divided between fighters and medium attack aircraft. During the entire period of the Eighth Air Force's operations of WWII, well over 100,000 American airmen saw combat. The main problems centered on the oxygen system, the extreme temperatures, flight environment, and physiological problems. Morale also started to become an issue due to the constant pressures applied from higher echelons to complete the missions.

The main morale issue the 8th AF had to contend with was the question that always seems to surface during combat: when do we go home? In examining crew members who began a series of 25 missions for the 8th, only 559, or 26.8% completed all their missions.[11] The habit of viewing flying as just a numbers game was reinforced by the Army Air Force's policy of not fixing limits to combat duty for airmen. It appears from the evidence that USAAF Headquarters never officially prescribed a limit to the number of combat missions crews might fly. This discrepancy of not affixing a definitive number of combat missions generated morale problems and also suppressed reporting of aircrew physiology problems. The main problem was that the crews often resisted reporting physical or morale difficulties for fear of getting dropped out of rotation. Some other causes were that crews did not like to sever bonds with comrades, and there was always an increased danger of having to get used to a new crew member. Superstition and minor personal idiosyncrasies played major parts in the relations of crew members and morale was a constant issue for the 8th AF Commanders.

There are numerous stories about Eighth AF crew members and their experiences. One that stands out is the story of SSgt Shorty Gordon, a ball turret gunner in a B-17.

> Two thirds of his turret projects from the bottom of the B-17 to meet attacks from below. In it are two .50 caliber machine guns, several hundred rounds of ammunition, a range mechanism, gun sight, switches, buttons, pedals, and petcocks. The gunner gets what room there is left, squeezing in between the guns, legs thrown forward, left foot on the range pedal and right foot on the interphone switch. His knees rest so close to the bolt mechanisms that their action during combat often tears his clothes. Remarkable as this strictly GI invention may be, it is not nearly so popular in a particular Fortress Squadron in England as the twenty-year-old kid

> who operates it. For Shorty hasn't missed a mission yet. His feet have been frozen and his electrically heated baby-blue jumper has failed him at 45 degrees below zero. He has had to work all night inside the wing of a Fortress and go up to fight the Luftwaffe the following day. He has had to beg, wheedle, or steal his way to a gun position in another ship when his own was out of commission. He has worked on frozen guns at 24,000 feet while fighters were boring in and flesh was tearing off his fingers each time he touched his guns to coax them back into action. But he hasn't missed a mission yet. Shorty Gordon eases his nerves after a mission by taking a triple scotch—''more if I can get it." Then he might go off on a forty-eight hour pass to see his girl. The one he's going to marry after that twenty-fifth mission.[12]

Shortys' situation sums up the hardships the crew members had to put up with in order to complete their missions. If the crew members were not enduring the harsh environment of high altitude, they were battling the psychological strain of fighting a determined enemy. Such was the daily life in the B-17s and the mission of the Eighth Air Force.

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Chapter 3

The Physiological Problems In The Bomber Force

Technological warfare imposed an abnormal load on the physiological and psychological motivations of human spirit.[1] The Flight Doctors and Physiologists had to deal with the fact that the aeronautical engineer had carried the mechanical performance of the aircraft far beyond the physiological limits of the human body. The unique environment of aerial combat put extraordinary strains on Allied airmen during the strategic bombing offensive against Germany. The young aviators who flew with the Eighth Air Force were required to adapt to startlingly new experiences of combat. The environment was often life threatening, the physical challenges often intolerable and the pressure to perform enormous. The only real reward for most crew members was to survive, and yet the statistics frequently showed this to be unlikely. The maintenance of the health and efficiency of the crew members in the face of enormous stresses and strains was the task of military aviation medicine. It was not an easy task in the early forties, since the knowledge of high altitude flight was in its infancy and the "experts" were still learning.

The biggest problem was with the flight environment itself. Trainers had to prepare a man, whose body is adapted to function at ground level and whose mind is conditioned to seek peace and security, and prepare him for a life of flying and fighting. The only alternatives the early flight doctors had were to select and train the individuals best fitted physically and mentally for flight duty. He then provided them with devices and methods for protection against their own human limitations.

Once selected, the flight doctors had to train the individuals on physiological effects of flight. They taught the crew members how to protect themselves against the forces of barometric pressure, temperature, centrifugal force and gravity. Any one of these forces is sufficient to kill a flier if he makes any serious mistake or loses control in the operation of a technological maze of instruments. The initial training of fliers in the high altitude environment was left up to the Flight Surgeons of 1939-1941. The knowledge they had was limited and the training facilities and techniques were still emerging.

The Aviation Physiologists Emerge

The first emergence of a dedicated force of Aviation Physiologists was in June 1942, when a program for the training of Aviation Physiologists was established by a directive from the Air Surgeons Office. [2] The first course to train current medical doctors and Ph.D's was started on July 6, 1942. Twenty-two doctors graduated as Aviation Physiologists and were assigned to the AAC to train crew members in the hazards of high altitude flight. This is the first time in aviation history that a dedicated group of doctors had the knowledge and charter to advise the AAC leadership of potential physiological problems during high altitude flight. The newly created physiology department began publishing bulletins in April 1943. These bulletins discussed the problems aircrew members were encountering and how they could be solved. These bulletins were published and distributed to all Eighth Air Force commands and were available for all to read.

Generals Arnold, Eaker and Spaatz, though having a great quantity of low altitude flight time in their records, were apparently not aware of the severe problems the aircrews faced at high altitude. The newly appointed physiologists tried to enlighten them and heed the warnings. The published bulletins were the primary means of enlightenment and included information on how the lengthy exposure to higher altitudes challenged airmen and created life-threatening problems. The life-threatening problems were caused by lower air pressures and a lack of breathable oxygen. Similarly, the leaders learned how large numbers of airmen were affected by the extremely low temperatures at combat altitudes. They also learned that ill-fitting and bulky flight clothing only partially protected flyers from the rigors of open windows and sub-zero temperatures. In fact, the electrical suits that were designed to protect the flier often malfunctioned and even burned their wearers. The altitude became the main focus of the Physiologists and as a result of their persistence, the leadership now had to consider the problems the crews were facing. One glaring problem discovered dealt with the 20,000 foot training altitude done during 1942-44. Even though confirmatory information was available late in 1942, it was not until September 1944 that the USAAF recommended increasing the training altitude to align it with more realistic combat altitudes.(Refer to Table 1) This was a full two years after it was highlighted by the physiologists in their bulletins.

The information published yearly in the physiology bulletins finally brought about this needed change. A sample of the type of information the leadership had to work with is in table 1. This table was analyzed according to the altitudes aircraft flew in actual combat missions. While this table is a synopsis of 1942-1944, the information available to the leadership was given to them on a semi-annual basis or when requested. As evidenced from the table, it clearly shows that from the start of the war, there was a preponderous of flights in the 23-25,000 foot range.

Table 1. Average Altitude of Bombing Missions

PERIOD % OF MEN FLYING AT AVERAGE ALT OF:			
	20-22,000 FEET	**23-25,000 FEET**	**26-28,000 FEET**
1942-43	**21**	**68**	**11**
1943	**15**	**68**	**17**
1943-44	**25**	**63**	**12**

Source: Air Force Publication. *Aviation Physiologists Bulletin,* US Army Air Forces, Bulletin No 7., Sept 1944. 5-6

The purpose of highlighting the average altitude was to point out what an actual operational altitude for training requirements should have been back in 1939, when B-17 training actually began. If the AWPD-1 planners and Generals Arnold and Spaatz could have foreseen the altitude their crews were going to fly, then they could have prepared them better. Training altitudes should approximate actual combat altitudes and a more realistic training altitude might have highlighted problems earlier and ultimately saved lives and machines.

Anoxia

When flying at high altitudes, the biggest fear for any crew member is succumbing to anoxia. Anoxia is the lack of breathable oxygen above 10,000 feet. The human body is adapted to an environment below 10,000 feet and whenever it goes above this altitude it requires supplemental oxygen to survive. To highlight this problem, Flight Surgeons and Physiologists found fatal and non-fatal anoxia occurring in operational aircraft from 1942 - 1944. While there was evidence of some mild cases during the first six months of operations in the Eighth Air Force, it was not until a death was reported that the problem got the needed attention. The seriousness of the problem was identified in the first two years of operations, from Aug 1942 through Aug 1944. During this time there had been a small number of deaths, but a larger number of non-fatal cases of anoxia. As the scope and type of operations of the Eighth Air Force became more clearly defined, and the frequency of missions increased, it became possible to obtain more worthwhile information on the anoxia cases. The resulting information provided material and insights for effective countermeasure developments.

Causes of Anoxia from 1942-1945

In the Eighth Air Force, there were three hundred and three cases of anoxia of which forty-seven were fatal.[3] In most cases, especially the early ones involving the E models, the main causes of anoxia were oxygen system failure, the freezing of delivery hoses, personnel failure, regulator failure, and freezing of the A-14 mask.[4]

Table 2. Overall B-17 Position Distribution for Fatal and Non-Fatal Anoxia Cases

POSITION	**NUMBER OF CASES**	**PERCENT**
PILOT	**14**	**4.8**
CO-PILOT	**5**	**1.7**
NAVIGATOR	**28**	**9.7**
BOMBARDIER	**15**	**5.2**
TOP TURRET GUNNER	**25**	**8.6**
RADIO OPERATOR	**41**	**14.2**

Table 2 (continued)

POSITION	**NUMBER OF CASES**	**PERCENT**
WAIST GUNNER	**53**	**18.3**
BALL TURRET GUNNER	**60**	**20.8**
TAIL GUNNER	**48**	**16.6**

Source: Quip, John. "Letter to HQ Eighth Air Force from 1st Central Medical about fatal and non-fatal anoxia cases." Letter dated 6 October 1944. 11.

There was always a possibility of anoxia occurring at any position because of an equipment failure. The probability of serious or fatal anoxia may be expected to be greater in the more isolated positions. The peak for anoxia cases came in November 1943 with an overall rate of 18.1 cases per 1,000 heavy bomber aircraft sorties.[5] Table 2 provides the overall anoxia cases for the Eighth AF and where in the B-17 the most dangerous positions existed for anoxia. One point identified by the Physiologists was that combat experience had a definite effect in decreasing the incidence of anoxia. It appears experience was the best teacher to prevent anoxia in each crew member. This indicated a need for more careful training during the initial phases of flight training.

Other Physiological Manifestations

The altitude was not the only problem. The sheer anxiety of flying combat missions also began to take a toll on the Eighth Air Force crew members. Aviation Physiologists know today that anxiety can lead to very real physiological manifestations. The principal cause, of course,

was the flyer's instinctive fear of death, maiming, burning or capture. It was, therefore, a flyer's emotional response to anxiety that produced the physiological problems reported to the flight doctors. The dilemma faced by flight doctors was that they could insulate a crews physical discomforts, but there was no simple device for fortifying or insulating a crew members central nervous system against the impact of fear and fatigue in combat flying.

The breakdown common to combat fliers is called operational fatigue. This syndrome does not differ fundamentally from the nervous breakdown of an overworked desk worker. It is an illness composed of emotional and fatigue symptoms, generally manifesting itself in a state of anxiety. The syndrome does not appear suddenly among combat airmen but is usually the result of a chain of distressing, harrowing, fatiguing, conflicting and terrifying events. The bomber crews had a higher rate of operational fatigue because of a fear and inability to vent adequate expressions of the fear. Every man had to stay at his post and every bomber had to hold its position in the formation. This allowed little chance to act in response to the flee-or-fight responses every crew member experienced. In comparison, the fighter pilots had a lower rate of operational fatigue because they had more freedom of action and could respond to the flee-or fight response if overwhelmed.

Fatigue is one of the leading causes of human error in the aviation community today. Operational fatigue problems in the 1940’s were new to the physicians and physiologists and were referred to as “gutting it out” by most crew members. Also, keep in mind that for up to 10 hours, aircrew could be subjected to continuous environmental stresses. They had to contend with loud noise, vibration, glare, cramped and bitterly cold quarters, heavy flight clothing and adherence to oxygen discipline. All this contributed to extreme fatigue even without the stress of combat. As a result of the constant battle with fatigue, most bomber crew members did little else but eat and sleep between missions.

Crew Attire

The final aspect of physiological problems experienced by crews involves adaptation to the extreme cold of flying at 25-30,000 feet during their long missions. Here again, many unanticipated problems had to be overcome. Minus 30 to 50 degree temperatures were quite normal over northern Europe at 25,000 feet, the optimum altitude for heavy bombers. Frostbite, the predominant hazard, made the provision of suitable flight crew clothing essential. The USAAF had developed electrically heated flying suits in 1940, but they only became available to gunners during the winter of 1942-43. The suits were completely unreliable, when subjected to the rigors of operational flying. The electrically heated F-1 suit supplied to B-17 crews was made by General Electric and had an inherent weakness—it failed to keep the crews warm. Being wired in series, if any element wire fractured, it would cause a complete electrical failure throughout the whole suit. When the suit failed, it had serious consequences for the wearer if flying in sub-zero temperatures. The frequency of failure, due to movement of the limbs, was so great that most men chose either not to use them or, if they did, to wear heavy clothing over the electric suit. Through trial and error, the crews learned how to adapt to the short-comings of their equipment once again.

In the spring of 1943, a typical combat dress for a B-17 gunner consisted of: heavy woolen underwear, two pairs of lined wool socks, a modified F-1 electric suit, RAF designed electric gloves and socks, standard A-6 boots, and A-4 coveralls with a B-5 helmet. Additionally, some men wore a leather A-2 jacket over the coveralls. If an electric suit was not worn, the standard protective garb was the heavy fleece-lined B-6 jacket and A-5 trousers in its place. Clearly, all this clothing was a lot to wear and maintain and became cumbersome while trying to perform even the simplest task. Could better clothing have been supplied to combat the cold? After repeated requests from Physiologists and Commanders, new flight garments finally became available to bomber crews in early 1944. The new equipment included a more efficient electric suit that was wired in parallel to prevent the entire suit from failing if a wire was bent or fractured. This *one* modification improved the suit's reliability over 75%.

Another important piece of crew equipment found to be defective in the B-17 was the oxygen system. The early B-17s had the continuous flow type oxygen regulators. The Eighth AF had considerable trouble with this type of system because it had a tendency to allow the breath moisture to freeze and obstruct the oxygen flow. During many flights a crew member found himself constantly squeezing the O2 hoses just to break up ice crystals before they totally stopped the flow of oxygen. This deadly problem was immediately addressed because of crew complaints and cases of anoxia. By the spring of 1943, B-17s were retrofitted with the new demand-type regulator at each crew station, preventing the O2 hoses from freezing. The USAAF leadership appeared to be responsive in this matter, but, in reality, the crews only got their upgraded equipment after someone died or was overcome by the environment.

Notes

[1] Fishbein, Morris. *Doctors at War* (New York: E.P. Publishers and Co., 1945), 280

[2] Air Force Publication. *Aviation Physiologists Bulletin*, US Army Air Forces, Bulletin No.1, April 1943. 3

[3] Quip, John. "Letter to HQ Eighth Air Force from 1st Central Medical about fatal and non-fatal anoxia cases." Letter dated 6 October 1944. 3-4

[4] Ibid., 9

[5] Ibid., 10

Chapter 4

Aircraft Accidents In The Eighth Air Force

The bane of early aviation was the accident rates associated with it. Early war machines had a lot of problems and despite the often nostalgic reflections of many veterans about the pleasant aerodynamic qualities of a B-17, it was especially difficult to fly. Usually overburdened by bombs, fuel, flight crews, and armament, they often barely managed to take off, and could be downright treacherous if they suffered engine failure. To highlight this problem one only needs to look at the data from 1944 in the Eighth AF: there were 2562 aircraft accidents not related to combat, involving 2835 aircraft, and resulting in the death of 1692 persons. This amounts to seven accidents and 4.6 fatalities *every day* of the year.[1] With this many accidents, a modern day Wing Commander would be fired, but this was not the case in 1944. In comparison, today's USAF has an annual mishap rate of under two mishaps per 100,000 flying hours and averages only thirty fatalities per year. The year of 1944 is examined because by this time the USAAF leadership had plenty of time to deal with early high accident rates. In fact, Air Force Safety Agency data from 1942 to 1945 shows most major mishaps occurring in 1943 and 1944. The mishap rates, USAAF wide, were at 71, 64, 45, and 44 mishaps per 100,000 hours of flying for 1942-1945. [2] This information was published yearly and available to any commander upon request during the war.

Numbers and Rates

A portion of the missions that most history books leave out is the stressful time on board the aircraft *after* bombing the target. During their long trips back to England the crew continuously fought against the possibility of interception, the unrelenting necessity of monitoring aircraft systems (especially if battle damage had occurred), and the ever present danger of bad weather. In reality, the crews were not truly safe from the moment of take-off until after engine shutdown.

In 1944, 2,835 aircraft of the Eighth Air Force were involved in 2,562 non-combat related accidents, of which 47.5% were completely destroyed and 17.4% resulted in the death of one or more persons. The total number of accidents per month averaged more than 200, ranging from 148 in February to 271 in July, with well over half the accidents occurring during non-operational flights.[3] Over the twelve month period, the Eighth Air Force averaged 1.79 non-operational accidents per 1000 hours of flying time.[4] Translating this into today's figures would mean the Eighth AF was averaging 179 non-operational accidents per 100,000 hours of flight time. The B-17 had an accident rate of 110 per 100,000 hours of flight time and the B-24 was experiencing 96 accidents per 100,000 hours of flight time.[5] These mishap rates were nearly twice as bad as the average mishap rate USAAF wide. Clearly, these would be unacceptable numbers in anyone's mind today and evidence suggests that Generals Arnold, Spaatz, Eaker, and Doolittle, did not comprehend the severity of these rates or thought of these as the "costs of doing business."

Nature of the Accidents

Nearly 40% of all 1944 accidents occurred during the process of landing. Second in importance were accidents which took place in flight. These in flight accidents accounted for approximately 29% of the total. An additional 16.1% were taxiing accidents and 11.5% occurred during take-off, while only 3.4% involved parked aircraft.[6] As table three indicates, accidents while landing and in flight were of virtually equal significance during the early months of the year. However, the landing accidents showed a definite increase throughout 1944, whereas the proportion of accidents in flight dropped sharply toward the close of the year. Take-off accidents increased during the later months and taxiing accidents accounted for a substantial percentage of the total.

Table 3. 1944 Nature of Accidents in the Eighth Air Force B-17s and B-24s

Month	**Landings**		**Taking Off**		**In Flight**		**Taxing**		**Parked**		**Total**	
B-17s	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
Jan	27	47.3	5	8.8	16	28.1	9	15.8	0	-	57	100
Feb	15	39.5	4	10.5	12	31.6	5	13.1	2	5.3	38	100
March	21	51.3	1	2.4	13	31.7	5	12.2	1	2.4	41	100
April	18	36.7	4	8.2	20	40.8	6	12.3	1	2	49	100
May	18	40	2	4.4	11	24.5	12	26.7	2	4.4	45	100
June	19	41.3	3	6.5	12	26.1	11	23.9	1	2.2	46	100
July	33	47.1	3	4.3	18	25.7	13	18.6	3	4.3	70	100
Aug	26	45.6	2	3.5	8	14.1	17	29.8	4	7	57	100
Sept	17	36.2	4	8.5	7	14.9	14	29.8	5	10.6	47	100
Oct	28	43.7	6	9.4	14	21.9	12	18.8	4	6.2	64	100
Nov	30	43.5	2	2.8	12	17.4	15	21.8	10	14.5	69	100
Dec	44	53.6	10	12.2	10	12.2	13	15.8	5	6.2	82	100
Total	**296**	**44.6**	**46**	**6.9**	**153**	**23.0**	**132**	**19.8**	**38**	**5.7**	**665**	**100**
B-24s												
Jan	8	42.1	1	5.3	9	47.3	1	5.3	0	-	19	100
Feb	7	35.0	3	15	6	30	3	15	1	5	20	100
March	11	42.3	3	11.6	10	38.5	1	3.8	1	3.8	26	100
April	2	8.7	13	56.5	6	26.1	2	8.7	0	-	23	100
May	17	37.0	8	17.4	14	30.4	5	10.9	2	4.3	46	100

Table 3 (continued)

B-24s												
June	16	41.0	4	10.3	11	28.2	7	17.9	1	2.6	39	100
July	20	42.6	4	8.5	12	25.5	10	21.3	1	2.1	47	100
Aug	15	48.4	4	12.9	8	25.8	4	12.9	0	-	31	100
Sept	16	47.0	2	5.9	8	23.6	7	20.6	1	2.9	34	100
Oct	10	38.5	4	15.4	5	19.2	5	19.2	2	7.7	26	100
Nov	15	36.6	6	14.6	6	14.6	9	22	5	12.2	41	100
Dec	17	43.6	13	33.3	1	2.6	6	15.4	2	5.1	39	100
Total	**154**	**39.5**	**65**	**16.6**	**96**	**24.5**	**60**	**15.3**	**16**	**4.1**	**391**	**100**

Accident Causes

A major cause of accidents in 1944 was unit morale. When morale is low, accidents increase. In May through October 1944 there was a total of 265 accidents. Since the weather at this time of the year is usually good, something else had to contribute. One notable thing that happened in the spring of 1944 was that General Jimmy Doolittle officially increased the minimum tour from 25 combat missions to 30. There was a predictable drop in unit morale, and the General was the subject of bitter feelings by many, especially bomber crews, who felt their contracts had been unfairly broken.[7] Worse perhaps, USAAF Headquarters in Washington eventually recommended the abolition of tour lengths altogether, substituting "positive evidence of combat fatigue" as the requirement for relief from combat flying duties. This drop in unit morale and the general feeling of being abandoned may have contributed significantly to the rise in accidents, but this possibility was never addressed by Doolittle or Eaker.

Other causes for the accidents were: pilot error, material failure, personnel other than pilots, and miscellaneous. Pilot error, responsible for 53.6% of all accidents, was the most significant cause. Material failures accounted for 24.5%, divided between power plant and aircraft structure. Personnel, other than pilots, were charged with 8.3% of all accidents, while miscellaneous and undetermined causes came to a combined total of 13.6%.[8] Pilot error was the primary cause of B-17 accidents in the Eighth AF. The most common forms of pilot error were: improper taxiing, leveling off too high, hitting too hard, overshooting the landing, and misuse of landing gear or flaps. When the accident data is examined, pilot errors and personnel other than pilots tended to account for an large percentage of B-17 accidents, while notable improvements was evidenced in the reduction of material failures. Pilot error in today's aviation community indicates a problem with crew training, physiological conditioning or crew fatigue. No evidence was found to suggest the *root causes* of pilot error in 1944. The evidence does support findings that B-17 equipment was improving, but the men who flew it were not. Research evidence also suggests that the 8th AF Headquarters had the indicators of pilot error and, for unknown reasons, were unable to act upon the evidence and correct the problems.

Notes

[1] Air Force Publication. *Summary of Aircraft Accidents in the Eighth Air Force for the Year 1944*. p1

[2] Air Force Safety Center. "1942-1945 Statistics for Class A Mishaps." Kirtland AFB, NM.1997

[3] Air Force Publications. *Summary of 8th AF Accidents*. 3

[4] Ibid., 4

[5] Ibid., 16

[6] Ibid., 21

[7] Doolittle, James H. *I Could Never Be So Lucky Again.* (New York: Bantam Books, 1991), 386-388

[8] Air Force Publications. *Summary of 8th AF Accidents*. 28

Chapter 5

Conclusions

The Allied Forces defeated Germany in World War II; there is no disputing that fact. The casualties inflicted on ourselves were tremendous and if the planners of AWPD-1 and the leadership of the USAAF had managed the personnel as well as they managed the equipment, a lot more allied men and women would have been able to come home to their families. The central theme of the problem was the traditional approaches to measuring combat success; but the leaders disregarded the human element. Bombing accuracy and the destruction it caused was clearly important, but many bomber crewmen measured their personal success quite differently from the number of bombs on target or aircraft shot down. Most veterans, both past and present, comment on the feeling of euphoria they experienced as they touched down after a long mission. For many, even if their bombs had fallen well wide of any target, just coming home was reward enough.

When reviewing all the data compiled, the research shows that the war was thought of as a process in scientific analysis. The AWPD-1 planners stuck strictly to number crunching and how much equipment it would take to execute a winning war. During the next phase of war planning, AWPD-42, they had a chance to redeem themselves, but the only thing that changed was the targeting priority. From the aircrew point of view there were problems with such a mathematical approach to their survival. First, attrition rates never quite matched the idealistic model set forth by local commanders. Less than 50 per cent would actually survive a major campaign. Second, pure mathematics ignores the nature of the casualties, which is always more important than the actual numbers. Overall, there was a lack of concern for crew members physical and physiological needs and the emotional price they had to pay to carry the battle to the enemy.

An abundant amount of evidence showed the ineffectiveness of the USAAF and the 8th AF leadership in dealing with the high aircraft accident rates and crew problems. In response, evidence suggests the blame rests with the medical community's inability to convey the results of research and knowledge. The best evidence of this was that the Physiological Department of the Air Surgeon's Office was not created until 1942, six years after the development of the B-17 and one year after the creation of AWPD-1. This probably contributed to the leadership's lack of concern for the effects of high altitude flight in an unpressurized aircraft. The reason being; the effects were simply not known when AWPD-1 was developed or during B-17 construction. In 1941-42, individual flight surgeons definitely had the knowledge to advise the AWPD planners and leadership of the USAAF, but did not have the expertise or specialty needed to highlight and publish any literature on high altitude problems. The Flight Surgeons had their hands full at the time, trying to medically qualify aircrew members for flight training. Clearly they were occupied with more pressing matters and this might be one explanation for the lack of human concern.

Although a good airplane, the B-17 was far behind what the AWPD planners and ACTS theorists envisioned it could do. This again was probably because they were not knowledgeable in the effects of high altitude flight. Clearly, the aircraft improved as the war progressed, but only after evidence surfaced of crew mortality or repeated complaints by commanders. So, the aircraft manufacturers learned, through mistakes, what was needed to make the high altitude flight environment safer for all. In contrast, judging from the continuous high accident rates, the USAAF leaders did not completely learn what it took to keep crews flying safely. Not until after the war did safety become a real issue in the USAF. In years following, the Air Force has learned what it takes to keep accident rates down and they can proudly say that flying today is safer then it has ever been. One good result of the B-17 experience was with the next generation bomber, the B-29. The B-29 was a much improved aircraft with better equipped to proceed safely with high altitude flight, including a pressurized and heated cabin for the crew members.

Aerospace Physiology today is a robust part of the aviation community both in the military and civilian world. As an Air Force member of the physiology community, one has to feel sorry for what the aircrews had to endure while existing technology could have made it better. The Air Force learned a painful lesson with the high accident rates of World War II and have made major improvements in both treatment of the crew and development of the aircraft. As of result, the Physiologists of today are a part of the operational community and are sought after, often, for advice on physiological problems that cause aircraft accidents. The Air Force is proud of its accomplishments during World War II, but if they knew then, what we know now, the war would have been a safer place to do business.

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