AIR FORCE
AEROSPACE MEDICAL RESEARCH
LABORATORY

50 Years Of Research
On Man In Flight

CHARLES A. DEMPSEY
AUTHOR

PUBLISHED BY
UNITED STATES AIR FORCE
This 50th Anniversary Celebration is a gala review of the last half century of research in aviation medicine. This research has fundamentally shaped the evolution of aircraft design from the wood and wire biplanes to the Space Shuttle. Many renowned scientists have worked in this creative multidisciplinary environment, to evolve pioneering knowledge and established World records that have stood the test of time. Their numbers are legend. Their efforts are unsurpassed anywhere in the world. The published literature from 1935 to 1985 has set the standard for air vehicle design in this country and abroad. Wherever man interfaces with the air vehicle, the mark of aero medical research is clearly evident in both the hardware design and its functional operation. It is the integration of engineering and medicine which made these achievements possible. The next half century will make even bolder strokes in manned flight.
AERO MEDICAL LABORATORY

"The primary mission is to provide the necessary technical information based on scientific research, to enable the aeronautical engineer to design aircraft which are best suited to the mission without surpassing the physiological or psychological limitations of its crew."

Colonel Jack Bollierud
COMMANDER, AERO MEDICAL LABORATORY

1955
The Air Force Aerospace Medical Research Laboratory marks fifty years of achievement and service to the nation. From the beginning, the Laboratory and its people were dedicated to enhancing personnel safety and mission effectiveness through research contributions to advanced system design and military operations. The Laboratory today is a renowned center of excellence for research in toxicology, biodynamics and human engineering. Its many contributions to life support technology, environmental hazard control and crewstation design have in a very real sense made modern manned weapon systems capable instruments in defense of our nation. Through analysis, simulation, human and biological experimentation and model formulation, laboratory scientists seek to enhance man and mission in the tactical, strategic, command and control and ground operational arenas. The Laboratory has unique facilities and multidisciplinary scientists able to extend man’s reach with each advance in systems technology. The Laboratory is ready for whatever challenge awaits in the next fifty years.
AFAMRL AND A CENTURY OF FLIGHT

This 50th Anniversary Celebration is a gala review of the last half century of research in aviation medicine. This research has fundamentally shaped the evolution of aircraft design from the wood and wire biplanes to the Space Shuttle. Many renowned scientists have worked in this creative multidisciplinary environment, to evolve pioneering knowledge and establish World records that have stood the test of time. Their efforts are unsurpassed anywhere in the world. The published literature from 1935 to 1985 has set the standard for air vehicle design in this country and abroad. Wherever man interfaces with the air vehicle, the mark of aeronomedical research is clearly evident in both the hardware design and its functional operation. It is the integration of engineering and medicine which made these achievements possible. The next half century will make even bolder strokes in manned flight.
50th ANNIVERSARY
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Program Coordinator
Chairman Technical Symposium
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Memorialization of Bldg. 248
Guided Tours, Transportation
Exhibits and Displays
Celebration Ceremonies
Rededication/Renaming Laboratory
Awards Banquet
Public Relations
THE PIONEERS OF MANNED FLIGHT

Orville and Wilbur Wright were the first men in history to develop and successfully fly a heavier than air machine. Many men had attempted this goal but they all failed before the Wright brothers began their activities.

The Wright “Kitty Hawk” Flyer permitted man to fly and also be exposed to the unknown environmental conditions of flight. The brothers were often unaware of the environment and yet were the first to experience: multidirectional acceleration forces, flight control coordination while trying to maintain their own physiological equilibrium, abrupt acceleration forces during crash landing, unprotected wind forces in flight, thermal physiology limits while flying in cold weather, high propeller and engine noise in the cockpit.

They first encountered negative accelerations while flying the 1902 glider at Kitty Hawk. This negative acceleration forced the pilot’s body up and away from the prone position cradle. With his body out of the cradle, he could not use the lateral wing warping flight control. The pilot did not have a body restraint system. He held on to the vertical wing strut with his right hand and tried to pull his body back into the cradle with his left hand, which was holding the flight control stick. This forced him to move the pitch control stick aft and fly the airplane into the dangerous stall/spin condition which had killed Lilienthal.

The first powered flight was made on December 17, 1903 at Kitty Hawk. The wind velocity was 25 MPH with high gusts. There was ice in the small ponds around the sand dunes. They had no winter flying clothing. The Flyer could simply not carry the additional weight of protective clothing. The gusty winds acting on the 745 pound airplane required rapid and coordinated control movements by the pilot. They were flying between one and ten foot altitude in those gusts. This type of vertical movement along the flight path produces vertigo in the most experienced pilot. The Wrights had only 20 minutes of pilot time in gliders before their first attempt with an engine and two propellers.

It has been proven from the beginning of manned flight that aero medical research is fundamental to aeronautics. Captain Harry G. Armstrong emulated the Wrights in aero medical research. His initial efforts and the next five decades are the “GOLDEN ERA OF AVIATION.”

Charles A. Demsey
ACKNOWLEDGMENTS

Colonel George C. Mohr, Commander, Air Force Aerospace Medical Research Laboratory, provided the leadership and command emphasis essential for this project. He was always available for discussion and guidance during the preparation of this book. Mr. Bill Crawford, Chief, Plans and Programs, did an outstanding job of providing management support. He constantly made Laboratory resources available to the project. The author was given a free hand within the boundaries of his charter, and he alone decided which events would be included in the book as well as how they would be presented. The highly diverse nature of the Laboratory activities plus the fifty years of research information presents a detailed discussion of all the work in the Laboratory. The selected projects provide the reader with an understanding of the scope and complexity of the overall research and development program. There are many dedicated scientists who worked on programs which are not discussed in this book. Their efforts are just as important to the Laboratory and the Air Force as those selected for review. Complete historical documentation of the entire Laboratory needs to be written in the near future.

Thanks are due to the many EARLY YEARS veterans. They have contributed anecdotes and details which helped to fill in gaps in the early history. Special acknowledgment is due to the colleagues of the founder: Dr. J. W. Heim, Dr. Ernest Potson, Mr. Ray Whitney, Mrs. Alice (Callis) Pozzvayek, Mr. John Hall, and Mrs. Patricia (Crane) Lichty, wife of MSGt. Harold Lichty (deceased). They were there from the beginning with Captain Armstrong. These are the true pioneers of the Physiological Research Laboratory. They gave generously of their time for interviews and supplied photographs and documentation from their private collections to supplement the Laboratory historical material.

Special mention is given to the WAR YEARS veterans who first occupied Building 29. The author worked with different members of this group over the past thirty years. In this long association he obtained valuable background information and technical understanding of the research work conducted in the Laboratory. They are Mr. Ernest Martin, Dr. Harvey Steedy, Mr. Don Huxley, Colored Mike Sweeten (deceased), Dr. Fred Berner (deceased), Mr. Charles Castellino, Colonel Pharo Gage, and Mr. Donald Good (deceased). These men were involved when the research was fast and furious in support of the war effort. They often made the impossible book easy and achieved many firsts in science and biotechnology.

My very dear friend, Mrs. Jean Robinette, was the Laboratory Scientific and Technical Information Officer (STINFO). Her services in this capacity made possible the many thousands of technical reports and papers which have been published by the Laboratory. This experience prompted her to organize a chronology of the Laboratory and maintain historical copies of all this material. Her work has been one of the prime reference sources for this book. She was truly the guardian angel of the historical material in the Laboratory.

The outstanding work of Mr. John Bullard, Historian, Aerospace Medical Division is acknowledged. This renowned author prepared the semiannual and annual historical documents for the Division. They are meticulous with regard to dates and research programs. His work is the other prime reference source for the material in this book. His special efforts in obtaining detailed personal interviews with leaders in aeronautical research is without parallel. These first person documents cleared the blurring effects of time and made the understanding of reality possible. The author extends special thanks to him for his writings which often went unnoticed.

These acknowledgments would not be complete if I did not give particular thanks to Dr. Walter Gretch, Dr. Homer van Gieken, Mr. Charles Bates, Dr. Bruce Stuart, Mr. Steve Heckart, Mr. Ray Whitney, Mrs. Patricia (Crane) Lichty, Mrs. Mildred Pinkerton, Mr. Jim Brinkley, Dr. Charles Nicos, Mrs. Josh Robinette. They reviewed the text and furnished creative contributions to the book.

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The creative art work was provided by Mrs. Virginia Greene an outstanding artist in the Laboratory.

The final thanks go to my Southern bride; without her help the book would not have been completed.

CD
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Lt Colons Elizabeth Guild

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On May 18, 1925 Captain Harry G. Armstrong was appointed Chief of the Physiological Research Laboratory at Wright Field, Ohio. This event placed Captain Armstrong on an ascending path leading to international acclaim and distinguished service to his country. From the outset, Dr. Armstrong was intimately familiar with the harsh environment confronting the military aviator; extremes of heat and cold, noise, windblast, oxygen wane, toxic fumes and severe acceleration forces contributed to physical and mental fatigue tainting even the best pilot's ability to control his unforgiving aircraft. Today, Major General Harry G. Armstrong is recognized as one of the great pioneers in aviation medicine. His contributions to aero-medical research have yielded measurable benefits to flying safety and mission effectiveness. This volume recounts the history of a living organization and the life of an outstanding individual. With great pride, this book is dedicated to the memory of Major General Harry G. Armstrong, the physician, the scientist, and pioneering founder of the Air Force Aerospace Medical Research Laboratory.
PROLOGUE

Aeronautical research and development projects were established at McCook Field, Dayton, Ohio, in the autumn of 1917. The Airplane Engineering Department was the center of all new aircraft design and development. In August 1918, this department was renamed the Airplane Engineering Division and reported directly to the Chief, Army Air Service. The new Engineering Division was subdivided into five units: The Aircraft Branch, Equipment Branch, Armament Branch, Engine Branch, and Materials Branch.

The Army Air Corps was formed in July 1926 and the resulting organization changes produced the Materiel Division at McCook Field. On October 12, 1927 the Materiel Division moved to the new Wright Field facilities. The engineering function was located in Building 16. The organizational chart was revised on June 19, 1928 to reflect a new type of management structure. There was the Engineering Section, Procurement Section, Field Service Section, Repair Section, Industrial War Plane Section and the Administration Section. The Experimental Engineering Section contained the Airplane Branch, Equipment Branch, Armament Branch, Power Plant Branch, Lighter/Air Branch, and Materials Branch. The Administration Section had the Medical Branch and other base service functions. The Medical Branch was a dispensary. When requested it also provided medical assistance to the engineering organizations located at Wright Field. Captain Eugene Reinartz was Chief, Medical Branch, in 1928. Major Reed was Chief, Medical Branch in 1934. The Equipment Branch engineers, prior to 1935, frequently requested medical assistance when they were conducting experiments involving human subjects in their altitude chambers. (The large chamber was formerly located at Mineola, New York.)

Major Borum was Chief, Equipment Branch, on January 1, 1937. The Equipment Branch contained six Laboratories: Instrument & Navigation, Electrical, Parachute & Clothing, Aerial Photography, Miscellaneous Equipment, Physiological Research. The Equipment Branch was responsible for research, development, and standardization of 600 items of ground and air equipment. This overall management structure remained unchanged from 1928 until early 1942 when it was reorganized into the Materiel Command.

The Experimental Engineering Section was an active and lively technology center. Its hallmark was entrepreneurship and a do-it-yourself spirit. It was responsible for the development of all new aircraft and equipment for the Army Air Corps. In the period 1925-1934, engineering worked on 30 different aircraft designs which resulted in the production of 3923 airplanes. During 1935-1940 the development types totaled 97 and the aircraft quantity was 2532. The average annual assigned strength was 89 officers, 53 enlisted, and 1177 civilians. Major Howard was Chief, Airplane Branch, and Captain Olive Everts was Chief, Equipment Branch, in 1928.

There were many young engineering pilots assigned to the Airplane Branch and the Equipment Branch. These intensive aircraft and equipment development programs produced a significant number of aviation achievements and some of these pilots became world famous. Typical examples were 1/Lt. James Doolittle, Captain Oliver Scholz, Captain Albert Stevens, Captain Anderson, 1/Lt. Albert Hegenberger. In 1934 a young medical officer, Captain Armstrong, was assigned to this center of aircraft research and development. These pilots were Armstrong's daily working associates, his friends, his flying companions. In addition, Armstrong was their flight surgeon and a loyal bird that was steeped in military aviation tradition.

Documented first person history statements, by respected scientists who worked on a daily basis with Armstrong, provide an intimate view of this military pioneer. He was a dedicated medical officer, soft spoken, with great personal charm and possessing a strong loyalty to the service. He was quiet, relaxed, with a self-assured manner. No thrashing about, no hurried pace, no long overtime hours, yet everything he did seemed to count. As an outstanding characteristic, he appeared to thoroughly enjoy everything he did and his enthusiasm was infectious. An almost undetected talent was his ability as an entrepreneur par excellence. With his disarming yet convincing manner, he was a master of the soft sell. He had a creative mind, was a penetrating observer and a superb pragmatist, with an almost uncanny ability to isolate the core of a problem and develop a practical solution.

xxvi
Armstrong was cut from the same cloth as Jimmy Doolittle, Albert Hegenberger, Oliver Echols, and Albert Stevens. Together they were the perfect medical/engineer team to work on the cutting edge of aviation. In the development test of the XB-15, Echols established new standards for high altitude flight. His work made the B-17 an effective fighting machine. Flying at 25,000 feet, the XB-15 and Echols established new standards for high altitude flight. His work made the B-17 an effective fighting machine. Flying at 25,000 feet, the XB-15 and Echols established new standards for high altitude flight.
with the problem at Patterson Field and Armstrong made attempts at problem solution while stationed at Selfridge Field. Crow, the more senior officer, had orders in 1934 transferring him to Washington where he was able to apply stronger arguments for problem solution. With this greater authority and position, Crow served in the role of medical mentor to the young Captain Armstrong. The documented record, however, shows that Captain Armstrong was the individual who used Air Corps management channels to prepare and submit for approval, the basic proposal to organize the Physiological Research Laboratory. This Armstrong proposal was submitted through the engineering channels of the Materiel Division. Major Echols was Chief, Engineering Section at Wright Field. Armstrong had often sought his advice and guidance. Echols became the engineering mentor for Armstrong. It was this dual approach that resulted in the Air Corps approval to establish the Physiological Research Laboratory in 1935.

Army Air Corps historical records indicate that Armstrong’s opportunity at Wright Field was a lucky event. The Equipment Branch often called upon the Chief, Medical Branch, at Wright Field for medical assistance. The Medical Branch was assigned to the Administration Section of the Materiel Division. If Captain Reisart, a graduate Flight Surgeon from the School of Aviation Medicine, had been more interested in the problems of engineering/medicine while he was Chief, Medical Branch, in 1928, he would have been the founder of the Physiological Research Laboratory. In 1931-1934, the same situation applied to Major Reed, who was the Chief, Medical Branch. He provided the entire medical support for the first chamber experiments at the Wiley Post pressure suit. This suit was tested in the Minnola N.Y. chamber which then belonged to the Equipment Branch. Major Reed left his office on the first floor of Building 16 and descended the circular stairway into the basement to serve as medical monitor for the high altitude chamber tests. The suit, with Mr. Wiley Post inside, was pressurized to 5 PSI in those experiments. Published Air Corps letters in August 1934, one month prior to Armstrong’s arrival at Wright Field, requested Major Reed’s assistance. He responded to those requests with medical support. Major Crow was not contacted for those tests since he was stationed at Patterson Field and was not assigned to the Materiel Division. None of the historical medical literature mentions this major event in aviation history. The engineering/pilot officer requesting this medical assistance was Captain Albert Hegenberger. He won the Collier Trophy for the operational development of blind (instrument) flying. Captain Hegenberger was Chief, Equipment Branch, when the Wiley Post suit was tested. He was still the Branch Chief when Captain Armstrong was first assigned to the Equipment Branch. It is abundantly clear that Captain Armstrong was totally dedicated to the science of aviation medicine and that he pursued this goal with strong determination. Within four years after his arrival at Wright Field, he was awarded the Collier Trophy. No other flight surgeon ever matched his accomplishment. Captain Armstrong became a legend in his own time. HE IS THE DOCUMENTED FOUNDER OF THE PHYSIOLOGICAL RESEARCH LABORATORY.

** AUTHORS NOTE
Classified research programs are not covered in this history book.
Fig 5  The Wright Field complex when Captain Armstrong founded the Physiological Research Laboratory, in May 1965.
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<th>Year</th>
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Chronology

1973
1976
1979  AF Aerospace Medical Research Laboratory
1985  Harry G. Armstrong Aerospace Medical Laboratory

Col. Doppelt
Col. DeHart
Col. Mohr
CHAPTER ONE

EARLY AEROMEDICAL RESEARCH

1934-1940

ORGANIZATION AND COMMAND

Lieutenant Harry G. Armstrong was assigned to duty as Flight Surgeon in the First Pursuit Group, Selfridge Field, Michigan, on September 15, 1931. He regularly flew with the Group in the P-16 aircraft, a two-place open cockpit biplane. These flights exposed the aircrew to extremely cold temperatures, windblast, noise, high altitude, vibration and high acceleration forces in combat maneuvers. This flying environment prompted Armstrong to begin a series of efforts to develop better aircrew protective equipment. He quickly encountered local resistance to his activities. Frustrated, Armstrong wrote a letter to Major Beaven, Air Surgeon, Hq. Army Air Corps, in June 1934. He described the flight environment and the resistance to his efforts. He requested assistance from the Air Surgeon and the Engineering Section at Wright Field. Armstrong did not receive a reply to his letter. Instead he was issued orders in July, 1934, transferring him to the Medical Branch at Wright Field. Captain Armstrong, who had no research or development experience, flew to Washington and contacted Major Beaven about the assignment. Major Beaven told him "you are the one that complained and you are the logical man to try and solve it." Captain Armstrong flew to Wright Field in August 1934 to meet the resident medical officers and obtain information about the assignment. He had lunch with Major Crow, Flight Surgeon, Patterson Field, and Major Reed, Chief, Medical Branch, Wright Field. Armstrong had never met or been acquainted with either of these officers prior to this luncheon. A heated argument developed between these two men over the assignment of Captain Armstrong. Shortly after his return to Selfridge Field, Armstrong was advised that his orders had been changed and he was now assigned to the Engineering Section, Equipment Branch.

Captain Harry Armstrong was transferred to the Material Division, Engineering Section, Equipment Branch, at Wright Field on September 16, 1934. He was the only medical officer in the entire Engineering Section. When Captain Armstrong reported for duty in the Equipment Branch, Bldg 16, he was treated as a consultant and not assigned to any project. He spent the next few days getting acquainted with the people, programs, and facilities in the Equipment Branch. The Branch was responsible for research, development, and testing of all subsystem equipment used in support of Army Air Corps flight operations. To accomplish its mission, the Branch had available in the basement of Bldg. 16, an extensive machine shop, an engineering group, photo department and a drafting group. To reach these facilities from the first floor of Building 16, there was a circular stairway within the Equipment Branch that descended to the basement. Also located in the basement was the climate chamber which had been used previously for the testing of the School of Aviation Medicine at Mirenda, New York. The chamber was in good operating condition. The Equipment Branch used this chamber plus two smaller chambers and a cold box for testing new experimental equipment. When the chamber tests involved human subjects, the Equipment Branch requested a medical officer from the direction.

Two months before Armstrong's arrival, the chamber had been used to test a full pressure suit designed by the world famous pilot, Wiley Post (E.O. 666-2, Serial No.154-431, June 21, 1934, Capt. Hagmanberger)

For the next few months, Armstrong worked on the problems he encountered at Selfridge Field and the projects assigned by the Chief, Equipment Branch. He was also assigned to work solving the Explorer II sealed gondola being manufactured in Building 16. Captain Armstrong led as the Flight Surgeon for this record breaking balloon flight which attained an altitude of 27,000 feet. Concerned that he might be working on misdirected efforts, he sought guidance
from Major Echols, Chief Engineering Section. Major Echols stated "that he was not a physician and that he felt research in the field of medicine should be Armstrong's responsibility and that he should pursue his own ideas." Echols further said "that if Armstrong got into trouble with his work, that he would back him one hundred percent." Captain Armstrong then proposed and sent to Major Echols a proposal to establish a Physiological Research Laboratory within the Equipment Branch. Major Echols favorably reviewed the proposal and forwarded it through the Material Division to HQ Army Air Corps.

Captain Armstrong flew to Washington on April 15, 1935 and met with LtCol Grow, Chief, Medical Division, Office of the Chief, Army Air Corps, and the Army Surgeon General. Captain Armstrong presented the proposal he had submitted to Major Echols. The Armstrong proposal was accepted by these senior medical officers. Their only guidance was to establish a coordinated relationship between the Physiological Research Laboratory and the School of Aviation Medicine to avoid duplication of effort. The Material Division, Engineering Section, formally recommended the establishment of a Physiological Research Laboratory on April 25, 1935. The Chief, Army Air Corps, issued a directive on May 29, 1935, establishing the Physiological Research Laboratory within the Equipment Branch.

(Historical Note) In 1935 there was a rapidly evolving need for a formalized medical research activity at Wright Field. Headquarters, Army Air Corps, had directed the Engineering Section to initiate a sealed pressure cabin airplane development program on April 29, 1935. The Equipment Branch was assigned responsibility for development of the sealed pressure cabin. The Branch was also directed to conduct a comprehensive study of the combined engineering and physiological requirements and to incorporate the data into an engineering specification. The Chief, Equipment Branch, assigned Armstrong the job of providing the physiological data. Armstrong's report, ACTR #4165, dated December 19, 1935, was used in the aircraft specification. A contract was awarded to the Lockheed Corporation in 1936 and the XC-35 aircraft was delivered to Wright Field in the spring 1937. It was a derivative of the commercial Lockheed Electra. Amelia Earhart used this type of aircraft on her ill-fated flight around the world.

The mission of the new Physiological Research Laboratory was established at Langley Field, Virginia, on June 19, 1935.

The approved mission defined three research goals which were necessary for the satisfactory performance of tactical combat flights:

* Physical discomfort
* Mental distraction
* Fatigue

These goals were further refined into prime technical areas.

* Protection from cold, windblast, heat, oxygen want
* Comfortable seating
* Clear vision
* Reduction of noise
* Avoidance of extreme centrifugal and centripetal forces
* Avoidance of heavy, bulky, or constricting clothing, and personal equipment
* Simplification of airplane operation

The staff of the new Physiological Research Laboratory was Captain Armstrong and Sgt. Lloyd Stevens, a medical technician on loan from the dispensary. The annual budget was $100.00 for supplies and $600.00 for animals. Captain Armstrong flew to Harvard University in an O-25 aircraft on November 30, 1935, to consult with Professor Drinker about laboratory equipment and hiring personnel. Professor Drinker recommended his graduate assistant, Dr. J.W. Heim. After an interview, Captain Armstrong hired Dr. Heim for the position of associate physiological. He reported on June 21, 1935. Private Ray Whitney was assigned to the Laboratory in November 1937. In the fall of 1938, Sgt. Fuhrly was assigned to the Laboratory and two other men, Pvt. Moyer and Pvt. Robinson, were on loan from the Base dispensary. On February 10, 1939, the Equipment Branch was renamed the Equipment Laboratory and the Physiological Research
Laboratory name was changed to the Aero Medical Research Unit. Miss Mae Callen joined the Unit as stenographer in June 1939. Mr. John Hall joined the Unit on September 5, 1939, as assistant physiologist. Dr. Ernest Pinnson was hired on September 11, 1939, as an associate research physiologist. Sgt. Harold Lichty was assigned to the Unit in 1940.

Captain Armstrong was reassigned on May 30, 1940, to a course of instruction at the Banting Institute, Toronto, Canada. Dr. J.W. Heim was appointed Acting Chief, Aero Medical Research Unit, on May 30, 1940. Captain Otis Benson, Jr. was appointed Chief, Aero Medical Research Unit, on September 16, 1940.

**ARMY AIR CORPS AIRCRAFT**

A-17, B-10, XB-15, YB-17, B-18, C-33, O-47  
P-26, P-35, P-36, BT-9, PT-13  
XC-35 the first successful pressurized aircraft

**CHALLENGING AEROMEDICAL PROBLEMS**

- Human physiology in high altitude flight  
- Acceleration physiology in combat flight maneuvers  
- Thermal physiology during cold weather flight  
- Development of personal protective equipment  
- Development of emergency medical equipment

**PIONEERING ACHIEVEMENTS**

**BEFORE APPROVAL OF PHYSIOLOGICAL RESEARCH LABORATORY**

- Design of a small first aid kit for aircraft (October 25, 1934)  
- First recommendation on use of a carbon monoxide detector for aircraft (January 2, 1935)  
- Study on bone conduction of aircraft sound and vibration during flight (January 31, 1935)

**AFTER APPROVAL OF PHYSIOLOGICAL RESEARCH LABORATORY**

- National Geographic Balloon flight to 72,000 feet for which Captain Armstrong provided the physiological data for the sealed gondola and served as flight surgeon (November 11, 1935)  
- Literature study on the effect of pilot stature on aircraft design and performance (December 11, 1935)  
- Literature study on physiological requirements of sealed high altitude aircraft compartments (December 19, 1935)  
- Research on the effects of acceleration on the living organism (December 1, 1937)  
- First experiments and actual demonstration that body fluids will boil at an altitude of 63,000 feet (March 23, 1939)  
- Evolution of the concept of "aero-otitis media," the pathological changes in the middle ear caused by differences in barometric pressure.

**PROJECT NUMBER**  
E. O. 453  
E. O. 616  
E. O. 469  
E. O. 664  
E. O. 666  
E. O. 903

**TITLE**  
Clinical Studies  
Aircraft Lighting  
Oxygen Equipment  
Aircraft Equipment  
Protective Equipment  
Administrative
**FACILITIES**

| Office, Captain Armstrong, Miss Callen | Bldg 16 |
| Office, Dr. Hein, Dr. Pinson, Mr. Hall | basement Bldg 16 |
| High Altitude laboratory | basement Bldg 16 |
| Biochemical laboratory | basement Bldg 16 |
| Physiological laboratory | basement Bldg 16 |
| Operating room | basement Bldg 15 |
| Balance room | basement Bldg 16 |
| Stock room | Balloon Hanger |
| Man-rated centrifuge | Balloon Hanger |
| Abrupt acceleration swing |

**THE LABORATORY PROGRAMS**

**OVERVIEW**

The research program was created entirely by Captain Armstrong. It was an integration of the flying experiences at Selfridge Field, the aircraft and missions under development at Wright Field, the personnel, laboratory equipment, and facilities available at Wright Field. There were three fundamental drivers in the program. The first was in the area of high altitude flight physiology. The National Geographic balloon had just flown to an altitude of 72,000 feet. Wiby Post was using his own full pressure suit in high altitude flights, the XC-35 was under development, and there was an urgent need to develop an operational oxygen mask. (During high altitude flight, a pilot received oxygen through a pipe stem he kept in his mouth). Second, was the all metal P-35 fighter which could fly high acceleration combat maneuvers and exhibited a high rate of climb to altitude. Third, was the high altitude extended range test flights of the new XB-15 and Xb-19 aircraft. The aircrew were exposed to extreme cold and repeatedly experienced high altitude oxygen conditions for long periods of time.

**BEFORE APPROVAL OF PHYSIOLOGICAL RESEARCH LABORATORY**

In this period, the only personnel available were Captain Armstrong and one enlisted medical technician. There were neither medical instrumentation nor equipment available to conduct a major research effort. Dr. Armstrong, therefore, was restricted to activities which could be explored and completed using his medical training and entrepreneurial spirit for developing aircraft equipment. These studies were primarily in the area of medical safety. They were easy to initiate and deal with problems of mutual interest to engineers in the Equipment Branch. Some of these studies were also based on the unsatisfactory reports and engineering problems being submitted to the Equipment Branch.

- First design of a small first aid kit for aircraft installation (October 25, 1934)
- First recommendation on use of a carbon monoxide detector for aircraft (January 2, 1935)
- Chief, Equipment Branch, appoints Captain Armstrong as the chairman of a group to study the merits of liquid and gaseous oxygen for use in high altitude flight (January 24, 1935)
- Study on bone conduction of aircraft sound and vibration during flight (January 31, 1935)
- Study on the effect of cold temperatures on the pilot’s flying efficiency (March 1, 1935)
- Study on the need for crash tools to remove pilots from wrecked aircraft (March 2, 1935)

**AFTER APPROVAL OF PHYSIOLOGICAL RESEARCH LABORATORY OVERVIEW**

This period can truly be described as the fundamental start of organized new medical research. This organization was located at the center of all new aircraft development. Captain Armstrong had been assigned official organization authority, an annual budget, civilian and military personnel positions with approval to hire professional personnel. Dr. J. W. Hein arrived in June 1936 and assisted Armstrong in refining the research program.

These two men now began the task of organizing and equipping the Laboratory with all the necessary scientific apparatus. Captain Armstrong’s office was located on the first floor in the Equipment Branch area. The basement facility was 120 feet long and 30 feet wide.
established four space for an office, physiological laboratory, biochemical laboratory, and high altitude laboratory. There was also an operating room, balance room and stock room. The various areas were separated by steel and glass partitions and all were completely air conditioned. The office had three desks for Dr. Heim, Dr. Pincen, and Mr. Hall. It also contained a library of standard medical books, reference works on aviation medicine and appropriate current periodicals. The physiological laboratory was equipped for research on human subjects and contained all apparatus necessary for the performance of the metabolic and blood gas studies. Complete equipment for air analysis was also located in this area. The biochemical laboratory was provided with all facilities for complete blood analysis and studies of a chemical nature. It contained a chemical table with an acid proof top and a central sink and drain board of chemical stoneware. The table was provided with abundant drawer space and was serviced with direct and alternating current power, compressed air, vacuum gas and water. In addition, the laboratory contained a fume hood, exhaust canopy, the kymograph smoker, the water still, centrifuge, and refrigerator. The balance room was dust proof and contained two high precision analytical balances. The operating room was equipped with the usual facilities including a long paper variable speed kymograph and accessories. It was provided with both direct and indirect lighting which insured ample illumination of the operating field. The large laboratory possessed three high altitude chambers. Two small chambers had a capacity of three cubic feet and were provided with windows which afforded a view of the entire interior. They were surrounded by insulating cabinets of balsa wood and could be refrigerated by means of dry ice. Evacuation was produced either by means of individual hyvac pumps or by connecting the chambers to the main laboratory vacuum system. The altitude could be maintained at any desired value by means of a special manometric control system. The large chamber was of cylindrical construction 31 feet long and 8 feet in diameter, supported in a horizontal position. It was divided into three sections, a central compartment opened on either side into two end compartments. The central compartment thus served as a lock through which entrance from the outside could be made to the other sections without disturbing the pressure conditions in them. The chamber could be evacuated to the equivalent of 80,000 feet and could be refrigerated to -65°F.

The Physiological Research Laboratory was ready to undertake its first work in January 1937. The first effort was a series of animal experiments to gather baseline physiological data on hypoxia, and the effects of explosive decompression associated with sealed cabins flying at high altitudes. The second was a human and animal program to obtain physiological data on the effects of acceleration. While Armstrong and Heim served as the principal investigators, they also participated as subjects. Pvt. Whitney was the technician who accompanied the animals in these high altitude chamber flights. Srgt. Stevens was the centrifuge technician and frequently flew with the test subjects. The Unit began to experience a significant increase in professional personnel in 1939. This growth was associated with the war effort and progressively increased until a considerable staff was assigned to the Unit.

**SELECTED PROGRAMS**

- Literature study on the effect of pilot stature on aircraft design and performance (December 11, 1935)
- Literature study on physiological requirements of sealed high altitude aircraft compartments. This effort conducted a comprehensive review of all the English and French literature on high altitude balloon flights, books on respiration and general physiology, medical articles on oxygen-wntil, oxygen poisoning, CO poisoning, nasorax guses, cassisen disease, and air conditioning. The information was integrated with the available engineering data for sealed aircraft cabins. The results of this study established the physiological requirements for long range flight while the crew were operating in a sealed cabin environment. This work was incorporated into the Army Air Corps specification for the development of the XC-35 airplane (E.O. 417-2-358, Report ACTR #465, December 19, 1935)
- Follow up study on pilot stature as it affected the design and performance of aircraft (February 4, 1936)
- Literature study on the effect of barometric changes on the ear and accessory nasal sinuses (February 8, 1936)
- Study on the effect of flight at high altitude on teeth (August 31, 1936)
- Study to develop equipment for the rescue of injured personnel in crashes in Arctic regions (September 18, 1936)
• Study to develop an Air Corps medical kit for use with flying units. (September 23, 1936)

• Study to develop lightweight gas-oxygen cylinders, a reliable manually operated gas-oxygen flow regulator and valve and an oxygen mask. (September 25, 1936)

• Study and in-flight testing of pilot crash helmets (December 31, 1936)

• Study to devise a test and design the necessary equipment required for a practical test of color blindness in Air Corps pilots (January 16, 1937)

• Study on the factors which influence altitude tolerance in experimental animals. This definitive work exposed one hundred rabbits in the altitude chamber to 10,000 feet per minute rate of climb and an average altitude of 33,000 feet with a maximum altitude of 41,000 feet (July 15, 1937)

• Study to determine the absorption rate of CO into the blood at high altitude. Goats were exposed to an altitude of 15,446 feet for a period of ten minutes. Clinical techniques determined the quantity of CO in the blood and tissue (October 28, 1937)

• Study on the effect of acceleration on the living organism was a highly organised study using humans and goats to gather baseline data on human tolerance in the positive, negative and transverse acceleration positions. An instrumented PT-13 airplane was used for the in-flight experiments. A twenty foot centrifuge was constructed with a variable speed drive and a twenty five horsepower electric motor. It was equipped with an adjustable seat for human subjects and an adjustable board for the animal experiments. The centrifuge had a maximum velocity of 80 RPM and could produce an acceleration of 20 G. A second piece of equipment was developed for creating high linear accelerations for short periods. The abrupt acceleration swing was suspended from the ceiling by four 40 foot cables and was equipped with a seat for human subjects and a board for animal experiments. It used a brake controlled windlass which could produce an acceleration of 16 G with a duration of 0.5 seconds. These experiments produced baseline information on the physiology of acceleration. Preliminary tests were also conducted on the use of an air inflatable belt to increase the pilots tolerance to positive accelerations. It is interesting to note that one recommendation suggested the pilot be placed in the prone position if the aircraft is designed to exceed 9G in flight (EO 604-1-250, Report #462, December 1, 1937)

• Study on the effect of repeated exposures to anaemia on the adrenal glands and metabolic processes of experimental animals (January 15, 1938)

• Study to determine whether or not the decrease of barometric pressure at high altitude will cause oxygen bubbles to be formed in the blood (February 24, 1938)

• Study on the effect of repeated exposures to high altitude in relation to the function of the adrenal glands. The results of this animal study prompted the recommendation that pilots continually use oxygen on all flights above 12,000 feet (E 0 635-1-27, February 18, 1939)

• First experiments and actual demonstration that body fluids will boil at an altitude of 60,000 feet. Using animals, a special viewing tube was surgically inserted in the artery. The animal was then placed in the altitude chamber and exposed to very high altitudes (March 25, 1939)

• Study on the causes and possible prevention of airsickness (July 31, 1940)

This comprehensive research program evolved the concept (auto-otaxis media), and a new medical disease entity (auto-embolism). Other work established the physiological limits of breathing pure oxygen in unpressurized high altitude flight, the pathology of altitude sickness (anaemia), and the significance of the rate of ascent, duration and frequency of exposure to high altitude flight.

The Aero Medical Research Unit published over thirty technical papers. Using these papers and other references, Armstrong published a book PRINCIPLES AND PRACTICE OF AVIATION MEDICINE in 1939. It was the first inclusive text covering all the complex and diversified medical problems encountered in modern flight. This broad and comprehensive technical program fully established the Aero Medical Research Unit at Wright Field as the major aero medical center in the United States.
## AWARDS

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<td>Capt. Armstrong</td>
<td>Welcome Award and prize in Military medicine</td>
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<td>1940</td>
<td>Pfc. Whitney</td>
<td>Distinguished Flying Cross</td>
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<td>1940</td>
<td>Capt. Armstrong</td>
<td>Collier Trophy for high altitude physiology research</td>
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<tr>
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Fig I-1  Captain Harry Armstrong, Flight Surgeon First Pursuit Group, Selfridge Field, Michigan, 1931-1934
Fig 1-2  Flights in this P-16 airplane began Armstrongs attempts to improve pilot personal equipment—First Pursuit Group, Selfridge Field Michigan, 1931-1934.
Fig 1-9 Captain Stevens and Captain Anderson set the world altitude record in Explorer II on November 11, 1935. Captain Armstrong specified the pressurized closed cabin atmosphere and served as flight surgeon.
Fig 1-4  XC-35, first successful pressurized sealed cabin aircraft. Armstrong specified the physiological requirements for the cabin atmosphere. The cabin pressurization system was manually controlled by Armstrong or Pvt. Whitney on each test flight.

Fig 1-5  Captain Armstrong flew to Boston in this O-25 aircraft to hire Dr. John Heim in 1935
Fig 1-7  Dr. Armstrong and Dr. Heim in the main office Aero Medical Research Unit (Building 16, 1950)
Fig 14 Curtiss F5 high altitude fighter. The first supercharged aircraft to enter operational service. This new era of regular high-altitude flight required more physiological research on frequent and repeated exposure to low oxygen environments.

Fig 15 Boeing P-26 fighter. The open cockpit created many physiological problems for the pilot.
Fig 1-10  Swarmsky P-35 fighter. Its high performance required studies in human tolerance to acceleration.

Fig 1-11  Boeing XB-15 bomber. The fore runner of the B-17. This airplane prompted the work on high altitude oxygen masks and long term exposure to oxygen conditions.
Fig 1-12 Second low pressure chamber located at Medical Research Laboratory, Hazelhurst Field, N.Y. The chamber was 10 feet high and 9 feet diameter. When the School of Aviation Medicine was moved to Brooks Field, Texas in June 1928, this chamber was declared surplus. It was relocated to the Equipment Branch, basement Bldg 16 at Wright Field, Ohio.
Fig 1-13  Wiley Post in his second pressure suit in the altitude chamber basement Bldg 16, 1934.
Fig 1-14  Wiley Post in his third pressure suit in the altitude chamber basement Bldg 16, 1935.
Fig 1-18 First human centrifuge at Wright Field. It was designed by Captain Armstrong and was located in the Balloon Hanger, 1908.
Fig 120  The BGB oxygen mask. The first successful delivery system for high altitude flight. (Boothby, Lovelace, Armstrong, 1938)

Fig 121  The team of Boothby, Lovelace, Armstrong receiving the Collier Trophy from President Roosevelt at the White House, 1943.
CHAPTER TWO

THE WAR YEARS
1941-1945

ORGANIZATION AND COMMAND

The Aero Medical Research Unit experienced the same rapid expansion as other organizations in the Army Air Forces during 1941. Captain Otis Benson was Chief, Aero Medical Research Unit. Major Dill, assigned as Chief of Research, Dr. J. W. Heim, Chief, Personnel and Administration.

The Aero Medical Research Unit was removed from the Equipment Laboratory on July 1, 1942. It was reorganized as an independent laboratory and renamed the Aero Medical Research Laboratory. Major Otis Benson was Chief of the Laboratory. The new laboratory was divided into five branches: Dr. J. W. Heim, Chief, Administrative Branch; Captain John Murphy, Chief, Funds, Property, Maintenance Branch; Major Dill, Chief, Physiology Branch; Major Randy Lovelace II, Chief, Service Liaison Branch; Major Adolph Gagne, Chief, Biophysics Branch; Captain Frank G. Hall, Chief, Chamber Unit in the Physiology Branch. Lt. Francis Randall, Chief, Anthropology Unit in the Biophysics Branch. Dr. Guillermin, Chief, Physics Unit in the Biophysics Branch. LtCol. Craig Taylor, Chief, Clothing Test Unit in the Biophysics Branch.

The following mission was assigned to the Laboratory:

- To conduct research to determine the effect of flight on the human organism and to recommend methods or means of neutralizing or eliminating those effects of a deleterious nature which adversely influence the efficiency, health, or safety of flying personnel
- To coordinate the activities of the Laboratory with service and nonservice organizations engaged in similar investigative problems
- To coordinate the human requirements of flight with the development of equipment by other Laboratories in the Materiel Center
- To conduct research on the problems in biophysics, physics, and engineering of importance in aviation medicine
- To initiate and supervise service and field tests of items of medical interest
- To develop standardized and test items of medical equipment used in connection with military flying
- To develop educational devices for indoctrination of flying personnel

The Aero Medical Research Laboratory was renamed Aero Medical Laboratory in December 1942. Lt. George Maison was appointed Chief, Centrifuge Unit in the Physiological Branch, on December 11, 1942. Colonel Otis Benson was reassigned overseas and Colonel W. Randolph Lovelace was appointed Chief, Aero Medical Laboratory, in April 1943.

The Equipment Laboratory transferred responsibility for research and development of oxygen equipment to the Aero Medical Laboratory on April 5, 1943. Captain Loran Carlson was appointed Chief, Oxygen Branch, in May 1943. The Laboratory was reorganized into seven branches in September 1943. Colonel Randy Lovelace, Chief, Aero Medical Research Laboratory; Dr. J. W. Heim, Chief, Administration Branch; Captain John Murphy, Chief, Medical Detachment Branch; Major Carl Johnson, Chief, Medical Speciality Branch; Captain Loran Carlson, Chief, Oxygen Branch; Major Adolph Gagne, Chief, Biophysics Branch; LtCol. Frank
The War Years 1941-1945

6. Hall Chief, Physiology Branch; Captain Doyle Clark, Chief, Service Liaison Branch. At this time the Laboratory had assigned 46 officers, 92 enlisted men, and 73 civilians.

The responsibility for research and development of goggles, sun glasses, and eye protection equipment was transferred to the Laboratory on May 30, 1944. The Hydroponics Unit was established on January 1, 1945.

Establishment of a new Psychology Branch was approved on May 29, 1945. LC Colonel Paul M. Fitts was assigned as Chief, Psychology Branch, when he reported for duty in August 1945. The initial staff members were Major Walter F. Grether, Dr. William Jenkins, and Miss Patricia Wall.

Colonel W. Randolph Lovelace departed the Laboratory in September 1945. Colonel Lloyd Griffit was appointed Chief of the Laboratory in October, 1945.

ARMS AIR FORCES AIRCRAFT


First flight of P-58 jet aircraft at March Air Field (October 2, 1942)

CHALLENGING AEROMEDICAL PROBLEMS

- Developing the first anthropological data base on aircrews
- Anthropology sizing of personnel equipment, flight clothing and aircraft workstations
- Defining the physiological tolerance to prolonged cold exposures in high altitude flight
- Establishment of thermal protection requirements of protective flying clothing
- Development and standardization of the anti-G suit/valve system for acceleration protection during air combat
- Establishment of human tolerance to high altitude bailout, descent oxygen, descent frothbite, and parachute opening forces at altitude
- Development of air borne oxygen equipment, including oxygen masks, bail out oxygen bottle, low pressure aircraft oxygen system for multiscram long range flight
- Developing the first pressure breathing equipment for long term high altitude flight
- Defining the physiological limitations of explosive decompression for the AAF standard on engineering design of aircraft sealed cabins
- Development of airborne medical evacuation facilities, supplies, and related equipment for the transport of wounded
- Establish human tolerances to ejection escape and windblast

PIONEERING ACHIEVEMENTS

- Established the first physiological training programs for aviators (1941)
- Prepared the first military service manuals concerning the high altitude health hazards to aircrew, PHYSIOLOGY OF FLIGHT (?1941)
- First chamber flight of pressure breathing equipment up to altitudes of 42,000 feet (Capt. Gagge, 1941)
- First anthropometric data base on aircrews (Dr. Bamon, Dr. Randall, Dr. Bruer, Miss King, 1942)
• Initiation of thermal studies for development of aircrew clothing; tropical, arctic (Capt. Gaggs, 1942)
• Development of the first AAF pressure breathing mask (Lt. Randall, 1942)
• First aircraft flight using pressure breathing equipment at 42,000 feet (Lt/Col. Lovelace, 1942)
• Development of the first aerosol bomb for the dispersal of insecticides (Lt. Sullivan, 1942)
• First simulated parachute descent in chamber from 45,000 feet using pressure breathing equipment (1943)
• First experiments to establish AAF aircraft design standards for explosive decompression (Major Sweeney, 1945)
• First high altitude bailout with parachute deployment above 40,000 feet (Lt/Col. Lovelace, 1943)
• First human pick-up system (Capt. Maisen, Lt. Martin, September 5, 1943)
• First AAF service test and flight tests of anti-G devices, AOS suit and GPS suit at Eglin Field, Florida (Capt. Maisen, 1943)
• First operational use of F-2 electrically heated flying suit (Lt/Col. Taylor, 1943)
• Pressure breathing equipment accepted for AAF operational use in 28th Photo Sqdn. (1943)
• First measurements of parachute opening forces in dummy drops from a B-17 at Muroc Army Air Field, California (Major Hallenbeck, 1944)
• First operational combat mission using pressure breathing equipment in Europe (1944)
• Studies of flyers' night vision, the establishment of vision standards for aircrew, and the development of flying goggles and other vision aids (Captain Pinson, 1944)
• Development of first automatic parachute opening device (Major Hallenbeck, Lt. Martin, 1944)
• First AAF standardization of G-3 suit/valve system (1944)
• Development of the pneumatic balance resuscitator (Mr. Burns, 1945)
• First American tests of the upward ejection seat using human subjects and the 30 foot test facility (Major Savelly, 1945)

PROJECT NUMBERS

E. O. 688
E. O. 695
E. O. 696
E. O. 696
E. O. 660
E. O. 670
E. O. 690
E. O. 998

TITLES

Development of Anti-G devices
Human Tolerance to Acceleration
Personal and Protective Clothing
Physiological Research
Oxygen Equipment
Survival Equipment
Eye Protective Equipment
Survival Medical Equipment

FACILITIES

Office, Captain Benson, Miss Mae Callen
Office, Dr. Heise, Mr. Hall, Dr. Pinske
Altitude chamber
Animal operating room
Biochemical Laboratory
Animal breeding room
Gas analysis room
First Human Centrifuge
Autopsy accelerator caging
Construction contract (March 1942)

Bldg 16
Bldg 16
Bldg 16
Bldg 16
Bldg 16
Bldg 16
Bldg 16
Bldg 16
Bldg 16
Bldg 29
**THE LABORATORY PROGRAMS**

**OVERVIEW**

World War II developed the first use of military airplanes as both a strategic offensive weapon and a defensive weapon. It also evolved the high-altitude massive air-bridge concept which delivered tremendous destruction on any known target. There were many bombarding missions which involved more than one thousand bomber aircraft plus another five hundred supporting fighters and reconnaissance airplanes. This type of air combat logistics at 30,000 feet in a westerly sky over Europe, placed significant pressure on new medical research to provide the technology for human performance and protection. The research programs in the Laboratory during those four years fully reflect the combat needs of the airforces. History completely documents the heroic efforts of the scientists in this Laboratory. A review of the combat equipment available to the front line airforces shows that it included the five little white buildings situated on the side of the hill just below the monument to the Wright Brothers. The most significant fact about that life support equipment was that it flowed from Wright Field to the Central Medical Establishment (CME) in the Eighth Air Force. The Commander of the CME, in 1944, was that very same young entrepreneur doctor who started it all in 1935. Colonel Harry Armstrong and his gang were back together once again. A direct pipeline across the ocean, Armstrong's ten years of leadership were now keeping the airforce on the front line of aerial combat using pressure demand oxygen systems, electric flying suits, aircraft systems, high altitude flight clothing, anti-g suits, and anthropometric sizing of aircraft equipment.

**SELECTED PROGRAMS**

In 1940, there were shortages in some sizes of flying clothing and supplies in others. Many aircraft escape hatches were too small for safe use, and gun turrets imposed a limitation on the size of gunners. The Army Air Forces had inadequate body data on the highly selected population of flyers. Captain Otto Besame invited Dr. Ernest A. Howard, professor of anthropology at Harvard University, to visit Wright Field. They inspected American and British gun turrets and reviewed the flight clothing test schedules. This meeting established the immediate need for an anthropological survey and the development of new body dimension data for aircraft designers. The major anthropological surveys were body size surveys, clothing surveys, somatotypes, and facial surveys ranging from aviation cadets to women flyers. Lt. Damms and Lt. Randall conducted the anthropological surveys. They were assisted by Dr. Bruin, Miss Alice
King and others. The first results were used to adjust body dimensions on gun turrets in B-17, B-24, and B-25 aircraft. A year later Captain Randall also used the data in a major research program to design the first AAF pressure breathing mask. The survey data also impacted development of anti-G suits, high altitude flight clothing, oxygen masks, the sizing of aircraft equipment and the layout of aircraft workstations. A series of technical reports prepared in design standard format were published and distributed to the aircraft industry (Lt. Damon,Lt. Randall, E.O. O. 653-92, February 21, 1943).

Fundamental research on acceleration physiology was conducted by the Acceleration Section. There was a research program using the manned centrifuge in the Mayo Clinic and the Air Force's new centrifuge which became operational in May 1943. These two facilities established the unexpected and protected human tolerance to long term acceleration in the +Gz, -Gx, +Gy, -Dx, +Gx, -Dx directions. Human tolerance to acceleration onset rates were also determined. This information was obtained by highly specialized physiological experiments using volunteers. These extremely dedicated and very brave scientists underwent life threatening experiments to fully comprehend the physiological factors while exposed to acceleration forces. The physiology data from these experiments indicated that it was possible to design and develop an anti-G suit to protect the pilot. This information was integrated with the pioneering work of Captainropin (USN) and Dr. Wood (Mayo Clinic) to establish the fundamental base for development of the AAF standardized G-3 suit/valve. The Wood Clark AOS suit and the Navy GPS suit were service tested at Eglin Field in September 1943. The GPS suit was selected as the technical direction for further development. Improvements in the GPS suit produced the G-1 suit. Captain Monson delivered twenty two G-1 suits to operational units in Europe for noncombat tests in December 1943. The results of these tests suggested improvement which resulted in the G-2 suit and the G-3 suit. The Army Air Force standardized the G-3 suit in November 1944. The Laboratory then sent Lt. Ernest Martin and his assistant, Lt. Ken Pennard, to England in 1944 with a quantity of G-3 suits/valves. He supervised Eighth and Ninth Air Force personnel in England and France on the installation of this equipment in the P-51 and other fighter aircraft. In addition, Lt. Martin instructed the aircrews in the use of this new equipment (Capt. Maison, Lt. Martin E.O. O. 696-37, 1942-1945).

The Aero Medical Laboratory in association with the Equipment Laboratory initiated a research program to demonstrate that a human could be successfully picked up from the ground by an aircraft employing anti-G indicated airspeed of 130 M.P.H. The objective of this work was to redraw a man from behind enemy lines after he had been dropped there to perform intelligence or sabotage work. The equipment design was established by Laboratory data and testing. Initial field tests were conducted with a Stinson XC181D aircraft, using sheen as human analogs. The first human pickup, Lt. Alexis Goster, was accomplished at Wilmington, Ohio on September 5, 1943 (Capt. Maison, Lt. Martin E.O. O. 696-53, 1943).

Major Henry Sweeney directed a program on explosive decompression to establish the first Army Air Force requirements for the prevention of fighter and bomber aircraft. A P-38 cockpit mock-up was installed in the Laboratory's altitude chamber facility. The mock-up had interchangeable metal plates with openings of various sizes which simulated the gun fire holes encountered in combat. These holes were covered with paper which could be ruptured in the chamber to produce an explosive decompression in the cockpit mock-up. Using human subjects equipped with diverse oxygen equipment, the size of the opening, the degree of differential, and the altitude were increased. Complete medical evaluations were conducted on each subject after a test. The fighter aircraft tests were conducted at 45,000 feet using 2.75 PSI and an opening of 18 square inches. The bomber aircraft tests were at 30,000 feet using 66 square inch opening, 6.55 PSI and a one thousand cubic foot cabin volume. One hundred fifty explosive decompression tests were conducted. Twenty percent of the subjects suffered the bends during the ensuing five minutes. These tests established the safe pressure differential at 7.5 PSI for combat aircraft (Major Sweeney. E.O. O. 696 May 1943).

The Laboratory studied the serious limitations of the demand oxygen system when flying at very high altitudes. Captain Gage's work showed that the only way to keep blood oxygen saturation above 85%, when flying at altitudes in excess of 41,000 feet, was to increase the oxygen pressure in the lungs. Captain Gage, wearing the prototype pressure breathing equipment, made the first chamber experiment to an altitude of 43,000 feet on December 12, 1941. He began a two year development program using human subjects and the Laboratory altitude chamber. The new pressure breathing mask was designed by Captain Randall,
Anthropology Unit, Biophysics Branch. The compensated exhalation valve was designed by William Wildbeck. The initial pressure breathing regulator was designed by the Emerson Company, and modified by Pioneer Instruments. The pressure breathing equipment delivered Compressair, and was modified by Pioneer Instruments. The pressure breathing equipment delivered pure oxygen at pressures of 15 to 25 mm Hg above the ambient pressure. LtCol. Lovelace made the first aircraft flight with pressure breathing equipment in a B-17 to an altitude of 42,000 feet. In April 1943, the pressure in November 1942. He made another flight in a P-38 to 44,980 feet in April 1943. The pressure in November 1942. He made another flight in a P-38 to 44,980 feet in April 1943. The pressure in November 1944, it was used in high altitude flights over Tibet. B-21, B-24, and B-29 aircraft flew combat missions at altitudes in excess of 30,000 feet to minimize air pressure. These combat flights significantly increased the frequency of high altitude blackouts. Combat reports received in the laboratory, from the Eighth Air Force, from many commands, including those of the paratroopers. A comprehensive technical review of these combat reports showed that descent from high altitude with an open parachute created the hazards of anoxia, frost bite, increased parachute opening shock, loss of personal equipment, and vulnerability to fire during descent. These dangers made free fall descent more desirable to the immediate parachute inflation. The free fall descent, however, presented the following hazards: failure to pull the ripcord due to spinning accelerations, combat wounds or a frozen parachute pin, fall, or falling objects. The results of this technical review indicated that several research programs were needed to solve the emergency bailout problem. The major research efforts included: (1) Conduct a study on the materials and physics of parachute design, (2) Conduct instrumentation high altitude tests using the 24 foot and 50 foot parachutes to measure the opening acceleration forces, (3) Improve the design of emergency bailout oxygen equipment, (4) Develop a portable parachute opening device, (5) Establish the physiological time relationship of frost bite during free fall descent, (6) Design the personal equipment to prevent loss during high opening shock, (7) Obtain first hand data on these problems, LtCol. Lovelace, Chief, Aeronautical Medical Laboratory, made a static line opening parachute jump from 40,200 feet at Edwards, California. In June 1943, he used A.A.P standard personal equipment issued to the bomber crews. Upon landing, he was found to be suffering from severe shock, frost bitten hands and arms, and pneumothorax. The jump verified the information on parachute opening shock and frost bite equipment loss which had been received from the combat units. This jump established a world altitude record for parachute descent.

Precise technical data on parachute operating forces at high altitudes was not available in 1943. An experimental program to collect this information was initiated in a joint activity between the Aero Medical Laboratory and the Personal Equipment Laboratory. This program studied the opening forces of silk and nylon parachutes at various altitudes. The opening forces in both 24 ft. and 28 ft. parachutes at various altitudes. The data showed that the minimum altitude for opening forces at various altitudes and air speeds. The experiments were conducted at Muroc Army Air Field in the winter of 1944. The test data indicated that the accelerations varied from 8.5 G at 7000 feet to 33 G at 40,000 feet. The new 28 foot canopy made from nylon material produced the lowest accelerations at all altitudes. Mr. Lundquist, Prof. Ryan, Univ. of Minnesota, Dr. Baclay, Mayo Clinic, Major Hallenbeck, Lt. Penrod, Capt. Maisen, E. O. 696, 1944-1945

Another experimental program was directed to the development of an automatic parachute opening device for long free fall bailouts. Through equipment tests the scientists measured the pressure of the atmosphere at the point of parachute opening. They required for a man to manually open the standard backpack parachute and the standard parachute opening device. They also studied and developed the first aneroid activated parachute opening device. They employed the contract with Friss Instrument Corp. which constructed these devices. They also made a series of dummy drops from altitudes as high as 15,000 feet to demonstrate that the device operated satisfactorily (Capt. Maisen, Lt. Martin E. O. 696-66A, October 25, 1944)

The Laboratory conducted an extensive testing program on aircrew clothing using the all weather room and the refrigerated low-pressure chamber. This work also included various combinations of temperature and wind movement. The thermal insulation value of the clothing was determined in terms of CLO units. The results indicated that clothing required to maintain comfort at 20°F with no wind. Concurrent with these equipment tests, the physiological studies on the effects of climatic stresses, such as temperature, wind, humidity, and solar radiation, were
being conducted with human subjects. This work exposed the subjects to human tolerance limits for temperature and humidity (Mr. Hall, E. O. 696, 1944)

The oxygen equipment program was totally involved in the engineering development of aircraft bottles, walk-around bottles, bailout bottles, regulators and the associated hardware. They also conducted engineering modifications and hastened the production of oxygen equipment program. In 1944, the Laboratory started a program to develop a new liquid oxygen system to meet the demands of high-speed long range jet flight (Dr. Berner E. O. 660, 1944)

The medical logistics work in the Laboratory was devoted to development of facilities for the air transport of wounded, medical supplies, and medical equipment. The program covered research, development, testing, standardization, and procurement. Litter supports and other small airborne medical equipment were developed. Two other items deserve special mention because of their widespread usefulness. The first was the aerosol hanger for dispersal of insecticides. L.t. William Sullivan in 1941, developed a portable bomb for dispersing a fluor-oxygen-hydrogen-ozone insecticide in aerosol form for the disinfection of aircraft. The other item was the pneumatic balance stretcher developed by Henry Buss in 1945. These vehicles was developed for flying personnel who had succumbed to anoxia and frequently required artificial respiration.

The clinical aviation medicine program was devoted to the areas of ophthalmology and wound ballistics. In the ophthalmology area the studies were mainly directed along three lines of approach: studies of visibility and fields of vision from aircraft, design and development of goggles and flying sun glasses, and night vision studies (Captain Parsons, E. O. 690, 1941-45)

In the area of wound ballistics there was little detailed information on the wounding effects of the standard ammunition in use during the war. Modern weapons, such as the machine gun, were often stated to have caused extensive damage to tissue. While undoubtedly true, these statements usually were unqualified and unsupported by specific data. For medical reasons, it was considered important to have detailed information whereby damage could be estimated. In the winter of 1944, experimental animals were used in these tests.

Colonel Randy Lovelace, Dr. Edward Halder, and L.t. Werner Wulff traveled to England, Germany and Sweden in May and June 1945. Their purpose was to gather technical and scientific data on the development of the ejection seat. The results of this study were published in an AAF Memorandum Report TSEA/AC-3-695764 in August 1945. The laboratories on the basis of this overseas study, initiated an ejection seat research program in July 1945. Under the direction of Major Harvey Savely, the program concentrated for an ejection seat testing tower. The tower was 30 feet high and was adjustable up to 30 degrees aft of the vertical. There was an air brake to stop the seat near the top of the tower. It was constructed in three weeks by the Allied Chalmers Company under the direction of Dr. Baldey. The first AAF ejection seat used in these tests was a reproduction of the German ejection seat which had been brought back from Germany. The Frankford Arsenal provided a T-3 telescoping catapult that extended from 36 to 60 inches. Using a half charge of powder in the T-3 catapult, the first two human ejections were conducted on the 36 foot tower in November 1945. The seat accelerations were 11G and the subject accelerations were 20G on the hip, 15G on the head and 10G on the shoulder (Major Savely, E. O. 695, November 1945)

Two final projects worthy of note during the war were the preparation of the first service manuals concerned with high altitude health hazards, PHYSIOLOGY OF FLIGHT and YOUR BODY IN FLIGHT (1941) and the establishment of physiological training programs for aviators (1941).

AWARDS

1943 Lt.Col. Lovelace Distinguished Flying Cross
Fig 11.1 P-51 aircraft. The performance in combat turned to the development of the G-3 anti-G suit. This was the first type of operational aircraft to be equipped with the new anti-G suit. Aero Medical team leader, Lt. Morris.

Fig 11.2 B-24J aircraft. Required anthropometric sizing of the many gun turrets and internal rocket equipment used by the aircrew. Lt. Randell.
Fig II-3  B-17G aircraft. The extremely cold temperatures in the open rear gunners station prompted work with winter flying equipment and oxygen masks.

Fig II-4  B-29 aircraft. The sealed cabin required work on explosive decompression and pressure breathing equipment.
Fig II-5  P-80 jet fighter. Its performance required significant advances in aero medical research, human engineering, high altitude physiology, ejection escape, clothing and oxygen equipment.
The new Building 29 which was ready for occupancy on January 1, 1943.
Fig 11-7  The new Aero Medical Laboratory complex, 1944.
Fig 116. The second human cannonball installed at Wright Field, Ohio, May 1942. This machine was used in the development of the new anti-aircraft suit.
Fig. 119  The Army Air Force standardized G-3 anti-G suit, November 1944.
Fig 11.20
Major J. Martin attaching medical electrodes to a subject prior to an experiment on the centrifuge.

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Fig 11-11 Lt. Alexis Gaster at lift-off from the ground in the first human pick-up, Wilmington, Ohio, September 5, 1943.
Fig II-13  Sixteen man altitude/cold chamber located in the basement of Bldg. 29.
Fig II-15  Twenty man altitude chamber located in the basement of Bldg. 29

Fig II-16  Sgt. Harold Lichty at the controls of the twenty man altitude chamber in basement of Bldg. 29.
Fig 11-17  New all weather test facility basement Bldg. 29
Fig II/38 High altitude free fall parachute program. Lt. Morris demonstrating parachute pull force test unit 1942.
Fig II-19 High altitude flight equipment used in B-17, B-24, B-29. This personal equipment was tested in the Laboratory facilities, Captain Taylor.
Fig 11-20  Four-man quonset type pneumatic shelter.
Fig 11.21 Modified German ejection seat brought back from Europe and used for the first American human tests on the 30 foot ejection tower, 1945.
Fig 11.20  The thirty foot ejection tower. The first ejection test facility in the AAF, 1945.
II-23 Laboratory organization on July 1, 1944.
1st Row

2nd Row

3rd Row

4th Row

5th Row
CHAPTER THREE

JET FLIGHT RESEARCH
1946-1958

ORGANIZATION AND COMMAND

Colonel Edward J. Kendricks was assigned as Chief, Aero Medical Laboratory in May 1946.

A special group of German scientists and their associated technical support personnel were assigned ordered "Project Paper Clip," to the Aero Medical Laboratory in May 1947. They had been involved in related aero medical research during the war. Primarily from the Helmholtz Institute in Bavaria, they were Dr. Hans Mauch, Dr. Herschke, Dr. Ernst Franke, Dr. Otto Gauer, Dr. Henning Von Gierke, Dr. Hans Oestreich, Mr. Henry Seeker, Dr. Hans Amtmann, Mr. Frank, Dr. Ernstshausen, Mr. Fritz Klemm, Mr. Willie Bushing, Mr. Franz Rinecker, Mr. Paul Hermann, Mr. Wolf Von Wittern, and Mr. Erich Gienapp.

An Aero Medical remote location facility was established at Muroc Army Air Field, California in 1946. LtCol. Mike Sweeney sent Captain John Paul Stapp to the 2000 foot track to build a rocket sled and conduct human and animal experiments in abrupt acceleration.

The Personal Equipment Laboratory transferred responsibility for research and development on all clothing to the Aero Medical Laboratory on April 12, 1947. Mr. Don Huxley was appointed Chief, Clothing Branch. Other members of the Clothing Branch were Mr. Abe Plotkin, Mr. Bill Walker, Mr. Lonnie Moore, Mr. Roy Harlan, and Mrs. June Murphy. The Clothing Branch occupied two offices on the first floor of Bldg. 29.

United States Air Force was activated on September 18, 1947.

Construction of Bldg. 33 was completed in the fall of 1947. The human centrifuge in Bldg. 55 was disassembled in summer 1948. Clothing Branch moved into the refurbished building in October 1948. The Clothing Branch was the center of all new developments in uniform clothing, flight clothing and personal protective clothing in the Air Force.

The Aero Medical Field Laboratory was established at Holloman Air Force Base, New Mexico, in 1949. It provided technical assistance for the Aerobee rocket flights using animals. Several years later it became the primary facility for abrupt acceleration sled tests, under the supervision of LtCol. John Paul Stapp.

Col. Kendricks was transferred from the Laboratory in June 1949. LtCol. Adolph P. Gagge (MSC) served as Acting Chief of the Laboratory from June 1949 until December 1949. Colonel Walter A. Carlson was assigned as Chief, Aero Medical Laboratory in December 1949.

Dr. Paul Fitts, founder of the Psychology Branch in the Army Air Forces, departed the Laboratory in 1949. Dr. Walter Grether was assigned as Chief.

Air Research and Development Command (ARDC) was established on April 2, 1951.

The Aero Medical Laboratory was transferred from the Directorate of Research and Development, Air Materiel Command, to Wright Air Development Center, ARDC, in accordance with ARDC G.O. No. 10, June 7, 1951.
Colonel Walter A. Carlson was transferred and Colonel Robert N. Blount was assigned as Chief, Aero Medical Laboratory, in June 1951. Colonel Jack Bollwed was assigned as Chief of the Laboratory, in January 1956. Dr. Harvey Sauer left the Laboratory for the Office of Scientific Research, in 1956. Wright Air Development Center (WADC) combined all the Laboratories into the single Directorate of Laboratories in July 1957. Colonel Bollwed was transferred in April 1960. Colonel John P. Stapp was assigned as Chief, Aero Medical Laboratory.

NASA was reorganized into the new NASA to conduct the civiliss space program in July 1958.

In the spring of 1958, the Aero Medical Laboratory was reorganized into a three Division management structure with Captain Edward DeWolfe (USN) Chief, Bio-Medical Sciences Division, Mr. Wayne McCandless, Chief, Engineering Division, and LtCol. Howard Parrin, Chief, Behavioral Sciences Division.

The greatest increment in growth of the Behavioral Sciences Division occurred in 1958 when the Air Force Personnel and Training Research Center, with headquarters in San Antonio, Texas, was abolished. The Behavioral Sciences Division was given added responsibilities in the areas of operator and maintenance training and qualitative personnel requirements information (QPR).

As a consequence of this increased responsibility, the Behavioral Sciences Division established a new Branch, Training Psychology, headed by Dr. Gordon Ekstrand.

U.S. AIR FORCE AIRCRAFT


CHALLENGING AEROMEDICAL PROBLEMS

- Organize and create the first human engineering research program in the Army Air Force
- Establish the human tolerance limits and protective equipment requirements for ejection escape systems in the Air Force
- Develop the first operational pressure suits in the Air Force
- Organize and establish the human tolerance limits and standards for bioacoustics environments in the Air Force
- Initiate the first noise survey and loud sound program in the Air Force
- Establish the first physiological and psychological requirements for low earth orbit space flight
- Develop an operational liquid oxygen system for high altitude jet flight
- Develop uniform, flight clothing, and protective clothing for the new jet aircraft era

PIONEERING ACHIEVEMENTS

- First demonstration of the 80/1 partial pressure suit in an altitude chamber (Dr. Henry, E. O. 696, 1945)
- First flight tests of the five liter liquid oxygen converter (Dr. Berner, E. O. 660, 1948)
- Design of Air Force standard B-2 Navigational Plotter (Dr. Christiansen, E. O. 694, 1950)
- First shape coding of aircraft cockpit controls for improved human performance (Dr. Jenkins, E. O. 694, 1949)
- First studies of instruments reading performance under acceleration on the centrifuge (Dr. Warrick, Dr. Lund, E. O. 694, 1946)
• Participate in the first live in-flight ejection seat test in the Army Air Force with subject Sgt. Larry Lambert in a P-61 aircraft at Patterson Field, velocity 228 KTS, altitude 7800 feet (Major Sweezy, E. O. 695, August 17, 1949)
• High altitude sky brightness measurements for vision problem when using the CRT in the navigator-bombardier crew station (Dr. Christensen, E. O. 694, 1946)
• Research on Navigators’ performance during Arctic high-altitude flights (Dr. Christensen, E. O. 694, 1947)
• Research on flight instrument design and legibility (Dr. Grether, E. O. 694, 1947)
• First human tolerance studies in linear deceleration using a rocket sled on a 2000 foot track at Morro Army Air Field, California (Captain Stepp, E. O. 695, 1947)
• Establishment of human tolerance for orbital ejection seat accelerations (Dr. Ames, Dr. Savery, E. O. 695, 1947)
• Studies of human performance in the direction of movement of controls (Dr. Warrick, Dr. Grether, E. O. 694, 1947)
• Development of pointer alignment principle for rapid check reading of cockpit instruments in an emergency situation (Dr. Warrick, Dr. Grether, E. O. 694, 1948)
• Study of pilot eye movement in flight to establish instrument reading pattern (Dr. Fitz, Major Cole, E. O. 694, 1948)
• First research program which led to the development of V-1 helmet (Mr. Moore, Z. O. 666, August 20, 1948)
• Research on the physiological effects of intense sound (Dr. Parrack, E. O. 695, 1948)
• Research program to establish the mechanical impedance of the body (Dr. Franke, Dr. von Gierke, E. O. 695, 1948)
• First downward ejection test tower for human testing (Dr. Savery, E. O. 695, 1948)
• Establishment of human tolerance to downward seat ejections (Dr. Shaw, E. O. 695, 1948)
• First anthropological research on the prone pilot position (Mr. Hertzberg, E. O. 695, 1948)
• First animal experiments using V-2 rocket at White Sands, N.M. (Dr. Henry, E. O. 695, June 18,1948)
• Research on the effects of control lag on human performance (Dr. Warrick, E. O. 694, 1949)
• Publication of the first Blue Book on UFO phenomenon (Dr. Flitts, E. O. 694, 1949)
• Air Force high speed human ejection, Capt. Vincent Mazza, P-61 aircraft, 555 MPH at 9000 feet at Patterson Field (Mr. Santi, Captain Mazza, Mr. Carroll, 1949)
• Research on the effects of training transfer as related to the design of training equipment (Dr. Eckford, E. O. 694, 1949)
• Second series of animal experiments using V-2 rocket at White Sands, N.M. (Dr. Henry, E. O. 695, 1949)
• First human test of the downward ejection seat in a B-47 aircraft (Lt. Col. Henderson, E. O. 695, 1949)
• First human engineering applications group initiates a system study of the Air Weather Service (Dr. Davidson, Mr. Flint, E. O. 694, 1949)
• Major anthropometric survey of Air Force flying personnel (Mr. Hertzberg, Lt. Daniels, E. O. 695, 1950)
• First animal cosmic ray balloon flights to 97,000 feet (Major Simons, E. O. 695, 1950)
• Incorporation of body size criteria into Air Force manuals (Lt. Daniels, RDO 695, 1951)
• First Aerobee high rocket flights using monkeys and mice (Dr. Henry, RDO 695, April 18, 1951 and September 20, 1951)
• Human engineering research on low color temperature white lighting (Dr. Grether, RDO 694, 1955)
• First operational partial pressure suit S-1. Based on the work of Dr. Jem Henry (Capt. Vail, RDO 496, 1952)
• First human tests to 12 G in the prone and supine body position (Lt. Dempsey, Capt. Ballinger, RDO 685, 1952)
• Aerobee rocket flights with animals, two monkeys and two mice, altitude 38 miles (Dr. Henry, RDO 695, May 22, 1952)
• High-altitude downward ejection tests from a B-47 aircraft (Mr. Hecht, Mr. Beaupre, Captain Sperry, RDO 685, 1953)
• First human tolerance studies on high altitude free fall spinning, using a laboratory spin table (Captain Edsberg, RDO 695, 1953)
• Standardization of the T1 partial pressure suit developed by Dr. Henry (Capt. Vail, RDO 696, 1953)
• First high altitude human spin tests during a parachute free fall (Lt. Nielsen, 7222, 1954)
• First inflatable ejection seat to relieve aircrew fatigue during long-range flight (Mr. Dempsey, 7222, 1954)
• Handbook on the visual presentation of information (Mr. Bates, Dr. Grether, 7184, 1954)
• First human engineering research on air traffic control (Dr. Ques, 7184, 1954)
• Development of the first successful ventilating garment for body cooling when wearing a full pressure suit or other protective garments (Dr. Hausch, 7184, 1954)
• World record sled test at Valiantan ARP using a human subject, 632 MPH (LtCol. Stapp, 7222, 1954)
• First research program to conduct aircraft noise field surveys (Dr. Parrack, 7231, 1955)
• Research program on human performance in long range flight (Br. Chiles, 7184, 1955)
• First omnivertical protective suit development program (Mr. Martin, 6373, 1955)
• Formulation of the Human Engineering Application program (Mr. Ring, 7184, 1955)
• First standard height/weight sizing system for all personal protective equipment, except the oxygen mask and helmet (Mr. Emanuel, 7222, 1956)
• World record ascent in an altitude chamber with a human subject, 156,700 feet (Major Bech, 7164, 1956)
• First Biological Data Handbook series (Dr. Hym, 1956)
• Criteria for short time exposure to high intensity jet aircraft noise (Captain Eifred, Major Gannon, Dr. von Gierke, 7231, 1956)
• Influence of training on the design of aircraft control coding (Dr. Eckstrand, Dr. Morgan, 7196, 1956)
• Three dimensional sizing system for Air Force clothing (Mr. Alexander, 7222, 1957)
• Joint AMRL/FAA determination of mass, centers of mass, and moment of inertia of the major segments of the body (Mr. Clausen, 7184, 1957)
• First full pressure suit X-15 (Capt. Vail, 7184, 1957)
• First basic procedures established for land use with respect to airplane noise (LtCol. Guild, Mr. Cole, Dr. von Gierke, 7231, 1957)
• First USAF MAN IN SPACE program (AMRL, Staff, 1957)
• First research program on the biophysics of concussion (Dr. Hollister, 7222, 1957)
• A new technique for establishing human body contour by means of stereophotogrammetry was successfully developed. (Mr. Griffen, Mr. Ring, 7184, 1957)
• Publication of MIL-H-20946, Human Factors for Manned Aircraft Weapon Systems (Mr. Griffin, Mr. Ring, 7184, 1957)
• Publication of MIL-H-25907, Human Factors Data for Missile Weapon Systems (Lt. Ribler, Mr. Bates, Mr. Greek, 7184, 1957)
First successful test of hand-held propulsion gun for use in zero gravity (Mr. Hertzberg, 7222, 1958)
First airborne weightlessness training program, C-131 (Captain Simens, Major Brown, 7184, 1958)
First aircrew habitability studies of nuclear powered aircraft (Mr. Dempsey, 7222, 1958)
First human tests to 16 G in the supine body position (Captain Starke, 7222, 1958)
Study of vibration and noise environments of missiles and spacecraft (Dr. Von Gierke, 7231, 1958)

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<th>PROJECT NUMBERS</th>
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<tr>
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<td>Oxygen Equipment</td>
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Altitude chamber
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Acoustics Chamber
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Electronics laboratory
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Speech recognition laboratory
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Survival equipment test facility
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Oxygen equipment test facility
  Bldg 824

Laboratory Flight Test Aircraft

C-45   Psychology Branch
C-47   Psychology Branch
C-131  Psychology Branch
B-17   Biophysics Branch/Engineering & Development Branch
S-82   Biophysics Branch
P-80   Biophysics Branch (Probe Pilot)

THE LABORATORY PROGRAMS

OVERVIEW

The new era of Jet Flight required fundamental aeronautical medical research on the significantly increased flight velocities, the high acceleration forces, the extremely short event times for human responses, and the very high altitude flight profiles. Military aviation had suddenly moved from propeller to jets, and was rapidly approaching the first attempt at human flight in near earth orbit.

The first organized research in engineering psychology began in this Laboratory in 1945. The experiences of the war had more than demonstrated a fundamental need for human engineering research in the design of aircraft equipment, training procedures, and aircrew combat training in emergency situations. The Army Air Force was fortunate that the great leaders in such research were brought to the Laboratory through the foresight of Colonel Lovelace.

LtCol. Paul Pitts and Majur Walter Grether were given full responsibility for planning and organizing the new research program. Their technical program plan organized the work into four areas: research activities, coordination of university research, consultation with scientists and engineers from other Wright Field laboratories and liaison with outside agencies. These four areas were then integrated into two research activities. The first was to conduct research on the past problems and apply the data to correct current needs, and to prevent intermediate term future problems. The second was to initiate an advanced research program which dealt with the new requirements of jet aircraft and to have technical data available for their preliminary
design. This comprehensive activity stretched the limits of the available human engineering manpower, approximately 25 people.

That new human engineering program started exactly ten years after the approval of the Physiological Research Laboratory: Fats and Grease in aviation engineering research (1946) were comparable to Armstrong and Helm in aviation physiology research (1936).

The Aero Medical Laboratory was now totally engaged in the professional areas of human engineering, biophysics, physiology, engineering, clothing, medical specialties, and aviation equipment development. The Laboratory work in these fields covered: basic and applied research, new engineering development and the standardization of new equipment items. The research, development, and standardization of end item specifications and drawings represented approximately one-half of the Laboratory’s output. The remainder of the Laboratory work was directed toward supplying information for the Handbook of Instruction for Aircraft Designers, and for technical reports used by other military organizations and aviation contractors.

SELECTED PROGRAMS

A significant percentage of aircraft accidents resulted from confusion of the pilot in reading instruments, selection and location of controls, etc. Part of this confusion was a result of the variation in cockpit arrangement from one aircraft to another. The Laboratory participated in a coordinated USAF program to standardize cockpit arrangement, as well as codify controls through uniform and distinctive knob design. An example of the results of this work, the Office of Technical Inspection and Flight Safety informed the Laboratory that elimination of the confusion between the landing gear and wing flap controls had virtually eliminated the accidental raising of the landing gear while the aircraft was on the ground (Dr. Jenkins, E. O. 694, 1946).

The design of jet aircraft demanded more compact and lighter oxygen equipment. An engineering program was initiated to produce a satisfactory system for storing liquid oxygen on the aircraft and converting it into aviator’s breathing oxygen in gaseous form as required. The high density of the liquid as compared to gas resulted in a saving in space of approximately 30 to 1. Since the oxygen could be kept in a liquid state by insulation from the surrounding atmosphere, heavy steel containers were not required, as is the case with storing compressed gas. These efforts resulted in the standardization of the 5 liter, Type A-3 Liquid Oxygen Converter. The LOX system was first installed in the F-84 aircraft (Dr. Birner, E. O. 660, 1948).

The advent of jet aircraft with extremely loud noise generators posed the problem of protecting flying and maintenance personnel from noise intensities never encountered before and poorly understood at that time. In a series of reports and publications the Laboratory provided a comprehensive, quantitative study of the hazards of high intensity noise and ways to protect Air Force personnel (Dr. Parrack, Dr. von Gierke, Mr. Cole, E. O. 690, 1947).

The Clothing Branch was responsible for the design and development of specialized ground crew protective clothing, as well as uniform and functional clothing. The fire entry suit and fire fighter’s suit were two examples of the specialized protective garments. Personnel engaged in combating fires of high temperature, such as gasoline or fuel oil fires, needed a high degree of protection against radiant heat. A suit assembly, designed to be worn over the standard fireman’s coat and trousers, was developed. The assembly consisted of an outer shell made of aluminum asbestos- fiberglass material and a lining of viscous rayon (Mr. Huxley, E. O. 666, 1948).

A new regulatory (D-2) was developed for dispensing breathing oxygen to aviators at altitudes up to 50,000 feet at the required pressure and concentration. It was completely automatic and did not require any adjustments from the aviator. This regulator corrected latent faults uncovered in the old regulator (Mr. Good, E. O. 660, 1949).

Six German V-2 rockets had been sent to this country after the war. They were used for high altitude physics research by the Cambridge Research Center. The third V-2 rocket experiment was scheduled for flight dynamic studies of the X-2 escape capsule. Dr. Henry was asked to provide a “simulated pilot” to ride in a small capsule inside the nose cone, which was externally shaped like the nose of the X-2 aircraft. The monkey and the nose cone were instrumented to obtain information on the flight forces. The parachute failed to deploy and the monkey was lost. There were two additional flights with monkeys. The last flight carried a mouse. The four
experiments gathered valuable instrumentation data during flight but all the parachutes failed and the animals were lost. Dr. Henry then obtained three Aerobee rockets to continue the research program. The first Aerobee carried a single mouse, an instrumentation package, and an onboard camera. The miniaturized camera and instrument package had been built by Mr. Eric Ginnapp in his machine shop in Bldg. 33. The recovery parachute failed and the animal was killed. The second Aerobee carried two mice, one monkey, and the Ginapp instrumentation package. The flight was a success with full recovery of the nose cone. The three animals died after landing because of excessive heat stress inside the nose cone before they could be cooled. The third Aerobee flight was completely successful. It carried two monkeys and two white mice. The Ginapp instrumentation package and camera provide excellent scientific data. These animals became the first living creatures to survive the test program. They flew to an altitude of 211,000 feet, a speed of 2000 MPH, and had been in a zero g environment for two minutes. Dr. Henry, Dr. Gasier, Major Simon, Major Maher, Captain Ballinger, Mr. McLennan, Mr. Correl, Mr. Ginapp, Mr. Chidley, Mrs. Pettit, E. O. 685, 5448-1952

A new anthropometric survey was conducted on Air Force flying personnel and 132 measurements were made on over 400 men. One of the first applications of this work was the establishment of a complete sizing schedule for the T-1 altitude suit and the new AF Navy anti-g suits. A fit test of the latter garment resulted in better than 99.5% successful fittings of twelve sample suits on a group of over 200 Navy personnel. Previous sizing schedules for that garment had usually produced only 20% to 50% successful fittings (Mr. Hertberg, Lt. Daniels, E. O. 685, 1952)

Mr. Henry Seeker developed a resuscitator capable of operating at varying altitudes for use in combat or aeromedical evacuation type aircraft. A prototype resuscitator was produced. It was a versatile instrument that could be used in either aircraft or any place a low power electrical source was available. It produced negative and positive pressures, thereby blowing air or oxygen into the lungs and then sucking out the air to be exhaled. The advantages of this device could not be over emphasized. It would serve the Air Force in aeromedical evacuation, the ground forces in ambulance installations, and all branches of Service in various types of hospitals. The Army Chemical Center had also become interested in its use in the treatment of large numbers of patients suffering from chemical weapons effects. The resuscitator was particularly suited for treatment of those people that might suffer from “nerve gas” (Mr. Seeker, RDO 685, 1952)

Downward ejection gave the aircraft designer an alternate method for escape from aircraft. Factors that precluded the possibility of upward ejection were radio or instrument location, location of air scoops or the rudder to a given crew position and crew station on the lower deck of multipurpose aircraft. Downward ejection required a modified harness to insure that the force of ejection was distributed to the body in a manner that would prevent injury. The seat also incorporated restraint devices to insure that the arms and legs were properly positioned during ejection. These features were tested by human subjects on the downward ejection test tower and were found to be adequate within the limits of human tolerance. A windblast testing program was conducted, giving helmets, visors, and masks to determine their retention capabilities during high speed escape. The windblasts ranged from approximately 336 to 788 MPH. Standard P-3 helmets and visors proved to be sufficiently strong to withstand the most severe windblast (Captain Sperry, Lt. Nelson, RDO 685, 1953)

Ejection from high speed aircraft introduced a complex problem: the effects of multidirectional acceleration forces on the human body coupled with a rapid tumbling rate. The tumbling which occurs immediately after clearing aircraft structure produces rotation about a center within the body. Laboratory studies on the physiological and pathological effects of rapid tumbling on animals and humans were conducted with a spin table. Critical values of rotational speed about an axis through the abdomen and the heart in humans were determined. These studies furnished information to designers about the degree of stability required in ejection seats. Concomitant with the tumbling problem, new restraints and harnesses were developed to maintain man in the ejection seat (Captain Edelberg, Captain Weiss, RDO 685, 1953)

Atomic weapons created the need for nonmedical personnel to rapidly apply a sterile dressing for minor therapy of burns. Aeroblend was a sprayable film-forming transparent plastic disposed from aerosol containers. The most important advantages of that form of local burn therapy was time saving, feasibility of its use by relatively untrained personnel, applicability to parts of the body poorly adapted to pressure dressings, transparency, flexibility, minimal storage problem.
The Air Force T-1 partial pressure suit assembly was developed to meet high altitude emergency requirements. Its development was the result of Dr. Jim Henry's seven years of intensive team research. Dr. Henry served as subject in tests up to 100,000 feet in the altitude chamber. In addition to fulfilling the altitude requirement, the T-1 assembly provided anti-g suit protection, and contained communication equipment, oxygen valves, regulators, protective helmet, protective suit, and oxygen bailout cylinder. The helmet was windblown to a velocity of 725 MPH. The T-1 suit was standardized by The Air Force in May 1953 (Dr. Henry, RDO 696, 1953).

The Army Air Force provided canned survival rations and poorly stored table food to airmen during the war. The extended range flight of new jet aircraft created a fundamental need for in-flight feeding equipment and the development of professionally prepared meals. The Nutrition Unit developed the first airborne freezers and electric ovens especially designed for prepackaged frozen meals. These meals were designed to meet the unique requirements of long term confinement in pressurized compartments at high altitude missions. The survival rations were completely revised to provide more nutritional support under long term emergency conditions. The advent of the B-52 and the nuclear powered airplanes brought the nutrition program and the associated equipment development activity to a high state of activity. The results of this work became the basis for the NASA nutrition and feeding equipment development programs (Mr. Chatham, RDO 691, Miss Finkelstein, 716, 1946-1950).

Human engineering design principles and procedures for future ATC systems were being developed. A study using computer simulation indicated that when the identity of each target was provided on ATC radar displays, system performance under high work load conditions improved significantly. When target altitude information was added as an auxiliary display, a decrease in communication load time occurred. When the number of controllers in a radar approach control center was increased a more complex traffic situation was accommodated (Dr. Quinl, 7184, 1954).

Protective flight equipment and survival equipment usually totally enclosed the human body. This situation made the development of a body ventilation garment a key element in these protective equipment research programs. Dr. Hans Mauch, Chief, Environmental Section, was responsible for the development of the first successful ventilated garment. It was a night-timers layered system, like the tops manufactured on the mainland. The liner contained thousands of pinholes which permitted air or liquid to flow through the garment. The system was hooked to an external blower. The garment cooled its wearer and also considerably reduced humidity by venting off the moisture of perspiration. A modification of this development was later used by NASA in the Mercury and Gemini pressure suits (Dr. Mauch, 7164, 1959).

One of the most important functions of the Laboratory was preparing handbooks for Training Command, Operating Continents, aircraft manufacturers, and other ARDC laboratories, medical departments of the three services and educational and private research institutions.

- Psychology Research on Equipment Design (Dr. Pitts, E. O. 694, 1947)
- Handbook on Training and Training Equipment Design (Dr. Eckstron, RDO 694, 1953)
- A Human Engineering Guide to Equipment Design was prepared for use by design engineers.
  This was part of a joint Army, Navy, Air Force project (Dr. Grether, Dr. Warrick 7184, 1964)
- In cooperation with the National Academy of Sciences and the Federation of American Societies for Experimental Biology, the Handbooks of Biological Data were originated. These fifteen volumes contain the most complete and authentic collection of quantitative information concerning the composition, structure and functioning of living things ever assembled (Dr. Hetin, 7164, 1952).
- A handbook on Vision in Military Aviation was used as the design standard for military aircraft (Colonel Emerson, 7157, 1957)
- A Handbook of Acoustic Noise Control that summarized the state of our knowledge pertaining to aircraft and power plant noise was completed (Dr. Parrack, 7251, 1959)
The limits of human tolerance to deceleration were defined in terms of rate of onset, magnitude, and duration for a stable flight system in a transverse G field. The curves describing the limits were divided into three zones: a zone of safety, a zone of probable disorientation, and a zone of collapse or fatal injury. The zone of probable disorientation had a lower limit established by a curve with a rate of onset of 1000 G per second to a maximum of 30 G with an exponential decay from this peak through 9 G at 10 seconds. The dividing line between the zone of probable disorientation and zone of collapse was established as a line with a rate of onset of 1000 G per second, peaking at 30 G with an exponential decay through 11 G at 10 seconds. Using this information for engineering design work, a milestone in biodynamic research was reached at the SMART track in November 1956. Three separate rocket sled tests with open ejection seats and chimpanzee subjects were successfully accomplished. The animals were recovered alive following ejection at velocities approaching MACH 1 (Major Pessberg, 7222, 1956)

Two partial pressure altitude suits were developed in 1956 the OMC-3) for bomber aircraft and the (OMC-4) for fighter aircraft. They provided improved time-altitude capabilities for the crewmember. In conjunction with an improved pressure helmet and oxygen regulator, these suits had built in oxygen provisions and anti-capability. As a result of these improved suits and helmets, all previous pressure suit equipment was classified as "Limited Standard" (Captain Vall, Mr. Rosenbaum, 7164, 1956)

An early effort recognizing the significance of increasing costs of ownership for weapon systems produced the first of a series of maintainability design guides, Guide to Design of Electronic Equipment for Maintainability (Dr. Eckstrand, 7150, 1956)

Tactical use of jet aircraft required a capability for high speed, very low altitude flight. Under these flight conditions, buffet, caused by turbulence in the atmosphere, had become a serious problem. To study the effects of buffeting this laboratory developed a "vertical acceleration" which could be programmed to simulate the vertical component of accelerative forces in the frequency range from 0-10 Hz with a maximum peak-to-peak displacement of 20 feet to which aircraft personnel were subjected in turbulent atmosphere. This simulator was delivered and, following completion of its assembly, studies were carried out to determine the physiological and psychological effects of buffeting on aircrew performance. Results of these studies have been directed toward the protection of flight personnel and the establishment of buffeting tolerance criteria (Major Gunson, 7231, 1957)

Two human factors data specifications were published, one for missiles, and one for manned aircraft systems. Human engineering design standards were also prepared for the contractor compliance in the Air Force Intercontinental Ballistic Missile program. These publications stimulated a major increase in human factors effort by weapon systems contractors (Mr. Ring, Dr. Topmiller, Mr. Brooks, Mr. Bates, Captain Riebler, 7184, 1957)

Modification of the previously developed omnienvironmental suit and incorporation of the ventilated garment produced the first experimental full pressure suit. It was tested in the altitude chambers in June 1957. With additional minor modifications, this suit was adopted for use in the X-15 flight test program, and the X-15 escape system sled test program (Dr. Vall, Mr. Rosenbaum, 7164, 1957)

The first developmental plans for a nuclear powered aircraft indicated it would be a vehicle in the class of a B-36. That vehicle was to have a normal flight duration of 120 hours, using a crew of five men confined in a relatively small shielded crew compartment. The WS-125A System Program Office requested the laboratory to conduct a research program on aircrew habitability. An investigation of the crew compartment facilities produced several areas where crew performance and fatigue would be affected by the long range and high performance aircraft requirements. The most critical area was the integration of crew members into a compartment that seriously restricted mobility, and required the aircrew to fly the aircraft continuously on instruments without outside visibility. Another area was the close crew scheduling which disrupted the individuals diurnal cycle and the overall crew diurnal pattern. A complete aircraft crew compartment simulator was constructed which incorporated principles, facilities, and subjective concepts that were well beyond contemporary technologies. Five different aircrews participated in a typical 120 hour simulated flight. Integrated medical instrumentation of both the aircrew and the compartment recorded a complete picture of the functional efficiency of this man-machine system. The data from this program were provided to the WS-125A weapon
system program, and also published in technical reports as well as a book written by the Air University on the problems of nuclear flight (Mr. Dempsey, 7222, 1958)

The Aircrew Equipment Section conducted two full scale survival programs using human subjects in the B-58 emergency escape capsule. The first survival test was conducted in the warm tropical waters off Key West, Florida. The second survival test was conducted under winter conditions on land. The B-58 individual escape capsule was the first such device used in production military aircraft. The capsule eliminated the need for the aircrewman to wear heavy protective clothing during flight or escape. The capsule and its stored personal equipment was the only capability for human survival in an emergency condition. These crucial tests were directed to an evaluation of this new concept and to obtain information on changes or improvements which would be identified by these realistic tests under actual field conditions. Medical and field instrumentation provided data on the occupant’s physical condition during the prolonged habitation on the water. It also provided data about the frequency, roll rate and amplitude of the motion produced by the flotation characteristics of the capsule. Finally the habitable conditions inside the capsule were recorded to establish the need for specific types of survival equipment and their packaging requirements (Mr. Ruzy, 6373, 1958)

The need for highly autonomous intelligent weapons and control systems led to a systematic investigation and modeling of those structures of the nervous system which are responsible for “intelligent” behavior. This ambitious “Bionics Project” was a joint program between the AMRL and the Avionics Laboratory, which were both at this time parts of the Wright Air Development Division of AFSC. Primary objects of these investigations were the mechanisms for such functions as pattern recognition, automatic speech recognition, scene analysis, and sophisticated control algorithms for multiple degree of freedom goal oriented systems. The AMRL had one of the first limited vocabulary word recognition machines, and prototypes of other pattern recognition devices were developed. The Bionics program prepared much of the foundation for work presently continuing under the name of "Artificial Intelligence." (Dr. von Gierke, Dr. Oostreicher, Colonel Steele, 7231, 1958)

A maintainability research program emphasizing development of human engineering design criteria for both ground and space maintenance operations was initiated. Concerns included design of job aids, remote manipulators, automatic check-out equipment and maintainability prediction (Captain Fegg, 7184, 1958)

FIRST ORGANIZED AEROMEDICAL RESEARCH ON MANNED SPACE FLIGHT

In 1957-1958, Colonel Don Flickinger designated the Aerospace Medical Research Laboratory as the fundamental focal point for the then new USAF initiative, MAN IN SPACE. The Laboratory staff and division chiefs were organized into a comprehensive technical management team to create a major technical initiative to develop the aeromedical information necessary for the engineering design of a manned vehicle for low earth-orbital flight. A project, “Physiology of Space Flight,” was organized to implement the requirements for techniques, equipment and knowledge to operate manned space vehicles with maximum effectiveness and safety. The tasks included were:

- Human thermal stress in space environment
- Physiological criteria for space environments
- Personal protection for astronautical operations
- Nutrition in space flight
- Visual problems in space environment
- Development of materials for personal protection
- Systematization of biological knowledge

A working prototype of a closed circuit breathing and ventilating system was developed. This system provided the oxygen supply, carbon dioxide absorption capacity, and cooling necessary for one man flying a 12 hour mission. The system was smaller and weighed less than available equipment. It had the capability to operate in a zero-G field (Mr. Roundy, 6373, 1958)

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An industrial hygiene program for missile bases was developed to ease military and civilian concerns about the new rocket propellants toxic properties. Surveys were made of potential hazards, handling procedures, and preventive remedial measures were formulated (Major Westlake, 7164, 1958).

The problem of human performance under conditions of weightlessness required a new approach to gather research data. A C-131 aircraft was modified into an airborne facility and a flight maneuver was developed to produce fifteen seconds of true weightlessness. This flying laboratory permitted human performance research under reduced G conditions. The work included control manipulation, human locomotion, body control, use of personal propellant devices, orbital transfer, and performance of maintenance and assembly tasks (Captain Simons, Major Brown, 7184, 1958).

NASA requested the Laboratory to determine if a man could tolerate certain acceleration patterns anticipated in the maneuvered flights into orbit and return. Human subjects supported on a nest couch were tested for tolerance to an acceleration profile of 16.5 G. The MC-2 pressure suit was worn during tests to see if it impaired tolerance. Subjects were able to perform finger-tip control during all but the peak phases of acceleration (Captain Clarke, 7222, 1958).

Research was conducted on human tolerance and performance under severe vibration and transient acceleration conditions. The mechanical shake table with a 4.5 inch displacement and a vertical accelerator with a 10 foot displacement were used in the study of human tolerance to sinusoidal vibration from 0 to 15 cps. These low frequencies were possible for the first time because of large displacement capability (Captain Hansen, 7231, 1958).

Extensive studies of the noise generated by rockets and tests on several means of modifying rocket noise led to important new knowledge in that field. The rocket data in conjunction with additional analysis of turbojet noise fields, measured previously, made possible the formulation of a scheme to predict noise fields fairly accurately from a knowledge of the engine parameters. These, plus other data, also led to a method for evaluating the noise problems of a given air base without having to make measurements on the spot (Mr. Cole, 7231, 1958).

Research was conducted on maintenance training, especially optional features of automatic testing devices and on ways to isolate the significant intellectual aspects of maintenance operations. Space flight necessitated research on the conditions influencing reliable performance of operators despite unavoidable physical and emotional stress (Dr. Eckstrand, 1710, 1958).

AWARDS

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<td>Dr. Berner</td>
<td>Exceptional Civilian Service Award</td>
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<td>1949</td>
<td>Mr. Good</td>
<td>Exceptional Civilian Service Award</td>
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<td>1952</td>
<td>Mr. Seiler</td>
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<td>1953</td>
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<td>1954</td>
<td>Captain Sperry</td>
<td>Distinguished Flying Cross</td>
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<tr>
<td>1954</td>
<td>Colonel Henderson</td>
<td>Distinguished Flying Cross</td>
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<tr>
<td>1954</td>
<td>Sgt. Post</td>
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<td>L. Neilson</td>
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<tr>
<td>1955</td>
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<td>Chewy Award</td>
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Fig III-2  LtCol. Paul Fitts, Founder Psychology Branch

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8th Row
Don Penrose, Julian Christensen, Horace van Saun

7th Row
Fred Tressler, Larry Campbell, Paul Ritter, Glen Finch, John Wilson, Alexander Byriff, James Peskin, John Sullivan.

6th Row

5th Row

4th Row

3rd Row

2nd Row

1st Row
Virgil Cartwright, Bill Burgess, Ann Parker, Joe Bokaluk, Curt Masgrove, Charlie Castellano, Ed Hertsberg, Marguerite Knorr, Francis Moyer, Winnie Wilde, Mae Callen.
Fig III-4  Civilians assigned to the Laboratory, 1946.
Fig III-5  Personnel assigned to the Psychology Branch.

Back Row
Lt. Wise, Mr. Bakulja, Mr. Gardner, Miss Fuerst, Mr. Reuttele, Miss Connell, Mr. Warrick, Mrs. Morris, Mr. Christensen, Maj. Kubo, Sgt. Edison, Mr. White.

Front Row
Capt. Jones, Major Long, Dr. Fitts, Dr. Grether, Dr. Biel, Capt. Wilcox.
Fig III-6  Dr. Christensen conducting a human engineering experiment, 1946.
Fig III-7  Dr. Grether and John Gardner conducting an experiment in the Link trainer.

Fig III-8  Link trainer used in human engineering research on cockpit instrument design and arrangement.
Fig III.9  Human engineering experiment on the development of horizontal pointer alignment for aircraft powerplant instruments.
Fig III-10  Experiment in the development of shape coding of aircraft cockpit controls.
Fig IV-13  Cockpit of the C-47 airborne laboratory in which new concepts for cockpit design were extensively tested and scored in flight. This pioneering research established the new Air Force standard for future cockpit design and was incorporated in the Handbook of Instruction for Aircraft Designers (HIAD).
Fig 111-14: Aerobee rocket flight package which carried the first two monkeys and two white mice on high altitude ballistic flights (1949-1951).
Fig III-14A. Mr. Eric Gienapp and the Aerobee flight package the designed and constructed in the Laboratory.
Fig III-14B  The AMRL project team which conducted the Aerobee rocket flights.

Unknown, Miles McLennan, Unknown, Ed Correll, Harald Childers, Eric Gienapp, Unknown, Jim Henry
Fig III-15  Two white mice in zero G environment during Aerobee rocket flight to 36 miles altitude.
Fig III-15A  Aero Medical Laboratory project personnel and AMRL E-17 #5570 used in the Aerobee project.

2nd Row

1st Row
Unknown, Vince Mazea, Unknown, Unknown.
Fig III.16 First AAF designed ejection seat which was used in the first American live ejection tests.
Fig III-17  The first downward ejection tower, used in the development of the new downward ejection seat.
Fig III-19 The first rocket sled built for the pioneering human deceleration tests at Marvoc Air Field.
Fig III.30 Major John Stapp on the second rocket sled built for human deceleration experiments at Holloman AFB.
Fig III-21 Colonel Henderson being dressed by Lt. Sperry for the first human test of the new downward ejection seat in the B-47.
Fig 11922  Lt. Nelson after downed jet 112 experiment from a B-47. Lt. Nelson has a broken shoulder. Colonel

Referee is seated at the left.
Fig III-22A  Live downward ejection test from the B-47.
Fig III-23  The production area of the Clothing Branch. All USAF experimental uniforms and flight clothing were fabricated in this facility.
HOT BALANCED MEALS AT ALL ALTITUDES

Fig III-25  Individual in-flight combat meals for use in multiengine aircraft with food warming ovens.
Fig III.36  Altitude chambers in the basement, 268. These chambers were used for the development of first operational full pressure suit DX-130.
Fig 111-27 The S-1 partial pressure suit was developed by Dr. Henry. It was standardized in 1953.
Fig III-28 The first operational liquid oxygen system for jet fighter aircraft. Five liter converter.
Fig III.29  The new ejection seat survival kit.
Fig III.31
Mr. John Foster meets the new MB3 and G suit prior to a test on the centrifuge
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Fig III-34  Modified F-86 aircraft equipped with a prone position cockpit. Aircraft was routinely flown to +9G.
Fig III-35  Vertical accelerator which can simulate the accelerations encountered in low altitude high speed flight.
Fig III-36  Laboratory test facility for the first crew fatigue study of the nuclear powered aircraft.

Top Row
Unknown, Unknown, Unknown, Cecil Lazar

Middle Row
Chuck Dempsey, Unknown, Len Eisen, John Duddy, George Raff, Rufus Hessberg, Vic Thaler

Bottom Row
Charley Meyers, Jim Braakley
Fig III-37  First aircrew used in the nuclear powered aircraft crew fatigue studies (120 hours)

Len Eisen, Chuck Dempsey, John Duddy, Dick Willis, Unknown, John Simons, Bob Hegentherger,
Unknown, Rufus Hessberg, George Ruff, John Roth.
Fig III-38 High altitude flight clothing for jet aircraft, developed and tested by the Clothing Branch.
Fig III-29  The first tiltable ejection seat for long range jet flight missions.
Fig III-40. First contour mapping of the surface of the human body for anthropometric measurements.
CHAPTER FOUR

SPACE FLIGHT RESEARCH
1959-1969

ORGANIZATION AND COMMAND

The name of the Aero Medical Laboratory was changed to Aerospace Medical Laboratory on August 3, 1959.

Wright Air Development Center was redesignated Wright Air Development Division on December 15, 1959. The Aerospace Medical Laboratory was concurrently renamed Aerospace Medical Division. It was organized into four components: Biomedical Laboratory, Behavioral Sciences Laboratory, Life Support Systems Laboratory, and Personnel Laboratory (located at Lackland Air Force Base, Texas).

The Biomedical Laboratory directed research in the biomedical, biological, and related physical sciences for application to aerospace systems, to produce maximum effectiveness of both the human and physical components of systems to which biological knowledge may contribute.

The Behavioral Sciences Laboratory directed research in the behavioral sciences to produce maximum effectiveness of the human component in aerospace systems.

The Life Support Systems Laboratory directed research in engineering sciences to develop techniques and principles for the protection, sustenance, and survival of aerospace systems operating personnel.

Personnel Laboratory conducted research and development in support of the operation and qualitative improvement of the Air Force Personnel System. This included the development of concepts and techniques concerned with the functional areas of personnel requirements, procurement, classification, training assignment, utilization, proficiency measurement, promotion, retention, separation, and accounting.

Colonel John H. Stapp was transferred to the Aerospace Medical Center at Brooks Air Force Base, Texas, in August 1960, and at that time Col. Andrews Karstens assumed command of the Division.

The Aerospace Medical Division was redesignated from the Directorate of Advanced System Technology, WADD, to the Assistant for Bioastronautics, Hq ARDC, and redesignated the Aerospace Medical Laboratory on November 20, 1966.

On this date, the Laboratory lost responsibility for engineering and development of end items. The operational support development area (880 A) human factors, human engineering application work, systems engineering functions, and personnel subsystems activities were removed from the bioastronautics research mission. They remained the responsibility of the Directorate of Systems Engineering under WADD. The Clothing Branch was transferred into the Systems Engineering organization. Various other smaller functions and their personnel were reassigned to the Systems Engineering organization. The Laboratory was directed to provide bioastronautics technical support to the engineering organizations when requested.

In 1961, Bioastronautics Systems Division (ASD) was established at Wright-Patterson in conjunction with the activation of the Air Force Systems Command (AFSC) with headquarters at Andrews Air Force Base, Maryland. This change reflected a growing need to meld the
acquisition, delivery, and support of modern systems, together with their development, into a single management effort. Need for this concept of systems management was spurred on by the quickening pace in technological development. Creation of the Air Force Systems Command consolidated research and development of systems with the follow-on functions of systems procurement and production. Previously these follow-on functions had been carried out by the Air Materiel Command (AMC), which in the reorganization became the Air Force Logistics Command (AFLC). ASD, then, was born from the merger of two organizations at WPAFB, the former Wright Air Development Division and AMC Aeronautical Systems Center.

The Aerospace Medical Laboratory was assigned to the Aeronautical Systems Division on May 8, 1961. The Physical Anthropology Section was transferred from the Biophysics Branch, Biomedical Laboratory, to the Human Engineering Division, Behavioral Sciences Laboratory.

The Aerospace Medical Division, Air Force Systems Command, was established on November 1, 1961. It was formed by combining certain elements which had been assigned to three different major commands of the Air Force: the Alaskan Air Command, the Air Training Command, and the Air Force Systems Command.

The Aerospace Medical Laboratory was assigned to the new Aerospace Medical Division on January 1, 1962. The name was changed to 6570th Aerospace Medical Research Laboratories.

The emblem of the 6570th Aerospace Medical Research Laboratories was approved on December 13, 1962.


The Laboratory went through a major reorganization on November 22, 1965. The Biophysics Laboratory, Physiology Division, Multienvironment Division, and Biotechnology Division were all abolished. The Environmental Medicine Division, Life Support Division and Toxic Hazards Division were established. These three Divisions and the existing Biodynamics and Bionics Division were all placed under the existing Biomedical Laboratory. The Technical Editing Office, and the Library were assigned to the Technical Operations Office. The Biocobiology Branch was abolished and the Nutrition program was transferred to the School of Aerospace Medicine. Project 6301 was transferred to the School of Aerospace Medicine.

Col. Quashnock was transferred to the Aerospace Medical Division on June 13, 1966 and Col. Ray Yerg assumed Command of the Laboratory.

The Training Research Division of the Behavioral Laboratory was transferred to the newly established Air Force Human Resources Laboratory on July 1, 1966.

Col. Ray Yerg was transferred to Hq. USAF on August 1, 1968 and Col. Clyde Kratochvil assumed Command of the Laboratory.

Dr. J. W. Hein, the first civilian employee of the Physiological Research Laboratory, retired in August 1968 after 32 years service. Dr. Hein was hired by Captain Armstrong in June 1936.

The Laboratory was reorganized on September 1, 1968. The Behavioral Sciences Laboratory and the Biomedical Laboratory were abolished. The Biodynamics and Bionics Division, Human Engineering Division, Multienvironment Division, and Toxic Hazard Division were established.

The Laboratory management structure on 30 June 1969 included Biodynamics & Bionics Division, Environmental Medicine Division, Human Engineering Division, Support Services Division, Technical Operations Division, Toxic Hazards Division and Veterinary Medicine Division.
U. S. AIR FORCE AIRCRAFT
B-1, B-47, B-52, B-58, C-123, C-124, C-135, C-141
F-4, F-15, FB-111, F-16, F-101, F-104, F-106
T-33, T-37, T-38, T-39, KC-135
Manned Orbiting Laboratory (MOL X-29 (Dyna-Soar)

NASA SPACECRAFT
Project Mercury, Project Gemini, Project Apollo
X-15 Research Vehicle

CHALLENGING AEROMEDICAL PROBLEMS
- Environmental control standards for space cabins
- Abrupt accelerations for landing of manned space vehicles
- Human performance and mobility in weightless environment
- Human performance in rendezvous of two space vehicles
- Human tolerance to emergency thermal conditions in space
- Nutritional requirements for long term space flight
- Toxicological requirements of space cabins
- Operational validation of space pressure suits
- Human protection requirements for space radiation
- Human tolerance and performance during reentry flight
- Environmental noise standards for rocket engines
- Human tolerance to low altitude buffeting flight
- Training research requirements, simulation and personnel

PIONEERING ACHIEVEMENTS
- Aero medical crew selection program on thirty-two astronaut candidates for NASA, Project Mercury (AMRL, 1958)
- Establishment of Bionics program (Dr. von Gierke, 7221, 1959)
- Extended range aircrew fatigue study using a B-47, established a World record for non-stop jet flight: 39,000 miles in 80 hours (Mr. Dempsey, Capt. Van Wart, 7222, 1959)
- First operational full pressure suit (X-15) (Dr. Vail, 7161, 1959)
- Established Project Mercury reentry tolerance (Captain Clarke, 7222, 1959)
- Anthropological criteria for pressure suit evaluation (Mr. Alexander, 7222, 1959)
- Initiated research on design of remotely controlled devices, manipulators, and robots in anticipation of nuclear aircraft and space maintenance requirements (Mr. Baker, Mr. Crawford, Mr. Kanz, Captain Pigg, 7164, 1959)
- Developed frictionless devices based on concepts for air bearing cars, to simulate weightlessness in support of human engineering research related to anticipated space maintenance requirements (Mr. DeHonotl, Mr. Roes, Mr. Kanz, Mr. Riebley, Captain Pigg, 7184, 1959)
- Landing impact criteria for B-58 and B-70 crew escape capsules (Captain Headley, Mr. Brinkley, 7222, 1959)
- First Human Engineering Design Criteria Military Standard (Mr. Ring, Mr. Peagans, 7184, 1959)
- Spacecraft landing impact program (Project Mercury) (Mr. Brinkley, Captain Headley, 7222, 1960)
• High altitude emergency escape program. Captain Kittinger set new World record with a 102,400 feet free-fall parachute jump (Capt. Kittinger, Mr. Detoevery, 7222, 1966)
• Passive environmental control system, seven day human experiments (Mr. Keating, 8373, 1960)
• First quantification of the contribution of human performance to missile system test reliability (Mr. Baten, 7144, 1960)
• Space radiation shielding flights using Discoverer XXXII (Mr. Pittman, Mr. Speakman, 6301, 1963)
• Large scale community rocket noise survey of Cape Kennedy (Mr. Cole, 7231, 1961)
• Anthropometric survey of Turkey, Greece, and Italy (Mr. Hertzberg, 7184, 1961)
• Anthropometric survey of Japan and sizing program for Japanese pressure suit (Mr. Alexander, 7144, 1961)
• Vibration tolerance criteria for space flight (Dr. Coermann, 7222, 1961)
• Human ejection test of the B-58 capsule (Captain Clarke, 7222, 1962)
• Space Radiation Guide for designers of manned space vehicles (Mr. McGuire, Mr. Speakman, 7165, 1962)
• Spacecraft and Lunar Excursion Module landing impact program (Project Apollo) (Mr. Brinkley, Major Clarke, Captain Weis, 7222, 1962-1964)
• Life Support Environmental simulator, with four man capability becomes operational (Mr. Metzger, 6373, 1962)
• Nutritional requirements study of astronauts (Miss Finkelstein, 7164, 1962)
• Sponsored a technical symposium on “Remote Handling in Space” (Mr. Baker, Mr. Crawford, Captain Pigg, 7184, 1962)
• Joint services Human Engineering Guide to Equipment Design (Dr. Grether, Dr. Warrick, 7194, 1963)
• First training research on cross-cultural conduct skills for Air Force personnel (Mr. Snyder, 1710, 1963)
• Measurement of the effects of “body shock” during ejection acceleration (Project Gemini) (Mr. Brinkley, Captain Weis, 7231, 1963-1964)
• Thomas Dames toxicology research facility becomes fully operational (Dr. Thomas, 6302, 1964)
• Dynamic space rendezvous simulator program (Dr. Clark, Mr. Frost, 7184, 1964)
• Research program to develop perselective membranes for continuous carbon dioxide control (Mr. Keating, 8373, 1964)
• Initiation of the research program on helmet mounted sights (Mr. Bates, 7184, 1965)
• First multisensor real-time reconnaissance flight tests in conjunction with the Avionics Laboratory (Mr. Bates, Mr. Heckart, 7184, 1965)
• Conduct of Mission Panel #1, Manned Orbiting Laboratory, flight tests aboard JRB-47 aircraft with Dr. Fitz representing the Scientific Advisory Board. This was Dr. Fitz’s last participation in a Laboratory/Air Force program before his death in 1965 (Mr. Bates, 7154, 1965)
• First toxicology conference on Atmospheric Contamination in Confined Spaces (Dr. Thomas, 6302, 1965)
• First research program on toxicological qualification of Apollo, MOL, SKYLAB cabin materials in the Thomas Dames. This research was a two year program and included 500 materials either singly or in combination (Dr. Back, 6302, 1965)
• The lateral firing gun sight was developed. Firing tests were conducted in a C-47 at Eglin AFB Captian Simon, Mr. Flexman, 7184, 1965)
• Mobile laboratory measurement of acoustic noises from rocket nozzles (Mr. Cole, 7231, 1965)
• The Dynamic Response Index (DRI), an integrated mathematical measure of physiological response to abrupt acceleration, was developed for the Air Force ejection seat specification (Capt. Mohr, Mr. Brinkley, 7231, 1966)

• The Air Force escape capsule specification was modified to include the radial, a mathematical measure of physiological response to multivector abrupt accelerations. It was first used in the development of the F-111 capsule (Capt. Mohr, Mr. Brinkley, 7231, 1966)

• Established the physiological limitations for the development of the HC-130H aerial retrieval system and provided the medical support for human testing of the system (Capt. Mohr, 7231, 1966)

• Titan II propellant toxicity research program (Dr. Thomas, 6302, 1967)

• Development of first Helmet Mounted Sight (Mr. Bates, Mr. McKechnie, 7184, 1967)

• Development of the first successful constant volume jousts for full-pressure suits (Mr. Bowen, 7164, 1967)

• F-111 crew escape module landing impact program (Capt. Mohr, Mr. Brinkley, 7231, 1967)

• A new anthropometric survey of rated male officers was conducted. It included 3,069 men at nineteen different Air Force bases. (Mr. Clauser, 7184, 1965)

• Development of the magnetic pressure sealing closure for pressure suits (Mr. Rosenbaum, 7164, 1967)

• Vibration exposure, performance, and combat standards were adopted as national and international standards (Dr. von Gierke, 7231, 1967)

• Anthropometric survey of 1900 women in the Air Force (The findings furnished 137 dimensions for the design of clothing and personal equipment for women.) (Mr. Clauser, 7184, 1968)

• Joint AF/NASA study on the radiative-convective heat losses in Gemini and Apollo pressure suits (Mr. Ball, 7164, 1968)

• Study of human tolerance and safe exposure criteria for intense transient heat pulses such as would be encountered in rapid reentry from space (Majov Veghte, Capt. Cailin, 7164, 1968)

• Three Bionics Symposia with international participation were held at WPAPF and one symposium under AGARD auspices was held in Brussels, Belgium (Dr. von Gierke, Dr. Östtreicher, Col. Seelie, 7231, 1960-1968)

• First human test on the Dynamic Environmental Simulator (DES) was conducted on December 19, 1969. Dr. Michael McCally made four runs (Dr. McCally, 7222, 1969)

• Development of first Helmet Mounted Display (Capt. Brindle, Mr. Furness, 7184, 1969)

• Development of the partial pressure suit glove (Mr. Rosenbaum, 7164, 1969)

• Development of the Human Engineering System Simulator for multiparameter studies of command and control (HESS) (Dr. Topruler, 7184, 1969)

• First flight test of the Helmet Mounted Sight for air-to-air combat applications in conjunction with the U. S. Navy (Capt. Kocian, Mr. Furness, 7184, 1969)

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<td>Personal Protection</td>
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### FACILITIES

Acceptance of Vivarium Bldg 838 (1965)

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<td>Vertical Accelerator</td>
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<td>Heat Pulse Thermal Facility</td>
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<td>Fourth Human Centrifuge (DES)</td>
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<td>Instrumentation Laboratory</td>
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<td>Biochemistry Laboratory</td>
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<td>Flower Hot House</td>
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<td>Fish tank</td>
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<td>Lunar Landing Facility</td>
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**Flight Test Aircraft**

- KC-135 Human Engineering Division
- JHC-135 Human Engineering Division/Avionics Laboratory
- JWB-50 Human Engineering Division
- JRB-47 Human Engineering Division
- JC-131 Human Engineering Division

### OVERVIEW

The Laboratory had been in existence only twenty-four years when the challenge of manned space flight dominated the conversation, research, and funding. The Air Force had several programs in planning, research and development while the NASA was developing their own
program on a national scale. The NASA activity did not have adequate Biotechnology capability, and the Air Force was utilizing existing resources of the Laboratory to provide the level of capability needed. In addition, the Air Force manned aircraft programs were highly sophisticated with flight missions which reached the outer limits of human capability. Two aircraft, the B-1 and the F-111, were to be equipped with the new multipurpose emergency crew escape module system. The human engineering problems were at the threshold of technology due to air vehicle performance and the growing interest in avionics. This was truly the beginning of space flight research in all areas of the Laboratory. It was an exciting time.

This period also saw the escalation of warfare in Southeast Asia and a renewed interest in air-to-air and air-to-ground combat effectiveness. In 1966, many of the Laboratory programs were focused on weapon system support activities and classified combat programs. The majority of the work was devoted to rapid corrections of technical or combat problems based on the weekly briefings and technical assignments given to the Laboratory through the ASD Limited War Office. This office was the focal point for all engineering support and funding assigned to Wright Field. The Laboratory also provided biotechnology support to other agencies who had limited war assignments requiring physiological or psychological data. The Human Engineering Division activities were primarily in support of the urgent need for reliable near real time reconnaissance under poor weather conditions in a heavy jungle environment and the accurate delivery of aerial ordnance in close proximity to friendly forces. The Biodynamics and Bionic Division was involved in the communications problems encountered on combat missions and correction of the F-4 ejection seat spinal injury problems.

SELECTED PROGRAMS

At the request of NASA, the Laboratory conducted, over a seven week period, a special Crew Selection Program and astronaut training for all thirty-two candidates in Project Mercury. The candidates were processed through a series of tests designed to determine individual ability to withstand physiological and psychological stress. This test program revealed a few subjects were not suitable for the project. All candidates recommended by the Laboratory Crew Selection Program were also chosen by NASA. Each astronaut candidate underwent an altitude chamber test, acceleration test, high temperature test, and a performance check in the X-15 simulator. They were also flown in weightlessness maneuvers in the C-131B aircraft. Full pressure suits were used in all tests for familiarization and training of the astronauts (AMRL, 1959).

Using a B-47 aircraft with a three man crew, extended flight experiments on aircrew habitability and the explosive gorn conducted. Special equipment was designed and installed in the rear cockpit for this flight: the first inflatable ejection seat, a pulsating seat cushion, an inflatable back cushion, and a massaging G suit. The pilot in this special cockpit flew the aircraft and never got out of the seat for the entire flight. He was equipped with an electronic recording device which continuously transmitted his physiological status to the ground receiving equipment for analysis. This program established a new world's record for nonstop jet flight, 26 hours 36 minutes for a distance of 39,200 miles (Mr. Dempsey, Captain Van Wart, 7222, 1969).

The first landing impact tests of manned space vehicles using human subjects were made at the Inclined Test Facility at Wright Field. One hundred twenty drop tests were conducted using the Project Mercury simulator. Forty-one were made with the volunteer subjects in the rigid Mercury couch. The test program explored impact values up to 3 feet/secet terminal stopping in 5 inches (Captain Headley, Mr. Brinkley, 7222, 1959-1960).

Project Hermes, a closed circuit, integrated life support system capable of supporting one man for 7 days, was developed. An experiment using one human subject was conducted for 168 hours. This test used a passive atmosphere-chemical reaction principle involved potassium superoxide and proved the feasibility of using solid chemicals to maintain a life-supporting environment. This was a fundamental and dramatic demonstration of an alternate approach to environmental control (Mr. Keating, 6373, 1969).

Experiments to establish mass discrimination capabilities of maintenance personnel under simulated weightlessness conditions were conducted using frictionless devices (air bearings) and aircraft flying Keplerian trajectories (Mr. Rees, Ms. Copeland, 7184, 1960).

The Laboratory initiated a high-altitude emergency escape program in 1955. This five year program was designed to gather biotechnology data on escape at altitudes in excess of 100,000
The significant advances in aircraft flight speeds and the acceleration forces encountered during emergency escape required the development of mathematical analogs to depict the human response to impact, predict potential injury, and serve as an objective basis for protection system design and evaluation. This combined contract and in-house efforts studied the ejection seat acceleration environments and operational injury rates to verify the mathematical analog used to assess spinal injury. The spinal model was modified to account for operational experience. This model was incorporated into MIL-STD-9479, the specification for upward ejection seats, and MIL-C-25969B, the specification for enclosed escape systems. The Dynamic Response Index is now used throughout the escape system industry. It forms the basis for an Air Standard on acceleration limits used by the United Kingdom, Canada, Australia and New Zealand. (Mr. Brinkley, 7222, 7231, 1960-1975)

The 50 foot vertical deceleration tower became operational and was manned. This was an indoor test facility for studying the effects of abrupt acceleration on animal and human subjects. It used a fully programmable water piston decelerator. The drop carriage had an adjustable device to accept different types of seat support systems or animal supporting devices (Captain Clarke, 7231, 1961)

The Biosonic program developed a new mathematical technique for the analysis of human controller dynamics. A self-adapting controller program in remote systems was initiated. The term "biosonic" was coined by Dr. Jack Steele of the Laboratory. (Dr. Oestreich, 7231, 1961)

Equipment and facilities were developed to conduct realistic research on training of operator and maintenance personnel. The major facilities were an AN/APQ T-1 Radar Trainer, a modified AN/ASB-4 Bomb-Nav system, and a bench test set for the MA-2 Bomb-Nav system. Four studies were made that outlined system procedures for planning the needed personnel requirements and training aspects for weapon systems. In cooperation with the Air Training Command, a course on the fundamentals of electronics was automated and comparisons were made between conventional training and two techniques of automation (Mr. McNulty, 1710, 1961)

The second experimental model pressure suit from the International Latex Corp. showed a vast improvement over the previous model. The garment had a number of interesting features that could be considered for future use and product improvement. The bellows-type joints were of interest because they were applied not only to the legs and arms, but also to the hip, shoulder, and neck areas. The garment created considerable interest among those concerned with the capability of man to do useful work in orbit around the Earth and Moon (Mr. Bowen, 7164, 1961)

At the request of the Dyna-Soar Engineering Office, the Laboratory engaged in an investigation of five pressure suits. Data on ventilation, flow, and leak rates were compiled. Comparative data, such as suit weights and subjective comments on mobility and comfort were obtained. Critical anthropometric measurements were taken on each suit at 3.5 and 5 psi inflation pressures (Mr. Bowen, 7164, 1961)
A major facility, the Life Support Systems Evaluation, was designed by Laboratory project engineers. This facility, a four-man environmental test chamber allowed study of the technical feasibility of theories and principles of life support systems and system components. Two unique features that made the facility outstanding were a controlled and calibrated atmosphere tank, and a double wall construction permitting an area of lesser pressure around the interior environment, thus assuring that the atmosphere being researched was not contaminated by inboard leakage (Mr. Roundy, 6377, 1962).

Fit tests of the A/P 225-2 Full Pressure Assemblies were conducted at Tynall AFB. Preliminary results indicated the sizing program was highly successful. Anthropology Section's 8′-size, height-weight sizing program was used as the sizing specification for the pressure suit. Advantages afforded by the height-weight system were comfort of the assembly, accuracy of determining procurement tariffs, minimizing custom-tailoring, ease of issuing the correct indicated size (only pilot's height and weight were necessary) and coverage of the body size distribution of the USAF pilot population (Mr. Alexander, 7178, 1962).

In response to an urgent request from NASA, a series of studies were expedited exploring man's response to the impact forces associated with ground landing of the Apollo command module. One hundred human tests were conducted. Results were immediately applied to design of the Apollo vehicle (Major Clarke, Captain Veirs, Mr. Brinkley, 7231, 1962).

The development of an electrical analog of the ear was completed. Theoretical background, relative to speech recognition was formulated and intelligible speech compression to a bandwidth of 20Hz was demonstrated (Dr. Mundie, 7231, 1963).

Over 50 biotherm research experiments were performed in the Environmental Test Facility. Cardiovascular effects of steady state heat stress (100-160 F) were studied with catheterization techniques and correlated with biotherm responses. Human circulatory and temperature adjustments to extreme heat pulse (50 to 400 F at 180 F/min) were also measured. Using the new precision weighing system, the insensible weight losses of clothed resting subjects in comfort temperatures were measured and importance of ambient temperature control in human water balance during extended aerospace missions demonstrated. Experiments in extreme heat (110-160 F) to determine air flow temperature requirements for various prototype full pressure suits and range of unimpaired physiological performance were completed. In cooperation with NASA, several Gemini prototype suit evaluations were included. New predictive data useful in cold water immersion exposures were developed. These included both wet and dry clothing concepts and applied to both water and life raft exposures (Mr. Hall, 7164, 1962).

The Medical Electronics Section developed a telemetering technique for use in both human and animal studies. This system recorded ECG, impedance, respiration, and body temperature. This equipment can be used for telemetering physiological and associated data from space vehicles in extended flight missions (Dr. Markes, 7231, 1962).

Data from a program on radiation shielding for personal protection were assembled into a complete set of computer codes that described the geophysical radiation environment, mission trajectory of a manned space vehicle to the moon, the attenuation of vehicles having a 6 gram/sq centimeter structure, and the interactions of radiation with known materials. In addition, the biomedical tolerance of man to space radiation was obtained for use with these data. The program was augmented by a research contract that integrated this complete spectrum of data into a computer trade-off study of radiation protection concepts for shielding of astronauts. The computer programming employed subroutines representing discrete blocks of data that could be easily withdrawn and replaced, for example, with variations in mission trajectory, vehicle construction details, or new environmental data (Mr. McGuire, Mr. Speaksman, 7165, 1962).

A summary report of the results of a joint FAA-NASA-USAF study of community reactions to sonic booms was completed and a contract for continuation of the work for another two years was negotiated with the contractor. This work was designed to predict the type and extent of community responses to be expected from regular operations of supersonic transport aircraft. Information gained from studies of reactions to current military supersonic operations was expected to influence strongly the design and operation of future US supersonic transport aircraft (Mr. Cole, 7231, 1963).
Walking behavior during lunar and other low gravity conditions was analyzed with time and displacement measures of the lower limbs. Two subjects were photographed as they walked over a calibrated distance in an aircraft flying low gravity maneuvers. The inadequacy of proper body control in the region below 0.2 G tended to substantiate previous estimates of the lower gravity limit for walking (Capt. Simons, Major Brown, 7184, 1963).

The Training Research Division conducted an intensive study of the training requirements for USAF operations in limited warfare. The most important finding in this study was that USAF personnel were inadequately prepared for contact and work with people in other cultures. A major research program to develop techniques for training cross-cultural interaction skills was initiated (Mr. Snyder, 1710, 1963).

A jointly sponsored AF and NASA program was initiated to determine the energy, water, and protein requirements of man during the prolonged wearing of pressure suits and the superimposed stresses of isolation, reduced atmosphere, and heat. There were four experiments which lasted 27 days each. In each experiment, four subjects were confined in the Life Support Systems Evaluator. During the first 21 days of the experiment, each subject subsisted on a one day cycle of fresh, frozen and heat processed foods. The last 2 days of each subject was given a liquid nutrient refined diet providing 2,700 kilocalories per day (McConkey, 6573, 1964).

A dynamic visual space simulator was installed in the Laboratory. The simulator has a cathode ray tube to display the visual environment that an astronaut might observe through a porthole of a space vehicle with regard to the star background, earth horizon, and a target vehicle. A subject sitting in a simulated vehicle was able to interact with the simulated environment by controlling his vehicle in terms of 6 degrees of motion and 6 degrees of attitude. The simulation was in real-time and the visual dynamics simulate those of operational spacecraft (Dr. Clark, Mr. Frost, 7184, 1964).

The F-111 Crew Escape Module was a major advance in the design of high speed, multipurpose aircraft. This new developmental program required a detailed analysis of the acceleration environments generated during the ejection, aerodynamic deceleration and landing impact phases of the crew module escape sequence. The analytical techniques used to evaluate the environments employed the dynamic response analysis technique and the new acceleration radical as a developmental tool. Consultation was also provided on the design or other crew module components such as the restraint harness, the powered inertia reel, and the seat cushion. (Capt. Mohr, 7221, 1964).

Working with the Air Defense Command, self-study techniques for crew and refresher training were developed. The training consisted of three major items. First, there was a comprehensive series of multiple choice questions covering the subject matter with each question bearing reference to the page and paragraph of the manual. Second, there was a punch board where the students could determine immediately whether their answer to each question was correct or incorrect. Third, there was the manual to which students referred for information when they chose to correct their answer to a question (Dr. Eckstrand, 1710, 1965).

Emergency escape from the F-4 in South East Asia produced an abnormally high spinal injury rate of 90%. A research program was initiated to measure the pilot's spinal misalignment with regard to the Martin-Baker seat ejection thrust vector. With this information and the application of Dynamic Response Index (DRI) technique, changes in the thrust of the ejection catapult were recommended. This action led to a reduction of the spinal injury rate to approximately 12% (Major Mohr, 7231, 1966).

In the area of toxicology, 90 day continuous inhalation exposures to trace contaminants were started on N204, hydrazine, decaborane and UD912 using monkeys, rats, and mice. The toxicity of pyridoxamine and L-arginine were determined with possible use for therapy of hydrazine intoxication in mind. Six newly synthesized fluorinated benzene polymers were tested for acute toxicity parameters. Two of them, pentafluorophenylhydrazine and pentafluorophenol, possessed an appreciable toxicity having LD50's of 160 and 130mg/kg, respectively. Thirty new propellants and chemical intermediates were screened for toxicological and industrial medicine information. This work helped identify hazardous operations during synthesis, analysis, purification, testing, and firing phases of new liquid and solid propellants (Dr. Back, 6302, 1966).
The Laboratory participated in the development and demonstration of the HC-190H ground-to-air retrieval system. The work included medical consultation on system design, subject selection, medical monitoring and consultation of the test results. After approval of the test protocol, a series of real-in-rent tests, using human subjects were conducted with the HC-190H aircraft. The successful demonstration of the ground-to-air personnel retrieval system was completed when six volunteer subjects were picked up. The tests with humans were accomplished after a series of qualification tests with anthropomorphic dummies. (Major Mohr, 723, 1966)

Subsequent to the escalation of hostilities in South East Asia, the Laboratory human performance exploratory and advanced development programs in the area of recombinant/strike were oriented from strategic emphasis to tactical. The human performance problems associated with multisensory hunter-killer concepts as employed in a limited war environment were investigated at length within the laboratory and by use of airborne flight test programs. The studies focused on target acquisition utilizing a wide variety of sensors including unaided vision, infrared, low light level television, light amplification devices (such as sniper scopes), laser line scanner and side looking radar (Dr. Selr, Mr. Porterfield, Mr. Bates, 7184, 65A, 1966)

A five year study of animals exposed to multiple acute doses of rocket motor exhaust products containing beryllium was initiated. This work in the area of propellant toxicity was particularly significant to the Air Force because it dealt with the characterization of environmental pollution from storable intercontinental ballistic missiles and other large boosters (Dr. Back, 6302, 1967)

A JWB-5D aircraft was acquired by the ASD Test Wing in early 1966 to support human factors test requirements in support of the Program 665A Tactical Near Real Time Reconnaissance (TAC NRT Recce). The aircraft was selected as a flight test platform because the nose observation window and the side scanner windows were conducive to the accomplishment of unaided visual human performance experiments. The complement of receive equipment included a AN/APS-96 Side-Looking Radar (SLR) with Moving Target Indication, a Beconfax VI downward-looking Infra Red set, a modified R-46 Aerial Strip Camera, two K-17 Aerial Frame Cameras, a CA-112 Aerial Frame Camera, and an experimental subject scoring system. The purpose of this test program was to gather in-flight data on human performance in the airborne detection and recognition of tactical targets with unaided vision and with Infrared and Radio displays and to collect IR and SLR imagery of tactical targets in a simulated South East Asia (SEA) environment. In order to better simulate the SEA vegetative environment and with appropriate targets the aircraft was deployed for the nomal of July, 1967 to Howard AFB, Panama Canal Zone, and operated with gratifying success. This aircraft was the last JWB-50 to fly for an Air Force unit and was retired to the Air Force Museum upon completion of the test program. The project pilot, Major Ernest P. Hanavan Jr., was formerly assigned to the Human Engineering Division (Mr. Bates, Mr. Heckart, Mr. Porterfield, 7184, 65A, 1967)

Using a special bio-thermal test facility, pioneering research information was obtained concerning human physiologic response to the hazards of high intensity aerospace thermal environments which may occurred at supersonic planes and space flight and during emergencies in such environments. Temperatures ranged from 70°F to 60°F (21°C to 12°C) with special emphasis on the range of 200°F to 400°F. A critical need to precisely determine safe human tolerance to these extreme heat stresses existed since at these high temperatures time exposure differences of 60-120 seconds could represent a difference between more discomfort and painful, disabling burns. Peak exposures of 400°F for 3 minutes for Major Veghte, and 392°F for 2 minutes for Captain Callin were recorded on September 10, 1969. (Major Veghte, Captain Callin, 7184, 1969)

Considerable progress was achieved in the speech-sounds recognition program. Working with an electronic model of the inner ear, the scientists developed a word recognition system for simulation by a computer. Accuracies of 95-99% in word recognition from a 15 word vocabulary were achieved. (Dr. Mundie, 7233, 1969)

Alternative designs for fasteners proposed for space systems applications were evaluated using the Air Force Propulsion Laboratory's 80-degree-of-freedom device to simulate zero gravity effects. (Mr. Martin, Mr. Crawford, Mr. Kama, 7184. 1969)

The Dynamic Escape Simulator (DES) was completed in early 1969. Engineering checkout tests were conducted and preliminary operation of the simulator continued throughout the remainder of the year. On December 19, 1969, Dr. Michael McCaII made the first human tests on the
DES. There were four runs in this series. This completed the maserating of the new centrifuge. (Dr. McCully, 7222, 1969)

The Human Engineering Division initiated the development of a computer-centered, real-time simulator to study man-machine system problems. This Human Engineering System Simulator (HESS) was an IBM 360-60 computer with 266K storage capacity, later expanded to 912K memory. It was used to conduct the multigenera control and control simulation in support of the AWACS aircraft. (Dr. Tonnellier, 7184, 1969)

AWARDS

1969  Major Elizabeth Guild  Air Medal
1969  Mrs. John Cole  Arthur S. Fleming Award
1969  Mr. Don Rosenbaum  ASD Outstanding Inventor
1969  Captain Joe Kirkinger  Aerospace Primer Award
1969  Mr. John Cole  AEP B&D Award
1969  Dr. Henning von Gierke  AEP R&D Award
1969  Dr. Henning von Gierke  DOD Distinguished Civilian Service Award
1969  Major Jim Veghte  AF Commendation Medal
1969  Dr. Walter Grether  Franklin V. Taylor Award
1965  Major John Simons  AF Commendation Medal
1965  Major John Simons  Legion of Merit
1966  Mr. Thomas Furnas  Colonel Knight Award
1966  Dr. Julian Christensen  AFA Citation of Honor
1966  Dr. Henning von Gierke  Eric Liljenbahr Award
1966  Dr. Julian Christensen  Exceptional Civilian Service
1966  Dr. Walter Grether  Exceptional Civilian Service
1966  J. P. A M R L  AF Outstanding Unit Award
1967  Dr. Anton Thomas  Exceptional Civilian Service
1967  Captain George Mohr  AFSC Surgeon of the Year
1967  Mrs. Molly Pinderen  Meritorious Civilian Service
1967  Mr. Jim Brinkley  NSPE Engineer of the Year
1968  Mr. Jim Brinkley  Meritorious Civilian Service
1968  Dr. Jim Van Stee  NASA Science & Eng Award
1968  Captain George Mohr  Gen. Hoyt Vandenberg Trophy
1968  Captain George Mohr  USAP R&D Award
1969  Major John Simons  Legion of Merit (Oak Leaf)
1969  Major Jim Veghte  Aerospace Primer Award
1969  Captain Grant Callin  Aerospace Primer Award
Fig IV-1 Scotty Crossfield wearing the first X-15 full pressure suit (XMG-3 DC) with a modified MA-1 helmet.
Fig IV-2  C-131B aircraft modified into a weightlessness laboratory for human engineering research.
Fig IV-3  Mercury astronauts after weightlessness flight.

Fig IV-4  Mercury astronaut John Glenn in weightlessness flight training.
Fig IV-6  Mercury astronaut in the heat chamber

Fig IV-7  Mercury astronaut in the Physiology Laboratory.

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Fig IV-8  Mercury astronaut in the intense noise chamber.

Fig IV-9  Mercury astronaut in the altitude chamber.
Fig IV-10  Mr. Alexander taking anthropometric measurement on an inflated pressure suit for establishment of cockpit dimensions.
Fig IV-11  Inclined test facility at Wright Field. It was used in the first landing impact studies of the Mercury spacecraft.
Fig IV-13  Human subject in Mercury couch mounted on a simulated impact attenuation device of the NASA Mercury spacecraft.
Fig IV-14  First C47 used in the development of lateral firing guns program at Wright Field.
Fig IV-15  Dr. Ed Vail serves as test subject in the first centrifuge tests of the Apollo pressure suit.
Fig IV-16  Captain George Mohr supervises the vibration test of the Apollo seat position while the subject wears the pressure suit.
Fig IV-17  Abrupt landing impact tests of the Apollo seat using the vertical drop tower.
Fig IV-18  First operational tiltable ejection seat which was used in extended range flight experiments. The pilot did not leave this seat for 80 hours.
Fig IV-19  This B-47 established a new world record for non-stop jet flight, 30000 miles in 80 hours. The pilot remained in the tiltable ejection seat for the entire flight.
Fig IV-20  Captain Joe Kittinger at 102,400 feet in a free fall parachute experiment. He established a new world record in 1960 that has not been broken.
Fig IV.21  AMRL radiation protection experiment. Launched on Discoverer XXXII into polar orbit in 1961.
Fig IV.23 Fourth human centrifuge at Wright Field, 1969. This is the first USAF machine to have closed loop control for flight simulation.
Fig IV-24  Dr. VonGierke conducts a human equilibrium experiment in an intense sound field.
Fig IV-26  Dr. Thomas designed the new Thomas Domes in the toxicological research facility in Bldg. 79.
Fig IV-29  First helmet mounted sight was designed and tested in the Laboratory.
Fig IV-30. The JWB-30 aircraft used in human engineering tests of reconnaissance equipment in Panama.
CHAPTER FIVE

ADVANCED FLIGHT RESEARCH
1970-1984

ORGANIZATION AND COMMAND

The Holloman Aeromedical Laboratory, its daisy decelerator, related equipment, and nine personnel were reassigned to the 6570th Aerospace Medical Research Laboratory on July 1, 1970.

Colonel Holt was appointed Commander, 6570th Aerospace Medical Research Laboratory on August 24, 1970.

The Technical Advisor Office was abolished in October 1971.

Mrs. Mae (Calam) Poszywak, retired from the Air Force in 1971, after 32 years of service. She was the second civilian employee and the first full-time stenographer to be hired by Captain Armstrong in June 1939. Mrs. Poszywak had been responsible for all the administration activities in the Aero Medical Research Unit.

Mr. John Hall retired from the Laboratory in 1971, after 32 years of service. He was the third civilian employee to be hired by Captain Armstrong in September 1939. He worked as a physiologist in the Aero Medical Research Unit in the basement of Building 16.

The Laboratory was authorized a Vice Commander position in March 1972. Colonel Doppelt was appointed the first Vice Commander of the Laboratory.

Colonel Doppelt was appointed Commander, 6570th Aerospace Medical Research Laboratory in 1973.

Mr. Raymond U. Whitney retired from the Laboratory in June 1973, after 36 years of service. He was permanently assigned to work with Captain Armstrong in the Physiological Research Laboratory in 1937. He participated in the pioneering altitude chamber experiments, working directly with Dr. Armstrong. He also flew with Captain Armstrong in the pressurized cabin experiments in the XC-35 airplane. He was the first person in the Physiological Research Laboratory to receive the Distinguished Flying Cross for pioneering work in the altitude chambers. He also participated in the attitude tests of the B-58 oxygen mask with Dr. Lovelace and Dr. Boothby in 1938. Dr. Lovelace, Dr. Boothby and Dr. Armstrong received the Collier Trophy for this research and development work.

Dr. Walter Grether retired from the Laboratory in June 1973 after 32 years of service. Major Grether was the first officer assigned to work with Lt. Col. Paul Fitts, founder of the Air Force Engineering Psychology program. Fitts and Grether organized and developed the broad based human engineering research program.

Dr. Melvin Warrick retired from the Laboratory in June 1973 after 31 years of service.

Dr. Julian Christensen retired from the Laboratory in 1974 after 33 years of service. Mr. Charles Bates replaced him as Chief, Human Engineering Division.

Mr. Ernest Martin retired from the Laboratory in 1975 after 33 years of service. He was called to active duty in the Aero Medical Research Laboratory as an aviation physiologist. He worked
In the original altitude chambers located in the basement of Building 15, the site of the Physiological Research Laboratory.

Colonel DeHart was appointed Commander, 6570th Aerospace Medical Research Laboratory, in 1976.

The Navy Medical Research Institute established a Toxicology Detachment, in the Laboratory in July 1976.

In April 1977, there was a reorganization and renaming of the Biodynamics and Biomechanics Division. These changes included: the new name, Biodynamics and Bioengineering Division, abolishing the Neurophysiology Branch, expanding the mission of the Biomechanical Protection Branch, and the Biodynamic Effects Branch, establishing a position of Director, Plans and Programs, in the Division office.

A functional and organizational realignment of the Environmental Medicine Division was accomplished on July 15, 1977. These changes included: the new name, Manmade Systems Effectiveness Division, expansion of the mission of the Systems Technology Branch, the Analysis and Simulation Branch, the Simulation Support Branch, and abolishment of the Environmental Physiology Branch.

A Technical Services Division was established in September 1977. That action consolidated the Technical Operations Division and Support Services Division.

The Laboratory organizational name was changed from 6570th Aerospace Medical Research Laboratory to Air Force Aerospace Medical Research Laboratory, in 1979.

The Laboratory was reorganized in May 1978. The Manmade Systems Effectiveness Division was abolished, its research programs were distributed between the Biodynamics and Bioengineering Division and the Human Engineering Division. The Laboratory now had four operating divisions: Biodynamics and Bioengineering, Human Engineering, Toxic Hazards, Technical Services, and Veterinary Sciences.

Colonel Mohr was appointed Commander, Air Force Aerospace Medical Research Laboratory, in May 1980.

In 1982, two new Advanced Development Program Offices were established for management of the 6.7 program: Crew Automation Technology (CAT), and the Crew Escape Technology (CREST).

**U.S. AIR FORCE AIRCRAFT**

F-4, F-5, F-15, F-16, F-106, F-111, B-1, B-52, C-141, C-5A
C-5B, C-130, KC-10, KC-135, SR-71, T-37, T-38, T-39, T-41
U-2, AFT-16

**NASA SPACECRAFT**

APOLLO, SPACELAB, SPACE SHUTTLE

**CHALLENGING AEROMEDICAL PROBLEMS**

- Fully automated cockpit technology
- Voice control of cockpit functions
- Toxicology of rocket fuels in people and plants
- Visual standards of aircraft windshields
- Chemical defense modeling of human capability
• Establishment of aircrew workload standards
• Human operator modeling of AAA threats
• Computer modeling of anthropometrics for workspace design
• Open cockpit seat technology with protection to 1600G
• Computer modeling of escape system performance
• Secure tactical communications
• Environmental noise modeling for land use planning
• RPV multipilot real-time mission simulation
• High acceleration cockpit development
• Strategic systems crew station design
• Human engineering design of command and control systems
• Crew survivability/Vulnerability model for weapon systems

PIONEERING ACHIEVEMENTS

• DES-modified into a closed-loop gurney simulator (Mr. Varlappas, 72-31, 1970)
• High Acceleration Cockpit research program initiated (Mr. Kulwski, 71-84, 1970)
• First airborne qualified Helmen Mounted Display (Capt. James Brindle, 71-84, 1970)
• Development of “stickman” computer model (Dr. Kreximer, 71-84, 1970)
• Initiation of the Optical Counter Measures program (Dr. Repple, 83-1G, 1970)
• Development of drawing board manikins for NASA design program on the Space Shuttle (Dr. Kennedy, 71-84, 1970)
• Abrupt acceleration research program using automotive air bag restraints (AFDOR) (Mr. Boothby, 72-31, 1971)
• First flight tests of the Helmet-Mounted Sight at Tysdall AFB (Mr. Furness, 71-84, 1971)
• Completion of the first experiments involving combined heat, noise, and vibration stress using the DES (Dr. Gether, 71-84, 1971)
• SACDEF strategic mission simulation program (Mr. Sharp, 71-84, 1971)
• First centrifuge demonstration of pilot capability to withstand +8Gz in the F-15 cockpit configuration (Colonel Mohr, Dr. Levieth, 72-31/75-20, 1971)
• First computerized Anthropometric Data Bank established of U.S. military populations and allied military population (Mr. Coassen, 71-84, 1972)
• Development of the Systems Analysis Integrated Network of Tanks (SAINT). First man system model for predicting nuclear SV effects, is used worldwide in man-machine simulation research programs (Dr. Chubb, M.S. Seifert, 71-84, 1972)
• The impulse accelerator mannequin as an impact test facility in Bldg 824 (Mr. Brinkley, 72-31, 1972)
• The largest scale habitation exposure study ever performed in the THRU facility initiated to establish oncogenic dose-response to hydrazine, antimonydial dimethylhydrazine and monomethylhydrazine (Dr. Rake, 83-05, 1972)
• Flight tests of the Long Line Loiter program successfully completed (Captain Simoes, 71-84, 1972)
• Visually Coupled Aids research organized into a 6.4 program (Project 5970) (Mr. Bates, 71-84, 1972)
• The Helmet Mounted Sight successfully demonstrated in combat flight maneuvers and weapon launches at Tysdall AFB (Mr. Furness, 71-84, 1972)
• The first real-time multipilot RPV mission simulation conducted using five operators (Dr. Mills, 71-84, 1972)
• The SIXMODE a large six degree of freedom vibration table manned (Captain Wilborn, 7231, 1973)
• First computerized graphics of anthropometric data for use in aircraft design (COMBIMAN) (Dr. Kroemer, 7184, 1974)
• First comprehensive research effort on the toxicology of halogenated fire extinguishing agents completed (Dr. Back, 6302, 1974)
• First flight test of Visually Coupled Airborne Systems Simulator (VCASS) for air-to-air missile control (Captain Kocio, 5973, 1974)
• AMRL AFFDL ASD ENC planning study and program plan for new advanced escape system (CREST) (Mr. Brinkley, Mr. Dempsey, 7231, 1975)
• F-16 canopy off windblast studies (Major Kendall, 7231, 1976)
• NOISEMAP transitioned to AFSEC (Mr. Cole, 7231, 1977)
• Motion cues research program for the design of flight simulators (Mr. Martin, 7184, 1977)
• Studies of the influence of fuselage proximity on limb fail forces, wind tunnel tests to Mach 1.2 (Mr. Specker, 7231, 1978)
• Development of human performance model for anti-aircraft threat systems (Dr. Replogle, 6893, 1978)
• The Visually Coupled Airborne Systems Simulator (VCASS) feasibility demonstration (Mr. Kocio, 7184, 1978)
• Chemical defense research program (Dr. Replogle, 2729, 1979)
• F-16 EPU hydrazine hazard analysis (Colonel Carter, 6302, 1979)
• F-111 windscreens standards established (Mr. Welde, LtCol. Genco, 7184, 1979)
• Transition of NOISECHECK technology (Mr. Cole, 7231, 1979)
• Nationally accredited animal facility with laminar air flow for lifetime holding of animals; annual animal population 12,000 (Colonel Bockmeier, 1979)
• Electronic high-output rate G valve (Mr. Vastlumen, 7222, 1981)
• First initiative on C3 operator performance program (COPE) (Captain Potraski, 7184, 1981)
• Voice communication research and evaluation system (VOCRESS) (Mr. McKinley, 7231, 1981)
• Initiation of operator workload assessment program (Colonel O'Donnell, 7184, 1981)
• Effects of optical countermeasures on target acquisition (Captain Tuin, 6893, 1982)
• Interim factor X standard (Dr. McDaniel, 7184, 1982)
• Threshold Exposure Limits Recommendations for JP-10 fuels (D. Back, 6302, 1982)
• Tactical Communications research program (Dr. Moore, Mr. McKinley, 7231, 1982)
• Voice control is flight tested in the AFTI/F-16 aircraft (Dr. Moore, 7231, 1982)
• Establishment of objective strength-selection criteria for all Air Force enlistees (Dr. McDaniel, 7184, 1982)
• Night vision goggle leads up display (Dr. Task, Mr. Craig, 7184, 1983)
• Established strength and endurance capabilities of men and women to operate aircraft controls (Dr. McDaniel, 7184, 1983)
• Visual Function Tester developed and flown aboard the space shuttle (LtCol. Genco, Dr. Task, 7184, 1984)
### PROJECT NUMBERS  TITLES

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<th>Toxicity of AF Chemicals and Materials</th>
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| 6.2  | 2729   | Chemical Defense Analysis               |
|      | 6302   | Toxic Hazards of Propellants and Materials |
|      | 6373   | Equipment for Life Support in Aerospace  |
|      | 6893   | Crew Factors in Countermeasures and Threat |
|      | 7164   | Thermal Effects and Altitude Protection |
|      | 7184   | Human Engineering for Air Force Systems  |
|      | 7222   | Simulated Stress Environments            |
|      | 7231   | Biomechanics of Air Force Operations      |

| 6.3  | 2722   | Chemical Defense                         |
|      | 2829   | Cockpit Automation Technology (CAT)        |
|      | 2866   | Crew Escape Techniques (CREST)             |

| 6.4  | 5973   | Visually Coupled Aids                     |

### FACILITIES

- Evans & Sutherland Picture System  
  Building 33
- Neuroradiometer  
  Building 33
- Dynamic Environmental Simulator  
  Building 33
- MPSS Simulator  
  Building 33
- C3 Threat Simulator  
  Building 33
- SAM Simulator  
  Building 33
- AAA Simulator  
  Building 33
- Roll-Axis Tracking Simulator  
  Building 33
- Visual Flight Research Simulator  
  Building 33
- Flight Simulation Laboratory  
  Building 33
- Motion-Base Simulation Facility  
  Building 33
- Dynamic Strength Test Cockpit  
  Building 33
- Heracles  
  Building 33
- Beckman TOXSYS Automated Record System  
  Building 79
- Thomas Dome  
  Building 79
- Toxic Hazards Research Unit  
  Building 79
- Necropsy Room  
  Building 79
- Contrast Sensitivity Measurement Lab  
  Building 106
- Visual Evoked Response Laboratory  
  Building 199
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THE LABORATORY PROGRAMS

OVERVIEW

The technical direction of Air Force weapon system development began to make a fundamental change in this period. This change was as dramatic as the shift from propellers to jets in 1946. The change at first was slow and almost imperceptible, but it began to accelerate in the first three years and became a full fledged storm around 1975. The change was entirely based on the advent of low cost, highly reliable, computer technology. The engineering community at Wright Field was quick to exploit and further develop this fast moving technology.

This technical advance had two major elements that would significantly drive the overall technical program of the Laboratory. The first element was the explosive advance in avionics technology. Avionics achieved a breakthrough in design, production and reliability which had a direct effect on military aviation. The mission capability of the weapon system was now measured in inches rather than yards from the target. Target acquisition, threat warning, and jamming in real time became a mission reality instead of a hit and miss proposition. Human performance was now pushed to the limit and combat aircrews were often overwhelmed with information processing and decision making. The avionics technology also opened up new approaches for human engineering to evolve technology that would improve the pilot’s performance and reduce his workload. The Human Engineering Division did outstanding work in managing this major technology change, pursuing new initiatives, and supporting the engineering community.

The second element was the rapid advance in aircraft design and propulsion technology. The new computers permitted preliminary and detailed aircraft design work, structural analysis, and the integration of aerodynamics and propulsion technology. Sophisticated graphics packages permitted real time simulations of flight profiles, structural loadings, and pilot interactions. All of this work could be accomplished in the Laboratory. The need for construction and testing of many major subsystems parts was greatly reduced. This new capability for design engineers produced advanced weapon systems with performance envelopes which were at or beyond the border of human tolerance to the physical environment. Significant increase in cruise airspeeds made ejection and windblast limits often beyond human tolerance. These speeds with excess thrust capability at all mission points made 9G combat turns a routine maneuver instead of an accidental event. More powerful engines also created new problems in community noise.
The AMRL response to this computer-driven change in technology was a gradual realignment of the technical program. This realignment process necessitated a restructure of the overall technical program into packages identified as thrust, core and support. The manpower and funding resources had to be adjusted to meet the challenge. This shift in program began to create centers of technology with specific goals. The thrust goal was aimed at the future weapon system developments and technology with specific endpoints. The core programs were basic technology that would in a more relaxed time frame provide new knowledge to the thrust program. The support program was the quick assistance to the engineering world when technology advanced at a faster pace. Within all the Laboratory research programs there was also a shift to the use of computer technology. There was significant growth in in-house simulators and they rapidly became more sophisticated and very complicated research devices. Biotechnology modeling was introduced on a grand scale for both human engineering and physiology. Human testing was no longer "cut and try" but more of a prediction with limited testing at certain junctures to check data validity and verify future postulates. In 1946, a subject would ride an ejection seat up the 100 foot ejection tower on the side wall of the static test building. Major attempts were made to gather reliable acceleration and physiological data during the rather brief event. Today the Laboratory is able to computer model the entire event and watch the computer graphics present every body motion in slow time. This computer modeling also permits exploration into an area where the environment or circumstance would be fatal for actual human test. This major technology advance did one other thing; it permitted the application of biotechnology data in specific quantitative terms similar to engineering data. Biotechnology was now on a par with the engineering world and in many instances exceeding them in knowledge.

The greatest impact of this computer revolution was on the Human Engineering Division. They did a superb job of managing the change and focusing their research program on the reality of the need that was being thrust upon them or a daily basis.

The Aerospace Medical Division established a new policy of developing and managing advanced development programs. They created an Advanced Development Directorate and initiated new technical programs. Three of these programs were assigned to the Laboratory. Advanced Development Program Officers were formed in the Laboratory and personnel were assigned to the programs.

The Laboratory Commander initiated a fundamental change in the technical management of the Laboratory programs. Under his direction and leadership the Laboratory for the first time in its history was automated through the use of computer technology. The technical program was repackaged into major thrust and core technology. This activity was carried down to the workload level. This change was then integrated into a computerized management information system. The Laboratory level Management Information System (MIS) permitted comprehensive planning, program adjustment, and accurate tracking of the funding and manpower resources. It also permitted daily review of any significant changes that were occurring in the program. The Commander and Technical Council could now take effective action on any problems which might arise prior to the development of a major impact on Laboratory resources. The major thrust efforts also spurred the Laboratory to compete with the overall future direction of the Air Force and the engineering planning agencies in a more timely manner.

SELECTED PROGRAMS

The DES was modified to provide closed loop control up to 7.5 ft. This increased capability permitted new research on human performance in chemical defense, advanced light vehicle performance, and the testing of technical problems in aircraft design or flight missions (Mr. VanPatten, 6803 1970).

Anthropometric research was initiated on a program to develop computerized models of the man to be used in the support of aircraft design (COMBIMAN). The effort included as an objective the acquisition of data on functional body-segment length and the measurement of paths of movement of body-segment joint centers. Other objectives sought to determine segmented masses and centers of mass of human body segments as well as to determine bone density and the digital angular lengths. Measurements were also to be made of muscle strength as the body in typical use of flight controls (Dr. Rosenmeier, 7184, 1970).

The High Acceleration Cockpit (HAC) program was initiated to significantly improve pilot performance and the cockpit working environment of advanced design fighter aircraft. Those
aerospace beyond the F-15 had the capability for sustained +9 G combat turns and excess thrust availability. This flight environment exposed the pilot to multiple acceleration situations on a single flight. He would now spend significantly more time flying and fighting in the high acceleration environment. Using the tiltrack seat concept introduced in the F-16, a high technology cockpit was evolved. This cockpit optimized the pilot working environment and provided the opportunity to ameliorate the acceleration effects. The research program was transitioned to the FDL 6.3 advanced development program on the AFTI/16 (Mr. Kulwicki, 7184, 1070).

The helmet mounted sight completed 27 successful flight tests in the F-101 and 71 tests in the F-106. These tests flown at Tyndall AFB Florida, were used to determine the utility of the HMS under high G conditions in acquiring and tracking a target. Live missiles were launched in this program. The success of this program led to the authorization in February 1971 of Project 5973, Visual Coupling Aids. This new 5.4 program enabled the Laboratory to perform the engineering development of visual-coupling aids for fire control, weapon delivery, reconnaissance, navigation, and flight control applications (Mr. Furness, 7184, 1971).

A major milestone in the National Highway Safety Program was achieved with the completed 35 impact tests using volunteers to determine the efficiency of automotive air bag restraint system during simulated automobile barrier crashes at velocities up to 30 MPH. The air bag system consisted of a pneumatically deployed double bag that was designed to be positioned under the instrument panel of a passenger car. No injuries or mechanical failures were experienced during this program and audiometry tests of human subjects proved that the intense low frequency impulsive noise associated with air bag deployment posed no risk of hearing loss. This series of tests were the first to use human subjects with a near-production prototype air bag restraint that did not require the use of a lap belt (Mr. Brinkley, Dr. Nixon, 7237, 1971).

At the request of Brigadier General Bellis, Director, F-15 SPV, AMRL/USASFA conducted a research program to determine human capability to the higher operational accelerations in new combat tactics. Wearing standard personal protective equipment, and seated in a simulated F-15 cockpit position, thirteen subjects were exposed to +9 G for 45 seconds. Using a physiological straining maneuver in conjunction with their G-suit inflation, these subjects tolerated the high acceleration without loss of central vision. This program represented a record achievement for tolerable acceleration exposure. These data were used in the first preliminary design of the F-15 airplane (Colonel Mohr, Dr. Leverett, 7227/7228, 1970).

Representatives from AMRL and Surgeon General’s Office met at WPAPF and completed the revised AFFR 160-8, Hazardous Noise Exposure. The revised regulation was broadened in scope to include criteria for limiting exposures to infrasound, ultrasound, and impulse noise as well as the normal audio range noise. Criteria were spelt out for minimizing hearing damage risk, interference with communication, and undesirable whole body effects. It is also provided for the simplification and improvement of procedures for evaluating ear protector performance and noise hazards (Dr. Von Gierke, Dr. Nixon, Mr. Cole, 7201, 1971).

The Laboratory established an extensive anthropometric data bank. This computerized effort stored data from 11 anthropometric surveys of U. S. military populations and 7 surveys of allied military populations. The data included dimensions on more than 50,000 subjects, including about 2,000 women. This international data bank was a first in the field of anthropology. It has provided the capability to use standard computer programs for carrying out a wide variety of data analyses, such as correlation, multiregression, factor analysis, and generation of bivariates and trivariates. It is also provides for the development of sizing systems based on key dimensions (Mr. Clauser, 7184, 1972).

The Visually Coupled System (VCS) has its genesis in two highly related efforts: the Helmet Mounted Sight (HMS) and the Helmet Mounted Display (HMD). The functions of the HMS are to provide wide off-bore sight weapon aiming, short reaction times, hands-free head-tracking and allow natural use of the head tracking abilities. It does this by projecting a sight reticle on the pilot's visor, measures the line of sight of the reticle and outputs the line of sight to applicable aircraft subsystems. The HMD receives video signals from aircraft subsystems, generates an image on a small cathode ray tube and projects the image to the pilot's eye. The HMD provides the advantages of a large screen head up display, sufficient image quality and can be continuously
presented with no requirement for instrument panel space. Combining the two technologies in effect "couples" the visual display system and improves the use of the visual system as a control mode also. It yields a low cost visual fires control system and increases the effectiveness of existing weapons as well as provides new ways of accomplishing traditional functions of navigation and target acquisition. (Mr. Bates, Dr. Furness, 7184, 5973, 1972)

Flight tests of the Long-Line Loiter program were successfully completed at Eglin AFB, Florida. This program demonstrated a point of delivery and pick-up system from a stationary point on the ground and at another location on the same system. The flight tests demonstrated the system to be effective and reliable.

Remote Piloted Vehicles (RPV) began to evolve as a fundamental weapon system which could be used against highly defended targets. In such military missions, the use of multiple RPV in a single attack presented a major opportunity for mission success. The use of such a flight formation at low altitude in a highly jammed aural environment, had never been attempted by the Air Force. At the direct request of the RPV System Program Office, a multipurpose real-time RPV mission simulation was conducted at the HESS. This research used five operators, individually flying their own RPV, in a mass formation with four microwave corrections to specifically designated targets. The narrow band communications link and jamming were also used in this simulation. The result of this work was presented to the RPV System Program Office (Dr. Mills, 7184, 1972)

NASA requested research on long term toxicity of methyl isobutylketone and freon 113 under conditions of continuous exposure in space cabin atmosphere. Both of these solvents had been found in vapor form in the cabin atmosphere of Apollo flights (B. Back, 6302, 1974)

The largest scale inhalation experiment ever performed in the Toxic Hazard Research Unit (THRU) was initiated to establish oncogenic dose-responses to hydrazine, unsymmetrical dimethylhydrazine and monomethylhydrazine. The experiments involved six months to one year exposures of mice, rats, hamsters, and dogs to graded concentrations of each missile fuel and lifetime post-exposure holding of animals. Complete histopathological work-up involved the evaluation of over 300,000 tissues according to the protocol designed by the National Cancer Institute. The exposure period for the three fuels covered a three year span, with histopathology completion date in CY1977 (Dr. Thomas, 6302, 1974)

APARML, AFFDL, and ADI/ENEC initiated a planning study and program plan for the development of one or more space shuttle compatible systems that would meet the tactical requirements of future weapon systems. This program provided for a 6.2 research program which then would transition into a 6.3 advanced development program. The results of this test activity would transition to a 6.4 engineering development program. The specific technical programs in all programs element areas were identified along with schedules and resources. The results of this work became the 6.3 program CREST (Mr. Breckley, Mr. Dempsey, 7231, 1976)

This research evaluated the ability of pilots to recover the F-16 aircraft after inadvertent canopy loss. A wind tunnel test program was completed using F-16 fighter pilots as volunteer subjects in a full-scale forebody of an F-16. Protective maneuvers were developed to enable the pilot to regain control of the aircraft. A second test was conducted at Edwards AFB using a TF-15 without its canopy to examine the potential hazard to rear seat crew members in the event of canopy loss. An instrumented dummy and then a human subject (Major Wayne Kendall, Jr.) were flown in an open cockpit to 5000 feet and 415 knots. Dr. Kendall avoided injury by adopting the techniques developed in the F-16 wind tunnel tests (Major Kendall, 7231, 1976)

This research program investigated the influence of the F-16 fuselage and cockpit configuration on the aerodynamic forces which act on an ejecting crewmember. One-half scale models of an ejection seat, and an F-16 forebody and cockpit section were tested in a transonic wind tunnel at MACH numbers from 0.4 to 1.2. Crewmember extremity force measurements were taken beginning with the crewman-seat model positioned in the full-down, pre-ejection position in the cockpit and then repositioned and predetermined intervals until seatrail separation had occurred. The flow over the forebody was found to increase the magnitude and direction of the forces acting on the various limb segments (Mr. Specker, 7231, 1977)
Toxic Hazards Division/NASA Space Shuttle environmental effects research program was initiated. It was expected to missile launch activities where large amounts of toxic products are found in the exhaust plume. The work determines the most potent toxic products occurring in the exhaust plume and exposures of selected plant species to these products. The results of the research provide information on environmental pollution and the impact of these rocket launches on the agriculture industry. Environmental work has also been accomplished on the fish industry (Captain Lind, 6307, 1977)

Theoretical biodynamic investigations have led to a detailed integrated picture of the mechanical properties of the human body and its responses to mechanical forces, particularly by means of a sophisticated computer model of the body. This provided a sound basis for biodynamic injury prediction and unified the field of biodynamics. Symposium with international participation were held at AMRL on two different occasions (Dr. von Gierke, Dr. Oestricher, Dr. Kales, 7231, 1970-1977)

Chemical defense research program was initiated in the Laboratory. The Laboratory Commander appointed Dr. Replogle to serve as the overall coordinator. The research approach was to assess the system impact of degraded personnel operations caused by CW stressors such as low dose effects, protective ensemble deficiencies, and thermal burden. An operations research and human factors program was initiated to create an Air Force capability for analytical assessment of operations in a CW environment. The modeling and analysis capabilities included CW agent effects, air base systems assessment, task-time degradation and risk analysis. The program was supported by a CW data base consisting of a computerized annotated bibliography which has over 5000 documents. The data base was used throughout DOD and industry (Dr. Replogle, 2729, 1979-1984)

Minimum vision requirements for aircraft transparencies became an important Air Force need with the development of polycarbonate windshields. Previously accepted optical standards were difficult to achieve with this material and the flight environment it experienced. Typical problems were complex curvatures, high angle of incidence to provide optimum aerodynamic shaping, composition of the multi-layered materials for bird strike protection, and the radar reflective qualities. This was concentrated on the optical variables of the optical elements and the secondary effects of multiple images, rainbowing, and light transmission. Human vision and performance studies were conducted to gather data and windscreens specification techniques. Other work included analysis of windscreen geometry, and new optical measurement procedures. A new minimum vision specification was established in cooperation with the Air Force Flight Dynamics Laboratory (LCol. Bix, Dr. Task, 7184, 1979)

The Tactical Aircraft Cockpit Development and Evaluation Program (TACDEP) consolidated the pilot factors data base and developed a low cost computer-vision simulation program. It permits the development of quantitative pilot workload/performance measurements and the demonstration of advanced control/display concepts. In the data base area the acquisition and consolidation of all information processing and psychomotor control knowledge has been organized into a handbook, Integrated Perceptual Information for Designers (IPID) (Dr. Furness, 7184, 1980)

In January 1980, the Human Engineering Division of AFAMRL received a request from Headquarters, North American Aerospace Defense Command (NORAD) for assistance in evaluating human engineering at the NORAD Missile Warning Center (MWC). In response to that request, AFAMRL conducted a thorough investigation of the MWC which considered human factors, lighting, noise, and man-machine interfaces. The assessment concluded that noise, facility layout, display quality, and display content could be significantly improved. Recommendations included developing a new operations concept that emphasized the relationship between crew members and the systems and operational conditions they worked in. The MWC assessment proved to be the beginning of a long working relationship between NORAD and AFAMRL. In the year following, AFAMRL personnel again were invited to NORAD, this time to conduct a Human Factors Engineering assessment of the NORAD Command Post. The report of that assessment was published in April 1981. Some recommendations contained in that report were immediately implemented. The implications of remaining issues, however, suggested that a larger effort, leading to eventual upgrade or replacement of the facility was warranted. As a result, AFAMRL provided a more extensive analysis and development of design concepts for a new Command Post. By 1983, AFAMRL
support included a survey of human factors affecting the ADCOM Intelligence Center at NORAD. AFAMRL/HE supported NORAD (now Space Command/NORAD) in the laboratory as well. Another example of the characteristics and applications of large displays, begun in 1983, contributed to the more effective design of command centers at Space Command and throughout the Department of Defense. Another example is the Human Engineering Division’s design and construction of an advanced integrated workstation to demonstrate the potential application of advanced technologies and techniques to specific Space Command needs and feed the design of Space Command/NORAD workstation of the future (Captain Poturalski, Mr. Vikmanis, Captain Leupp, 7184, 1980-1984).

The Tactical Communications research program conducts empirical investigations of conventional and novel audio jammer effectiveness based on measures of human performance in realistic system and noise environments. This work has developed novel audio jamming modulations to exploit signal processing principles used by the auditory nervous system as determined by experiments conducted under the by-now-cancelled bionics research project. Work continues to explore high quality digital voice, voice control/voice response in the tactical cockpit environment (Dr. Moore, 7231, 1982).

The current innovations in aircraft technology (e.g., integrated digital flight control systems, automatic aids, voice actuated controller, etc.) have dramatically shifted the nature of the activities performed by people from that of “manual control” to one of “management” of a set of automated or semi-automated functions. The new reliance on automation in future systems must change the designer’s conception of the role of the crew members in future vehicle design in that the traditional role of direct manual control will have to be balanced against a role of supervisory control. The Cockpit Automation Technology program develops this dual role for the fighter/attack pilots (Mr. Kulwicki, 2829, 1982).

An articulated total body model has been developed using a highly specialized computer graphics technique. This model supports the development of advanced ejection seat concepts and escape technology. It predicts the body motion with respect to the seat, assesses the effect of seat/man dynamics, evaluates the effectiveness of various body restraints, and provides criteria for design of rocket thrust systems. The parameters incorporated into the model include seat geometry, seated system, crewmember body size and mass distribution characteristics, ejection acceleration, aircraft altitude, aircraft attitude, aircraft airspeed, seat rocket placement, rocket thrust, and human tolerance data of abrupt accelerations (Dr. Kalepa, 7231, 1982).

Noise impact technology program has developed an advanced version of NOISEMAP and NOISEFILE. The objectives of these two activities was to develop the technology required to predict community noise exposure caused by aircraft operations in proper physical/psycho-acoustic metrics. The NOISEMAP is a computer based model which inputs aircraft flight and ground operations, the meteorological conditions, and the suppressors being used. The program outputs are noise contour maps with single event footprints, cumulative exposure, land areas exposed and the number of people either exposed or annoyed. The NOISEFILE uses magnetic tape to gather aircraft noise characteristics in flyovers, run-up, and use of suppressors. The technical factors are sound pressure, duration effects, spectral content, psycho-acoustic response, propagation and the aircraft power plant (Mr. Cole, 7231, 1982).

The standard USAF ejection seat is now the Advanced Concept Escape System called ACES II. It uses technology of the late 1960's and is certainly the best seat ever fielded by the USAF. - a tribute to the joint AFAMRL/ASD team that developed it between 1965 and 1974, using a controlled force catapult, a gyro controlled stabilizer rocket and a sustainer rocket to assure safe ejections from a wide variety of emergencies while minimizing the probability of injury due to ejection forces, seat tumbling or parachute opening shock. Computerized control now allows development of a more capable seat and AMD asked AFAMRL and AFWAL to jointly man an Advanced Development Program (Office to demonstrate Advanced Crew Escape Technologies (CREST ADP) to extend the safe ejection envelope to include higher speeds, higher sink rates and wider variety of adverse attitudes, low-altitude emergencies. To do so required development of the first 6-degrees-of-freedom human impact acceleration tolerance criteria in a transfer function formulation suitable to mechanization in the adaptive digital flight controller. A flow stagnation windblast protection system was developed to simultaneously control aerodynamic forces on the seat occupant and seat drag coefficients. Finally, the Advanced Dynamic Anthropomorphic
Manikin (ADAM) program was initiated to insure availability of a suitable "live load" for demonstration ejection tests (Mr. Binkley, Lt/Col. Rock, Mr. Specker, Dr. Kulepa, 2688, 1983)

Anthropometric support to weapon system development is a critical factor in cockpit and equipment sizing. This Laboratory has maintained through the past forty years a singular expert capability which has been applied to a broad range of Air Force problems. Specifically, the sizing and critical fit testing of the constant streams of developments in personal protective equipment. Primary examples are chemical defense protective clothing for flying and ground crews, improvements in oxygen masks, protective helmets, pressure suits, fire fighter suits, uniform clothing, and aircraft mounted equipment. No other organization in the Air Force has this capability (Mr. Alexander, 7184, 1984)

The Strategic Avionics Crew Station Design Facility (SACDEF) conducts strategic mission simulations with computer controlled man-in-the-loop monitoring of systems and aircrew performance. The mission scenarios and combat ready crews were supplied by Strategic Air Command (SAC). The output of this program was used by Strategic Air Command for crew station design modification and the development of combat tactics. The SACDEF is also used by the ASD/Deputy of Advanced Planning for studies of new weapon systems penetration ability and new automated avionics controls (Dr. Chubb, Mr. Sharp, Lt/Col Brisky, 7184, 1984)

AWARDS

1970 Dr. Thomas Furness AFSC Scientific Achievement
1970 Major John Simons Alex C. Williams Jr. Award
1971 Mr. Jim Brinkley AFSC Scientific Achievement
1971 Mr. Robert Powell AFSC Scientific Achievement
1971 Dr. Clyde Replagle AFSC Scientific Achievement
1971 Mr. Jerry Speakman AFSC Scientific Achievement
1972 Mr. Charles Dempsey NSFC Engineer of the Year
1972 Dr. Leon Kamaran Eric Lijencrantz Award
1972 Mrs. Debbie Seifert Patrick Reys Glass Award
1972 Mr. Philip Kuswicki AFSC Scientific Achievement
1973 Dr. Leon Kamaran George-Shmolz Preis Award
1974 Dr. Henning von Gierke Arnold D. Tuttle Award
1975 Mr. Charles Dempsey Meritorious Civilian Service
1976 Mr. Jim Brinkley NASA Group Achievement Award
1976 Major Jim Vogtke Legion of Merit
1977 Mr. William Albery AFSC Scientific Achievement
1977 Col. Dan Johnson Harry G. Armstrong Award
1978 Lt/Col Wayne Kendall Jacoba Award
1980 A F A M R L AF Outstanding Unit Award
1980 Mr. Charles Bates AFSC Distinguished Civilian Service Award
1980 Mr. James Murphy St. J. Katchman Award
1981 Mr. Jim Brinkley GECO Public Service Award
1981 Dr. Henning von Gierke Distinguished Executive Award
1981 Dr. Joe McDaniel Federal Employee of the Year
1981 Mr. Dan Hopperger Harry G. Armstrong Award
1982 Mr. Michael Gargas Frank R. Blood Award
1982 Dr. Tom Moors AFSC Scientific Achievement
1982 Mr. Richard McKinley AFSC Scientific Achievement
1982 Dr. Mel Andersen AFSC Scientific Achievement
1982 Mr. Richard McKeeley Arthur S. Fleming Award
1983 Mr. Charles Dempsey Exceptional Civilian Service Award
1983 Mr. Jim Brinkley Eric Lijencrantz Award
1983 Dr. Lee Task Harry G. Armstrong Award
1983 Dr. Lee Task AFSC Scientific Achievement
1983 Mrs. Katherine Smith Federal Woman of the Year Award
1983 Mr. Gil Kupersman AFSC Scientific Achievement
1983 Mr. Gill Welde AFSC Scientific Achievement
1984 Major William Keller AFSC Scientific Achievement
1984 Mr. Eberhardt Privitzer AFSC Scientific Achievement
1984 Mr. Larry Specker AFSC Scientific Achievement
1984 Dr. Lee Tank Sloan Management Award
1984 Col. Michael McNaughton AMA Science & Eng. Award
1984 Dr. Lee Tank Exceptional Civilian Service Award
1984 Mr. Lee Griffin Exceptional Civilian Service Award
1984 Mr. Duane Starbuck Exceptional Civilian Service Award
Fig V-1  Long line loiter flight maneuver modified and improved for military use by Major Simons.
Fig 10: Captain Bubbling holding the ground end of the long line attached to the circling aircraft.
Fig V-3 Anthropomorphic dummy is being towed in trail following a pick-up from the ground by the long line hoist system.
Fig V-5  First flight test of the helmet mounted sight in an F-101 aircraft at Tyndall AFB.
Fig V-6 Visually coupled airborne system simulator is a fundamental new approach to aircrew training.
Fig V9 Test dummy entering the deceleration device at the end of the impulse accelerator track.
Fig. V.6  First high acceleration cockpit design using the tiltable seat and computerized displays.
Fig 17. Subject in the high acceleration cockpit seat while being exposed to $+g_0$ in the centrifuge.
Fig V.18: AAA simulator used in human performance tests of defense systems.
Fig V.19 First computer graphics of articulated total body model used in analysis of ejection forces.
Fig. V.21  Multiple operator experiments in the voice communications research program.
Fig V.23 Anthropometric study of new chemical defense protective equipment.
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<td>Commander</td>
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<td>Soudier, Marivo, Mr</td>
<td>Branch Chief</td>
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<tr>
<td></td>
<td>Tuth, David, LtCol</td>
<td>Branch Chief</td>
</tr>
<tr>
<td></td>
<td>Wesley, Lisa, Ms</td>
<td>Branch Secretary</td>
</tr>
</tbody>
</table>
BBE  BIODYNAMIC ENVIRONMENT BRANCH
Cole, John, Mr. Branch Chief
Hille, Harald, Mr.
Lee, Robert, Mr.
Peache, Norma, Mrs
Powell, Robert, Mr.
Spaakman, Jerry, Mr.

BBM  MODELING AND ANALYSIS BRANCH
Brown, Timothy, Mr Branch Chief
Carroll, Cory, Capt
Cheestnut, Gary, 2d Lt
Kalepa, Ints, Dr
Parsons, Linda, Ms
Privatzer, Eberhardt, Dr
Rasmussen, Roy, Mr
Urena, Erasmo, 2d Lt

BBP  BIOMECHANICAL PROTECTION BRANCH
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Berry, Jimmy, SSGt
Blake, Jeni, Mrs Branch Secretary
Brinkley, James, Mr
Brown, John, Mr
Christopherson, Hal, MSgt
Connors, Michael, Capt.
Dewerd, Carter, 1st Lt
Gaudreau, Dianne, SSGt
Goodwin, Mark, 2d Lt
Jaster, Mark, 2nd Lt
Mays, William, 2d Lt
Ozech, Mary Ann, Capt.
Salerno, Mark, Capt.
Saylor, William, CMSgt
Schimmel, Dale, MSgt
Specker, Lawrence, Mr
Toler, Carl, Mr.

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Frazier, John, Mr
Howell, Lora, SSGt
Jennings, Thomas, Capt
Potter, George, Dr
Raino, David, Mr
Reppenger, Daniel, Dr
Riggs, Kenneth, SSGt
Rodriguez, Luis, 1st Lt
Scoggins, Terrell, 2d Lt
Shriver, Thomas, Mr
Skowronskii, Vance, Mr
Swinhart, James, SSGt
Swisher, Michael, SSGt
Tripp, Lloyd, SSGt
VanPutten, Robert, Dr
Waite, Ilonda, Ms

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Osman, Barbara, Mrs Division Chief

Division Director
Division Secretary
HEX TECHNOLOGY INTEGRATION BRANCH
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Penick, Lee, 1st Lt
Stevenson, Sandra, Miss

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Calhoun, Gloria, Ms
Cannon, Mark, Jr
Easterly, JF, Mrs
Ellis, Tanya, Ms
Harned, Thomas, Dr
Gibson, Arthur, Maj
Green, Francine, Mrs
Henderson, Jonathan, Mr
Kocian, Dean, Mr
Kupersman, Gilbert, Mr
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Sembler, George, 1st Lt
Self, Horst, Dr
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Dowsay, Cheryl, Ms
Forester, John, Dr
Hatt, Ronald, Dr
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Nikawa, John, MSgt
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Stee, Leonard, 2d Lt
Svensen, Walter, Mr
Vikranis, Maria, Mr
Work, Sharon, Ms

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Barren, Gerald, Mr
Chapin, Albert, S/Sgt
Connor, Robert, T/Sgt
Colvis, James, S/Sgt
Green, Thomas, Mr
Halges, Richard, MSgt
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Roberts, Leon, Maj
Sharp, Ead, Mr
Walters, Gene, A1C
Wilson, Glenn, Dr
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HEF CREW SYSTEMS EFFECTIVENESS BRANCH
Bruderbaugh, John, Mr
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Craig, Jeffrey, Mr
Doucet, Perry, Mary, Mrs

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Genco, Louis, LtCol  Branch Chief
Karna, William, Mr
McKeehan, Don, Mr
McMillan, Grant, Dr
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Mills, Robert, Dr
Myers, Joann, Ms  Branch Secretary
Slusher, William, Mr
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Topmiller, Donald, Dr
Warren, Richard, Dr

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Eggleslon, Robert, Maj
Floyd, Loreetta, Maj
Junker, Andrew, Mr
Kennedy, Kenneth, Dr
McDaniel, Joe, Dr
Pearson, William, Mr
Reid, Gary, Mr
Robinetto, Kathleen, Mrs
Yates, Ronald, Mr

HET SPECIAL PROJECTS BRANCH
James, Ronald, Maj  Branch Chief
Masak, Jonzuo, 2d Lt
Reploge, Clyde, Dr
Unfried, Karen, Mrs  Branch Secretary

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Garcia, Oscar, SMSgt  Division Superintendent
Martone, Joseph, Maj
Staats, Bruce, Dr  Division Director

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Gowell, Harvey, Maj
Bel Pazo, Nicholas, Mr
Gargus, Michael, Mr
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Gergely, Patoy, Mrs
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Murphy, James, Mr
Richard, Roger, SSgt
Sudberry, Gregory, A1C
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Chase, Matthew, SSgt
Guiles, Patricia, Sgt
Kendrick, Judy, SSgt
Mattie, David, Dr
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Hoover, David, SSgt
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Nitz, Harold, SSgt
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Yu, Kyung, Mrs

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Troy, Alex, Mrs Division Secretary

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Crosley, Tammy, Mrs
Dennard, Phyllis, Mrs
Green, Rebecca, Mrs
Hull, Leona, Mrs
Krusemark, Thomas, Cpt
Lester, Angela, Mrs
Leskauskis, Patricia, Mrs
Smith, Darrell, SSgt
Weaver, Rebecca, Ms NCOIC MNGT Services Branch
Simmons, Kenneth, Mr STINFO Secretary

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Theo, Norman, Mr Branch Secretary
Trusky, Teresa, Mrs
Villa, Michelle, 1st Lt

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Gottrell, Jr, Paul, Mr Sect Sec Chief
Hensley, Roger, Mr
Molden, Stafford, Sgt
Schroeder, Pamela, Mrs

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Carson, Benton, SrA
Gorden, Anthony, Ann
Molden, Cynthia, Sgt
Wolford, Joyce, Mrs

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Haddrick, Scott, MSGt Section Chief
Hale, John, Sgt
Holler, Gary, TSgt
Yackoboskie, Richard, TSgt
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Bashett, Richard, Mr Branch Chief
Bolhannon, Katherine, Mrs Branch Secretary
Crutchfield, Margaret, Mrs
Hicks, Veresta, Ms
McCarthy, James, Mr
McCamboy, John, Mr
Zampedro, Jon, 1st Lt

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Crawford, Billy, Mr Branch Chief
Cross, Charlene, Mrs

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Bauman, Timothy, Mr
Cooper, James, Maj
Edstrom, William, SSGt
Flaute, William, Mr
Hermann, Linda, Capt
Johnson, William, CMSgt
Nul, Connie, Mrs Division Superintendent
Obeck, Douglas, LtCol
Reed, Theron, SSgt
Switzer, Richard, TSgt
Taylor, Richard, Mr
von Bechmann, Derek, Ann
Young, Susan, Ms

CAT COCKPIT AUTOMATION TECHNOLOGY ADPO
Cole, Dean, Maj ADPO Director
Koziwicki, Philip, Mr

CREST CREW ESCAPE TECHNOLOGY ADPO
Higgins, A-Michael, Maj CREST Program Manager
Wach, Robert, Capt
Ward, Michael, SSGt

NSBHT NOISE AND SONIC BOOM ADPO
Living, Gerald, Maj
IN MEMORY

THE DEDICATED FEW WHO CLEARED THE PATH TO THE FUTURE

THE TYPICAL "CAN DO SPIRIT" OF THE LABORATORY
IN MEMORY

THE DEDICATED FEW WHO CLEARED THE PATH TO THE FUTURE

Miss Audrey Fano
Colonel Mike Swesty
Dr Fred Bernier
Colonel Randy Lovelace
Dr Hans Maugh
MG Harry Armstrong
Mr Henry Beecher
Dr Dean Chiles
Mr George Frost
MGTF Harold Libby
Mr Morse Dropper
Mr Dan Rosenhovin
Dr Howard Furrack
Miss Bion Finkelman
Mrs Edwin Miller
Mr Josh Chalmers
Mr Ronald Wissauzon
Captain Russell
Captain Harry Mayers
Mrs Margaret Marcin
Mrs Julia Pettit
Dr Paul Pitts
Dr Otto Gosser
Mr Don Good
Col Arthur Henderson
Miss Patricia Loch
Miss Glenna Hawke
Miss Helen Oster
Mr Miles McLean
Mr EG Correll
Lt Col Elizabeth Guild
Mrs Betty Sullivan
Mr Charles Wirth
Cpl. Freda Herrera
Mrs Marie Beckhaus
Mrs Edna Schramm
Mrs Virginia Comte
Lt Col Harry Collins
Mr Cornelius Dorsey
Lt Frank Bichardson
Mrs Anna Hirass
Miss Dorothy Leffel
Major Dave Maloney
Mr Roy Middleton
Mr John Sullivan
Lt Col Rob Summer
Capt. Harold Smidz
Mr Carl Witchell
Mr Louie Yeary
Colonel Kendrick
Dr Dwayne Ketsen

Secretary to the Commander
Biophysics Branch
Technical Director
Commander
Environmental Section
Founder, Aero Medical Laboratory
Engineering and Development Branch
Crew and System Section
Psychology Branch
Respiration Section
Coordinator, Noise and Vibration
Nutrition Section
Librarian
Nutrition Section
Accessories Section
Anthropology Section
Anthropology Section
Biophysics Branch
Respiration Section
Founder, Psychology Branch
Aviation Section
Engineering and Development Branch
Vice Commander
Operations Office
Biophysics Branch
Biophysics Branch
Bio-electronics Section
Bio-electronics Section
Clothing Branch
Engineering and Development Branch
Medical and Sanitation Section
Administration
Physiology Branch
Personnel and Mail Section
Psychology Branch
Lab Services Section
Adaptation
Biophysics
Administration
Respiration Section
Respiration Section
Lab Services Section
Medical and Sanitation Section
Respiration Section
Lab Services Section
Machine Shop
Commander
Human Engineering
Human Engineering
Human Engineering
Human Engineering
Biodynamics
Oxygen Branch
Protective Equipment Branch
Human Engineering
Human Engineering
Training Division
Human Engineering
Human Engineering
Training Division
Human Engineering
Biophysics
Human Engineering
Human Engineering
Human Engineering
Nutrition Section
Biophysics
Human Engineering
Administration
Human Engineering
Human Engineering
Human Engineering
Human Engineering
Human Engineering
Veterinary Medicine
Toxic Hazards Division
Toxic Hazards Division
Protection Branch
EPILOGUE

“LOOK AHEAD WHERE THE HORIZONS ARE ABSOLUTELY UNLIMITED”

Robert E. Gross
Lockheed Corporation.

This is an unfinished history about the continuing biotechnology research on manned flight vehicles. The United States leadership in aeronautics and astronautics continually dictates the future direction of flight based on the evolving technology in avionics, vehicle design, flight control and propulsion. This future direction can be easily summarized as: faster, higher and farther. Biotechnology is therefore challenged to the maximum limits of human tolerance and performance capability. MAN must always adjust and adapt to these new environments since the luxury of creative redesign is not available.

The first eighty-five years of flight, from the 1903 Wright glider on the sand dunes of Kitty Hawk to Neil Armstrong on the Moon and space probes on Mars, has been without parallel in human history. If the next eighty-five years are pursued as rapidly as the past, it is quite possible that MAN will be living in space for extended periods of time. This might be the ultimate challenge for biotechnology research. The past golden age of flight has established the AEROSPACE MEDICAL RESEARCH LABORATORY as the World leader in human factor criteria for manned aerospace vehicles. This leadership was obtained through the dedicated and heroic achievements of the many scientists who have passed through its doors. They, like Armstrong, are also the true pioneers, for they established base line knowledge which permits one to “LOOK AHEAD WHERE THE HORIZONS ARE ABSOLUTELY UNLIMITED.”
BUILDINGS

The Aerospace Medical Research Laboratory has continually increased the size of the physical plant to accommodate the evolving mission responsibilities and increased acquisition of sophisticated simulators and testing equipment. Founded in 1935, it was originally located in the basement of Building 16. The rapid demands of the war years required a major relocation and the construction of new facilities. Buildings 29, 55, 196, 197, 198 were constructed in 1943-1944 and became known as the aeromedical complex at Wright Field. The complex was further expanded with the construction of Building 33 in 1947, and Building 248 in 1954. Since there was not additional land space within the complex the Laboratory was forced to continue it’s building program at other locations on Wright Field. Building 824 was acquired in 1955, and Building 441 was constructed in 1957. These two structures are located on the east side of Wright Field approximately two miles away from the aeromedical complex. Building 79 located on the south side of Wright Field was acquired in 1965. The last new facility was the construction of Building 838 on the east side of Wright Field.

Since 1965, there have been extensive renovations or expansions of the existing buildings. Today the Laboratory is accommodated in the following structures:

<table>
<thead>
<tr>
<th>Building</th>
<th>Square Feet</th>
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</thead>
<tbody>
<tr>
<td>Building 29</td>
<td>25333 sq.ft.</td>
</tr>
<tr>
<td>Building 33</td>
<td>58696 sq.ft.</td>
</tr>
<tr>
<td>Building 79</td>
<td>37251 sq.ft.</td>
</tr>
<tr>
<td>Building 196</td>
<td>7680 sq.ft.</td>
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<tr>
<td>Building 197</td>
<td>8082 sq.ft.</td>
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<tr>
<td>Building 198</td>
<td>5647 sq.ft.</td>
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<tr>
<td>Building 248</td>
<td>66576 sq.ft.</td>
</tr>
<tr>
<td>Building 441</td>
<td>29311 sq.ft.</td>
</tr>
<tr>
<td>Building 824</td>
<td>36361 sq.ft.</td>
</tr>
<tr>
<td>Building 838</td>
<td>24502 sq.ft.</td>
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Fig B.1  Human engineering and biodynamics. Bldg 35.
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18. Trip to Washington, D.C. EO64-1 Serial #X-54-245, April 27, 1935 Armstrong, Equipment Branch, Engineering Section, Wright Field, Dayton Ohio

19. Conference with Commandant, School of Aviation Medicine, Randolph Field, Texas Serial #X-54-246-A1, May 13, 1935 Armstrong, Equipment Branch, Engineering Section, Dayton Ohio

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22. Trip to Harvard University, Boston, Massachusetts EO903-1 Serial #Q-54-5, November 30,1935 Armstrong, Equipment Branch, Engineering Section, Wright Field, Dayton Ohio
23. The Oxygen Equipment of Miss Alice M. Gibson of New York City EO660-1-33 Serial #X-54-203, December 6,1935 Armstrong, Equipment Branch, Engineering Section, Wright Field, Dayton Ohio
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